Ilizarov (Compression-distraction) method in Paediatric Orthopaedics

# ILIZAROV TECHNIQUE

MD.MOFAKHKHARUL BARI

ISBN: 978-0-9967956-5-4

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# Ilizarov Compression-distraction method in Paediatric Orthopaedics

This book is dedicated to my parents, father and mother-in-laws and to all my patients

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**Published by:**

MedCrave Group LLC
March 31, 2016

# Ilizarov (Compression-distraction) method in Paediatric Orthopaedics


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MD; MS (Ortho and Trauma) – Kiev,
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Post-Doctoral Fellowship on Ilizarov Technique (RISC, RTO)– Kurgan, Russia.

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**Published by:**

MedCrave Group LLC
1st Edition – March 31, 2016

# About the Author

Kurgan Ilizarov Center in Russia, the largest Orthopaedic Institute in the World, conferred the most Prestigious degree on Dr. Md. Mofakhkharul Bari as Honorary professor symbolizing “the globally reputed medical scientist (Orthopaedics)”.

Prof. Dr. Md. Mofakhkharul Bari, former Unit Chief, National Institute of Traumatology & Orthopaedic Rehabilitation (NITOR)– (Limb lengthening, deformity correction, surgical reconstruction Unit) has been awarded the most dignified degree as “Honored Professor” symbolizing the globally reputed medical Scientist (Orthopaedics) in recognition to his outstanding professional expertise. He is the first foreigner qualified for this great global honor on the 14th of June 2013. Dr. Md. Mofakhkharul Bari obtained M.D. from Kiev Medical Institute in 1982 and in 1984 he accomplished his M.S. degree in orthopaedics from Kiev Scientific Research Institute of Orthopaedics and Traumatology (KSRIOT). In 1995 he obtained Ph.D. degree from Tashkent Scientific Research Institute of Orthopaedics and Traumatology. In 2003 and 2006 he persued Post-Doctoral fellowship on Ilizarov technique in the Kurgan Ilizarov Center. He has enormous publications totaling 67 on different topics of Orthopaedics and Traumatology. Out of his total publications 26 and 41 have been brought in public through International and National Journal respectively. He authored rich textured books, now being widely read out as reference in different countries of the world. Besides professional obligations he spares much of his time in teaching as well as in research.

Among his outstanding performances, deformity correction, limb lengthening, stature lengthening, osteomyelitis, all non-unions & pseudoarthrosis, open fractures etc are amazing and remarkable. He successfully put them to work in Bangladesh with tremendous outcome.

This great honor conferred on Dr. Md. Mofakhkharul Bari is an iconic image of Bangladesh. This outstanding achievement is a professional milestone in the Orthopaedic arena.

# Foreword

I am honored to have this opportunity and share with you my deepest inspirations for writing a few words on the eve of this excellent paediatric orthopaedic book titled "Ilizarov (Compression-distraction) method in Paediatric Orthopaedics", by our Honored Professor of Kurgan Ilizarov Centre Md. Mofakhkharul Bari.

Bangladesh is a developing country and is burdened with a huge number of population with disabilities in desperate need of attention. Infact, many of the paediatric orthopaedic books do not provide information for the young surgeons. So, a need of this kind paediatric orthopaedic book has long been felt. Professor M.M. Bari, a teacher with distinct quality and a lifelong devotee of Ilizarov technique, has given time and effort to bring out this wonderful book. This book is extremely informative. The surgeon will find the book very gripping and absorbing.

My heartiest congratulations to him for publishing this paediatric orthopaedic book by Ilizarov technique in the coming New Year 2016.

I wish him all the success.

06.01.16

Professor A. V. Gubin
MD; MS; Ph.D; D.Sc.
Director, Russian Ilizarov Scientific Centre,
Restorative Traumatology & Orthopaedic (RISC, RTO),
Kurgan, Russia

# Foreword

This book “Ilizarov (Compression-distraction) method in Paediatric Orthopaedics”, is designed to provide the Orthopaedic surgeons with a rational treatment of paediatric trauma and orthopaedic problems. Professor Md. Mofakhkharul Bari’s large volume of personal expertise with Ilizarov technique since 1982 (during Orthopaedic residency) till date is a great achievement in the field of trauma and Orthopaedic surgery. This paediatric orthopaedic book by Ilizarov technique characterizes the professional carrier of Professor M.M. Bari. I have watched Professor M.M. Bari silently grow over the 33 years to become a leading author in the field of Ilizarov surgery. A good book is one which apart from convincing interest in the students about the subject, makes them desirous to know more and more about it. This paediatric orthopaedic book is very informative, innovative technique, clinical photographs, good radiograph are all there in plenty. Professor M.M. Bari was my very favourite fellow student. I congratulate him on his stupendous efforts. I consider Professor M.M. Bari very successful. I hope this publication will be well accepted by the readers at home and abroad.

I wish him all the best in the coming New Year 2016.

06.01.2016


Academician Professor V.I. Shevtsov
MD; MS; Ph.D; D.Sc.
Former Director, Russian Ilizarov Scientific Centre,
Restorative Traumatology & Orthopaedic (RISC, RTO),
Kurgan, Russia
Corresponding Member
Russian Academy of Medical Sciences.

# Foreword

With hardly a handful of Orthopaedic surgeons taking to writing books. I have watched Prof. Md. Mofakhkharul Bari silently grow over the three decades to become a leading author in the field of Ilizarov Technique. He has authored 5 (five) books on Ilizarov Technique single handedly and still counting-truly a global record. Prof. Md. Mofakhkharul Bari has a natural flair for writing and his books are liked by all. This book "**Ilizarov (Compression-Distraction) Method in Paediatric Orthopaedics**" is informative, thought provoking and entertaining and most up to date. It is very stylishly written and is neatly designed. It has so many unique features on cong enital and acquired deformities in children which is hitherto unprecedented in the history of Ilizarov book writing.

What makes this book "**Ilizarov (Compression-Distraction) Method in Paediatric Orthopaedics**" stand out from the rest is that, it never provides the Orthopaedic surgeon with a single dull moment and makes the reading very interesting and the surgeon will find it very gripping and absorbing.

I congratulate Prof. M.M. Bari on his stupendous efforts and is undoubtedly a matter of great pride and honor for him. Bari is good trendsetter as far as Orthopaedic writing is concerned and is worthy of emulation. He has truly put Bangladesh on the global map and deserve praise and accolades for all his efforts.

I wish him all the best and feel privileged to write this foreword for the book "Ilizarov (Compression-Distraction) Method in Paediatric Orthopaedics".

03/01/2016

**Dr. H. R. JHUNJHUNWALA**

Prof of Orthopaedic Surgery
Post Graduate Institute of Medical Sciences of Bombay Hospital Mumbai.
Senior consultant orth surgeon
Ex President INTERNATIONAL ASAMI
President – Elect Indian Orthopaedic Association
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Chairman of Dr K.T.Dholakia Foundation
Chairman of Vedic Heritage Lonavala
Chairman of Acharya Vishwanath Sarma Art Foundation

# Message

It is a great privilege for me to write a few words on the auspicious occasion of the publication of “Ilizarov (Compression-distraction) method in Paediatric Orthopaedics”, by Md. Mofakhkharul Bari who is a lifelong devotee to Ilizarov technique.

Our BARI-ILIZAROV Orthopaedic Centre, where he has done most of his magical works is a well recognized orthopaedic centre making difference in the lives of human being. Ilizarov technique has now gained a strong foothold in Bangladesh by which we can correct any kind of congenital, acquired deformities and limb lengthening and solve any complex trauma problems. Our motto is to make people able to do their normal work and go back to their normal life.

My appreciation to Professor M.M. Bari for his tireless work in publishing this book “Ilizarov (Compression- Distraction) Method in paediatric orthopaedics”.

03/01/2016

Nabia Bari
MSS. IR (International Relations) Managing Director
Bari-Ilizarov Orthopaedic Centre

## Contents

# Acknowledgements

It is a token of respect to my patients without whom I could not do this "Ilizarov (Compression-distraction) method in Paediatric Orthopaedics", is a vast topic which cannot be expressed in a few pages. I have tried my best to cover the important and basic points in this "Ilizarov (Compression- distraction) method in Paediatric Orthopaedics", Lengthening, reconstruction and deformity correction has occupied vast role in orthopaedic surgery. Professor V. I. Shevtsov, (Former-Director, RISC, RTO, Kurgan, Russia) is my beloved teacher, Professir A.B. Gubin, Director, RISc, RTO, Kurgan, Professor Dror Paley of USA, Professor G. S. Kulkarni of Miraj, Professor H. R. Jhunjhunwala of Mumbai, Professor H M Harshad Shah of Bangalore, are the leaders of overall advancement in this field. I have learned a great deal from them and I acknowledge the same. I recall the blessings given to me by Professor E. T. Skliarenko (my MS supervisor, from Kiev) and Professor B. M. Mirazimov (my Ph.D. supervisor, from Tashkent), Professor V.I. Shevtsov (Post-doctoral fellowship supervisor, from Kurgan, Russia) because of them my career could get a new shape. My wife Nabia Bari, my true love and better-half could work on this modern gadgets and my loving sons and daughter and entire family have been the backbone in all my efforts, they really deserve appreciation. I am greatly indebted to my friend, Professor Kh. Abdul Awal Rizvi, former Director, NITOR for his support, advice and encouragement. I am grateful to Dr. Mushiar Hossain Munshi, Professor Md. Abdul Gani Mollah, Secretary, ASAMI, Dr. ABM Golam Faruq, Organizing Secretary ASAMI, Dr. Shabir Reza, Dr. Nayeema Ferdousi Misty, Dr. Md. Arifuzzaman, Dr. Masum Billah, Dr. Md. Rafiqul Islam Khan, Dr. Md. Arif, Professor Sheikh Nurul Alam, Professor Amjad Hossain, Professor Shamim Adom, Professor Nazimuddin, Professor R. R. Kairy, Professor Shahiduzzamn, Professor Rafiqul Islam, Professor Humayun Kabir, Professor Kamrul Alam Saleh, Professor Iqbal Qavi, Professor Dr. Shah Alam, Professor Manjurul Haque Akanda Chowdhury, Dr. Md. Shahidul Islam, Professor M A Samad, Professor Sajjad Husain, Dr. Md. Wahidur Rahman, Dr. Md. Golam Sarwar, Dr. Abdus Salam, Dr. Md. Jahangir Alam, Dr. Qumruzzaman Monta, Dr. Jawaher Jahan for inspiring me regarding this "**Ilizarov (Compression- distraction) method in Paediatric Orthopaedics**".I must appreciate the activities of Mr. Sayeefur Rahman (Rizvi), Raihan Johney, Bashir Ahmed, Graphics Designer of this Md. Masudur Rahman. I also express my appreciation to my other friends. And finally I pray to Almighty Allah for the well-being of my patients.

## Preface

I am greatly indebted to all my reverend teachers and fellow colleagues for helping me in writing this “Ilizarov (Compression-distraction) method in Paediatric Orthopaedics” while working in the then Soviet Union (Kiev Scientific Research Institute of Orthopaedics and Traumatology, Tashkent Scientific Research Institute of Orthopaedics and Traumatology and Russian Ilizarov Scientific Centre) and different hospitals in Bangladesh from primary health care centres to the tertiary centres. I found that the fracture care has not gained much attention within the time of golden hour, that is the reason for development of deformity, non-unions and mal-unions which could have been prevented and corrected during the initial management at trauma hospitals. In our medical colleges, the orthopaedic units are not well equipped for managing the operation fractures and complex trauma patients, deformity, whatever maybe, is totally unproductive to the nation as a whole. The reconstruction of the limb deformity is my effort to bring attention towards it and fulfill the basic need of the hour in trauma care. I have tried my best to include the latest information in this “Ilizarov (Compression-distraction) method in Paediatric Orthopaedics” but nothing is complete. Reconstruction by Ilizarov is an art and skill which can only be mastered by the discipline of observation and practice. Ilizarov method has now gained a strong foothold in Bangladesh. Other techniques in orthopaedics, one can learn in 1-2weeks; but one cannot learn this technique in a short period of time. I have consulted many books and journals written in Russian language which inspired me in preparing this “Ilizarov (Compression-distraction) method in Paediatric Orthopaedics”.

Many people have asked me “How did you get into Ilizarov technique?” I would like to acknowledge the mentorship and support of many people by telling the story of my orthopaedic Ilizarov journey. The most complex and post-traumatic problems were bone loss and large deformity and nobody could give a good solution for these. That’s why I have taken a decision to pursue fellowship in Kurgan (the mother institute) under the guidance of Prof. V. I. Shevtsov, the successor of Prof. G. A. Ilizarov and that was life changing for me. I was totally amazed by his clinical work. He is a great teacher and a great man and I am indebted to him for teaching me the tools of this amazing technique. Limb lengthening and reconstruction of deformity is an exciting new discipline in the field of orthopaedic surgery. In Kurgan I met N. M. Marzhuk, V. M.Shegirov, Y. P. Saldatov. I worked with them on clinical and academic pursuits and they exposed me to many aspects of the classic Ilizarov method. Orthopaedic conferences have been very productive for the sharing of ideas and knowledge. That’s why I am travelling every year 6 to 8 times in different countries to share knowledge and exchange views regarding the orthopaedic problems.

We have come to appreciate the many indications for the Ilizarov method. I owe a great deal of gratitude to Prof. G. A Ilizarov, the great self-taught Orthopaedic surgeon, a pioneer genius with distinguished academic activities. This Ilizarov (Compression- distraction) method in Paediatric Orthopaedics “Surgical Reconstruction and Deformity Correction” is based on the experience and treatment of more than 10,000 paediatric patients for the last 33 years- in abroad, MMCH, Narayanganj 200 bedded hospital, Bio-Centre and NITOR. I believe that this Ilizarov (Compression- distraction) method in Paediatric Orthopaedics will stimulate budding doctors to explore this sub-specialty orthopaedic surgery. Ilizarov’s work inspired the formation of ASAMI, which is an international academic society with national branches and fortunately I am the President of ASAMI, Bangladesh Chapter at present. I always encourage doctors who are interested in this field to become the member of this association. It is a place where we can learn, share ideas and meet fellow “Ilizarovians”. In 2O10, June 16-19, we attended 6th ASAMI International Conference in Cairo for sharing new information regarding the orthopaedic problems.

Bangladesh is the life member of this society. In June 2O12, a 22 member group from ASAMI attended the 7th international conference in Greece. In September 18-21, 2014, 24 member attended the 8th International Conference in GOA. This **Ilizarov (Compression- distraction) method in Paediatric Orthopaedics** comprises of clinical photographs accompanied by brief captions wherever it is useful, by operating pictures, diagrams, tables and charts. I offer my sincere thanks to all who have directly or indirectly helped me in the preparation of this atlas in the last few years. I am thankful also to the staff in NITOR and BIO-Centre for their help at all times. My wife Nabia Bari (MSS, IR) who despite her family responsibilities and hospital Managing Director load has not only contributed but also helped in editing this **Ilizarov (Compression-distraction) method in Paediatric Orthopaedics**, and our children Shayan Bari, Zayan Bari and Ishmam Bari have stood beside me. I am greatly indebted to my patients for providing me with both typical and atypical problems to study. The first step is the pre-operative planning which is universally required and beneficial.

The typing, setting up manuscripts and photographs is the real tough job in preparing a book “Ilizarov (Compression-distraction) method in Paediatric Orthopaedics and I appreciate the kind contribution by my eldest son Shayan Bari, Prof. Md. Shahidul Islam, Dr. Nazmul Huda Shetu, Dr. Mahfuzer Rahman, Shahjahan, Munir, Jashim (OT Staffs), Minhat Majed Sami, Julekha Ruma (Physio therapist), Rajon (Accountant) of Bio-Centre.

I wholeheartedly always welcome readers comments and criticism ideas and after all appreciation too. This Ilizarov (Compression-distraction) method in Paediatric Orthopaedics is dedicated to my parents, my father and mother-in-laws and to my patients.

03.01.16

Md. Mofakhkharul Bari Professor & Chief Consultant BARI-ILIZAROV Orthopaedic Centre Dhanmondi, Dhaka

# Part 1
# Introduction

# Chapter I
# History

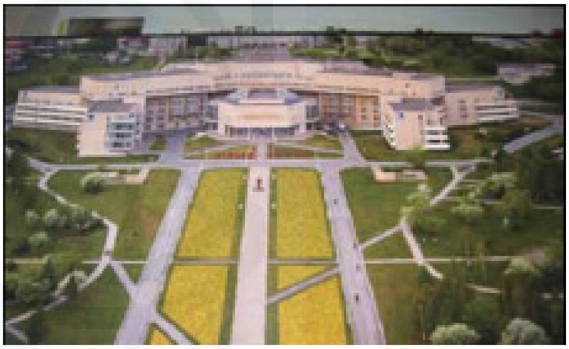
Professor Gabriil Abramovitch Ilizarov– graduated from medical school in the Soviet Union in 1943 near the end of World War II. After graduation, he was assigned to practice in Kurgan, a small town in western Siberia. He was the only physician with hundreds of miles and had little in the ways of supplies and medicine. Faced with numerous cases of bone deformities and trauma victims due to the war, Professor Ilizarov used the equipment at hand to treat his patients. Through trial and error with handmade equipment, this self-taught orthopaedic surgeon created the magical combination that would cause the bones to grow again. Thus the Ilizarov technique was created.

Academician G.A. Ilizarov
15.06.1921 – 24.07.1992

lizarov Technique- The Ilizarov technique/ method of treatment used Prof. Ilizarov's Principle of DISTRACTION OSTEOGENESIS. This refers to the formation of new bone between two bone surfaces that are pulled apart in a controlled and gradual manner. The distraction initially gives rise to NEO VASCULARISATION, which is what actually stimulates the new bone formation. In addition, there is histogenesis of muscles, nerves and skin and in diseases (osteomyelitis, fibrous dysplasia, pseudoarthroses) this new bone replaces pathological bone with normal bone. This is a revolutionary concept in medical science; diseases for which earlier there was no treatment possible can now successfully be treated with Ilizarov Method.

## The Ilizarov Method : History

In 1950, Ilizarov moved to Kurgan. In Kurgan, Ilizarov continued to explore ways to achieve improved results in bone healing and immobilization of fractures. While he was studying Mechanics he had an insight into the stability that an external ring with crossed wires would bring to a fracture setting. He then asked a local metal worker to fashion these specially designed parts for a new orthopaedic device, and as before did his preliminary testing on a broken broom stick. This time Ilizarov became convinced that his invention would provide secure immobilization. He sent an application for a certificate of invention and was invited to Moscow to demonstrate his external fixator. This application for authorship of the device



Typical of Siberia the institute is shaped like a snowflake. Each wing houses a separate clinical service, sharing central facilities of operating room, Radiology, Laboratory and Physical Theraphy.

was accepted in June 1952 and was finally approved in 1954. When he presented his data at the conferences, other physicians were skeptical because his results of treatment were dramatically shorter. That being said, devices similar to the Ilizarov apparatus started to emerge, in spite of the skepticism, using bow circular and rectangular shaped fixators. One of them was half ring external fixator by Gudushauri in 1954 from CITO. That was the "official" external fixator used in Moscow for many years. At that time Moscow "coryphaei" did not recognize "non-yielding" province director from Siberia. Prof Volkov was because the director of CITO in 1961 was one of the prominent figures who actively

Entry to Ilizarov's new hospital called the Russian Ilizarov Scientific Center, Restorative Traumatology and Orthopaedics (RISC, RTO inaugurated in 1983).

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Front view of the Ilizarov Center.

had patented a similar device to the one presented by Ilizarov at the conference on TB of bones and joints in Tomsk in 1963. But Volkov used his prestige and position, promote the application of his device in the Soviet Union and at international conferences. However the fortunes of Dr. Volkov would dramatically shift during perestroika, when he was removed in 1985 from his position as director of CITO. Among the reasons for his dismissal was oppression towards the acceptance and distribution of Professor Ilizarov’s external fixator and his method.

In front of Ilizarov’s monument author with Professor A.V. Gubin, Director of the Ilizarov Institute.

Despite the negative experiences in Moscow and his first attemps to introduce his new device to the Soviet Union. Professor Ilizarov and his innovative treatment started to gain recognition locally. In 1955 he became the Chief of the department of Trauma and Orthopaedics in the Veterans hospital in Kurgan.

Author in the dog square. Dogs are helping in research work.

In 1965, he was awarded the title of “Honored physician of Russia Federation” for his achievements in medicine. He also became known among patients, title as the “Magician from Kurgan”. The ‘title’ and little to do with Ilizarov’s lifelong love of hearing and showing off magic tricks, which became his hobby throughout his life and provided him great joy and relaxation.


Front Gate of the Ilizarov center.

In 1965, the Health Ministry decided to send a group of physicians to Kurgan to observe more clearly the surgery and progress of the patients according to Ilizarov method.

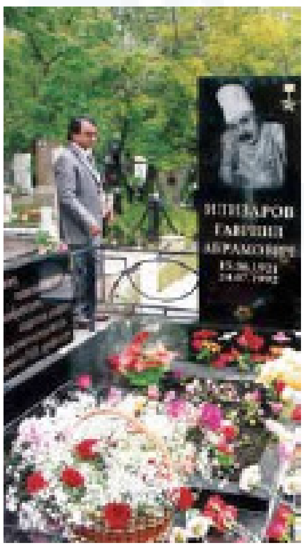
In 1968 Ilizarov operated on Valery Brumel (1942- 2003), a famous Russian athlete renowned in international sports, as high jumper who had set six world records during the 1960s. Tragically, he suffered a open fracture of the distal tibia in a motorcycle accident. The accident and his injuries and treatment received wide notice in the Soviet press. Brumel spent 3 years in various clinics and underwent about 20 unsuccessful operations.

Ultimately, he developed an infected nonunion as well as significant LLD. In 1965, Dr. Golyakhovsky was among the First group of specialists sent to Kurgan to observe and evaluate Prof. Ilizarov's work. Dr. Vladmir

In front of Ilizarov's museum author with Professor A.V. Gubin, Director of the Ilizarov Institute.
That chaika car was used by Ilizarov.

Golyakhovsky was a young successful surgeon from CITO (Central Institite of Traumatology and Orthopaedics, Moscow). Dr. V. Golyakhovsky spent one month in Kurgan and had returned to CITO, Moscow. He was amazed about the treatment and methods of Ilizarov; but Prof. Volkov of CITO was apathetic about supporting the device within CITO.

G. A. Ilizarov with Valery Brumel during his treatment in Kurgan.



Author iIn the graveyard of Academician G,A, Ilizarov.

Meanwhile Valery Brumel was started to lose hope of recovery in CITO. Dr. Golyakhovsky advised him to go to Kurgan to seek a consultation with Prof. Ilizarov. On being reassured that his infected non-union could be healed as his LLD of 3.5 cm could be corrected. The surgery was successful. Brumel resumed his athletic training session in 1968. These events brought substantial recognition and attention of high officials as well as fame to Prof. Gabriel Abramovich Ilizarov within the Soviet Union. Brumel's recovery was also published in the U.S. Medical Press, the Journal of Podiatry (Foot disorders) in 1973 and was titled "Kurgan: Revolution in Orthopaedics".

These media exposure of a famed athlete recovering against such overwhelming odds and prior treatments failures helped to gather support for financing a new orthopaedic Institute in Kurgan in 1971 (KNIIEKOT).

In 1982 an additional building in the shape of a snowflake was added to expand the clinic, research and diagnostic services of the institute. This snowflake design was an original concept of Prof. Ilizarov to prevent the spread of infection, by placing patient wards furthest away from the administrative center of the building and providing them with independent entrances. In case of serious infection breaking out in one ward, that block could be effectively isolated without interruption of the work of the hospital.

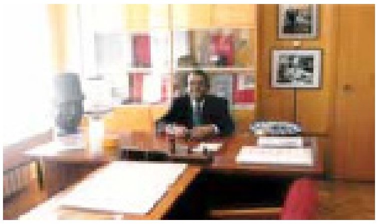
## The Michelangelo of Orthopaedics

Carlo Mauri (1930-1982) who was a well known Italian journalist, alpinist and explorer, helped to introduce the Ilizarov system into Western Europe. In 1980 Professor Ilizarov did the surgery in the Mauri's infected tibial non union and which was completely healed. On his return to Italy Mauri wrote an article in an Italian newspaper, naming the Russian Physician Gavriil Ilizarov as the "Michelangelo of Orthopaedics" . This would prove to be the break in the dam that would release the news of the Ilizarov method and external fixator to the world medical community and set in motion events that have led to world wide application and study of the Ilizarov method. Carlo Mauri's physician in Italy were amazed by the healing that had occurred of his longstanding non union condition. Mauri subsequently invited Prof. Ilizarov to Italy in June 1981 and arranged for his participation in XXII Italian AO conference in Bellagio, Italy through his physician friends. Italian physicians immediately realized the significance of these "Siberian technique" and were enthusiastic to learn the procedure. American surgeons first learn this technique from their European colleagues. Dr. Frankel with Dr. Stuart Green visited the Iliarov center in Kurgan in 1987. In 1987 Ilizarov visited Newyork and Dr. Golyakhovsky recall this event "Ilizarov requested three carousel projectors for his lecture, which surprised the inviting party. The auditorium was packed. People were sitting and standing in the aisles. Ilizarov showed 700 slides in one and half hours. When he finished the audience jumped from their seats and applauded, standing, for about 10 minutes. Interest in the Ilizarov external fixator in USA was contagious and many started to use the apparatus without proper training, making mistakes that led to complications as well as discouragement and misplaced blame on the external fixator. Ilizarov said "Boldness should not exceed one's skill". Fortunately, many of the orthopaedic surgeons carefully studied this method and became the world known famous expert.


Carlo Mauri with Academician Ilizarov

# Chapter 2
# Memorable Moments

## Memorable Moments



Author in the Chamber of Academician G. A. Ilizarov Museum.

Author in the O.T of Academician G.A. Ilizarov Museum.

In front of Ilizarov center Kurgan.

Dog Square

Author is doing operation in Ilizarov center (August 2012) Prof G. P. Ivanov is assisting him.

Author with Honored prof. of Kurgan Ilizarov center S. I. Shevd.

Flags of different countries. Author in Ilizarov conference June 13-15 2013; Kurgan Russia.

Author with Prof. A. V. Gubin, Director (RISC, RTO) in front of Ilizarov monument.

Author with N. Murzhikov.

Author with Valentina Kamysheva (Inter. Head) and N. Murzhikov

Author with Prof. Y. P. Saldatov.

Dog Square, Dogs are helping in Scientific research

Author in the department N-10 during his visiting Prof. program July 2012

Professor V. I. Shevtsov (Former Director RISC, RTO) with Author's family (Ishmam Bari, Nabia Bari), Greece, 2012


Delegates from different countries; in front of Ilizarov center, Kurgan June 2013

Professor A. V. Gubin with Professor MM Bari and Shayan Bari Directors office, Kurgan, Russia.

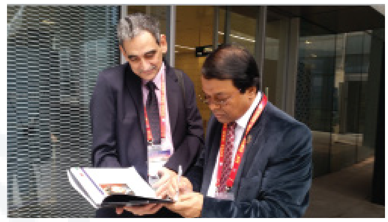
Delivering guest lecture

Chairing the session

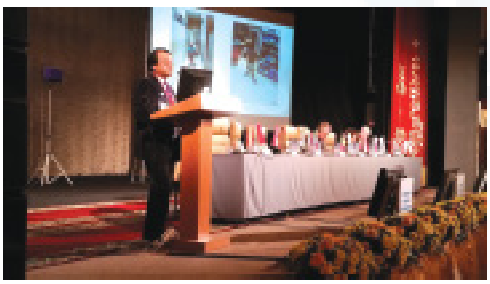
With Professor Mazakhanova from Karaganda, Kazakstan


Presenting book to Dr. N. Wolfson from Sanfransisco USA

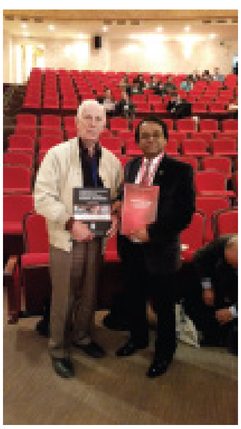
Chairing the session


Presenting book to Prof. Ashok N Johari, India

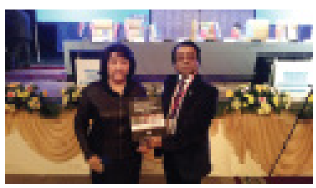

Delivering guest lecture


Delivering guest lecture in the plenary session


Presenting book to Prof. Volpin, Israil


Presenting book to Prof. N.N. Smelishev, Russia


Presenting book to Dr. Denis Remashevky, Russia


Presenting book to Prof. Mazakhano-va from Karaganda, Kazakstan


Facutlies from different countries of the globe


Doctors from Karaganda, Kazakstan with their National dresses

With Denis Remashevsky, Russia

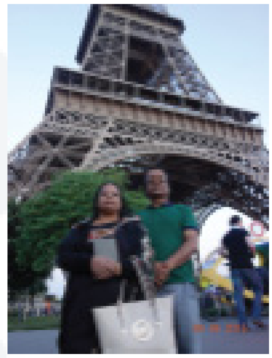
Faculties in EFORT Conference 2015


With Prof. Azizov, Director, Tashkent Orthopaedic Institute

Poster session in PRAGUE

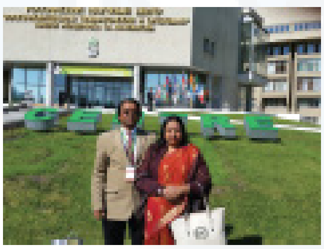
In Schönbrunn Palace, Vienna

In Geneva, Switzerland

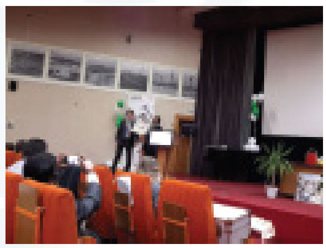


In Paris, Eiffel Tower

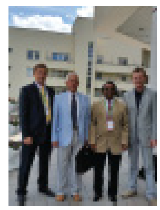
M.M. Bari with Nabia Bari, Kurgan



In front of Ilizarov centre



After delevering lecture, presenting emblem of Nokshi-katha to Prof. Gubin



Left to right Prof. Novikov, Academician Prof. Shevtsov, Prof. M.M. Bari & Prof. L. Solomin

Nabia Bari in Ilizarov Museum,Kurgan

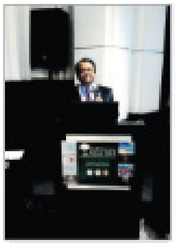
My book is in Ilizarov Museum, Kurgan

In front of Ilizarov Monument, Kurgan

In front of dog square, Kurgan

Ms. Nabia Bari in Ilizarov graveyard, Kurgan

Ms. Nabia Bari with Prof. Shevtsov and Ms. Shevtsov in their house in Kurgan



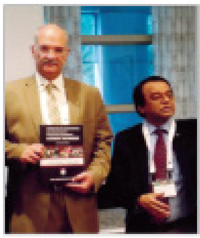
Delivering lecture in ILLRS Congress MIAMI 2015

Presenting book to Svetlana Ilizarov, Miami

Presenting book to Svetlana Ilizarov Prof. Gubin is egarly looking at the book

With Svetlana Ilizarov, Miami

Presenting book to Prof. Reggie C. Hamdy, Canada



Presenting book to Prof. Gamal Hosny, Egypt

Presenting book to Dato Thirumal, Malaysia

Presenting book to Prof. R.C. Meena, India

With Prof. Maurizio Catagni, Italy

With Prof. Dror Paley, Florida, USA

With Prof. Jhon E. Herzenberg, Maryland, USA

In front of LOEW'S hotel, MIAMI

With Prof. Reggie C. Hamdy, Canada and Prof. Hae-Ryong SONG, Korea

Faculties from different countries in Miami (Lt. to Rt. England, Korea, India, Bangladesh, Australia, Egypt)

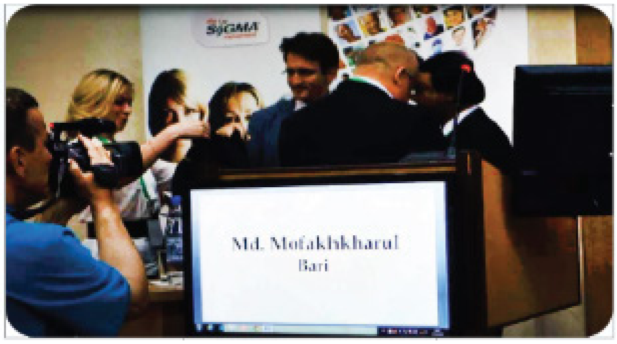
Faculties of different countries (India, Bangaldesh, Russia, Italy, Brazil) in Sri Sathya Sai Institute of Higher Medical Sciences (SSSIHMS), India

Front row, faculties and delegates behind

With Prof. Maurizio Catagni, Italy

## Honored Professor Ceremony in Ilizarov Centre Kurgan, Russia, 14 June, 2013


Welcome address by Prof. A.V. Gubin




Opening up the gown


Opening up the gown


Wearing the gown


Wearing the gown

The Moment of wearing the Cap

Cap on the head

Deputy Director for Scientific works Y. Borzhunov is clipping broach of Honored Prof. to MM Bari. Prof. A. V. Gubin is also welcoming him.

Delegates are welcoming Prof. M.M. Bari for with huge applause being the Honored Prof. of RISC, RTO

Clipping the Honored Prof. Broach.

Deputy Director for Scientific works Borzhunov is congratulating Honored Professor M.M. Bari

Professor A. V. Gubin is welcoming Honored Professor of Ilizarov Center M. M. Bari

Author is presenting his book to Professor Y. P. Saldatov after the Honored Professor Ceremony


Honored Prof. of Ilizarov Center Prof. S.I. Shevd and Prof. M.M.Bari

Y. Borzhunov Deputy Director for Scientific works, Professor A. V. Gubin with Honored Professor MM Bari and Honored Professor S I Shevd 14-06-2013

Professor A. V. Gubin, Honored Professor MM Bari, Professor V. I. Shevtsov ( 14-06-2013, 6:10 PM)

# Chapter 3
# Development of Compression-Distraction Method and External Transosseous Fixation of Bones

Compression-distraction is an independent sector in orthopaedics and traumatology has got definite history of its own development and may be analyzed on many parameters. Utilization of this method in orthopaedics attracts many specialists with opportunity without considerable surgical trauma to eliminate severe congenital & acquired deformities, which is connected with great regeneration.

Undoubtedly facts remains that compression-distraction method opens new era instead of using traditional methods of surgical interventions. Compression-distraction and reposition-distraction apparatuses were developed by K.M. Sibash (1952); G.A. Ilizarov (1952); O.N. Gudushauri (1954); S.S. Tkachenko, V.K. Kalnberz (1971) and others. In 1952. G.A. Ilizarov developed a principle of new type of cross wires transosseous apparatus and it is consists of cross wires and metallic rings. Subsequently other apparatuses were developed by other scientists. Among these wide spreading were found the apparatus of G.A. Ilizarov; V.K. Kalnberz; O.N. Gudushauri; Volkov-Oganesyan. Methods of limb lengthening suggested by G.A. Ilizarov were universally recognized and widely used in practice. Good results using the transosseous osteosynthesis of Ilizarov for treating pseudoarthrosis, defects and deformity of bones confirms highly its effectiveness. Compression distraction method in most of the cases gives good results in treating pseudoarthrosis and defects with infection (Gudushauri O.N. 1964; Shumilkina E.I.; Matusis J.E. 1970; Tashpulatov A.G. 1985 and others). Development and improvement of this prespective method of treatment have several directions. Firstly, it creates more perfect opportunity and constructions. Secondly it brings different changes in construction and details that have in transosseous apparatus. Thirdly new method of treatment are developing in orthopaedotraumatological patients with the use of compression distraction method. In 1843 Malgaigne designed a special device for external fixation of bone fragments in patella and olecranon fractures (Figure 3.1). It consists of two plates, each of them ending with two hooks. A spacing screw connects the plates. When a pair of hooks is introduced through the skin into each fragment, the plates and hooks fixed in the bone fragments are drawn together until tight contact is made and therefore reciprocal fixation of the fragments.

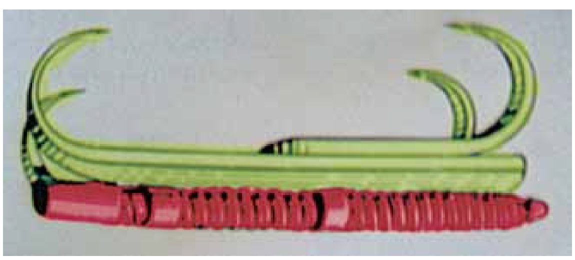


Figure-3.1: Apparatus of Malgaigne.

In 1902 Lambotte designed an apparatus (Figure 3.2) to fix fractures outside the fracture site. The apparatus consists of screws tightly fixed in bone fragments (2 to 3 screws in each) and two plates connecting the protruding ends of the screws by means of bolts.

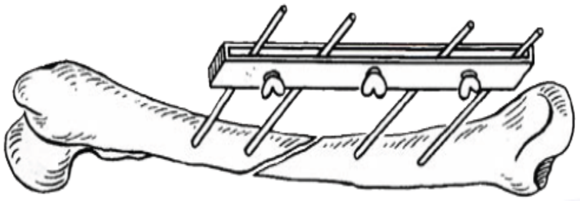


Figure-3.2: Apparatus of Lambotte.

In 1919 there were many publications on transfixion of bone fragments. Transfixion (Figure 3.3) means- a nail is introduced transversely into each fragment to fracture, distally and proximally, after reposition, then a circular plaster dressing is applied, the nail ends being cast into it.

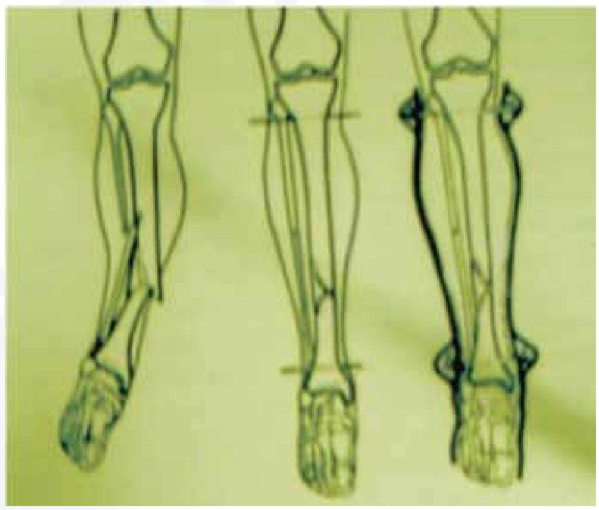


Figure-3.3: Transfixion of bone fragments.

In 1925 the device designed by Rosen L., consists of a T-shaped plate with two slots at right angles to each other and two screws with two fixing nuts in each. After the screws are introduced into bone fragments, the T-shaped plate is put on the protruding ends of the screws (Figigure-3.4). By shifting both screws along the slots and nuts along the screws, a surgeon shifts the fragments with respect to each other, thereby achieving reposition of the fragments.

In 1929 the device designed by Hempell consists of two semi rings, which fix the bone fragments with pins. The rings are connected to each other by screw rods.

In 1934 Bittner developed his apparatus (Figure 3.6) which consists of pins, metal rings, and hinged distractors. After a pin is passed through each fragment, the ends were fixed in the rings. The rings with fragments fixed there in were drawn apart or together by means of the distractors connecting them, which resulted in distraction or compression of bone fragments.

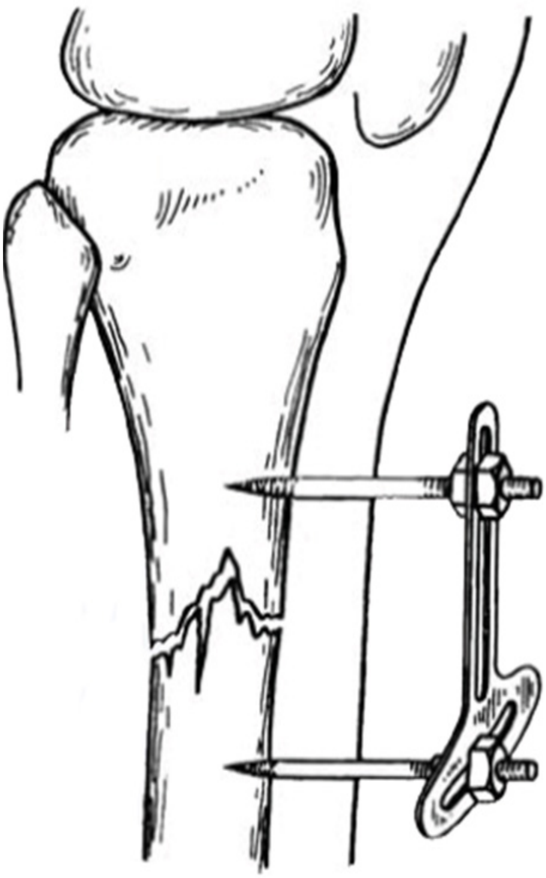


Figure-3.4: Apparatus of Rosen.

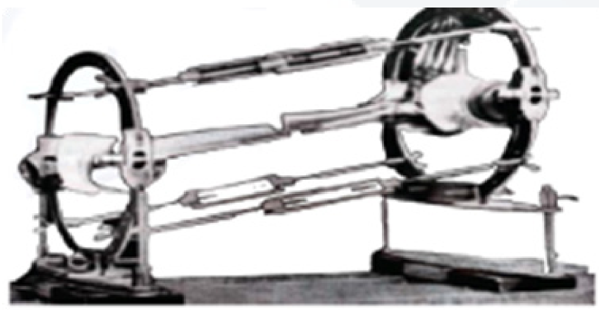


Figure-3.5 : Apparatus of Hempell.

In 1934 Bittner developed his apparatus (Figure 1.6) which consists of pins, metal rings, and hinged distractors. After a pin is passed through each fragment, the ends were fixed in the rings. The rings with fragments fixed there in were drawn apart or together by means of the distractors connecting them, which resulted in distraction or compression of bone fragments.

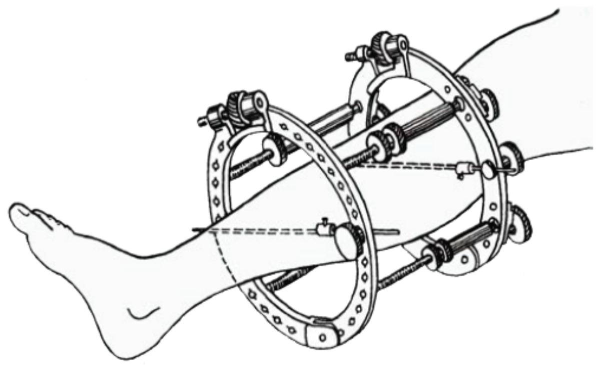


Figure-3.6: Apparatus of Bittner.

In 1937 Stader designed an apparatus (Figure 3.7) that he applied successfully in dogs with various fractures. His device consist of a pair of pins for each fragment and an adjusting connecting bar. The pins are to be inserted into the fragments at an angle to each other. The fragments are drawn apart or together with the aid of a turnbuckle. A screw arrangement at each end of the connector helps to reduce angular displacement of bone fragments. Later on Stader "reduction and fixation splint" were regularly used in man.

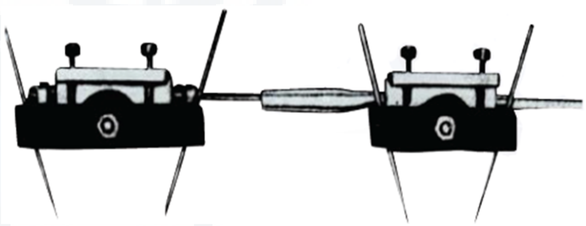


Figure-3.7: Stader Splint.

In 1938 Petrovsky designed an apparatus (Figure 3.8) for bone lengthening. After osteotomy, a pin was introduced into each fragment, the pin ends were fixed in metal rings. Two turnbuckles attached to the connector bars served the purpose of drawing the rings end therefore the fragments, apart or together. The idea of Petrovsky apparatus was used in some other external transosseous fixators that were designed later.

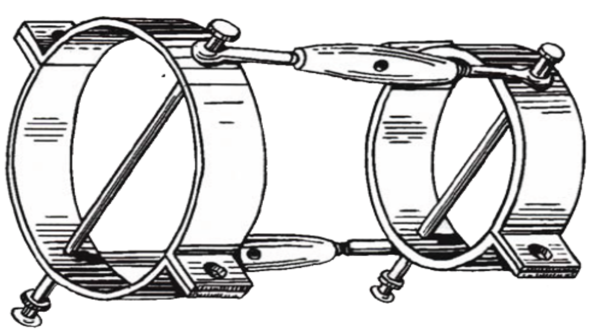


Figure-3.8: Apparatus of Petrovsky.

In 1942, Hoffmann applied an apparatus (Figure 3.9) of his own design in various bone injuries. Several tip threaded pins are screwed into each fragment, either along a straight line or in an arbitrary pattern. The protruding tips of pin groups are fixed with clamps. Two threaded rods are hinged to the clamps and connected with a turnbuckle. After repositioning, the connecting rods are locked in their hinges, thus fixing the fracture. According to Hoffmann the apparatus often reduced fragments and fixed them firmly in a closed manner. To increase stability of the apparatus, Vidal added another frame to the apparatus.

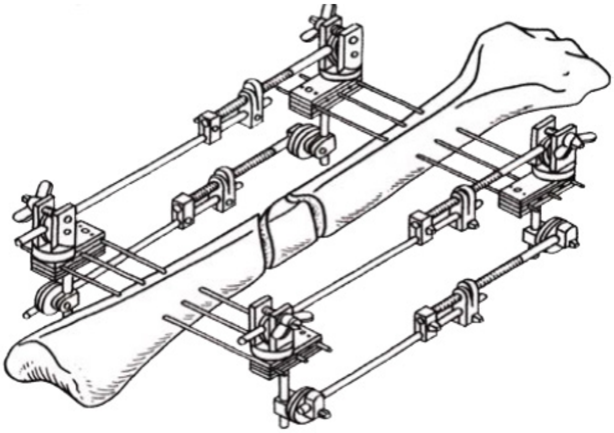


Figure-3.9: Apparatus of Hoffmann with a vidal double frame.

In 1944 Boston Pediatric Orthopaedic Surgeon Bost F. used the external transosseous fixation apparatus of his own design for the lengthening of lower extremity bones (Figure-3.10). For lengthening of femur, Z-osteotomy was followed by the insertion of two cross pins into the femur inferior to the lesser trochanter. The ends of those pins were fixed in the ring. Two other pins were passed through the lower third of the femur and fixed the ends of the pins in the lateral planks of the device. The ring and lateral planks were connected to each other with two sliding rods. The ring and planks with fixed bone fragments were disjoined using the nuts on the rods thus performing the bone fragments distraction. The rate of bone lengthening made up 3 to 4 mm daily. The apparatus was dissembled in 12-14 weeks and plaster cast was applied. That plaster cast was used to fix the ends of one upper pin and second upper pin that were kept in the extremity. Weight bearing was allowed 6 months after the operation. Plaster cast was used for 1 year. Application of that technique gave from 5 to 7 cm lengthening.

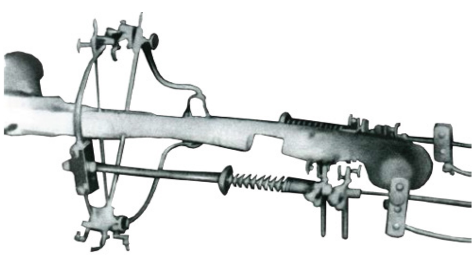


Figure-3.10: Apparatus of Bost.

In 1952 Sivash designed a fixator (Figure 3.11) that consists of two split screws with special clamps for pins, the basic principle is that the resected bones are rapidly drawn together with a force sufficient for their impacting. This accelerates bone union by several times.

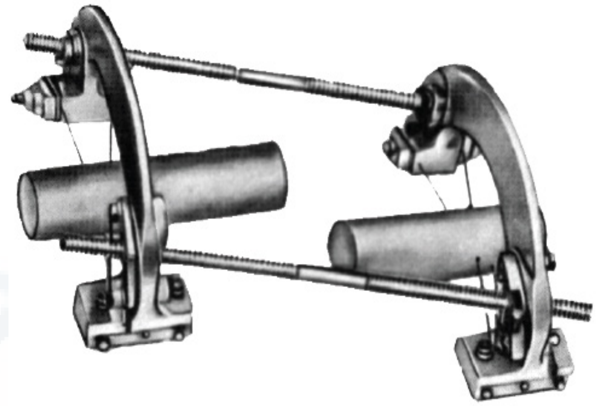


Figure-3.11: Appartaus of sivash.

In 1952 an apparatus (Figure-3.12) designed by Professor G. A. Ilizarov of Kurgan has came into wide used in Soviet Union. It is intended for arthrodesis, in diaphyseal fractures, non unions, pseudoarthrosis, limb lengthening and for deformity corrections. This device consists of rings and cross wires, the rings are connected by spacing screws. Two Ilizarovs wire are passed through each fragment crosswise, clamped to the metal ring and tensioned with a special appliance called Tensioner. 4 spacing screws provide for compression or distraction of bone fragments.

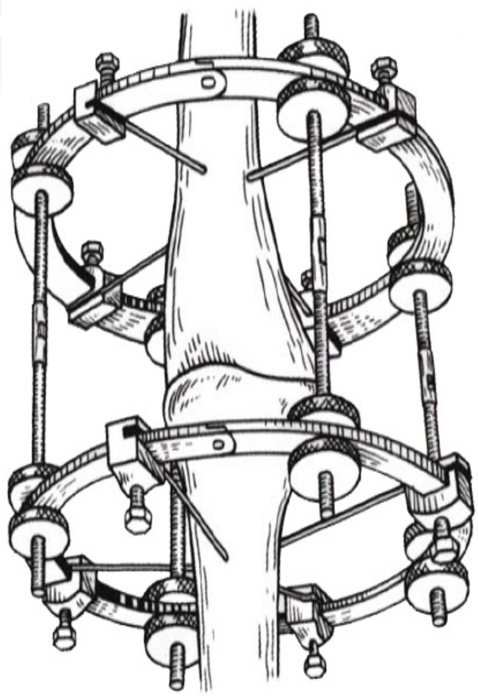


Figure-3.12: Apparatus of Ilizarov.

In 1953 Wittmosser R. invented an apparatus of his own design for bone fragments fixation. It consists of crossing pins and rings connected to each other with extensible distractors. It has a special screw device for repositioning bone fragments in width (Figure-3.13).

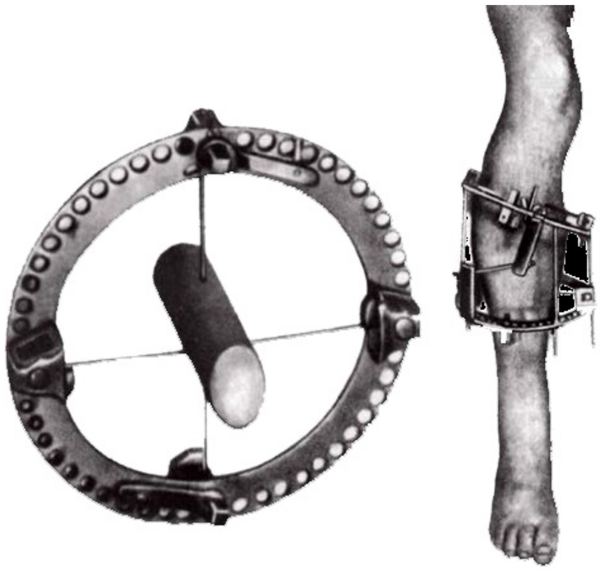


Figure-3.13: Apparatus of Wittmosser.

In 1954 Gudushauri designed an apparatus (Figure-3.14) for reposition and fixation of bone fragments and for bone lengthening. The apparatus consists of two pairs of coupled bows, a repositioning bow, and two spacing screws. One pair of the coupled bows holds two pins transfixing the distal fragment; the other holds the pins transfixing the proximal one. A repositioning bow is located between the coupled bows, providing for repositioning of bone fragments in width. The spacing screws correct displacement of bone fragments in length and proved their compression or distraction. The Gudushauri apparatus was widely used for compression osteosynthesis in non union and pseudarthrosis and for fragment repositioning with subsequent compression.

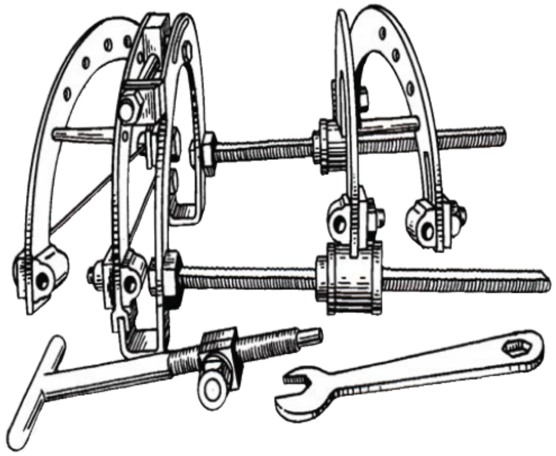


Figure-3.14: Apparatus of gudushauri.

In 1962 Grishin designed an apparatus (Figure- 3.15) for arthrodesis of the ankle joint. It consists of two uniform halves. Each half has a head with two 'legs' hinged to it. The legs are provided with screws and turnbuckles. When the ankle joint is exposed and the cartilage covering the tibia and the talus is removed, three metal pins 3.5mm in diameter are passed in the transverse direction; one through the distal tibia, another through the calcaneus, the third through the talus. Then the foot is put at a functional position and the device is applied, with the pins clamped on both sides. According to Grishin, the foot can be reliably fixed in the apparatus at any angle of flexion or extension with respect to the leg. To correct undesirable flexion, the anterior part of spacing screws are drawn together, as are posterior, to avoid extension. Varus or Valgus deformity of the posterior part of the foot is eliminated by exerting more effort in drawing together the lateral or medial pair of spacing screws, respectively. The disadvantage of Grishin device is that thick pins are to be applied and they may injure both soft tissues and bone.

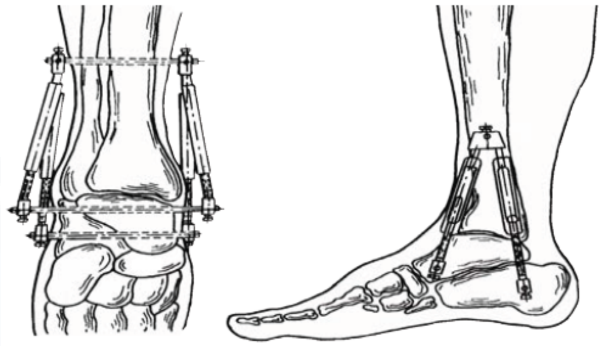


Figure-3.15: Apparatus of grishin.

In early 1970 Kalnberz of Riga, Alma- Ata designed an apparatus (Figure-3.16) which consists of plastic rings connected by coil springs. The coils serve as threads for nuts, with clamps allowing for holding and adjusting the rings. For compression, the springs are extended and they provide for constant traction. When apparatus is applied for distraction, the springs are to be compressed. The coil springs can also bend, which facilitates correction of limb deformities.

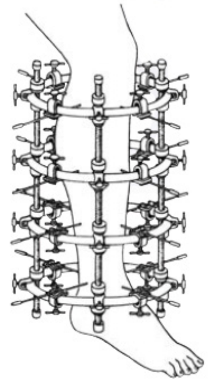
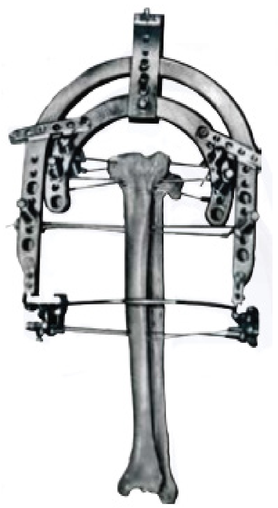


Figure-3.16: Apparatus of kalnberz.

In 1971 Valkov- Oganesyan reposition hinged distraction apparatuses (Figure - 3.17) are widely applied for reposition and fixation of bone fragments in fractures and pseudarthrosis, for limb lengthening, for fragment fixation after various correcting osteotomies, for compression arthrodesis.

Figure-3.17: Apparatus of volkov-oganesyan.



In 1974 Pichkhadze R. suggested the device for transosseous osteosynthesis in intra-and periarticular fractures of long tubular bones in shoulder, elbow and knee joints (Fig.-3.18). The apparatus is intended for and fixation of fragments in the required position with simultaneous development of movements in the injured and adjacent joints.

Fig.-3.18: Pichkhadze.

In 1988 the CITO (Central Institute of Traumatology and Orthopaedics, MOSCOW), orthopedic surgeons described the rod compression-distraction devices MKT (Fig.-3.19) for the fixation of bone fragments in fractures of long tubular bones and fractures of the pelvic bones, as well as for the treatment of congenital deformities. The apparatuses provide easy access to the fracture wounds and early mobilization of patients.

Figure-3.19: KT Apparatus

# Chapter 4

# Basic Ilizarov Frame and its Components

Osteosynthesis with Ilizarov frame is achieved by securing the bone fragment to the external fixator with wires. Ilizarov surgeon can assemble the individual components in to any configuration which is needed for particular problem.

External transosseous fixation system offers many advantages over the internal fixation devices:

1. Compression can be maintained during the entire treatment period.
2. Fixation can be obtained without inserting hardware at the site of pathology; this is very much importantin case of infected non-union or pseudoarthrosis.
3. Less traumatic than the implantation of an internal fixation device.
4. The compression-distraction device can be removed without an additional operation.

## Components:

Main support components are:

1. Half rings (Figure 4.4)
2. Arches (Figure 4.7, 4.8)
3. Long Connecting plates (Figure 4.15)

Auxillary support components are:

1. Short straight connecting plates (Figure 4.15)
2. Curved plates (Figure 4.16)
3. Twisted plates (Figure 4.17)
4. Posts, Male and female (Figure 4.43, 4.44)
5. Wires and olive wires (Figure 4.34, 4.35, 4.36)
6. Buckles (Figure 4.37)
7. Threaded rods (Figure 4.12)
8. Telescopic rods (Figure 4.13)
9. Wire fixation bolt (Figure 4.21)

Additional connecting elements are:

1. Bushing (Figure 4.19)
2. Threaded sockets (Figure 4.18)
3. Washers (Figure 4.23)
4. Bolts (Figure 4.20)
5. Nuts (Figure 4.21, 4.22)
6. Hinges (Figure 4.39, 4.40)
7. Multiple pin Fixation clamp (Figure 4.45)

## Half Ring:

It has got the mechanical resistance greater than 90 Kg/ Square mm and it is made up of titanium metal.

**Sizes :** 12 Viz 80, 100, 110, 120, 130, 140, 150, 160, 180, 200, 220, 240 mm inner diameter.

**Hole diameter:** 08 mm.

**Space between holes:** 04 mm.

It ends are bent into ledges. This allows attachment of one half ring to another in the same plane.

Figure 4.1: Steel ring.

Figure 4.2: Carbon ring (Non radio lucent and radio lucent).

Figure 4.3: Connecting ring.

Figure 4.4: Carbon half ring.

## 5/8th Ring:

**Sizes:** 130, 150, 160mm inner diameter.

### Advantages:

1. Facilitates joint movements
2. Wound dressing can be done easily
3. Myocutaneous flaps and large deep incision as in compartment syndrome it is useful

Figure 4.5: 5/8th ring.

**Disadvantages:**

1. Do not bear load of tensioned wires
2. It can be used only with full rings.

**FOOT RING:**

These rings are used in hind foot and fore foot to give better space for Ilizarov or K-wires.

Figure 4.6: Foot ring.

## Arch

### Original Russian Arch

Sizes: 80-260 mm inner diameter and is used in the upper 1/3 rd of the thigh to secure wires placed through the proximal femur.

Figure 4.7: Italian Arch (Non radiolucent).

## Italian Arch:

**Sizes: 90 and 120 small and large.**

Advantages: Slots and holes to secure tapered Schanz or half pins in multiple planes.

Application of location: Upper third of thigh & upper third of humerus.

Figure 4.8: Radiolucent Italian Arch (Carbon Composite).

Figure 4.9 : Russian Arch

T handle - Wrench for half pins or Schanz. Useful instrument to introduce half pins or Schanz into the bone with free hand.

Figure 4.10 : T handle.

Figure 4.11 : Special (Arch) for children; authors modification of M. Catagni arch.

## Threaded Rods:

Diameter: 6mm

Thread pitch: 1mm

Sizes: 40, 60, 80,100, 120, 150, 200, 250, 300, 350, 400 mm. It is used to interconnect rings and arches.

Figure 4.12 : Threaded rods.

Figure 4.14: Graduated Telescopic rods.

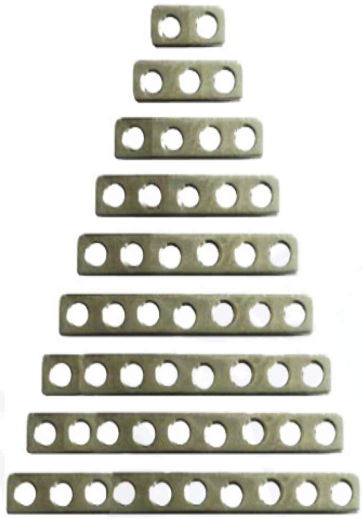


Figure 4.15 : Connecting Plates.

## Telescopic Rod

**Advantages:**

1. It increases frame rigidity when connecting rings or arches are greater than 150mm apart.
2. It has a threaded stud at one end and a perpendicular locking bolt at the other end to hold the threaded rod.

Sizes available: 100, 150, 250, 350, 400mm. It is a long hollow tube with its inner diameter larger than the outer diameter of any threaded rod.

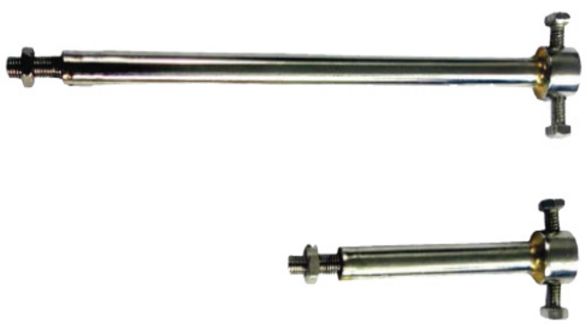


Figure 4.13 : Telescopic rods.

## GRADUATED TELESCOPIC ROD

**Advantage:**
It is used in lengthening and provides direct measurement.
**Sizes available:** 60, 100, 150, 200, 250 mm.

## Connection Plate

**Variants:**

1. Curved
2. Twisted
3. Straight
   a) Short connecting plate
   b) Long connecting plate
   c) Connecting plate with threaded ends.

Thickness : 5 mm

Wide : 4 mm

Hole diameter : 7 mm

## Twisted Plate

This plates are used to connect between the holes of vertical and horizontal planes.

Length : 45 mm, 65 mm 86 mm

2 holes 3 holes 4 holes

Figure 4.16 : Twisted Plate.

## Curved Plate

These are used as extension to half ring arch for accommodating Ilizarov or K-wires.

Figure 4.17 : Curved Plate.

## Threaded Socket

Length: 20, 40 mm External diameter: 10 mm

Both ends are threaded to accommodate bolts or connecting rods. Two perpendicular threaded holes are provided at the center on either side to connect bolts or rods as extension of threaded rods.

Figure 4.18 :Threaded Sockets.

## Bushing

Size: 12mm, 24mm with one and two perpendicular holes. It is one mm wider than threaded rod. It moves over the threaded rod. It can be used as a spacer.

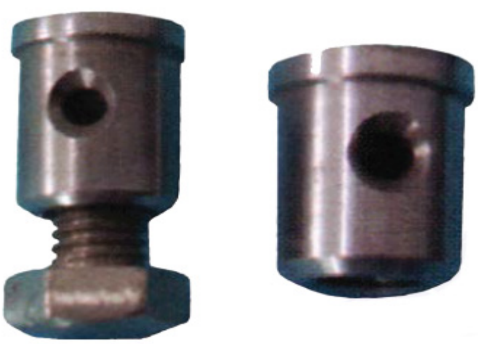


Figure 4.19: Bushing.

## Connecting Bolt

Sizes available: 10,16,20, 30 mm. Thickness: 4mm.

They can bridge the distance from the rings to pins or wires conveniently.

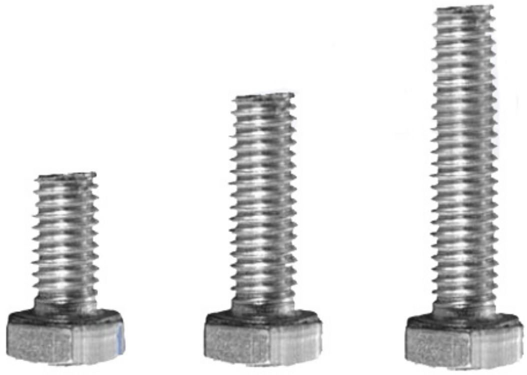


Figure 4.20 : Connecting Bolt.

## Nuts

Thickness: 3,5,6mm

3mm is used for locking nuts on hinges.

5mm is used for stabilizing all forms of frame construction. 6mm is used for connecting rods where compressiondistraction is required.

Figure 4.21 : Nuts in slotted and cannulated bolts.

## Wahser:

It is used to fill the space. 4 types are available.

1. Spacing washer.
2. Split locking washer.
3. Flat sided washer.
4. Slotted washer.

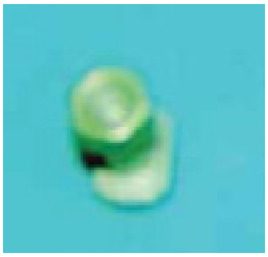


Figure 4.22 :Nut.

Figure 4.23 : Washer.

## Wire Fixation Bolts:

It is used to secure the wires to support components at the holes. Types

1. Slotted.
2. Cannulated.

These are of 6mm threaded diameter, 18mm length and a bolt head thickness of 6mm. The bolt heads are either hexagonal or with two flat and rounded surfaces. The cannulated bolts have a 2mm hole while slotted bolts have an oblique groove on the under surface of the bolt head.

Figure 4.24 : Wire fixation bolt slotted.

## Wire Fixation Cannulated Bolt:

Cannulated bolts are preferred for 1.5mm wires and slotted bolts for 1.8 mm wires.

Figure 4.25 : Cannulated wire fixation bolt.

## Block for Half Pins / Schanz

Sizes: 1,2,3,4 holes.

Figure 4.26: Block for half pins/Schanz.

## Box Wrench for Bolt:

Is used to tight & loosen the nut.

Figure 4.27 : Box wrench for bolt.


Figure 4.28 : Spanner 10mm size.

## Oblique Support:

is used to connect the Italian arch with ring.

Figure 4.29 : Oblique support

Figure 4.30 : Different Box Wrenches.

**Original Ilizarov Mechanical Wire Tensioner:**

Figure 4.31 : Wire Tensioner Mechanical

## Direct Measuring Wire Tensioner

Figure 4.32 : Direct Measuring wire tensioner (Russian Dynamometer)

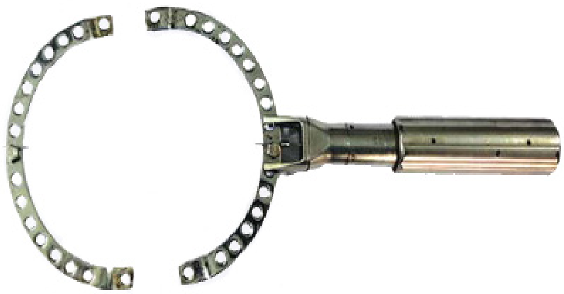


Figure 4.33 : Tensioning using wire tensioner.

## Corticotome:

Sizes available: 3, 5, 7, 9 mm.

Figure 4.34 : Different corticome.

## Wires:

They serve to connect bones or bone fragments to the support elements of frame. They differs in diameter length and shape of the point.

**Bayonet point:**

**Advantages:**

1. It has a greater penetrating power.
2. It causes less heating effect of bones and soft tissues.
3. It produces hole of a diameter slightly larger than that of wire, causing less friction.

Bayonet point cortical 1.5mmx300mm for forearms & foot bones.

Bayonet point cortical 1.8mm x 370mm for diaphysis of tibia and femur.

Figure 4.35 : Bayonet point.

**Trocar point:**

**Advantages:**

1. It is used for metaepiphyseal region because it has less penetrating power.
2. It has greater hold in the bones.
3. Trocar point cancellous 1.5 mm x 300 mm for metaepiphyseal region of radius & ulna
4. Trocar point cancellous 1.8 mm x 370 mm for metaepiphyseal region of tibia and femur.

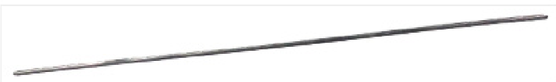


Figure 4.36 : Trocar point.

## Olive or Bead or Stopper Wire:

The olive or kink in the wire is used to achieve and maintain the position of fragment after the fracture. It has also a great role for deformity correction. Wires with olive are used in cases where much force (upto 180-200 kp) is applied to the bone. In osteoporotic bone; it is desirable to use wires with flat surfaced cones or wires with a corkscrew bend. The wire must be resilient with a well polished surface.

Figure 4.37 : Olive or bead or stopper wire.

## Wire Fixation Clamp:

**Buckle:**

The buckle has a U-shaped configuration with short threaded rods on each arm of a short plate. The clamp is completed by employing a short two hole plate and a pair of nuts, which creates a rectangle. This clamp has a groove for a wire and a threaded hole to secure components. A wire put into the groove of the clamp can be fixed to a support component - either a ring or a plate by tightening a small two hole plate against the supports opposite surface. The buckle is most commonly used where it becomes necessary to fix additional wires to The configuration.

Figure 4.38 : Buckle.

Figure 4.39 : Use of buckles to fix additional wires.

Figure 4.40: Hinges.

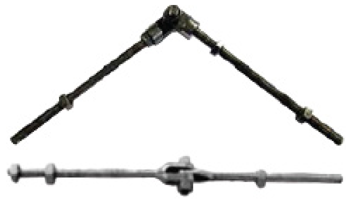


Figure 4.41: Formation of hinges.

Figure 4.42 : Female and male post.

Figure 4.43 : Universal joint and male post. hinges. Indications.

1. To correct any type of deformity.
2. It is used as a pivot (rotation) point component which is essential for strengthening.

**Advantages:**

1. Gives constrain motion in a specific plane.
2. It provides specific fulcrum for control of specific correction of angulations.

**Formation of Hinges:**

1. One male half hinge and one female half hinge.
2. Two female half hinges are connected to threaded rods.

**Important parameters for positioning hinges:**

1. Two rings to which hinges are attached must be strictly perpendicular to the bone fragments.
2. Two hinges are located at opposite sides of the deformity for stabilization.

3. The hinge rotation axis must be situated at the apex of horizontal level of the deformity. If two hinges applied both should be on the same level.
4. Hinges are applied at the same level of deformity.
5. The position of hinges can be used to achieve different types of deformity correction such as opening wedge distraction, compression, translation and derotation.

### Speed of correction with hinges:

Rule of triangle: Speed of distraction, compression is transferred to the hinge axis by factor 3:1. i.e. for 1 mm movement at axis there must be 3mm movement at device site.

### Post:

Posts are of 2 types. Male posts are 28,38 or 48 mm long with 2,3 and 4 holes respectively.

Female posts are 30, 40 or 50 mm long with 2, 3 and 4 holes

Figure 4.44: Male Post.

Figure 4.45: Female Post.

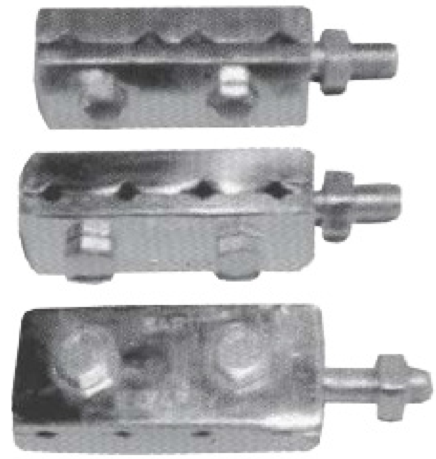


Figure 4.46: Multipe pin fixation clamp.

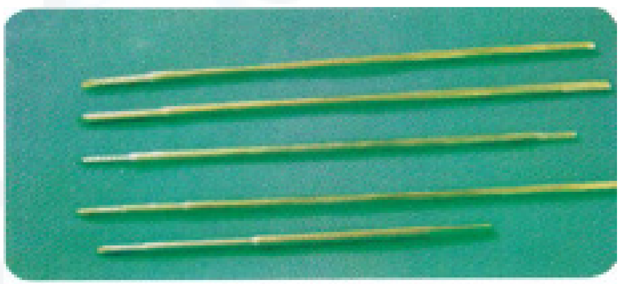


Figure-4.47: Schanz conical (different sizes).

Figure-4.48: Schanz tapered (different sizes).

Modification of oblique support by the author

Figure-4.49: Wire cutter.

Figure-4.50: Author's modified oblique support.

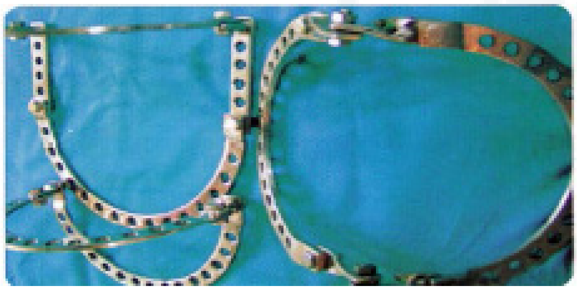


Figure-4.51: Half rings; Variants of assembly.

## Goniometer

Figure-4.52: Different types.

Figure-4.53: Ilizarov box for different components.

# Chapter 5

# Anatomo-Physiological Peculiarities of Children Extremities in using Compression-Distraction Method

Anatomical and plastic characteristics of osseo-articular systems for children significantly differs from the adult. Most of the methods for treating the children is based on using these peculiarities and that is why is not used in adults. Child is born without ossified skeleton. Bones of the new born extremities consists of bony and cartilagenous parts. In children the periosteum is thick and loosely attached to the cortex and produces new bone rapidly. In adult periosteum is thin, adherent to the cortex and produces new bone less rapidly. For these fundamental differences, healing of fractures in children is rapid. Epiphyseal plate cartilage is responsible for the growth of bone in length. It receives nutrition from bone through epiphyseal and metaphyesal vessels.

Epiphyseal plate cartilage has got 4 layers:

1. Zone of resting cartilage.
2. Zone of proliferating cartilage.
3. Zone of maturing cartilage.
4. Zone of calcifying cartilage.

Ossification of cartilagenous parts of bones goes on gradually and with the growth of children it is finished at the age of 16-17 years. In its development osseoarticular system passes through 5 stages (Sadofev-V.I.1990).

1$^{st}$ stage (from birth to 6-10 months). Epiphysis and greater part of metaphysis of long bones have got cartilagenous structures. Diaphysis consists of little bony tissue.

2$^{nd}$ stage (from6-10 months to 4 years)- determines as a beginning stage of epiphyseal ossification of long bones.In this stage complete ossification of metaphysis occurs and part of the epiphysis also. Apophysis remains cartilagenous.

3$^{rd}$ stage Formation of osseo-articular system (from 4 years to 8-9 years). In this period complete ossification of epiphysis occurs. Cartilaginous structures at the end of 3 stages remains in the acromial end of clavicle, apophysis of all bones and growing zones.

4$^{th}$ stage post natal formation of osseo- articular systems-epiphyseal and tuberosities of long bones and foot ossification occurs. Ages are from 15 to 18 years.

5$^{th}$ stage post natal formation of osseo- articular systems-synostosis of metaphyseal and apophyseal growing zone occurs. Tentative ages are from 15 to 18 years.

Knowledge of development of stages and formation of osseo-articular systems in children have got greatpractical significance in finding indications towards different methods of compression-distraction treatment. In selecting the methods of operations it takes into account the anatomical peculiarities of bone for every concrete ages. For example wide use ofdistraction epiphyseolysis method demands the presence of well ossification and solid epiphysis, consequently in 1$^{st}$ and 2$^{nd}$ stage of development, it cannot be used. Compression-distraction method is also ineffective in the 5$^{th}$ stage of development of osseo-articular system due to formation of synostosis of growing zones. Proceed from anatomical characteristics, every stages of bone formation may conclude that compression- distraction method can be used from the middle of 2$^{nd}$ stage (1.5-2 years), when diaphysis and metaphysis of long bones ossifies and have definite stability.

# Chapter 6

# Topography of Neurovascular bundles of children's superior & inferior extremities

## SUPERIOR EXTREMITY-

In children muscles of the arm is not so developed and in external view they are weak in this region we can see fascial sheath for anterior and posterior group of muscles and neurovascular bundles of arms.

In upper 1/3rd of the arm there is one neurovascular bundle which is situated medially. We can identify that very easily through pulsation of a. brachialis. Anterior, lateral and posterior surface of arm in upper 1/3rd is safe for introducing wires (Figure-a).

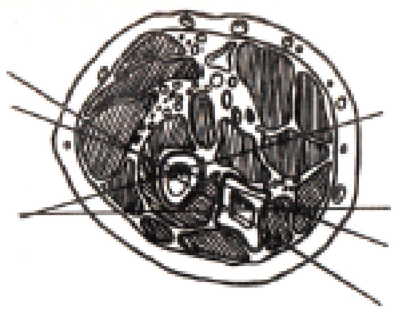


Figure-a

In middle 1/3rd of the arm quantity and distribution of neurovascular bundles are changing. Main neurovascular bundle (a et V. brachialis, N. medianus) is holding the medial position. Pulsation of brachial artery is easily identified in the projection of sulcus brachialis medialis. Second neurovascular bundle (a. profunda brachial, N. radialis) is situated in the posterior surface of the arm, immediately near the bone. Presence of two neurovascular bundles significantly serves the sector for safe introducing the wires (Figure-b).

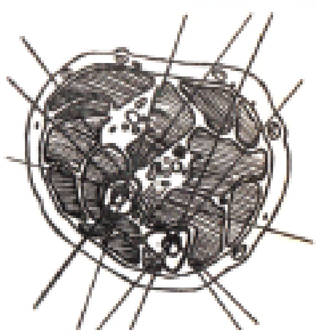


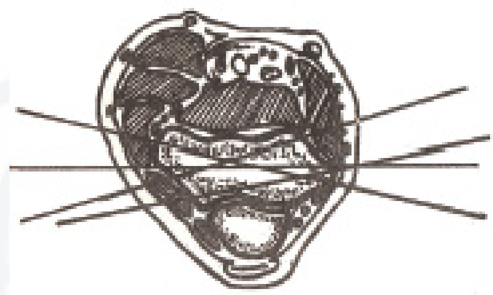
Figure-b

It is necessary to remember that the radial nerve is situated in the lateral surface of the bone in between the middle and lower 1/3rd of the arm. That's why it is not recommended to introduce wires and carry out surgical intervention in this direction.

In lower 1/3rd of the arm neurovascular trunk occupies anteromedial and anterolateral position, in consequence of that safe zone in this level is somewhat widen.

Besides these levels for application of transosseous apparatus in the region of arm it is very important to know structure and topographical level of humeral condyles, that's why very frequently ring is constructed particularly here. Major neurovascular bundles in this level is situated in the anterior (flexor) surface.

Exception is only for N, ulnaris, which runs through the internal surface of humerus back to the medial epicondyle. Humeral lateral surface is almost not covered by muscles, nicely palpated under skin. In this zone general rule is: "The near the bone, the better the safe corridor"



Forearm is very complex from anatomical point of view and in biomechanical plan of segment of the body, which explains the relative rarity of using transosseous method in this region. Altogether with this, here it has its own topographical peculiarities, which make it easier to introduce wires. First of all in the interosseous space the major vessel formation is absent.

It means that in any level of forearm, except lower 1/3rd of forearms introduction of wires through both forearm bones relatively safe. Considering this anatomical peculiarities, wires in the upper 1/3rd of forearm is necessary to introduce from the side of radial bone.

In palmar surface of forearm there are 4 distinguished neurovascular bundles.

Lateral projection or radial, neurovascular bundles (a. et V. radialis, r. superficialis, n. ulnaris) coincides with the line, connections the middle of elbow flexion with pulsation point of artery in the region of wrist joint. Medial or ulnar, neurovascular bundle (a.v.n. ulnaris) lies in the line, connecting the medial epicondyle of humerus with radial tuberosity, two different neurovascular bundle occupies middle position. One of them (a.v.n. medianus) passes through the muscular space and another one (a.v.n. interosseus Volaris) disposes in front from intraosseous membranes.

In upper 1/3rd of forearm, the above mentioned main vessels goes through the deep flexor muscles, bones of forearm are situated near to each other. Safe sector of introducing wires envelops posterior and partly the radial surface of forearm (Figure-a).

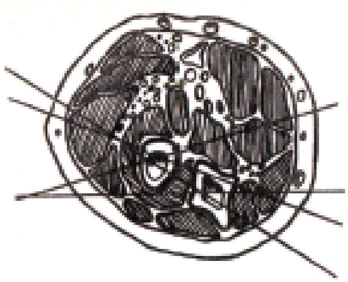


Figure-a

In middle 1/3rd of forearm, the position of neurovascular bundles are same, what judges the sector of interosseous direction of safe introduction of wires. Sometimes we must take into consideration, that often it happens for necessary introduction of wires separately though each bone. These wires are inevitably directed through volar surface, which is the dangerous surface of the forearm. In that situation orientation is necessary in the following ways:

In supination position median neurovascular bundle lies in the projection of interosseous space and direction of wires will be the safe from middle line (Figure-b).

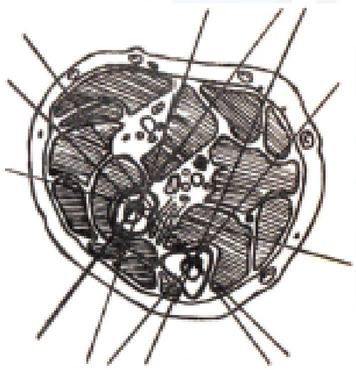


Figure-b

Safe sector in lower 1/3rd of forearm is more narrowed. Interosseous direction of wires goes practically in the projection of radial artery. But pulsation must be identified and even it is visible, which helps to safe that. Only wire insertion is necessary to introduce in the radial side of bone (Figure-c).

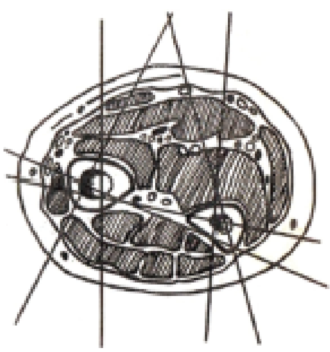


Figure-c

**INFERIOR EXTREMITY:**

Femoral region is characterized by strong muscles, in between remains the following major vessels and nerves, a, et. v. femoralis; n. ischiadicus (Sciatic nerve), a. et. v femoralis profunda, n. saphenus et. v. saphena magna. They pass through mainly in the posterior and medial surface of the thigh. Projection line of femoral artery and vein and also n. saphenus goes through the middle of inguinal ligament to medail supracondyle of femur (Ken, s line). This line approximately coincides with the direction of sartorius muscle (Figure-a).

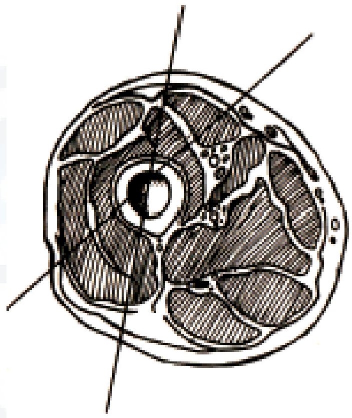


Figure-a

Course of sciatic nerve coincides with line which carries through middle distance in between greater trochanter and ischial tubercle to middle of popliteal fossa. Trunk of v. saphena magna is projected on line, which connects medial malleolus with point, situated in border in between medial and middle third of inguinal fold.

In upper 1/3rd of thigh, positions of neurovascular major vessels, do not permit to adopt the wires with great angular crossing. Lateral surface of thigh is perfectly safe, in this level Schanz screw can be rationally used (Figure-b).

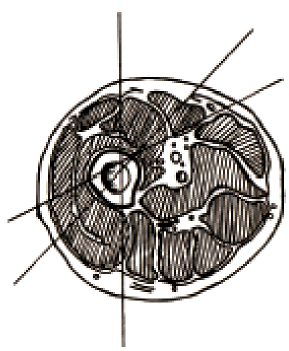


Figure-b

In middle 1/3rd of thigh femoral vessels enter in to the adductor canal and displaced slightly below. This permits to widen the sector safely through anterior surface of thigh (Figure-c).

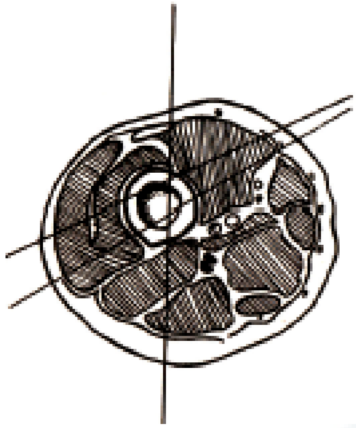


Figure-c

Lower 1/3rd of thigh appears the very comfortable level for adopting wires as vessels and nerves crosses in the posterior surface of the thigh and enters into the popliteal fossa (Figure-a).

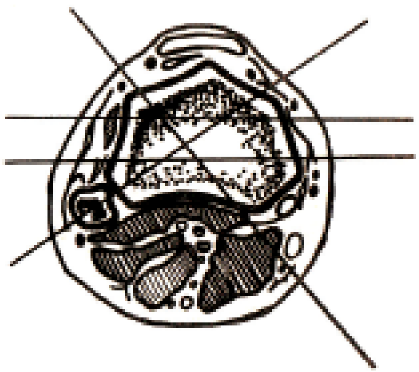


Figure-a

Anatomo-topographical peculiarities of leg is related with the existence of two bones and three osseo-fibrous tale for leg muscles. Main arterial trunks of leg a. tibialis anterior et posterior appears as branches of popliteal artery. First one of them with supporting pairs of veins lies in arterior tale. Its projection line goes from middle distance in between tibial tuberosity and fibula head in the middle distance in between tibial tuberosity and fibular head in the middle of transmalleolar distance (in front). Posterior tibial artery and vein, accompanied by tibial nerve lies in the canalis cruro popliteus and goes down almost vertically. This neurovascular bundle projects in line from lower angle of popliteal rhomb up to middle distance in between medial melleolus and side of Tendo Achilles; besides this in the leg there is another one major vessels a et.v.peroneus. They appear the branches of posterior tibial vessles, from them originate in upper 1/3rd level of leg and is directed to lower and lateral side. Besides these formations orthopaedic surgeon should know the topography of common peroneal nerve. It is situated in the posterior aspect of the fibular head and here it divides into two branches: superficial and deep. Deep peroneal nerve goes round the fibular head from lateral and lower side and further accompanies the anterior fibular artery. Superficial peroneal nerve is situated in the upper tibial canal, and the border of middle and lower 1/3rd of leg, it goes into the sub cutaneous cellular tissue. In the subcutaneous cellular region already in the antero-medial surface of the leg passes v. saphena magna et. nsaphenus. In transverse section, the proximal end of leg main space occupies the tibia and fibula. All vessels and nerves are situated in the posterior surface, and lateral and anterior surface of the leg is safe for adopting the wires. Careful attention should be taken for adopting wires through head of fibula, because n. peroneus is situated in the apex of fibular head posteriorly and 1-1.5 cm below and in front. Safe sector at the level of middle 1/3rd of leg remains wide and comfortable for creating the optimum angle of crossing wires (Figure-b).

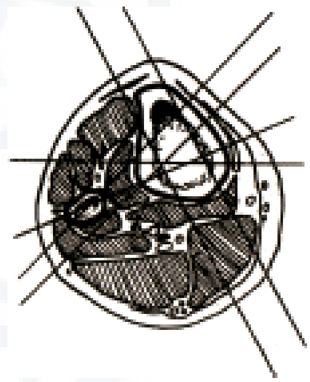


Figure-b

And finally we will look for the distal end of the leg. Here neurovascular bundle formation are situated in anterior and posterior surface, lateral surface is free and safe, posterior tibial artery is well palpated (Figure-c).

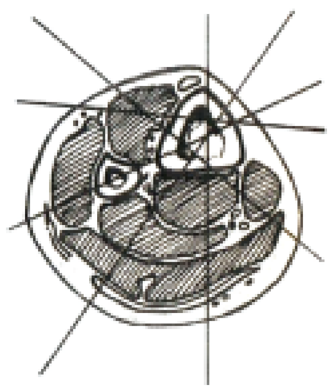


Figure-c

In this way we looked at the topography of different segments of extremities with the point of finding the most optimal and safe direction for adopting the wires and this appears the fundamental transosseous osteosynthesis in general and it guarantees the successful treatment of patients. Anatomical peculiarities always depends on age, disease character and quantity of deformities of the extremities.

On the basis of many years of my experience, surgical intervention for lengthening of extremities in children we calculated some general rules and positions.

1. Shortening upto 2 cm by surgical intervention is not always necessary.
2. If shortening can be abolished by one stage surgery and absence of secondary deformity of other segments (arthrosis, scoliosis), lengthening is better to do near the closing time of growth plate.
3. In case of secondary deformity lengthening is indicated for children of school age.
4. If lengthening of extremity is not possible in one stage surgery, then it must be done not less than in one year.
5. In case of accompanying deformity in the same segment, it is necessary to correct the deformity in the same time during lengthening.
6. Calculating the possible ossification of regenerate it is necessary to lengthen with 1-2 cm more.
7. In case of more than 5 cm lengthening it is necessary to fix the nearby joint for preventing autocompression and tension in two joint muscles.

Main methods of lengthening of bones are:

> Distraction of growth zone (Distraction epiphyseolysis).

> Distraction of osteotomized bone fragments.

> Distraction in the pathological zone changing bone tissue.

It is known that deformity of inferior extremity is seldom localizes only in one segment. In general deformity occurs in tibia and femur. There are some general rules which is necessary to support in treating deformity. First of all- deformity in one segment is not possible to correct by correcting another (in this case deformity of tibia by femur).

Neglecting these rules brings, to irregular orientation of knee joint space, which negatively tells the function of the next.

2nd thing is: axis of bending segment is necessary to correct in the true apex of the deformity. If deformity is arch like character then for its elimination it is necessary to do intervention in double and more levels.

Third thing is that- all kinds of deformity in one segment should be corrected at the same sitting.

Lastly in symmetrical deformity in the same named segment, it is desirable to correct at a time.

# Chapter 7

# Classification of Compression-Distraction Method

All methods for the treatment of orthopaedic pathology with compression-distraction method conditionally can be divided into 2 groups.

1. Apparatus methods of treatment: In this group those methods are included, that are not needed extrasurgical intervention in bones and soft tissue of extremities after applying the Ilizarov's apparatus. We can include here methods of correction of soft tissue deformity, contracture (CTEV, joint contracture etc) and distraction epi and metaphysiolysis.

2. Apparatus and surgical methods of treatment: This group includes those methods, when with the application of Ilizarov as well as surgical intervention is done in soft tissues and bones. Moreover, these interventions can be done in the same sitting with the application of Ilizarov (Osteotomy) for achieving the good outcomes (e.g. arthrodesis, skin grafting).

Orthopaedic intervention in the extremity can be classified in relation to the above mentioned classification-

a) Lengthening, shortening and widening of bones.

b) Correction of bowing deformities

c) Transportation and filling the defects of bones.

d) Correction of contracture, dislocations and arthrodesis of joint.

Stable transosseous osteosynthesis is the basic optimum process for adaptation of organism in trauma as well as in surgery. There is a dilemma regarding the question of how much limb lengthening is possible in one stage surgery, however; literature informs lengthening can be achieved upto 24cm in one stage surgery.

# Chapter 8

# Principles of prophylaxis, Diagnosis and treatment of paediatric orthopaedic diseases

Principles of prophylaxis, Diagnosis and treatment of paediatric orthopaedic diseases

Children orthopaedics is concerned with studying the aetiology and pathogenesis of various congenital and acquired deformities, prophylaxis and correction of deformities and restoration of their function.

Orthopaedic prophylaxis is directly related not only with acquired diseases, but also with congenital ones. Among acquired deformities gross disability is caused by diseases of nervous system (Poliomyelitis, cerebral palsy) and the skeleton (osteomyelitis, trauma, TB, bone tumours) including systemic skeletal diseases (rickets, achondroplasia & fibrous dysplasia).

Prevention of secondary deformities and proper treatment is the basic conditions of prophylaxis. To prevent orthopaedic deformities it is necessary to provide exact management of pregnancy and adequate medical aid during labour. A deformity which progresses rapidly as the child grows requires particular care with regards to his correct development.

Obligatory measures and principles in paediatric orthopaedics are-

1. Deformities in children should be diagnosed as early as possible.
2. Treatment should be started immediately when acquired deformity is diagnosed; congenital deformities should be treated from the first day of life.
3. When conservative methods fail, operative methods should be employed.
4. The child should be kept under constant supervision by an orthopaedic and reconstructive surgeon.
5. To avoid recurrences restorative therapy should be regularly employed.

For example, in case of two common developmental anomalies - DDH and CTEV we must pay attention seriously when the child is still at the maternity hospital. As the child grows, conservative treatment becomes more complicated.

Paediatric diseases are diagnosed from-

1. Clinical features
2. X-ray
3. Morphological examination
4. Special methods of neurology
5. Electrophysiology
6. Biochemistry
7. Bacteriology
8. Genetics

## Clinical examination:

1. Inspection of the child in the sitting and lying position, particularly attention being paid to the posture, static and dynamic movement
2. ROM- (Passive and active) by goniometer
3. Length of the limbs by tape measurement
4. To evaluate joint function active and passive movements are tested. We must see the-
    a) Rotation
    b) Abduction
    c) Adduction
    d) Flexion
    e) Extension
5. Bony projections are used as guides to measure the length of limbs and determine their shortening.
6. Absolute (Anatomical), relative and functional length of the limbs and similar type of shortening (difference between the lengths of the healthy and affected limb) are marked in orthopaedics.

The absolute length of a lower limb is measured from the greater trochanter to one of the malleolus with the patient lying and the limb stretched out, the relative length from the ASIS to the tip of the medial malleolus. The functional length is measured from the greater trochanter to the medial malleolus, normally it is the same as the absolute length. Relative shortening (which may be found in the absence of absolute shortening) occurs when the greater trochanter is displaced upward (Coxa vara, dislocation of the hip); but both types of shortening can be encountered in the same limb.

## Upper limb:

1. Absolute shortening in upper limb is measured from the greater tuberosity of the humerus to the olecranon or styloid process.
2. Relative shortening is measured from the acromion to the olecranon or styloid process.
3. Shortening can be observed by raising the arms and bringing the palms together, by placing both the elbows on the edge of a table and drawing both forearms together to compare their length and by bringing both olecranons together or comparing the length of the arms.

**Height:**

Height is measured in the standing and sitting position.

**Skull:**

Length of the circumference of the skull is measured.

**Chest wall:**

Circumference is determined during inspiration and expiration.

**Weight:**

Weight is also measured.

**Muscle atrophy:**

To determine atrophy of muscles the circumference of both limbs is compared at the same level. X-ray (compulsory), tomogram, angiogram are sometimes necessary.

**Main methods of treatment:**

In paediatric orthopaedics the main methods are:

1. Restorative and corrective exercises
2. Hydrotherapy
3. Massage
4. Wax-therapy
5. Physiotherapy (UST, short-wave, electrotherapy)
6. Splints, plaster casts, caliper-splint apparatus, corsets, orthopaedic footwear, appliances for correcting the foot (arch support)
7. Various surgical interventions.

**Contractures:**

Limitation of movement in a definite direction is called contracture. Depending on the tissue involvement it can be of 4 types:

1. Dermatogenic (cicatrical) contractures result from sc¬arring changes in the skin which are usually secondary to burns of the 3rd degress or healing wounds by second intention. They form when the limbs is inadequately immobilized or not immobilized at all owing to which the wound surfaces adhere and heal in that manner.
2. Desmogenic contractures form due to growth of connective tissue in the subcutaneous cellular tissue in inflammatory process like lymphadenitis, Phlegmon prophylaxis of this type of joint rigidity includes proper treatment of purulent diseases and prevention of the process from spreading in the subcutaneous cellular tissue to avoid cicatrical generation.
3. Neuromuscular contracture result from disturbance of muscle tone which occur in paralysis and injuries to the nerves. Contractures observed at the onset of poliomyelitis are associated with severe pain. Prophylaxis of neurovascular contractures includes proper immobilization, adequate treatment of main disease, proper reclining of a patient on a hard bed, application of special small splints.
4. Osteogenic contractures develop due to inflammatory processes in the joints i.e. trauma, epiphyseal osteomyelitis and TB of the bones and joints. It is essential to immobilize a joint in a functionally favourable position to prevent defective position of a limb, Modern treatment of contractures is accomplished both by a complex of conservative methods and by surgical methods depending on the character of the process that had caused it. In some cases only operative methods (by Ilizarov technique) prove effective.

**Abnormal mobility of a joint:**

Deficient muscle tone is responsible for abnormal mobility of a joint, e.g. in rickets. In marked osseous atrophy there is relative elongation of the ligaments and pronounced abnormal mobility of the joint which is manifested either by hyperextensibility, known as recurvatum or by hyperflexibility or by lateral movements owing to which the distal segments are displaced to the sides forming

1. Varus (Genu varum)
2. Valgus deformity (cubitus valgus)

Extreme degree of mobility in the joint is known as flail joint.

Prophylaxis of abnormal mobility of joints consists of proper treatment of the main disease.

**Limb segments:**

In limb segment we can find the change of shape and length of any limb. The distortion of the segments may result from malunion of fragments at an angle following fractures after trauma or pathological fractures in osteogenesis imperfecta, bone tumors and from systemic skeletal diseases (rickets, dyschondroplasia etc.)

In pseudoarthrosis the shape and function of the limb segments is impaired due to non-healed fractures.

A deformity of a lower limb with the whole foot turned inward is called varus foot.

An opposite deformity is called valgus foot.

Distortion of the tibial axis with outward bending of the leg is called bow legs (crus varus), which is more apparent when the femoral axis is distorted in the same way.

Adduction of the shaft of the femur in relation to the neck axis reduces NSA (Normal 125-135o) thus forming coxa vara.

An increase of the angle (with abduction of the shaft in relation to the neck axis) is known coxa valga.

Prophylaxis of the deformities consists in relieving the limb of strain at the right time, prescribing orthopaedic braces and performing corrective osteotomies when needed.

Gross shortening of a limb may be encountered after poliomyelitis, TB, epiphyseal osteomyelities, due to congenital deficient development of a limb and trauma (epiphyseolysis).

**Causes of shortening:**

1. Premature ossification of the epiphyseal growth plate.
2. Neurotrophic disturbances of the limb.
3. Direct disorders of the epiphyseal growth cartilage of long tubular bone.

Abnormally elongated limb segments result from increased blood supply to the epiphyseal cartilage. Any kinds of deformity can be corrected fantastically by (gradual controlled coordinated stretching) means of Ilizarov technique.

In modern era in paediatric orthopaedics growing importance in clinical medicine is being attached to problems of rehabilitation, which includes restoration of lost functions both during conservative treatment and after surgical interventions. Most of the deformities can be prevented at the stage at which they are diagnosed and treatment begun.

# Part 2

# Principles

# Chapter 9

# General Principles of Application of Apparatus

## Assembly:

The Assembly and designof the frame depends on the pathology, anatomic location and other features of local tissues. Rings provide rigid bone fragment fixation. Arches are used in locations where rings are either impossible to use or would interfere with joint motion: the hip, the shoulder, & the elbow.

## Precautions:

Ring or arch should be about 1.5 to 2cm (at least 1 finger breadth) larger than the maximum diameter of the limb at each level of fixation.

## General rules of Ilizarov application:

Biomechanical principle of Ilizarov ring fixator is very important for osteoneogenesis. That is why we must follow the some fundamental rules for better results:

1. The bone fragments must have the same position with respect to their rings or arch supports.
2. Connecting threaded rods must be parallel to each other and to the longitudinal axis of the bone fragments.
3. The wires must be tensioned uniformly, it should be maintained till consolidation of bone fragment is complete
4. Stable fixation is absolutely mandatory for pain free motion.
5. Use smaller rings for better stability and use larger rings whenever necessary.
6. Wire inserted close to the joints should not limit the range of motion.

## Ilizarov wires insertion technique:

For each individual case we emphasize the

following things into consideration:

1. The number of wires used.
2. Their positions and locations.
3. And the planes in which they are inserted.

The rigidity of fixation of bone fragment depends on both biomechanical and biological factors.

The mechanical factors are:

a) The number of wires.
b) The stiffness of wires.
c) The shapes, size, and position of the rings.
d) The distance between the wires.
e) Other supporting elements of the frame.

The biological factors are:

a) The level of fracture (Osteotomy)
b) The position of the fracture plane.
c) The stiffness of interfragmentary soft tissues.
d) The width and contact surface area of the fragment ends.
e) Local biologic status.

Wires can be inserted at any level of long bones. The direction and crossing of the wires is determined by the local anatomic constraints - the vessels, nerves and tendons. Wire should be inserted straight through the soft tissues down to the bone. Drilling should be started after the wire tip has engaged the bone surface.

## Precautions:

To prevent thermal injury to the bone and soft tissues we must follow the following rules during drilling:

1. Cool the wire by holding it with an alcohol - soaked gauze or betadine gauze or hexisol gauze at the wire skin interface.
2. Give pause during drilling to allow the wire tip to cool.
3. Drive the tip of the wire quickly through the soft tissues on the same side of the limb.
4. Cool the wire tip with an alcohol gauze or betadine gauze, or hexisol gauze as it emerges.
5. When the bone is subcutaneous, like in medial surface of tibia insert, wires from the opposite side to prevent heat conduct direct to the skin.
6. Don't bend the wire while drilling; because deformedwire increases the size of the wire tract, traumatizes soft tissues, deviates from its path, can enlarge bone holes which reduces the rigidity of fixation and increases the risk of wire tract infection.
7. Transmedullary wire insertion is important rather than only cortical, because it provides wire stability and prevents cortical osteomyelitis.
8. The Close the wire is to the joint, more attention should be paid.
9. Introduction of wire must be done correctly at first attempt, the rule is, one wire one hole.

## Soft tissue considerations:

To reduce skin necrosis at wire entry and exit sites during ring movement i.e., compression- distraction, angulations or transport by creating an excess stock of soft tissues at the appropriate location. If a compression osteosynthesis is planned, the skin and soft tissues are pulled away from the center of the configuration when inserting wires.

When distraction osteosynthesis or lengthening is done the stock of soft tissues is shifted slightly towards the center of the configuration at the time of wire insertion. Proper wire placement can preserve joint motion. When you insert a wire near a joint, extend the joint as a wire penetrates soft tissues on the flexor surface, and flex the joint as a wire passes through the extensor muscle.

## Alignment of rings and arches:

As a rule, the position of the fragments with respect to their respective rings must be similar. If we can follow this principle, displaced fracture fragments will automatically reduced as the rings are made coaxial to each other. If the rings are made parallal the angular deformities will be eliminated.

## Tensioning and securing wires:

After fixing the ring or arch in proper relationship to the bone's longitudinal axis, the assistant should hold the ring in position and the surgeon applies tension by tensioner and secures the wires. Each wire must remain straight as it is fastened to the ring.

## Precautions:

Secure one end of the wire and apply tension to the other and try to maintain equal tension on the wires. This will create an even distribution of the forces on the apparatus. We must emphasize special attention to wires attached to arches. All the wires connected to an arch must be equally tensioned.

## Maintaining wire tension:

We should maintain uniform wire tension during whole period of treatment. Sometimes we can use one or two supplementary wires through each bone fragment to improve stability in cases of compression osteosynthesis if the bone fragment ends are either incongruent or have large gaps along the edges.

## Arrangement of connecting rods:

Stable fixation is absolutely mandatory for good regeneration. The rods should be parallel to each other and to the longitudinal axis of the bone segments which is especially very important for a frame that is used for compression, distraction or bone transport.

# Chapter 10

# Ilizarov Basic Concepts

In this Atlas our basic aim is to describe the use of Ilizarov technique for correcting the equinus and equinocavus and CTEV deformities of foot and ankle. For excellent outcome 3 important things have to be keep in mind.

1. Meticulous follow up.
2. Appropriate selection of rings and wires and other components.
3. Proper construction of frames prior to application.

## Proper Selection of Entry and Exit Points for Passing Ilizarov's or K-Wires.

1. Initially if lengthening of tibia is needed along with deformity correction then in this situation three sets of cross wires are passed in the leg- the proximal, middle and distal.
2. Secondly, the frame configuration is indicated where only the correction of deformity is required. In this situation two sets of wires are passed at about the junction of proximal to the middle third and middle to the distal third.

## Proximal tibial wires:

### Entry and exit points

The first wire (1.8mm) enters through the most prominent part of the head of the fibula with an inclination aiming parallel to knee joint line and to emerge at a point just posterior to the vertical line drawn from the medial border of the patella. The second wire enters on the anterolateral surface of upper end of tibia just behind and about 1/2 cm (5mm) below the point drawn by the horizontal line of the head of the fibula and vertical line drawn from the lateral border of the patella with an inclination of the wire aiming to emerge at the same level just anterior to the medial border (Figure 10.1). Sometimes a 3rd wire can be passed from the lateral side anterior to the head of the fibula aiming to emerge on the medial side at the same level, in case of more stability and for tibial lengthening.

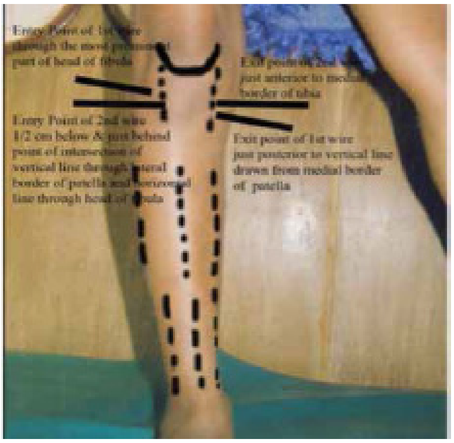



Figure-10.1: Proximal tibial wires.

## Middle tibial wires:

### Entry - Exit points

The first wire is inserted at about 1 finger breadth (2 cm) lateral and behind the shin of the tibia with an inclination of the wire aiming to emerge at the same level just anterior to the medial border. The 2nd wire is inserted

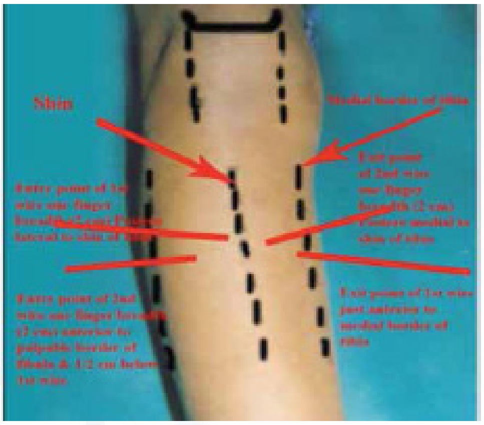



Figure-10.2: Middle tibial wires.

about 1 finger breadth (2 cm) anterior to the palpable anterior border of the fibula at a point about 1/2 cm (5 mm) below the level of the first wire with an inclination anteriorly aiming the wire to emerge about one finger breadth (2cm) postero- medial to the shin of tibia (Figure-10.2).

## Distal tibial wires:

Two Ilizarov's wires or K-wires (1.8 mm) are inserted at the junction of the distal and middle third of tibia. The first wire inserted through fibula and passed through the tibia with an inclination aiming the wire to emerge one finger breadth (2cm) postero medial to the shin of the tibia (Figure-10.3). Regarding the insertion of the 2nd wire, one must be very much cautious. The space between the anterior border of the tibia and fibula is divided into three equal zones. * The anterior zone contains neurovascular structures and tendons. * The middle zone is safe and contains muscular parts. Now the 2nd wire inserted through safe corridor of middle zone 1/2cm (5mm) below the 1st wire into the tibia with an inclination to emerge just anterior to the medial border of the tibia (Figure-10.4). One must be careful to avoid piercing the Vena saphena magna (Great saphenous vein) which crosses the medial border of the tibia about 10cm (5 finger breadth) above the medial malleolus (Figure-10.5, 10.6, 10.7).

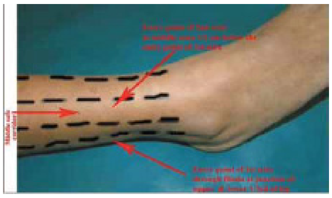


Figure-10.3: Entry point of distal tibial wires.

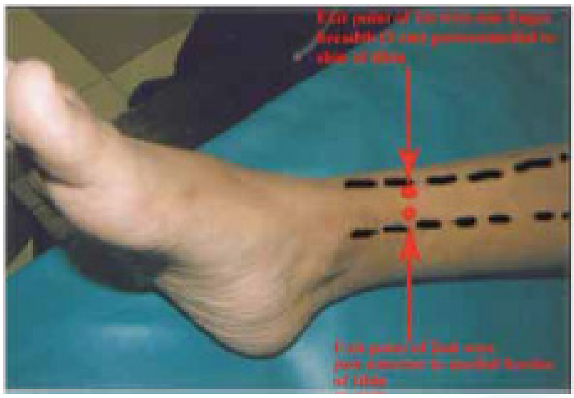


Figure-10.4: Exit point of 1st ans 2nd wires.

Figure-10.5: Middle tibial wires.

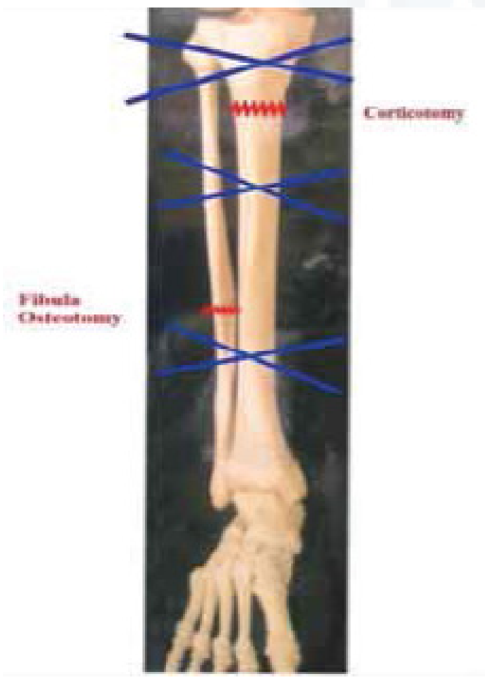



Figure-10.6: Position of wires tibial rings (Proximal, middle, distal).

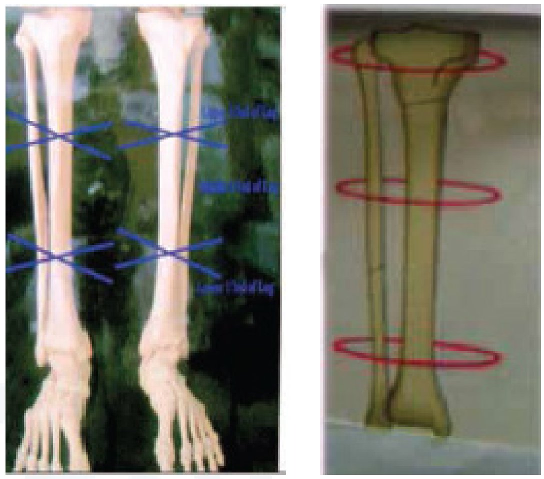


Figure-10.7 : Position of  wires (Middle and distal tibial rings).

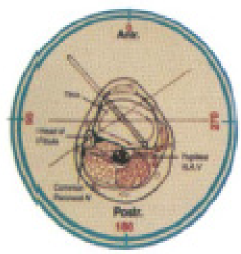



Figure-10.8a: Proximal schanz screws.

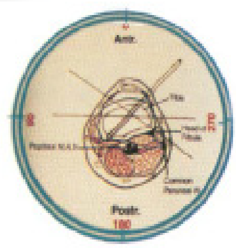



Figure-10.8b: Proximal schanz screws.

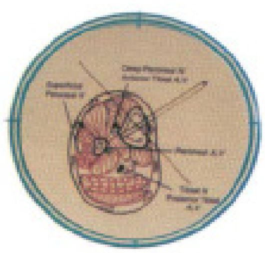


Figure-10.9a: Middle schanz screws.

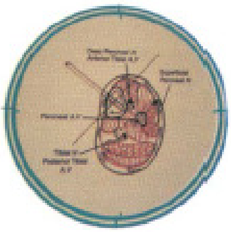


Figure-10.9b: Schanz in lower 1/3rd of tibia

## Hybrid technique:

Means the product of a cross between genetically unlike individuals i.e the combination of transosseous wires with Schanz or half pins.

The half pins inserted on the sagittal plane crosses the transverse wire at 90, allows for stability without transfixion of muscular masses. Half pin fixation or Schanz has the advantages of inserting at the site away from the neurovascular structure.

Proximal Tibial Schanz Screw: After inserting the 1st reference wire through the most prominent part of the head of the fibula with an inclination to emerge at a point just posterior to the vertical line dropping from the medial border of patella, one Schanz screw is passed through the anterolateral surface of upper end of tibia from a point about 1.2 cm. below the reference wire on the vertical line drawn from the lateral border of the patella. The screw is inserted with a inclination to engage the thicker cortex just behind the medial border (Figure-10.8a & 10.8b).

## Middle tibial Schanz Screw:

One Ilizarov wire or K-wire and one Schanz

screw is passed (Figure-10.9a).

## Distal (Lower) tibial Schanz Screw:

The first Ilizarov or K-wire is inserted through the fibula and passed through tibia with an inclination aiming the wire to emerge one finger breadth (2 cm) postero- medial to the shin of tibia. First Schanz screw is fixed from medial border of tibia and the second Schanz screw from medial surface of tibia making maximum angle at a distance from 1st screw with the help of 3 to 4 hole Ranche Cube block (Figure-10.9b).

### Proper points of Selection of wires in foot:

1. For calcaneum - 1.8mm two wires.
2. For mid-trasal - 1.5 mm two wires.
3. For metatarsals - 1.5 mm two wires.

## Calcaneal Wires:

### Medial approach:

The pulsation of posteror tibial artery should be felt and posterior tibial nerve can also be palpated. One and a half finger breadth behind artery and nerve is the safe corridor on the medial surface of calcaneum which emerges about 2 to 3 finger breadth (4-6 cm) behind the posterior border of posterior malleolus. The first K-wire is inserted at one finger breadth (2 cm) above the undersurface of calcaneum and one finger breadth (2 cm) in front of Tendo Achilles insertion. The second wire is inserted at a point 1cm anterior to the first point and 1cm above the inferior surface of calcaneum. The angles between the two wires will be more or less 30 degree (Figure- 10.10, 10.11, 10.12)

Figure-10.10: Wire position in calcaneus and metatarsals.

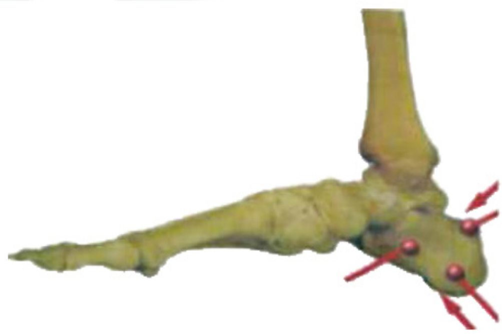


Figure-10.11: Wire in calcaneum.

Figure-10.12: Wire position in calcaneus and metatarsals.

## Lateral Approach:

### Insertion Point:

First wire is inserted through outer surface of calcaneum 1 cm above its inferior surface and 1cm distal to the attachment of Achille's tendon and the wire is further introduced with an inclination anteromedially aiming to emerge on the medial surface of the calcaneum 2 finger breadth (4 cm) below the medial melleolus. The second wire is inserted one finger breadth (2 cm) distal to the entry point of first wire and is advanced posteromedially to emerge one finger breadth (2 cm) behind the first wire in the same level. Here the angle between the two wires should be more or less 30 degree (Figure-10.11 & 10.12).

### Proper position of wires in mid tarsal region:

If equinus is associated with cavus two additional K-wires or Ilizarov's wire are required to correct such deformity. One wire is passed on the medial surface of navicular to emerge at the summit of the cavus and other wire is introduced at the centre of outer surface of cuboid and aiming to emerge in the summit of the cavus and both the wires are making angle of 30 degree between them. Wires should not be tensioned.

The first wire is inserted from the outer side of distal part of 5th metatarsal between the head & neck and is advanced obliquely piercing the 5th, 4th & 3rd metatarsal just proximal to their head to emerge on the surface on the dorsum of the foot. The second wire is inserted on the medial surface in the distal first metatarsal just proximal to its head and advances obliquely to emerge on the dorsum of the foot after piercing through second metatarsal.

Figure-10.13: Position of wires in mid tarsal region.

### Position of wires at the base of metatarsal head:

The first wire is inserted from the outer side of distal part of 5th metatarsal between the head & neck and is advanced obliquely piercing the 5th, 4th & 3rd metatarsal just proximal to their head to emerge on the surface on the dorsum of the foot. The second wire is inserted on the medial surface in the distal first metatarsal just proximal to its head and advances obliquely to emerge on the dorsum of the foot after piercing through second metatarsal.

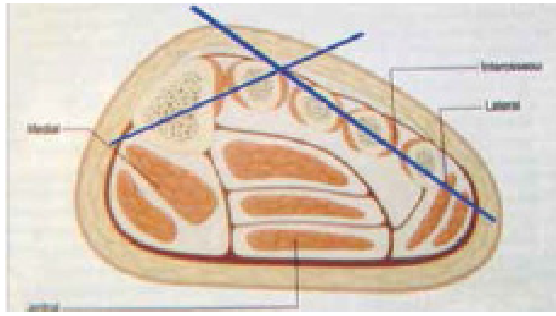


Figure-10.14a: Position of wires in mid tarsal region.

Figure-10.14b: (Position of K wires in standard approach).

Figure-10.14c: (Position of K wires in standard approach). Proper size of the ring:

Try to use smaller rings but use larger rings whenever necessary. At least two finger breadth (3 to 4cm) should be considered at the maximum girth of the limb. Special attention should be given for proper selection of optimum measurement of the ring. But often the doctor selects the size of the ring by mere assumption his eyes. On the basis of our long years of clinical experience we can use transosseous apparatus through a mathematical calculation and we have identified the optimum measurement of rings, which depends on circumference of the extremity. For longer diameter rings it is better to use Ilizarov's wire Optimum measurement of ring always depends upon the volume of the extremity.

| Circumference of extrimity in cm | Measurement of Ring |
|---|---|
| 10 | 90-100 |
| 15 | 100-110 |
| 20 | 120-130 |
| 25 | 140-150 |
| 30 | 150-160 |
| 35 | 160-180 |
| 40 | 180-195 |

## Proper position of the rings:

### Proximal tibial ring:

Proximal tibial ring is used when lengthening is performed. A full ring should be fixed at the level of the head of the fibula (Figure-10.15a & 15b).

### Middle tibial ring:

A full ring is placed approximately at the junction of upper 1/3rd to middle 1/3rd of the leg (Figure-10.15C).

### Distal tibial ring:

A full ring is placed about 10-12 cm above the ankle joint, about the junction of lower 1/3rd and middle 1/3rd of leg.

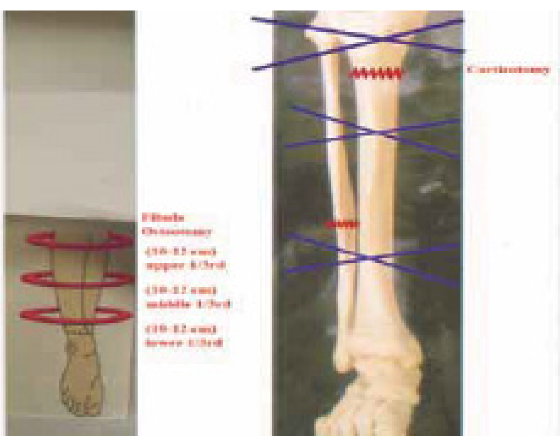


Figure-10.15a & 10.15b: Position of rings in tibial lengthening.

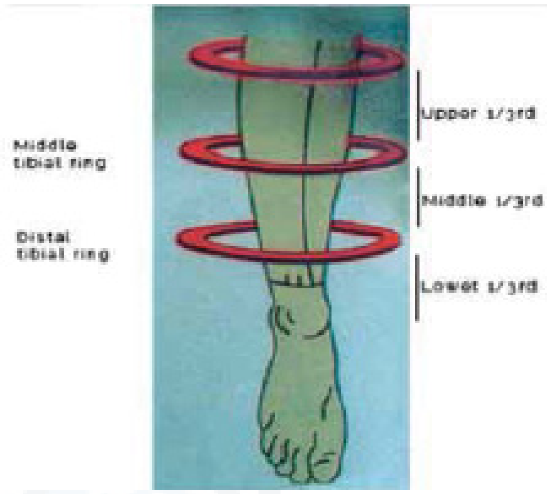



Figure-10.15c

## Half Calcaneal ring:

Improtant thing is that the half calcaneal ring should be placed behind and parallel to plantar surface of heel, which will be more or less horizontal when the patient stands but in cases of varus or valgus deformity the inclination of the ring will be according to the concerned deformity and will not be horizontal (Figure-10.16).

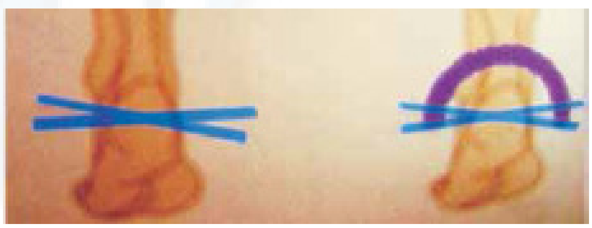


Figure-10.16: Placement of the ring in calcaneum.

## Forefoot half ring:

Here half ring is placed proximal to the head of metatarsals and the ring should be perpendicular to the head of metatarsals.

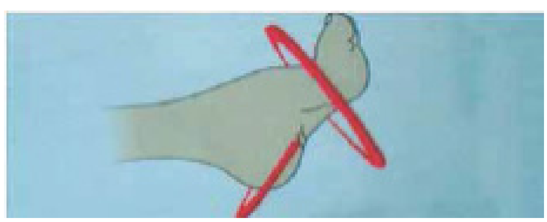


Figure-10.17: Placement of rings in calcaneus & forefoot.

### Full ring in forefoot:

It is justify to mention that if the equinus deformity is combined with the cavus or excavatus a full ring should be placed around the forefoot (Figure-10.18).

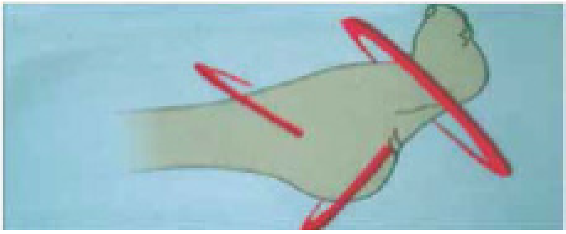


Figure-10.18: Placement of half ring in calcaneus and full ring at forefoot.

### Half ring in mid-foot:

A half ring is also sometimes needed in the mid foot when equinus is associated with cavus or excavatus deformity.

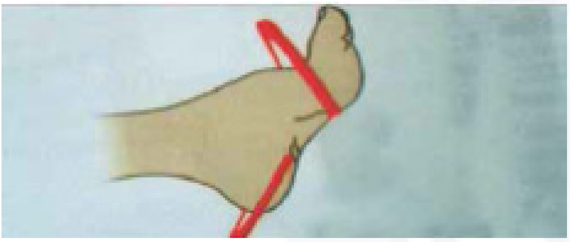


Figure-10.19: Placement of half ring in mid foot region.

### Full ring in mid foot:

In the mid foot a full ring is also needed when equinus is associated with severe equinocavus deformity (Figure-10.20).

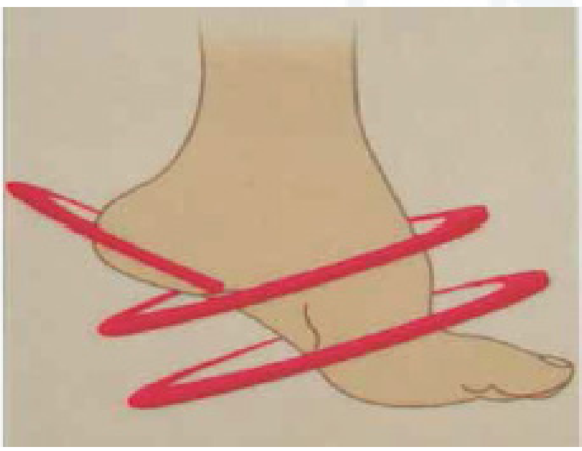


Figure-10.20: Placement of full ring in mid foot and forefoot region.

### Pre construction of the frame:

To save time during surgery we can pre-construct the tibial frame. The frame constructed will be different for correcting equinus deformity alone and equinus deformity along with lengthening of short leg (Figure-10.21). For correcting equinus deformity alone proximal ring is not at all required, middle & the distal ring will serve our purpose.

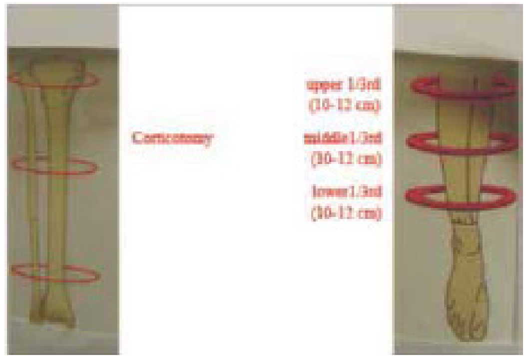



Figure-10.21a,b: Position of the rings for tibial lengthening.

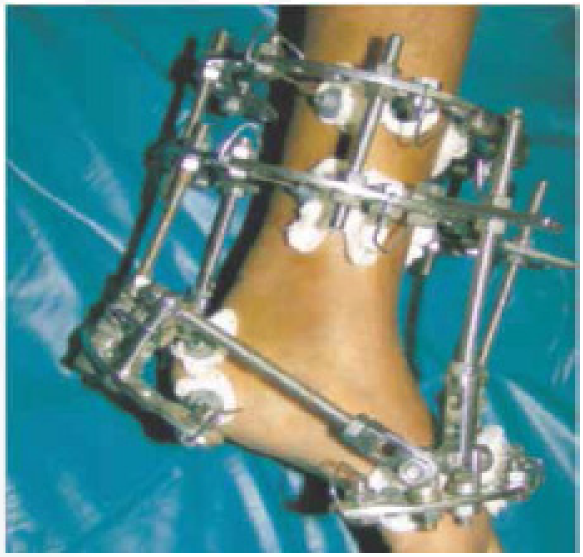


Figure-10.22: Complete frame assembly two anterior and two posterior threaded connecting rods.

## Equinus and Equinocavus with short limb (Equinus with LLD):

Equinus with associated short limb can be corrected simultaneously by lengthening the tibia in the metaphyseal region with fibular osteotomy.


Figure-10.23: Corticotomy of tibia

## Osteotomy of fibula:

Osteotomy of fibula is performed at the junction of middle third and lower third of fibula. Osteotomy of fibula can be performed in two ways.

1. By making 2 or 3 drill hole over the fibula.
2. Or by direct using 1-1.5cm corticotome over the fibula.

## Corticotomy of tibia:

### Step 1

The levels of osteotomy, K-wires, knee joint space, fibula osteotomy should be determined and clearly marked.

P - Patella.

T.T - Tibial tuberosity.

C.L - Corticotomy level.

J.L - Knee joint line.

### Step 2

Skin incision 2cm on the level of tibia osteotomy (0.5-1cm below tibial tuberosity).

* Ilizarov corticotomy is a low energy osteotomy with the preservation of periosteum and endosteum.
* In choosing corticotomy level, anatomic, biomechanical and physiological factors must be considered.

## Anatomical factors:

Corticotomy should not be performed in the middle of the bone.

Corticotomy is suitable in between diaphysis and beginning of metaphysis.

## Biomechanical factors:

1. The bone segment must be large enough to accomodate two rings situated between bone and bone transection.
2. Appropriate distance must be 4-6 cm from joint.
3. Corticotomy must not interfere the joint motion.

## Physiological factors:

1. Preservation of Periosteum - which is responsible for bone growth in width.
2. Preservation of Endosteum - Responsible for bone formation and bone resorption.
3. Preservation of local blood circulation.
4. Status of local tissues i.e scar from previous injury, infection or previous surgery can interfere in true regeneration (Osteogenesis).
5. Cyst, porosis and sclerosis can delay or prevent bone formation.

## Common mistakes during corticotomy:

1. Too large skin incision.
2. Poor choice of corticotomy level.
3. Uses of over sized osteotome.
4. Destructive hammering of the cortex.
5. Direct cutting of bone marrow canal.
6. Injury to near by vessels and nerves.
7. Performance of twisting corticotome maneuver before complete cutting of medial and lateral cortex.
8. Incomplete corticotomy.
9. Traumatic corticotomy.

## Limb lengthening:

Limb length discrepancy (LLD) is a common orthopaedic problem in Bangladesh which arising from either shortening or lengthening of one or more bones in the limb. Poliomyelitis is the most common cause of the LLD, the second important cause is the growth arrest due to osteomyelitis or trauma. Limb lengthening is a long procedure which is associated with many complications but Ilizarov method has least complications which are predictable, preventable and tractable.

## Biology:

Distraction osteogenesis

It is a mechanical induction between bony surfaces that are gradually pulled apart in a controlled manner.

1. Gradual lengthening 1mm/day.
2. Faster lengthening leads to failure of bone formation
3. Slower lengthening required in some, can lead topremature consolidation.
4. Rhythm of distraction: increased frequency better e.g.º1/4 mm 4x/day better than 1mm once a day.
5. Bone formation is in line with direction of distraction.
6. Collagen fibres lined up with direction of distraction. Ifinstabilityoffixationpresent collagen fibres become sinusoidal.
7. Mechanism of bone formationis INTRAMEMBRANEOUS.
8. Endochondral bone formation less common but does occur.
9. Fibrous interzone is the layer between the forming columns of new bone.
10. Trabeculae looks like stalactites and stalagmites.
11. Interzone has the undifferentiated mesenchymal cells that can form bone, cartilage or fibrous tissue.

## Distraction Histogenesis of Soft Tissues:

1. Gradual distraction is important for soft tissues.
2. Soft tissues lengthening is a combination of stretch and regeneration.
3. Muscle regeneration secondary to addition of sarcomeres as well as recruitment of satellite cells.
4. Nerve regeneration includes new Schwann cells.

## Distraction is indicated for:

1. Limb lengthening.
2. Correction of deformities.
3. Bone fragment transport.
4. Stimulusfornon-unionandPseudoarthrosis.
5. Neovascularization.
6. Correction of joint contractures.

## Complications of limb lengthening:

Bone complications

1. Premature consolidation.
2. Delayed consolidation.
3. Non union.
4. Axial deviation (secondary deformity)
5. Fracture.
6. Infection.

## Joint complications

1. Stiffness
2. Contracture
3. Subluxation
4. Dislocation
5. Arthritis

## Soft tissue complications

1. Nerve injury
2. Vascular injury
3. Oedema
4. DVT
5. Muscle contracture
6. Muscle scarring
7. Skin scars

There are many ways to prevent complications. Since distraction related complication occurs gradually they can be identified early and treated early. So frequent follow up (at least every two weeks during distraction and every month during consolidation) are required.

## Post operative correction and management:

Before starting deformity correction mathematical calculation has to be done for soft tissue distraction. The equinus is corrected by tightening the anterior threaded rods and loosening of posterior threaded rods. Mean latency period is the 7$^{th}$ day. Correction can be started on the 6$^{th}$ day also. The process of loosening and tightening of connecting threaded rods should be performed 4 times a day @ 0.25mm at 8AM, 12PM, 4PM and 8PM. At the time of correction all hinges should be loosened and after correction all hinges should be tightened if we don't do it the frame will be unstable and regeneration of Achilles tendon may be hampered; but if the tenotomy of Achilles tendon is not done and only soft tissue distraction is done, then hinges remain fixed with nuts, which provides controlled smooth motion. The frame should be retained for a period of 6-8 weeks after full correction or equal to the time needed in achieving the correction except for bone lengthening. Sometimes plaster immobilization is needed after dismounting the frame.

# Chapter 11

# Hormonal Changes in Limb Lengthening Process

## Hormonal Changes in Limb Lengthening Process

The synthesis of hormones, products of high biological activity is strictly regulated by actual needs of a macro-organism.

Osteosynthesis with the Ilizarov apparatus in closedfractures isa perfect model forstudying of the bone regeneration process in reply to the frame. It has an advantage regarding other methods of treatment: skeletal traction and plaster cast do not provide bone fragment immobilization because traumatic factor is constantly preserved. The osteosynthesis with the Ilizarov lacks all these draw-backs, besides the functional activity of a patient is considerably preserved. In Kurgan the scientific study revealed that a concentration of corticotropin, aldosterone, hydrocortisone, PTH increases right after trauma (3-5 hours). This is a hormonal reply of organism to the trauma. The maximum concentration of those hormones in transosseous osteosynthesis with the Ilizarov apparatus is observed on the 35$^{th}$ posttraumatic day. On the 14$^{th}$ day after trauma, contents of STH and CT increases in blood. On the 5$^{th}$ postoperative day a concentration of all the hormones increased: STH by 3-4 times; CT 2 times, PTH 6 times, adenosine- monophosphate ( AMP) 11 times and cyclic guanine monophosphate (cGMP) 6 times.

By the 7$^{th}$ day of distraction the hormonal concentration is reduced by 1-2 times. PTH concentration remains at a high level during 14-30 days of distraction. Calcium (Ca2+) and Phosphate concentration is also increased in blood plasma ( W.B. High et al 1982).

The most noticeable increase of CT concentration is observed in fixation period; when process of regenerative mineralization is the most intensive. The growth hormone (STH), which concentration exceeds the normal during the whole distraction period, stimulates the synthesisof proteo-glycans and collagen, that is conductive to bone growth. Growth hormone (STH) concentration is 2-3 times higher in a growing child in comparison to healthy adult. (M I Balabolkin, 1978).

In Kurgan, the radiologic and immunologic studies showed that bony tissue regeneration is regulated by hormonal system. Human organism also reacts to distraction rate changes; it reflects in a hormonal dynamics.

In Kurgan, an automatic mode of lengthening is more widely used. In comparison to the classic distraction method. When a daily lengthening rate (1mm) is performed in day time by 4 steps ( 0.25mm X 4 times), the automatic distraction is less traumatic because the lengthening of 1mm is achieved within 24 hours.( -.017 X 60 times).

Lengthening of a long bone, corticotomy through a sub cutaneous approach, leads to biologically active site. Local undifferentiated megenchyonal cells evolve into osteoblasts producing collagen, osteoid matrix and then bone unireval. Distraction force helps to produce osteogenesis longitudinally in the direction of line of force. The internal distractor, endochondral proliferation, stretches periosteal vessels, nerves, muscle and skin to induce growth. Distraction osteogenesis is the mechanical induction between bony surfaces that are gradually pulled apart in a controlled manner. Distraction osteogenesis is the primary method of bone lengthening.

# Chapter 12

# Blood Supply and Metabolic Activities of Bony Tissue

## Blood Supply and Metabolic Activities of Bony Tissue

In Kurgan (RISC, RTO), experimental studies proved that distraction osteosynthesis stimulates development of dense capillary network. The rate of distraction leads to sufficient increase of volume speed of tibial blood flow by 3 times.

Radio-nuclear studies give the authentic idea about blood flow changes in the extremity being lengthened and metabolic changes constantly connected with it in bony tissue. Metabolic process of both internal and organic bone components constantly and intensively takes place in bony tissue. At present radio-nuclear diagnostics is widely used in studying of metabolic processes in different organs and in bone as well, in diagnostics of different diseases. New osteotropic radio- pharmaceuticals preparations (RPP) e.g. nucleids participating in mineral metabolism is conductive to it.

The activity of metabolic processes in the extremity grows after osteotomy; marked phosphine accumulation in regenerate increased to 452+ 0.77% at P< 0.05, speed of the volume blood flow to 250 + 0.18% at P< 0.05.

The capillary blood was sped up in the whole extremity practically within the 1st month of distraction in simultaneous femoral and tibial lengthening. RPP circulation made up to 73% in tibia and 279% in femur. But already by the 3rd month of distraction its circulation increased mostly in femur ( 353 + 0.23%) than in tibia (302 + 0.32%).

During the 1st month of fixation the blood circulation practically remains at the same level ( 350 & 303%). RPP circulation level decreases very slowly. By the 6th month after distraction it is reduced to 24% in femur and to 20% in tibia. Blood circulation normalizes in 12 months after the removal of the apparatus. Intensity of metabolic processes in segments being lengthened changes along with the blood circulation of the extremity.

# Chapter 13

# Enhancement of regenerate bone healing

## ENHANCEMENT OF REGENERATE BONE HEALING

Various biological and mechanical strategies are responsible for improving the ability to enhance the rate and volume of regenerate formation. These are:

1. Latency period
2. The performance of low energy osteotomy
3. Soft tissue preservation
4. Soft tissue preservation

## DISTRACTION OSTEOGENESIS CAN BE CHARACTERIZED INTO THREE GROUPS:

1. Failure of adequate regenerate formation in an expected time frame
2. Fracture through the regenerate or adjacent bone
3. Bending of the regenerate after the removal of the frame.

## MOTORIZED DISTRACTION

8-step distraction (0.125mm increments) compared to 4-steps (0.125mm increments) daily distraction is better. BMD is significantly higher in the 8 step groups than 4-step groups. Motorized distraction may increase patient compliance and comfort.

## HBO (HYPERBARIC OXYGEN THERAPY)

HBO increases hypertrophy of cartilage and increases bone formation. In Kurgan center the clinical trial showed that bone healing is increased by HBO and they are routinely using HBO.

## ANTICATABOLIC THERAPHY

Biphosphonates: Modern nitrogen containing Biphosphonates (N-bps) prevent fractures from occurring in osteoporotic conditions, control pain. The rationale for the use of N-bps in distraction osteogenesis is to prevent catabolic effects. It increases BMC (bone mineral contents) and BMD and bone volume both in and around the regenerate area.

# Chapter 14

# Mechanical Principle of Ilizarov Method

## Mechanical Principle of Ilizarov Method

### Pearls of Frame Mounting

Rule of Two's

1. 2 cm between skin and frame.
2. 2 rings/bone segment
3. 2 points fixation/ring
4. 2 x 2 = 4 connecting rods between rings
5. Fixation both 2 ends of the bone segment (near-near and far-far)
6. Pin and wire fixation in 2 planes.

### Methods to increase frame stability:

N.B.: Don't violate the original Russian Rule of Technique.

**Case No. 1**

**Picture 1:** Ring sizes are much more bigger, rings that are too large do not support the transfixing wires adequately and osteogenesis impaired. No rubber stopper, no dressing gauge is seen.

### Methods to Increase Frame Stability:

| | |
|---|---|
| Rings | Decreasing ring diameter<br>Decreasing ring to skin distance<br>Securing near and far ends of bone segment<br>Increasing number of rings (use" dummy ring" to span long distances) |
| Ring connections | Increasing number of connections<br>Increasing rigidity of connections (telescopic rods to span long distances) |
| Wires | Increasing number of wires<br>Increasing diameter of wires<br>Maximizing crossing angle wires<br>Opposing olive wires<br>Drop wires |
| Bone considerations | Maximize bone end contact Apply compression / distraction |

N.B.: Don't violate the original Russian Rule of Technique.

## What Not To Do?

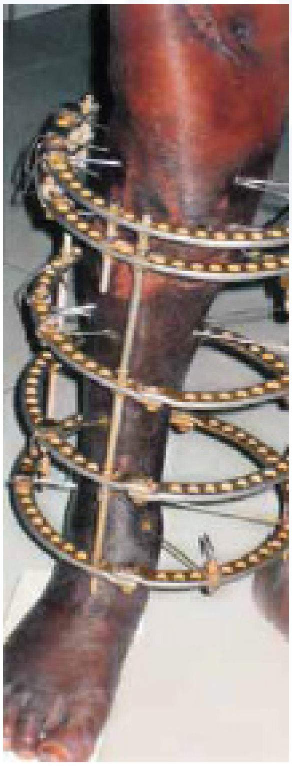
Some of the following cases were done outside Bangladesh and in Bangladesh.

## Case No. 1


Picture 2: Close up view of the rings. Violation of mechanical estability (lose of trampoline effect), 4 cm LLD persists.

Picture 3: 2 fingers in the lateral side, 5 fingers in the middle side.

Picture 4: 5 fingers in the medial side, 2 fingers in the lateral side.



Picture 5: Close up view, ugly frame assembly.

## Case No. 2

Picture 1: 3 fingers in the lateral side and one finger in the medial side.

Picture 2: Violation of mechanical stability, no dressing gauge is seen. 4 fingers in the medial side and one finger in the lateral side.

## Case No. 3

Picture 1: No proper ring sizes. No mechanical stability, No rubber stopper, No dressing gauge is visible.

## Case No. 3

Picture 2: Close uo view of the frame, Wires are loose, No rubber stopper and no dressing gauge is visible.

Picture 3: 3 fingers in the lateral side and one finger in the medial side.

Picture 4: No dressing is seen, no rubber stopper, foot is equinus position.

## Case No. 4

Picture 1: Radiograph of right lower tibia fibula fracture with 2 rings in situ which is not adequate in case of adult patient.

Picture 2: Two rings are not adequate. Rings are not in proper position, mechanically unstable.

Picture 3: 4 fingers in the medial side and 1 finger in the lateral side, This is the violation of the rule.

# Chapter 15

# Different Plane (Frontal plane, Sagittal plane and Horizontal plane) Deformities and Bio-mechanics of the Ankle & Foot

## Frontal/Coronal Plane Deformities of Ankle and Foot

Clinically frontal plane is best evaluated from behind. In the frontal plane the axis of the body of the calcaneus is normally parallel to the anatomic axis of the tibia. Heel varus and heel valgus are seen in this plane and the plane of deformity is hind foot.

Figure 15.1a: Varus heel.

Figure 15.1b: Valgus heel.

## Sagittal Plane Deformities of Ankle and Foot

This plane is visible when we see the deformity from the side. Pes equinus, Pes Equinocavus, Pes planus and Pes calcaneus are seen in this plane and the place of deformities we see in hind foot, mid foot and forefoot (Figure 15.2a-15.2e).

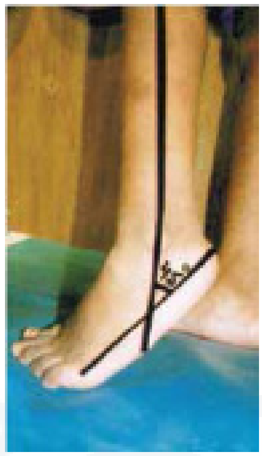


Figure 15.2a: Pes Equinus.

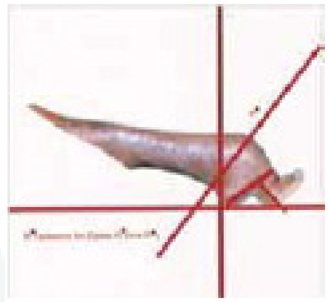


Figure 15.2b: Pes Equinocavus.

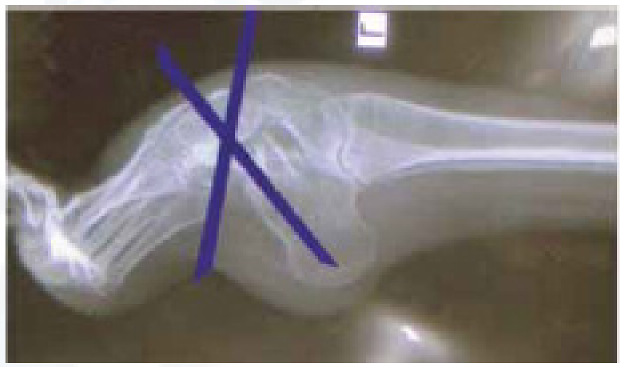


Figure 15.2c: Valgus heel.

Figure 15.2d: Pes Planus.

Figure 15.2e: Pes Calcaneus.

**Horizontal plane deformities of ankle and foot:**

This plane is visualized when we see the deformity from the up-down. Adduction & abduction of the fore foot are seen in this plane.

Figure15.3a: Adducted foot.

Figure 15.2b: Pes Planus.

Figure15.3c: Planes of ankle and foot (Horizontal, sagittal and frontal).

The human foot is complex structure adopted to allow orthrograde bipedal stance and locomotion. It is the only part of the human body which is always in contract with the ground. There are 28 major bones in the foot, 31 major joints including the ankle joint. Functionally the skeleton of the foot may be divided into tarsus, metatarsus and phalanges.

## Arches of the Foot

Three main arches are recognized in the foot.

**Medial longitudinal arch.**

It is made of the calcaneus, talus, navicular and three cuneiform and three metatarsals. The pillars are the posterior aspect of the calcaneus and three metatarsal heads.

**Lateral longitudinal arch:**

The bone making up the longitudinal arch are the calcaneus, the cuboid and the $4^{th}$ & $5^{th}$ metatarsals. The pillars are calcaneus and the lateral 2 metatarsal heads.

**Transverse arch:**

The bones involved here are the bases of the 5 metatarsals, the cuboid and the cuneiforms.

**Biomechanics of ankle and foot:**

Planes of motion: Plantar flexion and dorsiflexion refers to movement in the sagittal plane and occur principally; but not exclusively at the ankle, metatarsophalangeal and interphalangeal joints.

Inversion is tilting of the plantar surface of the foot towards the midline.

Eversion is tilting away from the midline, this is motion in coronal/ frontal plane.

## Different planes and deformities:

| Planes and Deformity | Place of Deformity | View |
|---|---|---|
| 1. Sagittal Plane | | |
| a) Equinus | Ankle | To be Seen from side |
| b) Equinocavus | Hind foot, | |
| c) Pes planus | Mid foot | |
| d) Pes planovalgus | and | |
| e) Pes calcaneus | Fore foot | |
| 2. Frontal Plane | | |
| a) Heel varus | Hind foot | To be seen from back |
| b) Heel valgus | deformity | |
| 3. Horizontal Plane | | |
| a) Fore foot adduction | Fore foot deformity | To be seen from up to down |
| b) Fore foot abduction | | |

Adduction is the movement of the foot towards the midline in the transverse plane.

Abduction is the movement away from the midline. This movement occurs at the transverse tarsal joints and to a limited degree, the first tarso metatarsal joint and the metatarsophalangeal joints.

Supination describes a three dimensional movement and is a combination of adduction, inversion & plantar flexion.

Pronation is the opposite motion i.e., a combination of abduction, eversion and dorsiflexion.

Humans are bipedal. We are plantigrade, i.e., we set the whole length of the foot down on the ground; whereas most mammals are digitigrade i.e., they stand and walk on their toes. Mid foot is responsible for dynamic distribution of weight through medial longitudinal arch.

Weight is transmitted from hind foot to fore foot through the transverse arches.

Any abnormality from the plantigrade will lead to deformities in the foot.

# Part 3

# Congenital deformity of locomotor apparatus in paediatric group.

# Chapter 16
# Correction of CTEV by Ponseti and Ilizarov Technique

Clubfoot deformity is the commonest congenital anomaly which has been treated in the past by several methods by several orthopaedic surgeons with variable success. Early treatment of this disorder were manipulative. Several surgical options were also tried by several surgeons later, but the results have not proven to be superior and more complication have been reported after surgical intervention. The number of operations is many, from the minimalist percutaneous TA lengthening, plantar fasciotomies & abductor hallucis resections to small procedures like posterior Attenborough soft tissue release, going on to extensive PMR by Turco. Complete subtalar release by Cincinnati approach probably leave no soft tissues intact around the subtalar joint. Recently a big marketing push for external fixation devices - all claiming simplicity and perfect results and are being put on tiny babies feet leading to much misery. Bones of young plants and saplings grow slowly and it takes many years to see the true results of the procedures we do on growing bones. I.V ponseti has been the pioneer of the manipulation and casting technique and he has practiced and perfected his technique for over 50 years.

In this confusing scenario, how does a young Orthopaedic surgeon decide which method of treatment to adopt for clubfoot?

The answer is very straight and simple. We can choose the technique that

- has firm scientific ground.
- has a clear understanding about the biology of soft tissue behavior,
- follows the kinesiology of tarsal joint to achieve correction of foot deformities.
- uses the simplest and minimally invasive methods to treat the tiny babies and
- has proved to give excellent results more that 45 years later.

Ponseti technique can fulfill all of these criteria. Dr. I. V. Ponseti has followed up his patients as long as 45 years. The Ponseti technique is gathering momentum all over the world due to its advantages of-

- low cost
- minimal surgery and
- good result in trained hands.

**Development of the technique:**

Mid 1940s,

**Effect of operative correction:**

After PMR the important ligament of the tarsus and midtalar joints could be abducted under the talus. Severe scarring in the foot and stiffness are common.

**Anatomical considerations:**

Histological sections revealed that the abundant collagen in the ligaments are wavy, very cellular and could be easily stretched. The displaced navicular, cuboid, and calaneus could be gradually abducted under the talus without cutting any of the tarsal ligaments.

**Initial treatment:**

1. Non operative
2. Begin in first week
3. Favorable viscoelastic properties of connective tissue.
4. Early surgery - severe scarring, fibrosis.

**Manipulation treatment:**

1. Ligaments, joint capsule, tendons stretch.
2. Bones gradually aligned.
3. Joints surfaces progressively remodel.
4. Surgery needed when ligaments do not yield.

**Misconception:**

1. Axis of rotation of subtalar and Chopart joints goes from anteromedio superior to posterolatero inferior through tarsi.
2. Inversion of hind foot.

**Pathoanatomy:**

1. Axes medially deflected.
2. Medial displacement and inversion of tarsal bone.

**Errors in corrections:**

1. Pronation of the whole foot.
2. Pronation of the fore foot.

**Ponsetis manipulation:**

1. Navicular laterally displaced, abducted and finally everted.
2. Cuboid abducted
3. Calcaneus abducted in flexion under the talus before it can be everted.
4. Cavus, varus and adduction corrected simultaneously, because the tarsal joints are in a strict mechanical interdependence and cannot be corrected sequentially. Clubfoot is easily corrected when the functional anatomy of the foot is well understood. The completely supinated foot is abducted under the talus that is secured against rotation in the ankle mortise by applying counter pressure with the thumb against the lateral aspect of the head of the talus.
5. Equinus corrected in the end by tenotomy.

**Ponsetis treatment:**

1. Start soon after birth (7-10 days)
2. Before 9 months of age most clubfoot deformities can be corrected, if the deformity is not corrected after 6 or 7 casts, the treatment is most likely faulty.
3. Treatment is most effective if a started before 9 months of age.
4. Treatment between 9-28 months is still helpful in correcting all or much of the deformity.

**Verdict:**

1. Not more than 10 casts
2. Average 5
3. Always above knee cast
4. Tenotomy after all components are corrected except equinus. Tenotomy should be performed approximately 1 cm above the calcaneus. Avoid cutting into the cartilage of the calcaneus. A "pop" is felt as the tendon is released. An additional 10-15 of dorsiflexion is typically gained after the tenotomy.
5. Post-tenotomy cast: Cast should be applied with the foot abducted 60-70˜ with respect to the frontal plane of the tibia. The foot is never pronated. This cast is left in place for 3 weeks after complete correction.
6. Cast removal: The cast is removed after 3 weeks. Now 30 of dorsiflexion is possible. The foot ready for bracing.
7. At least 2 casts after tenotomy
8. Shoes are given continuously for 3 months
9. Night shoes to be continued
10. Ponsetis bracing Protocol: The brace is applied immediately after the last cast is removed, 3 weeks after tenotomy. The brace consists of open toe hightop straight last shoes attached to a bar.
11. Rationale for bracing: At the end of casting, the foot is abducted to an exaggerated amount, which should be 75 (TFA-Thigh foot axis). Ponsetis protocol calls for a brace to maintain the abduction. This degree of foot abduction is required to maintain the abduction of the calcaneus and fore foot and prevent recurrence.
12. Importance of bracing: Only the brace as described by Ponseti is an acceptable brace for Ponseti management and should be worn at night until the child is 3-4 years of age.

**Surgery:**

- Failure of conservative treatment
- T. A. lengthening
- Transfers of tibialis anterior tendon.

**Causes of failure:**

- Late presentation
- Failure to wear shoes
- Rigid foot: e.g arthrogryposis.

**How does Ponseti management fail?**

1. The success rate depends on
2. the degree of stiffness of foot.
3. the experience of the surgeon
4. the reliability of the patient's guardian. In most situations, the success rate is more than 90%, failure is most likely, if the foot is the stiff with a deep crease on the sole of the foot.

**Outcome of the surgery and Ponseti management:**

Surgery improves the initial management but does not prevent recurrence. Surgically treated feet become weak, stiff and painful in adult life.

**The Ponseti method in babies: (Our experience)**

We have been performing casting and manipulation with the Ponseti technique since 2000 for the last 13 years and have finished treatment of more than 146 feet in 94 babies. What we do?

- We generally keep the baby on the mothers lap, encourage breast feeding while casting is going on.
- Surgeon should mould the plaster of paris around the talar head and the heel.
- Once the below knee plaster is hard then above knee is applied with hip held in extension.
- No anaesthetic support is needed.

Tenotomy was done in most of the cases, rocker bottom foot was seen in 4 feet. Gentle technique and moulding is the key to success.

Lt. sided CTEV.

Bilateral CTEV with plaster immobilization.

Bilateral CTEV

Same patient after plaster immobilization.

Bilateral CTEV

Bilateral CTEV with plaster immobilization.

Bilateral CTEV

Bilateral CTEV with plaster immobilization

Bilateral CTEV

Baby with Bilateral CTEV (A)

Bilateral CTEV with lt left sided CTEV

After plaster (B).

With clubfoot shoes (C).

Patient is in plantigrade position (D).

After treatment (C).

Bilateral clubfoot.

Varus, inversion, adduction is corrected but equinus is persisted (B).

During treatment with plaster cast (B).

Tenotomy is done ( C),

After Tenotomy full correction is achieved (D),

**PONSETI'S PRINCIPLES FOR CORRECTION OF RELAPSED OR UNCORRECTED CLUBFOOT WITH ILIZAROV:**

The treatment algorithm is decided by age, stiffness of the ankle and sphericity of the Talar dome. If the talar dome is significantly flattened and movement in the ankle joint is reduced, it is best achieve correction of the foot deformities by applying the Ilizarov fixator and performing a V osteotomy in the older children.

In older children or in those with very stiff feet, the Ilizarov device offers significant advantages due to modularity & flexibility in application.

For the forefoot to be able to abduct we need a counter pressure on the head of talus. A olive wire should be inserted through the lateral side of the talar head, and this is attached to the tibial ring with long dropped posts. On the medial side it is attached to a screw traction mechanism to pull the talus medially as well. This wire gives counter pressure on the talar head to allow the fore foot to abduct and the calcaneum be pushed in to abduction. Absence of this wire can cause posterior displacement of fibula, which is an iatrogenic deformity.

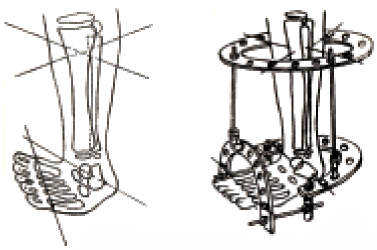


Figure-16.1: Schematic presentation of methods of application of Ilizarov apparatus. a. projection of introducing wires, b. assembly of Ilizarov apparatus

**Ilizarov VS Simpler Fixators:**

Simpler fixators offer no control over the talus at all. So it frequently leads to external rotation of the talus and pushing the lateral malleolus behind. The other disadvantage is the inability to offer constrained correction using hinges. The non constrained correction is also inadequate, as it is impossible to alter the direction of forces that are applied to various parts of the foot. Lastly lack of modularity of the JESS (Joshi External Stabilization System) & UMEX (Universal Mini External) fixators do not permit the correction of any complications if may arise. The budding Orthopaedic surgeon should not worried about the complexity of Ilizarov fixator and should try to master it as it gives total control and excellent results.

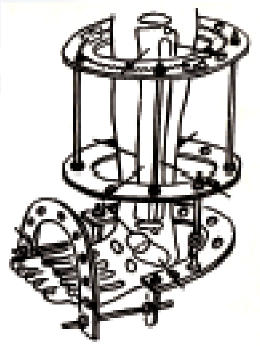


Figure-16.2: Scheme of position of Ilizarov apparatus in leg and foot.

**Complications:**

Wires in the calcaneum need careful insertion and tensioning as the hind foot is frequently osteoporotic. The hind foot fixation must be stable and be able to last the duration of the treatment. The correction is monitored carefully by taking frequent X-ray, which ensure that the cartilage is neither getting crushed nor the ankle is undergoing excessive distraction. The biggest risk is the anterior subluxaton or dislocation of the talus. Asymmetric distraction of the joint is also possible if the hinges are placed in accurately.

Modularity of the Ilizarov fixator permits us to have a kinesiological correction with fewer complications.

Figure 1a : Neglected bilateral clubfoot before treatment, (11 years old girl).

Figure 1b : Treatment with Ilizarov apparatus.

Figure 1c : After one year of treatment full correction is achieved.

Figure 3a : Bilateral clubfoot (1 year old girl) rigid variety.

Figure 3b : With Ilizarov apparatus.

Figure 2a : Neglected bilateral clubfoot (18 years old girl) before treatment (Front view and Back view).

Figure 3c : Full correction is achieved after 2 months.

Figure 2b : With Iliza rov apparatus.

Figure 2c : Full correction is achieved.

Figure 4a : 3 years old boy, relapsed right clubfoot after PMR (Front and back view)

Figure 4c : Pt. is in plantigrade position.

Figure 4b : 3 years old boy, relapsed right clubfoot after PMR (Front and back view)

Figure 5a : 7 months old Bilateral CTEV.

Figure 5b : With Ilizarov device.

Figure 5c : Full correction is achieved.

Figure 6a : 8 months old right CTEV.

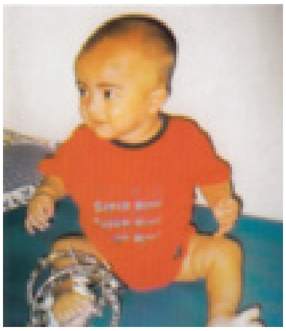


Figure 6b : With Ilizarov device.

Figure-7b: With Ilizarov device.

Figure-7c: Full correction is achieved

Figure 6c : Full correction is achieved.

Figure 8a : 3 years old boy with left CTEV.

Figure-7a: 1 year old boy with bilateral CTEV, rigid varuety.

Back view of rigid varuety.

Figure-8b: With Ilizarov device.

Figure-8c: Full correction is achieved.

Figure-9a: 5 years old boy with bilateral CTEV, ulcer right Dorsum of the foot; rigid variety.

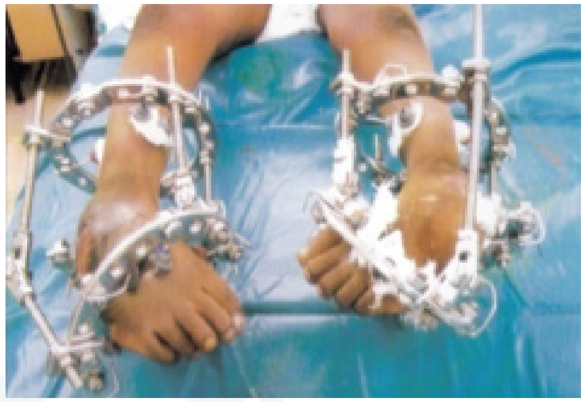


Figure 9b : With Ilizarov device.


Figure 9c: Full correction is achieved, ulcer is healed.

Figure 9d: Full correction is achieved, ulcer is healed.

Figure-1: Bilateral CTEV 1 month old baby.

Figure-2: Bilateral CTEV with plaster immobilization.

Figure-3: Same patient after 2 times cast immobilization.

Figure-4: After full correction with Ponseti technique.

Figure-5: Same patient after 5 years follow up

Figure-1: Bilateral CTEV 1 month old

Figure-2: Bilateral CTEV 1 month old with plaster immobilization

Figure-3: After removal of 1st cast

Figure-4: After removal of 2nd cast

Figure-5: After removal of 3rd cast

Figure-6: Follow up after 10 months

Figure-7: Follow up after 10 months

Figure-8: Final follow up after 2.5 years

Figure-1: Right sided CTEV
7 days old baby

Figure-2: 1st cast
immobilization

Figure-3: After removal of
the 1st cast

Figure-4: 2nd cast immobi-
lization

Figure-5: 4th cast immobi-
lization

Figure-6: With AFO, after 5
cast immobilization

Figure-1: Bilateral CTEV, 7 days old baby

Figure-2: After removal of 1st cast

Figure-3: After removal of 5th cast AFO in the both leg with Denis-Brownis brace

Figure-4: Follow up after 5 years (front & back view)

# Chapter 17

# Developmental dysplasia of hip (DDH)/Congenital Dislocation of Hip (CDH)

## CONGENITAL DISLOCATION OF HIP (CDH)

The new technique for treating congenital dislocation of hip in older children and teenagers is well established by Ilizarov technique.

Our approach permits us to achieve good locomotor furnction of the affected limb, eliminate shortening and the Trendelenburg sign and preserve some hip motion. We can gain our objective by doing one stage operation that entails minimal surgical intervention.

In principle, the proximal femoral reconstruction is designed to give support for the pelvis by placing the upper femur under the acetabulum- either within the acetabular notch or beneath the transverse part of the pubic bone.

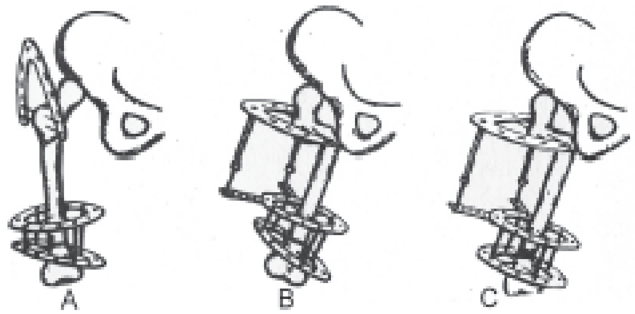



Figure-17.3: Scheme of operation by Ilizarov method with the fixation of proximal end of femur through parallel introducing wires.

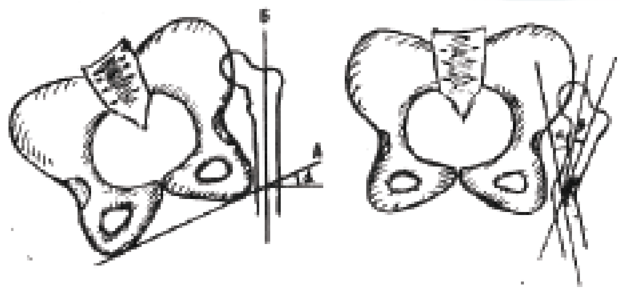


Figure-17.1: Scheme of detecting the angle in the sub-trochanteric region.

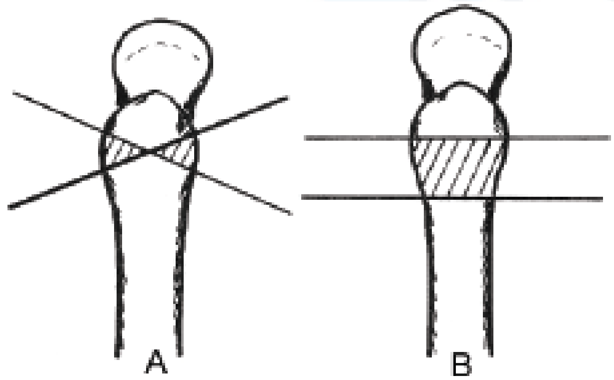



Figure-17.2: Scheme of introducing wires through proximal part of femur.

## Case Study 1

1. Radiograph of DDH of left side.
2. Radiograph of DDH of left side.
3. 7 years old girl marked LLD left side.
4. The patient in O.R.
5. Application on Ilizarov in the left hip for distraction of dislocated hip.
6. Patient is walking with Ilizarov apparatus.
7. Radiographic view of left dislocated hip which is already in the acetabulum after 3 months of disctraction
8. Close up view of the left hip and the Ilizarov apparatus.
9. Radiographic view of left hip after supraacetabular osteotomy.
10. No LLD anymore.

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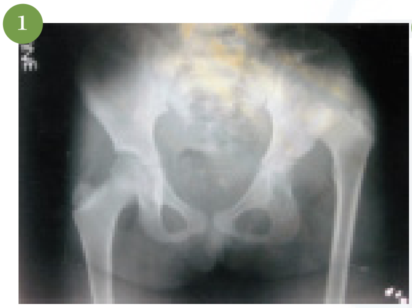
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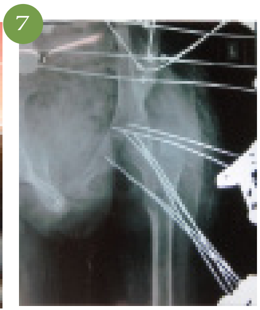
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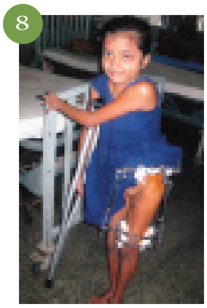
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11. Close up view of the apparatus.

12. Radiograph of left hip after 4 months follow up.

13. Close up view of the apparatus after 4 months follow up.

14 & 15. Back view of the left hip. 15. Patient is happy with the treatment . No LLD.

16. The author with the patient.

17. Radiographic result after supraacetabular osteotomy.

18. In O.R. for removal of the Ilizarov apparatus.

19. Radiographic final result after 1 year.

20. Clinical appearance of the patient after 1 year.

21. Clinical appearance of the patient after 1 year.

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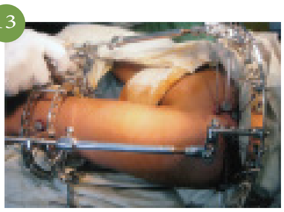

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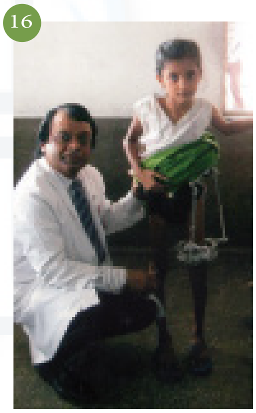

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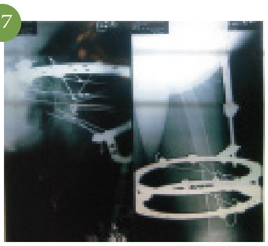

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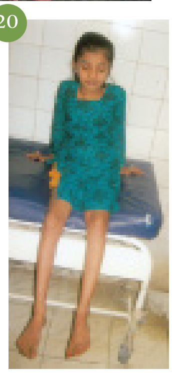

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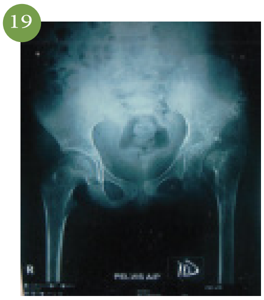
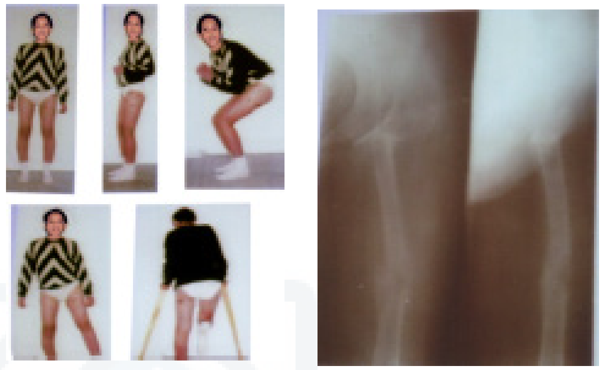


## Case Study 2

13 years old patient with high CDH Symtomatic hip & shortening



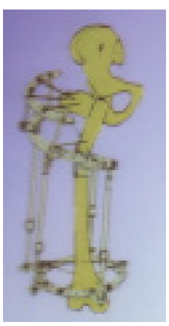
One month after frame removal

### Aim:

Present our experience in pelvie support osteotomy (PSO) procedure, highlighting indications, outcomes, details of the surgical technique and rehabilitation in patients with congenital high hip dislocation.

### Goal of treatment

1. Restoration or improvement of weight bearing function
2. Elimination of leg length discrepancy (LLD).
3. Increase of hip ROM
4. Gait improvement
5. Elimination of pain syndrome



### Method (technique):

- Application of Ilizarov frame
- 2-3 half-pin in proximal metaphysis.
- Olive wire and half-pin in diaphyseal part.
- 3-4 wires in distal metaphysis

Subtrochanteric osteotomy, acute creation of pelvic support joint in subacetabular area with angulation:

- Lateral up to 45
- Posterior up to 15
- Elimination of external rotation up to 200 in 10 patients.

Compactotomy of proximal/distal part of diaphysis is done for biomechanical axis and lengthening. Results: A summary of outcomes based on the four key goals of the procedure

| **Gait** | **Patient** |
|---|---|
| • Perfect gait | 2 |
| • Insignificant limping | 1 |
| • Significant limping | 0 |
| **Trendelenburg sign** | |
| • Absence of Trendelenburg sign | 2 |
| • Light Trendelenburg | 1 |
| • Same as before treatment | 0 |
| **Pain** | |
| • Absence of pain | 3 |
| • Same as before | 1 |
| • Increase in pain after treatment | 0 |
| **Rom** | |
| • Improvement in ROM | 3 |
| • ROM same as before treatment | 1 |
| • Decrease in ROM | 0 |

**Discussion and conclusion:** PSO is a valuable solution for treatment of CDH. Intensive physical therapy is an integral component of this procedure. Children and adolescents can expect better results. PSO may technically complicate THR in the future, however, none of our patients underwent THR after PSO.

## Case Study 3

1. AMC total body involvement, congenital dilocation of right hip
2. Prone position
3. Supine position (Hyper extension of the left knee).
4. Prone position
5. After the surgery and Ilizarov application patient can stand with plaster cast.
6. After surgery in the left knee (combination of soft tissue release and Ilizarov application), Right ankle gradual controlled coordinated stretching by Ilizarov.
7. View of the surgery in the left knee with Ilizarov in situ.

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8. Pelvic support osteotomy was done in the right hip, Ilizarov in the right hip and thigh.
9. Radiographic view of right disloacted hip.
10. Ilizarov in the right hip and thigh PSO (Pelvic support osteotomy) done.
11. Radiographic view of right hip, shaft of femur after PSO (Pelvic support osteotomy)
12-13. Radiograph of right and left knee, both tibia fibula, both ankle and foot.
14. Clinical picture of the smiling patient after 8 months follow up, correcting all the diformitis.
15. Clinical appearance of the patient in standing position.

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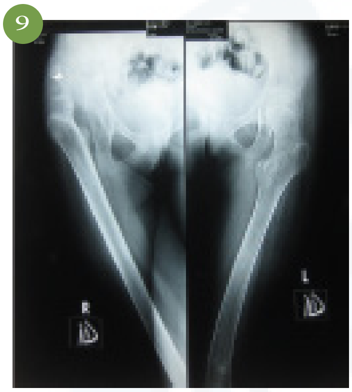

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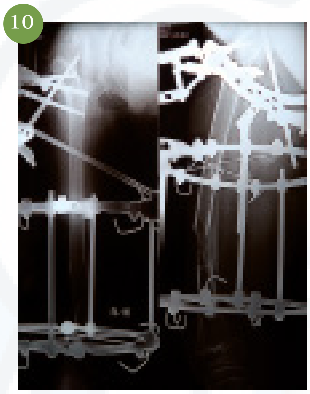

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## Case Study 4

**Bilateral Pes Plano Valgus, flexion contracture both knees with left sided CDH**

1. 12 years old girl with bilateral knee flexion contracture with bilateral pes plano valgus.
2. Correction of both knee flexion contracture with Ilizarov apparatus.
3. After 1 month follow up with Ilizarov apparatus.
4. Grice operation was done in both ankle (Extra articular arthrodesis).
5. Ilizarov in both knee and plaster immobilization in both ankle and foot.
6. Pelvic support osteotomy was done in the left hip.
7. Radiographic view of Pelvic support osteotomy.
8. Ilizarov removed and long leg plaster cast is applied.
9. Patient is walking with plaster cast. Since birth she could not stand & walk.
10. Anatomic situation, joint capsule dissected free. Joint exposed, groove for bone graft; graft inserted, optimal graft shape is visible.
11. Radiographic view of hip and shaft of the femur after pelvic support osteotomy (PSO).
12. Clinical appearance of patient after full correction, patient can stand and walk with KAFO.

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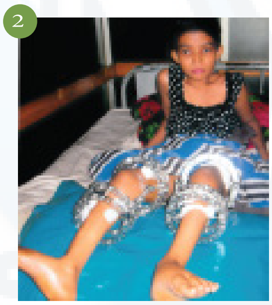
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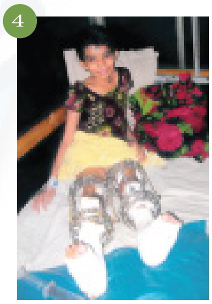
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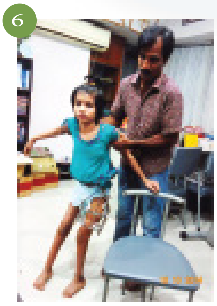
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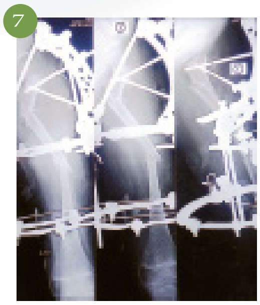
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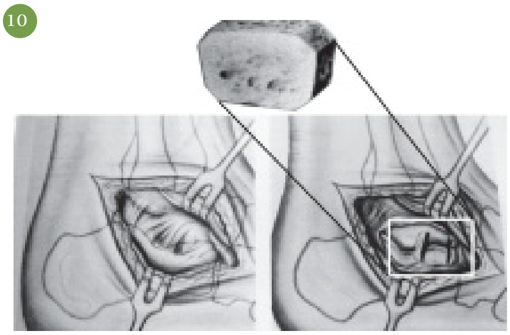
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# Chapter 18

# Slipped capital femoral epiphysis (SCFE)

## Introduction:

It is a rare condition 2 in 1 lac, is one of the most common types of paediatric and adolescent hip disorder.

## Incidence:

1. SCFE is more common in boyes (75%), with incedence occuring at 12 to 15 years compared with 10 to 13 years in girls.
2. Younger patients and those with endocrime or metabolic abnormalities are at much higher risk of bilateral involvement.

## Aetiology:

The head of the femur stays in the acetabulum and the neck slips forward and outward-

1. Increased weight (>80% centile),
2. Femoral retroversion (>10%),
3. Trauma
4. A more vertical slope of the physis
5. Increased physis height due to widened hypertrophic zone,

## Weakness of the physis may be due to-

1. Renal failure osteodystrophy (95% bilateral),
2. Endocrine disorders (65% bilateral)
   a) Growth hormone deficiency
   b) Growth hormone excess
   c) Hypothyroidism (usually SCFE is the first presenting feature)
   d) Panhypopituitarism
   e) Craniopharyngioma
   f) Hypogonadism
   g) Hyperparathyroidism
   h) Mulple endocrime neoplasias
   i) Turner's syndrome

## Clinical features:

1. Classical feature is an overweight child who has poorly localized groin, thigh or knee pain and is limping.
2. History of minor truma
3. Age in between 11 to 14 years
4. With a stable slip, a child is able to bear weight with or without crutches
5. With an unstable slip a child has severe pain, walking is not possible even with crutches
6. On examination, the leg is shortened and externally rotated
7. Flexion, abduction and internal rotation of the hip is affected

## Case Study 1

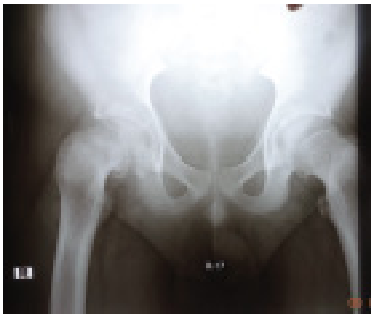


Figure-1: Bilateral SCFE

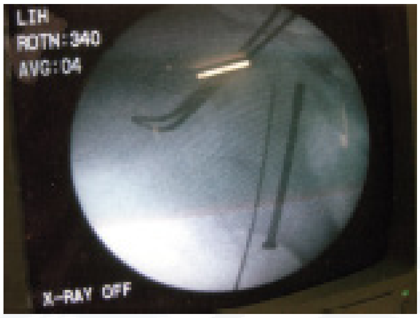



Figure-2: During surgery in the right hip under C-arm controle

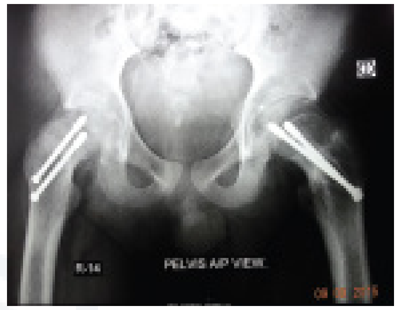



Figure-3: Fixation in situ in both sides

Figure-4: Radiographic view after removal of the screws

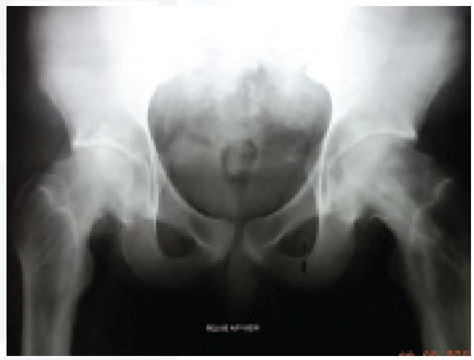


Figure-5: Radiographic ÿnal follow after 1 year


Figure-6: Clinical appearance of the patient after 1 year

Figure-7: After 15 months follow up

# Chapter 19
# Coxa Vara

## COXA VARA (CV)

Coxa Vara is a proximal femoral varus deformity in which there is a reduction in the neck shaft angle (NSA <110o).


Pelvis x-ray of a limping child with Coxa Vara

It is a wide spectrum of different types, pathologies, aetiologies and natural history. There are 3 types of Coxa Vara.

### 1. Congenital Coxa Vara (CCV)-

It is caused by a primary cartilagenous defect in the femoral neck. Congenital Coxa Vara presents at birth but it manifests clinically during early childhood and very progressive with growth. Moreover it is associated with a LLD (Leg length discrepancy), congenital short femur, proximal focal femoral deficiency (PFFD) and congenital bowed femur.

### 2. Developmental Coxa Vara (DCV)-

It is seen in early childhood. There are radiographic changes in the anterior and posterior bony metaphyseal fragments and no other skeletal manifestations.

### 3. Acquired Coxa Vara (ACV)

a. The sequelae of AVN of femoral epiphysis due to:

- i. Legg-Calvé- Perthes disease
- ii. Trauma
- iii. Femoral neck fracture
- iv. Traumatic hip dislocation
- v. DDH (Post-reduction)
- vi. Septic arthritis

b. Slipped upper femoral epiphysis

c. Coxa Vara with pathological bone disorders

- i. Fibrous dysplasia
- ii. Osteogenesis imperfecta
- iii. Renal osteodystrophy
- iv. Osteopetrosis

**Table-I**
**Different Types of Coxa Vara**

| | CCV (Con-genital Coxa Vara) | DCV Developmental Coxa Vara | ACV Acquired Coxa Vara |
|---|---|---|---|
| Location | Sub-trochanteric | Physics | Any (epiphysics, metaphysics, Sub-trochanteric |
| Onset Age | Birth | Walking age to 7 years | usually older than CCV and DCV |
| Cause | Embryonic limb bud abnormality | Primary ossification defect in inferior femoral neck | Vascular insult sepsis, AVN, fracture |
| Presenting features | Unilateral short and deformed leg | Limping Trendelenburg gait (unilateral) or waddling (bilateral) LLD (2-3 cm) | Presenting features of cause |
| X-ray findings | Features of PFFD | NSA-decreased vertical physis decreased anteversion | Features of Coxa Vara |
| Natural anamnesis | Progression | Progression if HEA>60o Hilgenreiner's epiphyseal angle | Progression if the physis or epiphysis is involved. Fractures may remodel, varus deformity may resolve |

**Presentation:**
**Developmental Coxa Vara (DCV)**

Age of presentation is usually in the first 4-5 years of life. There may be pelvic tilt secondary to LLD and there is usually a positive Trendelenburg test.

3 Very important measures in x-ray identifies the Coxa Vara.

1. NSA- neck shaft angle
2. HEA- hilgenreiner's epiphyseal angle
3. ATD- articulo-trochanteric distence

A Decreased ATD indicates- Pathology in the physis or intertrochanteric area, normal ATD suggests that it is in the sub-trochanteric region.

**Treatment:**

Treatment of congenital Coxa Vara for acquired case is directed at the cause. Anatomical correction is mandatory.

Hilgenreiner epiphyseal angle is very important for surgical decision making. The average normal value is 20$^o$.

- HEA <45$^o$ usually improves without intervention.
- HEA >60$^o$ usually worsens if left untreated and is an absolute indication for surgery.
- HEA, if 45$^o$-60$^o$ – it needs observation for either healing or progression. Surgical intervention is needed if progressive.

**Our goals are:**

1. NSA should be 140$^o$ and HEA to less than 35$^o$-40$^o$.
2. Correction of femoral version to normal values (usually we see retroversion).
3. Healing of defective inferomedial femoral neck fragment.
4. ATD- Articulo trochanteric distance restoration.
5. Adductor tenotomy to resolve deforming force.

**Our objectives are:**

1. Correction of NSA that allows normalization of femoral head and acetabulum.
2. Restoration of normal position of femoral head within the acetabulum.
3. Gradual controlled coordinated lengthening of the gluteus medius and abductors, which are often shortened by 3-6 cm. Acute lengthening in such cases may cause excessive pressure on the articular cartilage of the hip, leading to osteoaorthrosis of hip.
4. Creation of enough leverage to increase the efficiency of gluteus minimus and gluteus medius, which eliminates the Trendelenburg sign. To fulfill this goal, the greater trochanter should be placed so that the distance from its tip to a vertical line runs through the femoral head equals that on the normal side.
5. Elimination of LLD and any knee deformity in the frontal plane.

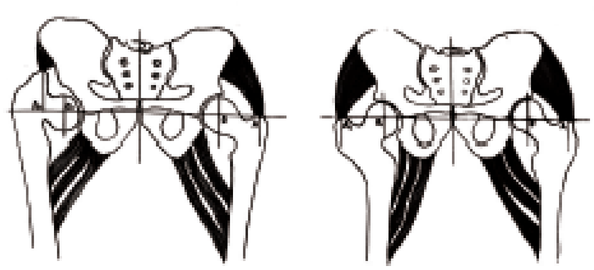


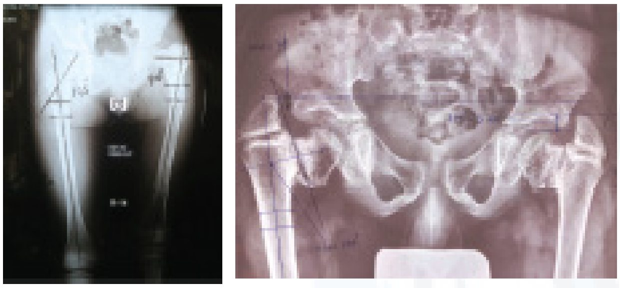
**Figure-19.1:** Principles for normalizing the femoral neck shaft angle with this Ilizarov technique.

We can correct femoral neck varus deformity. In all cases, reconstruction of the femoral neck is done after a hinge osteotomy in the sagittal or frontal plane.

### Mild, Moderate Coxa Vara and Coxa Vara with femoral shortening:

In mild Coxa Vara with slight shortening of the soft tissues, the correction can be done acutely, after osteotomy.

If a Coxa Vara is combined with considerable femoral shortening and a knee deformity in the frontal plane, we correct the shortening and knee deformity simultaneously and femur can be lengthened at one level or at two levels.



Strategy for overcoming Coxa Vara combined with marked femoral shortening.

To overcome both problems, we performed a sub trochanteric osteotomy with acute turning of the proximal arch as well as a corticotomy of the middle third of the femur. Distraction lasted 28 days. Fixation continued for 2 months (60 days), when we saw adequate good bone regeneration, and consolidation we dismounted the whole frame-

At 7 months follow up, function of the hip joint and limb length were restored.

LLD, femoral retroversion or trochanteric overgrowth can be corrected simultaneously by this wonderful Ilizarov technique.

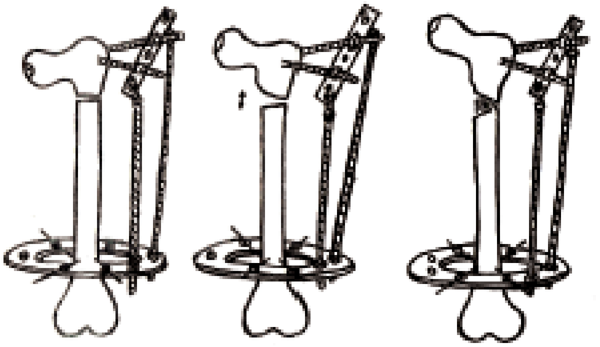


Figure- 19.2: Schematic presentation of operative treatment of varus deformity of femoral neck.

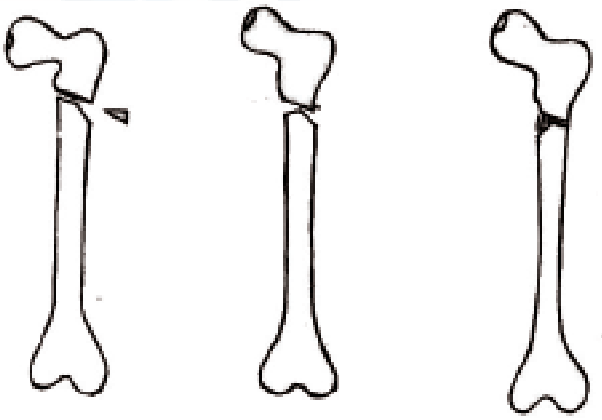


Figure- 19.3: Scheme of femoral wedge osteotomy (a,b,c) a. wedge osteotomy, b. stage of correction, c. results of triangle regenerate.

## Case Study 1

### Left Coxa Vara

**Figure-1:** Left hip coxa-vara 2cm shortening of 7 years old boy (front & back view)

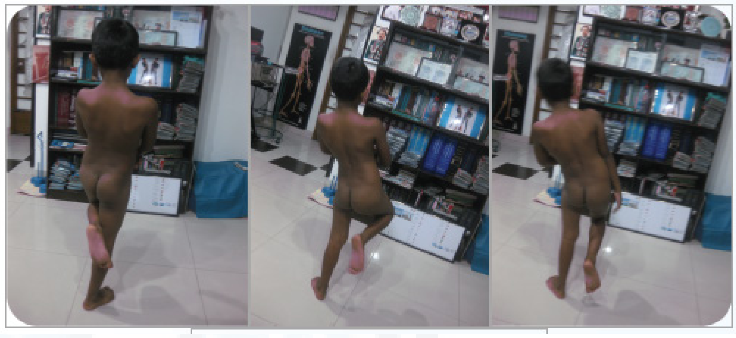


**Figure-2:** Trendelenburg sign positive.

**Figure-3:** Radiographic view before surgery

**Figure-4:** After surgery with Ilizarov apparatus

**Figure-5:** Radiographic view of left hip and thigh with Ilizarov

**Figure-6:** Trendelenburg sign negative.

**Figure-7:** Corrected coxa-vara and lengthing is achieved.

## Case Study 2

### Right Coxa Vara

1. Radiographic view of right coxa vara.
2. Radiographic view of pelvis including hip, right coxa vara.
3. Subtrochanteric close wedge osteotomy was done and Ilizarov frame was applied, 2nd post op.
4. Radiographic view of right hip with Ilizarov in situ, after 1 month follow up.
5. After 2 months follow up
6. After 21/2 months follow up
7. Smiling boy with Ilizarov apparatus in the right hip after 2 and 1/2 months follow up.
8. Radiographic view of the right hip after 3 months follow up.
9. External close up view of the Ilizarov apparatus in the right hip.
10. Raiographic final result after removal of the apparatus. Clinical appearance of the patient after 5 months.
11. Clinical appearance of the patient.

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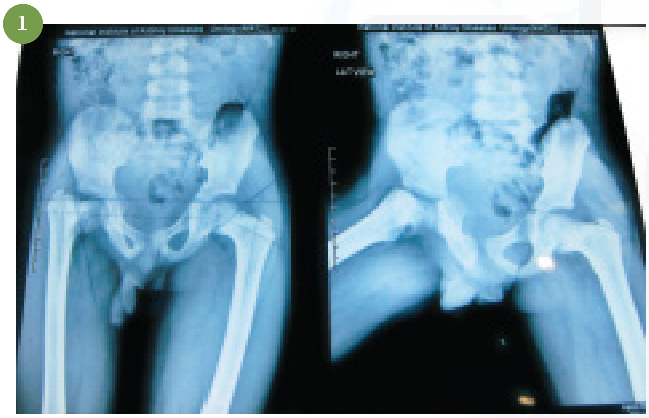

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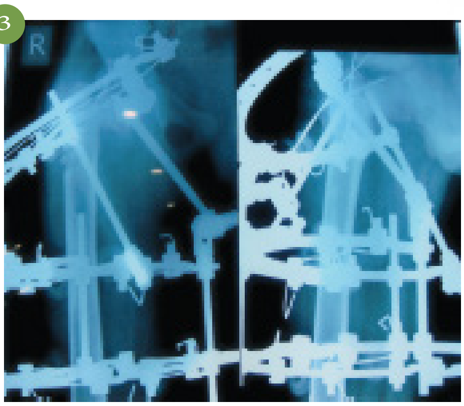


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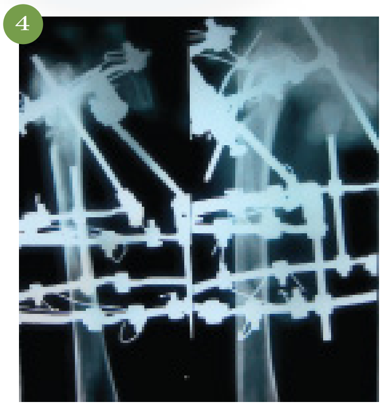

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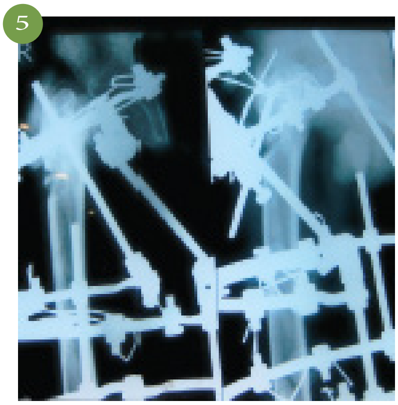

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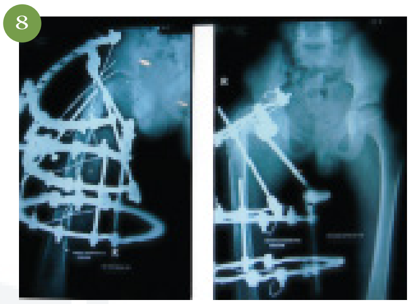

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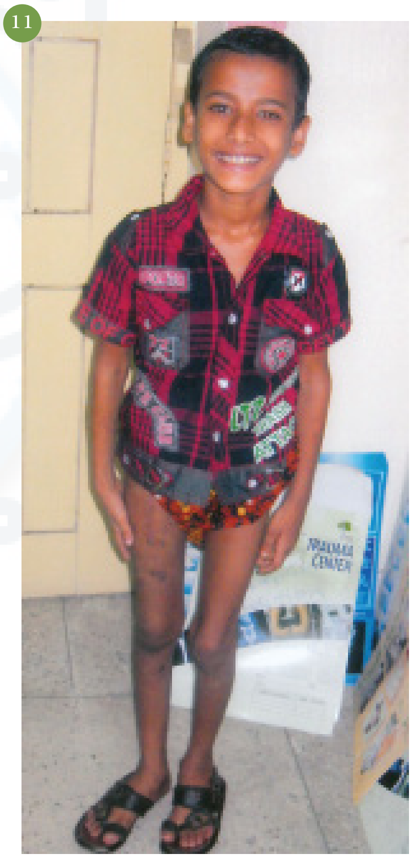


# Chapter 20
# Club Hand

## CLUB HAND (RADIAL LONGITUDINAL DEFICIENCY):

Radial longitudinal deficiencies consist of a spectrum of abnormalities that are characterized by deficiency of the radius and radiocarpal structures. Skeletal hypoplasia can occur in the whole arm, including the humeral and ulnar elements, a characteristic radial deviation of the wrist secondary to reduced radial support for the carpus is observed.

## ANAMNESIS AND EXAMINATION:

Children with radial longitudinal deficiencies should be managed by a multidisciprinary team involving paediatricians and physiotherapists. Blood testing, echocardiography, renal ultrasound and genetic screening are also mandatory. We must examine to assess should, elbow and hand function.

Careful examination of the elbow is required, as severe forms of radial deficiencies are associated with poor elbow function.

Flexion contractures of the index and middle fingers is observed in association with thumb hypoplasia or aplasia in up to 60% of patients with total radial absence.

Careful examination of index finger movement and function is required, as a stiff and ignored index finger will not make a good pollicized thumb.

We must do the x-ray which should be bilateral including the digits, hands, wrists and forearms (including the elbow).

Acceptable **Baynes classification** is based on x-ray findings:

Type-I: Short distal radius (>2mm shorter than ulna with normal proximal radius).

Type-II: Hypoplastic distal and proximal radius.

Type-III: Partial absence of radius.

Type-IV: Complete absence of radius.

It is important to note that fibrocartilaginous radial ruminant or anlage may be seen during surgery.

### Treatment option:

1. Treatment is based on the severity of deformity, although functional impairment, secondary to forearm length, wrist instability and thumb hypoplasia, is the main indication for the treatment.
2. In type 1 and 2 stretching and splintage is necessary. Severe type 2 deficiencies require soft tissue release or tendon transfer.
3. In type 3 and 4 with wrist instabilty and severe radial deviation, soft-tissue distraction by Ilizarov technique and surgical realignment of carpus on the ulna is useually required.

**Distraction by Ilizarov technique offers** both osseous realignment, making wrist stabilization easier, and soft-tissue lengthening, thus reducing the requirement for local skin flaps to cover radial shortages and reducing the need for tendon lengthening procedures. Tendon transfer and rebalancing is still required to help maintaing the carpus in its new position.

Once we have distracted by Ilizarov technique adequately, the realignment procedure can be done by-

1. Centralization:

With the carpus repositioned over the ulna (usually by making a notch in the carpus) and stabilized with mini Ilizarov fixation through the third metacarpal.

2. Radilization:

Wth the scaphoid placed over the ulnar head and secured through the second metacarpal.

Radialization is preferred as the risk of physeal injury is low, thus maximizing potential longitudinal growth.

Pollicization to reconstruct an absent or hypoplastic thumb is then taken in to consideration.

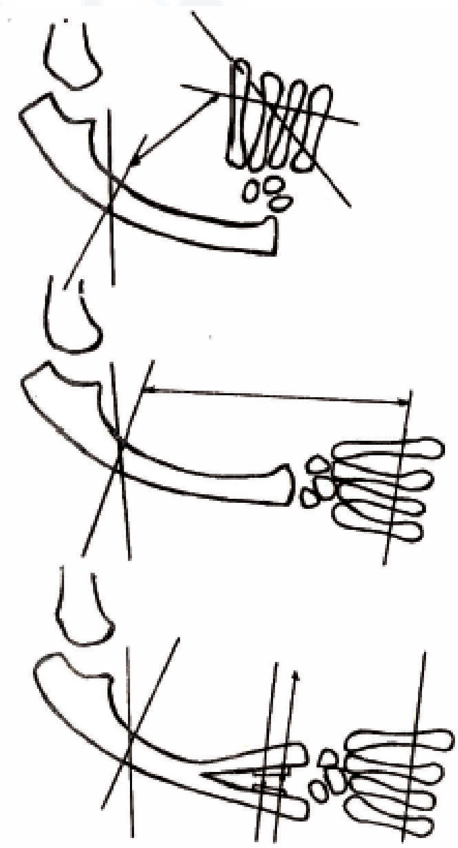


Figure-20.1: Schematic presentation of opervative method in congenetal radial club hand in absence or sub-total defects of radial bone.

## Case Study 1

Figure-1: Right radial club hand type-IV

Figure-2: Before surgery right radial club hand type-IV


Figure-3: Radiographic view right radial club hand

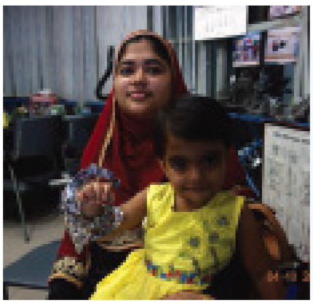


Figure-4: Correction of the deformity with Ilizarov apparatus

Figure-5: Radiographic view of right radial club hand with Ilizarov in situ

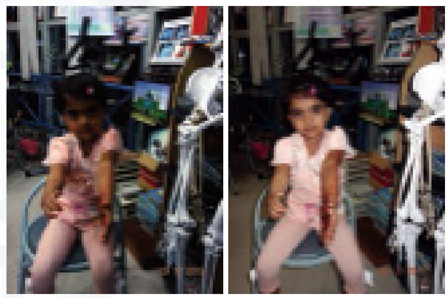


Figure-6: After removal of the Ilizarov apparatus, almost corrected bowing ulna and wrist

Figure-7: Radiographic view of corrected ulna and wrist

Figure-8: nal clinical appearance of the patient.

# Chapter 21

# AMC (ARTHROGRYPOSIS MULTIPLEX CONGENITA)

## AMC (ARTHROGRYPOSIS MULTIPLEX CONGENITA)

Arthrogryposis – The term
Gr. Arthro – Joint and
Grypos – Curved
Osis – Condition, was introduced by Stern in 1928.

Arthrogryposis is a broad term used to describe in which children are born with multiple non progressive soft tissue contractures and restriction of joint movement.

The most common form of - AMC (now a days known as amyoplasia) – all joints of the upper and lower limbs are involved. The incidence is 1 in 3000 live births. Deformities and contractures develop in utero and remain largely unchanged throughout life.

### CLASSIFICATION:

### 3 major categories:

1. Total body involvement – That is AMC and now amyoplasia;
2. Predominantly hand or foot involvement and that is called distal arthrogryposis. There is the Freeman-Sheldon syndrome in which we can see abnormal facial features (whistling face syndrome);
3. Pterygia syndrome: It is characterized by

arthrogrypotic joint contractures with identifiable soft tissue webs, usually across the flexor aspects of the knees and ankles.

### Aetiology and Pathogenesis:

The typical inward rotation of the upper extremities and outward rotation of the lower extremities in arthrogryposis and the described deformities of the bones and feel with semiextension at the knee and elbow joints are all characteristic of the position of the embryo between the sixth and tenth week of its development. Disturbances in this period of embrogenesis, with retardation and distortion of the development, apparently lead to the anomaly discussed. In this connection the mechanical factors linked with an incorrect position of the foetus and abnormal delivery which are written in the literature as causes of arthrogryposis are simply a sequel to the foetus abnormal position and its restricted movement in the uterus.

Mothers who give birth to infants with arthrogryposis usually feel very bad during the second half of pregnancy.

From postmortem examination of a six month old infant with arthrogryposis who had died from pneumonia, Kazantseva (from USSR) in 1950 found that the muscles of the extremities were developed but were marked by diffuse atrophy and the muscle fibres were in various stages of degeneration.

Author study at turner children's orthopaedic institute in Saint-Petersburg of the excitability of muscles in patients with arthrogryposis has shown that in addition to its total loss in the muscles about the affected joint, there is prolonged chronaxia in the muscles around non affected joints, which is consequently indirect evidence of changes in the central nervous system.

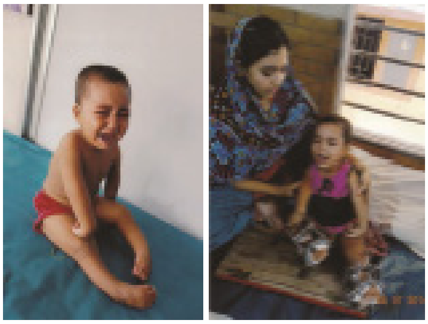
**Clinical features:**

1. Arthrogryposis patient is quite typical. There are contractures of the large joints of the upper and lower extremities, club-foot and club-hand, muscles wastings with incomplete development of nerves of the limbs.
2. Hip movements are restricted and the things are rather drawn to the abdomen and can not be fully extended. Unilateral as bilateral congenital dislocation of the hip is a frequent occurrence. The thighs are rotated outward.
3. The knee joints have effaced contours and full extension and flexion are impossible.
4. Equinovarus deformity is pronounced and severe contracture in the ankle joint resistance to one stage surgery.
5. The upper extremities are rotated inward, the contours of the elbow joints are effaced and the limbs can be neither fully flexed nor fully extended at these joints.
6. The shoulder girdle is deficiently developed.
7. Severe flexion contractures are seen in the wrist.
8. The hands are in plantar flexion and abducted or adducted.
9. Raising of the arm, flexion at the elbow and rotation at the shoulder and elbow joints are impossible which hampers the use of the hands even though their grasping power is preserved;

when the hand is in a fixed position of extreme flexion, active flexion and extension of the fingers are preserved.

10. The leg and arm segments lack normal rounded contours because of the deficient development of the muscles (gastrocnemius and biceps brachii) and appear atropied.

a



b

Arthrogryposis in a 14 months old child (a) and 2 years old child (b)

Their exceptional adaptability and great striving for normal activity are amazing.

**Treatment modality:**

Since the disease of arthrogryposis is complicated it needs long term treatment and follow up. All the main principles of childhood orthopaedics should be strictly, muticulously and methodically followed with regards to these patients.

Treatment should be started from birth and as soon as diagnosis is established. Treatment involves long term persistant use of conservative measures.

The effectiveness of treatment of the contractures depends on when it begins.

Passive corrective exercises from birth is the main method for combating contractures. On the 1st week of the infants life it is advisable to being applying a series of plaster cast for correcting the flexion contractures at the knees with simultaneous correction of the club-foot using the same bandage (Plaster cast extending from the toes to the upper 1/3rd of the thigh, they are changed at 7 days internal).

Contractures at the knee can be corrected conservatively; (it is easier to achieve flexion, than extension). When these measures fails, then supracondylar osteotomy of the femur is performed at the age of 5 or 6; or we can correct those contractures by applying Ilizarov technique (gradual controlled coordinated stretching by Ilizarov. Sometimes with the release of soft tissue in combination with Ilizarov).

The treatment of club-foot in arthrogrypotic patient is very difficult. Being in essence a stable contracture with fixation of large joints, club-foot is very resistant to treatment with a series of plaster bandages. In many cases we treated the club at the age of 1 by Ilizarov technique.

The treatment of deformities in the upper extremities is more difficult. Proper physiotherapy, which make it easier for the child to use the hands later for eating and taking case of himself. Early manipulation in the elbow and fixation of the achieved flexion with a plaster bandages are recommended. Treatment of arthrogryposis associated with congenital dislocation of the hip is most difficult; open reduction leads to some stiffness of the hip joint, it gives the extremity, a functional favourable position.


Baby with Ilizarov.

Treatment is always continued over a long period of time; nevertheless, if it is started from the first month of life and continued systematically, definite success can be achieved and the patient can made quite fit for work; the results of treatment in arthrogryposis are not at all rewarding all the time. The aim and objective of treatment is defeated if a patient can not be made to stand or work and do his or her usual work. In our 36 series of patients for the last 25 years of treatment 75% patients with lower extremity reveals a not too gloomy picture, where 65% walked without braces.

## Case Study 1

1. AMC total body involvement
2. Prone position
3. Supine position (Hyper extension of the knee).
4. Prone position
5. After athe surgery and Ilizarov application patient can stand with plaster cast.
6. After surgery in the left knee (combination of soft tissue release and Ilizarov application), Right ankle gradual controlled coordinated stretching by Ilizarov.
7. View of the surgery in the left knee with Ilizarov in situ.

8. & 9. Radiograph of right and left knee, both tibia fibula, both ankle and foot.

10. & 11. Clinical picture of the smiling patient after 8 months follow up.

## Case Study 2

1. Bilateral Pterygium of knees
2. Soft tissue release with application of Ilizarov
3. 4 years old girl with Ilizarov for correcting the bilateral plerygium of knees
4. After 2 months follow up
5. After removal of the Ilizarov fixator and Plaster Immobilization
6. After removal of the Ilizarov fixator and Plaster Immobilization (lateral view)
7. After 4 months follow up, almost corrected the bilateral pterygium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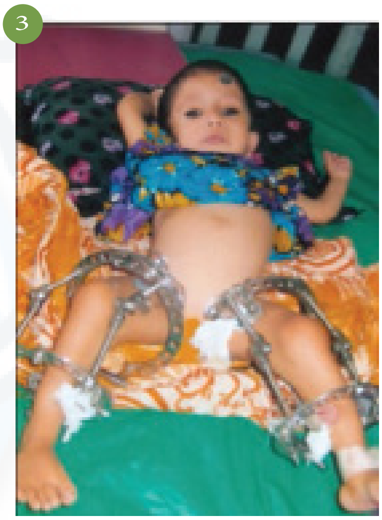
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## Case Study 3

1. 5 years old girl with bilateral pterygium of knees.
2. Radiograph of the same patient before surgery
3. Radiograph of the same patient before surgery
4. After the application of Ilizarov apparatus and combination of soft tissue release in both knee simultaneously in the same sitting.
5. Baby with the Ilizarov apparatus in the mother's lap.
6. After the removal of the apparatus, almost corrected deformities of the knee, 5 months follow up.
7. Patient with the support of KAFO

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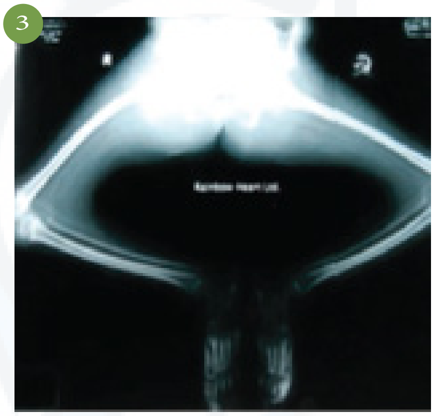

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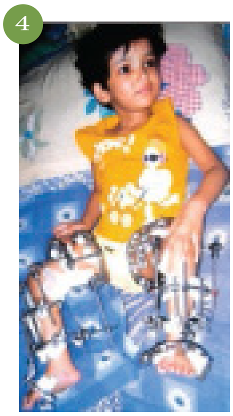

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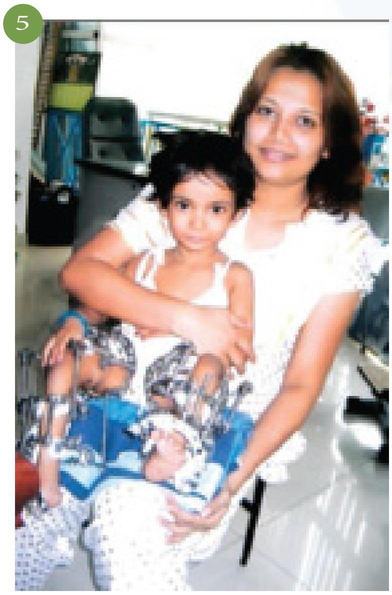

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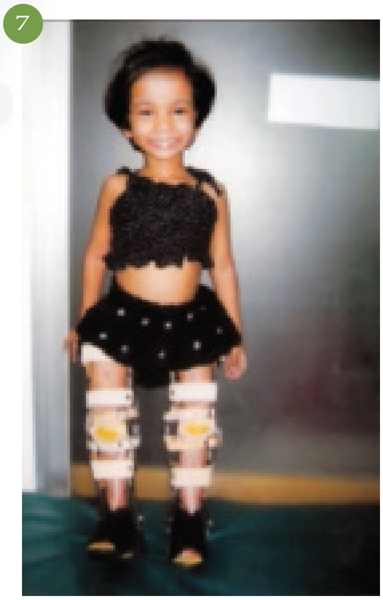


## Case Study 4

**Pterygium – right knee, 15 yrs. old boy**

1. Pterygium right knee with gross LLD (3cm in femur and 5cm in tibia fibula)
2. Close up view of the right knee with webbing
3. Patient is in sitting before treatment
4. Combination of soft tissue release and Ilizarov fixator in the thigh and leg with hinges
5. After 1 month follow up
6. Radiographic view of the rt. femur knee & tibia
7. Radiographic view of right knee with FFD
8. Radiographic view of the right knee with Ilizarov in situ hinges are visible
9. Gradual correction of the right knee flexion with Ilizarov apparatus
10. Almost corrected pterygium of the right knee and LLD
11. Clinical appearance of the patient after 11 months follow up (front view)
12. Back view of the right knee

# Case Study 5

## Arthrogryposis

1. Clinical photograph of 8 years old girl, AMC, bilateral knee flexion contracture with bilateral equinovarus deformity.

2 & 3. Front and back biew of the patint.

4. After the application of Ilizarov in the right knee, leg and foot in OR.

5 & 6. Ilizarov in both inferior extremity.

7. After the removal of Ilizarov apparatus, 4 months follow up.

8. Patient is walking with KAFO in the left side.

9. Walking with the help of axillary crutches

# Chapter 22
# SYSTEMIC DISEASES OF THE SKELETON

## SYSTEMIC DISEASES OF THE SKELETON:

Systemic skeletal disease are mainly congenital. They are included in the common term "systemic dysplasia" where anomalous shaping of tissues are seen in bone and cartilage. Some dysplasias are associated with deficient osteogenesis of the whole skeleton (osteogenesis imperfecta, chondrodystrophy), others with the development of thickened bones (marble bones or osteopetrosis and melorheostosis etc), others still with the presence of non-calcified or anomalously developing foci of embryonal-like bone in the skeleton (dyschondroplasia or Ollier's disease, fibrous osteodysplasia).

### 01. CONGENITAL BRITTLENESS OF BONE (OSTEOGENESIS IMPERFECTA)

It is a disease of the whole organism with predominant involvement of the bone tissue. Individual forms are clinically manifested by frequent fractures, others by gross deformities of the long tubular bones without apparent fractures. It was first described by Dr. Lobstein in 1825. In 1845 Dr. Vrolic described intrauterine congenital bone brittleness which he called osteogenesis imperfecta.

At present two forms are distinguished:

1. Osteogenesis imperfecta congenita with the features occurring in intra-uterine life
2. Osteogenesis imperfecta tarda, a delayed form, in which the fractures and deformities occur after birth. The two forms differ not in essence but in the intensity of the pathological changes. It is noted that the earlier the disease is manifested, the more severe its course.

**Aetiology and pathogenesis:**

1. Some authors link it with the disturbances in the CNS, the evidence of which is associated involvement of the bone and muscular system.
2. 2nd group attribute it to disorders in the endocrine system, which is confirmed by the fractures being healed or number diminished by their time of sexual maturity and
3. A 3rd group of authors connect the disease with disturbances in phosphorus-calcium metabolism and irregular distribution of these substances and
4. A 4th group with a developmental anomaly of the bone system (deficiency of osteoblasts, dysplasia of the periosteum) advocates this.

**Clinical features:**

The diaphyses of femur, tibia, radius and ulna and humerus are affected most frequently. Fractures occur from the slightest causes, e.g when the infant is being swaddled or dressed, when he is playing etc. A peculiarity of the fracture is absence of vertical displacement of the fragments in spite of marked angulation, and rapid healing. Numerous fractures occurring one after another in the same limb when proper immobilization is not applied in time lead to its considerable shortening and deformity.

Osteogenesis imperfecta.

The following triad is typical of the disease:

a. brittleness of bones
b. blue colored sclera and
c. deafness

that develops by the age of 20 or 30 due to progressing otosclerosis. Besides that, there are also atrophy of the muscles, and small crumbling, amber coloured teeth; all these are signs of mesenchymal deficiency. There are usually no changes in the internal organs. Marked disturbances in phosphorus-calcium metabolism are not encountered.

**Classification of Sillence:**

Best known, which divides patient into 4 groups based on clinical features.

| Type | Sub Type | Teeth | Sclerae | Clinical Features | Prognesis |
|---|---|---|---|---|---|
| I | IA | Normal | Blue | Autosomal Dominantform, Less Severe Fragility Fracture, Short Stature | Normal Life Expectancy |
| | IB | Dentinogenesis, Imperfecta | Blue | Less Severe, Fragility, Fracture, Short Stature | Normal Life Expectancy |
| II | II | Normal | Blue | Autosomal Recessive, Autosomal Dominant, Progressive Deformity | Perinatal, or Early Infant Death |
| III | III | Dentinogenesis Imperfecta | Bluish at Birth, White by Puberty | Autosomal Recessive, Autosomal Dominant, Progressivey Deformity | Will Usually Require Wheel Chair, Premature Death |
| IV | IVA | Normal | White | Autosomal Dominant Moderate Deformity of Long Bones; Kyphoscoliosis | Fair |
| | IVB | Dentinogenesis Imperfecta | White | Fragility Fracture, Short Stature, Moderate Deformity of Long Bones, Kyphoscoliosis | Fair |

It has been established that with the sexual maturity the fractures in some cases occur less frequently or cease completely.

The congenital form may be marked by severely impaired physical development of the children with considerable retardation in body weight and height. Some children do not survive; they die from a concomitant infection in the first 3 or 4 years of life.

X-rays findings:

1. This is characterized by abnormal translucency of the bone tissue (particularly in the diaphysis of long tubular bones).
2. The bone trabeculae are thin and rarely spaced; in the trabecular pattern of the bone disappears.
3. The cortex is thin.
4. The spongy bone has a honey-combed structure.
5. The epiphysis appear thickened as compared to the thinned diaphysis.

Figure- 22.1: X-ray showing multiple fracture of the femur in a child with osteogenesis imperfecta.

**Differential diagnosis:**

Clinical picture and x-ray findings in osteogenesis imperfecta usually so typical that differential diagnosis is not difficult.

**Treatment modality:**

Biphosphonates are the mainstay of medical therapy. These drugs inhibit osteoclastic resorption of bone, increases bone mass. They reduce bone turnover rates and increase the bone mineral density. It improves muscle straight, mobility and give a sense of well-being. They are very effective when used in the children under the age of 3 years. The most common regime reported is 3 monthly cycles of intravenous Pamidronate. For each cycle of biphosphonate therapy, a classic transverse line of selerosis is seen in x-ray, allowing monitoring of growth between cycles.

All attempts to treat osteogenesis imperfecta constantly proved unsuccessful. In some cases the deformities are corrected by various operations like osteoclasis wedge osteotomy and segmental osteotomy. Intraosseous metal pin fixation holds the segments in the corrected and closely aligned position. In severe deformity cases, Ilizarov fixator can be used to correct the multi-apical deformity in older child. Surgical intervention for deformity correction does not exclude conservative measures like massage, carefully performed exercises.

Orthopaedic braces with an ischial abutment and rigid attachment with a belt are worn in the post-operative period for preventing fractures. Thus by combining external braces with internal metal pin the patient can be brought to the period of sexual maturity when the pathological process terminates without causing severe deformities.

Much attention should be attached to the orthopaedic prophyolaxis of deformities of the long tubular bones following their fractures.

**Conclusion:**

Prognosis in congenital osteogenesis imperfecta is poor; functional prognosis in the delayed form should be carefully considered. Frequent fracture which are inadequately immobilized, though healing rapidly, may lead to secondary shortening and distortion of the extremities.

**02. CONGENITAL CHONDRODYSTROPHY (ACHONDROPLASIA)**

Chondrodystrophy belongs to the group of developmental anomalies of the embryonal chondroblast system and is a systemic disease mainly affecting the bones of the extremities and base of the skull i.e. bones of primary ossification. It was also described under the names of achondroplasia, nanismus chondrodystrophicus, micromelia, chondrodystrophia foetalis and parrot-Marie disease. Parrot described the disease in 1976 and Marie in 1900.

Chondrodystrophy is characterized by dwarfism and disproportionate growth, shortening of the limbs, mainly the proximal segment, in normal growth of the spine. The aetiology of the disease is still unknown. Chondrodystrophy is in essence abnormal enchondral development of the bone skeleton, i.e. one of the types of deficient chondrogenesis. Only the bones of secondary ossification are affected. The flat bones forming the vault of the skull and clavicle, being bones which undergo connective tissue calcification, are usually not affected. As a result of abnormal irregular arrangement of the cells of the growth cartilage normal ossification is already disturbed in the period of blastogenesis (on the 3rd or 4th week of embryonal development) and the growth of bones in length is retarded. Periosteal and endosteal ossification is not impaired in chondrodystrophy as distinct from osteogenesis imperfecta.

**Clinical features:**

Achondroplasia has a typical clinical picture since, it is linked with abnormal, suppressed enchondral ossification and retarded and distorted epiphyseal growth shortening of the limbs is the main clinical symptom. The upper limbs hardly reach the navel in a newborn child and groin in the adult. The limb shortening is a rhizomelic character (rhizus-root melos-limb) i.e. the proximal segments (the arm and thigh) are more shortened as compared to the distal (forearm and leg).

The manifestation of the disease on the limbs is not confined to a simple shortening. Owing to distorted and delayed epiphyseal growth but normal periosteal growth all the tubular bones are thickened and bent, and the protruding aprophyses (sites of muscle attachment) make them uneven. Abnormal and uneven growth along the surface of the epiphyseal growth plate distorts the epiphyses, leading to varus and valgus deformities.

Coxa Vara causes secondary inclination of the pelvis and sacrum and marked lordosis. The distal 1/3rd of both femurs has a “riding breeches” deformity and is slightly twisted inward. The trunk is normal in size but the spine lacks the normal curvatures and a flat back is encountered.

Macrocephalia and brachycephalia with protruding frontal and parietal eminences are typical in achondroplasia. The vault of the skull seems to hand over the small and rather wide face. There is a wise saddle nose with a sunken bridge, which makes all patients alike.

**Differential diagnosis:**

The disease should be differentiated from

1. Marquio- Ulrich disease
2. Hurler’s disease
3. Rickets

**Treatment modality:**

Is purely orthopaedic Hormone therapy may intensify the growth of extremities. Deformities of lower extremities are managed by corrective osteotomy. Coxa Vara can be corrected by subtrochanteric transverse osteotomy with pin fixation.

Lengthening of the extremities by means of Ilizarov apparatus of the femur and tibia can be done easily and lengthening of the arm can also be done by applying the Ilizarov apparatus.

Shortening of the proximal portions of the thigh in achondroplasia, front and back view.

## Case Study 1

### Achondroplasia

1. 6 years old achondroplasic child.
2. Lengthening was done in the right femur and left tibia (1st time).
3. Patient is in squatting position (Disproportionate limb).
4. Lengthening left femur and opposite tibia is done (2nd time).

5 & 6. Clinical appearance of the patient after lengthening, both limbs are eaual.

**OLLIERS DISEASE (DYSCHONDROPLASIA)**

It was first described by French surgeon Ollier in 1899. It is a disease marked by anomalous ossification of the cartilagenous skeleton. Dyschondroplasia is an essence delayed and abnormal ossification of the primordial cartilage. In dyschondroplasia area of embryonal hyaline cartilage remain, not replaced by bone in the metaphyseal and diaphyseal portions of the bones, which is evidence that the disease begins in the early period of embryagenesis (between 3rd and 6th months). Foci of dyschondroplasia are mainly found in the long bones (tibia and femur) and in the small bones of the feet and hands. Next in order of frequency of involvement are the pelvic bones, the scapula, the ribs, the talus and calcaneus.

It is the unilateral character of the limb development. Dyschondroplasia is always characterized by metameric involvement i.e only the distal segments of extremities suffer, for instance the hand, the forearm, the arm, the forearm and the hand.

The first manifestation of the disease are shortening of the affected extremity and various types of deformities which progress with age.

There is usually no pain. Arophy of muscles occurs only as the result of impaired function. X-ray findings is marked by oval or radial Foci of translucency in the metaphyses of the long bones and in the scapula.

Lt. genu varum in dyschondroplasia.

**Prognosis:**

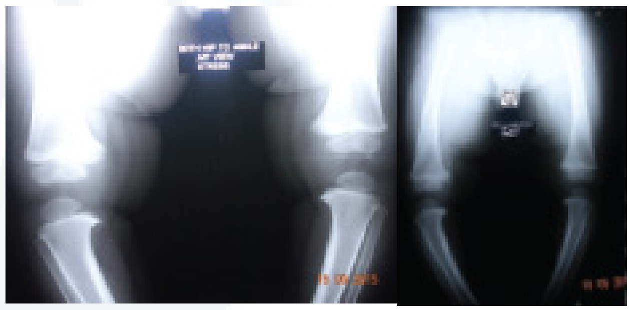
Favourable, the disease never progresses, the deformity and the shortening become more and more apparent with growth.

Ilizarov apparatus is the best tool for treating the deformities and shortening due to dyschondroplasia.

Figure- X-ray shows characteristic of dyschondroplasia, with Foci of non-calcified cartilage and deformities.

Patient with Blount-Biezin disease.

**04. BLOUNT-BIEZIN DISEASE (CARTILAGENOUS DYSPLASIA OF THE GROWTH ZONE)**



X-ray of Blount-Biezin disease.

Manifested by postnatal disturbances in the function of the epiphyseal cartilagenous growth zone. They are marked either by its widening or by premature ossification of part of the growth lamina, which leads to defective growth of the corresponding bone. This type of chondrodysplasia is encountered in the proximal growth zone of the tibia (Blount-Biezin disease).

Blount-Biezin disease is revealed between the age of 3 and 5 years with the appearance of genu varum, the affection being often bilateral.

**Treatment:**

An early osteotomy of the tibia allows further epiphyseal growth of its proximal portion to be regulated.

**05. FIBROUS DYSPLASIA**

Fibrous dysplasia or Braitsev-Lichtenstein disease is a systemic affection associated with disturbances in the development of bone tissue. The name was first given to the disease in 1938 by Lichtenstein. Owing to disturbances in the ossification of the foetal skeleton and the arrest of its development in some areas at the stage of incomplete classification the x-ray shows foci of rarefaction in the bone tissue. Lichtenstein described that the affected areas contained the commonly encountered fibrous connective tissue which he called fibrous tissue. The name fibrous dysplasia, which is firmly accepted in the literature does not reflect the true essence of the disease since the pathological foci arising as a result of embroyogenesis do not contain the usual fibrous tissue but are filled with a derivative of bone tissue, osteogenic fibrous tissue, in which dense bone trabeculae are differentiated. For that reason it is better to say ‘fibrous osteodysplasia’ which is more correct.

Shepherd’s crook deformity

Fibrous dysplasia is not a tumour, but it causes close to tumorous process and sometimes it is difficult to distinguish them. Delayed postnatal forms are encountered at the age of 6-10 years in children who previously did not have any apparent signs of abnormal development of the bone tissue. There are two forms are distinguished.

1. Monofocal monostotic form and the diaphysis and metaphysis are involved sparing the epiphysis presenting as an intramedullary lytic lesion. Many of the monostatic lesions are symptomatic and detected as chance finding.

## Case Study 1

1. 16 years old boy with Fibrous Dysplasia (left femur).
2. Radiographic view of Sheppard crook deformity of left femur with pathological fracture.
3. Patient with Ilizarov device.
4. Radiograph of left femur during treatment period.
5. After removal of the Ilizarov frame( 7 months follow up).
6. After 2 years follow up. Union is achieved and deformity is corrected.

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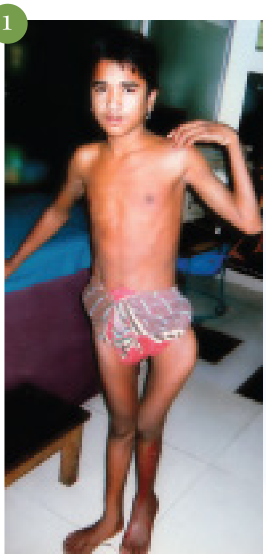

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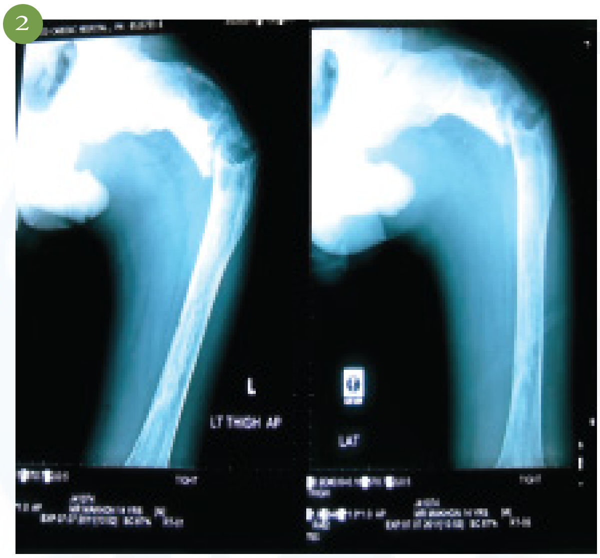


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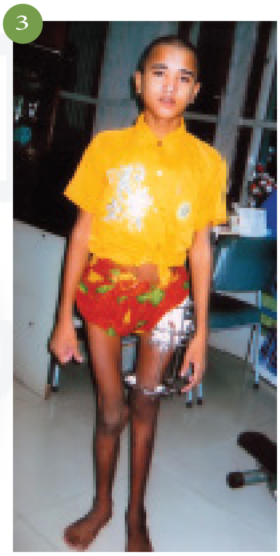

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## Case Study 2

1. Fibrous dysplasia of Left Trochanter with pathological fracture.
2. Fixation with DHS.
3. Broken implant with nonunion.
4. 2nd post op after with Ilizarov Frame fixation (17 yrs. old boy)
5. Removal of implant and osteosynlthesis by Ilizarov ring fixator radiographic view.
6. Radiograph of pathological site and Ilizarov frame in situ.
7. 2months after the osteosynthesis with Ilizarov ring fixator.
8. Final radiograph of the left hip after 5 months follow up.
9. After the removal of the Ilizarov fixator patient can squat, 5 months follow up.
10. After the removal of the Ilizarov fixator 5 months follow up.

## Case Study 3

### Fibrous dysplasia of humerus

1. Radiograph fibrous dysplasia of left humerus.
2. After the application of Ilizarov in OR.
3. Close up view of the patient with Ilizarov in left shoulder and arm.
4. After 2 months follow up.
5. After 4 months follow up with Ilizarov in situ.
6. After the removal of Ilizarov, 5 months follow up.

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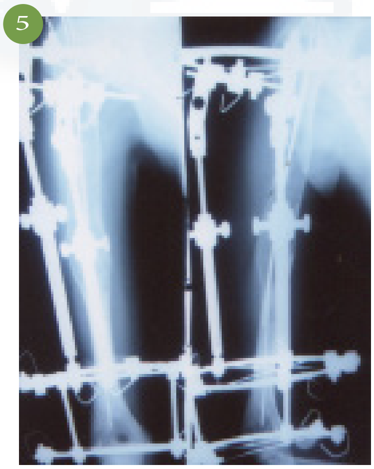

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## Case Study 4

### Fibrous dysplasia right tibia

1. 17 years old boy with procurvatum deformity of right tibia
2. Procurvatum deformity (Front view)
3. Right tibia with procurvatum deformity (Lateral view)
4. Radiograph of right tibia segmental non union with fibrous dysplasia
5. Patient with Ilizarov fixator
6. Radiograph of right tibia fibula with proximal metaphyseal corticotomy and gradual correction of non union site.
7. Close up view of right leg with Ilizarov ring fixator.
8. After 8 months follow up. Radiograph with good regenerate in the corticotomy site and non union site.
9. Radiographic final result after 9 months follow-up correction deformity and union is achieved.
10. Radiographic final result after 14 months follow up.
11. Clinical appearance of the patient in sitting and standing position after 14 months.

2. Polyostofic unilateral and bilateral forms.

The fibrous dysplasia is revealed clinically due to a deformity of the extremities or pathological fractures and infractions

Figure- Procurvatum deformity (Front view)
Foci of rarefaction of an irregular density which resemble frosted glass are seen in the metaphyseal and diaphyseal protions of bones on x-ray, a dense sclerotic border demarcates the focus

Figure- Radiograph of right tibia segmental non union with fibrous dysplasia

Extensive foci cause flask-like swelling of the bone with thinning of the cortex. In frequent involvement of the upper femoral end the bone is deformed like a shepherd's crook extensive diaphyseal involvement is often found.

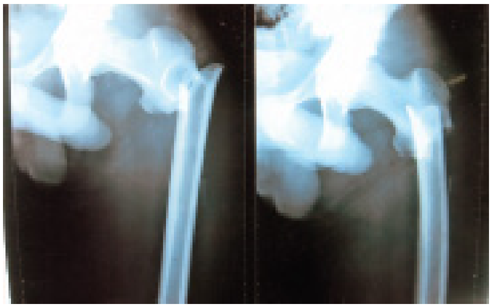

Figure- Fibrous dysplasia of Left Trochanter with pathological fracture.

**Histological examination:**

Foci usually shows blastic tissue compressed of cellular fibrous elements and inclusions of a hard bone substance.

**X-ray and histological**

Examination: is very important in differential diagnosis with GCT. The foci of fibrous dysplasia are found not in the bone cavity but in the compact substance, often subperiostially. To differentiate the conditon from parathyroid osteodystrophy not only hypercalcaemia and hypercalciuria have to be excluded, but the parathyroid glands have to be examined in difficult cases.

**Treatment:**

Deformities and false joints of the bones are recently managed by means of Ilizarov apparatus which effects gradual controlled coordinated distraction of the extremity with correction of the deformity, lengthening of the limb and ossification of the defect. In view of frequent recurrences it is better to resect large foci of fibrous-dysplasia than to remove them by curettage.

## Case Study 5

Figure-1:13 years old girl, fibrous displasia of right whole tibia fibula with procurvatum deformity (front and back view)

Figure-2: Radiographic view of fibrous displasia of right whole tibia fibula with procurvatum deformity

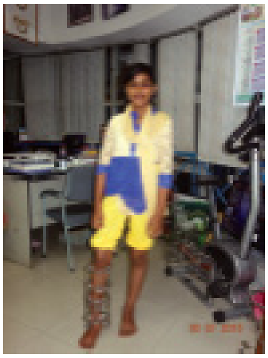

Figure-3: During treatment with Ilizarov apparatus

Figure-4: Radiographic view of right tibia fibula with correction of procurvatum deformity by Ilizarov technique with hinges

Figure-5: Radiographic view of right tibia fibula with correction of procurvatum deformity, after removal of Ilizarov apparatus with plaster immobilization

Figure-6: Radiographic final view of right tibia fibula after 6 monthsfollow up (AP & Lateral view)

Figure-7: Clinical appearance of the patient after 8 months follow up (front and back view) procurvatum deformity is fully corrected

**06. DIAPHYSEAL ACLASIS, (EHRENFRIED'S DISEASE) MULTIPLE OSTEOCARTILAGENEOUS EXOSTOSES OR FAMILIAL OSTEOCHONDROMATOSIS.**

The term 'diaphyseal aclasis' was introduced by Keith. The multiple exostosis of this disorder arises not from the diaphysis but from the epiphysio-metaphyseal junction. With the bone growth they move away from the epiphyseal zone and in older children can be found on the metaphysis and even on the diaphysis. Exostosis always grow in a definite direction, to the centre of the bone, in distinction to true tumours which grow in disorder.

Left radial head is migrated, ulna is shortened, Clinical photograph of 14 years old boy before surgery.

Radiograph of both elbow, fore arm, wrist and hand. Left sided radial head is migrated proximally, and ulna is shortened distally. Clinical prograph of 6 years old girl before surgery.

## Case Study 1

### Diaphyseal aclasis (multiple hereditory exostoses, Ehrenfried's disease)

1 & 2. Left radial head is migrated, ulna is shortened

3 & 4. Clinical photograph of 14 years old boy before surgery

5. Process of distraction of radial head.

6. Radial head is at the lavel of capitelum.

7. Radiograph of proximal corticotomy of ulna and distraction is seen, distal radio ulnar joint is maintained.

8-11. Clinical appearance of the patient after 5 months follow up.

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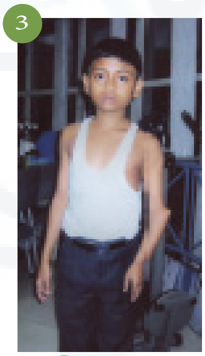
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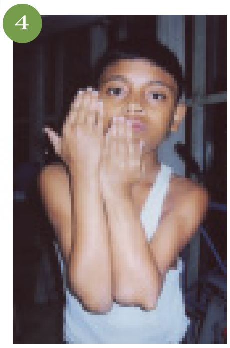
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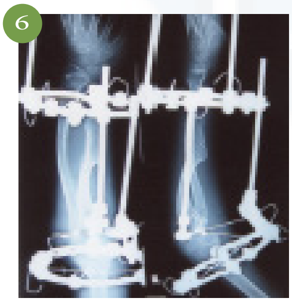
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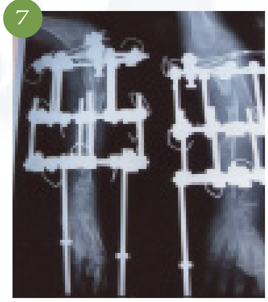
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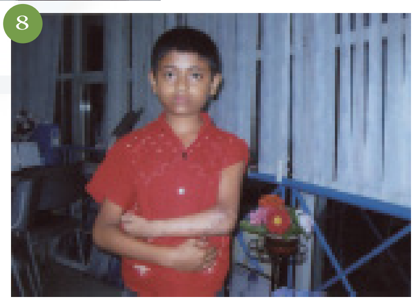
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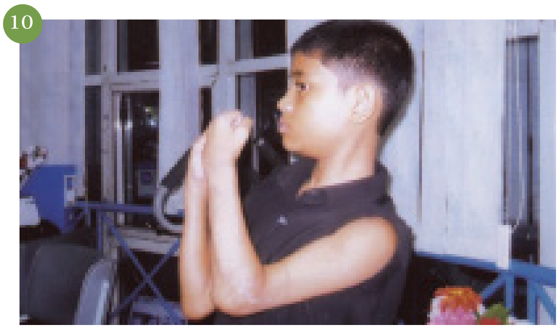
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# Case Study 2

**Hereditary multiple exostoses - diaphyseal aclasis**

Exostoses grow as the child grows and may cause cosmetic or functional difficulties that justify excision. The later the excision is performed, the less the risk of recurrence and/or physeal damage. Differential growth between hte paired bones of the lower arm and leg can lead to joint deformity and loss of function. Deformities can be corrected by Ilizarov technique.

**Diaphyseal aclasis (multiple hereditory exostoses, Ehrenfried's disease)**

1. Radiograph of both elbow, fore arm, wrist and hand. Left sided radial head is migrated proximally, and ulna is shortened distally.
2. Clinical prograph of 6 years old girl before surgery.
3. Smilling girl with Ilizarov in the left fore arm.
4. Radiographic result after 4 months follow up.
5. Clinical appearance of the girl after the treatment.

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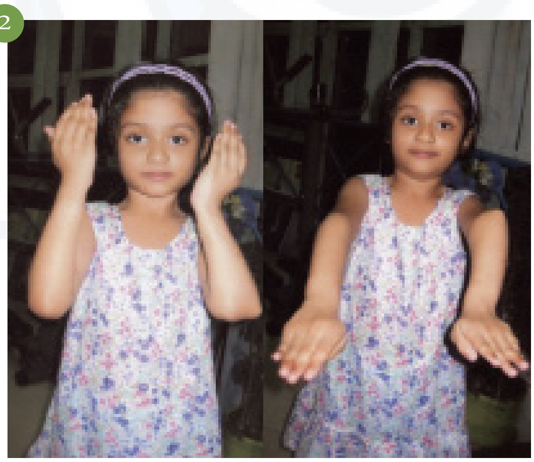

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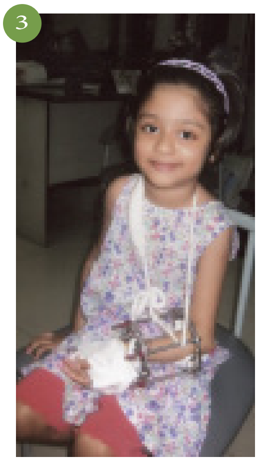

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As the exostosis grows its cartilagenous growth tissue draws away from the base to form a cartilagenous covering at its apex. Ossification of the exostosis begins from main bone and spreads to the periphery. Growth of an exostosis ceases as soon as the patient stops growing. The most common localization of exostosis are the growth zones in the active epiphysis of the long bones, the distal epiphysis of the femur, forearm bones and the proximal epiphysis of the tibia and humerus.

Lower end of ulna affected in diaphyseal aclasis showing unequal growth of the radius and ulna.

**Treatment:**

The surgeons tactics are determined by the clinical picture of the exostosis. Surgical removal is absolutely indicated in compression of a neuro-vascular bundle and when the exostosis presses against an adjoining bone, causing the distraction. Large exostosis which do not trouble the patient should also be remarked, bearing in mind the possibility of their conversion to a true tumour.

Multiple exostosis are often associated with congenital incomplete development of some of the epiphysis (most commonly the distal epiphysis of ulna) Ilizarov can be applied for the lengthening of ulna.

# Part 4
# Acquired deformities of locomotor apparatus in paediatric group

# Chapter 23
# Sequalae of Poliomyelitis

## ACQUIRED DISEASES AND DEFORMITY OF LOCOMOTOR APPARATUS:

### SEQUALAE OF POLIOMYELITIS.

Poliomyelitis is an acute infectious viral disease, spread by the oropharyngeal route, that passes through several distinct phases.

### Clinical features

Typically passes through several clinical phases, from an acute illness resembling meningitis to paralysis, then slow recovery or convalescence and finally the long period of residual paralysis.

### Early treatment

During acute phase the patient is isolated and kept at complete bed rest, with symptomatic treatment for pain and muscle spasm. Once the acute illness settles, physiotherapy is stepped up, active movements are encouraged.

### Late treatment

Isolated muscle weakness without deformity, passively correctable deformity, fixed deformity, flail joint and shortening, all should be addressed according to the need of the patient.

## Case Study 1

### Post-Polio Residual deformity- 5.3 cm shortening

1. 18 years old girl post-pollio LLD (5.3 cm) left tibia shortening, flexion contracture of left knee, unstable hip and ankle.
2. Galeazzi sign (+).
3. Ilizarov in the left knee and leg.
4. After 6 months follow up.
5. No LLD and no flexion contracture of the left knee is visible.

## Case Study 2

### Post-Polio Residual deformity

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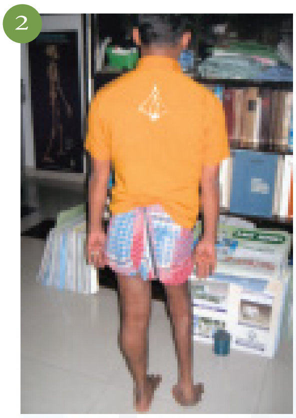

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1. 18 years old male- Post polio residual deformity; 5 cm LLD, unstable knee, ankle with front heal, equino cavo rarus deformity.
2. Back view.
3. Walks with hand knee support.
4. In sitting position.
5. Flexion position of the knee.
6. In O.R.
7. During treatment with Ilizarov apparatus. After 6 months follow up. Gradual controlled co-ordinated stretching was done for the correction of the deformity.
8. With thigh, knee, ankle and foot orthosis, patient can walk without any support.

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## Case Study 2

### Post-Polio Residual Deformity

1. 18 years old girl. Post polio residual deformity 4 cm shortening with right ankle valgus.

2 & 3. Back view & front view.

4. Galeazzi sign (+).

5. During treatment with Ilizarov apparatus.

6. Radiograph of right tibia fibula after lengthening.

7. Arthrodesis of right ankle and lengthening of tibia fibula by Ilizarov technique.

8. Clinical appearance of the patient, final outcome after 7 months. 9. Both legs are eaual.

10. Clinical appearance of the patient, final outcome after 7 months patient is happy.

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## Case Study 3

### Post-Polio Residual Deformity

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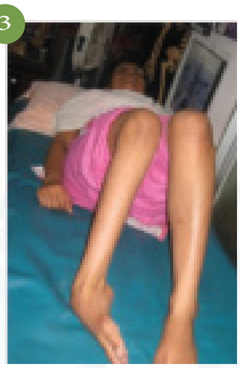
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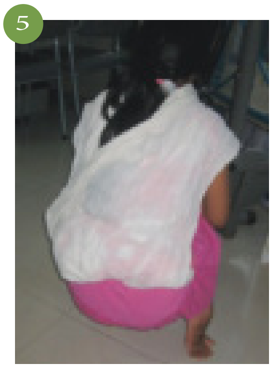
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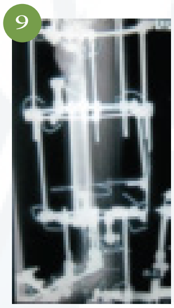
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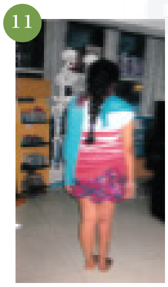
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1. 18 years old girl, post polio residual deformity of right leg, ankle and foot with external tibial torsion, 2 cm shortening with equinocavovarus deformity >65 degree (severe)

2. Back view.

3. Lying position.

4. Sitting position.

5. Sitting position back view.

6. Radiograph of right and left tibia 2 cm shortening.

7. After removal of the Ilizarov apparatus in O.R. Deformity of right leg ankle and foot, external tibial torsion, equino cavo varus.

8. Plaster immobilization.

9. Radiograph result of right tibia fibula with Ilizarov fixator in situ.

10 & 11. Clinical appearance of the patient after 11 months follow up (Back view and front view).

12. No LLD, right tibia is lengthened 2 cm and torsion is corrected.

13. Clinical appearance of the patient, sitting position after 1 year.

14. Author with the patient.

15. Clinical appearance of the patient after 1 year.

# Chapter 24
# Sequalae of Osteomyelitis

## DEFORMITIES OF THE EXTREMITIES DUE TO OSTEOMYELITIS

Post-osteomyelitic deformities in paediatric patient can be divided in to 2 groups-

1. Epiphyseal and
2. Metaphyseal

Epiphyseal osteomyelitis predominates among infants, it usually causes early and most severe disorders. Complete and partial distraction of the epiphysis in osteomyelitis may lead to dislocation.

Pathological dislocation due to epiphyseal osteomyelitis usually occurs at the hip. Pathological post-osteomyelitic dislocation of the hip is to be differentiated from congenital dislocation.

It has to be remembered that there is a possibility of pathological dislocation of the hip developing as a sequelae to infection of the hip in older children.

Pathological dislocation of the hip causes limp. Trendelenburg'ssign, relative and absolute shortening of the extremity, which is 2-3 cm in distraction of proximal femoral epiphysis. In osteomyelitis of distal femoral epiphysis, gross disturbance of growth is visible, which leads to 10 to 15cm shortening at the end of growth period.

Involvement of one of the femoral condyles or part of the epiphysis usually gives rise to Genu valgum or genu varum Osteomyelitis of metaphysis or diaphysis or pandiaphyseal osteomyelitis with pathological fracture of the long tubular bones can be treated by Ilizarov technique only by fixing it with Ilizarov apparatus and advise your children to walk with full weight bearing by the affected limb which is the fundamental principle of Ilizarov methodology.

## TREATMENT OF CHRONIC OSTEOMYELITIS

**Introduction:**

During the past decade orthopedic surgeons have confronted new clinical entities in the management of chronic osteomyelitis, such as toxic shock, Acquired Immunodeficiency Syndrome (AIDS), Lyme disease and have faced problems with resistant organisms. However, the patient with chronic osteomyelitis has a new hope of cure by recent advances in the management of chronic osteomyelitis.

These are:

1. Bold radical resection and bone transport.
2. Intramedullary reaming
3. Improving nutritional status
4. Anatomic and physiologic emphasis on classification.
5. Newer antibiotics and antibiotic beads.

Chronic osteomyelitis is often associated with

i. Angular or rotational deformity, the angle may be in any plane such as a procurvatum, recurvatum, varus, valgus or in the oblique plane.
ii. Juxta articular deformity
iii. Deformities of the neighboring joints such as hip, knee, ankle in the lower extremity
iv. Limb length discrepancy usually shortening and rarely lengthening
v. A deep cavity
vi. There may be a large sequestrum
vii. Deep rooted chronic infection of intramedullary canal containing small sequestrum and infected granulation tissue.

Ilizarov concept of chronic osteomyelitis is that there are small tiny cavities filled with infective organisms around the large fixed focus. Unless these cavitis are radically excised, the diseased may recur. According to him the small cavities are the case of recurrence. Therefore, he advocated radical resection of the segments of bone which may create a large gap. This large gap can be filled by bone transport. With the procedure of bone transport, one can excise very large segment. Another advantage of Ilizarov method is one can correct all the associated deformities of the bone and neighboring joints.

**Chronicity of Osteomyelitis:**

The following are the causes of chronicity of osteomyelitis:

1. The ischemia and relative avascular nature of the infected and necrotic area, sequestrum, produces an area of lowered oxygen tension as well as an arc that antibiotics cannot penetrate. The lowered oxygen tension effectively reduces the bactericidal activities of polymorpholeukocytes and also favours the conversion of a previously aerobic infection to one that is anaerobic.
2. Resistance of organisms to antibiotics due to multiple usages of antibiotics. The infections tend to be polymicrobial in terms aerobic and anaerobic microorganisms. The dead spaces becomes reinfected.

Causes of Recurrence (Failure of Surgery)

There are several causes of failure of primary surgical treatment. These are-

i. Inadequate surgical debridement in removing the entire squestrum
ii. Decreased blood flow as a result of the initial insult or secondary to operative dissection resulting in diminished healing capacity and resistance to recurrent hematogenous or local bacteremia and seeding
iii. Scar tissue or residual dead space servicing as nidus for recurrent infection

iv. The presence of a mixed aerobic and anaerobic infection.

**Cierny-Mader Classification:**

Cierny and Mader have developed a classification system wherein anatomical situation of the chronic osteomyelitis and physiological response of the host are taken into consideration.

Cierny-Mader have described four anatomically defined types of osteomyelitis.

1. Medullary
2. Superficial
3. Local
4. Diffuse

The condition of the host, the anatomic site and the extent of necrosis influence both the natural history and the treatment of each disease type.

**Anatomic Classification:**

Anatomic classification of osteomyelitis is of following types.

**Medullary Osteomyelitis**

The primary lesion is endosteal. The etiology of the disease is variable but the nidus remains constant: ischemicscar, chronic granulations and sequestered trabeculae within the medullary canal. The classical example is an infected intramedullary nailing done for fractures of the shaft of the long bones. In this situation when the canal is removed, lot of granulation tissue and small pieces of sequestril are flushed.

**Superficial Osteomyelitis**

The problem is on the outer surface of the bone. This is a true contiguous focus lesion. A compromised soft tissue envelope either begins or perpetuates the bony exposure. The involved surface may be within an old saucerization, a de-epithelialized Papineau graft, deep within a venous stasis lesion, or the metatarsal head in a neuropathic plantar ulcer.

**Localized Osteomyelitis:**

This is the typical osteomyelitis often encountered in clinical practice. The hallmark is full–thickness cortical sequestration, a discrete lesion within a stable bony segment. Localized osteomyelitis usually stems from trauma. It often has the combined features of the medullary and superficial types and indeed may evolve from either. Characteristically this entire lesion can be completely excised with a cuff of viable tissue while preserving the integrity/stability of the segment involved.

**Diffuse Osteomyelitis:**

In this permeative, circumferential or through and through disease of hard and soft tissue an intercalary segment of the skeletal unit must be involved in order to excise the nidus tissues. Segmental instability is present either before or after debridement. Stabilization is an essential feature in the treatment of the diffuse lesion, often an expression of all three of the other disease types. Examples of this fourth type include infected nonunions end stage septic joints and through-and-through metaphyseal/epiphyseal lesions of the proximal femur.

**Treatment:**

The first step is the identification of the organisms. The patient is evaluated and clinical staging is noted down. The antibiotics started according to sensitivity of the organisms. The principles of surgical treatment consist of:

1. Through radical debridement
2. Adequate drainage
3. Obliteration of the cavity of gap.

The treatment of chronic osteomyelitis should be similar to the treatment of giant cell tumor of bone. Careful surgical debridement remains to be a sheet anchor of the treatment. All the infected tissues, sequestrii, dead avascular bony end implants, if any are removed. If the intramedullary nail, the nail is removed, the medullary canal is reamed to remove all small sequestrii and granulation tissues. A cavity is cleared with a jet lavage, we use Betadine solution. The bony ends are debrided till punctate bleeding surfaces are seen. The whitish yellow color of the bone indicates dead bone, which must be removed. The osteomyelitis is extensively saucerized using a drill hole to remove bony roof and then using sharp cutting rongeurs. If the bone is very severely infected and sclerosed the entire bony segment is removed. This bold step can now be taken filled with bone transport. Jet pulsatile lavage is used to cleanse the wound. The wound is rinsed using a 50-50 mixture of Bacitacin/ Polymyxin B) solution. Finally, normal saline is used. Unless the entire dead bone is removed and woozing haversion systems are visualized the surgery is not complete. The cavity is packed with Betadine soaked bandage. The wound is loosely closed to retain the gauze.

## Case Study 1

1. Chronic osteomyelitis of left femur with Ilizarov fixator in situ.
2. 2 years old child in the mother's lap.
3. Radiographic result after 3 months. Osteomyelitis burns in the fire of regeneration.
4. After removal of Ilizrov fixator.

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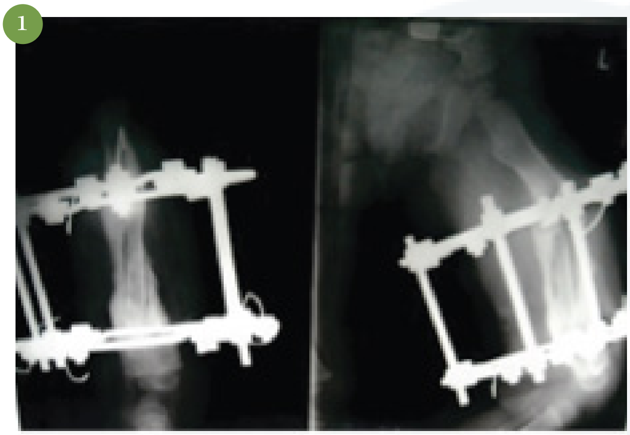

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## Case Study 2

1. Chronic osteomyelitis of right femur with pathological fracture.
2. Radiographic view of right femur with Ilizarov fixator in situ.
3. Radiographic result, union is achieved after 4 months.
4. 6 years old boy, during treatment with Ilizarov fixator in the right hip and thigh.
5. Just after removal of the Ilizarov fixator.

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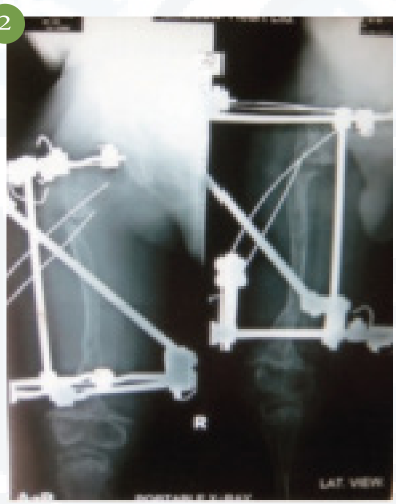

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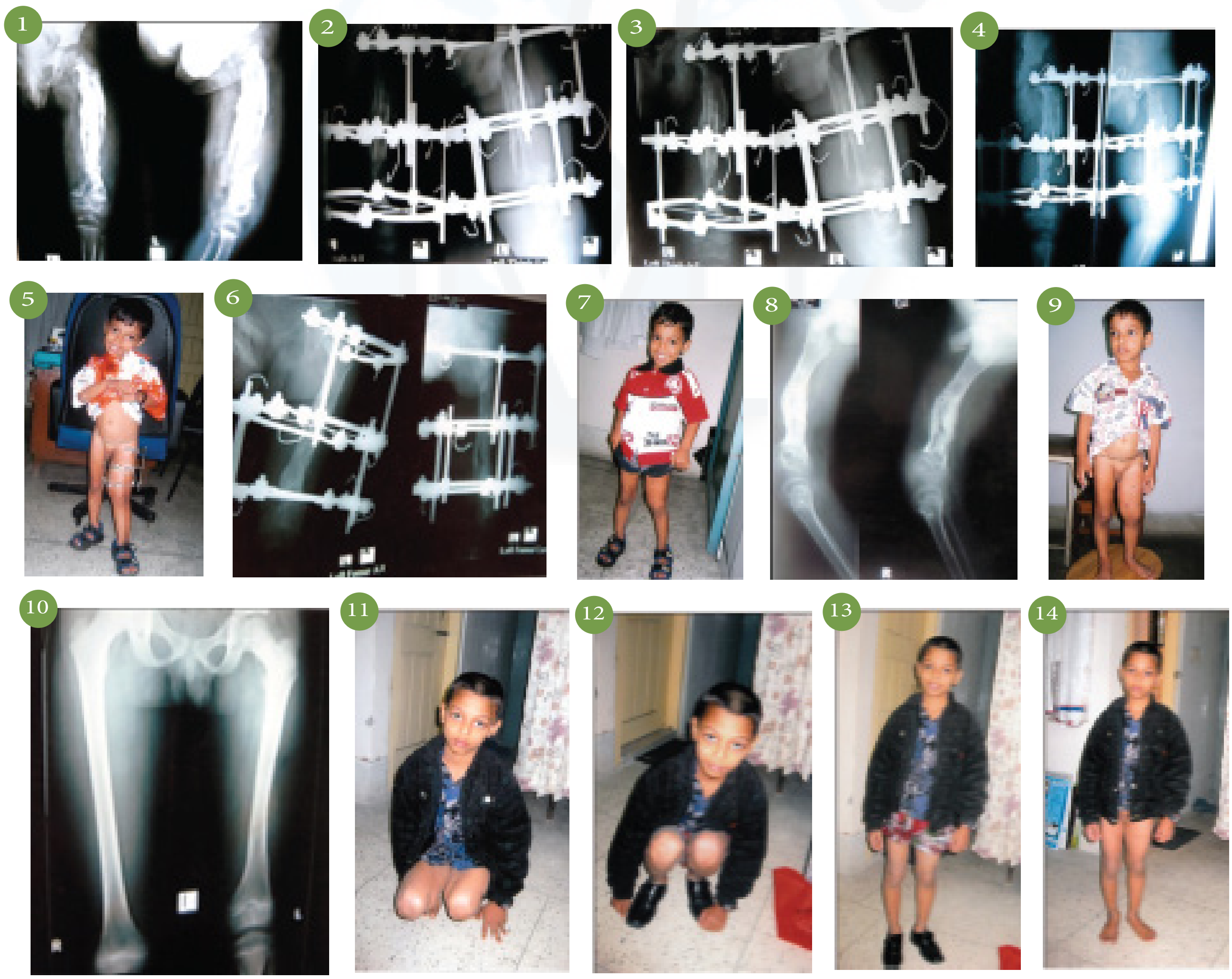
## Case Study 3

1. Pandiaphyseal osteomyelitis with pathological fracture of left femur.
2. 5 days after application of Ilizarov.
3. 2 months after application of Ilizarov.
4. 3 months after application of Ilizarov.
5. Smiling baby with Ilizarov in situ.
6. 4 months follow up after application of Ilizarov.
7. Patient is happy.
8. Radiograph result after 5 months.
9. Clinical appearance of the patient after 5 months.
10. Radiograph after 6 years follow up.
11. Baby can squat.
12. Full range of movements.
13. Clinical appearance of the patient after 6 years.
14. After 6 years of follow up.



## Case Study 4

1. Chronic Osteomyelitis of right femur with implant in situ, visible sinuses.
2. Osteomyelitis of right femur with visible sinuses.
3. Radiographic view of right femur with implant in situ (lateral view)
4. Implant failure with osteomyelitis.
5. Patient with Ilizarov ring fixator in a special cot.
6. Smiling patient with Ilizarov in the right thigh.
7. After removal of the Ilizarov, 5 months follow up. (AP view)
8. After removal of the Ilizarov, 5 months follow up. (lateral view)
9. Radiographic view of right femur union is achieved.
10. Walking with the aid of walker just after removal of Fixator.
11. Patient is doing excersies for bending the knees.

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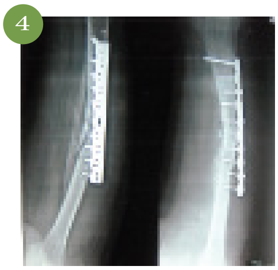

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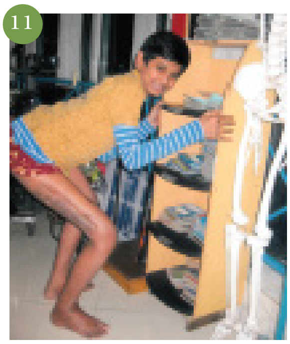

## Case Study 5

1. Radiographic view of left tibia, and pandiaphyseal osteomyelities left of tibia with pathological fracture.
2. Radiographic view of left tibia with Ilizarov in situ, visible corticotomy site.
3. After 2 months follow up a good regenerate is seen.
4. 2 years old child in the fathers lap.
5. In O.R. before removal of the fixator.
6. Radiographic result, osteomyelities burns in the fire of regeneration.

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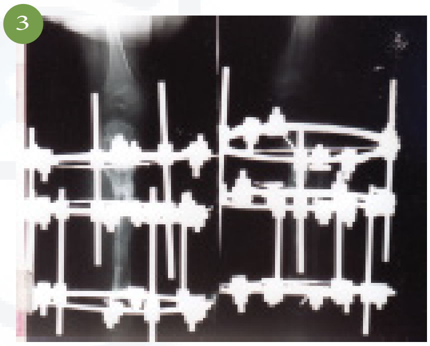

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## Case Study 6

1. Radiograph of left femur with pathological fracture.
2. 8 years old boy – deformity of left femur with chronic osteomyelitis.
3. During treatment with Ilizarov 2nd post op.
4. Radiograph of left femur with Ilizarov frame after 3 months follow up.
5. The radiographic result after 4 months follow up.
6. Final follow up after 5 months. Clinical appearance of the ptient

## Case Study 7

1. Radiographic view of Chronic Osteomylitis of right tibia with pathological fracture.
2. Osteomyelitis with Ilizarov apparatus after 1 month follow up.
3. Radiographic result after 3 months follow up.

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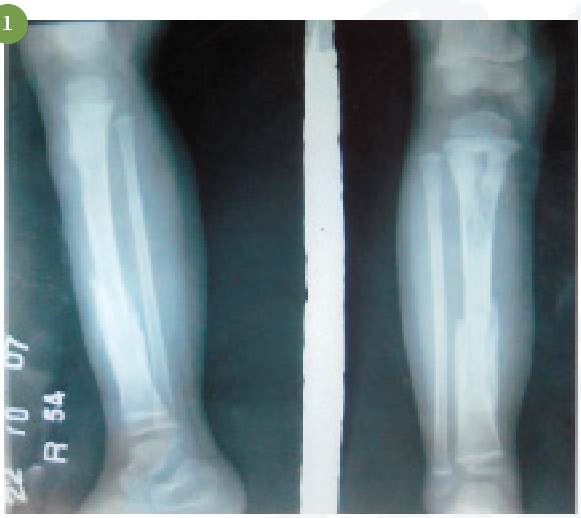

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## Case Study 8

1. 5.3 cm LLD left sided – 7 yrs old girl (front view)
2. 5.3 cm LLD left sided – 7 yrs old girl (back view)
3. Galeazzi sign positive, 7 yrs old girl
4. Radiograph of sequalae of ch. osteomyelitis 5.3 cm LLD left femur.
5. Radiograph of left femur lateral view.
6. Radiographic view of distraction osteogenesis.
7. Lengthening is achieved with Ilizarov ring fixator.
8. Radiographic view of left femur 5.3 cm LLD is achieved.
9. After 8 months full correction is achieved (front view)
10. After 8 months full correction is achieved (back view)

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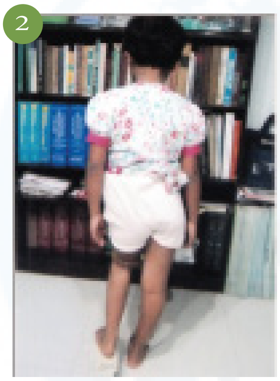
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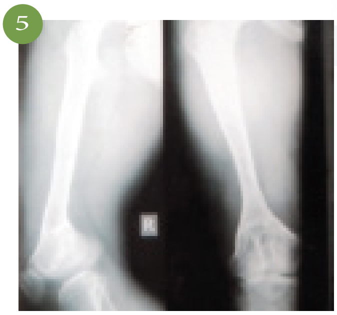
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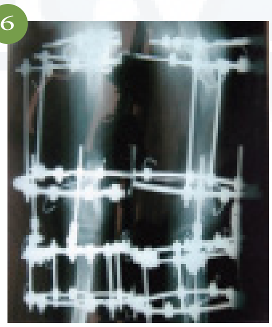
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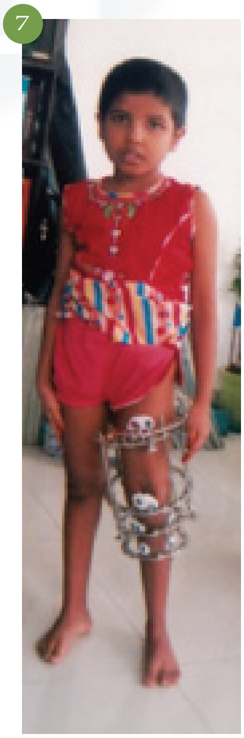
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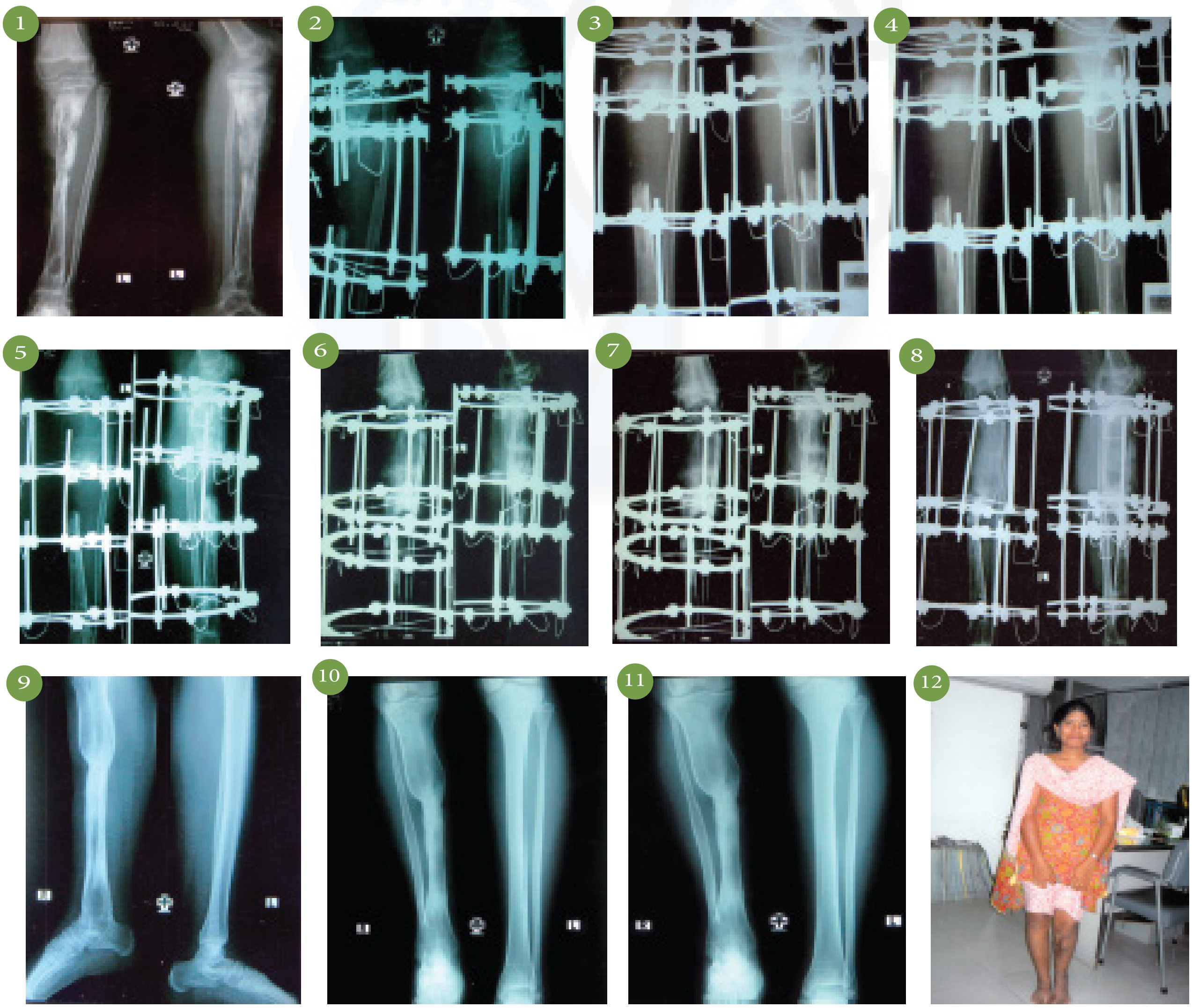
## Case Study 9

### Pandiaphyseal osteomyelitis of left tibia

1. Pandiaphyseal osteomyelitis of left tibia.
2. 2nd post OP
3. After 10 days follow up.
4. After 3 weeks follow up.
5. After 1 month follow up.
6. After 1 and ½ months follow up.
7. After 2 months follow up.
8. After 2 and ½ months follow up.

9-11. Radiographic result After 3 months follow up.

12. Clinical appearance of the patient after 6 months.

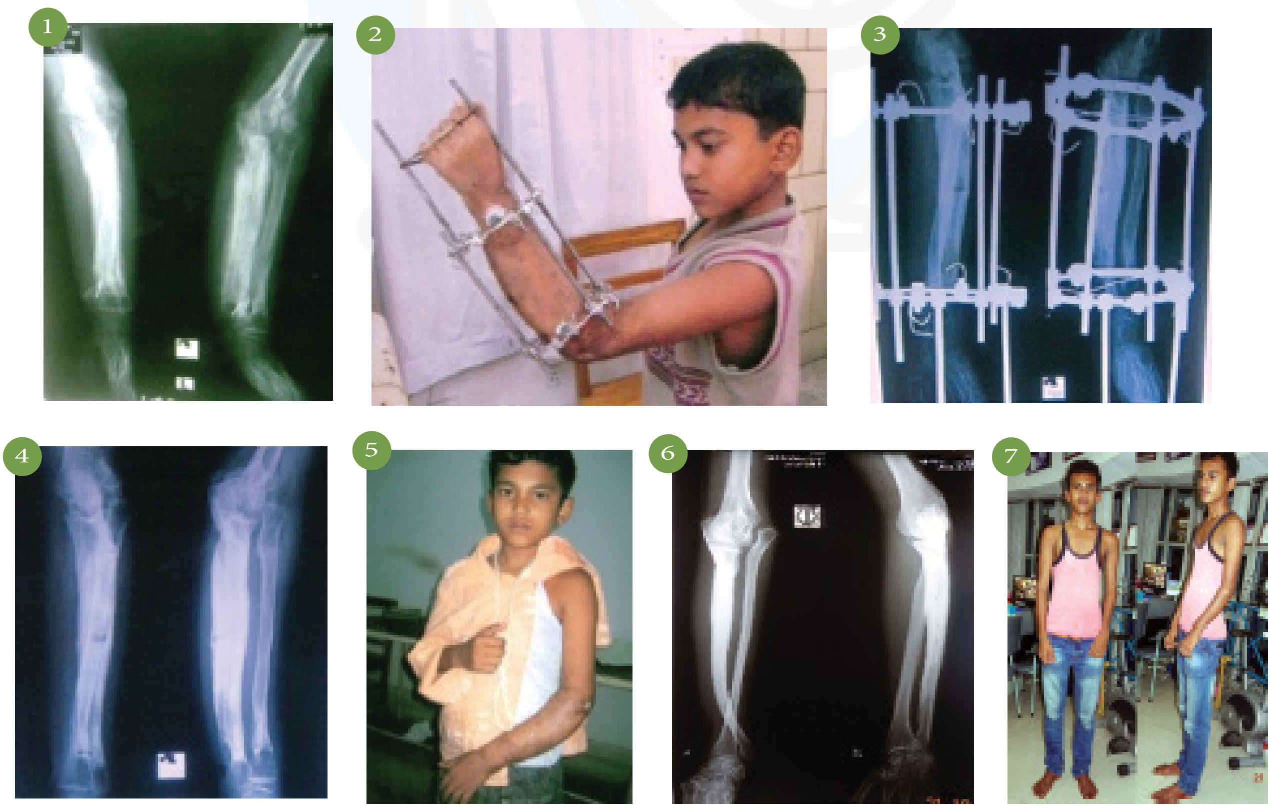


Considerable shortening can be corrected by osteotomy with extension of the extremity in Ilizarov's apparatus.

We may face certain difficulties in treating post- osteotomyelitic pseudoarthrosis and bone defects. Ilizarov successfully employed a compression-distraction apparatus for treating the pseudoarthrosis even in the presence of a purulent infections what Academician Prof. Ilizarov said- "Infection burns in the fire of regeneration.

## Case Study 10

1. Radiographic view of pan-diaphyseal osteomyelitis of whole ulna & proximal part of radius with visible sinus.
2. After application of Ilizarov.
3. Second post operative with Ilizarov apparatus.
4. Radiographic follow-up after 2 months
5. Final follow after 4 months.
6. Radiographic view of left radius and ulna after 8 years.
7. Clinical appearance of the patient after 8 years.



## Case Study 11

1. 4.5 yrs. old Baby with chronic osteomyelitis of right tibia fibula.
2. Radiograph of right tibia fibula before treatment, normal left tibia fibula.
3. Baby with Ilizarov apparatus.
4. Radiograph of right tibia fibula with Ilizarov in situ.
5. After 1 month follow up.
6. Radiograph of right tibia fibula after 3 months.
7. Patient can walk with the Ilizarov apparatus.
8. Final radiograph, union is achieved.
9. Clinical appearance of the baby after 4 months.

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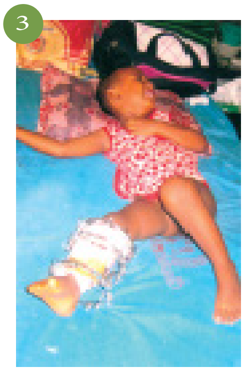

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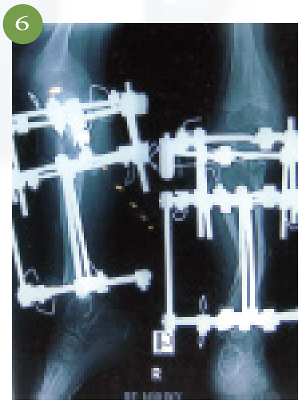

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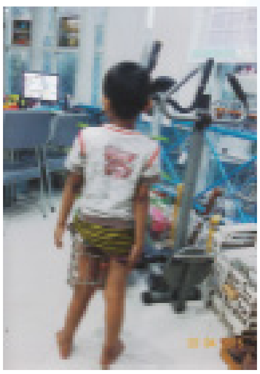
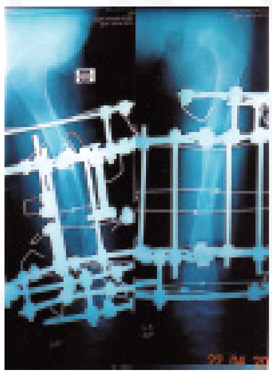
## Case Study 12

Chronic osteomyelitis of left femur, 8.5 yrs. old boy.

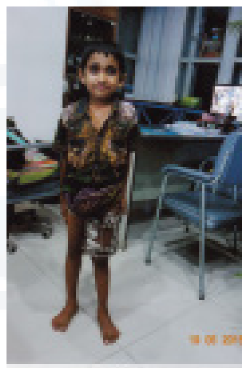
Radiograph of pathological fracture of left femur.



Child with Ilizarov apparatus back view.



Left femur with Ilizarov apparatus in situ.



Child with Ilizarov apparatus front view.

Radiograph of left femur with good union.

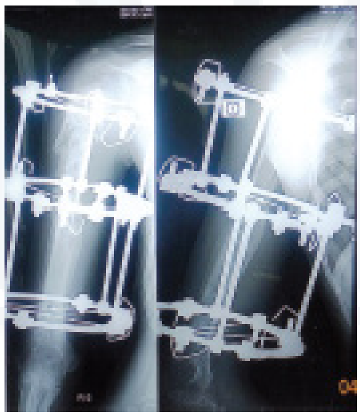
Clinical appearance of the child after 6 months follow up.

## Case Study 13

Radiograph of chronic osteomyelitis upper humerus

14 years old boy with discharging sinus in the upper humerus.

Radiograph of chronic osteomyelitis upper humerus



Radiograph of right humerus after 1 month.

Patient with Ilizarov apparatus in the right humerus

Final radiograph of right humerus after 4 months follow up.

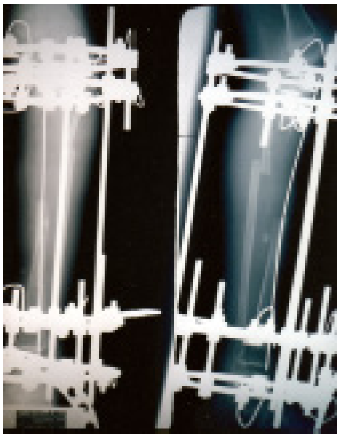
Final clinical appearance of the patient.

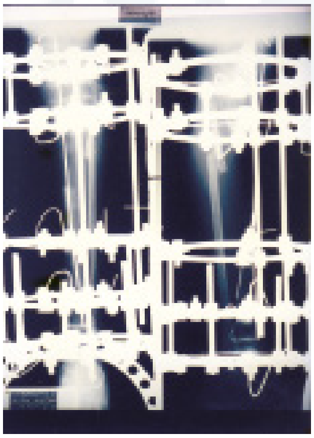
## Case Study 14


Radiograph of right tibia with chronic osteomyelitis rush nail in situ


external view of deformed left tibia


9 years old girl with Ilizarov in the left tibia


Radiograph of left tibia with Ilizarov apparatus in situ.


During bone transportation


Final radiograph of left tibia with Ilizarov with good union.

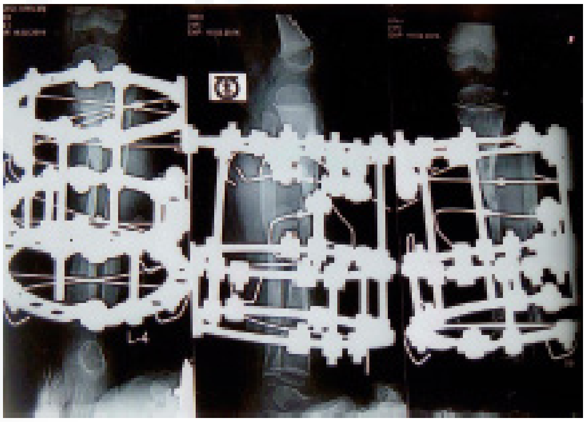

Clinical appearance of the patient after 7 months follow up.

## Case Study 15

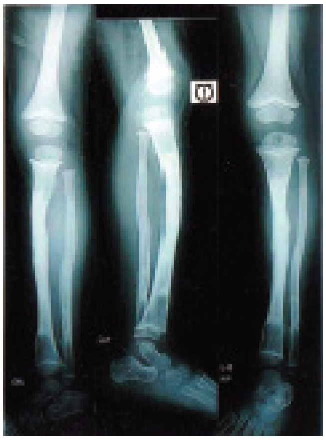
Baby 3.5 yrs. in the father's lap.

Radiograph of left tibia, chronic osteomyelitis normal right tibia.

Baby with mother, Ilizarov in the right leg.



During treatment.

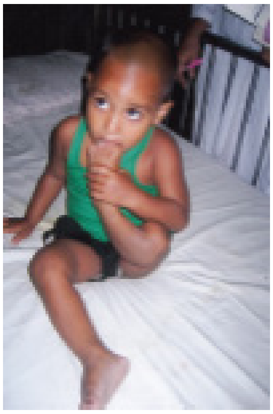


Final radiograph with full consolidation.

Smiling baby after treatment.

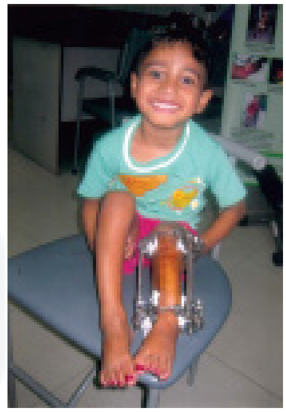
Clinical appearance of the patient after 12 months.

## Case Study 16

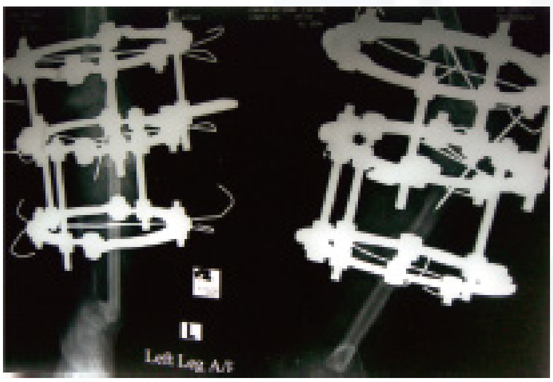


Post osteomyelitic deformed by leg


Radiograph of left fibula before treatment

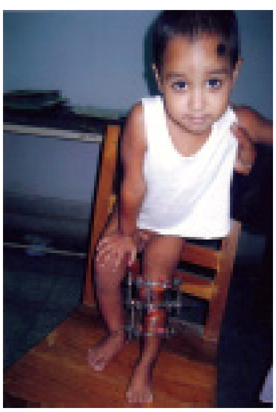


During treatment with Ilizarov apparatus




Radiograph of left fibula with Ilizarov in situ

Radiograph of left side after treatment



Baby with Ilizarov apparatus


After 2nd stage lengthening of fibula

Smiling baby after the correction of deformity

# Chapter 25
# Deformities of Cerebral Palsy

## DEFORMITIES OF CEREBRAL PALSY

Cerebral palsy is a condition that affects thousands of babies and children each year. It is not contagious, which means no one can catch it from anyone who has it. The word cerebral means having to do with the brain. The word palsy means a weakness or problem in the way a person moves or positions his or her body. A kid with Cerebral palsy (CP) has trouble controlling the muscles of the body (hall mark of the condition is motor dysfunction, i.e. there is abnormal muscle tone, abnormal posture and movement). Normally, the brain tells the rest of the body exactly what to do and when to do it. But because CP affects the brain, depending on what part of the brain is affected, a kid might not be able to walk, talk, eat or play the way most kids do. It is a non-progressive but often changing motor impairment syndromes. It is usually secondary to an insult of limited duration or anomalies of the brain arising in the early stages of development. (Viz. prenatal, intranatal, neonatal and post natal up to 5 years). The changing clinical picture results from developmental maturation and intervention. The clinical expression of the case depends on the extent and area of brain damage, growth of the child, coexisting developmental problems.

Introduction Cerebral palsy is a condition that affects thousands of babies and children each year. It is not contagious, which means no one can catch it from anyone who has it.

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**Types of cerebral palsy (CP)**

Cerebral palsy can be classified as:

I. Physiological
  a. Spastic
  b. Dyskinetic (dystonic and athetoid)
  c. Hypotonic
  d. Ataxic
  e. Mixed

II. Topographic
  a. Quadri/tetraplegia
  b. Hemiplegia
  c. Diplegia
  d. Monoplegia
  e. Triplegia

**Spastic cerebral palsy (CP)**

Spastic cerebral palsy (CP) is the most common type of cerebral palsy. It causes the muscles to be stiff and permanently contracted. Spastic cerebral palsy is often sub classified as one of five types that describe the affected limbs. The names of these type combine a Latin prefix describing the number of affected limbs (e.g. di-means two) with the term plegia or paresis, meaning paralyzed or weak.

I. Diplegia: either both arms or both legs

II. Hemiplegia: limbs on only one side of the body

III. Quadriplegia: all four limbs

IV. Monoplegia: one limb (extremely rare)

V. Triplegia: three limbs (extremely rare)

Spastic diplegia: Spastic diplegia affects the legs more than the arms. The legs often turn in and cross at the knees. This causes a scissors gait, in which the hips are flexed, the knees nearly touch, the feet are flexed and the ankles turn out from the leg, causing toe-walking. Learning disabilities and seizures are less common than in spastic hemiplegia.

**Spastic hemiplegia:**

Persons with spastic hemiplegia (hemiparesis) also may experience hemiparetic tremorsuncontrollable shaking of the limbs on one side of the body. Severe hemiparetic tremors can seriously impair movement. The arm is generally affected more than the leg. Learning disabilities, vision problems, seizures and dysfunction of the muscles of the mouth and tongue are classic symptoms.

**Spastic quadriplegia:**

Spastic quadriplegia involves all four limbs. There is dysfunction of the muscles of the mouth and tongue, seizures, medical complication and increased risk for cognitive difficulties.

**Mixed CP:**

Mixed CP involves two or more types of cerebral palsy. While any mix of types and subtypes can occur, the most common are athetodic-spastic-diplegic and athetoid-spastic-hemiplegic; the least common is athetoid-ataxic. It is possible to have a mix of all three (spastic-athetoid-ataxic).

**Complication**

Some people with CP have associated disorders, such as impaired intellectual development, seizures, failure to grow and thrive and vision and sense of touch problems. Roughly a third of patients with CP also have mild intellectual impairment, another third are moderately or severely impaired and the remainder, intellectually normal. Mental impairment is most common in children with spastic quadriplegia.

**Diagnosis**

The diagnosis of CP is essentially involves detail history of prenatal, natal and postal history and careful physical and neurodevelopment examination to identify deficit type and topography, which is required for management. Early identification has significant implication for the family and necessitates early intervention to achieve the maximum holistic potential of the child. The philosophy behind early intervention is bases on the following facts:

I. A neurological insult recovers better with stimulation.

II. I.Q. of emotionally deprived children is poorer than stimulated children.

III. The plasticity of the brain in the first decade of life provides a window of opportunity for active intervention.

IV. Actually a child with CP is not hopeless. Half of the child with CP have average or above I.Q.

V. With timely help and proper guidance a vast majority can lead active, self supporting and long lives.

VI. Thus early diagnosis is prerequisite.

**Evaluation**

The diagnosis of CP is essentially clinical. It involves a detail prenatal, natal and post natal history and careful physical and neurodevelopmental examination to identify deficit type and topography which is required for management.

**Investigation**

Laboratory test are not necessary to confirm diagnosis. Brain imaging studies including USG, CT and MRI may be useful in elucidating the etiology of CP and suggesting prognosis. Vision, auditory screening along with EEG should be done if patient is not improving after adequate physiotherapy. presynaptic terminal and blocks signal transmission at neuromuscular junction. It works for 3-5 months. Beclophen orally or intrathecal continuous pump can be implanted.

**Materials and Methods**

Since 1990 to till 2014, we treated 46 patients of different categories of CP. Outcome of the patients are satisfactory.

**Management**

It is multidisciplinary approach:

I. Physical Therapy: Through this helps the child walking, sitting and keeping his/her balance. Also to prevent contracture.

II. Occupational therapy: Help the child develop fine motor skills such as dressing, feeding, writing and other daily living skills.

III. Speech therapy: To develop communication skill.

IV. Feeding problem: Initially start with soft, small frequent feed. Drooling can be minimized by improving swallowing. Drugs are not very effective.

V. Educational problem: Mild CP does well in mainstream schools. Moderate to severe CP need to be educated in special school.

VI. Communication: Discourage sign language and encourage speaking.

VII. Spasticity: If it does not improve with physiotherapy, then Botulinum Toxin Type-A injection can be given, which block release of acetylcholine from

**Choice of Surgery**

I. Operation on muscles and tendons

II. Tenotomy, tendon lengthening tendon transfers

III. Myotomy and muscle transposition

IV. Operation on bones and joints

V. Bone lengthening by Ilizarov technique VI. Osteotomies to correct knock knee

VII. Arthrodesis of wrist, hip and foot to correct deformity

**Aim of Surgery in CP**

I. To correct the deformity

II. To balance the muscle power

III. To stabilize uncontrollable joints

**Complication**

So early intervention is the key for improvement of CP, specially the first 2 years is most important. This is the time when brain is growing very fast. In simple word this is the express train. Try to catch it. If you miss it try to catch the local train, which is up to 5 years. Still it is better than something.

## Case Study 1

### Bilateral Pes Plano Valgus, flexion contracture both knees with left sided CDH

1. 12 years old girl with bilateral knee flexion contracture with bilateral pes plano valgus.
2. Correction of both knee flexion contracture with Ilizarov apparatus.
3. After 1 month follow up with Ilizarov apparatus.
4. Grice operation was done in both ankle (Extra articular arthrodesis).
5. Ilizarov in both knee and plaster immobilization in both ankle and foot.
6. Pelvic support osteotomy was done in the left hip.
7. Radiographic view of Pelvic support osteotomy.
8. Ilizarov removed and long leg plaster cast is applied.
9. Patient is walking with plaster cast. Since birth she could not stand & walk.
10. Anatomic situation, joint capsule dissected free. Joint exposed, groove for bone graft; graft inserted, optimal graft shape is visible.
11. Radiographic view of hip and shaft of the femur after pelvic support osteotomy (PSO).
12. Clinical appearance of patient after full correction, patient can stand and walk with KAFO.

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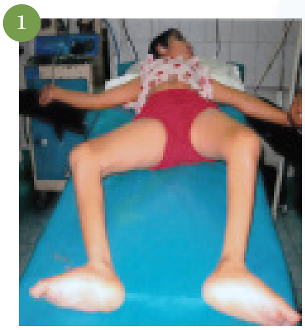

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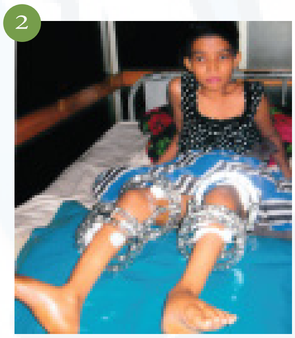

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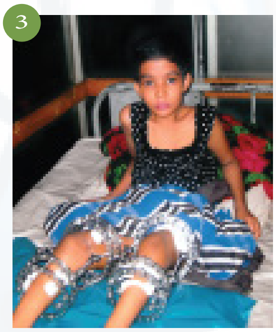

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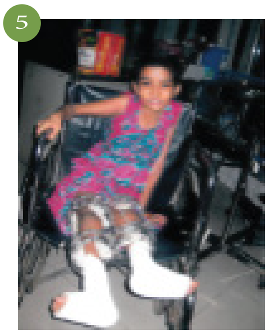

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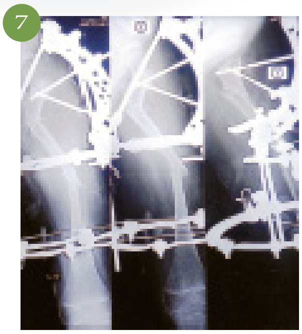

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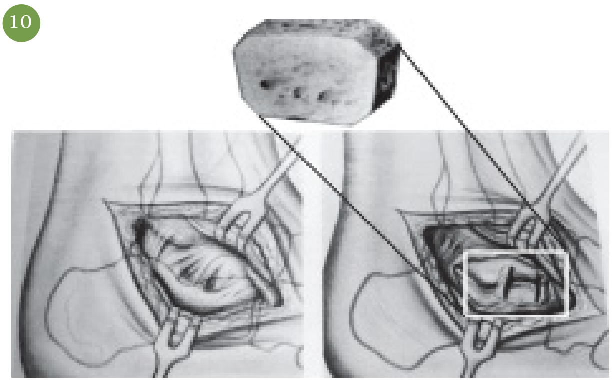

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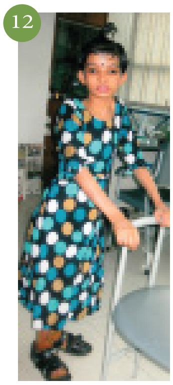

## Case Study 2

### Knee Flexion Contracture Pes Equinus

1. 9 years old boy – Right Pes Equinus >650
2. Right Pes Equinus >650 (Lateral view)
3. Cannot squat.
4. During treatment with Ilizarov.
5. Plaster immobilization in the knee with Ilizarov in the ankle.
6. With KAFO (knee ankle and foot orthosis).
7. Clinical appearance of the patient. Final follow up (Front view)
8. Clinical appearance of the patient. Final follow up (Back view).

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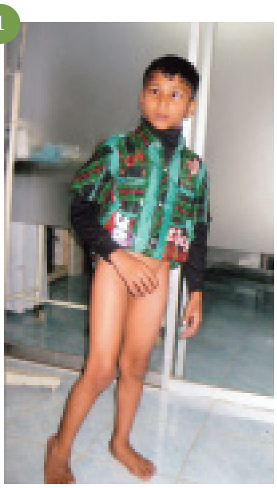
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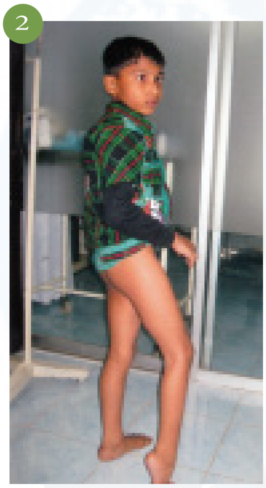
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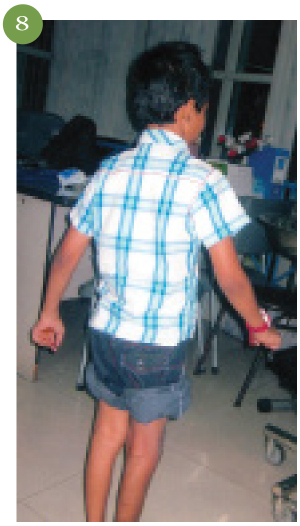

N.B: Published in MedCrave, MOJ Orthop Rheumatol, Received: December 16, 2015 | Published: January 04, 2016.

## Case Study 3

17 years old CP patient, FFD both knee with bilateral ankle valgus (front and back view).

After correction thigh knee brace.

Clinical appearance of the patient after full correction with Ilizarov apparatus.

# Case Study 4

10 years old girl, bilateral knee flexion contracture with bilateral ankle equinus >45o (sitting and lying condition), before treatment.

Patient is in standing position before treatment.

Patient can not extend her knees.

Front and side view of the patient.

During treatment with Ilizarov apparatus.

Mother with child durting treatment with Ilizarov apparatus.

After removal of Ilizarov apparatus, plaster cast is applied

Full correction is achieved

Clinical appearance of the patient, patient can walk with the walker easily (front and back view)

# Chapter 26

# Deformities of the extremities due to rickets (ricketic deformity in lower extremity)

## DEFORMITIES OF THE EXTREMITIES DUE TO RICKETS (RICKETIC DEFORMITY IN LOWER EXTREMITY):

Rickets is a disease of the whole organism, which is associated with lack of vitamin D. The gross changes we see in the skeleton; muscles are not strong enough and under the stress of weight bearing and due to dystrophy of the cartilagenous tissue various curvatures and deformities arise not only in the spine chest and skull, but also in the extremities.

**Aetiology:**

1. Acquired chondrodystrophy caused by lack of vitamin D.
2. Due to functional loading the lower extremity suffers most.
3. Deformity in the upper extremities are mild and the changes that occur in the metaepiphyseal parts of the distal end of forearm.

Deformities of the lower extremities in rickets become apparent when the child begins to walk and are distinguished both by their shape and the extent of disfigurement. There are two typical types of deformities are seen in rickets.

O - shaped and
X - shaped

**Genu Varum (Bow leg, O-Shaped deformity)-**

Consists in the distal portion of the legs and also the feet being abnormally close together and the space between the knees increased, so that the extent of the deformity can be judged from the distance between them. Genu Varum arises not only form looseness of the knee joint, but mainly from an outward convex curvature of the axes of the tibia fibula at the junction of the upper and middle thirds. In very severe cases the lower third of the leg is rotated inwards. The condition is marked by pes planovalgus. In considerable softening of the bones and continued weight bearing a rachitic deformity of the thighs also develops. The physiological forward convexity of the femur increases and the femoral axis acquires a lateral convexity which is largest in the lower third.

Weight bearing in the severe cases leads to development of Coxa Vara; the normally obtuse angle formed by the axis of neck and axis of femoral diaphysis reduces from 125-135o to 90o and even to 60o. In this situation greater trochanter is raised, which changes the traction of the gluteus muscles and leads to inclination of the pelvis and to the appearance of Trendelenburg sign and a waddling gait.

Sometimes genu varum is found on one side and genu valgum on the other (Wind swept deformity).

Genu varum with wind swept deformity

Genu valgum (Khock knee, X-shaped deformity) is a common rachitic deformity. In mild cases the thigh and leg axes are straight but meet at an angle with the apex pointed inward because the leg is tilted outward due to looseness of the knee joint. The space between the feet is increased and the size of the genu valgum deformity can be judges from the distance between the malleoli. In severe deformities the femoral condyles are unevenly developed; the lateral condyle is small while the epiphyseal line is slightly raised on the external surface instead of being strictly horizontal. The axes of leg bones are convex inward and may in addition have a forward sabre-like curvature (Figure-00) with the largest angulation at the borders of the middle and lower thirds of the leg. Children with a such deformity often have a flail knee joint and genu recurvatum. In genu valgum the feet are distorted and pes planovalgus is frequent. When prophylactic measures and treatment are not applied genu valgum progresses and does not disappear by itself.

Genu Valgum in rickets

**Treatment:**

Treatment should start immediately when the diagnosis is established. Our aim is to prevent the gross deformities along with general antirachitic measures (Vitaminotherapy, cord-liver oil, ultraviolet radiation) massage and therapeutic exercises for the extremities, a rational diet preventing weight gaining and orthopaedic measures are very important.

## Case Study 1

### Genu Valgum

1. Left Genu Valgum of 16 years old boy
2. Standing position, 3cm shortening
3. During treatment with Ilizarov fixator
4. Radiographic results.
5. After 5 months follow up (back view)
6. After 5 months follow up (front view)

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# Case Study 2

## Right Genu Valgum

1. Right Genu Valgum of 18 years old boy (front view).
2. Right Genu Valgum – 18 years old boy (back view).
3. Open wedge good regenerate with Ilizarov in situ.
4. After full correction with Ilizarov in situ.
5. Radiograph of Genu Valgum, after full correction.
6. After full correction (front view).
7. After full correction (back view).

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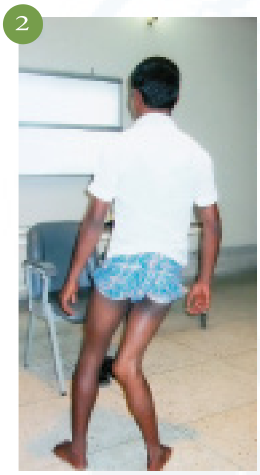

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## Case Study 3

### Severely deformed bilateral genu valgum, patellar dislocation and antero-lateral bowing of tibia – 13 years old girl

1. 13 years old girl – Severe Bilateral Genu Valgum with Patalla Tracking (Front view).
2. Severe Bilateral Genu Valgum with Patalla Tracking (Back view).
3. Sitting position (Back view) before surgery.
4. Sitting position (Front view) before surgery.
5. 59 cm – Intermalleolar distance.
6. Tracking of Patella.
7. Bowing Femur (Right)
8. Bowing Femur (Left)
9. Gradual correction with Ilizarov Frame.
10. Patient is doing exercises with Ilizarov frame.
11. During treatment with Ilizarov Frame – 8 months follow up.
12. Father and daughter.
13. After full correction – 9 months follow up.
14. After removal of Ilizarov Frame –9 months follow up.
15. After correction with brace (KAFO).

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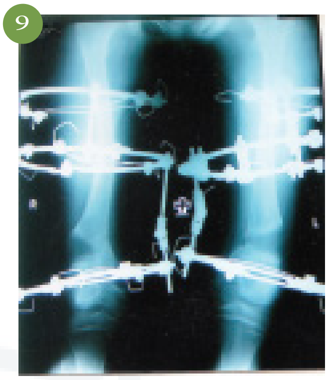
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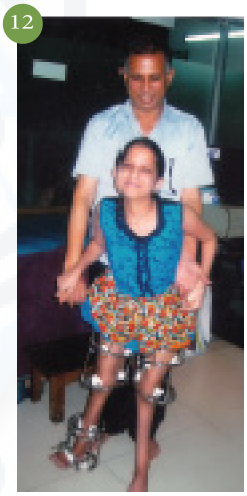
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## Case Study 4

**Severely deformed bilateral genu valgum with patellar dislocation– 17yrs. Old boy**

1. Severe bilateral Genu Valgum – 17 years old boy (front view). Patella Tracking laterally.
2. Severe bilateral Genu Valgum – 17 years old boy (back view).
3. 65 cm intermalleolar distance.
4. Patella Tracking laterally.
5. Radiograph of right and left knee AP view.
6. Radiograph of right and left knee lateral view.
7. Radiograph of both knee.
8. Raiographic view of osteotomy site is visible with Ilizarov device in situ.
9. Almost corrected radiographic view of femur and tibia.
10. Radiographic view with good regenerate is seen.
11. Ilizarov frame in both femur.
12. Patient is walking with the help of crutches.
13. Full correction of the both femur and tibia with Ilizarov device in situ.
14. Patient is doing exercises with Ilizarov frame.
15. After removal of the frame with plaster cast immobilization.
16. Final result of the patient. Deformity is corrected and height is increased. (back view)
17. Final result of the patient. Deformity is corrected and height is increased. (front view)
18. Final follow up after 11 months (front view).
19. Final follow up after 11 months (back view).

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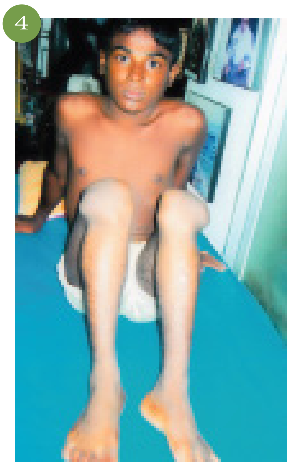

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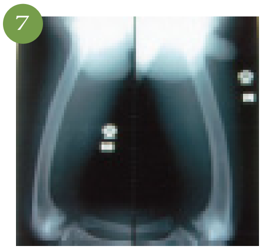

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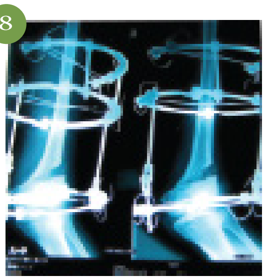

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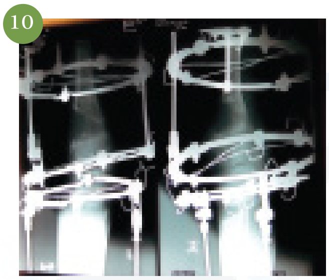

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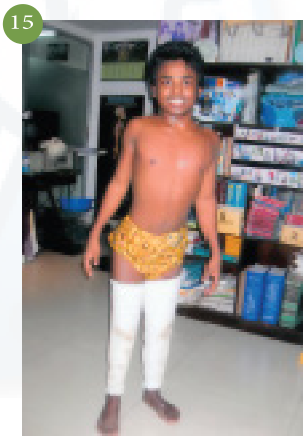

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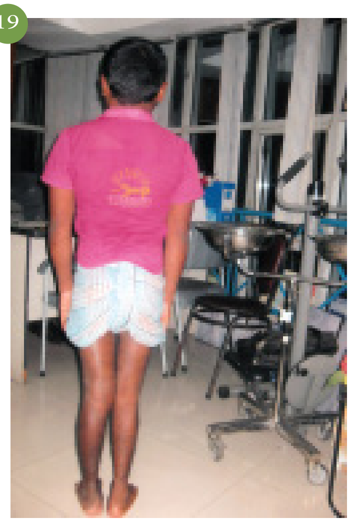

## Case Study 5

### Bilateral Genu Valgum with patella tracking

1 & 2. Bilateral Genu Valgum – 17 years old boy (Front view and Back view).

3. 40 cm intermalleolar distance.

4. Biletateral Genu Valgum – Prone position.

5. During treatment, after 2 months with Ilizarov device.

6. Follow up after 3 months. (front view)

7. Follow up after 3 months. (back view)

8. Follow up after 4 months.

9. Final follow up after 6 months . (Front view)

10. Final follow up after 6 months . (Front view)

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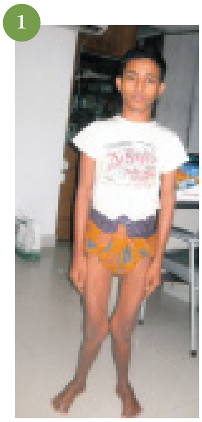
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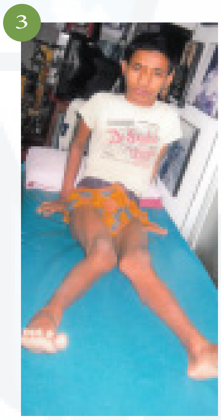
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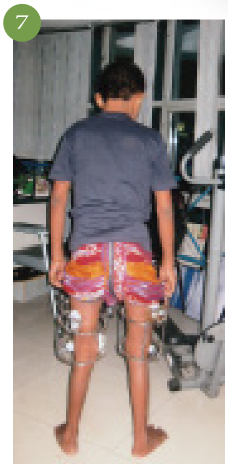
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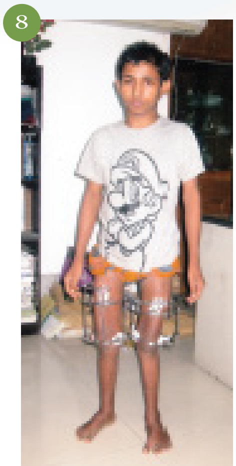
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## Case Study 6

1. 14 years old boy – Bilateral Genu Valgum (front view). Patella facing laterally.
2. 14 years old boy – Bilateral Genu Valgum (back view).
3. In O.R.
4. Radiographic view of both hip and both knee.
5. During treatment with Ilizarov Frame.
6. Radiographic view of osteotomy and placement of hinges (AP view).
7. Radiographic view of osteotomy and placement of hinges (lateral view).
8. Right sided final follow up after 5 months. Sitting position.
9. Right sided final follow up after 5 months. Standing position.

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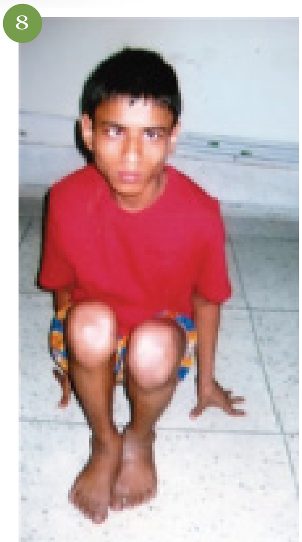

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## Case Study 7

1. 15 years old boy Genu valgum. Left sided (front view).
2. 15 years old boy Genu valgum left sided (back view).
3. Radiographic view of both Knee. Right side– mild, Left side – severe.
4. In OR.
5. 2 months post op.
6. External view, placement of hinges are seen.
7. After 5 months of follow up (front view).
8. After 5 months of follow up (back view).

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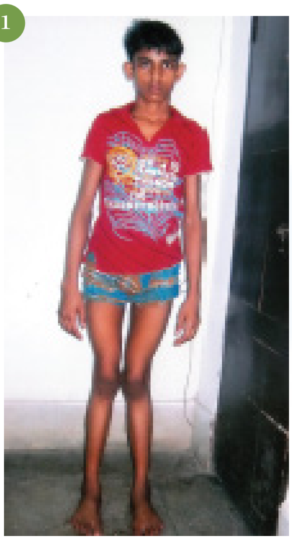

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## Case Study 8

1. 5 years old child Bilataral Genu Valgum
2. Lying position.
3. Radiographic lateral view.
4. Radiographic view of both Genu Valgum.
5. Patient on the operating table.
6. Both twin brothers in the bed.
7. After correction of both brothers Genu Valgum.
8. Radiographic result with Ilizarov In Situ.
9. Final follow up after 3 months.
10. After removal of Rings.
11. Final follow up after 3 months.
12. Bilateral genu valgum (front view).
13. Bilateral genu valgum (back view).
14. Before correction, Radiographic view
15. Before correction, Radiographic lateral view
16. Radiographic view before correction.
17. Twin brothers are in bed.
18. Radiographic result.
19. Twin brothers with Ilizarov ring fixator.
20. Twin brothers in the bed after the correction.
21. Both twin brothers, corrected Genu Valgum.

22 & 23. Final outcome of twin brothers.

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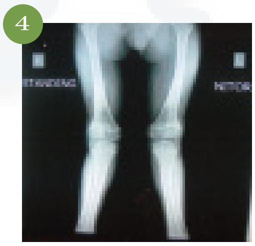

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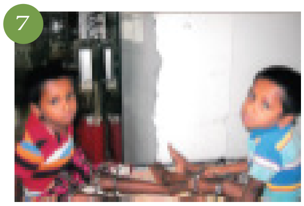

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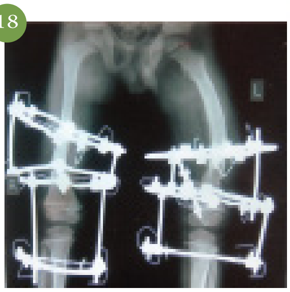

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## Case Study 9

### Bilateral Genu Valgum of 12yrs old girl

1. 12 years old girl, Bilateral genu valgum (front view)
2. Bilateral genu valgum (back view)
3. Radiograph of the bilateral genu valgum
4. Radiograph of both corrected genu valgum with Ilizarov in situ
5. Author with patient during treatment
6. After removal of the apparatus, 4 months follow up
7. Before Ilizarov treatment
8. Clinical appearance of the patient after 10 months follow up
9. The Girl can squat easily.
10. Clinical appearance of the girl after 1 year

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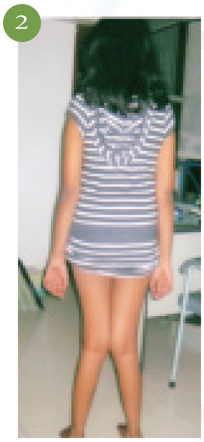

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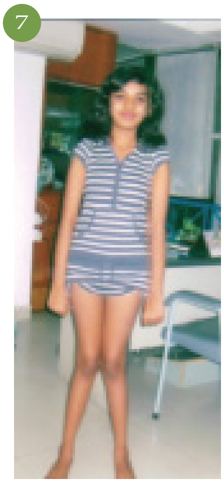

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## Case Study 10

### Wind Swept Deformity – 17years old boy

1. Right sided Genu Varum left sided Genu Valgum (front view)
2. Right sided Genu Varum left sided Genu Valgum (back view)
3. Simultaneous correction of both the deformities
4. After correction of the Genu Varum and Genu Valgum, 7 months follow up

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## Case Study 11

### Wind Swept Deformity – 14 yrs old boy

1. Right Genu Valgum with left Genu Varum (front view)
2. Right Genu Valgum with left Genu Varum (back view)
3. During treatment with Ilizarov apparatus, simultaneous correction of both the deformities
4. Before treatment
5. Clinicl appearance of the patient after 6 months follow up
6. Clinical appearance of both the brothers

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## Case Study 12

### Genu Varum (Bowing of femur and tibia)

1. 13 years old girl. bilateral bowing (Femur and tibia)- Front view.
2. Back view.
3. Sitting position.
4. Showing inter condylar distance.
5. Almost corrected left femur and tibial.
6. Standing position with Ilizarov apparatus in both femur and both tibia.
7. Almost corrected femur and tibia bowing deformity, Ilizarov in both inferior extremity.
8. After 6 months follow up.
9. Clinical appearance of the patient after 1 year follow up.

## Case Study 13

1. 6 years old boy, bilateral bowing femur and tibia (front view).
2. 6 years old boy, bilateral bowing femur and tibia – (back view).
3. Ilizarov apparatus in right inferior extremity.
4. Right inferior extremity with Ilizarov in situ.
5. Left inferior extremity with Ilizarov in situ.
6. Standing view with Ilizarov in left inferior extremety.
7. Radiographic result of right femur and tibia after 5 months follow up. A good consolidation is seen.
8. Radiographic result of left femur and tibia after 6 months follow up. A good consolidation is seen.
9. After full correction.

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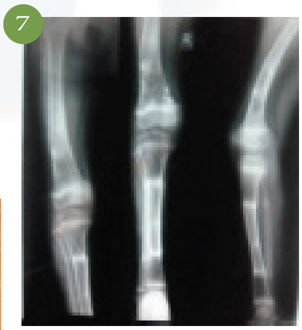

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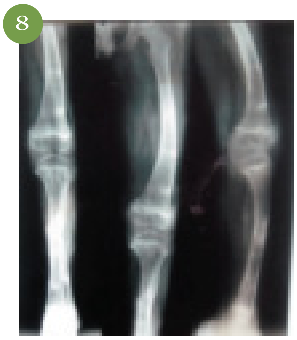

## Case Study 14

1. 16 years old girl, bilateral bowing of Femur & Tibia (front view)
2. Bilateral bowing of Femur and Tibia (back view
3. Ilizarov in right inferior extremity, after 2 months follow up.
4. Ilizarov in right lower limb. Patient can walk with the help of axiliary crutches.
5. After the correction of the right inferior extremity. Left side is waiting for correction.
6. Ilizarov in left lower limb.
7. Corrected Right lower limb and Ilizarov in the left lower limb.
8. After 6 months follow up. Front view.

9 & 10. After 8 months follow up. Front and back view.

## Case Study 15

1 & 2. 9 years old girl, bilateral bowing (Femur and Tibia), (front and back view).

3. Radiograph of both femur.

4. Radiograph of both tibia.

5. Lying position.

6. Ilizarov in both lower limbs. 4 months follow up.

7. After removal of Ilizarov fixator, the patient is in plaster immobilization.

8. After removal of plaster.

9. With brace, almost corrected lower limbs. (front view). After 6 months follow up, patient with KAFO

## Case Study 16

1. 14 years old boy, Bilateral Bowing both Femur and tibia is singing a song (standing view before surgery)

2. Bilateral Bowing – Both Femur and tibia (sitting position before surgery).

3a. Radiograph of right tibia fibula

3b. Radiograph of left tibia fibula

4 & 5. Radiograph of both tibia fibula with Ilizarov in situ.

6. Almost corrected both femur and both tibia.

7. Ilizarov apparatus in the both tibia.

8. Ilizarov in both lower limbs. Patient can walk without any support.

9 & 10. After full correction – 5 months follow up. (front and back view)

11. Clinical appearance of the smilling patient after 10 months

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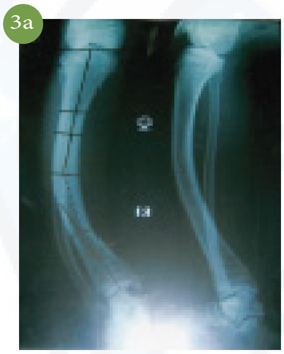

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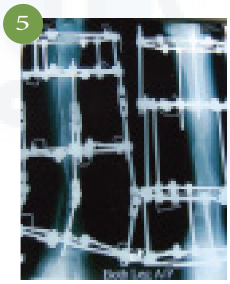

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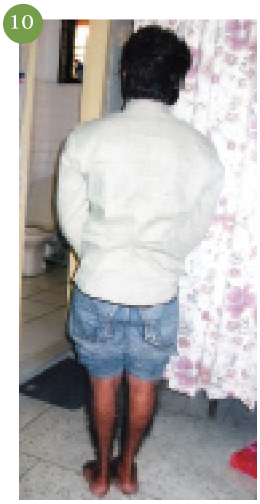

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# Chapter 27

# Deformities of the extremities due to injury (Sequalae of Trauma)

## DEFORMITIES OF THE EXTREMITIES DUE TO INJURY

In children post-traumatic deformities occur when the main principles of treating injuries are violated. Gross deformities are encountered in FRACTURES when the rules of reduction and immobilization are not followed.

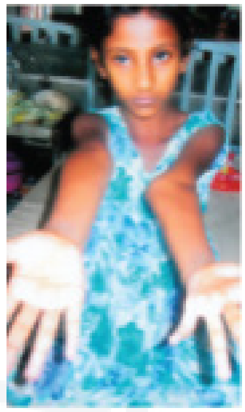
Complications are a fact of life that every orthopaedic surgeon has to face. Complications linked with immobilization are caused by incorrect choice of the type of immobilization and lack of control over the extremity.

These faults are:

1. Application of the plaster cast to an extremity with extensive post traumatic swelling of the soft tissues, in which the fragments are usually displaced. When the swelling diminishes or drastic circulatory disorders develop with progression of the swelling.
2. Application of a plaster splint where traction is needed (in oblique fracture of the femur) or vice versa (in fractures of tibia fibula without displacement of fragments), application of surface traction where skeletal traction is needed and application of an insufficient load.
3. Insufficient or overdue immobilization.
4. Surgical intervention without proper indications, which causes complications more often.
5. Closed methods of treatment when there are absolute indications for surgical intervention (e.g. in soft tissue interposition)

In epiphyseolysis the fragments must be accurately aligned, otherwise growth will be impaired and the extremity shortened and distorted due to irregular development of the newly formed tissue on the whole area of the cartilagenous growth plate. These complications are mainly encountered in evulsion of the condyles and epicondyles in epiphyseolysis of the distal humeral apiphysis (cubitusvarus or cubitus valgus is observed), or the distal radial epiphysis.

cubitusvarus



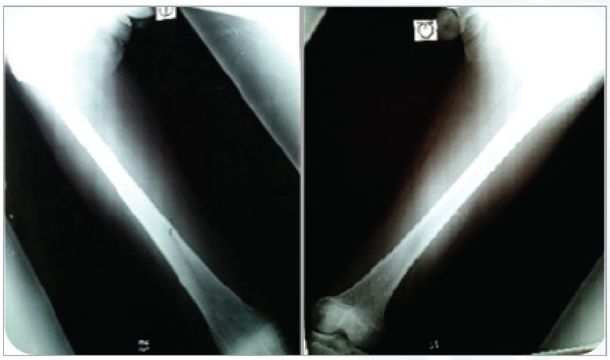
Left cubitus valgus

A nonaligned epiphysis is attended with retardation of radial growth and may lead to Madelung's deformity.


The femur can be considerably shortened upto 10 cm in epiphyseolysis of its lower end.

Tilting of the pelvis (left side) due to injury of left lower femoral growth plate front and back view.

Wooden block showing 3cm LLD front and back view.



X-ray showing injury to the left lower femoral growth plate, as a result 3cm shortening.

**Neglected trauma**

Because of ignorance, poverty and non availability of medical aid, the rural people can not get proper treatment and they are getting mismanagement of their injuries. In Bangladesh almost every village has a bonesetter. Even in big cities there are unqualified bonesetter or massagists. It is obvious that under such circumstances, neglected trauma is a major problem in developing countries like ours.

If there is a neglected nonunion near any joint, the joint becomes stiff and the nature treats the nonunion as the joint, and no mobility occurs at the natural joint. This perpetuates the nonunion which is converted in to synovial pseudarthrosis. When patients come many months or years after injury established principles have to be modified to meet each individual case.

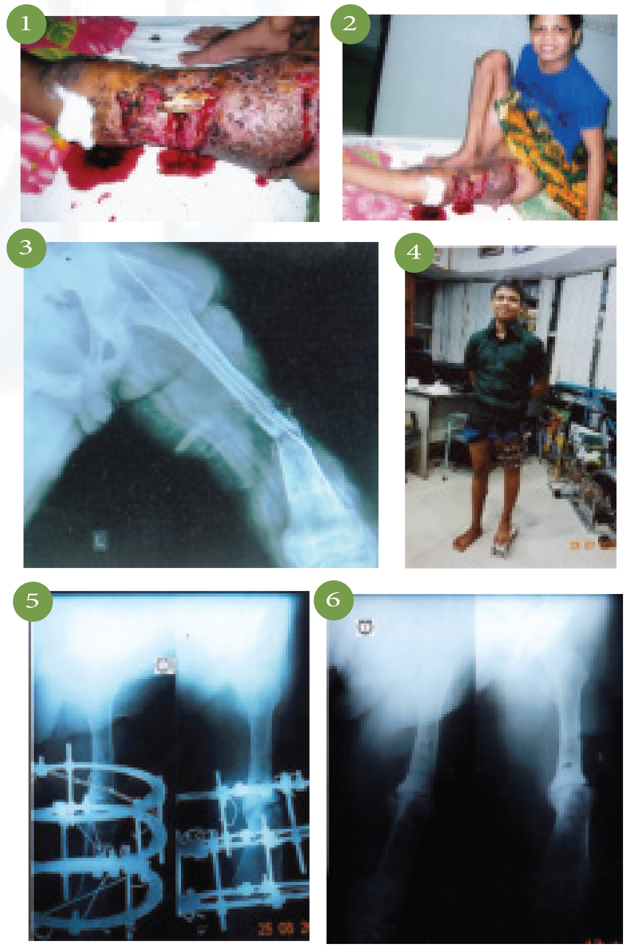
Types of neglected trauma

1. Traumatic and orthopaedic diseases may be totally neglected by the patient
2. The condition may be treated by quack, massagist or a bonesetter or by an unqualified doctor.
3. Negligence by a qualified surgeon.

The untreated fracture may unite in a malposition or may go to nonunion.

Complications due to negligence or wrong treatment Neglected or wrongly treated fracture may develop the following complications-

1. Malunion.
2. Nonunion.
3. Myositis ossificans.
4. Stiffness of the joint.
5. Neurological complication.
6. Vascular complication.
7. Compartment syndrome.
8. Chronic osteomyelitis.
9. Functional loss of the limb due to wasting, stiffness, oedema etc.



1. Open neglected injury of the left femur 12 years old boy.
2. Maltreated by a quack, local bonesetter.
3. Radiographic view of the left femur after 9 months which leads to nonunion.
4. During treatment with Ilizarov apparatus.
5. Radiograph of the left femur with Ilizarov in situ.
6. Final radiographic view with union of the left femur.

Displacement of fragments along the circumference of the bone in fractures of the shaft with time becomesunnoticeable because the compensatory properties of a child's bone, and does not need orthopaedic treatment.

Displacement along the length causes shortening of the bone which, if mild, is also compensated with the child's growth;

Malunion right femur with angulation.

but displacement with angulation has to be fully corrected by reduction. Academician Ilizarov's method for closed reduction of an angular deformities is widely used recently. Gradual controlled coordinated stretching with the application of hinges at the level of CORA can easily correct the deformity if the bone callus is still not sufficiently strong.

## Case Study 1

1. Antero lateral bowing (angulation) of right tibia.
2. X-ray showing hypertrophic nonunion with gross antero lateral angulation.
3. During treatment with Ilizarov apparatus.
4. X-ray showing correction of the deformity.
5. X-ray showing full correction of the deformity with good consolidation.
6. Clinical appearance of the child after the correction of the deformity.

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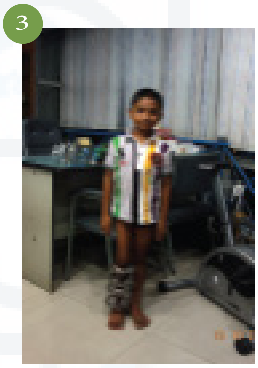

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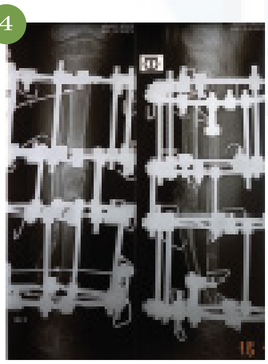

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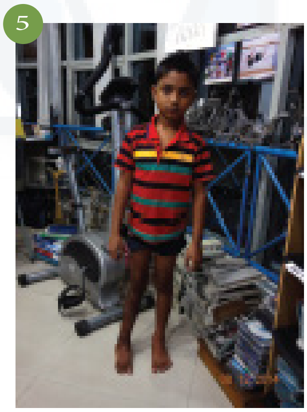

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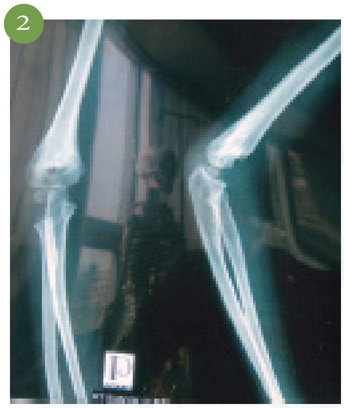
Pseudoarthrosis are a very rare sequelae to fractures in paediatric group and arise in vertical displacement of the fragments with simultaneous soft tissue interposition or when infection develops in the fracture area. Pseudoarthrosis which forms after fractures are best treated by compression or distraction method by Ilizarov apparatus.

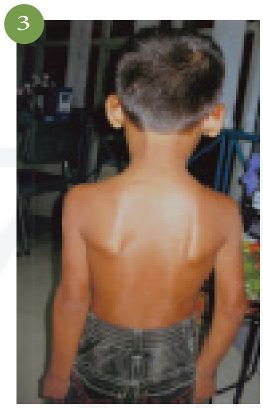
The distorted joints in children after intra-articular fractures or injuries are aggravated by haemarthrosis.

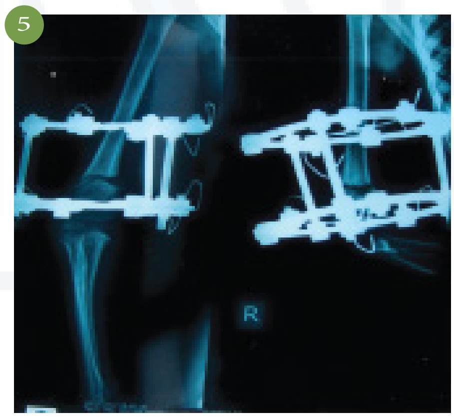
The complications that we see in children in elbow like bony or dermatogenic contractures and ankylosis

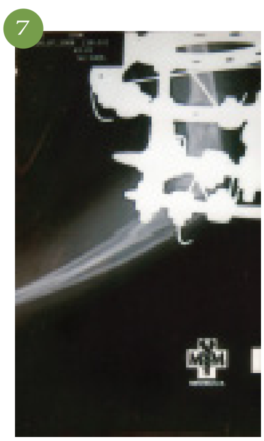
Gross varus and valgus deformities (cubitus varus and cubitus valgus) in older children can be treated by gradual open-wedge osteotomy with Ilizarov apparatus.

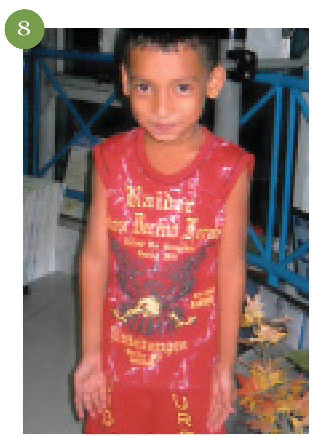
## Case Study 2









1. 6 years old child, right cubitus varus (front view).
2. Radiograph of right elbow, cubitus varus, before surgery.
3. 6 years old child, right cubitus varus (back view).
4. Placement of Ilizarov wires.
5. Radiograph of right elbow with Ilizarov fixator in situ.
6. Child with Ilizarov ring fixator.
7. Correction of the varus deformity with Ilizarov in situ.
8. After correction (front view view).
9. After correction (back view)

## Case Study 3

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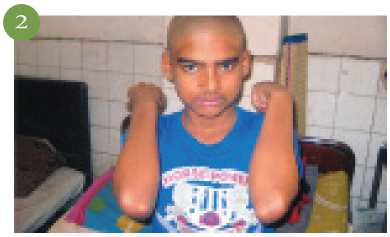

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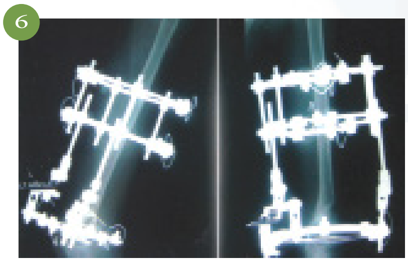

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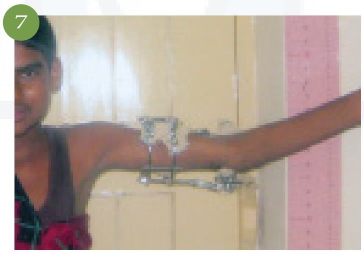

1. 14 years old boy left cubitus valgus.
2. Flexion position before surgery.
3. Smilling patient with Ilizarov apparatus in the left humerus.
4. Full correction of left cubitus valgus with Ilizarov apparatus in situ after 1 month follow up.
5. Lateral view of left humerus with Ilizarov apparatus after one month follow up.
6. Radiographic view of opening wedge osteotomy with placement of hinges over the CORA (Center of rotation of angulation) after 2 months follow up.
7. Patient is doing exercises with Ilizarov apparatus.
8. Patient can continue exercises with the Ilizarov apparatus.
9. Clinical appearance of the patient after 3 months follow up (front view in extension of elbow).

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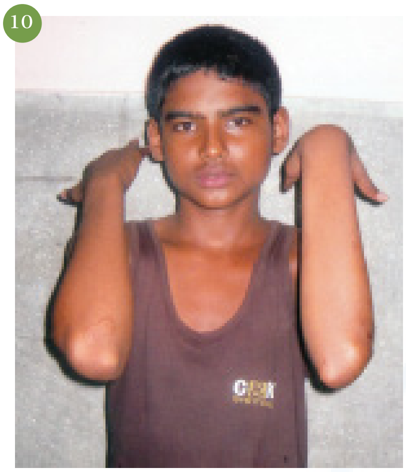

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10. Clinical appearance of the patient after 4 months follow up.

11. Clinical appearance of the patient after 3 months follow up (front view).

12. Clinical appearance of the patient after 3 months follow up (back view in abduction).

13. Clinical appearance of the patient after 3 months follow up (back view in extension of elbow).

14. Final radiographic result after 4 months follow up.

15. Clinical appearance of the patient after 4 months follow up.

16. Clinical appearance of the patient after 4 months follow up.

17. Clinical appearance of the patient after 4 months follow up.

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## Case Study 4

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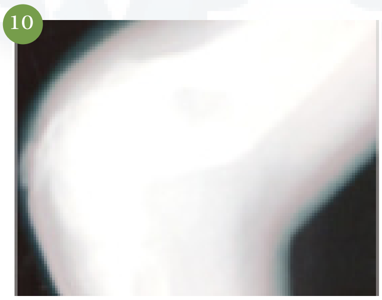
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1. 9 years old girl, nonunion lateral condyle, left cubitus valgus with tardy ulnar nerve palsy.
2. Late deformed elbow.
3. Left cubitus valgus 9 years old girl.
4. One month after osteosynthesis with Ilizarov (opening wedge valgus osteotomy).
5. After two months post. op.
6. Radiographic view of left elbow with Ilizarov in situ after one month follow up.
7. Radiograph of lateral condyle fracture with cubital valgus and open wedge osteotomy of left humerus.
8. Just after removal of the Ilizarov apparatus.
9. Radiographic union of left lateral condyle and correction of left cubitus valgus.
10. Radiographic union of left lateral condyle and correction of cubitus valgus is achieved (lateral view).
11. After 2½ months follow up.
12. Radiographic results aftr 3½ months.

## Case Study 5

Volkmann's ischaemic contracture is of particular importance among traumas of the extremities.

### Volkmann's Ischaemic contracture of left wrist and hand

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Ischaemic contracture of the superior extremity is marked by involvement of the median nerve and less frequently by the radial and ulnar nerves. The hand is bent and when an attempt is made to straighten it out the fingers flex owing to cicatrical (dermatogenic) degeneration and shortening of the flexors. Only mild and moderate forms of the disease respond to conservative treatment which includes massage and physiotherapy along with the application of extension splints. After correcting the wrist flexion deformity by Ilizarov method, the tendons of the flexors of the hand and fingers are lengthened or the radius and ulna can be shortened and fixed with Ilizarov apparatus.

## Case Study 6

1. VIC of right wrist and hand of a 7 years old boy (elbow in extension).
2. VIC of right wrist and hand (elbow in flexion).
3. X-ray of the elbow forearm wrist and hand before surgery.
4. Ilizarov in the right distal forearm and hand with hinges.
5. Radiographic view of forearm and hand with hinges.
6. Clinical appearance of the patient after 5 months follow up.

## Case Study 7

**Atrophic gap nonunion right upper humerus**

1. Radiographic view atrophic gap non union of right upper humerus.
2. Radiographic view of both shoulder and arms.
3. Author with the patient.
4. Smilling patient with Ilizarov apparatus.
5. Radiographic view of humerus with Ilizarov fixator in situ.
6. Smilling girl with the Ilizarov fixator.
7. Radiographic view of right shoulder; Union is achieved.
8. Flexion is almost gained.
9. Radiographic result after 5 months.
10. Patient can elevate her shoulder.
11. 3 cm LLD. Which is acceptable (Front view).
12. 3 cm LLD. Which is acceptable (Back view).

## Case Study 8

### Hypertrophic nonunion of humerus

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1. Radiograph of hypertrophic non union of right humerus.
2. Radiograph of right humerus with one ring below and author's innovated arch in the upper humerus with three schanz screws in the upper humerus.
3. Radiograph of right humerus with good union is seen because of distraction osteogenesis.
4. Radiograph of right humerus before treatment.
5. Radiograhp of right humerus with good consolidation is seen, after treatment

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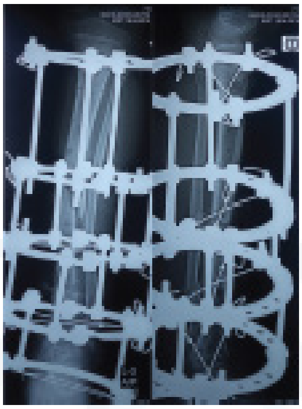
## Case Study 9

7 years old boy, 18 days old open fracture left lower tibia fibula with uniaxial fixator in situ.



Uniaxial fixator removed and Ilizarov applied.

External view of the left leg with Ilizarov in situ, during treatment after 4 weeks follow up.

Radiograph of left tibia fibula after removal of Ilizarov apparatus.

Clinical appearance of the patient after 2 months follow up (front and back view)

# Chapter 28
# Reconstruction of the Limb versus Amputation

Reconstruction of the limb due to badly injured trauma for successful outcome depends on several factors:

Some of these are-

1. Type of injury.
2. Time of injury.
3. Poor blood supply.
4. Age of the Patient.
5. Condition of the patient at the time of injury may be because of shock.
6. Multiple organ failure.
7. Other comorbid conditions and facilities for proper management of any trauma patient.

We leave in a time of great change. Our approach to trauma patient has changed, as well. We now try to save limbs and restore normal function in severely injured limbs that would have been amputed 40 years ago. We have made remarkable progress in the management of fractures and dislocations due to considerable new knowledge in fracture fixation. New options and procedure for managing simple and complex musculoskeletal injuries, advances in sepsis prevention and treatment, improved understanding of immunologic and metabolic response to trauma and better training for surgeons and paramedical staffs. For fracture and dislocation management there are various satisfactory treatment options. You can choose which option is appropriate for the particular musculoskeletal injury you are treating. The wise surgeon should discriminate among management options based on their merits.

Good blood supply to both soft tissue and bone is mandatory for a successful reconstruction of the limb. There is still controversy regarding early fixation of fractures by means of internal fixation, as it may damage the already injured vascular supply of a limbs by reaming the medullary canal both the thermal and mechanical damage in the presence of supplied periosteum. Intramedullary nailing may damage the vascular supply of medullary control while plating may hamper the blood supply of underlying bone.

In our opinion external transosseous Ilizarov Fixation offers certain advantages over internal fixation devices:

1. Compression can be maintained during the entire treatment period.
2. Fixation can be obtained without inserting hardware at the site of pathology- this is an absolute indication in infected pseudarthrosis.
3. As a rule, the application of transosseous apparatus, is less traumatic then the internal fixation device.
4. The fixator can be removed without an additional operation.

Many of the existing external skeletal fixators employ a single plane of pin placement, such a mounting ensures stable fixation of bone fragments in only a single plane i.e the plane of pin placement in clinical use, these devices can be used only to apply longitudinal compression or distraction. Gradual reposition in other places is either impossible or extremely difficult. For this reason, most external fixation systems require operative reduction of the fragments prior to frame application. The method of transosseous osteosynthesis for the past 60 years is a complex treatment system which incorporates many new and extremely effective tactics. The solution of many difficult problems in orthopaedic and traumatology is the discovery of several biologic laws governing the growth of tissues subjected to distraction and loading.

Indeed, the transosseous osteosynthesis can cure injuries, diseases & deformities previously considered incurable. With the fixator, for the first time, the optimum biologic and mechanical conditions for regeneration, remodeling and rehabilitation in the rehabilitation in the treatment of fractures and orthopaedic diseases. With the increasing knowledge for limb salvage procedure it is becoming clear to identify the need of limb amputation at first go rather than putting patient under tremendously expensive, occasionally life threatening and usually futile attempts to salvage the severely injured limb. Advances in the design of artificial limbs, particularly in the lower limbs may give a comparatively comfortable life with his savings, job, family and dignity intact. Decision to amputate the upper limb is even more difficult because of its use in day to day activities.

The absolute indication for primary amputation of the limb included complete disruption of posterior tibial nerve in adults or crush injuries with worm ischemia more than 6 hours. Relative indications included serious associated multiple injuries, severe ipsilateral foot trauma or an anticipated protracted course to obtain soft tissue coverage and tibial reconstruction. It has been recommended that primary amputation may be advised if either one of the absolute indications or two of the three relative indications were present. Amputation is the final answer for major injuries and should be considered, if the patient does not have sufficient resources to go through with the course of treatment or if the leg will be barely functional and a constant source of pain. Distraction osteogenesis introduced by Academician Gavriil Ilizarov and transplant with a free muscle flap have reduced the number of amputations about major bone and soft tissue defects, as well as reduced the time of treatment. Functional and useful lower limb which could bear the body weight is always demanding and more natural. Ilizarov technique is fantastic for paediatric age group and results of reconstruction in these age group are rewarding and encouraging also. Preference of treatment by Ilizarov remains the salvage of vascularized, sensate and non-infected limb.

Open fracture dislocation with arterial injury requiring repair is the most challenging problem for orthopaedic surgeon. The amputation rate in such injury ranges from 25% to 90%. The two major causes of amputation are sepsis and failure to achieve arterial flow to the involved extremities, particularly when arterial repair is not done within 6 hours of the injury. The two major risk factors in type III C injury are shock on admission and crush injury. 90% of patients with type III C injury with crush injury to the lower portion of the leg ended up with amputation in spite of immediate arterial repair. Arterial repair is strongly recommended within limb 4-6 hours, along with an interposition graft and adequate prophylactic fasciotomies. Treating the injury requires a high level of expertise and calls for an experienced vascular surgeon. The incidence of wound sepsis in open fractures correlates directly with the extent of safe tissue damage.

**INFECTION RATES ARE AS FOLLOWS:**

| | | |
|---|---|---|
| Gustilo Type-I | : | 1 % - 2% |
| Type-I | : | 2% - 7% |
| Type-III | : | 10% - 25% |
| Type-III A | : | 7% |
| Type-III B | : | 10% - 50% |
| Type-III C | : | 25% - 50% with an amputation rate of 50% or more. |

**PRINCIPLES OF TREATMENT:**

- Any open fracture should be treated as an emergency.
- Thorough initial evaluation is necessary to diagnose other life threatening injuries.
- Appropriate and adequate antibiotic therapy should be started.
- Debridement and irrigation of the wound is mandatory.
- Stabilization of the fracture is necessary.
- We must perform delayed closure of the wound within 3-7 days.
- Decision should be taken for early amputation.
- If compartment syndrome develops, treatment should be started immediately.
- Rehabilitation of the affected extremity.

**LIFE THREATENING INJURIES:**

90% open fractures occurs from MVC 30% of patients with open fractures have injuries to other system.

In case of open fractures we should follow the followings-

- Identify two intravenous sites.
- Obtain chest and skeletal X-ray films.
- Total blood Count and urine analysis, serum creatinine, serum electrolysis should be determined.

Accurate documentation of the anamnesis and physical findings in admission is important particularly in case of multiple system injury.

## Case Study 1

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1 & 2. Open fracture right tibial and medial femoral condyle GIIIB

3. Degloving injury with exposed medial tibial and femoral condyle

4. Coverage of the wound by medial gastrocnemius.

5. Partial failure of the coverage due to infection.

6. After 14 days follow up.

7. 7 years old child clinical appearance after 3 months follow up with Ilizarov in situ.

8. 7 years old child clinical follow up after 5 months. Some varus deformity with stiff knee persists.

9. Clinical appearance after 6 months follow up.

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## Case Study 2

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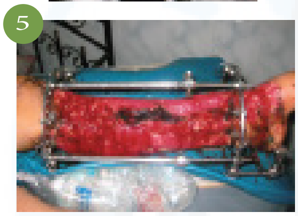

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1. Open degloving injury of left leg with bone loss of left tibia GIIIB.
2. Radiograph of left tibia fibula with bone loss in the lower tibia.
3. Close up view of the left leg with Ilizarov in situ.
4. Ilizarov in the left leg after 1 month follow up.
5. Close up view of the left leg with Ilizarov in situ.
6. Skin grafting was done.
7. After 2 month follow up.
8. Radiograph of right tibia fibula with distraction osteogenesis.
9. After 3 months follow up.
10. Radiograph of left tibia fibula with good regenerate in the upper tibia .
11. After 4 months follow up.

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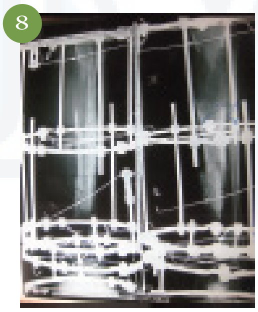

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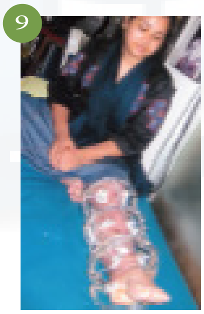

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12. After 4½ months follow up. Front view.
13. After 4½ months follow up. back view.
14. After 6 months follow up.
15. After 6 months follow up.
16. In OR Table before removal of Ilizarov apparatus.
17. Radiographic result after 6 months.
18. Clinical appearance of the patient.

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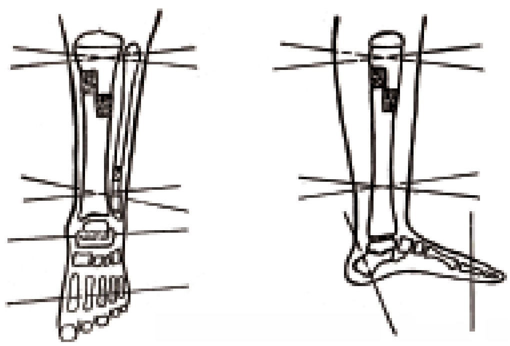

Figure- 4.6: Scheme of methods of leg lengthening. a. Introducing wires and Z-type osteotomy of tibia b. condition after correction of the deformity with distraction regenerate.

## Case Study 3

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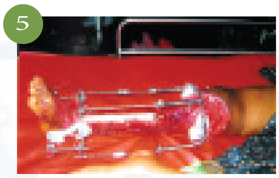

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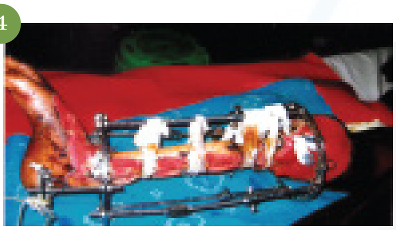

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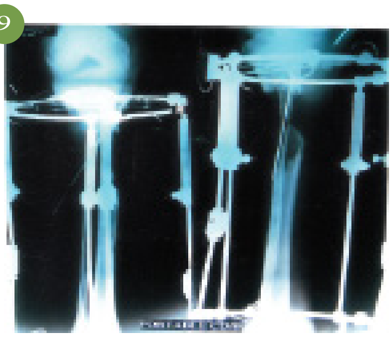

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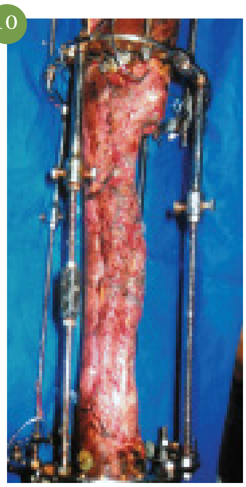

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1. Crush injury of right lowrer femur with right tibia fibula & ankle GIIIB (Floating knee)
2. 14 yrs. old girl with Crush injury of right lower femur with right tibia fibula & ankle GIIIB
3. Exposed right whole tibia with Ilizarov in situ, patient in OR
4. After 1 month follow up the right leg with Ilizarov fixator
5. After 1 ½ follow up, right leg with Ilizarov fixator
6. Almost covered the whole tibia with granulation tissue
7. The whole tibia is covered by a good granulation tissue
8. Skin grafting was done
9. Radiographic view tibialization with Ilizarov in situ
10. The whole leg is covered by skin and bone is stabilized by Ilizarov ring fixator
11. Smiling patient after 5 ½ months follow up
12. Clinical appearance of patient after 7 months

## Case Study 4

### OPEN LEFT SUBTROCHANTERIC FRACTURE GIIIA

1. Open left subtrochanteric fracture GIIIA with uniaxial Exfix in situ.
2. Patient is in OR
3. After 2nd post OP.
4. 11 yrs. old boy, Ilizarov apparatus in the left thigh.
5. Patient can walk with the help of axillary crutches.
6. After 4 months follow up.

7 & 8. Clinical appearance of the patient after 5 months.

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# Chapter 29

# Legg-Calvé-Perthes Disease (LCPD)

## LEGG-CALVÉ-PERTHES DISEASE

Legg-Calvé-Perthes disease, also known as Perthes' or Legg-Perthes disease, osteochondritis deformans juvenilis, and coxa plana-is a disorder affecting the capital femoral epiphysis. Although it is one of the most common hip disorders of childhood, it has been one of the most confusing and poorly understood diseases in pediatric orthopedics.

In 1909, Waldenstrom first described the radiographic characteristics of Legg-Calvé-perthes disease; the clinical manifestations had been reported earlier. Waldenstrom theorized that the disease was a form of tuberculosis. In separate publications in 1910, Legg in Boston, Calvé in France, and Perthes in Germany described the disorder and recognized it as noninfectious in origin. Legg reported the cases of five children who limped and had femoral head deformity following an injury. He conjectured that trauma or injury and the resultant pressure produced the characteristic flattening of the femoral head. Calvé presented ten cases of femoral head deformity that he thought were a consequence of abnormal or delayed osteogenesis. Perthes attributed the deformity to nonspecific inflammation. In 1973, he was the first to describe the histologic changes (cartilaginous islands in the epiphysis and wide, fat-filled marrow spaces) associated with the disorder.

Since these initial reports, many articles have been written on Legg-Calvé-Perthes disease. Most of these articles were speculative with regard to etiology and pathogenesis, or they presented the results of a variety of methods of treatment. The scarcity of scientific investigative work on this disorder has led to considerable confusion.

## OSTEOCHONDROSES

Legg-Calvé-Perthes disease is classified as one of the osteochondroses, a group of disorders characterized by avascular necrosis and disordered endochondral ossification of the primary and secondary centers of ossification. The etiology is idiopathic and may be different for each of these disorders. The commonly involved primary centers of ossification include the tarsal navicular bone (Kohler's disease), carpai lunate bone (Kienbock's disease), and vertebral body (Calvé's disease). The secondary ossification centers (epiphyses and apophyses) that are frequently involved include the capitulum humeri (Panner's disease) and metatarsal head (Freiberg's disease), as well as the capital femoral epiphysis. Disturbed endochondral ossification of the secondary centers may result in partial or complete closure of the epiphyseal growth plate (physis) with resultant shortening or angular, deformity of a long bone. Deformities, of the articular surface of an involved epiphysis can also occur and affect the integrity of the joint surfaces. Both alterations can predispose to pain and late degenerative osteoarthritis. Legg-Calvé- Perthes disease, one of the most common osteochondroses, is associated with potential long-term morbidity.

## DIFFERENTIAL DIAGNOSIS

Transient monoarticular synovitis of the hip frequently mimics early Legg_Calvé_perthes disease. Synovitis, a common cause of limping, often occurs 1-2 weeks after a viral upper respiratory infection. Radiographic examination is usually normal but occasionally reveals hip capsular distension. Bone scans are also normal but can aid in distinguishing between these two disorders. Early in the acute phase of bacterial infections of the hip joint (for example, septic arthritis and osteomyelitis), the clinical characteristics may be similar to those of Legg-Calvé-Perthes disease. If a child exhibits an irritable hip and low-grade fever, a diagnostic hip aspiration (arthrocentesis) may be necessary. On aspiration, the presence of seropurulent fluid with an elevated white blood cell count indicates a septic disorder.

Gaucher's disease, sickle cell disease, and skeletal dysplasias such as multiple epiphyseal dysplasia and spondyloepiphyseal dysplasia are other disorders associated with avascular necrosis of the capital femoral epiphysis. In these diseases, the radiographic changes are similar to those in Legg-Calvé-Perthes disease If a child has bilateral involvement, skeletal dysplasia must be considered. A radiographic skeletal survey, including a lateral view of the spine, is necessary for a definitive diagnosis. Avascular necrosis of the capital femoral epiphysis can also occur as a complication of trauma (femoral neck fracture and hip dislocation) or as a result of therapy for congenital dislocation of the hip or slipped capital femoral epiphysis.

## PREDISPOSING FACTORS

### Genetic Aspects

The families of children with Legg-Calvé-Perthes disease exhibit an increased incidence of the disorder varying trom 2% to 20%; there is, however, no consistent pattern of inheritance. In 1978, Wynne- Davis and Gormley (in a study of 350 involved children) reported that, although the pregnancies had been uneventful, the incidence of low birth weight and abnormal birth presentations was higher than the norm. They also found that the parents were older than in the general population, and that the disease occurred more often in later born children, particularly the third to sixth child.

The disorder occurs predominantly in males (four to five times more often than in females). Asians, Eskimos, and whites have a higher incidence of the disease, whereas Australian origines, American Indians, Polynesians, and blacks have a lower incidence of Legg-Calvé-Perthes disease. A higher than normal incidence of minor congenital genitourinary anomalies, such as renal abnormalities, inguinal hernias, or undescended testicles, is seen in children with Legg-Calvé-Perthes disease as well as in their first-degree relatives.

### Abnormal Growth and Development

Legg-Calvé-Perthes disease may be a manifestation of an unknown systemic disorder rather than an isolated abnormality of the hip joint. The bone age of children with Legg-Calvé-Perthes disease is typically lower than their chronologic age by 1 to 3 years. As a consequence, involved children are usually shorter than normal children of the same age, and the shortness of stature, although slight, persists into adulthood.

Burwell and associates demonstrated disproportionate growth as well as abnormalities in skeletal growth and maturation in involved children. The affected children were smaller in all dimensions (except head circumference) with disproportionately smaller distal segments of the extremities. The association between abnormal growth and development and subsequent Legg-Calvé-Perthes disease is unknown.

**Environmental Factors**

Although the effect of environment on the incidence of the disorder is unclear, a high percentage of involved children come from lower socioeconomic groups. Whether this reflects dietary or environmental influences or a combination thereof is uncertain.

**ETIOLOGY**

The etiology of Legg-Calvé-Perthes disease remains unknown, but it is currently accepted that the disorder is caused by an interruption of the blood supply to the capital femoral epiphysis. Avascular necrosis of the capital femoral epiphysis has been produced experimentally in animals by placing a ligature around the femoral neck, thereby interrupting the extraosseous (but intracapsular) blood supply to the epiphysis. Correlation of the radiographic and histologic changes in experimental animals with the few available specimens of involved human hips has revealed a similar pathologic process.

The unique arterial blood supply to the developing proximal femur during childhood must be appreciated to understand the pathogenesis and pathology of Legg-Calvé-perthes disease. The three main sources of blood to the proximal femur are the extra capsular arterial ring, the ascending retinacular vessels, and the artery of the round ligament of the femur (ligamentumteres).

The extracapsular arterial ring and the ascending retinacular vessels derive from the medial and lateral femoral circumflex arteries, which arise in the femoral triangle (plate 1). The medial circumflex femoral artery, usually a branch of the medial or posterior aspect of the femoral artery, courses posteriorly between the iliopsoas and pectineus muscles and then between the medial capsule and obturator externus muscle before passing along the posterior intertrochanteric line. It gives off the small inferior retinacular (medial ascending) artery that penetrates the capsule and progresses subsynovially up the femoral neck, giving branches to the femoral neck and then passing over the epiphyseal growth plate to enter the capital femoral epiphysis.

Posteriorly, the continuation of the medial femoral circumflex artery communicates with branches of the superior gluteal artery and gives off very small posterior retinacular branches. The termination of the medial femoral circumflex artery becomes the superior retinacular (lateral ascending) artery, which subsequently supplies the greatest proportion of arterial blood to the capital femoral epiphysis. The superior retinacular artery penetrates the capsule in the trochanteric notch (an extremely narrow space between the greater trochanter and femoral neck) and is, therefore, vulnerable to occlusion from compression.

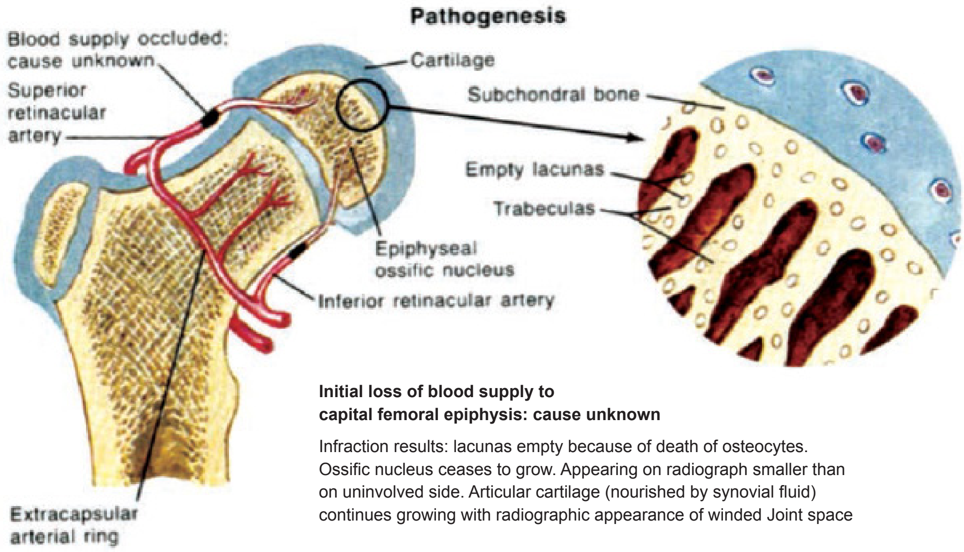
The lateral femoral circumflex artery usually originates from the deep femoral (profunda femoris) artery but can be a branch of the femoral artery. It passes lateral and anterior to the iliopsoas muscle, giving off the anterior retinacular (anterior ascending) branch to the femoral neck and epiphysis. The lateral femoral circumflex artery communicates with the medial femoral circumflex arterv in the trochanteric fossa, completing the extracapsular arterial ring. The anterior portion of this ring is thus derived primarily from the lateral femoral circumflex artery, whereas the medial, posterior, and lateral portions branch from the medial femoral circumflex artery.

The branches of the ascending retinacular arteries form a subsynovial anastomotic intraarticular arterial ring at the margin of the articular, cartilage of the femoral head. Chung's postmortem perfusion study of immature human hips revealed that the anterior portion of the intra-capsular ring was often incomplete, especially in males; he proposed that this had possible etiologic significance in Legg-Calvé-Peithes Disease. This study also showed that the epiphyseal growth plate was an absolute barrier to blood flow between the epiphysis and metaphysis or femoral neck, which explains why the primary changes of avascular necrosis are limited to the capital femoral epiphysis. The artery of the ligamentum teres contributes only a small portion of the arterial blood supply to the center of the femoral head and does not seem to be etiologically significant.

Proposed conditions that may cause interruption of arterial blood flow to the femoral head include trauma to the retinacular vessels, vascular occlusion secondary to increased intra-capsular pressure from acute transient synovitis, venous obstruction with secondary intraepiphyseal thrombosis, and increased blood viscosity resulting in stasis and decreased blood flow. Although all these factors may be causative, no conclusive data are available. The etiology may be ultimately multifactorial.

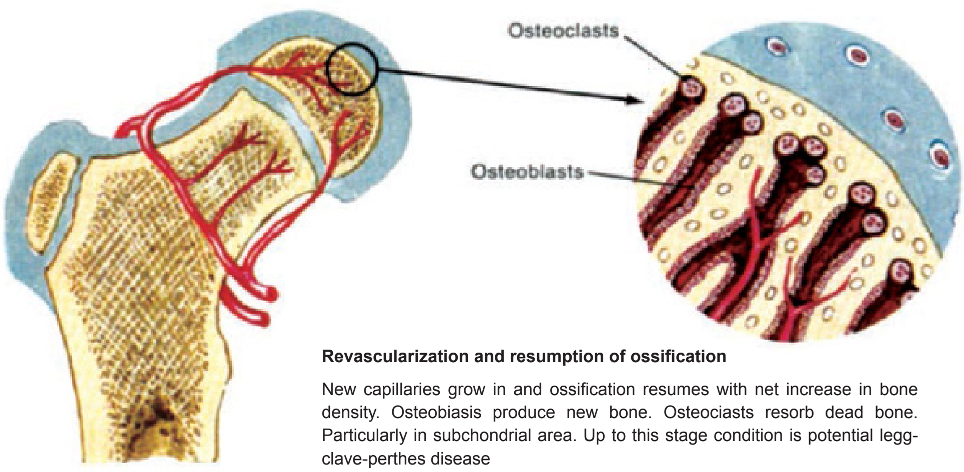
**PATHOGENESIS**

Although the etiology of Legg-Calvé-Perthes Disease is unknown, its pathogenesis and pathology have been demonstrated by investigations of induced avascular necrosis in young pigs, histopathologic studies of a few human specimens, and sequential radiographic analyses of the hip, of many involved children. Initially, an ischemic episode of unknown cause occurs, rendering most, if not all, of the capital femoral piphysis avascular. Endochondral ossification in the preosseous epiphyseal cartilage and growth plate ceases temporarily, while the articular cartilage, nourished by the synovial fluid.



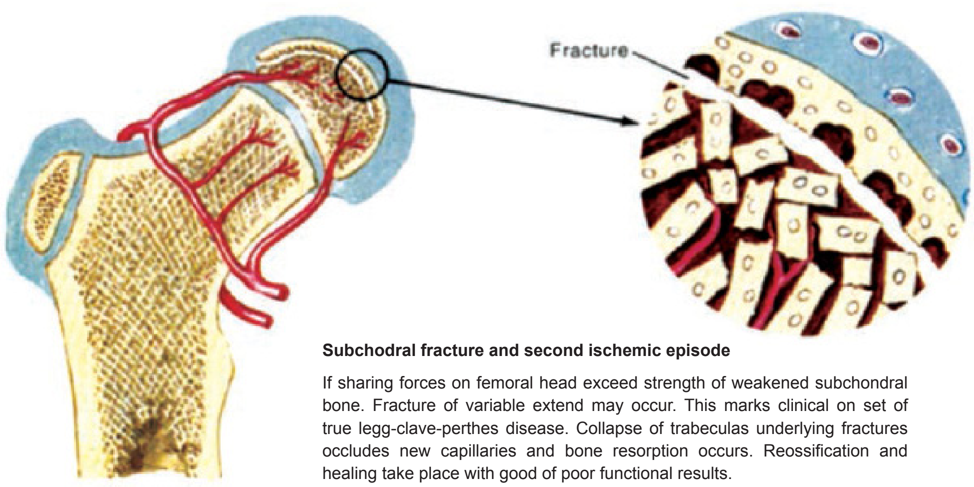

**Initial loss of blood supply to capital femoral epiphysis: cause unknown**

Infraction results: lacunas empty because of death of osteocytes. Ossific nucleus ceases to grow. Appearing on radiograph smaller than on uninvolved side. Articular cartilage (nourished by synovial fluid) continues growing with radiographic appearance of winded Joint space




**Revascularization and resumption of ossification**

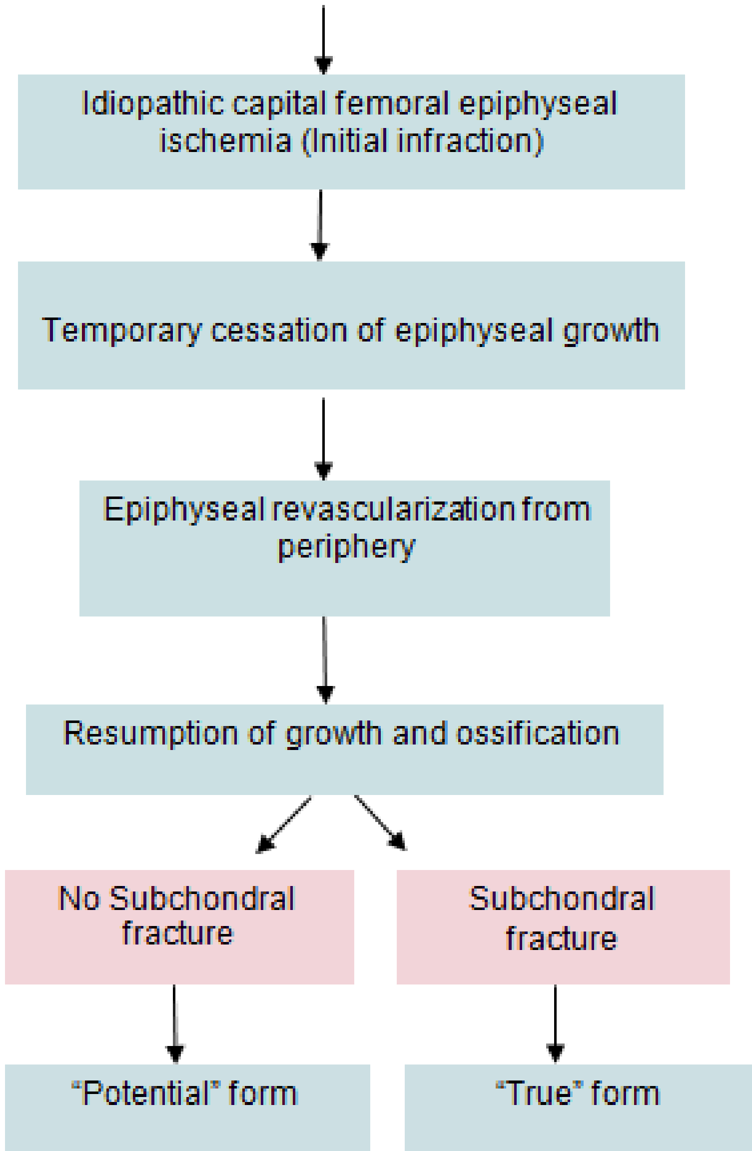
New capillaries grow in and ossification resumes with net increase in bone density. Osteobiasis produce new bone. Osteociasts resorb dead bone. Particularly in subchondrial area. Up to this stage condition is potential legg-clave-perthes disease




**Subchodral fracture and second ischemic episode**

If sharing forces on femoral head exceed strength of weakened subchondral bone. Fracture of variable extend may occur. This marks clinical on set of true legg-clave-perthes disease. Collapse of trabeculas underlying fractures occludes new capillaries and bone resorption occurs. Reossification and healing take place with good of poor functional results.

**Pathogenesis of Legg-Calve-Perthes Disease**



## CLINICAL CHARACTERISTICS

The clinical onset of Legg-Calvé-Perthes disease typically occurs in boys between the ages of 4 and 8 (mean age, 7 years), but it can appear as early as 2 years of age or as late as 12 years. When involvement is bilateral, the changes usually appear in one hip at least 1 year earlier than in the other. If the child is older than 12 at the time of clinical onset, the disorder is not considered true Legg-Calvé- Perthes disease but rather adolescent avascular necrosis, which has a poor prognosis similar to that of the adult form.

## SYMPTOMS

Most children present with mild and intermittent pain in the thigh or a limp, or both. The onset of pain may be acute or insidious. A small percentage of children have a history of trauma, but this is usually mild. Nevertheless, such trauma may be sufficient to produce the pathologic subchondral fracture. The classic presentation has been described as a "painless limp": the child limps but does not complain of discomfort. Upon close questioning, however, most children admit to mild pain either in the hip or in the anterior thigh or the knee. Referred pain from the hip to the anterior thigh or knee must be considered in this or any other pediatric hip disorder, and such pain always necessitates careful examination of the hip.

Because the child's presenting symptoms are usually mild, parents frequently do not seek medical attention for several weeks, or longer, after clinical onset. If the underlying cause of the referred pain is not recognized, the diagnosis may be delayed even further.

EXAMINATION

The pertinent early physical findings in Legg-Calvé-Perthes disease include the following:

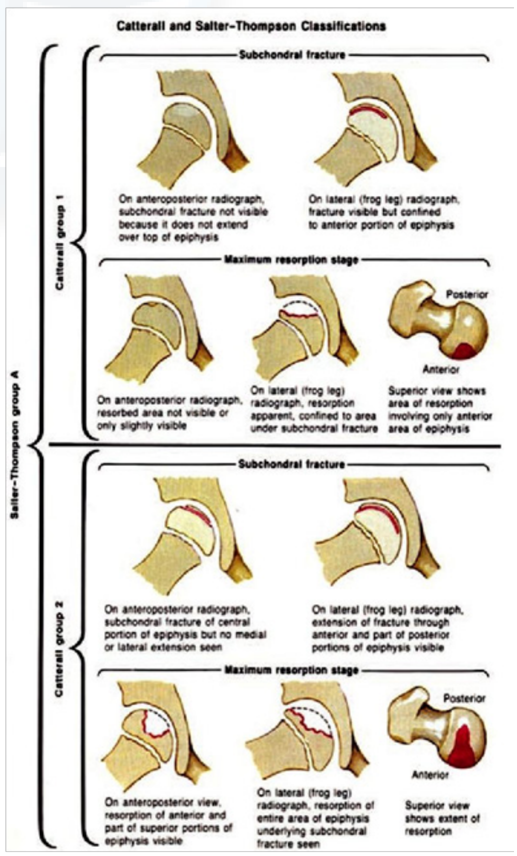
1) Antalgic gait;
2) Muscle spasm and restricted hip motion;
3) Proximal thigh atrophy; and
4) Short stature.

Antalgic gait. A patient with an antalgic (painful) gait shortens the time of weight bearing on the involved extremity during the stance phase of walking. The stance phase on the uninvolved side is normal. The pain from an irritable hip can also cause reflex inhibition of the hip abductor muscles with a resultant positive Trendelenburg test, a common early sign.

Muscle spasm. This is best detected by the "roll" test, which reveals any guarding or muscle spasm (secondary to irritability of the hip joint) on the involved side, especially when the limb is rolled inward. This gentle, painless test relieves the child's apprehension about the examination. Once the child's confidence is gained, the hip can usually be examined more completely to determine the complete range of motion. The typical finding is mild limitation of motion, particularly abduction and internal rotation. There also may be limitation of extension as evidenced by a mild hip flexion contracture (Plate 3), as well as deep tenderness over the anterior aspect of the hip.

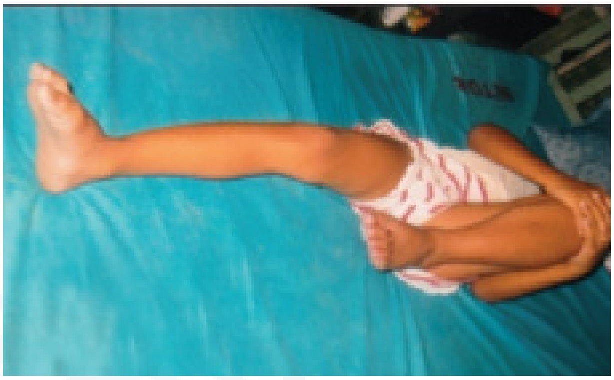
Proximal thigh atrophy. Disuse atrophy of the proximal thigh muscles is a consequence of prolonged hip irritability and the resultant limitation of motion. To determine the amount of atrophy, it is important to measure the circumference of both thighs at the same level, using a standard measurement from a bony landmark (such as the anterior superior iliac spine) as a guide. Usually, the atrophic thigh is 2 to cm smaller (occasionally more), specially during the early symptomatic phases. As the symptoms subside, the atrophy resolves.

**SHORT STATURE:** Children with legg-Calvé- Perthes disease are typically short in stature because of a delayed bone age. A comparison of radiographs of the left hand and wrist with the Greulieh and Pyle atlas determines the child's bone age. The only laboratory test that is occasionally abnormal is the erythrocyte sedimentation rate, which is often slightly elevated (30 to 40 mm/hour).



## Physical Examination

9-years-old child demonstrating limitation of internal rotation of right hip. Hip rotation best assessed in prone position because any restriction can be detected and measured easily



Same child demonstrating Thomas test for hip flexion contracture. Opposite hip flexed only until lumbar spine is flat against examining table. Lack of full extension in involved hip recorded. Child demonstrates 15o hip flexion contracture typically found in Legg-Calvé- Perthes disease.

Trendelenburg test. Boy at left, standing on left leg, demonstrates negative test of right hip. At right, same boy demonstrates positive Trendelenburg test of involved right hip. Left side of pelvis drops; pelvis cannot be maintained level by left gluteus medius because of pain originating in hip joint. Trunk shifts right as patient attempts to decrease biomechanical stresses across involved hip and thereby maintain balance

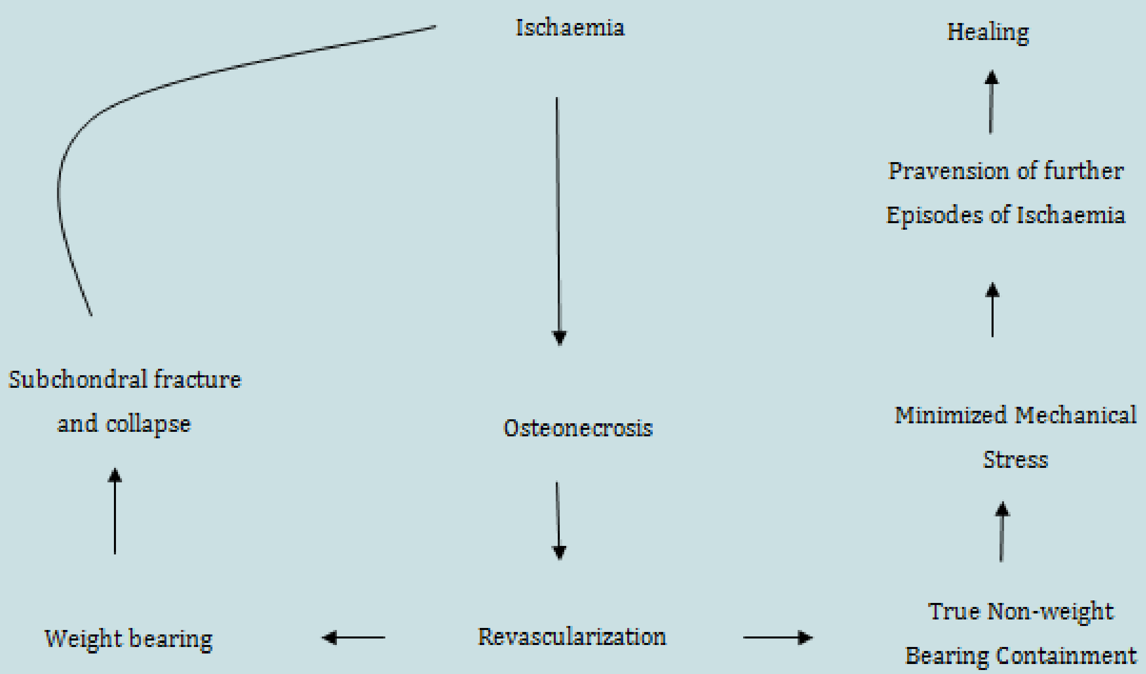
“Roll” test for muscle spasm. Patient relaxed, lying supine on table. Examiner places hands on right limb, gently rolls hip into internal and external rotation, noting resistance

Test for limitation of abduction. With child supine on table and relaxed, lower limbs gently and passively abducted to determine degree of motion of each limb.

Determination of proximal thigh atrophy. Circumference of each upper thigh measured and difference noted. Measurements should be made at most proximal level of thigh

**PERTHES DISEASE**

Hypothetical Vicious Cycle indicating relations among the mechanical stresses, femoral had deformity and Ischaemia episodes



## Case Study 1

1. Radiograph of left hip Legg-Calvé–Parthes disease, caterall type iv.
2. 7 years old smiling patient with Ilizarov apparatus in the left hip and thigh. Special cot is for hip and thigh.
3. Patient with Ilizarov apparatus.
4. Radiographic view of left hip with Ilizarov in situ after 2 months.
5. Radiographic view of left hip; good repair of the equiphyis is seen.
6. 7 years old girl–Legg-Calvé-Parthes disease: Clinical appearance after removal of the apparatus.

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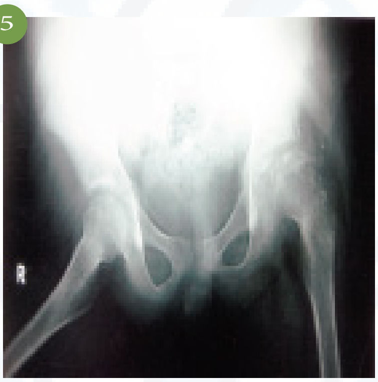

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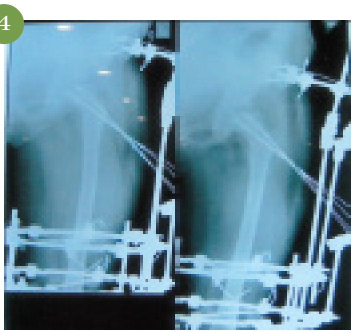

## Case Study 2

1. Frog leg view- damage of epiphysis; before surgery.
2. Radiograph of both hip; effecting the right hip.
3. 12 years old girl – Ilizarov fixator in the right hip.
4. Radiograph of right hip with Ilizarov in situ, repair of epiphysis is going on.
5. Doing abduction exercises with Ilizarov fixator.
6. Doing forward bending exercises with Ilizarov fixator.
7. Doing extension exercise with Ilizarov fixator.
8. Radiographic result of right hip. A good repair of the epiphysis is seen.
9. Clinical appearance of the patient. Final results after 6 months.

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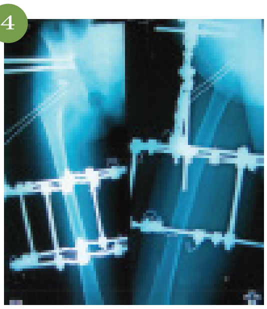

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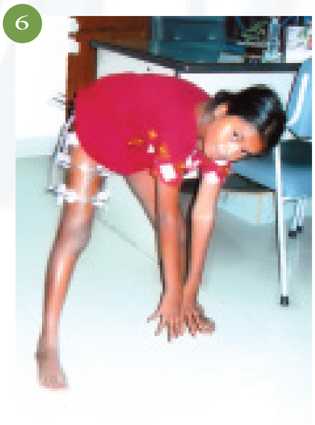

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## Case Study 3

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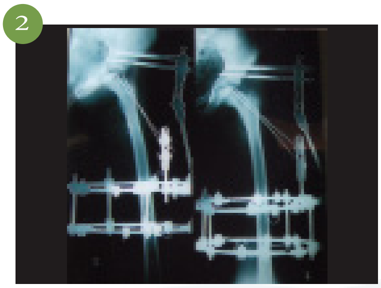

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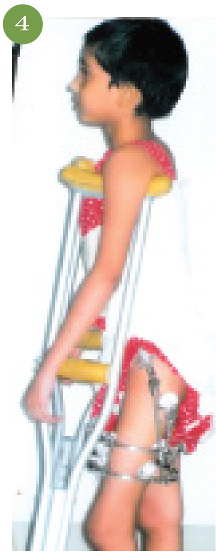

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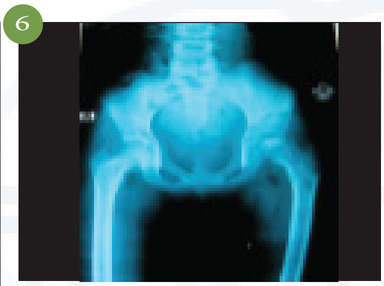

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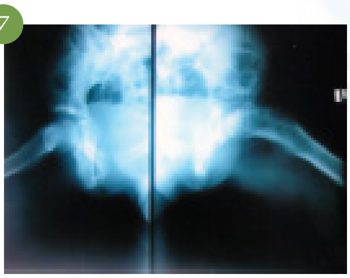

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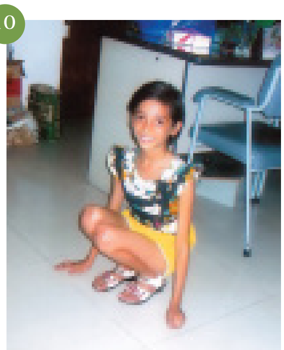

1. Radiograph of both hip, Frog leg view. Left hip is affected. (before surgery).
2. Radiograph of left hip with Ilizarov in situ.
3. 10 years old girl– With Iliarov fixator in the left hip.
4. Patient can move with the crutches easily.
5. Radiographic result after the removal of the fixator, 4 months follow up.
6. Radiographic result after 5 months follow up. (AP view)
7. Radiographic frog leg view after 5 months follow up.
8. Abduction is normal.
9. Radiographic result after 9 months follow up.
10. Clinical appearance of the patient. The patient can squat easily.

## Case Study 4

1. 6 years old boy– Right hip abduction is restricted.
2. Left side abduction is free.
3. Radiograph of both hip; right side is affected caterall type - IV
4. Radiongraph of right hip with Ilizarov fixator in situ (after 1 month follow up).
5. Child is doing Abduction exercises.
6. Fibrous repair of right hip is going on. 2 months follow up.
7. Radiographic result of right hip epiphyseal height is increased.
8. Clinical appearance of the patient.
9. Abduction of both hip is increased after the treatment. Follow up after 6 months
10. The child can squat easily.

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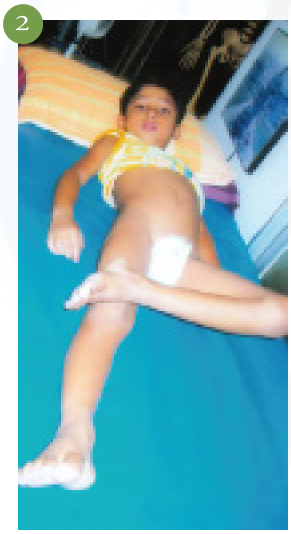

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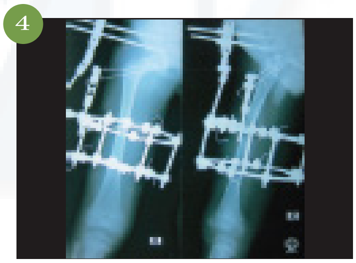

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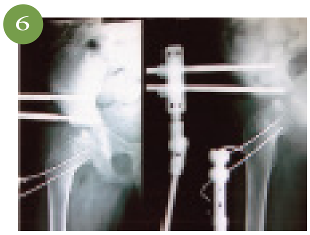

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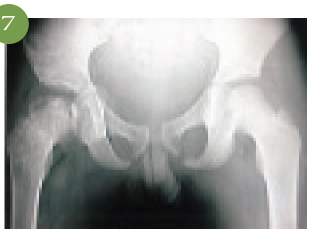

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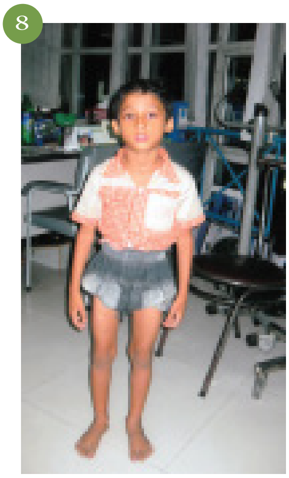

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## Case Study 5

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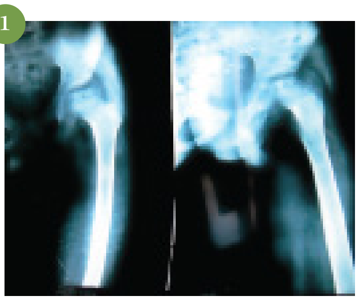

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1. Radiograph of affected left hip.
2. 8 years old boy with Ilizarov fixator in the left hip.
3. Radiograph of left hip with containment, Ilizarov fixator in situ.
4. Radiograph of left hip after 3 months follow up.
5. Radiographic result after 5 months follow up.
6. Clinical appearance of the child.
7. Free abduction of the both hip after the treatment.
8. The child can squat easily after months follow up.

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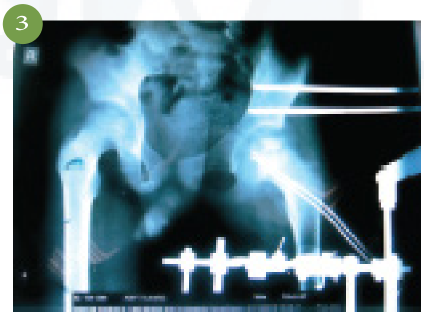

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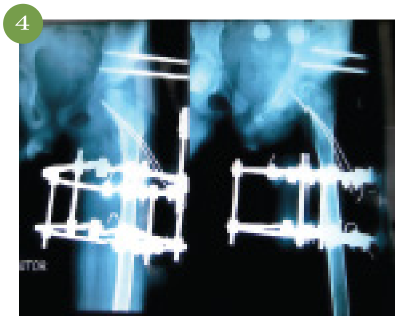

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## Case Study 6

1. Radiograph of both hip; affected right hip caterall type IV
2. 6 years old boy is happy with the Ilizarov fixator.
3. Radiograph of right hip with Ilizarov in situ after 1 month.
4. Close up View of Ilizarov fixator in the right hip.
5. 6 years old child with Ilizarov fixator in the right hip after 1½ months.
6. Smiling patient with the Ilizarov fixator after 2 months follow up.
7. Radiographic result of right hip; after 6 months. A good fibrous repair is seen in the right hip.

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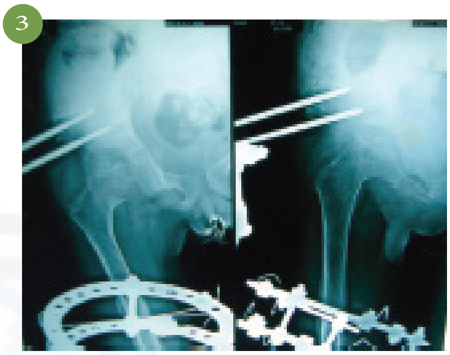

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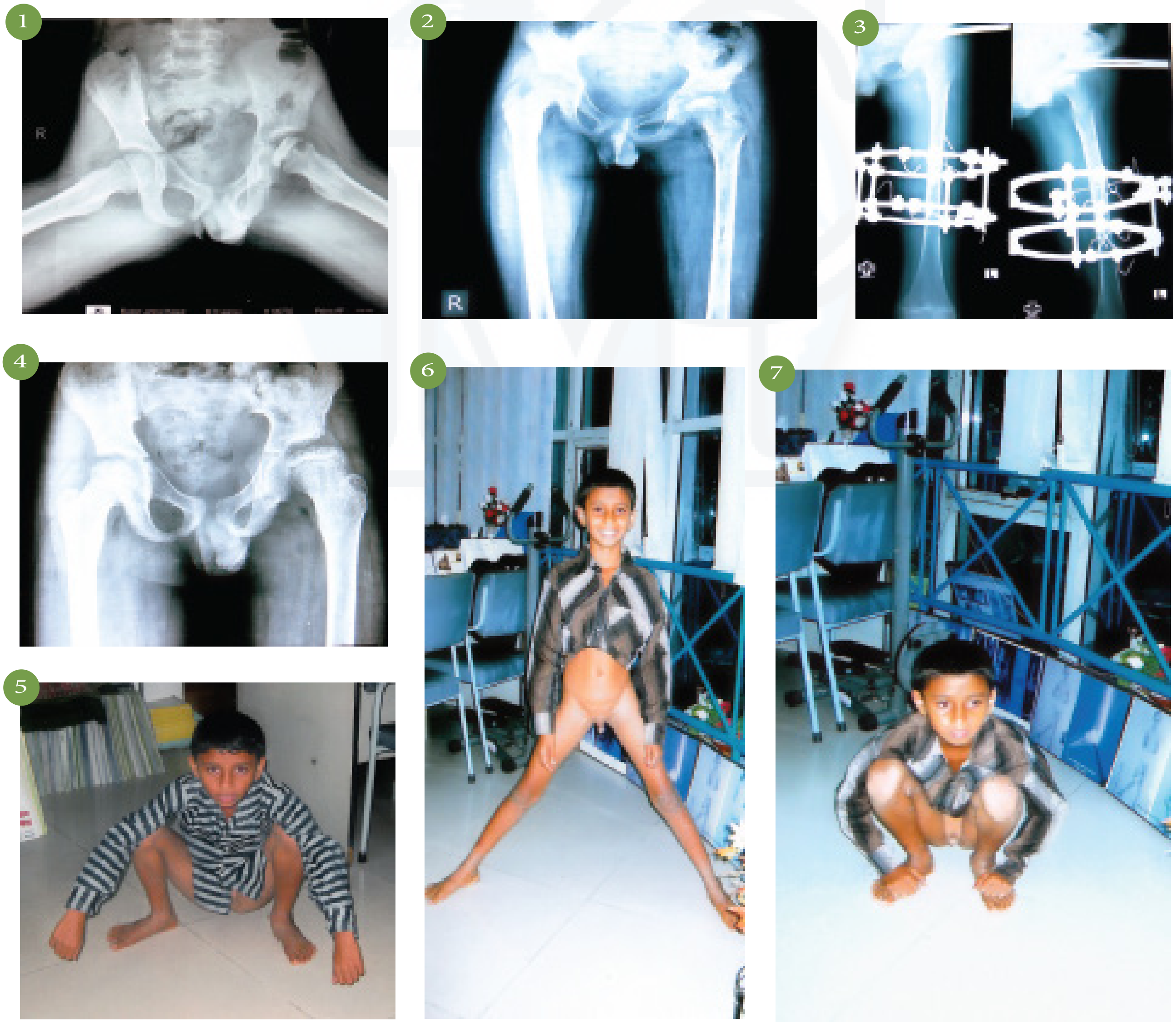
# Case Study 7

1. Radiograph of both hip; affected left hip frog leg view; (before treatment).
2. Radiograph of both hip, affected left hip (AP view).
3. Radiograph of left hip with Ilizarov fixator in situ.
4. Radiographic result after 5 months.
5. The patient can squat easily.
6. The patient can abduct both hips easily.
7. After 6 months follow up.



## Case Study 8

1. 7 years old child – Left sided legg-Calvé-perthes disease.
2. Radiograph of left hip. AP/Frog leg view before treatment.
3. Radiograph of left hip with Ilizarov in situ.
4. Radiograph of left hip, after 4 months follow up.
5. View of Ilizarov fixator in the left hip and thigh.
6. Radiographic result of left hip. Good formation of the epiphysis. 5 months follow up.
7. Clinical appearance of the child.
8. Child can squat easily without any pain.

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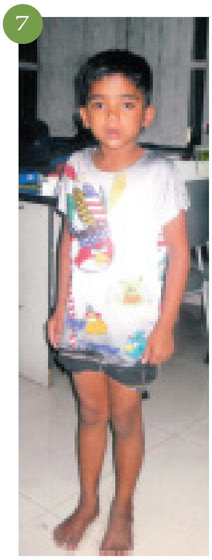

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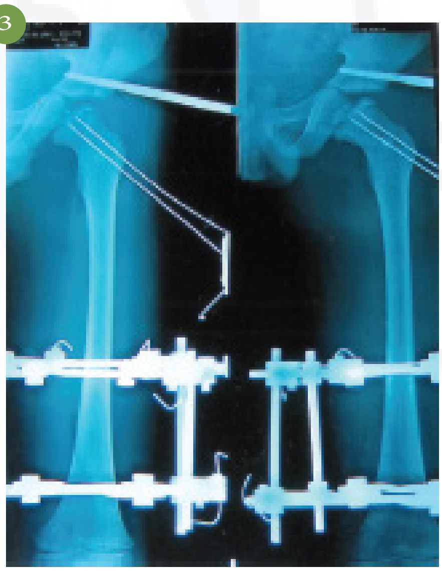

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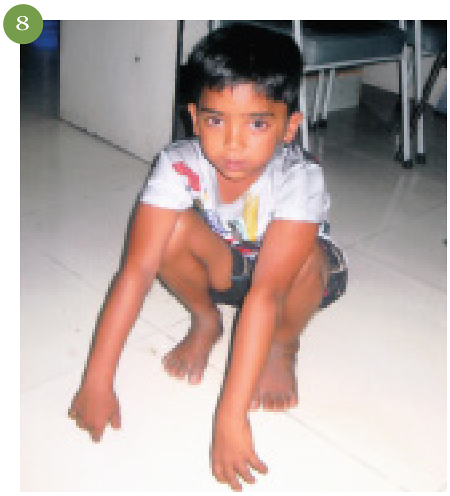

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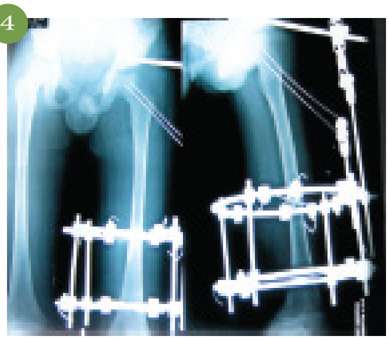


# Part 5
# Deformity and its problems

# Chapter 30
# Deformity and its problems

**DEFORMITY AND ITS PROBLEMS:**

**DEFINITION:** deviation from normally is called deformity.

The most dramatic progress in orthopaedic surgery during the last three decades has been in the field of deformity correction. Brilliant doctors have worked in the field of deformity correction. Academician G.A. Ilizarov developed new methods of limb lengthening and deformity correction. Professor V.I. Shevtsov and Professor Dror Paley inaugurated many innovations in the field of deformity correction. The limb lengthening and deformity correction in Kurgan is not only the clinical laboratory where this deformity correction work was developed and it also become the Mecca for orthopaedic students in this medical specialty.

The treatment of skeletal deformity is the heart of our specialty. It has been my proud privilege and honour to be associated with Academician Professor V. I Shevtsov and Professor Dror Paley and I probably know them better than anyone else.

Malalignment refers to loss of collinearity of the hip, knee and ankle. It is therefore possible to have a deformity without malalignment. Deformity and malalignment can lead to-

1. pain,
2. abnormal gait,
3. loss of function and
4. cosmetic deformity.

Accurate assessment of deformity, planning of correction and choice of the most appropriate management tool are the keys to success in managing these complex children.

Our knowledge of assessment and management of deformity has progressed tremendously in the last 3 decades.

The concept of distraction neo-histogenesis was pioneered by Academician Professor G.A. Ilizarov. He noted that bone had formed at a fracture site after distraction. When one of his patients misunderstood the instructions and turned the nuts in the wrong direction, lengthening the fracture site rather than compressing it. He called this “distraction neohistogenesis” and subsequently used it for-

1) Limb lengthening,
2) Gradual correction of bony deformity and
3) For bone transport to correct intercalary bone defects.

**RATIONALE FOR DEFORMITY CORRECTION: COSMESIS:**

A mild or gradual developing deformity may manifest initially with only a visible deformity. The cosmetic appearance in such cases may be alarming to parents and might be the initial reason for consultation.

**LOSS OF FUNCTION:**

The objective of deformity correction is to restore the anatomical alignment of the femur and tibia, such that a child’s efficient gait and exercise tolerance is restored.

**JOINT PAIN AND PROGRESSIVE OSTEOARTHROSIS**

In deformities joint pain is likely to be due to synovitis, abnormal joint shear stresses or joint instability secondary to deformity. There is evidence to associate a distal femoral valgus deformity with lateral compartment osteoartrosis of the knee. Distal femoral varus and proximal tibial varus are associated with medial compartment osteoarthrosis of the knee.

**ASSESSMENT OF LIMB DEFORMITY:**

A detail anamnesis will determine symptoms and functional loss. Getting a detailed anamnesis of previous treatments, including non-surgical and surgical interventions.

**CAUSES OF LIMB DEFORMITY:**

**CONGENITAL**

1. PFFD (Proximal Focal Femoral Deformity)
2. Posteromedial bowing of tibia
3. Fibular Hemimelia
4. Tibial pseudoarthrosis
5. Blount-Biezin disease
6. Skeletal dysplasia e.g, multiple hereditary exostosis

**ACQUIRED**

1. Infection
2. Malunion
3. Metabolic bone disease
4. Physeal arrest
5. Neurologic condition (cp. polio)
6. Joint diseases and contractures (DDH, LCPD)

**CLINICAL ASSESSMENT:**

During clinical assessment we must include the following-

1. Affected segment and site of deformity.
2. Congenital versus acquired causes
3. LLD

**Gait:**

Clinical assessment beginning with examination of gait. For genu varum deformities, it is important to look for a lateral thrust at the knee, to give an idea of instability or laxity.

We must examine the deformity, paying attention to rotational or torsional abnormalities.

**Joints:**

We must examine the joints both above and below the deformity for range of motion, to rule out fixed contractures. It is important to assess for any joint laxity or instability. Any joint instability will put the joint at risk of subluxation or dislocation following deformity correction and lengthening.

**LLD- (LEG LENGTH DISCREPANCY):**

Clinically we must assess both apparent and true LLD and radiologically also.

**NEUROVASCULAR STATUS:**

Careful examination should be done to see the neurovascular status.

**X-RAY ASSESSMENT:**

The effect of body weight on lower limb alignment is seen on standing radiographs.

Three methods in common use to obtain leg alignment views.

**TELEROENTGENOGRAPHY:**

A long film and a ruler are placed under the patient, and a single exposure is made, centered over the limbs.

**ORTHOROENGENOGRAPHY:**

A long film and a ruler are placed under the patient. Several exposures are made at the hip, knee and ankle levels, without moving the patient or the film. These exposures are stitched together.

**SCANOGRAPHY:**

The film is advanced under the joint to be radiographed and exposed sequentially.

**RADIOLOGICAL ASSESSMENT OF DEFORMITY SOME STEPS:**

1. We need good quality x-rays.
2. MAD test: A line is drawn from the centre of the femoral head to the centre of the ankle joint in the coronal plane. This should pass within 8 mm of the centre of the knee joint.
3. Joint orientation angles: The mechanical axis line connects the cntre of a proximal joint to the centre of the distal joint. The anatomic axis line is the mid diaphyseal line. The mechanical axis is a feature of the coronal plane only. While the anatomic axis line is used in both coronal and sagittal planes. The orientation of each joint can be measured using angles (named joint orientation angles) created by these lines and the joint surface lines (JOLS)

**Table:** Joint orientation angles ($0^{o}$)

| | | |
|---|---|---|
| mLPFA | 90 (85-95) | MPFA 84 (80-89) |
| mLDFA | 87 (85-90) | NSA 124-136 |
| JLCA | 0-2 | aLDFA 81 (79-83) |
| MPTA | 87 (85-90) | JLCA 0-2 |
| mLDTA | 89 (86-92) | LDFA 89 (86-92) |

Mechanical axis- _________

**PIT FALLS:**

1. It is possible to have a normal mechanical axis hip or close to the ankle joint.
2. It is possible to have a normal mechanical axis with malorientation of the joint lines around the knee.

**X-RAY PLANNING FOR THE MANAGEMENT OF THE DEFORMITY**

Femoral deformities can have either mechanical or anatomic axis planning, depending on the mode of correction generally. It is safer to use mechanical axis planning and this is most commonly used when gradual correction is performed using Ilizarov fixators.

**PIT FALL:**

Rotational deformity cannot be assessed on an x-ray clinical assessment should be supplemented with CT examination.

**CORA (Centre of rotation of angulation)**

CORA method is not hard to learn but it does take effort and practice. The only tools required are a pencil, ruler and goniometer. The CORA method of deformity analysis is an attempt to make some sense of the Ilizarov apparatus. The concept of Ilizarov hinge made the Ilizarov fixator so unique in its ability to correct deformities in a controlled manner. Some secondary deformities may arise from mismatching the location of the hinges and the CORA. CORA method of mechanical and anatomical axis planning is the best concept to more accurately identify the label for the Ilizarov hinge. With the CORA method one can understand and plan surgery for any lower extremity deformity for the hip to the foot. CORA and osteotomy rules are much more universally applicable to deformity by any method. The surgeon must decide which device works best in his hands. In Kurgan I learnt that deformities could occur in multiple planes and that hinges could act as the axis of correction. I spent 11 years in Soviet Union and it was very easy for me that learning Russian language facilitated the learning process; knowing Russian language helped me a lot to clearly understand the basic science of distraction osteogenesis.

**PROBLEMS:**

Orthopaedics as a word is derived from two Greek words, “orthos” means straight and “pedis” means child to that means to be corrected or to straighten the deformed foot. From the beginning of the life, we have grown from being quadrupeds to the present developed shape, we are thinking ourselves as the superhuman. We work on our lower limbs and feet, we could simultaneously use our upper limbs holding or throwing, which most animals cannot. Our limbs are very important for us, as the mobility for a vehicle, life for the body itself. All kinds of post traumatic bone defects can be fantastically correct using the bone transport technique which include the correction of bone defects, soft tissue loss, infection, deformity and LLD. Conventional external fixators holds the fragments in the initial stage for sometime and for a few specific indications, but lead to more of nonunion than union.

**HYBRID:**

The product of a cross between genetically unlike individuals is called hybrid.

**DISADVANTAGE:**

1. Cannot be changed in any direction once applied.

2. Compression distraction is not possible, they are stiff in one plane.

**AIMS AND OBJECTIVES OF DEFORMITY CORRECTION:**

Our aim is to make the deformed patient walking, and useful to the society. Ilizarov compression distraction device is designed to fit the anatomy and biomechanics of each particular joint and their movement. Surgical treatment of limb joint lesions provide for simultaneous restoration of both the form and function of the joint.

Contractures, inveterate dislocations, intra-articular or peri-articular fractures and pseudoarthrosis with contracture of the neighboring joints, when there are no gross anatomical changes in the muscles impeding restoration of movements in the joints, are indications for restoring the functions of the joints with the aid of the apparatus.

**PLANNING AND CORRECTION OF DEFORMITY:**

Before planning for the correction of the lower limb deformity the normal anatomy and X-ray assessment is mandatory, along with the need of the patient. The patient should be evaluated nicely so that we can correct the deformity and bring back his/her normal life.

First, he should be informed regarding the type of surgery, total duration of the treatment, chances of repeat surgeries in it and the available prognosis and total counseling should be done. We should inform the patient’s guardians the following:

1. Ilizarov method is an excellent one but it is a complicated procedure.
2. The outcome of deformity correction will be as close as possible to normal opposite limb.
3. You may need repeated surgeries.

4. The procedure requires outcome patience.

5. The doctor being human works under the Blessings of The Almighty.

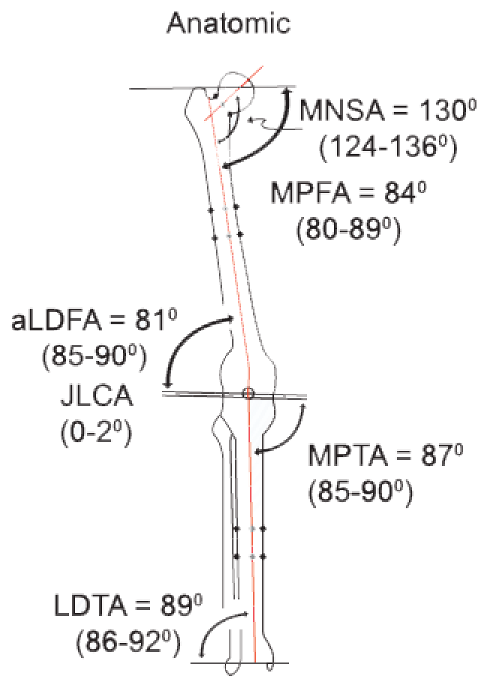
**THOROUGH EXAMINATION:**

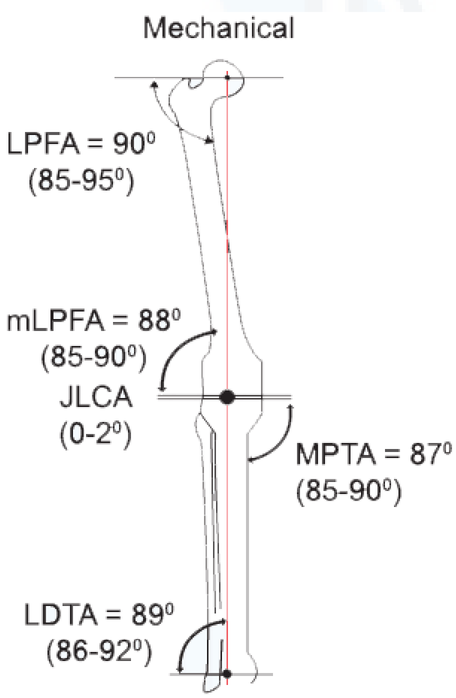
1. We should examine the patient in lying position, in standing position, just to find out the LLD, measurement of this is the basic thing and for axis of correction required for surgical intervention.
2. Measurement in standing position can be taken with the help of wooden blocks placing under the ankle and foot.
3. In lying position, we can get the true and apparent length measurement.

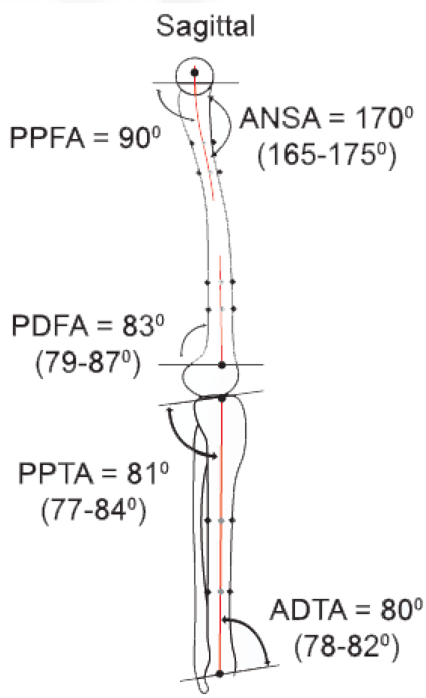
4. X-ray assessment from iliac crest to foot, with the patella facing forward, is taken both with the deformity present and with the deformity compensated.

Each joint have a mechanical and anatomical axis. In tibia, the mechanical and anatomical axis is almost same but different in femur.

The mechanical axis of femur is defined as the line from the centre of the hip to the centre of the knee joint. Anatomical axis is the mid diaphyseal line that runs from the piriformis fossa to the centre of the knee joint. The ankle joint reference line is the tibial plafond. The tibial plafond is normally perpendicular to the mechanical axis of the tibia.



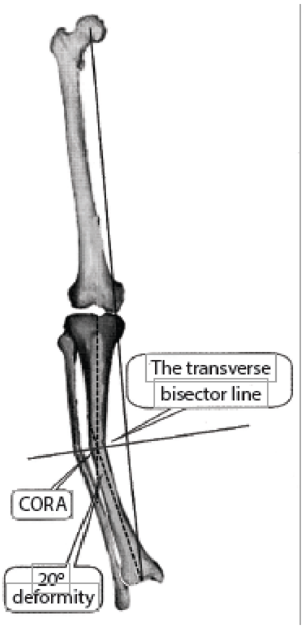
For correction of lower limb deformity, there are two considerations in evaluating the frontal plane mechanical axis of the lower extremity.

1. Joint alignment
2. Joint orientation

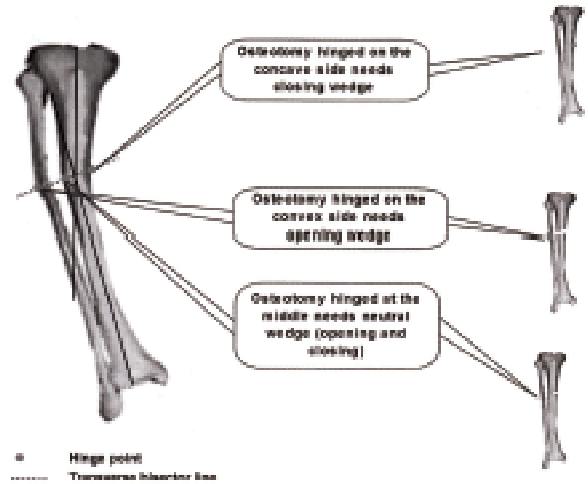
The normal alignment of the hip, knee and ankle joint centres is co-liner. The frontal plane deformity leads to mechanical axis deviation (MAD), which affects all the lower limb joints especially the knee. The normal line of weight bearing force in the frontal plane from hip to ankle joint passes immediately medial to the centre of the knee near the medial tibial spine.

In situations of MAD, it passes medial or lateral to the centre of the knee. In hip joint there is no obvious reference line in the frontal plane, but it can be oriented with the knee-shaft angle which is from 124-136. In case of lower limb deformity there is always a proximal point which is usually at the centre of the proximal joint of the limb. The second point is the distal articular surface. Two lines joining the upper and lower surfaces are marked, perpendicular line is drawn over these two lines, the point at which these two lines cross is called the CORA (centre of rotation of angulation) or the true apex of the deformity. These to line of the proximal and distal articular surfaces are known as proximal mechanical axis (PMA) and distal mechanical axis (DMA).

Mechanical and anatomic axis are straight lines; however when there is a deformity these lines are no longer straight and create an angle. CORA is the true apex of the deformity (centre of rotation of angulation); it is the intersection points of the anatomical or mechanical axes when there is a deformity




A simple malunited fracture usually has one CORA but a bone with congenital bowing may have several CORAs. If the CORA does not coincide with obvious deformity, there may be a hidden deformity.




## OSTEOTOMY RULES:

To correct a deformity the bone is osteotomised. Careful planning of the osteotomy and the hinge around which bone will be rotated is very vital for good correction.

We must know the following rules.

**Osteotomy rule-1:**

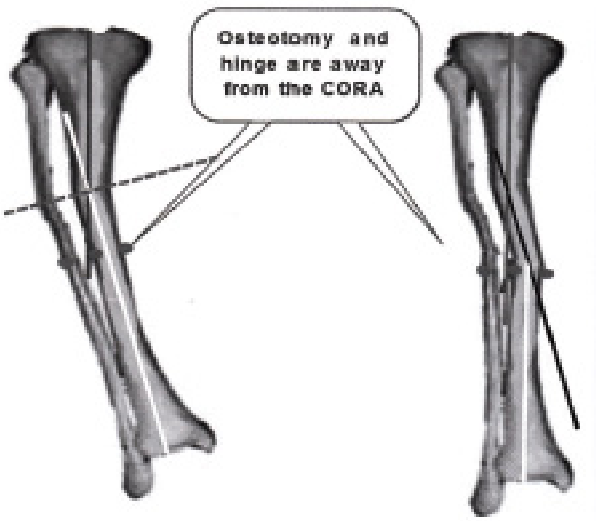
The osteotomy should pass through the transversive bisector line. If the hinge is placed on the convex side, an opening wedge is need, if on the concave side, a closing wedge and if at the centre, a half closing and half opening (neutral) wedge.

**Osteotomy rule-2:**

It the osteotomy is performed at a different level from the CORA, then translation occurs and you will get alignment with translation and angulation.

**Osteotomy rule-3:**

If the osteotomy is performed at a different level from the CORA but hinge is placed at the osteotomy site, the mechanical axis becomes parallel but anatomical axis becomes Zigzagged.




**Osteotomy rule-4:**

The point where the mechanical axis of the proximal and distal segments meet to termed the resolved CORA. If an osteotomy is performed at the resolved CORA, the limb is functionally normal; this avoids multiple osteotomies.

**Osteotomy rule-5:**

If the osteotomy is performed through the resolution CORA, rather than the true multiple apices, the mechanical axis and joint orientation will be corrected with a residual alteration in the anatomic axis of the bone. This may be a cosmetic problem but it does not affect joint orientation or mechanical axis alignment.

**DEFORMITY CORRECTION TECHNIQUE Acute correction:**

Mild to moderate deformities can be corrected acutely and then stabilized, either internally or using Ilizarov fixators

Post traumatic left tibia vara (Front view), 14 years old boy can walk with the Ilizarov apparatus. Clinical appearance of the patient (No Deformity).

Generally, deformities greater than 30o carry a risk of neurovascular injury and compartment syndrome and acute correction should be avoided. In Ilizarov surgery everything must be done gradually. Acute correction can be stabilized using either plates and screws or intramedullary nails.

**Gradual correction:** Distraction osteogenesis

It is a mechanical induction between bony surfaces that are gradually pulled apart in a controlled manner.

1. Gradual lengthening 1mm/day.
2. Faster lengthening leads to failure of bone formation.
3. Slower lengthening required in some, can lead to premature consolidation.
4. Rhythm of distraction: increased frequency better e.g. ¼ mm 4x/day better than 1 mm once a day.
5. Bone formation is in line with direction of distraction.
6. Collagen fibres lined up with direction of distraction. If instability of fixation present collagen fibres become sinusoidal.
7. Mechanism of bone formation is INTRAMEMBRANCEOUS.
8. Endochondral bone formation less common but does occur.
9. Fibrous interzone is the layer between the forming columns of new bone.
10. Trabeculae looks like stalactites and stalagmites.
11. Interzone has the undifferentiated mesenchymal cells that can from bone, cartilage or fibrous tissue.

**Distraction Histogenesis of soft tissues:**

1. Gradual distraction is important for soft tissue.
2. Soft tissues lengthening is a combination of stretch and regeneration.
3. Muscle regeneration secondary to addition of sarcomeres as well as recruitment of satellite cells.
4. Nerve regeneration is included new Schwann cells.

**Distraction is indicated for:**

1. Limb lengthening.
2. Correction of deformities.
3. Bone fragment transport.
4. Stimulus for non-union and Pseudoarthrosis.
5. Neovascularization.
6. Correction of joint contractures.

**Complications of limb lengthening: Bone complications**

1. Premature consolidation
2. Delayed consolidation
3. Non Union
4. Axial deviation (secondary deformity)
5. Fracture
6. Infection

**Joint complications**

1. Stiffness
2. Contracture
3. Subluxation
4. Dislocation
5. Arthritis

**Soft tissue complications**

1. Nerve injury
2. Vascular injury
3. Oedema
4. DVT
5. Muscle contracture
6. Muscle scarring
7. Skin scars

There are many ways to prevent complications. Since distraction related complication occurs gradually they can be identified early and treated early. So frequent follow up (at least every two weeks during distraction and every month during consolidation) are required.
Ex fix used for distraction osteogenesis can be Monolateral or Circular.

**Monolateral fixator Advantages:**

Patient comfort, causes minimal interference with joint range of motion.

**Disadvantages:**

Often rotational deformities are corrected acutely at the time of surgery. Generally less margin of error and less manocuvrability than Ilizarov circular fixator.

**ILIZAROV CIRCULAR FIXATORS:**

These are versatile deformity correction tools, all aspects of deformity can be corrected gradually with this wonderful fixator.

**Advantages:**

1. All aspects of deformity can be corrected gradually. It is mechanically more stable.
2. Customizable.
3. Modular.
4. Can articulate across the joint.
5. Can correct multilevel multiplanar deformities.

**Disadvantage:**

It is bulky.

**Acquired deformities of leg bones:**

a. Post traumatic (after multiple polyfragmental fractures - 42.1% of all the injuries)
b. Post infection (sequalae of haemotogenous osteomyelitis - 71.2%)
c. Flaccid pareses and paralyses (60-75%)
d. Metabolic and dystrophic (sequalae of rickets, rickets-like diseases, osteoarthrosis).

**Congenital deformities of leg bones (dysplastic systemic skeletal diseases):**

a. Dyschondroplasia (Ollie's disease)
b. Blaunt's disease
c. Osteogenesis imperfecta
d. Fibrous dysplasia
e. Developmental anomalies

**Classification of leg bone deformities by localization:**

a. Metaphyseal
b. Diaphyseal
c. Metadiaphyseal (subcondylar)
d. One-level (Monofocal)
e. Multilevel (Polyfocal)
f. Longitudinal
g. Transverse

**Classification of leg bone deformities by the number of segments:**

a. Monosegmental
b. Polysegmental

**Sequalae of Haematogenous osteomyelitis are characterized by:**

a. Multicomponent deformity of leg bones in the proximal part (52.9`%)
b. Multicomponent deformity of leg bones in the distal part (17.7%)
c. Varus deformity of leg bones in the proximal part (11.8%)
d. Varus deformity of leg bones in the distal part (5.9%)
e. Outward and inward torsion
f. Shortening of limb segments (in all patients)
g. The knee instability (57.7%)

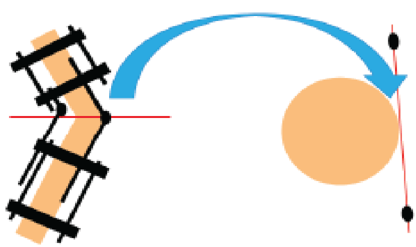
**Dyschondroplasia (Ollier's disease) is charactherized by:**

a. 1-25 cm shortening of the lower limb (by an average of 9.8 cm)
b. Preferential deformity localization in proximal leg (63.1%)
c. The presence of the knee and ankle contractures (45%)
d. The knee instability (75%)

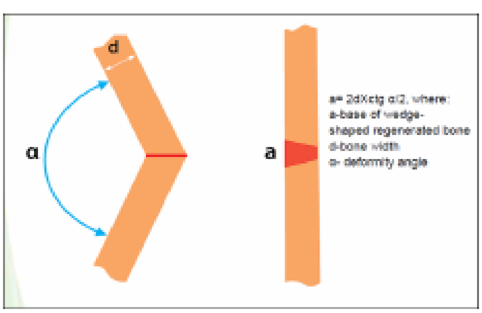
**Stages of preoperative planning:**

a. Determination of true deformity plane (CORA)
b. Calculation of the amount of deformity correction and lengthening
c. Biomechanical designing
d. Determination of osteotomy levels
e. Determination of osteotomy shape
f. Selection of deformity correction type

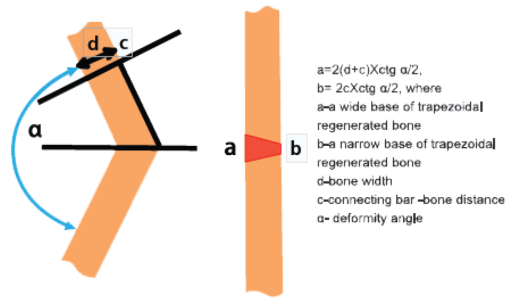
A diagram of hinge placement at the apex of deformity



The amount of the base of wedge-shaped regenerated bone




The amount of bone, for formation of trapezoidal regenerated bone




**Stages of Surgery**

a) Osteosynthesis of leg bones (insertion of wires, mounting of the Ilizarov fixator, placement of hinge units for deformity correction)
b) Skin incision, approach to bone
c) Osteotomies
d) Deformity correction (partial or complete -up to 150)
e) Skin closing
f) Control x-rays

**Main Principles of Transosseous Osteosynthesis for Deformity Correction**

a. Insertion of wires with stoppers in the process of deformity correction
b. Hypercorrection of the external supports of the transosseous fixator during its mounting
c. Proper and efficient arrangement of the fixator hinge units

**A variant of the fixator configuration for correction of varus deformity of the leg upper third with the knee «protection»**

**A variant of the fixator configuration for correction of valgus deformity of the leg upper third.**

**Stages of Postoperative Management**

a) Gradual correction of residual deformity

b) Proper dressings

c) Adequate functional and static weight bearing of the limb

d) Efficient exercise therapy

e) Controlling the regenerated bone condition

**Periods of the fixator removal are determined by the followings**

a) The mean periods of consolidation depending on the amount of deformity, limb shortening, patient's age, etiology

b) The presence of the X-ray signs of newly formed bone

c) The data of clinical testing the consolidation stability

**Principles of removing the transosseous ring fixator**

a) Adherence to the indications for the fixator removal (consolidation, clinical signs and those by x-rays),

b) Sound anaesthesia

c) Decreasing the forces in «fixator-bone» system

d) Adherence to asepsis and antisepsis

**A patient should observe the following rules after the removal of Ilizarov fixator**

a) Axial and functional loading of the limb should be gradually increased

b) Adequate exercise therapy should continue

c) Regular procedures of physical therapy

d) Control of subsequent examinations

**Tactical errors (Calculated errors)**

a) The wrong selection of the number and levels of osteotomies

b) The faults in the calculations of limb segmental deformity and shortening

c) Neglecting the disease etiology and patient's age

**Technical errors**

a) In the preoperative period- the wrong selection of the Ilizarov fixator supports and parts

b) While performing surgeries - non-observing the rules of wire insertion, biomechanical principles of mounting the fixator supports and units, making osteotomies, neglecting the creation of soft tissue reserve during wire insertion and fixation

**The errors that we should keep in mind in postoperative period**

a) Unreasonable frequently changing the fixator

b) Non-observance of deformity correction rates

c) The absence of timely x-ray control of the dynamics of bone regeneration

d) Incorrect interpretation of x-rays

e) Premature removal of the fixator

f) Underestimation of the importance of exercise therapy and the possibilities of early limb weight-bearing with the fixator applied

**Complications**

a. Inflammation of soft tissues at the site of wire skin interface.

b. Postoperative neuropathy of the peroneal nerve

c. Consolidation in osteotomy site

d. Cutting wires out of bone

e. Equinus foot deformity

f. The knee contracture

g. Pseudoarthrosis formation

h. Subluxation of the joint

i. Transformation of the regenerated bone

## CORRECTION OF LONG BONE DEFORMITIES USING THE ILIZAROV FIXATOR

**Introduction:**

Any deformities of limb long bones lead to anatomical and functional disorders of the limbs, as well to those of the locomotors system biomechanics, development of their secondary deformities.

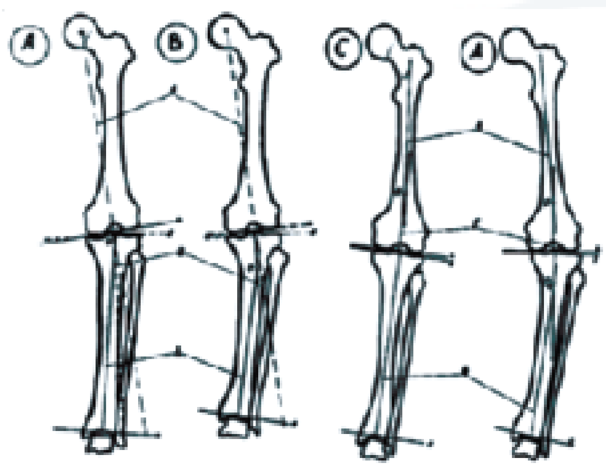
Recovery of limb biomechanics, of cosmetic defect, prevention of deformity recurrence- these are the aims of treatment of patients with limb long bone deformities.

These aims are realizable while using the method of transosseous osteosynthesis, and namely the compression distraction osteosynthesis with the Ilizarov fixator.

It is G.A. Ilizarov's discovery owing to which stress arising in tissues for their graduated tension has been established to excite and maintain active regeneration and growth of tissue structures regularly (G. A Ilizarov, 1978, 1983).

**Stages of preoperative planning:**

1. Calculation of the amount of deformity correction and lengthening.
2. Biomechanical designing
3. Determination of osteotomy shape
4. Selection of the type of deformity correction Osteotomy levels used for correction of the knee varus deformity.



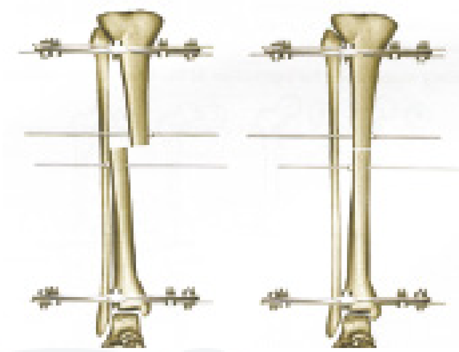
## Stages of surgery:

1. Osteosynthesis of the limb segment deformed (insertion of wires, mounting the Ilizarov fixator, adjusting hinged units for deformity correction)
2. Skin cutting, approach to bone
3. Ostetomies
4. Deformity correction (partial or complete- up to 15o)
5. Skin suturing
6. Roentgenography

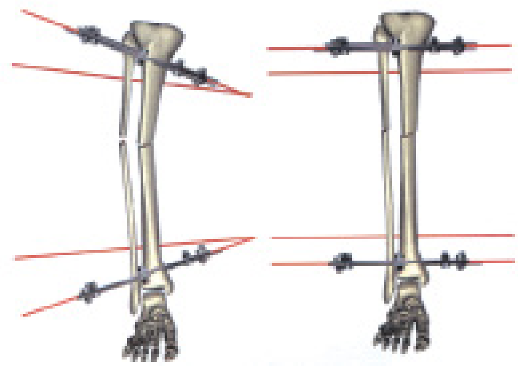
**The main principles of transosseous osteosynthesis to correct deformities:**

1. Insertion of wires with stoppers for deformity correction.
2. Hypercorrection of the outer supports of the device for transosseous fixation during its mounting.
3. Determination of real deformity plane.
4. Efficient arrangement of the fixator hinged unis.

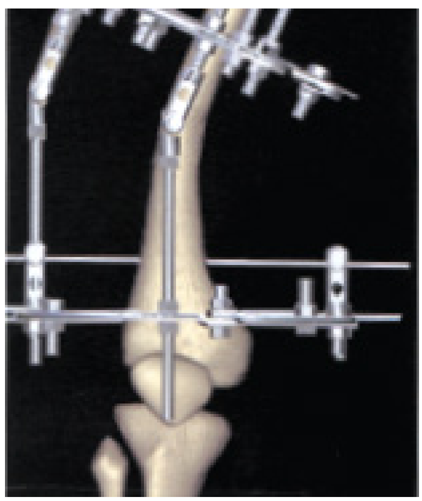
Insertion of wires with stoppers for deformity correction



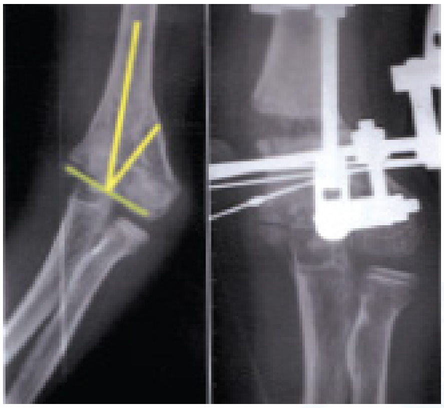
Hypercorrection of the outer supports during the fixator mounting to correct deformities



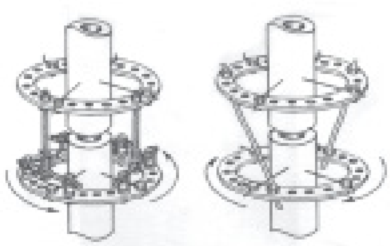
`Efficient arrangement of the fixator hinged units



Determination of axial hinge localization for deformity correction illustrated by the elbow with varus deformity

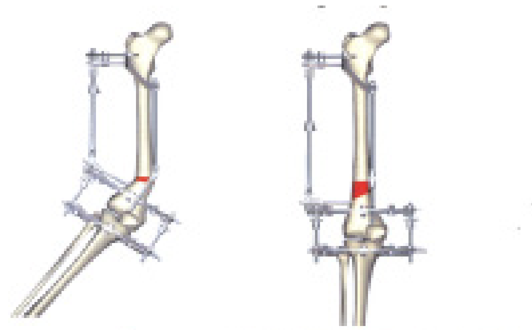


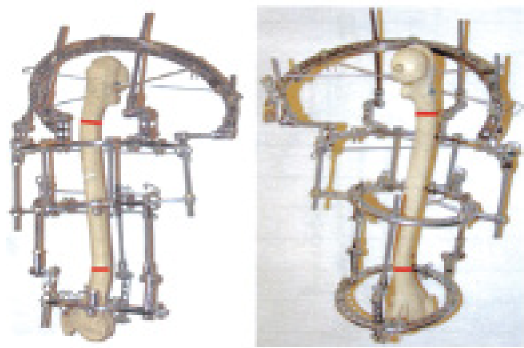
Correction of rotational deformity



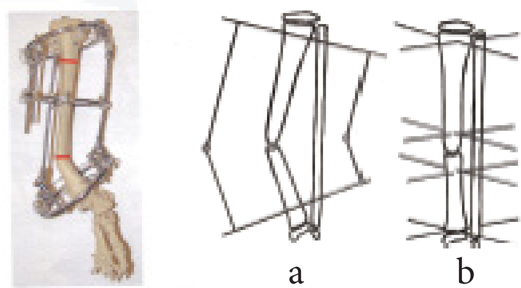
Diagrams of the Ilizarov fixator configuration to correct rotational deformities

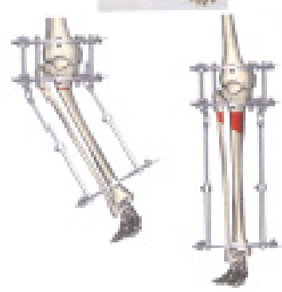
Variants of the Ilizarov fixator configuration for deformity correction and femoral lengthening





Variants of the Ilizarov fixator configuration for deformity correction and femoral lengthening



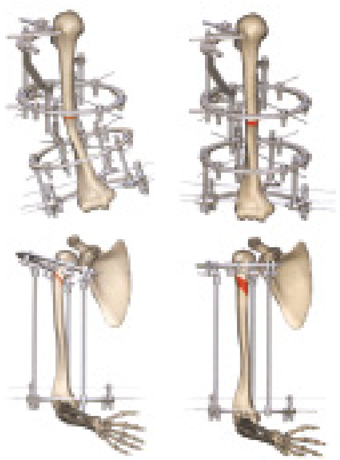
Scheme of application of Ilizarov apparatus in children with pseudoarthrosis without shortening.

a. axis correction with the help of hinges

b. compression of pseudorathrosis with the application of extra rings.

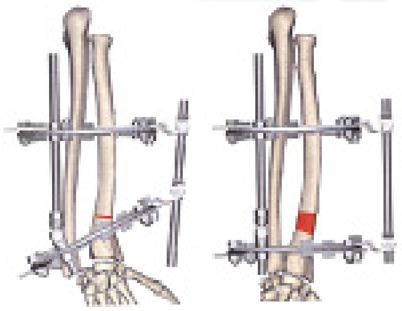
Variants of the Ilizarov fixator configuration for deformity correction and femoral lengthening

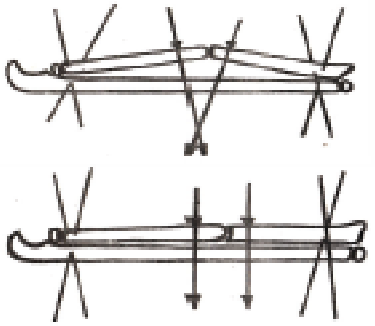
Tensioned wires holding the hanging bridge. A hanging bridge with wires, working on the principle of tensioned wires.



Variants of the Ilizarov fixator configuration for deformity correction and lengthening of one of forearm bones

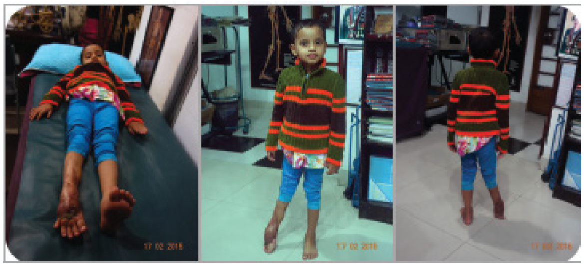
A deformity could be of any extent



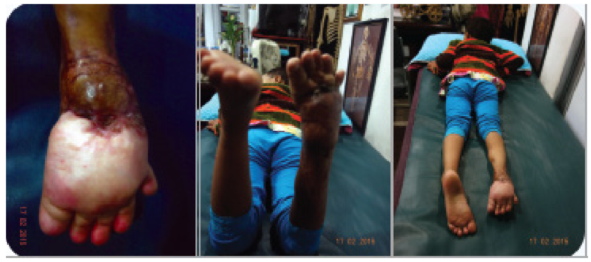


Same method of correction of a. correction of axis deformity with the olive wires b. stabilization in the region of pseudorathrosis.

## Case Study 1



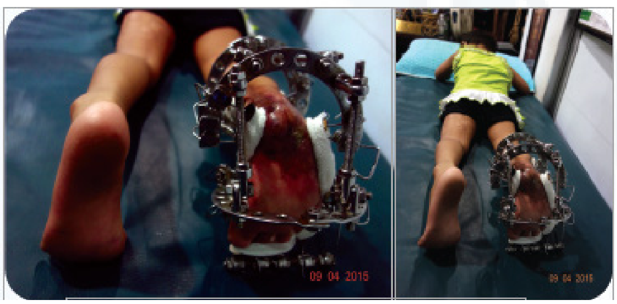
4 yrs. old girl, post-traumatic right ankle and foot deformity with fixed equinus>65o and disorganised tarseal and metatarsal bone (lying, standing front and back view).



Close up view of back and front side of right ankle and foot.

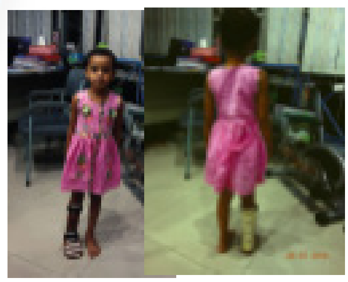

Radiograph of right ankle and foot (AP/Oblique view) and normal left ankle and foot.

During treatment with Ilizarov apparatus (front and back view) and radiograph with Ilizarov in situ.



After 1½ months follow up, close up view of ankle and foot (back view).

Just after removal of Ilizarov apparatus in O.R (Treatment after 2 months).



Baby with AFO (Ankle foot orthosis), front and back view.

Clinical appearance of the girl after 3½ months follow up.

## Case Study 2

**Gap nonunion of left tibia with gross deformity and LLD (12.6 cm)**

1 & 2. Posterolateral bowing of left leg with 12.6 cm LLD.

3. Clinical photograph of 14 years old boy before surgery.

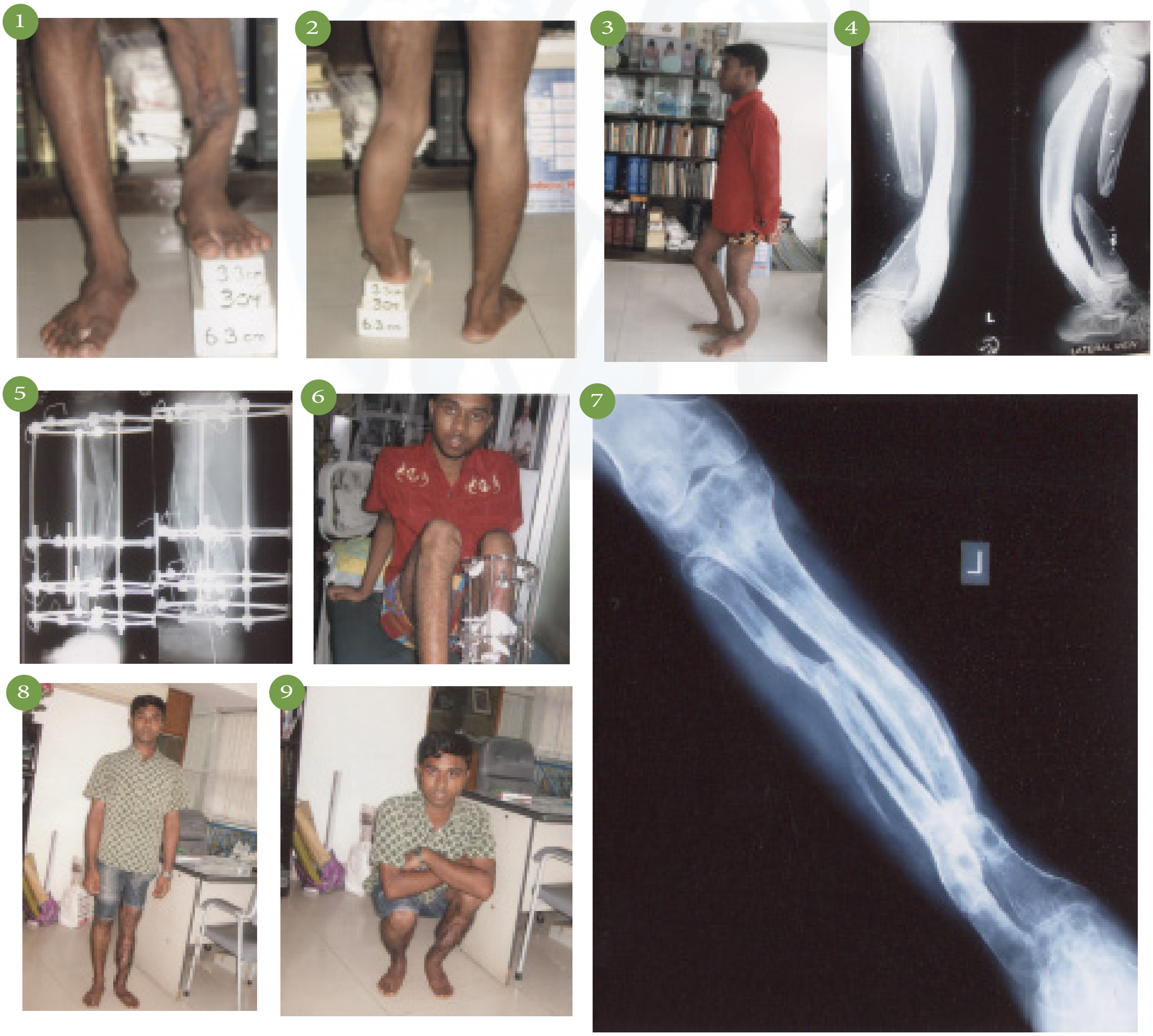
4. Radiograph of hypertrophic deformed fibula with gap nonunion of left tibia, before surgery.

5. Radiographic result of distraction osteogenesis with correction of deformity is seen.

6. Patient with Ilizarov apparatus after 8 months follow up.

7. Radiograhic result of tibia fibula.

8 & 9. Clinical appearance of the patient after 14 months. No LLD, No deformity.



# Chapter 31
# Bow legs and knock knees

## BOW LEGS AND KNOCK KNEES

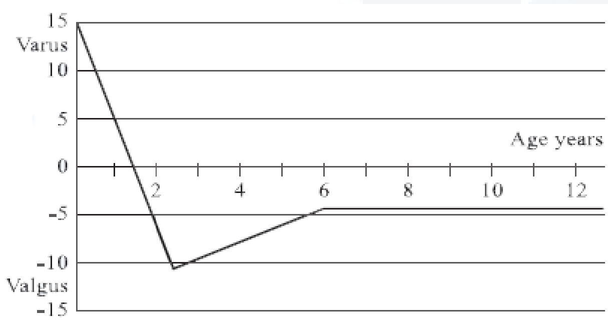
Bow legs and knock knees are common referrals to children's orthopaedic centres. Most are physiological; however, pathological causes must be excluded.

Standing child with symmetrical bow leg (bilateral genu varum) both feet look normal, right foot points forward and the left foot inwrads. The appearance of the tibial tuberosities and the ankles give the impression that there is internal tibial torsion as well.

Most newborn babies have an average knee varus of 10o-15o. This begins to be corrected during the second years of life, reaching about 10o of valgus at round 4 years of age. The valgus alignment then gradually decreases, reaching the adult value (5o of valgus) around 8 years of age (Figure-2: Salenius curve)

**salenius curve**

Mean tibiofemoral angle according to age ($^{\circ}$)




The standard deviation (SD) is 8o (more in the boys, 10o, and less in the girls, 7o). Children with physiological genu varum and internal tibial torsion typically come to medical attention after the standing age (between 12 and 24 months), usually because of parental concern regarding the appearance of the legs, and these children have no other significant findings on clinical examination.

In most cases, an anamnesis and clinical examination is all that is required to differentiate between pathological and physiological bowing.

A healthy child with normal developmental milestones fairly symmetrical bowing and no other skeletal abnormalities is likely to have a physiological bowing. Radiographs are generally unnecessary, but may be required occasionally to help differentiate pathological from physiological bowing.

In physiological bowing, radiographs may show an apparent delay in ossification of the medial side of the distal femoral and proximal tibial epiphyses or flaring of the medial distal femoral metaphyses and a normal looking physis.

The following rules are helpful but not certain.

Genu varum is more likely to be pathological if it is:

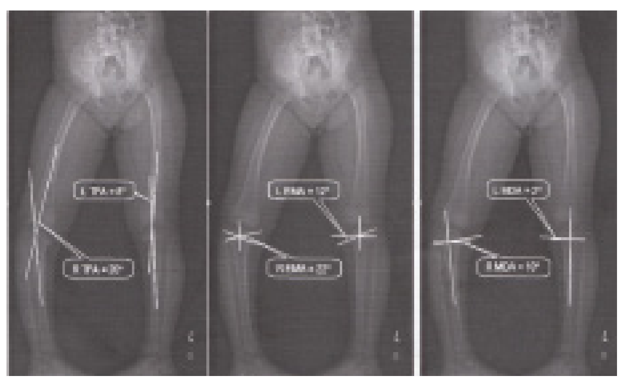
1. Present after 2 years
2. Unilateral or there is asymmetry of more than 5o
3. Associated with shortening of the limb
4. Severe (beyond 2 standard deviations of the mean, as per salenius chart; I SD=8o)
5. Present in an obese child

Genu valgum is more to be pathological if it is:

1. Severe (intermallcolar distance) 10 cm at 10 years or >15 cm at 5 years).
2. Unilateral

The following x-ray measurement (figure) are useful (ensure that the patella of faing forward)

1. TFA-Tibiofemoral angle
2. The mechanical and anatomical axes deviation.
3. MDA- Metaphyseal-diaphyseal angle of levine and Drennan (normal, $<11^{\circ}$, abnormal, $>16^{\circ}$).
4. EMA- Epiphyseal-metaphyseal angle (normal, $<20^{\circ}$)



X-ray measurement in genu varum. EMA, epiphyseal-metaphyseal angle; MDA, metaphyseal- diaphyseal angle, TFA, tibiofemoral angle.

X-ray measurement in genu varum. EMA, epiphyseal-metaphyseal angle; MDA, metaphyseal-diaphyseal angle, TFA, tibiofemoral angle.

The tibiofemoral angle is formed by the intersection of the two mid-diaphyseal lines of the femur and the tibia, respectively. The value should be within the normal range described by a Salenius curve.

The mechanical and anatomical axes deviation is the distance between the mechanical axes of the lower limb and the centre of the knee (the anatomic axes cross the knee almost at the centre). The normal mechanical axes pass 8 ± 7 mm medial to the centre of the knee.

MDA- The metaphyseal- diaphyseal angle is the angle formed by a line connecting the most distal point on the medial and lateral beaks of the proximal tibial metaphysis and a line perpendicular to the anatomic axis (or lateral cortex) of the tibia.

Levine and Drennan reported that a child develop Blount's disease if the initial MDA were more than 11o.

EMA- The epiphyseal- metaphyseal angle is determined by measuring the angle formed by a line through the proximal tibial physis parallel to the base of the epiphyseal ossification centre and a line connecting the midpoint of the base of the epiphyseal ossification centre to the most distal point on the medial beak of the proximal tibial metaphysis.

Devids et al observed that children younger than 3 with a MD>10o and an EMA>20o were at a greater risk of developing Blount-Biezins disease and should be monitored closely. In their study, more of the children with a MDA<10o and an EMA<20o developed Blount-Biezins disease.

**Table-1:**

Causes of Genu varum (Bowlegs) and Genu valgum (Knoc knee)

| Bow Legs | Knoc Knee |
|---|---|
| Physiological | Physiological |
| Skeletal Dysplasia | Skeletal Dysplasia |
| Blount's Biezins Disease | Primary Tibia Valga |
| Infection | Infection |
| Trauma | Trauma |
| Metabolic (Vit Defficiency, Osteotogenesis Imperfecta) | Renal Osteotodystrophy |
| Tumours (Osteochondromas) | Tumours (Osteochondromas) |
| Focal Fibro Cartilagenous Dysplasia | Neurovascular Disorders (Polio) and Tight Ilio Tibial Band |

**BLOUNT- BIEZINS DISEASE:**

It is a type of idiopathic tibia vara. It is characterized by disordered ossification of the medial aspect of the proximal tibial physis, epiphysis and metaphysis.

The cause of this disease is thought to be a combination of excessive compressive forces on the proximal medial metaphysis of the tibia and altered enchondral bone formation.

There are 2 recognised types of idiopathic tibia vara

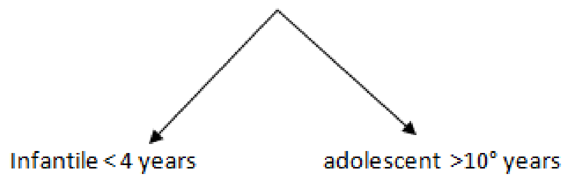


**Table-2:**

**Different between infantile and adolescent tibia vara**

| | **Infantile** | Adolescent |
|---|---|---|
| Clinical | Obese female <4 years with lateral knee thrust. | Male teen ager; bodyweight greatly exceeds 2 standard deviations (SD) above the mean |
| X-ray | Medial sloped and irregularly ossified epiphysis. Widened and irregular physeal line medially. Lateral subluxation of the proximal end of the tibia; varus angulation at the epiphyseal metaphyseal junction | The shape of epiphysis is usually normal. Lack of beaking of the medial tibial metaphysis. Widening of the proximal medial physeal plate, sometimes extending across to the lateral side of the physis. Widening of the lateral distal femoral physis in comparison to either the medial femoral physis of the same knee or the distal femoral physis of the normal knee. |
| Management plan (Treatment) | Orthosis in the early stage. | Orthosis is ineffective. |
| | The goal of surgical treatment is to overcorrect the mechanical axis by Ilizarov technique. Hemiepiphysiodesis is not effective | The goal of surgical treatment is to correct the MA (Mechanical axis) to normal by Ilizarov technique so that physeal growth is restored. Degenerative arthrosis of the medial compartment of the knee can be avoided. Lateral hemipiphysiodesis (alone) can be successful in 50-70% of the cases. |

**Infantile tibia vara:**

Bilateral in 80% of cases and more prevalent in girls with marked obesity

These children generally start walking early (before 10 months of age). Associated clinical findings include

1. Lateral thurst of the knee when waking
2. internal tibial torsim
3. LLD (Limb length discrepancy)

**Adolescent tibia vara:**

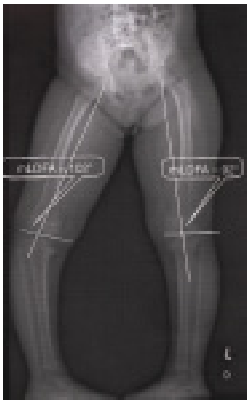
Unilateral in 80% of cases. Patients are usually overweight and complain of pain at the medial aspect of the knee. LLD is generally observed and the femoral alignment is often abnormal.

**How to diagnose?**

Diagnosis is based on clinical presentation and x-ray findings which include:

1. Varus angulation in the proximal tibial metaphysis.
2. Widened and irregular physeal line medially.
3. Medially sloped and irregularly ossified epiphysis.
4. Prominent beaking of the medial metaphysis with lucent cartilage islands within the beak.

It is important to assess the whole for any associated deformities. An increased mLDFA reveals a significant varus of both distal femurs. It is not unusual to have Blount-Biezins disease on a background of physiological varus.



Femoral involvement in Blout-Biezins disease. There is bilateral increase in the mLDFA, indicating varus deformity of the distal femur and proximal tibia.

**Classification:**

Langenskiold suggested a 6-stage x-ray classification.

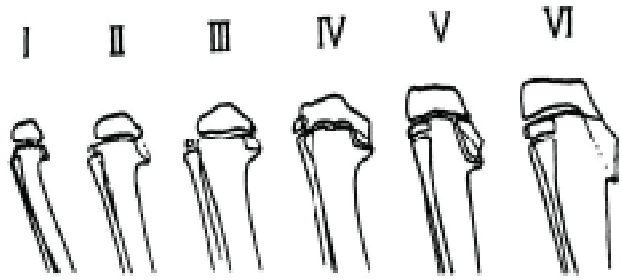



**Table-2:**

Different between infantile and adolescent tibia vara

| Stage | Description | Treatment |
|---|---|---|
| I | Medial beaking, irregular medial ossification with protrusion of the metaphysis | Orthotic for <3 years old |
| II | Cartilage fills depression progressive depression of medial epiphysis with the epiphysis sloping medially as disease progresses | Failure of full correction or progression to Type III --> surgery |
| III | Ossification of the inferomedial corner of the epiphysis | Surgery around the age of 4 |
| VI | Epiphyseal ossification filling the metaphyseal depression | |
| V | V Double epiphyseal plate (cleft separating two epiphysis) | |
| VI | Medial physeal closure | |

**Table-3:** Tibial bowing

| Type | Cause | Treatment |
|---|---|---|
| Posteromedial Bowing of the Tibia | Physiological | Observation, Spontaneous correction causes LLD which can be Lengthened by Ilizarov Technique |
| Anterolateral Bowing of the Tibia | Congenital Pseudarthrosis | Ilizarov External Fixator is the best option |
| Anteromedial Bowing of the Tibia | Fibular Hemimelia | Reconstruction for Severe Deformities by Ilizarov Technique |

It is generally accepted that surgical treatment is required for any child with stage III-VI changes-

**Treatment options:**

Younger than 3 years Bracing is recommended. Risk factors for failure are instability, obesity and delayed bracing. Bracing is not recommended for children older than 3 years.

**Older than 3 years:**

Lateral tibial hemiepiphysodesis (using 8 plate) can be done.

**Proximal tibial osteotomy:**

In the older child Ilizarov fixation is used to facilitate gradual controlled coordinated correction after osteotomy.

Management of Langenskiold stage V and VI needs special attention. Patient age, future growth, magnitude of deformity and joint surface congruity all influence decision making. Additional surgical procedures required at the time of tibial osteotomy may include:

- Resection of the bony bridge and placement of fat (interposition graft). This is indicated in children <7 years of age, to enable physeal growth and reduce the risk of recurrent of the deformity.
- Significant incongruity and depression of the medial joint surface may require a curved osteotomy to facilitate elevation of the medial tibial plateau by Ilizarov technique.

**BOWING OF THE TIBIA:**

Three types of tibial bowing are seen in our day today life.

**Congenital posteromedial bowing of the tibia**

Congenital posteromedial bowing of the tibia and fibula is a condition where unilateral bowing of the tibia and fibula is seen at birth along with a calcaneovalgus deformity of the foot. The condition is generally treated as benign as the foot deformity and the bowing of the tibia and fibula have been known to resolve with age. The limb length discrepancy which occurs may require treatment. A correlation between the severity of the initial angulation and the limb length discrepancy has been described. Although the natural history and treatment with the use of contralateral epiphysiodesis for the correction of limb length discrepancy has been described, the literature is silent on the surgical management of posteromedial bowing of the tibia and fibula & the complications of osteotomy and K wire fixation or Ilizarov lengthening. Our experience in the management of thirty six cases of posteromedial bowing where in 19 cases required surgical intervention for limb length discrepancies and angular deformities with osteotomy and the use of an Ilizarov fixator.

**The aims are as follows:**

1. To study the natural history of posteromedial bowing of the tibia and fibula with respect to the medial and posterior angulation of the tibia and fibula and limb length discrepancy.
2. To discuss the modalities of conservative and operative treatment.
3. To define the indications for surgical intervention.
4. To discuss the complications of surgical intervention.

Calcaneovalgus deformity of right foot.

Generally it is physiological and thought to be due to intrauterine malposition. Spontaneous correction is the rule, although the child may develop residual LLD. The foot deformity generally resolves by 9 months and tibial bowing by the age of 2-3 years. The parents are encouraged to do stretching exercise to facilitate correction of the foot deformity and should be counselled about the need for limb lengthening if a LLD develops.

## Case Study 1

### Congenital Posteromedial bowing

1. 2 months old baby in the mothers lap with left sided congenital postero-medial bowig.
2. Same baby at the age of 3 ½ years, 4 cm LLD.
3. Baby is in prone position.
4. 4 cm LLD, on the wooden block. - Front view
5. Back view.
6. Radiograph of both legs AP view.
7. Radiograph of both the legs lateral view.
8. Lengthening with Ilizarov technique.
9. Radiograph of left tibia fibula with Ilizarov in situ; corticotomy of both tibia fibula is seen.
10. Radiograph after 2 months follow up.
11. Baby is cutting jokes with Aunti.
12. Baby with the brace.
13. Radiographic result after 5 months follow up.
14. Baby in the mother’s lap.

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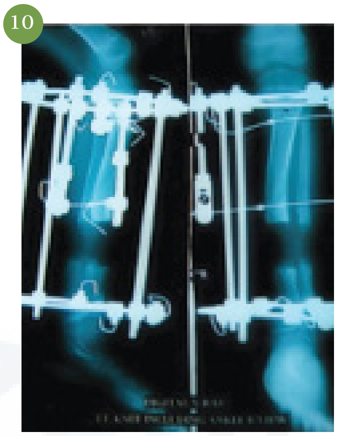

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## DIFFERENT CASES OF POSTEROMEDIAL BOWING:

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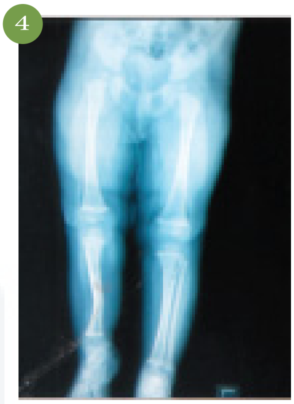

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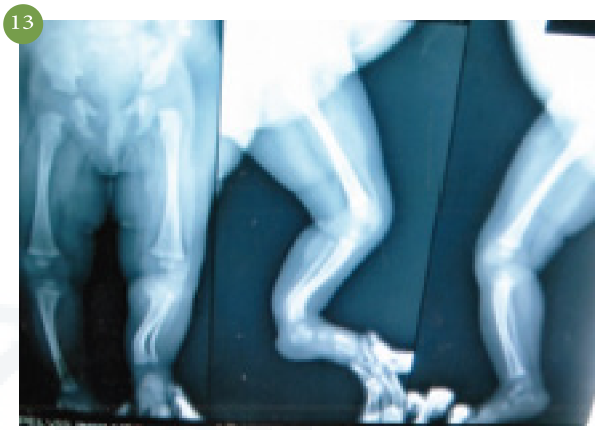

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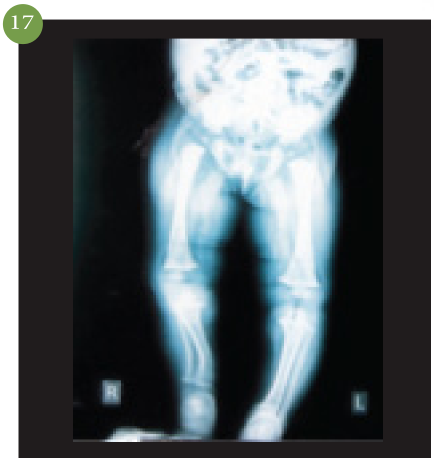


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## Case Study 2

### Congenital Posteromedial bowing (Radiographic follow up (Spontaneous correction)

1. Radiograph of right tibia, postero medial bowing
2. Radiograph of right tibia after 6 months follow up, spontaneous correction is going on
3. Radiograph of both hip, femur and knee (normal)
4. After one year follow up, almost corrected posteromedial bowing

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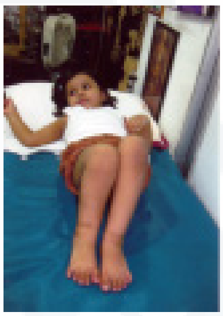
## Postero Medial bowing

Figure-1: Radiographic view of right tibia (postero medial bowing)

Figure-2: Postero medial bowing of right tibia

Figure-3: Postero medial bowing of right tibia (Front and back view)



Galeazzi sign (+)

Figure-4: View of Ilizarov wire placement

Figure-5: During treatment with Ilizarov apparatus

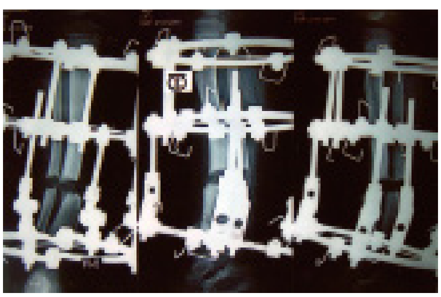


Figure-6: Correction of deformity with hinges

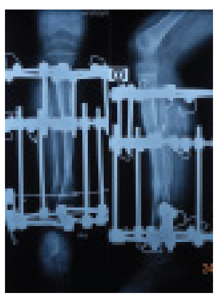


Figure-7: After deformity correction, the hinges are replaced by straight rods

Figure-8: Clinical appearance of the patient with AFO

## ANTEROLATERAL BOWING OF THE TIBIA

Congenital anterior or congenital anterolateral bowing of the tibia with partial sclerosis and narrowing of the medullary cavity is always vulnerable to fracture and psudoarthrosis. Teaching is that the anterolateral type of bowing has a bad prognosis as compared to the posteromedial bowing which is relatively benign in condition, and usually resolves spontaneously as the child grows.

**SHARRAD GIVES THE DESCRIPTION OF TWO TYPES OF ANTERIOR BOWING:**

1. Benign type:

   a. No stigmata of neurofibromatosis
   b. No fibrous dysplasia
   c. No pathological fracture
   d. Spontaneous correction occurs with aging.

2. Progressive type:

   a. Medullary cavity is narrowed
   b. Medullary cavity may be obliterated
   c. Bone texture is normal
   d. Usually due to neurofibromatosis or fibrous dysplasia in which the deformity slowly increases
   e. Spontaneous fracture with pseudoarthrosis may occur
   f. LLD may be present

Many cases have been linked to neurofibromatosis (50% but only 10% of patients with neurofibromatosis have this disorder), fibrous dysplasia and amniotic band syndrome. A callus does not form at the fracture site, resulting in a pseudarthrosis. The site universally has fibrous tissue.

The diagnosis can be made at birth in severe deformities or in those with a fracture. Milder forms may present later in childhood with tibial bowing, a limp and an actual fracture.

Classifications, such as Boyd's and Crawford's, have been advocated. They are more descriptive and do not provide guidance on management or eventual outcome.

**Crawford's four radiographic types are:**

1. Anterolateral bowing. The medullary canal is preserved and dense. Cortical thickening might be observed. This type has the best prognosis and may never fracture.
2. Anterolateral bowing with thinned medullary canal, cortical thickening and trabeculation defect. This type should be protected with a brace and considered for surgery.
3. Anterolateral bowing with a cystic lesion. This type has a high risk of fracture and should be treated with fixation and bone graft.
4. Anterolateral bowing with fracture or pseudarthrosis. This has the worst prognosis.

**Treatment:**

Treating anterolateral bowing with pseudarthrosis and fracture is very challenging. Our long experience shows that excision of the pseudarthrosis and bone transport by Ilizarov ring fixator is the best option.

## Case Study 1

### Anterolateral Bowing

1. Age 9 yrs old girl– lt. anterolateral bowing with ankle valgus.
2. Age 9 years old girl – Before treatment.
3. Before treatment, back view with knee flexion.
4. Before treatment, lying condition.
5. Radiograph before treatment.
6. Radiograph before treatment.
7. During treatment with Ilizarov apparatus.
8. During treatment with 90o flexion, front view of leg.
9. During treatment after 4 months.
10. The Radiographic result, AP Lat. view.
11. The Radiographic result, AP Lat. view.
12. During treatment patient is in standing position with Ilizarov apparatus.
13. Final follow up, back view.
14. Final follow up side view.
15. With AFO.
16. Clinical appearance of the patient after 5 months follow up (Front view and back view).
17. Clinical appearance of the patient after 6 months follow up
18. Clinical appearance of the patient after 7 months follow up

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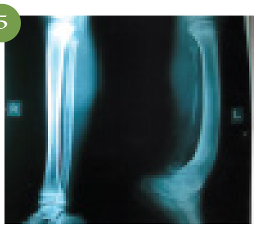

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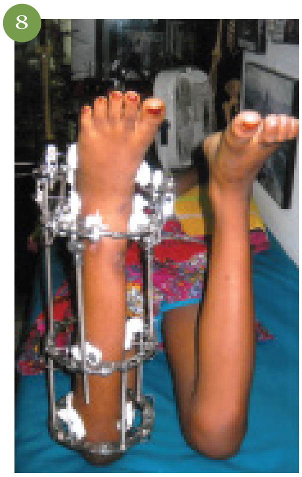

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# Case Study 2

## Anterolateral Bowing

1. Age 9 yrs old boy- lt. tibia anterolateral, bowing front view.
2. Left tibia Anterolateral, bowing (back view).
3. Anterolateral, bowing of left tibia.
4. Café an lait.
5. Radiograph of both tibia fibula before treatment.
6. Correction of Deformity with Ilizarov device.
7. The Radiographic result.
8. During treatment with Ilizarov device.
9. During treatment (back view).
10. Correction of the deformity.
11. Correction of the deformity.
12. Final follow up.
13. With AFO.

**Anteromedial bowing of the tibia:**

This is usually caused by fibular hemimelia and the treatment is directed toward the latter.

Fibular hemimelia is the most common long bone deficiency (1/600). The aetiology is unkonwn and the fibular deficiency may be intercalary of terminal.

Clinical features may include absence of the lateral foot rays, a hypoplastic foot, tarsal coalition, a ball-and-socket ankle joint, ankle instability, hindfoot valgus, a short tibial segment, the absence of knee ligaments (i.e. anterior cruciate ligament), a hypoplastic lateral femoral condyle with a valgus knee deformity, PFFD or significant LLD.

Various classifications have been advised to describe the condition and plan management.

**Achterman and Kalamchi**

Type I. Hypoplastic fibula:

Ia. Proximal fibula is more distal and distal fibula is more proximal

Ib. At least 30-50% of the fibula is absent. Type II. Complete absence.

**Coventry and Johnson**

Type I. Hypoplastic:

Ia. Normal foot,

Ib. Equinovalgus foot,

Type II. Complete absence,

Type III. Bilateral

**Birch's functional classification**

The treatment options depend on the predicted LLD and foot function. Hip dysplasia must be treated before undertaking femoral lengthening, to prevent subluxation of the hip joint. In a addition, the knee and ankle joints must be temporarily stabilized when undertaking femoral and tibial lengthening, thus preventing subluxation of these joints.

**Table:** Birch's functional classification and treatment guidelines

| Classification | | | Treatment |
|---|---|---|---|
| Type I: Functional Foot | IA | 0%-5% Inequality | Orthosis, Epiphysiodesis |
| | IB | 6%-10% Inequality | Epiphysiodesis with or without Limb Lengthening |
| | IC | 11%-30% Inequality | One or two Limb-lengthening Procedures or Amputation |
| | ID | >30% Inequality | More than two Limb-Lengthening Procedures or Amputation |
| Type II: Non Functional Foot | IIA Functional Upper Limb<br>IIB Non-Functional Upper Limb | | Early Amputation Consider Limb Salvage Procedure |

## Case Study 1

1 & 2. 2 years 3 months old child type 2: Complete absence of fibula with bowing and shortening of tibia(Achterman and kalamchi classification)

3. Radiograph of same child both femur and right sided tibua fibula normal. Left sided fibula complete absence.

4. During surgery in OR. Placement of introducing

Ilizarov wires.

5. Lengthening of tibia with good regenerate is seen.

6. Baby with Ilizarov apparatus after 1 month follow up.

7. Author is checking the apparatus of the child.

8. Baby is in the fathers lap.

9. After 3 months follow up, child with AFO.

**Fibular Hemimelia:**

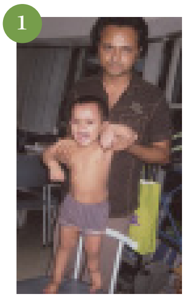
Other names are-

1) Congenital absence of fibula
2) Congital deficiency of fibula
3) Paraxial fibular hemimelia
4) Aplasia or hypoplasia of fibula

**Classification:**

Type 1= 1A, 1B (IB 30% to 50% length missing);

Type 2 Complete absence of fibula with bowing and shortening of tibia

1


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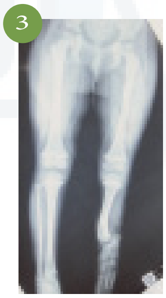

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9


**OTHER CONDITIONS:**

**Tibial hemimelia:**

Tibial hemimelia has an autosomal dominant mode of inheritance and is less common than fibular hemimelia. It is more commonly associated with other bony anomalies (preaxial polydactyly, cleft hand) or syndroms (75% of patients). Clinical featrues include a short tibia that is bowed anterolaterally with a prominent proximal fibula and equinovarus foot. There are two well known classification.

**Kalamachi:**

Type-I: Complete absence: the knee and ankle are grossly unstable.

Type-II: Absence of distal half: the ankle is unstable.

Type-III: Hypoplastic: the tibia is shortened, proximal migration of fibula and distasis of distal tibia-fibular joint.

Congenital Tibial Hemimelia was first described by Otto in 1941. Other names are 1) Congenital longitudinal deficiency of the tibia 2) Congenital dysplasia of tibia 3) Paraxial tibial hemimelia 4) Tibial dysplasia 5) Congenital absence of tibia

**Clinical features:** 1) Leg is short 2) Fibular head is palpable 3) Foot in severe equinovarus 4) Hind foot is stiff 5) Knee is generally flexed 6) Quadriceps in sufficiency causes a lack of knee extension

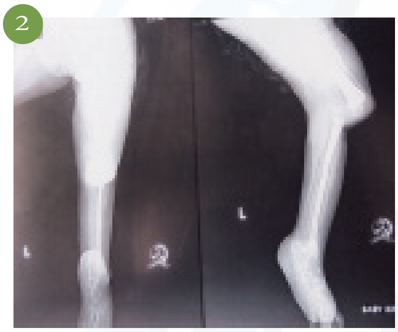
**N.B.:** Careful clinical evaluation of the quadriceps extension machanism is important because this has significant prognostic value regarding the potential for reconstruction of the knee.

## Case Study 1

1. 4 years old girl, tibial hemimelia with short leg, knee flaxed, foot is severely equinovarus, hind foot is stiff.
2. Radiograph of left knee, fibula, deformed ankle and foot.
3. Radiograph of pelvis including both femur, right tibia fibula and left fibula deformed left knee ankle and foot.
4. The baby is in the fathers lap after the surgery.
5. The baby is in the mothers lap after 15 days of surgery.
6. Knee contracture and equinovarus is almost corrected by Ilizarov fixator.
7. After the removal of Ilizarov apparatus.
8. The baby is in a plaster cast by which she can walk and that will be replaced by KAFO (knee, ankle, foot orthosis)

1

2



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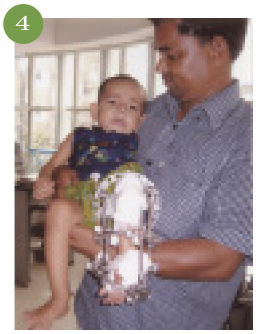

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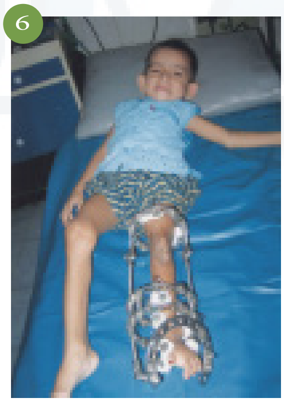

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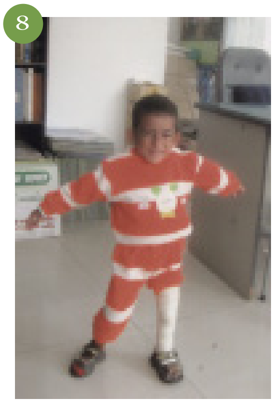
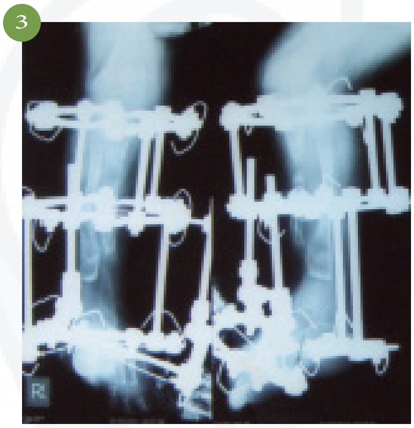


## Case Study 2

1. 1 Year old child tibial hemimelia right sided; child is in the mothers lap.
2. Radiographic view of right sided tibial hemimelia
3. Lengthening of tibia and correction of ankle deformity is going on.
4. The child can walk with Ilizarov apparatus.
5. Child is in the mothers lap with Ilizarov apparatus in situ.
6. After the removal of Ilizarov fixator.
7. Father and child with AFO (ankle, foot, orthosis) after 4 months follow up.

1


2


3


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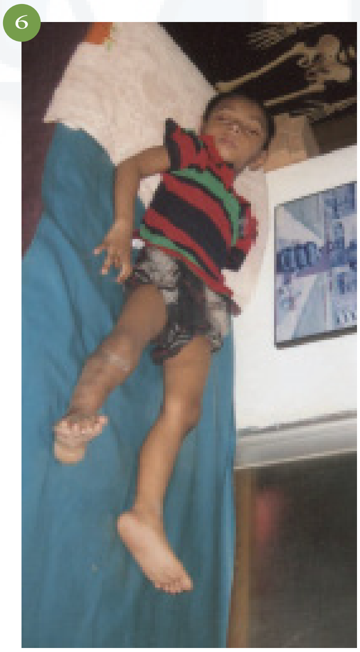

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## Case Study 3

### Tibial Hemimelia

Figure-1: Right sided tibial hemimelia, child in the father's lap.

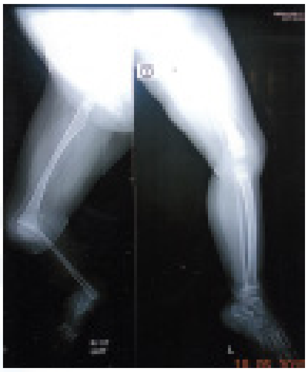

Figure-2: Radiograph of rt. sided tibial hemimelia.

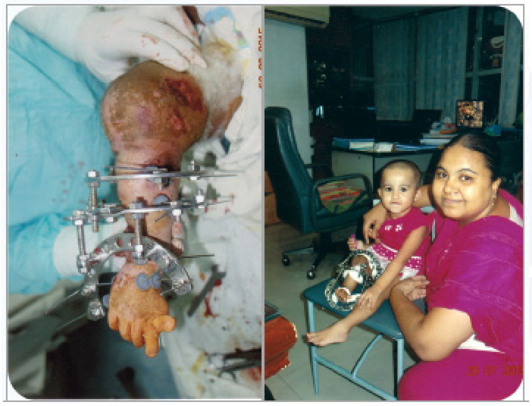

Figure-3: During treatment with Ilizarov apparatus

Figure-4: Radiographic view of rt. femur and fibula during treatment

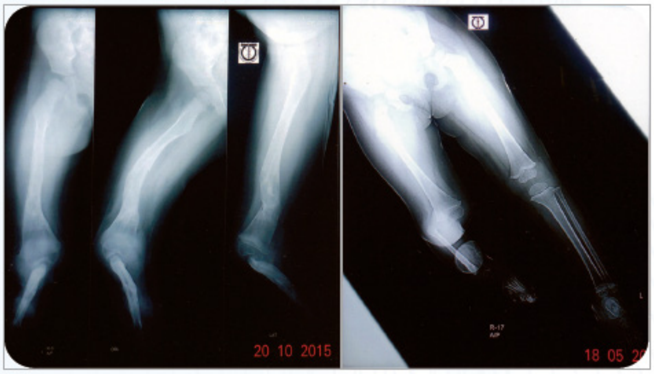

Figure-5: Final radiographic view, after correction

Figure-6: Clinical appearance of the baby after correction

## Case Study 4

### Tibial Hemimelia


Figure-1: Radiographic of right sided tibial hemimelia

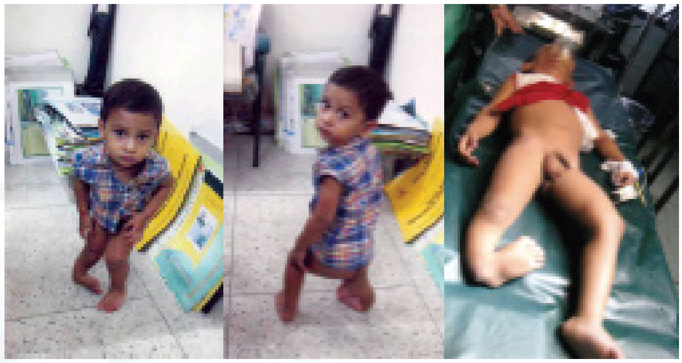

Figure-2: 3 yrs. old boy deformed right tibia and ankle,(front, back and lying view)

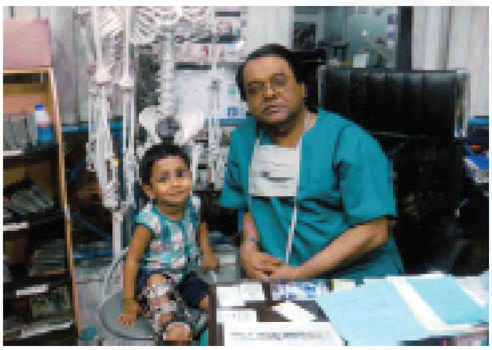

Figure-3: Smilling baby with Ilizarov apparatus

Figure-4: During treatment after 2 months follow up

Figure-5: After removal of Ilizarov apparatus with AFO

Figure-6: Radiographic view after lengthening of tibia and correction of ankle deformity

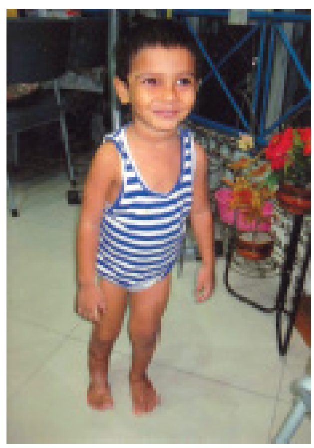

Figure-7: Clinical appearance of the baby after 5 months

# Chapter 32
# Rehabilitation with Ilizarov Ring Fixator

**Rehabilitation with Ilizarov Ring Fixator**

**The aim is to**

1. Restoration of complete function of the extrimity after injury or disease. This is only possible to achieve by restoring the normal shape and rigidity of the bone being treated. Ilizarov fixation with its anatomic reduction, stable fixation creates an optimum condition for natural bone union and curing of the wound with soft tissue damage.
2. With active exerciese the muscles are activated, trophics is improved and the muscles strengthen.
3. Ilizarov fixator enables variety of continuity of rehabilitation from injury until maximum possible result.

**Active exercises:**

a) Isometric (static) and

b) Isotonic (dynamic) Start immediately after the operation, together with the exercises of the joints 3 to 4 times a day.

4. Regular hygiene around the wires and pins is obligatory and it contributes more comfortable and better rehabilitation.
5. Application of electro stimulation in case of nerve lesion with the apparatus on the extremity is possible to perform.
6. After removal of Ilizarov apparatus underwater massage, paraffin application, stronger active and passive exercises are allowed. This will achieve the maximum function very quickly if the procedure has been observed all the time.

**Load and Motion:**

1. Walking with two crutches reduces tonus of the musculature and circulation. Slowing of the circulation leads to oedema and dermineralization. On the superior extremities this is less expressed because of the better relationship towards the heart and smaller influence of gravitation.
2. With the method of photon absorption the value of the mineral on the fractures site was found to be from 92-98% in cases treated by compression distraction method according to Ilizarov.
3. With the Ilizarov Ring Fixator complete mineralization was achieved 12 days, but with traditional method minerals on the fracture site lasts 150 days (Anderson, Nilsson 1974).
4. Ilizarov Ring Fixator leads to micro motion in the fracture site up to 1 mm, which stimulates osteogenesis and particularly the formation of the periostic callus and very fast restoration of the function.
5. We recall Wolf's law on bone transformation: The shape and the structure of bone is changed in accordance with the loading conditions. Increased pressure causes hypotrophy, while unloading leacks to bone dissolution.

# Part 6

# Ilizarov Today and in Futureg

# Chapter 33
# Ilizarov Today and in Futureg

Extensive injuries (RTI, Industrial trauma and War injuries) and infection are the leading problems in Trauma and Orthopaedic surgeons in future.

Ilizarov external fixation is the method of the best choice for the most serious cases, infected pseudarthrosis and infected fractures. To eliminate infection Ilizarov is the method of best choice.

**Ilizarov Ring Fixator is supposed:**

1. To be adjustable to the large scope of injuries and congenital deformities.
2. To give absolute stability.
3. To enable movements of the adjacent joints and bearing the full load.
4. To be safe for the patient.
5. To have low scope of complications.
6. With the development of medical science, metallurgy technology, electronics we can expect improvement in the field of Ilizarov Ring Fixator.

# Part 7
# Glossary

# Chapter 34

## Glossary

## Glossary

**AMBULANCE:**

Vehicle designed for the transportation of the sick or in injured. They provide immediate emergency care as well as safe and speedy transportation to the hospital. Modern ambulances are equipped with devices for administering blood transfusions, providing pure oxygen, defibrillation and appliances for fracture splinting.

**AMPUTATION:**

This is the surgical removal of a diseased part of and extremity. It is a type of surgery that is done by cutting off or removing infected, dead and harmful part of the body so that the patent's health and function may be preserved or improved. Sometimes it may be caused by trauma or other diseases. These are termed traumatic or auto imputation respectively.

**ANESTHESIA:**

Absence of physical sensation general or regional.

**ANATOMICAL POSITION:**

The reference position of the body; standing or lying and facing the observer, with the palms of the hands facing forward.

**ANATOMICAL REDUCTION:**

The exact adaptation of fracture fragments (hairline adjustment), it will result in complete restoration of the normal anatomy. While overall stability does not depend on precise reduction, precise reduction more reliably results instability and increased strength of fixation. It is more important in articular fractures than in diaphyseal fractures.

**ANGULATION:**

The orientation of one bone fragment in such a manner that the two parts meet at an angle rather than a straight line. The standard surgical convention is that the angulations are characterized by describing the deviation of the distal part from its anatomical position. For example, in a Colle's fracture, the distal radial fragment is dorsally (or posteriorly) angulated, even though the apex of the deformity points anteriorly; similarly a tibial fracture whose apex angulation points backward should be referred to as angulated anteriorly, as the distal part is indeed angulated anteriorly from its anatomical position.

**ANKYLOSIS:**

Fusion of a joint by bone or a tight fibrous tissue which may occur as a result of a disease process. Anterior: The front aspect of the body in the anatomical position. If A is in front of B in the anatomical position, then A is said to be anterior to B while B is posterior to A.

**ANTISEPTIC:**

Originally the surgical strategy for avoiding post operative sepsis by applying to the wound bactericidal chemicals, as in the carbolic acid aerosol described and used by Joseph Lister in the late 19th century the era of antiseptic surgery. Now a term used for non biological chemicals which have topical bactericidal properties.

**ARTHRITIS:**

Literally, an inflammatory condition of a synovial joint. It may be septic or aseptic. The former may be blood borne (haematogenous), as in children, or it may follow penetration of the joint by wounding or surgery. Aseptic Arthritis are usually of the rheumatoid type (including Reiter's syndrome, psoriatic arthropathy, etc) or due to degenerative change.

**ARTHRODESIS:**

Fusion of a joint by bone as a planned outcome of a surgical intervention.

**ARTHROPLASTY:**

Surgical reconstruction or replacement of part or whole joint with or without metal.

**ARTHROTOMY:**

Cutting into the joint as a form of treatment or diagnosis.

**ARTICULAR FRACTURE:**

Fracture involving the joint as well. It is a serious condition that usually requires open surgical intervention urgently.

**AVASCULAR NECROSIS (AVN):**

Bone death due to a cut in its blood supply by disease or injury. This result from injury, infection and metabolic as well as idiopathic diseases. In the absence of sepsis, this is called aseptic necrosis. The dead bone retains its normal strength until the natural process of revascularization by "creeping substitution" starts to remove the dead bone, in preparation for the laying down of new bone. Where the above process fails or there is undue load on the affected areas, segmental collapse takes place. This is commoner in the femoral head and the talus than at other skeletal sites.

**AVULSION:**

Pulling off, e.g. a bone fragment pulled off by a ligament or muscle attachment is an avulsion fracture.

**BIOMECHANICS:**

Is the application of mechanics principles to biologic systems.

**BIOPSY:**

The surgical removal of a piece of tissue for histological examination, usually undertaken to establish a diagnosis.

**BONE GRAFT:**

Bone removed from one skeletal site and placed at another. Bone grafts are used to stimulate bone union and also to restore skeletal continuity where there has been bone loss. Auto graft is a graft of tissue from one site to another within the same individual (homograft) while an allograft is one from another individual of the same species, who is genetically different from the recipient.

**CALLUS:**

A tissue complex formed at a site of bony repair. Following a fracture it makes a gradual and progressive transition through a series of tissue type haematoma granulation tissue fibrous tissue (or fibro cartilaginous tissue) calcified tissue remodeling into woven bone, gaining in stiffness as it does so, Callus formation is the response of living bone to any irritation (chemical, Infective, mechanical instability, etc. In Internal fixation with absolute stability, where direct (callus free) bone healing is expected the appearance of callus is a sign of unexpected mechanical instability (formerly referred to as irritation" callus) and will alert the surgeon to a failure of the original mechanical objective. Callus is welcome as a repair tissue in all treatment methods where relative fracture stability has been the planned goal.

**CANCELLOUS BONE:**

Is the spongy trabecular bone found mostly at the proximal and distal bone ends in contrast with the dense cortical bone of the shafts. Cancellous bone has a much larger surface area per unit volume and is, therefore, more readily available to its blood supply, as well as to osteoclasts for resorption. Its large surface/volume ratio also offers more surface for invading blood vessels attempting to revascularise dead cancellous bone, and this is an advantage when cancellous bone is used for grafting.

**CASTS:**

Casts are materials wrapped over the part of the body to provide immobilization. Mainly used on the extremities or spine following injuries, or in cases of other abnormalities of bone or soft tissues. It can be in the form of plaster of Paris (POP) or fiberglass. Casts when wrapped circumferentially around the extremity, provide more rigid support than splints.

**CAUSALGIA:**

A type of neuralgia or recurrent intractable pain occurring in an extremity as a complication of injury or surgical operation,

**CHONDROCYTES:**

The active cells of all cartilage, hether particular cartilage, growth cartilage, fibrocartilage etc. they produce the chondral matrix, both its collagen and the muscopolysaccharides of the ground substance.

**COMA:**

A level of consciousness where the patient fails to respond to all level of stimulation.

**COMPARTMENT SYNDROME:**

Is a condition is which increased pressure within a limited space compromises the circulation and function of the tissues within that space. The major factors in the pathology are:

- Elevated tissue pressure within a closed fascial space
- Reduced tissue perfusion -ischemia
- Leading to cell death – necrosis

**COMMINUTION:**

A condition where a fracture has more than two fragments, such fracture is termed a comminuted fracture.

**CONSOLIDATION:**

A stage in bone healing when there is stability and the woven bone (callus) is converted to mature bone.

**CORTICOTOMY:**

It is low energy to osteotomy with the preservation of Periosteum, endosteum and bone marrow.

**CORTICAL BONE:**

The dense bone forming the tabular element of the shaft, or disphysss (middle part) of a long bone. The term is also applied to the dense, thin shell convering the cancellous bone of the metaphysis. The term is generally used interchangeably with cortex. Cortical bone which has been completely deprived of its blood supply for any extended period of time dies. It may become revascularized by ingrowth of blood vessels and the newly formed Haversian canals which result from the penetration of osteons.

**DAMAGE CONTROL ORTHOPAEDICS:**

Emergency procedures aimed at rapid reduction and fixation and spanning of periarticular fractures has been termed "damage control orthopaedics".

**DEBRIDEMENT:**

The process of removing dead dying tissue as well as foreign bodies from a wound. Literally, it involves the surgical excision of all avascular, contaminated, infected or other undesirable tissue from the wound until there is bright red bleeding. Strictly speaking, it refers to the extension of a wound and the opening up of the planes of the injured tissue, usually in the context of open fractures, as described by Ambrose Pare in the 16th century. Today, some centres are using maggot for debridement of infected wounds.

**DEFORMITY:**

Any abnormality of the form or shape of a body part or in otherwords deviation from normality is called deformity.

**DELAYED UNION:**

May be defined as a failure of a fracture to consolidate within the normal expected time, which varies according to fracture type and location. Delayed union, like union is a surgical judgment and cannot be allocated time period.

**DIRECT HEALING:**

A type of fracture healing observed with absolutely stable (rigid) internal fixation. It is characterized by:

1. Absence of callus formation specific to the fracture site.
2. Absence of bone surface resorption at the fracture site.
3. Direct bone formation, without any intermediate repair tissue.

Direct fracture healing was formerly called "primary" healing, a term avoided today so as not to imply grading of the quality of fracture healing. Two types of direct healing are distinguished, namely contact healing and gap healing.

**DISASTER:**

It is also termed a Major incident. It occurs when the number, severity and type of casualties overwhelm the local medical resources such as personnel, equipment and consumables. It is usually sudden, unexpected and overwhelms the initial response mechanism of the Emergency department. Disaster can be natural or man-made and can occur as, trauma natural disasters, public health disasters or war and civil disorder.

**DISLOCATION:**

A displacement, usually traumatic of the components of a joint such that no part of one articular surface remains in contact with the other. The term subluxation applies when there is partial contact between the two surfaces.

**DISPLACEMENT:**

Out of place. A fracture is displaced if the fragments are not perfectly anatomically aligned. Displacements are:

- Translation (ad latus) - shift.
- Angulation (ad axin).
- Rotation (ad peripherium).
- Length (ad longitudinally).

**DISTRACTION OSTEOGENESIS:**

It is a mechanical induction between bony surfaces that are gradually pulled apart in a controlled number.

RICE for treatment of acute swellings- Rest, apply ice pack, Compress and elevate It.

CSM where you cheek for the circulation, Sensation and Movement in the effected limb.

**ENDOSTEAL:**

The adjective derived from endosteum, which means the interior surface of a bone, e.g. the wall of the medullary cavity.

**EPIPHYSIS:**

The end of long bone which bears the articular component; that fuses with the shaft at the point where it was previously separated by the bone growth plate. It develops from the cartilaginous element between the joint surface and the growth plate.

**EXTERNAL FIXATION:**

The technique of skeletal stabilization, which involves the implantation into bone of pins, wires or screws that protrude through the integument and are linked externally by bars, rods or other devices.

**FASCIOCUTANEOUS:**

A term describing tissue flaps which include the skin, the subcutaneous tissues, and the associated deep fascia as a single layer.

**FASCIOTOMY:**

The surgical division of the investing fascia wall of and osseofascial muscle compartment, usually to release pathologically high intra compartmental pressure in compartment syndrome.

**FIBROCARTILAGE:**

Tissue consisting of elements of cartilage and of fibrous tissue. This may be a normal anatomical entity, such as certain intra-articular structures (menisci, triangular fibrocartilage of the wrist, the symphysis pubis) or constitute the repair tissue after lesion of the articular cartilage.

**HEALING:**

Restoration of the original integrity. The healing process after all bone fracture lasts many years, until internal fracture remodeling subsides. For practical purposes, however, healing is considered to be complete when the bone has regained its normal stiffness and strength.

Health as defined by the WHO is a state of "complete physical mental and social wellbeing and not merely the absence of disease or infirmity" (Physical weakness).

**IMMOBILIZATION:**

Splinting or resting. The act and methods of stopping a patient or a limb from unwanted movement. Avoid vague use of this word e.g. "immobilize a patient". It is better to specify what is to be immobilized e.g, the ankle joint, the affected limb, the cervical spine or the patient (by admitting the patient in hospital).

**IMPACTED FRACTURE:**

A fracture in which the opposing bony surfaces are driven one into the other, resulting often in an inherent fracture stability and usually a degree of angulation.

**IMPLANTS:**

Mechanical (artificial) devices inserted into the body to maintain fracture after reduction. Implants are main components of osteosynthesis.

**INTRAMEDULLARY NAIL LOCKED OR UNLOCKED:**

An intramedullary nail provides some degree of stability, mainly as a result of its stiffness. An unlocked nail will allow the fragments to slide together along the nail, the fracture must, therefore be provided with a solid support against shortening. For the treatment of multifragmentary fractures, where there is axial instability (the fear of collapse into a shortened position) the nail can be interlocked above and below the fracture locus to prevent this shortening and also to reduce rotational displacement. This is achieved by locking bolts traversing a locking hole prepared in the nail and passing through the cortex on either side of the nail. If the locking hole is round and matches the size of the locking bolt, then static locking has been achieved. If the locking hole is elongated in the nail's long axis, the possibility of a limited excursion of axial movement is achieved, whilst preserving the rotational control so called dynamic locking.

**ISCHEMIA:**

Pathological absence of blood flow. Inadequate or lack of supply of blood to a part of the body, caused by partial or total blockage of an artery.

**MALUNION:**

A fracture that unites in an abnormal anatomical alignment and or rotation. (Consolidation of a fracture in a position of deformity).

**MASS CASUALTY:**

Generally, a mass casualty situation arises when the number of casualties arriving suddenly at a given time overwhelms the resources of hospital emergency services. These resources include personnel, equipment, infrastructure and consumables. It is also termed "major incident".

**METAPHYSIS:**

The segment of a long bone located between the end part (epiphysis) and the shaft (diaphysis). It consists mostly of cancellous bone within a thin cortical shell.

**MUSCULOSKELETAL SYSTEM:**

Body system comprising of muscles, bones and all other related tissues. The branch of Medicine that handles the problems of this system and all that makes it to function is called ORTHOPAEDICS. The specific area of Orthopaedic that deals with the study and management of injuries, particularly that of musculoskeletal is called TRAUMATOLOGY.

**NEUROPRAXIA:**

Temporary alteration of nerve functions following ischaemia from a bruising or compression of a peripheral nerve.

**NEUROTMESIS:**

Damage to the nerve fibre (neuron) and the sheath, a severest form of nerve injury with poor result if not promptly and expertly treated (Nerve transection).

**NONUNION:**

(Author's definition) Arrest of bony fracture repair process with the formation of fibrous or cartilaginous tissue in between the main fragments and fracture has remain un-united for 6-9 months due to mechanical or biological failure judged by clinical and radiological evidence.

**OPEN FRACTURE:**

This is a fracture whereby the fragment (s) communicates with the exterior including communication with hollow viscus. This is the opposite of closed fracture. Open fractures are classified into three types namely, types-I, II and III.

**ORIF:**

An abbreviation for open reduction and internal fixation. A form of osteosynthesis whereby an implant material is used in the fixation.

**ORTHOPAEDICS:**

The world "Orthopaedics" was coined from two Greek word," Orthos, "meaning", "straight" and "paedion", "meaning" "child". This relation of the subject to subject to children arose from the historical fact that orthopaedic practice at that time was based on "straightening-up" of children made "crooked" by various crippling diseases, especially poliomyelitis which was prevalent at that time. This term was coined by Nicholas Andry, a Professor of Medicine at the University of Paris in 1741. Modern Orthopaedics has gone beyond this; it manages all abnormal conditions, including injuries, affecting the musculoskeletal system.

For the Residents Orthopaedics is that branch of surgery that deals with the study and management (Diagnosis, treatment and prevention) of the problems of the musculoskeletal system and its related structures.

**AREAS COVERED IN ORTHOPAEDICS INCLUDE:**

- Congenital and developmental problems
- Degenerative (aging) conditions
- Metabolic/endocrine problems of bone & joints
- Tumors and tumor-like conditions
- Injuries and related problems (Traumatology)
- Infection and inflammatory conditions
- Neuromuscular disorders

**ORTHOTICS:**

The branch of medical engineering concerned with the design and fitting of devices such as braces in the treatment of orthopedic disorders. Such devices and appliances are grouped as orthotics.

**OSTEOARTHRITIS:**

This is a condition which affects (synovial) joints and is characterized by loss of articular cartilage, reactive subchondral bone sclerosis (sometimes with subchondral cysts), and the formation of peripheral bony outgrowths called osteophytes. The primary lesion is degeneration of the articular cartilage as a consequence of infection, trauma, overuse, congenital skeletal anomaly, or a part of the aging process.

**OSTEOBLAST:**

Cell that form new bone.

**OSTEOCLAST:**

Cell that destroy bone. They are typically responsible for remodeling and are found at the tip of the remodeling osteons. They are also found in all sites where bone is being removed by physiological process.

**OSTEOCLASIS:**

Breaking down (Surgical) a mal united fracture in order to offer the correct treatment. Opposite of osteosynthesis.

**OSTEOMALACIA:**

Insufficient mineralization.

**OSTEOMYELITIS:**

An acute or chronic inflammatory condition affecting bone and its medullary cavity, usually the result of bone infection. This may be a blood borne infection (haematogenous osteomyelitis) usually in children or in the immuno compromised or followed by an open fracture (post traumatic osteomyelitis). The acute form, if diagnosed early and treated vigorously, can heal with no residual effects. If the diagnosis is delayed or treatment neglected, then the infection and the consequent interference with the local vascularity, can result in dead bone (which may separate to form one or more sequestra that remains infected in the long term because the defence mechanisms have no vascular access to it. The treatment of chronic osteomyelitis is surgical and includes wide excision of all dead and infected tissue, the identification of the responsible organism and the delivery, both locally and systemically of appropriate antibacterial agents. In modern world Ilizarov is the best option for chronic osteomyelitis.

**OSTEON:**

The name given to the small channels which combine to make up the Haversian system in cortical bone.

**OSTEOPENIA:**

An abnormal reduction in bone mass. This may be generalized, as in some bone disease, or localized, as response to inflammation, infection, disuse, etc. Reduce bone density on Radiograph.

**OSTEOPOROSIS:**

A reduction in bone mass in a unit volume (insufficient bone mass). It is a natural aging process but may be pathological. It can result in pathological fracture (Most fractures of the femoral neck in the elderly are due to osteoporosis plus minimal trauma).

**OSTEOSYNTHESIS:**

This term was coined by Albin Lambotte to describe the fixing of a fractured bone by a surgical intervention using implanted material (surgically "united"). It differs from "internal fixation" in that is also includes external fixation.

**OSTEOTOMY:**

Controlled surgical division of a bone.

**PATHOLOGICAL FRACTURE:**

A fracture in a diseased bone. It may be the result of the application of a force less than which would be required to produce a fracture in a normal bone.

**PERIOSTEAL:**

Relating to or derived from periosteum.

**PERIOSTEUM:**

The inelastic membrane bounding the exterior surface of a bone. The periosteum plays an active

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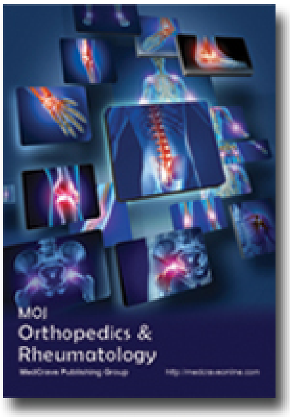

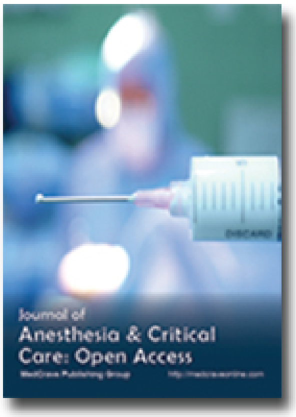

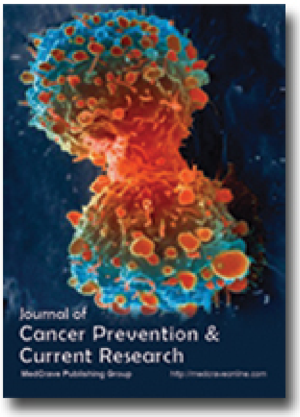


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ISBN 978-0-9967956-5-4
90000>
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