CORRECTION OF LEG DEFORMITES
AND RESTORATION OF
FUNCTION OF LEG BONES BY

ILIZAROV TECHNIQUE

Edition - I

MedCrave
Step into the World of Research

A TECHNICAL MANUAL FOR
ORTHOPAEDIC SURGEONS

MD.MOFAKHKHARUL BARI

ISBN: 978-0-9967956-0-9

This Technical Manual is written for professional orthopaedist and traumatologist mastering the method of transosseous osteosynthesis by Ilizarov technique.

Aim:

The aim of this manual is to highlight the main principles of treatment of patients with an orthopaedic pathology of leg bones (deformities, shortenings, defects, pseudoarthroses) using the method of transosseous compression-distraction osteosynthesis with the Ilizarov fixator.

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Published by:
MedCrave Group LLC
1st Edition – June 25, 2015

Foreword

It is indeed a great pleasure for me to write a few words on the eve of the publication of this excellent book titled “Correction of Leg Deformities and Restoration of Function of Leg Bones by Ilizarov Technique”, by our Honored Prof. of Kurgan Ilizarov Centre Md. Mofakhkharul Bari.

Bangladesh is a developing country and is burdened with a huge number of people with disabilities in desperate need of attention. But unfortunately many of the present day Orthopaedic surgeons are not well equipped with a knowledge to provide the treatment to these patients. Infact, many of the standard Orthopaedic books do not provide information for the young surgeons. So, a need for this kind of book has long been felt. Prof. MM Bari, a teacher with distinct quality and a lifelong devotee of deformity correction has given time and effort to bring out this book. This book is extremely informative and is most up-to-date. It is very stylishly written and neatly designed. What makes the book is that it makes the reading very interesting and thought provoking. The surgeon will find the book very gripping and absorbing.

My heartiest congratulations to him on his solo Herculean efforts. I wish him all the success.

02.06.14

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

Foreword

This book “Correction of leg deformities and restoration of Function of Leg Bones by Ilizarov Technique” is designed to provide the Orthopaedic surgeons with a rational treatment of trauma and orthopaedic problems. Professor Md. Mofakhkharul Bari’s large volume of personal expertise with Ilizarov technique since ’82 (during Orthopaedic residency) till date is a wonderful achievement in the field of trauma and Orthopaedic surgery. This book characterizes the professional career of Professor M. M. Bari. I have watched Professor M. M. Bari silently grow over the 32 years to become a leading author in the field of Ilizarov surgery. This book is very informative and thought provoking. Simple writing, lucid language, clarity of thought, innovative technique, clinical photographs, good radiographs are all there in plenty. Prof. Bari was my very favourite fellow student. I congratulate Prof. M. M. Bari on his stupendous efforts and this is undoubtedly a great pride and honour for him. He has truly put Bangladesh on the world map and deserves praise and appreciation for all his efforts. I consider Professor Bari very successful. I hope and believe that this publication will be well accepted by the readers at home and abroad.

I wish him all the best and feel privileged to be able to write a foreword for this beautiful book.

2.06.2014

Academician Prof. V. I. Shevtsov
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Message

It is a great privilege and honor for me to write a few words on the auspicious occasion of the publication of "Correction of Leg Deformities and Restoration of Function of Leg Bones by Ilizarov Technique" by Md. Mofakhkharul Bari who is a devotee to Ilizarov Surgery.

Our center, Bari-Ilizarov Scientific Centre (BISC) where he has done most of his magical works is a well recognized orthopaedic center making difference in the lives of human being. Ilizarov method has now gained a strong foothold in Bangladesh by which we can correct any congenital, acquired deformities and limb lengthening and solve any trauma problems. The motto of our center is to correct deformities, make people able to do their normal work and go back to their normal life.

My appreciation and congratulations to Dr. MM Bari for his tireless work in publishing this book.

02/06/15

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

Acknowledgements

It is a token of respect to my patients without whom I could not do this “Correction of Leg deformities and restoration of function of leg bones by Ilizarov Technique” which cannot be expressed in a few pages.

I have learned a great deal from my mentor prof. V. I. Shevtsov (former Director RISC, RTO, Kurgan, Russia) is my beloved teacher, Prof. A B Gubin, Director, RISC, RTO are the leaders of overall advancement in this field.

I recall the blessings given to me by Prof. E T Skliarenko (my MS supervisor, from Kiev) and Prof. B M Mirazimov (my Ph.D. supervisor, from Tshkent), because of them my career could get a new shape. My wife Nabia Bari 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. Finally I pray to Almighty Allah for the well-being of my patients.

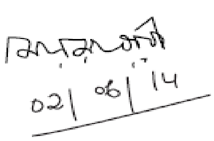
Preface

I am greatly indebted to all my reverend teachers and fellow colleagues for helping me in writing this book while working in the then Soviet Union (Kiev Scientific Research Institute of Orthopaedics and Traumatology, ashkent 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. Other techniques in orthopaedics, one can learn in 1-2 weeks; but one cannot learn this technique in a short period of time.

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. 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.

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 book “”**Correction of Leg deformities and restoration of function of leg bones by Ilizarov ring fixator**” is based on the experience and treatment of patients for the last 32 years- in abroad, MMCH, Narayanganj 200 bedded hospital, Bio-Centre and NITOR. I believe that this manual will stimulate budding doctors to explore this sub-specialty orthopaedic surgery. 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”. This manual 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 manual 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 manual, 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 manual and I appreciate the kind contribution by my eldest son Shayan Bari, Prof. Md. Shahidul Islam (Anaesthesiologist), Dr. Nazmul Huda Shetu, Dr. Mahfuzer Rahman, Hossain, Shahjahan, Munir, Jamir of Bio-Centre.

I wholeheartedly always welcome readers comments and criticism ideas and after all appreciation too. Thisbook is dedicated to my parents, my father and mother-in-laws and to my patients.



Md. Mofakhkharul Bari
MD, MS, PhD, Post-Doctoral Ilizarov fellow, Kurgan, Russia
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Chapter I

History

History

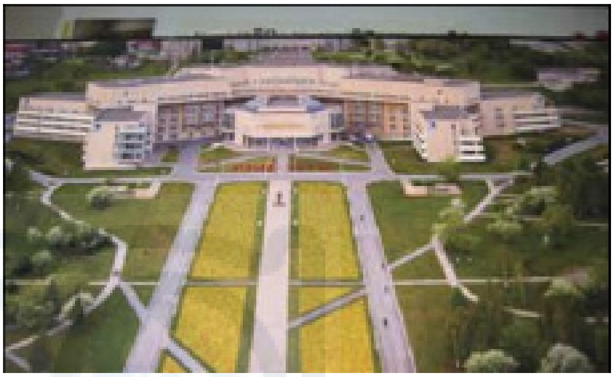
Professor Gabriil Abramovitch Ilizarov - graduated from medical school in the Soviet Union in 1944 near the end of World War II. After graduation, he was assigned to practice in Kurgan, a small town in western Siberia. He was the only physician with hundreds of miles and had little in the ways of supplies 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

Ilizarov 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 [1]. 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).

Front view of the Ilizarov Center.

worked against official acceptance of the Ilizarov device and method. In 1968 Prof. Volkov and Prof. Oganesyan 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 Prof. Ilizarov's external fixator and his method.

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

Despite the negative experiences in Moscow and his first attempts to introduce his new device to the Soviet Union. Prof. 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 "Honoured 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

Front Gate of the Ilizarov center.

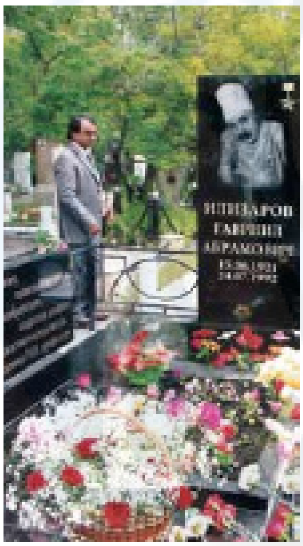
to do with Ilizarov's lifelong love of hearing and showing off magic tricks, which became his hobby throughout his life and provided him great joy and relaxation [2-4].

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 an 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 non-union as well as significant LLD. In 1965, Dr. Golyakhovsky [5] was among the First group of specialists sent to Kurgan to observe and evaluate Prof. Ilizarov's work. Dr. Vladimir [5].Golyakhovsky [5] 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.

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

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.

Carlo Mauri with Academician Ilizarov.

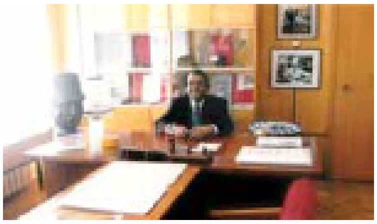
Mauri subsequently invited Prof. Ilizarov to Italy in June

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 New York and Dr. Golyakhovsky [5] 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.

Chapter II
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 Prof. Y. P. Saldatov.


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


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


Prof. A. V. Gubin is welcoming Honored Professor of Ilizarov center MM Bari.


Delegates in the Ilizarov center is welcoming Honored Professor MM Bari after the ceremony.


The Moment of wearing the Cap.

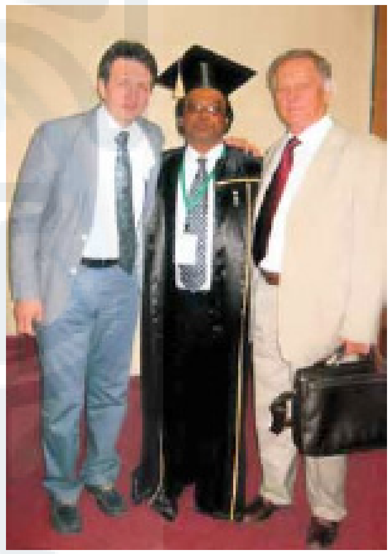

Deputy Director for Scientific works Y. Borzhunov is clipping broach of Honored Professor to MM Bari. Prof. A. V. Gubin is also welcoming him.

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

Prof. A. V. Gubin with Prof. MM Bari and Shayan Bari.

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

Dog Square, Dogs are helping in Scientific research.



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

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

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

Chapter III

Development of Compression-Distraction Method and External Transosseous Fixation of Bones.

Development of Compression-Distraction Method and External Transosseous Fixation of Bones

Compression-distraction is an independent sector in orthopedics and traumatology has got definite history of its own development and may be analyzed on many parameters. Utilization of this method in orthopedics attracts many specialists with opportunity without considerable surgical trauma to eliminate severe congenital and acquired deformities, which is connected with great regeneration. Undoubtedly facts remains that compressiondistraction 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 .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 Pseudoarthroses 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 perspective 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 orthopaedo-traumatological 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. 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.

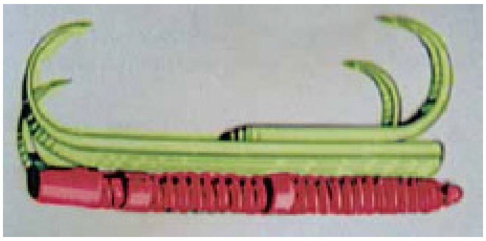


Figure 3.1: Apparatus of Malgaigne.

In 1902 Lambotte designed an apparatus (Figure 3.2) to fix fractures outside the

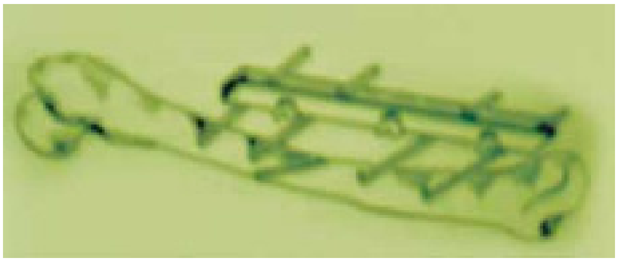


Figure 3.2: Apparatus of Lambotte.

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.

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.

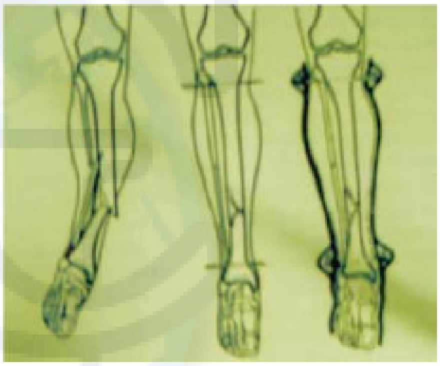


Figure 3.3: Transfixion of bone fragments.

In 1934 Bittner developed his apparatus (Figure 3.4) 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.

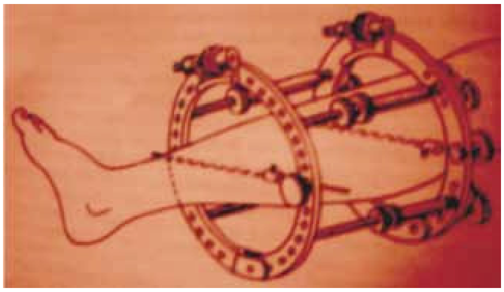


Figure 3.4: Apparatus of Bittner

In 1937 Stader designed an apparatus (Figure 3.5) 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 3.5: Stader Splint.

In 1938 Petrovsky designed an apparatus (Figure 3.6) 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.

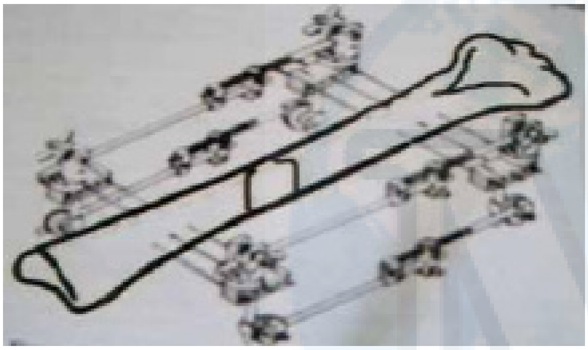


Figure 3.6: Apparatus of Petrovsky.

In 1942, Hoffmann applied an apparatus (Figure 3.7) 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.

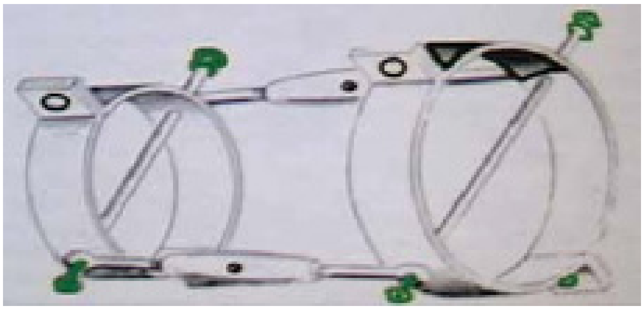


Figure 3.7: Apparatus of Hoffmann with a vidal double frame.

In 1952 Sivash designed a fixator (Figure 3.8) 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.

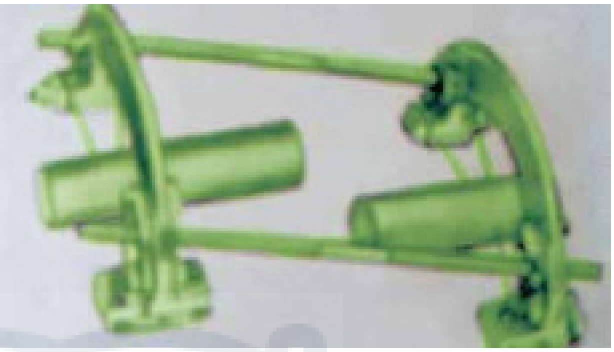


Figure 3.8: Appartaus of sivash.

In 1952 an apparatus (Figure 3.9) designed by Prof. G. A. Ilizarov of Kurgan has came into wide used in Soviet Union. It is intended for arthrodesis, in diaphyseal fractures, non unions, Pseudoarthroses, limb lengthening and for deformity corrections. This device consists of rings and cross wires, the rings are connected by spacing screws. Two Ilizarov's 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 3.9: Apparatus of Ilizarov.

In 1954 Gudushauri designed an apparatus (Figure 3.10) 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.

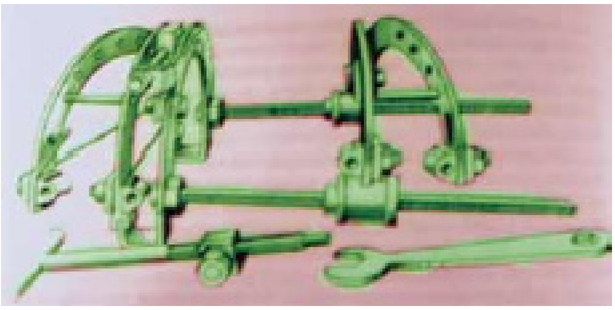


Figure 3.10: Apparatus of gudushauri.

In 1962 Grishin designed an apparatus (Figure 3.11) 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.

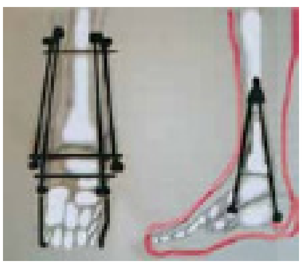


Figure 3.11: Apparatus of grishin.

Varus or Valgusde formity 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.

In early1970 Kalnberz of Riga, Alma- Ata designed an apparatus (Figure 3.12) 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.

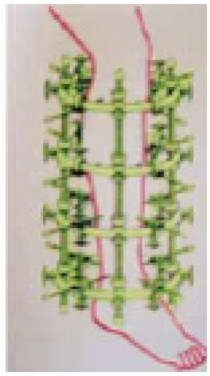


Figure 3.12: Apparatus of kalnberz.

In 1971 Valkov-Oganesyan reposition hinged distraction apparatuses (Figure 3.13) 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 3.13: Apparatus of volkov-oganesyan.

Chapter IV

Basic Ilizarov Frame and its Components

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 important in case of infected non-union or pseudoarthrosis.
3. Less traumatic than the implantation of an internal fixation device.
4. The compression-distraction device cam be be removed without an additional operation.

Components:

Main support components are:

a) Half rings (Figure 4.4)

b) Arches (Figure 4.7 & 4.8)

c) 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: 8mm.

Space between holes: 4 mm.

It ends are bent into ledges. This allows attachment of one half ring (Figure 4.1) to another in the same plane (Figure 4.2-4.4).

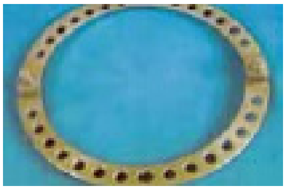


Figure 4.1: Steel ring.

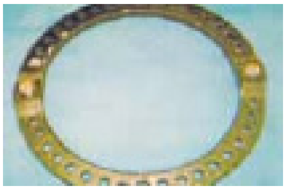


Figure 4.2: Carbon ring. (Non radio lucent and radio lucent).

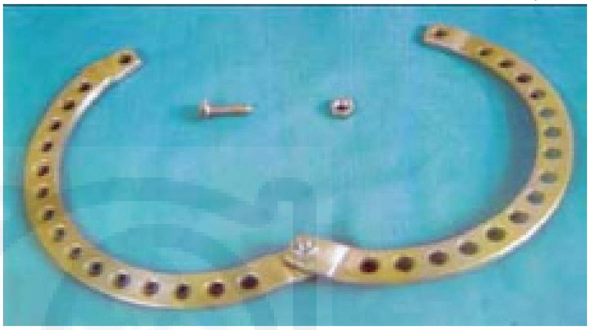


Figure 4.3: Connecting ring.

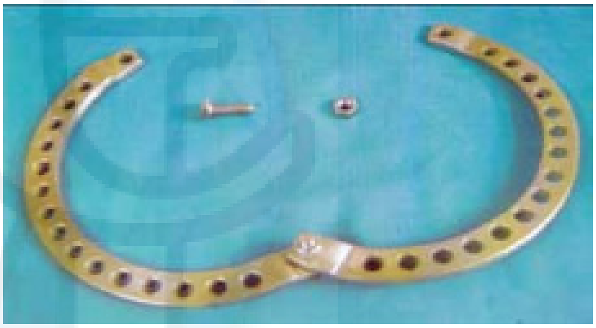


Figure 4.4: Carbon half ring.

5/8th Ring

1. Sizes: 130, 150, 160mm inner diameter. Advantages:
2. Facilitates joint movements
3. Wound dressing can be done easily

Myocutaneous flaps and large deep incision as in compartment syndrome it is useful (Figure 4.5).

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).

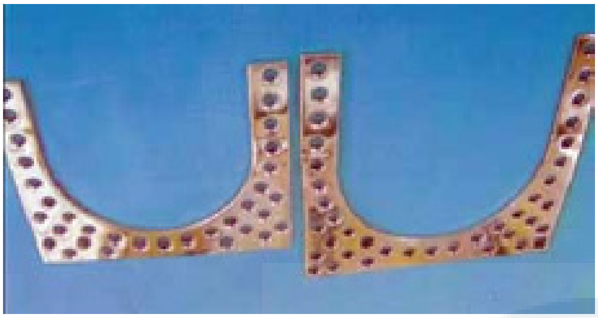


Figure 4.6: Foot ring.

Arch

Original Russian Arch

Sizes: 80-260 mm inner diameter and is used in the upper 1/3rd of the thigh to secure wires placed through the proximal femur (Figure 4.7).

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 & 4.9).

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 & 4.11).

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).

Figure 4.12: Threaded rods.

Telescopic Rod

Advantages

i. It increases frame rigidity when connecting rings or arches are greater than 150mm apart.

ii.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).

Figure 4.13: Telescopic rods.

Graduated Telescopic Rod

Advantage:

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

Figure 4.14: Telescopic rods.

Figure 4.15: Connecting Plates Graduated

Connecting Plate

Variants

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

Thickness: 5mm

Wide: 4 mm

Hole diameter: 7 mm (Figure 4.14 & 4.15).

Twisted Plate

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

Length: 45mm, 65mm 86mm

2 holes 3 holes 4 holes (Figure 4.16).

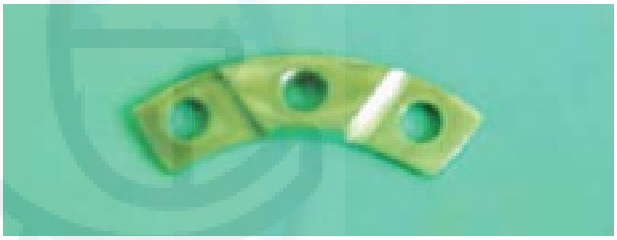


Figure 4.16: Twisted Plate.

Curved Plate

These are used as extension to half ring arch for accommodating Ilizarov or K-wires (Figure 4.17).

Figure 4.17: Curved Plate.

Threaded Socket

Length: 20, 40mm

External diameter: 10mm

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 exten-sion of threaded rods (Figure 4.18).

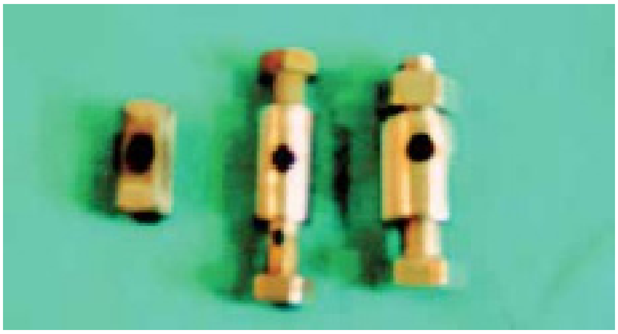


Figure 4.18: Threaded Sockets.

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).

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).

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 offrame construction. 6mm is used for connecting rods where compression-distraction is required (Figure 4.21 & 4.22).

Figure 4.21: Nuts in slotted and cannulated bolts.

Figure 4.22: Nut.

Washer

It is used to fill the space (Figure 4.23) 4 types are available.

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

Wire Fixation Bolts

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

Types

i. Slotted.

ii. 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 4.23).

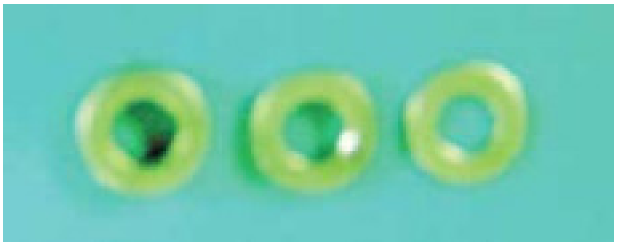


Figure 4.23: Washer.

Wire Fixation Cannulated Bolt: Cannulated bolts are preferred for 1.5mm wires and slotted bolts for 1.8 mm wires (Figure 4.24).

Figure 4.24: Cannulated wire fixation bolt.

Block For Half Pins/Schanz

Sizes: 1,2,3,4 holes (Figure 4.25).

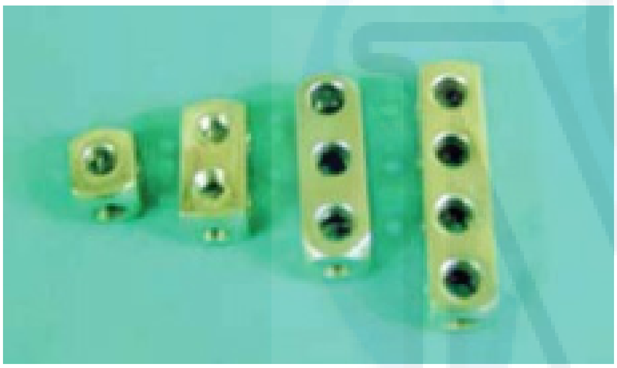


Figure 4.25: Block for half pins/Schanz.

Box Wrench for Bolt

Is used to tight & loosen the nut.

Figure 4.26: Box wrench for bolt.

Figure 4.27: Spanner 10mm size.

Oblique Support

Is used to connect the Italian arch with ring (Figure 4.28 & 4.29).

Figure 4.28: Oblique support.

Figure 4.29: Different Box Wrenches.

Original Ilizarov Mechanical Wire Tensioner:

Figure 4.30: Wire Tensioner Mechanical.

Direct Measuring Wire Tensioner

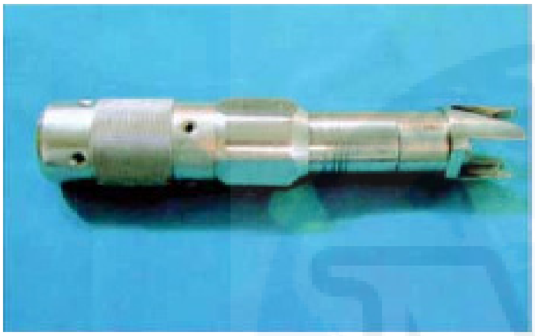


Figure 4.31: Direct Measuring wire tensioner (Russian Dynamometer)

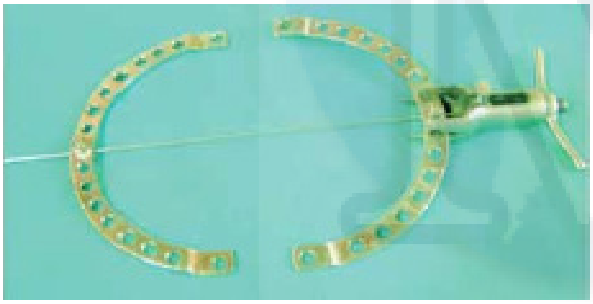


Figure 4.32: Tensioning using wire tensioner.

Corticotome

Sizes available: 3, 5, 7, 9 mm (Figure 4.33).

Figure 4.33: Different corticome.

Wires

They serve to connect bones or bone fragments to the support elements of frame. They differ 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 4.34).

Figure 4.34: Bayonet point.

Trocar point :

Advantages:

1. It is used for meta epiphyseal region because it has less penetrating power.
2. It has greater hold in the bones.

Trocar point cancellous 1.5mmx300mm for metaepiphyseal region of radius & ulna Trocar point cancellous 1.8mm x 370mm for metaepiphyseal region of tibia and femur (Figure 4.35).

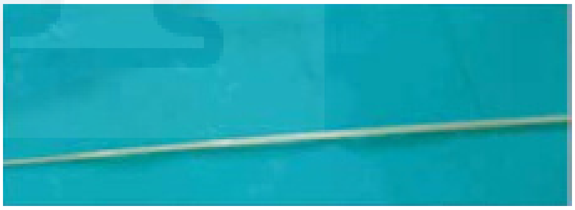


Figure 4.35: Bayonet point.

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 4.36).

Figure 4.36: 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 (Figure 4.37-4.42) the configuration.

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

Figure 4.37: Buckle.

Figure 4.38: Use of buckles to fix additional wires.

Figure 4.39: Hinges.

Figure 4.40: Formation of hinges.

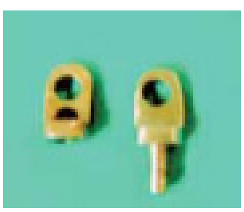


Figure 4.41: Female and male hinge

Figur 4.42: Universal joint hinges. Indications:

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

3. Two rings to which hinges are attached must be strictly perpendicular to the bone fragments.
4. Two hinges are located at opposite sides of the deformity for stabilization.
5. 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.
6. Hinges are applied at the same level of deformity.
7. The position of hinges can be used to achieve different types of deformity correction such as opening wedge distraction, compression, translation and deroriation.

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 1mm 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 4.43-4.47).

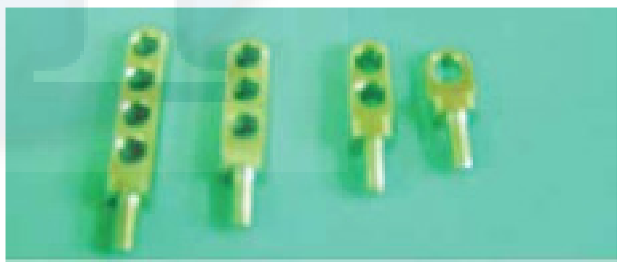


Figure 4.43: Male Post.

Figure 4.44: Female Post.

Figure 4.45: Multipe pin fixation clamp.

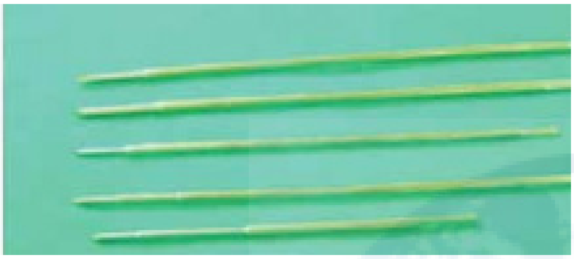


Figure 4.46: Schanz conical (different sizes).

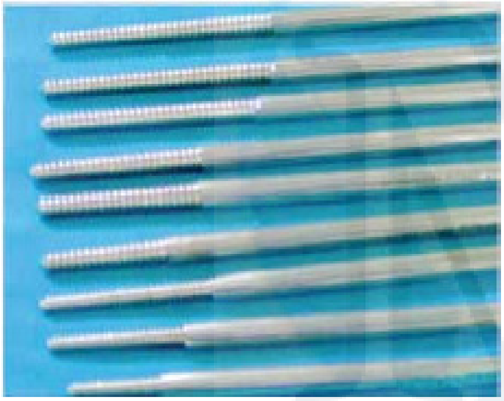


Figure 4.47: Schanz conical (different sizes).

Wire Cutter:

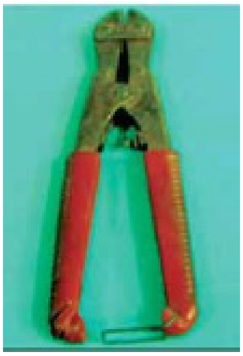


Figure 4.48: Wire Cutter.

Figure 4.49: Author's modified oblique support

Modification of oblique support by the author (Figure 4.48-4.50).

Figure 4.50: Half rings; Variants of assembly.

Goniometer

Figure 4.51: (Dfferent types).

Ilizarov Box for Different Components

Ilizarov box for different components.

Chapter V

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

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

Anatomical and plastic characteristics of osseo-articular systems for children significantly differ 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 osseo-articular system passes through 5 stages (Sadofev-V.I.1990).

1st 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.

2nd stage (from6-10 months to 4 years): Determines as a beginning stage of epiphyseal ossification of long bones. In this stage complete ossification of metaphysic occurs and part of the epiphysis also. Apophysis remains cartilagenous.

3rd 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.

4th 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. 5th 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 great practical 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 of distraction epiphyseolysis method demands the presence of well ossification and solid epiphysis, consequently in 1st and 2nd stage of development, it cannot be used. Compression-distraction method is also ineffective in the 5th 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 2nd stage (1.5-2 years), when diaphysis and metaphysis of long bones ossifies and have definite stability.

Chapter VI

Classification of Compression - Distraction Method

Classification of Compression - Distraction Method

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

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.

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 -

i. Lengthening, shortening and widening of bones.
ii. Correction of bowing deformities
iii. Transportation and filling the defects of bones.
iv. 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 VII

General Principles of Application of Apparatus

General Principles of Application of Apparatus

Assembly:

The Assembly and design of 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 when 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 deformed wire 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 parallel 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 VIII

Ilizarov Basic Concepts

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 kept 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.

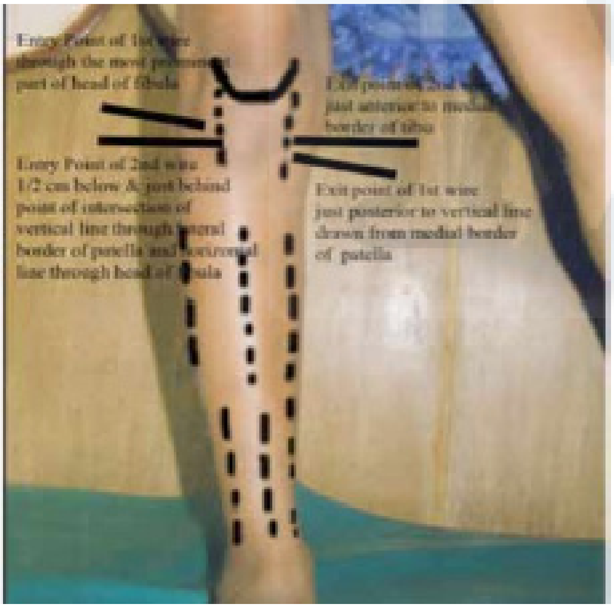


Figure 8.1: Proximal Tibial Wires.

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 8.1).

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.

Middle Tibial Wires

Entry - Exit points

The first wire is inserted at about 1 finger breadth (2cm) 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 about 1 finger breadth (2cm) anterior to the palpable anterior border of the fibula at a point about 1/2 cm (5mm) below the level of the first wire with an inclination anteriorly aiming the wire to emerge about one finger breadth (2cm) posteromedial to the shin of tibia (Figure 8.2).

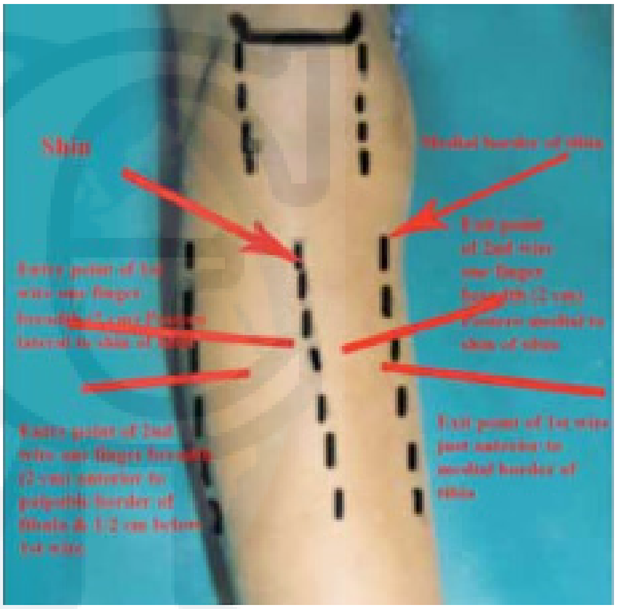


Figure 8.2: Middle tibial wires.

Distal Tibial Wires

Two Ilizarov's wires or K-wires (1.8mm) 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 8.3). 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 8.4). 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 8.5-8.7).

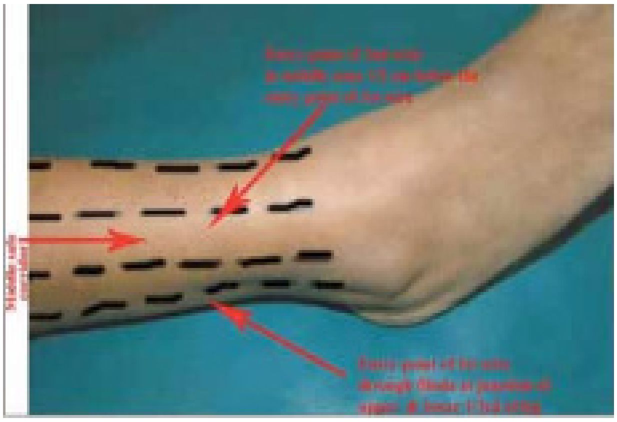


Figure 8.3: Entry point of distal tibial wires.

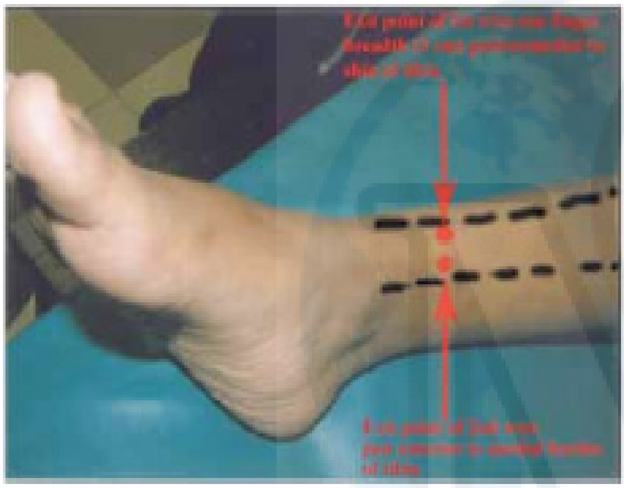


Figure 8.4: Exit point of 1st and 2nd wires.

Figure 8.5: Vena Saphena magna (Great saphenous vein).

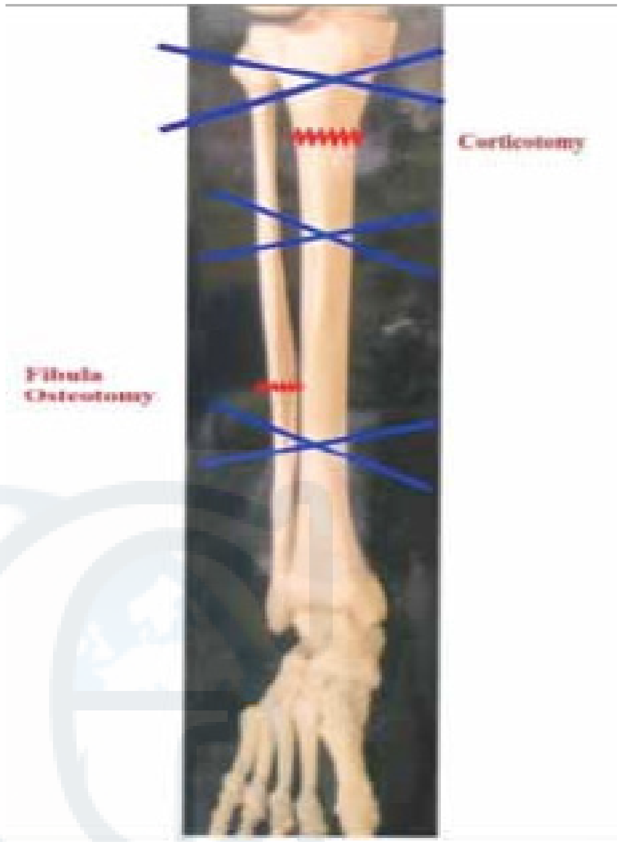


Figure 8.6: Position of wires tibial rings (Proximal, middle, distal).

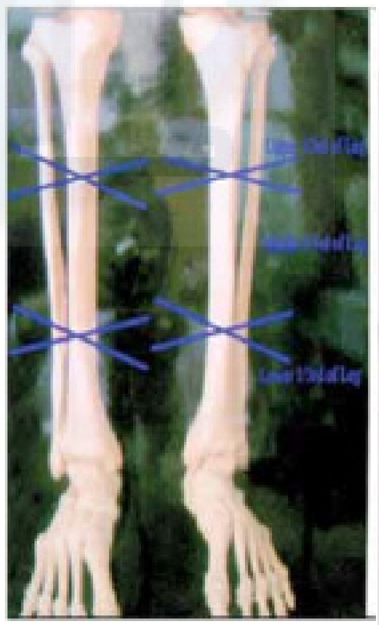


Figure 8.7: Position of wires (Middle and distal tibial rings).

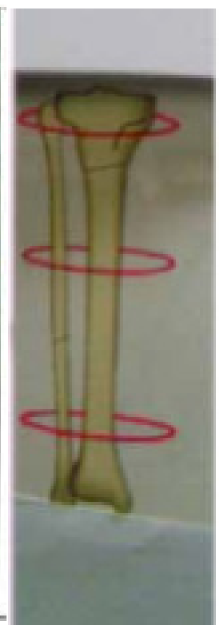


Figure 8.8: Proximal Tibial Schanz Screw

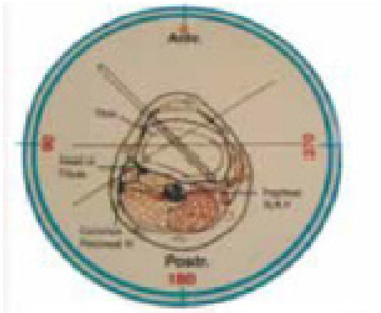


Figure 8.9a: Proximal schanz screws.

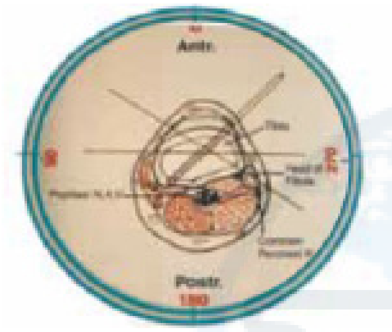


Figure 8.9b: Proximal schanz screws.

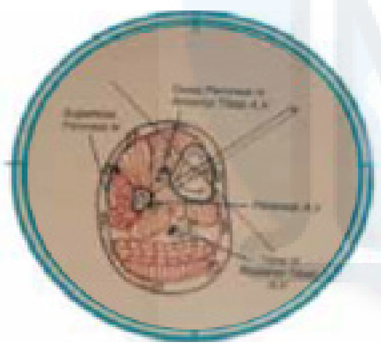


Figure 8.10: Middle schanz screws.

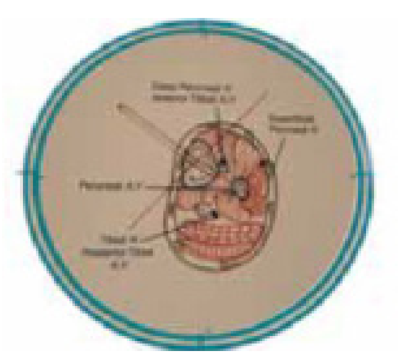


Figure 8.10a: Schanz in lower 1/3rd of tibia.

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 8.8)

Middle tibial Schanz Screw

One Ilizarov wire or K-wire and one Schanz screw is passed (Figure 8.9).

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 (2cm) 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 8.10).

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 posterior 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 (4-6cm) behind the posterior border of posterior malleolus. The first K-wire is inserted at one finger breadth (2cm) above the undersurface of calcaneum and one finger breadth (2cm) 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 8.11-8.13).

Figure 8.11: Wire position in calcaneus and metatarsals.

Figure 8.12: Wire in calcaneum.

Figure 8.13: Wires in calcaneum and ring in tibia.

Lateral Approach

Insertion Point

First wire is inserted through outer surface of calcaneum 1cm above its inferior surface and 1cm distal to the attachment of Achille's tendon and the wire is further introduced with an inclination antero-medially aiming to emerge on the medial surface of the calcaneum 2 finger breadth (4cm) below the medial melleolus. The second wire is inserted one finger breadth (2cm) distal to the entry point of first wire and is advanced posteromedially to emerge one finger breadth (2cm) behind the first wire in the same level. Here the angle between the two wires should be more or less 30 degree (Figure 8.12 & 8.13).

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 8.14).

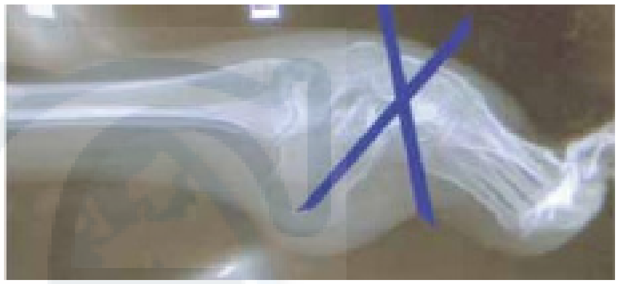


Figure 8.14: Position of wires in mid tarsal region.

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 8.15a-8.15c).

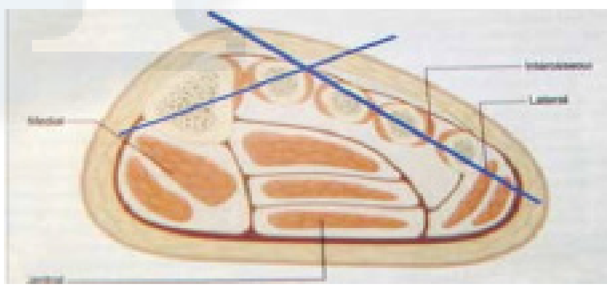


Figure 8.15 a: Position of wires in mid tarsal region.

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 (Table 8.1).

Figure 8.15b: (Position of K wires in standard approach).

Figure 8.15c: (Position of K wires in standard approach). Proper size of the ring:

Circumference of	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 8.16a & 8.16b).

Middle tibial ring:

A full ring is placed approximately at the junction of upper 1/3rd to middle 1/3rd of the leg (Figure-8.16C).

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.

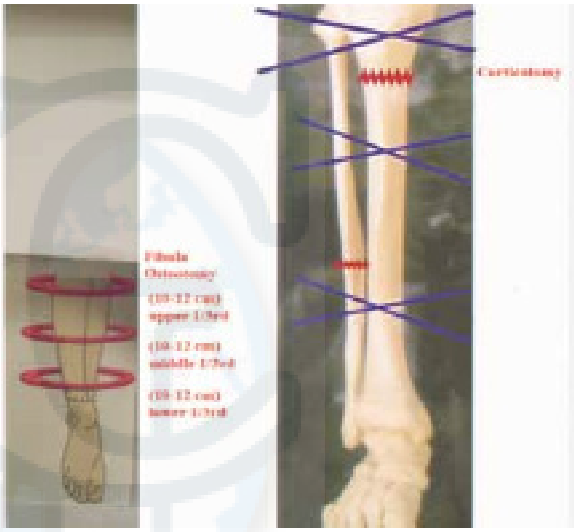


Figure 8.16a & Figure 8.16b: Position of rings in tibial lengthening.

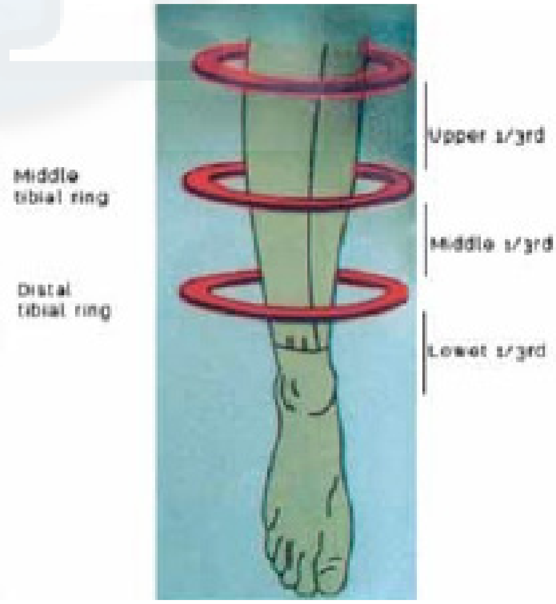


Figure 8.16a & Figure 8.16b: Position of rings in tibial lengthening.

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 8.17).

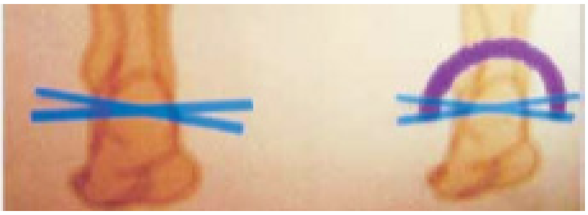


Figure 8.17: Placement of the ring in calcaneum.

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.

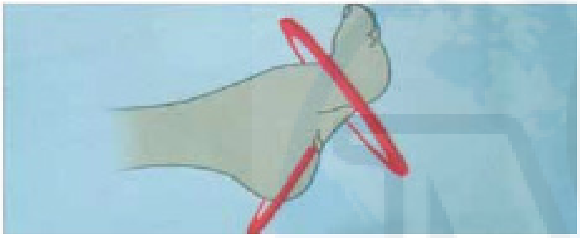


Figure 8.18: Placement of rings in calcaneus and forefoot.

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 8.19).

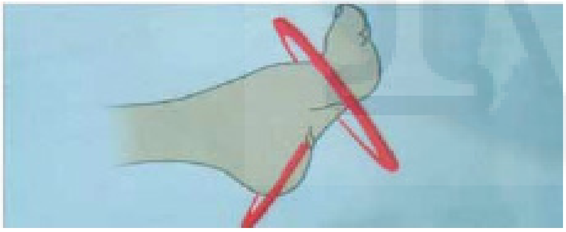


Figure 8.19: Placement of half ring in calcaneus and full ring at forefoot.

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 8.20).

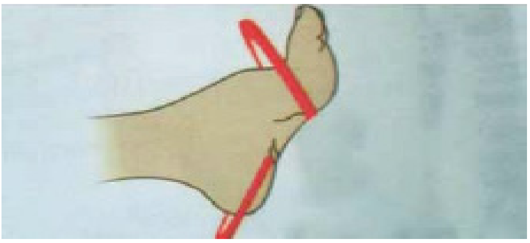


Figure 8.20: Placement of half ring in mid foot region.

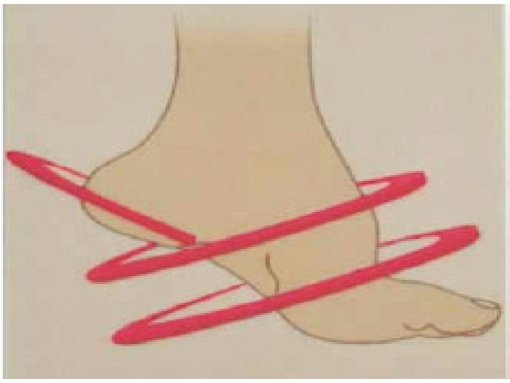


Figure 8.21: Placement of full ring in mid foot and forefoot region.

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 8.22). For correcting equinus deformity alone proximal ring is not at all required, middle and the distal ring will serve our purpose (Figure 8.23).

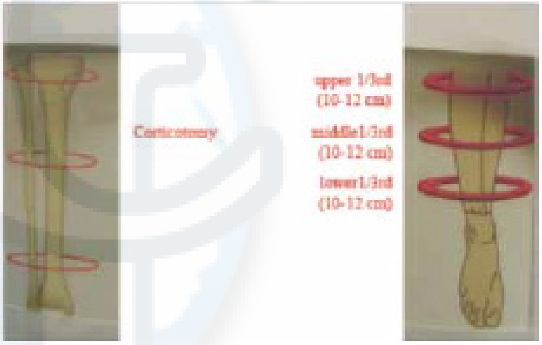


Figure 8.22a,b: Position of the rings for tibial lengthening.

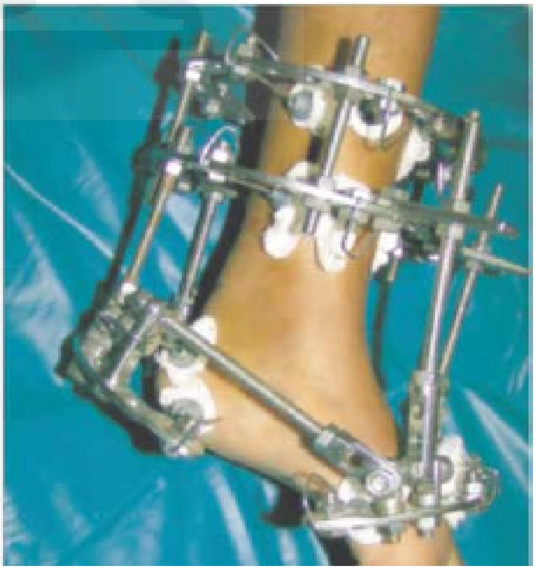


Figure 8.23: Complete frame assembly two anterior and two posterior threaded connecting rods.

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 8.24).

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

Figure 8.24: Corticotomy of tibia.

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

1. Corticotomy should not be performed in the middle of the bone.
2. Corticotomy is suitable in between diaphysis and beginning of metaphysis.

Biomechanical Factors

1. The bone segment must be large enough to accommodate two rings situated between bone and bone trans-section.
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 nearby 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 to premature 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.
7. If instability of fixation present collagen fibres become sinusoidal.
8. Mechanism of bone formation is intra-membraneous.
9. Endochondral bone formation less common but does occur.

10. Fibrous interzone is the layer between the forming columns of new bone.
11. Trabeculae looks like stalactites and stalagmites.
12. 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
3. regeneration.
4. Muscle regeneration secondary to addition of sarcomeres as well as recruitment of satellite cells.
5. Nerve regeneration includes 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.

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 7th day. Correction can be started on the 6th 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 IX

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 closed fractures is a perfect model for studying 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 35th post-traumatic day. On the 14th day after trauma, contents of STH and CT increase in blood. On the 5th post-operative 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 7th 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 (Ca^{2+}) 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 synthesis of 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 X

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. nuclides 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 XI

Biochemical Procedure of Metabolism in Lower Limb Lengthening in Adult Group

Biochemical Procedure of Metabolism in Lower Limb Lengthening in Adult Group

In Kurgan (RISC, RTO) proteins (albumin, total protein), low-molecular nitrogen containing substances (creatinine, urea, uric acid), lipids (triglycerides and cholesterol), hexoses (glucose, hexosamines), enzymes, alanine amino transferase ALAT; aspertatamino transferase-AsAT, lactose hydrogenase-LDG, hydroxybutirates-dehydrogenase; alkanine phosphates); electrolytes (calcium, magnesium, phosphates, chlorides) were measured in blood stream. Total contents of hydroxy peptide, calcium, magnesium, low-organic phosphates, total 17-oxycorticosteroids were measured in urine. Biochemical tests were performed in patients before treatments, after corticotomy, after lengthening of 1, 2, 3, 4, 6, 8 cm in every 30 days of fixation and within one week after removal of apparatus. During distraction and consequent fixation of the extremity no authentic changes of total protein, albumin, urea, uric acid, glucose, cholesterol, triglycerides, magnesium, chlorides concentration were found in blood serum of the patients. Excretion of total and -amino nitrogen and magnesium did not change in daily urine.

The greatest changes are found in alkaline phosphatase10 days after distraction its activity increase, 2 times approximately.

*AP is a marker of osteoblast bone synthesis activity and it enhances bone tissue regeneration.

Chapter XII

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. Load sharing fixator designs

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 Therapy

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 XIII

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.

What Not To Do?

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

Case No 1

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

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

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

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

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

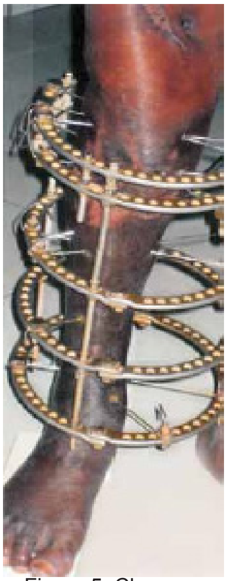


Figure 5: Close up view, ugly frame assembly.

Case No 2

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

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

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

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

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

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

Case No 3

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

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

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

Chapter XIV

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

Different Plane (Frontal plane, Sagittal plane and Horizontal plane) Deformities and Biomechanics of the Ankle and 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 14.1a: Varus heel.

Figure 14.1b: 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 14.2a-14.2e).

Figure 14.2a: Pes Equinus.

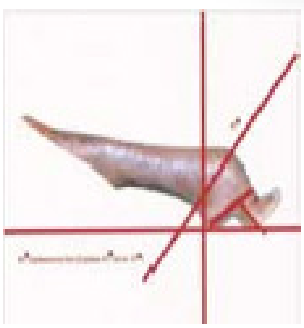


Figure 14.2b: Pes Equinocavus.

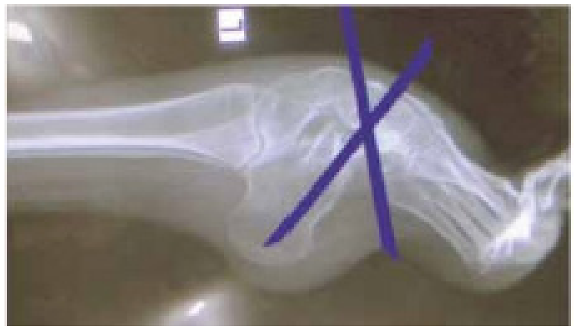


Figure 14.2c: Pes Equinocavus.

Figure 14.2d: Pes Planus

Figure 14.2e: 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 (Figure 14.3a-14.3c).

Figure 14.3a: Adducted foot.

Figure 14.3b: Abducted foot.

Figure 14.3c: 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 4th & 5th 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.

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		

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.

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 (Table 14.1).

Chapter XV

Disorders of the Bone Configuration and Function of Leg Bones

Chapter XV

Disorders of the Bone Configuration and Function of Leg Bones

I. Deformities of leg bones

II & III. Pseudoarthroses and Defects of Leg bones

IV & V. Leg Lengthening, Leg shortening with segmental axis disturbance
leg shortening without its axis disturbance

I. Deformities of leg bones

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 (Ollier's disease)

b) Blaunt's disease

c) Osteogenesis imperfect

d) Fibrous dysplasia

e) Developmental anomalies

Classification of Leg Bone Deformities According to Planes

a) Uniplanar

b) Biplanar

c) Multiplanar

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 Characterized 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

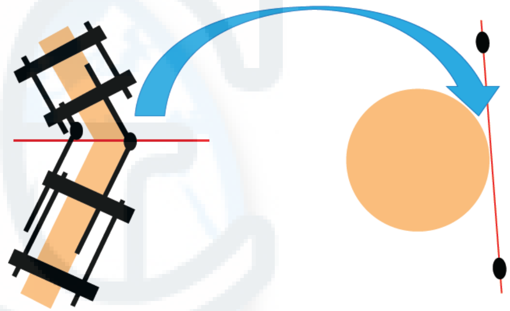
c) Biomechanical designing

d) Determination of osteotomy levels

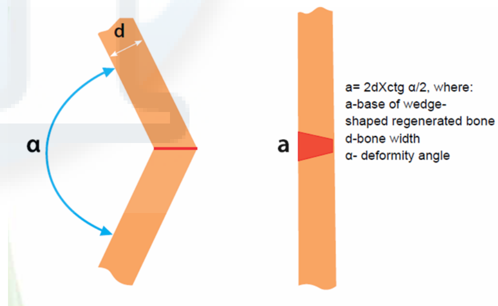
e) Determination of osteotomy shape

f) Selection of deformity correction type

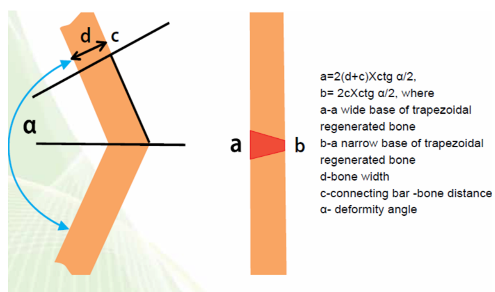
A diagram of hinge placement at the apex of deformity (Figure 15.1).



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)

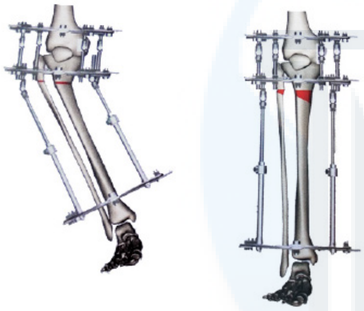
e) Skin closing

f) Control x-rays

Main Principles of Transosseous Osteosynthesis for Deformity Correction

- Insertion of wires with stoppers in the process of deformity correction
- Hypercorrection of the external supports of the transosseous fixator during its mounting
- 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» (Figure 15.4 & 15.5).



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

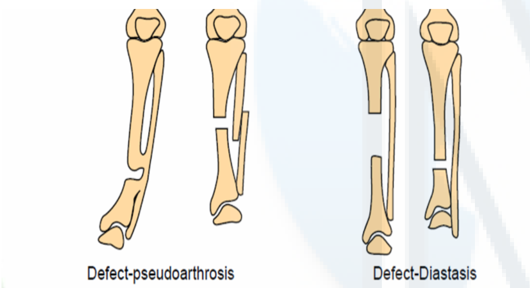
i) Transformation of the regenerated bone

II & III. Pseudoarthroses and Defects of Leg bones

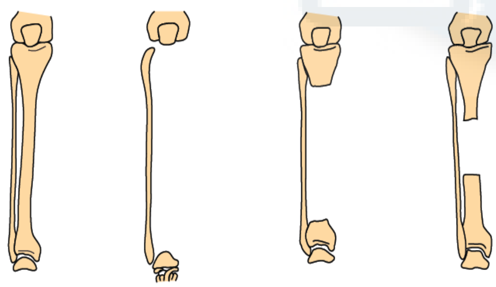
Pseudoarthrosis is a nonunion of bone in the average statistical period of time. True bone defects, means any loss of bone substance.

The true bone defect represents the total amount of interfragmental diastasis and anatomic segmental shortening. This takes into account the volume and amount of expected bone tissue loss in process ofthe planned removal of nonviable grafts, resection of the ends of fragments and their required the duplication at the docking site (Figure 15.6-15.9) and Table 15.1.

Classification of defects and pseudoarthroses



Classification by the amount of defe



Total subtotal partial

1 2 3 4 5 6

1- Preserved fibular integrity:

2- Fibular dislocation (subluxation) in the distal syndesmosis;

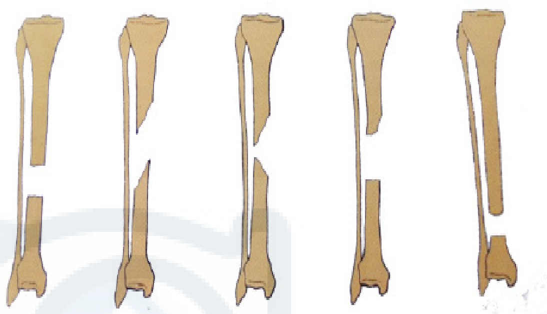
3-Fibular dislocation (subluxation) in the proximal syndesmosis;

4- Fibular defect-diastasis;

5- Fibular overlapping;

6- The presence of tibiofibular synostosis Etiolog

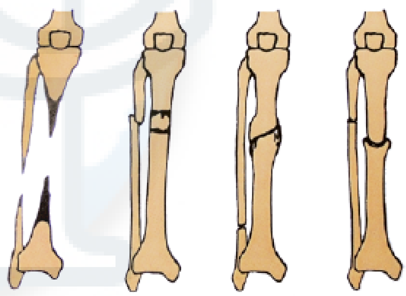
Classification by the shape of fragment ends:



1 2 3 4 5

1, 2, 5- congruent; 2, 3-oblique;
3, 4-incongruent; 4-oblique-and-transverse;
1- transverse; 5- hinged Congenital

Diagrams of the «articular»ends of pseudoarthrosis zone



Etiolog

- Congenital
- Acquired

a) Posttraumatic;

b) Post infective;

c) Postsurgical.

With regards to infection

a) Complicated by pyogenic infection;

b) Uncomplicated by pyogenic infection

Osteogenesis in pseudoarthrosis zone

a) Hypertrophic

b) Normotrophic

c) Atrophic.

Aim of Treatment and Rehabilitation Process - Recovery of Limb Anatomic-and-Functional Integrity

- Bone defect filling
- Integrity recovery of segmental bone
- Segment length restoration
- Correction of segmental deformities
- Correction of the defective contractures of adjacent joints

Main Approaches in The System of Reconstructive-And-Rehabilitative Treatment of Patients with Leg Defects by Ilizarov Technique

a) Union at the docking site of bone fragments
b) Lengthening of fragments
c) Tibiofibular synostosis
d) Closed gradual distraction of interfragmental tissues with formation of regenerated bones.

Types of Monofocal Transosseous Osteosynthesis

a) Monofocal combined distraction-compression osteosynthesis
b) Monofocal distraction-sequential compression osteosynthesis
c) Monofocal alternate compression-distraction osteosynthesis.

Indications for Monofocal Osteosynthesis

The presence of tibial pseudoarthrosis, including that with fixed angular deformity and anatomic segmental shortening not exceeding 2 cm.

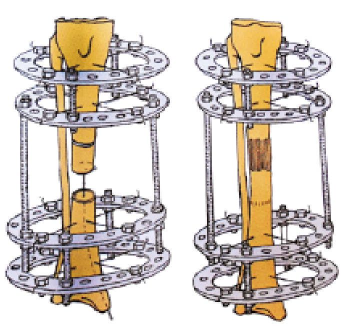
Indications for Bifocal Osteosynthesis

The presence of true tibial defect > 2-3 cm with anatomic segmental shortening and without it.

Types of bifocal transosseous osteosynthesis

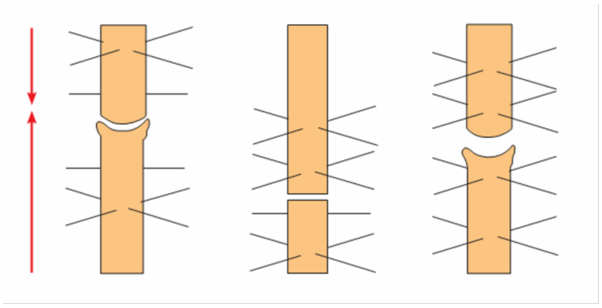
- Bifocal simultaneous compression-distraction osteosynthesis with fragmental lengthening
- Bifocal sequential compression-distraction osteosynthesis with fragmental lengthening (Figure 15.10).

A variant of the Ilizarov fixator configuration for bifocal transosseous osteosynthesis



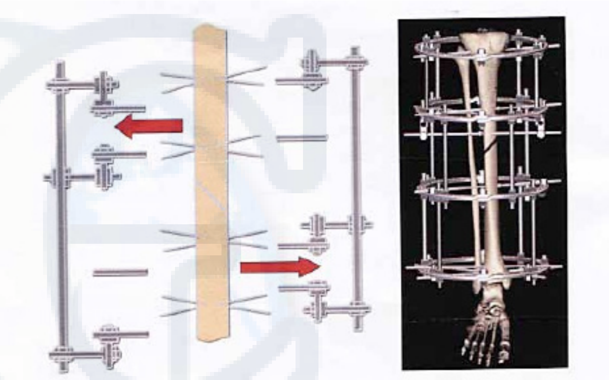
Principles of Transosseous Osteosynthesis for Pseudoarthrosis

Compression of bone frgments along bone axis



Side-to-side compression of bone fragments using posts

Side-to-side compression of bone fragments using olive wires



Tibiofibular Synostosis and Tibialization

Techniques of tibiofibular Synostosis

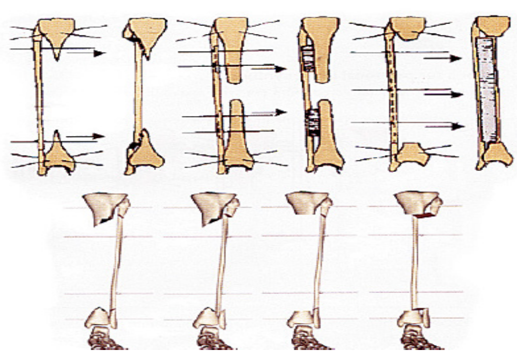
- Using a split-fragment;
- Using a cylinder-fragment

Indications for tibiofibular Synostosis

The presence of total (subtotal) tibial defect, when defect filling by fragmental lengthening is not possible. It is very effective in young person's only.

Classification of Tibiofibular Synostosis Techniques by Technological Features

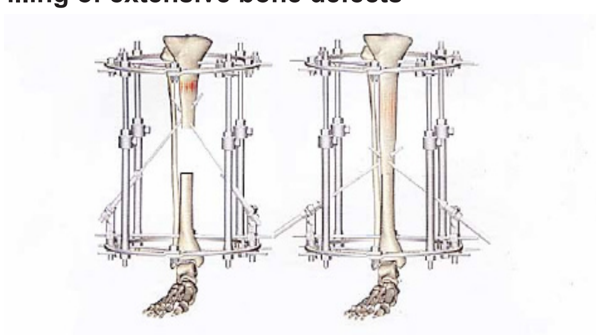
- Bypass tibiofibular Synostosis
- Fibula Tibialization (Figure 15.14 & 15.15).

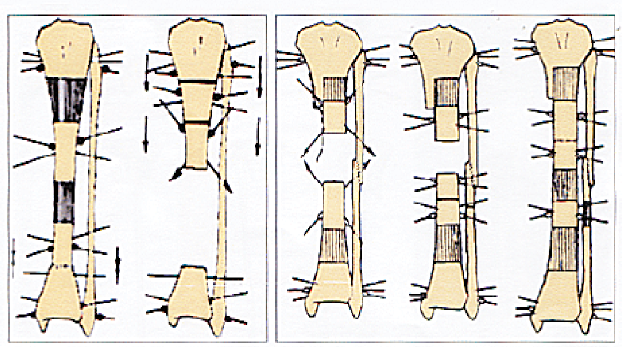


Pseudoarthrosis characterized by the type of articular ends (callus formation)

Defect (pseudoarthrosis Type)	Mobility at the Defect (Pseudo-arth rosis) Site	description of Fragment Ends	The Data of Radio include and Arteriographic Study
Hypoplastic	Excessive	Atrophy, sharpening, absence of periosteal growth, medullary canal eburnation	Accumulation of labelled pyrophosphate at the fragment ends is close to the norm, blood flow is decrease. Vascular network is poor.
Normoplastic	Moderate	Not changed or moderately osteoporotic, end-plates look like narrow sclerotic strips	Accumulation of labeled pyrophosphate at the fragment ends is 1.5-2=fold increased. blood flow is moderately accelerated. Hyper vascular.
Hyperplastic	Stiff	"Bamboo"-shaped thickening, the interfragmental gap is twisted and interrupted, end-plates are marked but their boundaries are unclear	Significant accumulation of marked pyrophosphate. Circulation in the interfragmental gap is 3-fold accelerated. Marked formation of vascular collaterals in the soft tissues surrounding the zone of nounion.
Neoarthrosis		The surface of fragments is smooth, convex and concave, an "articular" gap is present, medullary canals are closed by bone tissue over considerable extent.	Marked hypervascularization of soft tissues.

Filling of extensive bone defects





Fragmental multilevel lengthening

Combination of techniques

Indications for Polyfocal Osteosynthesis:

The presence of true tibial defect > 2-3 cm with anatomic segmental shortening and without it

Complications of the Following Structural Masses Can be Observed

a. Segmental soft-tissue components (skin, subcutaneous fat, muscles, vessels, nerves);
b. Adjacent joints and articulations of twin bones;
c. Bone fragments and regenerated bone.

Complications of Skin and Subcutaneous Fat

a. Inflammation in the zone of contact with inserted wires.
b. Soft tissue suppuration in places of compression produced by the fixator parts in case of Their improper selection.
c. Local limited erosive wound surfaces around the exit of wires may be observed.
d. Dermatitis.

Complications of Muscles

a. Insertion of wires through muscular masses during osteosynthesis may result in limiting some motor activity of the limb involved.
b. Complications of vessels and nerves.
c. Bleeding at the site of wire exit.
d. Erosive arterial bleeding.
e. Oedema.
f. Injury of nerve trunks.
g. Failure of innervation and limb segment being lengthened.

Complications of Adjacent Joints and Twin Bone Articulations

a. Purulent arthritis
b. Temporary or persistent limitations of movements in the neighboring joints
c. Development of subluxation.

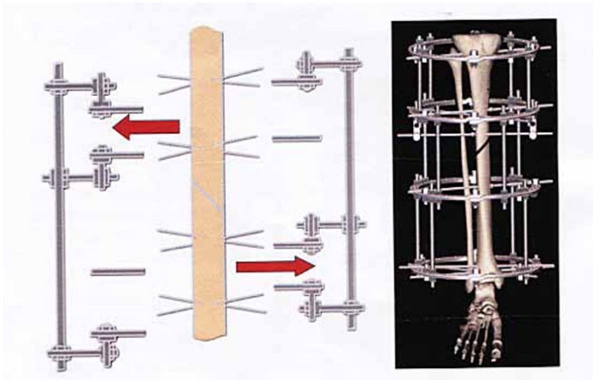
Complications of Bone Fragments and Regenerated Bone

a. «Wire» osteomyelitis-cortical osteomyelitis
b. Osteomyelitic process aggravation
c. Fracture at the level of wires
d. «Cutting out» of wires from the soft tissues
e. Transverse, angular or peripheral displacement of bone fragments
f. Formation of angular deformities in the zone of docking bone fragments or regenerated bone.

IV & V. Leg Lengthening, Leg shortening with segmental axis disturbance leg shortening without its axis disturbance

Generally Monofocal distraction osteosynthesis of the leg is indicated for segmental lengthening up to 5 cm Bifocal distraction osteosynthesis of the leg is indicated for segmental lengthening above 5 cm (Figure 15.17).

Variants of the Ilizarov fixator configurations for bifocal lengthening of the leg



Possible Complications During Leg Lengthening

- Inflammation of soft tissues around the wires - 18%
- Pareses development during distraction - 5.6%
- Development of the knee and the ankle contractures, foot deformities- 60%
- Regenerated bone fracture after the fixator removal - 3.2%

Case Study 1

Reconstruction of the Limb versus Amputation

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 tight 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.
12. After 4 ½ months follow up.Front view.
13. After 4 ½ months follow up.Back view.
14. After 6 months follow up.
15. After 6 months follow up
16. n OR Table before removal of Ilizarov apparatus.
17. Radiographic result after 6 months.
18. Clinical appearance of the patient.

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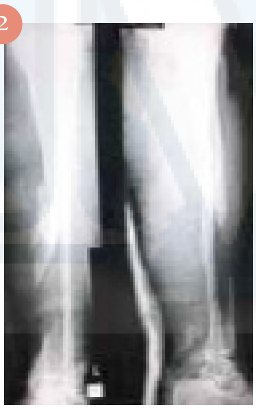

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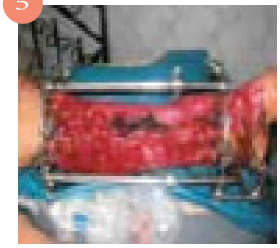

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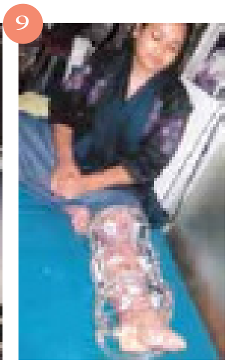

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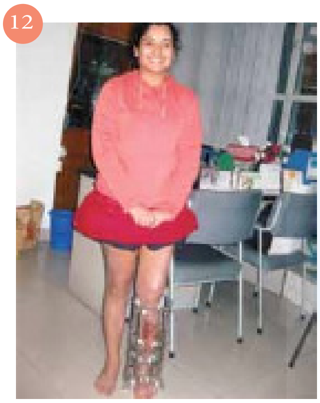

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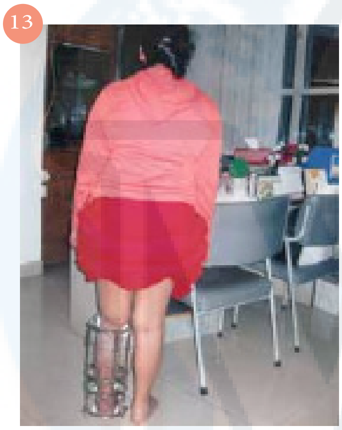

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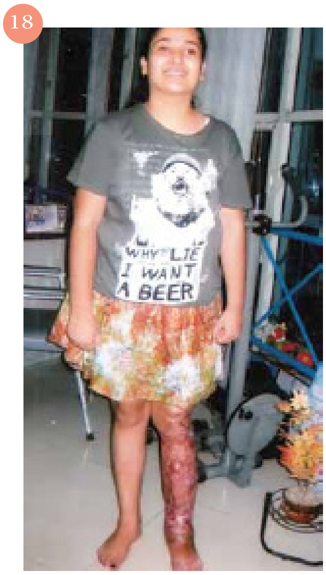

Case Study 2

1. Open comminuted fracture left tibia G IIIA
2. Radiograph of comminuted fracture of left tibia.
3. External view of left leg and anklewith Ilizarov in situ.
4. Skin grafting was done.
5. 47 years old lady with Ilizarov apparatus, 2 months after the application of Ilizarov.
6. Healing of tissues withIlizarov apparatus.
7. External view of the leg and ankle.
8. Radiograph of tibia fibula with Ilizarov in situ.
9. After 4 months follow up: correction of toes also visible.
10. Radiographic final result.

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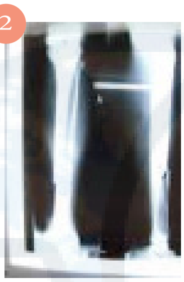
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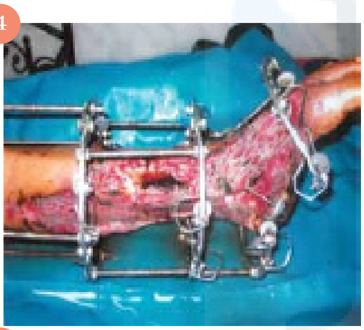
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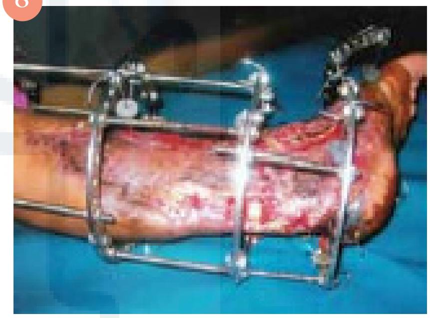
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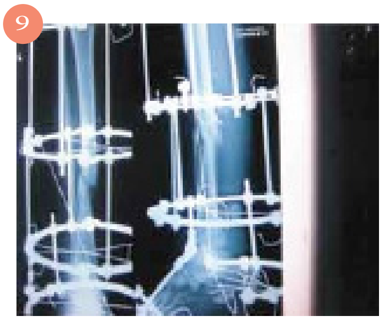
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Case Study 3

1. Crush injury of right lowrer femur with right tibia fibula and ankle GIIIB (Floating knee)
2. 14 years old girl with Crush injury of right lower femur with right tibia fibula and 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 of 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 the patient after 7 months

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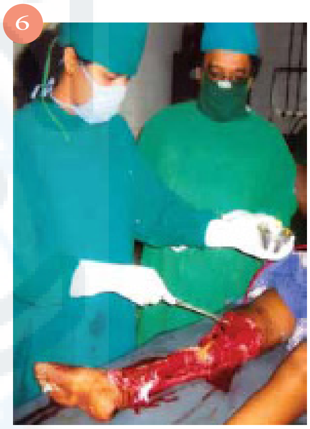

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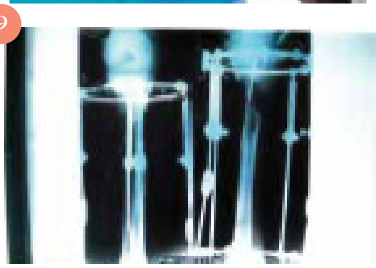

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Case Study 4

Open Fracture Tibia and Fibula

1. Open comminuted fracture right tibia fibula GIIIA
2. Radiograph of right tibia fibula
3. Ilizarov fixator in the right tibia fibula, 6th post OP, 24 years old male
4. After 21 days follow up
5. 16. Patient can walk with Ilizarov
6. Radiographic final result after 4 months
7. Clinical appearance of the patient after 4 months

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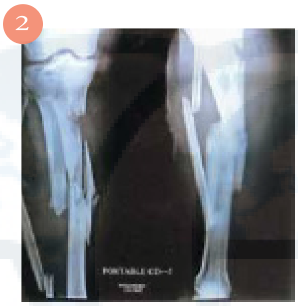

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Case Study 5

Mal Uniting Fracture Right Lower Tibia Fibula (3 & ½ Months Old) GII DSFS

1. 27 years old male with mal uniting fracture of right lower tibia fibula (3 & ½ months old) with varus de formity (Front view).
2. 27 years old male with mal uniting fracture of right lower tibia fibula (3 & ½ months old) with varus deformity (Back view).
3. Radiographic view of right tibia fibula with maluniting fracture.
4. Radiographic view of after the application of Ilizarov apparatus, 2nd post op.
5. Radiographic view of almost corrected varus deformity with union before removal of Ilizarov apparatus, 5 & ½ months follow up.
6. External view of the Ilizarov apparatus in the right leg during treatment.
7. Final Radiographic result of right tibia fibula after removal of Ilizarov apparatus.
8. Smiling patient in sitting position after 7 months follow up.
9. Clinical appearance of the patient after 8 months follow up.

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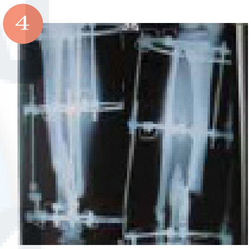

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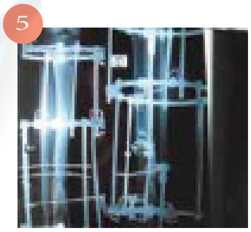

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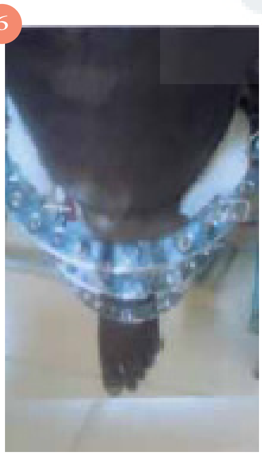

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Case Study 6

Open Fracture Right Lower Tibia Fibula G-IIIA

1. Radiograph of right lower tibia fibula with bone loss, uniaxial fixator in situ.
2. 48 years old male during treatment with Ilizarov apparatus.
3. Radiograph of right tibia fibula with Ilizarov fixator in situ. Docking and corticotomy site is clearly visible.
4. After removal of the fixator, 6 months follow up.
5. Radiograph of right tibia fibula after 8 months follow up, good union is achieved.
6. Clinical appearance of the patient in sitting positing.
7. Clinical appearance of the patient in standing position

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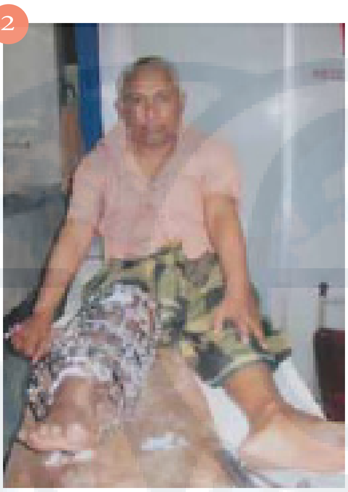

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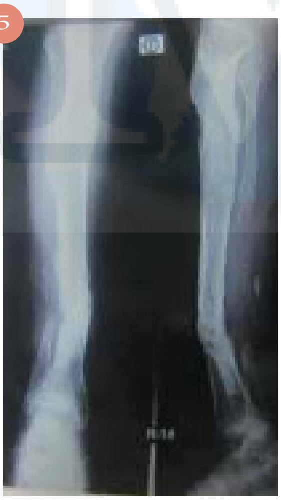

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Case Study 7

Infected non Union Right Tibia Fibula with Interlocking Nail in Situ GIIIB, Nail is Exposed

1. 22 years old male, Infected non union right tibiafibula with interlocking nail in situ GIIIB, nail is exposed.
2. Close up view of right upper tibia fibula, exposed nail with bone.
3. Radiograph of right tibia fibula, interlocking nail with non union.
4. Radiograph of right tibia fibula with gap afterremoval of inter locking nail.
5. Radiograph of right tibia fibula with segmentalbone transport(arrow marking), Ilizarov in situ.
6. Radiograph of right tibia fibula with segmentalbone transport(arrow marking), with good regeneration and consolidation after 5 months follow up, with Ilizarov in situ.
7. Clinical appreance of the patient with Ilizarov apparatus in the leg.
8. Smiling patient with healing of the exposed bone.
9. Final Radiographic result after 7 months follow up.
10. Clinical appreance of the patient after 7 months follow up.

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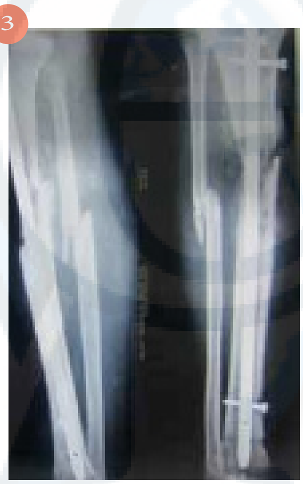

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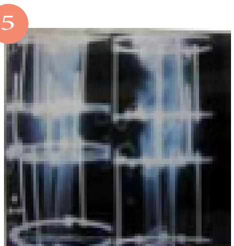

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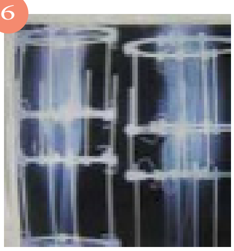

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Case Study 8

Infected Open Fracture Right Tibia Fibula GIIIB with Exposed Plate & Screws

1. & 2 Infaced open fracture right tibia fibula GIIIB with exposed plate & screws
2. After removal of the plate, screws & dead bone and debris
3. 45 years old male with Ilizarov fixator in the right leg
4. Radiographic view right tibia fibula with Ilizarov fixator in situ, after 2nd post OP
5. Radiographic view of right tibia fibula with Ilizarov fixator in situ, after 1 month follow up.
6. Radiographic view of right tibia fibula with Ilizarov fixator in situ, after 3 months follow up.
7. Radiographic view of right tibia fibula with Ilizarov fixator in situ, after 9 months follow up.
8. Patient is in standing position with Ilizarov apparatus in the right leg
9. Final radiographic result after 10 months follow up.
10. Clinical appearance of the patient with smiling face after 11 months follow up.

Case Study 9

Open Fracture (GIIIA) Left Tibia Fibula

1. Open gracture (GIIIA) with uniaxial Ex-fix in situ.
2. 23 years old girl, open fracture left tibia fibula (GIIIA); uniaxial Ex-fix in situ
3. Radiographic view of left tibia fibula with uniaxial Ex-fix in situ.
4. In OR with Ilizarov apparatus.
5. Clinical appearance of the patient after removal of Ilizarov fixator.
6. Radiographic consolidation of left tibia fibula after 6 months follow up.
7. Clinical appearance of the patient after 3 years follow up.
8. Radiographic result of left tibia fibula after 3 years follow up.

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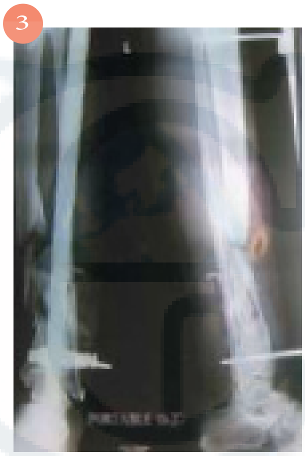

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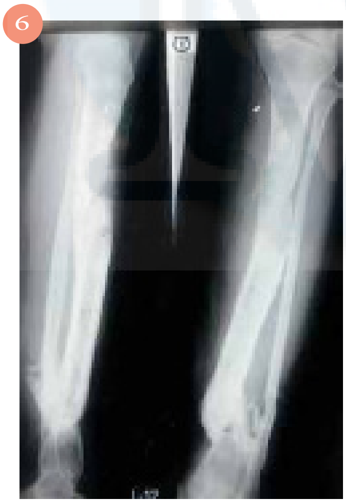

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Case Study 10

Open Comminuted Fracture Left Lower Tibia Fibula (GII)

1. Radiograph of left lower tibia, open comminuted fracture (G II).
2. 50 years old male – 2 weeks after surgery with Ilizarov device in the left leg and ankle.
3. 50 years old male – Ilizarov in situ, after 1 month.
4. Radiograph of left tibia and ankle, healing is going on, after 3 months follow up.
5. Radiograph of left tibia and ankle - 5 months follow up after removal of fixator.
6. Clinical appearance of the patient, after 9 months follow up.
7. Patient is in sitting position, after 9 months follow up.

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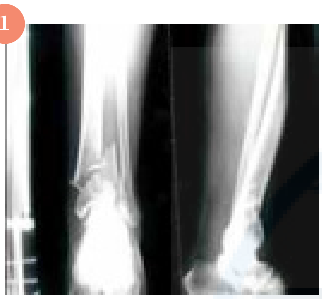
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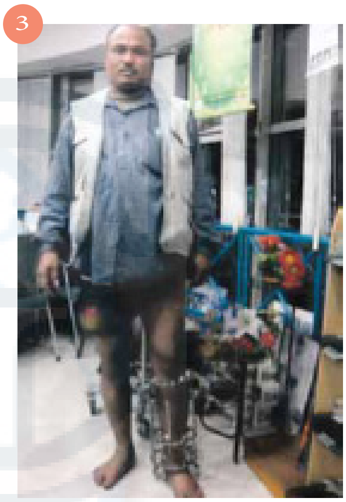
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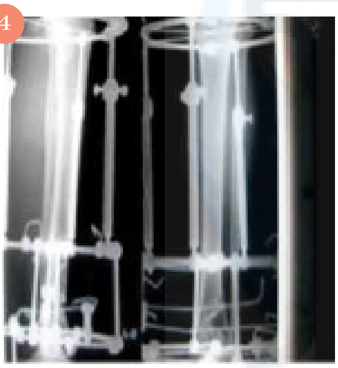
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Case Study 11

Non Union Left Upper Tibia

1. 8 years old girl – Deformity of left knee, heal is facing forward.
2. Radiographic non union left upper tibia with deformity of fibula and shortening (5 cm).
3. Side view of the leg.
4. Radiographic result of left tibia fibula with Ilizarov fixator in situ.
5. During treatment with the Ilizarov fixator.
6. Smiling patient with the Ilizarov fixator.
7. Radiographic result of left tibia fibula.
8. Clinical appearance of the patient.

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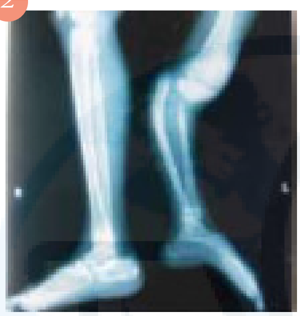

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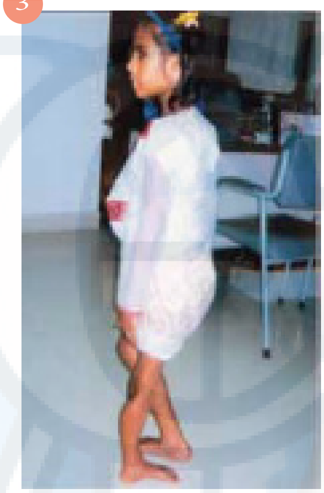

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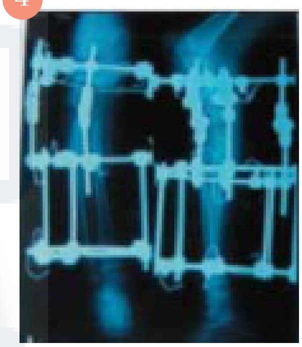

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Case Study 12

Aseptic Nonunion of Long Bones

1. 8 years old girl – Deformity of left knee, heal is facing forward.
2. Radiographic non union left upper tibia with deformity of fibula and shortening (5 cm).
3. Side view of the leg.
4. Radiographic result of left tibia fibula with Ilizarov fixator in situ.
5. During treatment with the Ilizarov fixator.
6. Smiling patient with the Ilizarov fixator.
7. Radiographic result of left tibia fibula.
8. Clinical appearance of the patient.

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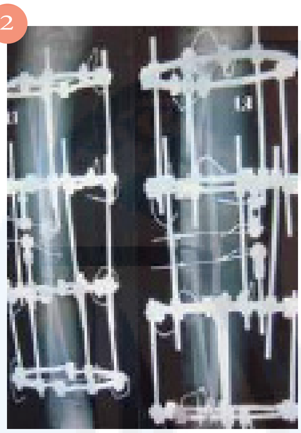

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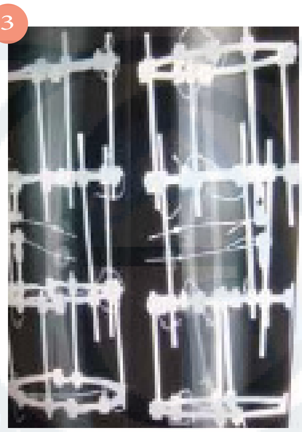

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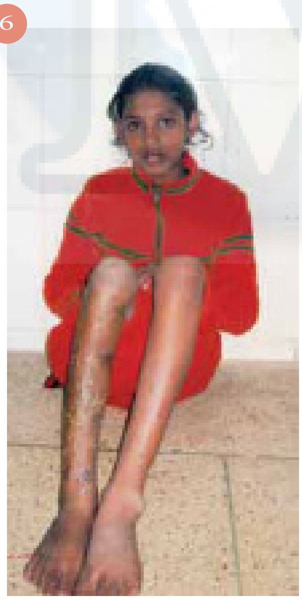

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Case Study 13

Infected Gap non Union Right Lower Tibia Fibula, Equinus Foot with AO Fixator in Situ, Treated in Apollo Hospital Dhaka

1. 36 years old male, External view of the AO fixator in the right leg and foot, patient in OR (Bari- Ilizarov orthopaedic center.)
2. Close up view of the AO fixator in situ.
3. Radiographic view of the right tibia fibula and ankle with AO fixator in situ.
4. Radiographic view of the right tibia fibula with Ilizarov fixator in situ. follow up after 10 days, corticotomy site is visible with 2 guide wires in tibia and fibula.
5. Radiographic view of the right tibia fibula and ankle after 2 months follow up. Corticotomy and docking sites are nicely visible.
6. Smiling patient with Ilizarov fixator in right leg and ankle after 5 months follow up.
7. Radiographic view of the right tibia fibula and ankle, after 6 months follow up.
8. Clinical appeance of the patient, final outcome after 7 months (front view).

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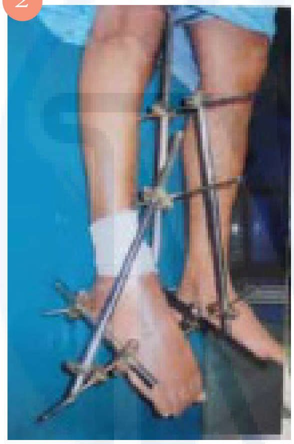

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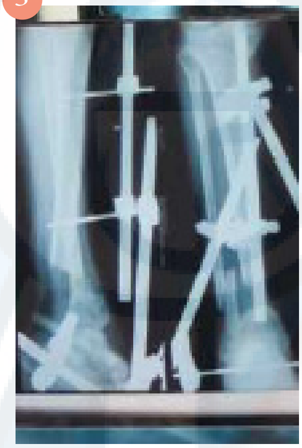

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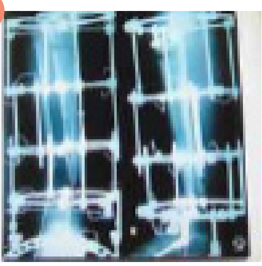

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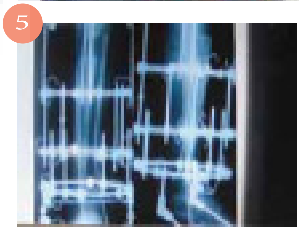

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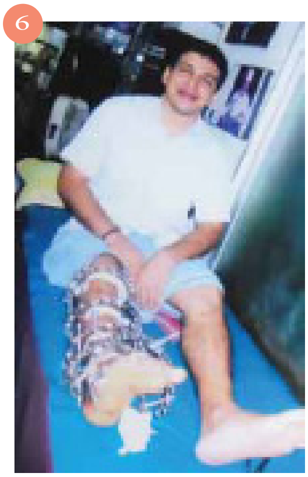

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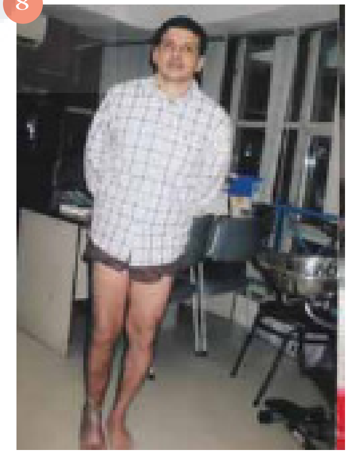

Case Study 14

Gap Nonunion of Left Tibia with Gross Deformity and LLD (12.6)

1. &2. Posterolateral bowing of left leg with 12.6 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.Radiographic result of tibia fibula.
8.&9 Clinical appearance of the patient after 14 months. No LLD, No deformity

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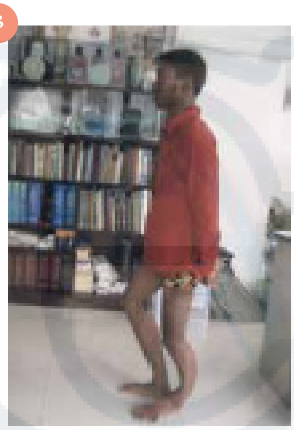
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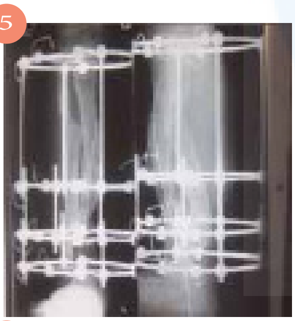
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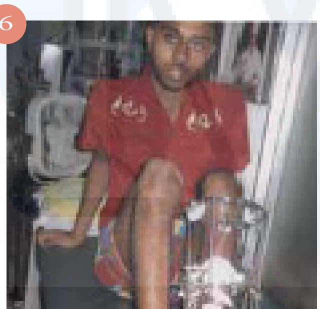
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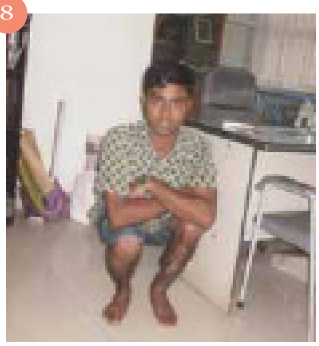

Case Study 15

Infected gap non Union Right Lower Tibia, Deformed Foot with Biaxial Fixator in Situ

1. 35 years old male, Infoected gap non-union right lower tibia, deformed foot with biaxial fixator in situ.
2. Radiograph of the same patient, tibia and foot with biaxial fixator in situ.
3. Close-up view of right leg and foot with biaxial fixator in situ.
4. Smiling patient with Ilizarov fixator in leg and foot.
5. Close-up view of Ilizarov fixator in leg and foot after 3 months follow up.
6. Patient with Ilizarov fixator in the leg and foot after 4 months follow up.
7. Radiographic view after the removal of the Ilizarov fixator.
8. External view of the patient leg and foot after 6 months follow up (sitting position).
9. Final follow up of the patient after 8 monthsfull correction is achieved, patient is in standing position (front view).

Case Study 16

Osteomyelitis of Right Upper Tibia Leading to Gap non Union

1. Radiographic view of right upper tibial chronic osteomyelities.
2. Radiographic view of same right tibia after 2 years leading to gap non union of right upper tibia.
3. 7 years old girl during treatment with Ilizarov apparatus.
4. Radiographic view of right tibia fibula withIlizarov in situ, distal corticotomy is done.
5. Final radiographic result after 4 months follow up, good union is achieved.
6. Clinical apperance of the patient in sitting positing.
7. Clinical apperance of the patient in standing positing.

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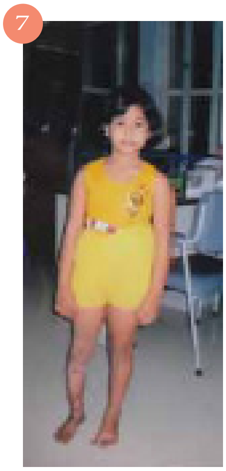

Case Study 17

Non Union of Right Lower Tibia with Broken Nail

1. Radiograph of right tibia with broken nail in situ
2. Radiograph of right tibia fibula with Ilizarov in situ after 1 month follow upc
3. 24 years old male with Ilizarov in the right leg
4. After 2 months follow up
5. Patient can walk with Ilizarov frame easily
6. Radiograph of right tibia with good regenerate
7. Radiographic result with good union
8. Clinical appearance of the patient after 6 months follow up
9. Patient can squat easily

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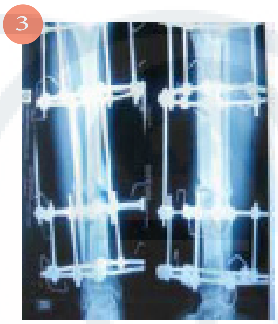

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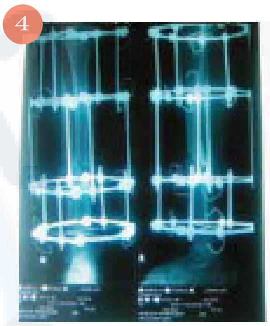

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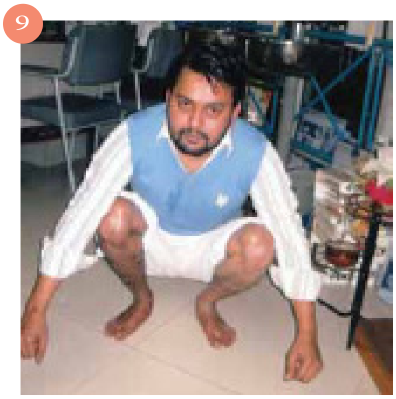

Case Study 18

Post Traumatic Left Tibia Vara

1. 1,2 & 3 27 years old male with post traumatic leftsided tibia vara (Bad scar) (Front & Back View)
4. Radiographic view of the left knee before surgey
5. Radiographic view of the left knee with Ilizarovapparatus, visible opening wedge osteotomy with hinges
6. External view of the leg with Ilizarov apparatus in situ
7. Final Radiographic result after surgery
8. Clinical appearance of the patient after 6 years follow up, no tibia vara, discoloration of the skin disappeared

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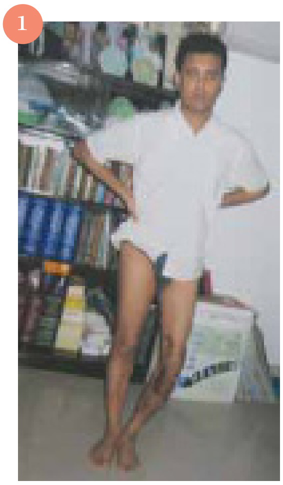

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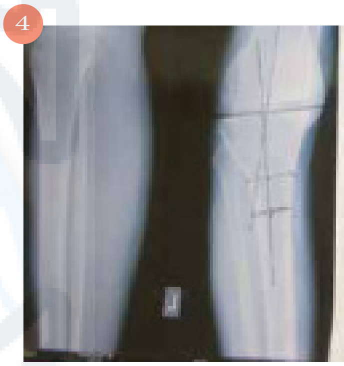

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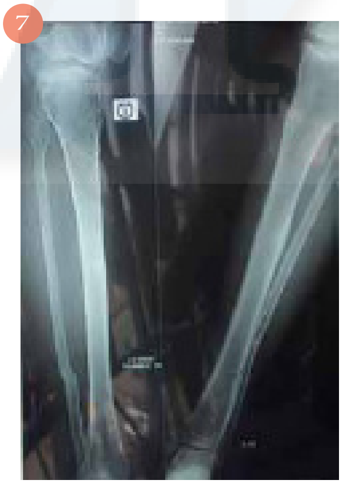

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Case Study 19

Post Traumatic Tibia Vara

1. Post traumatic left tibia vara (Front view)
2. Back View
3. Sitting position Galeazzi sign (+)
4. During squatting deformity of left knee is seen.
5. After the application of Ilizarov, 2nd post-op.
6. 14 years old boy can walk with the Ilizarov apparators.
7. Radiographic final result after 4 months follow up.
8. Clinical appearance of the patient (No Deformity).
9. No deformity is seen when squatting.

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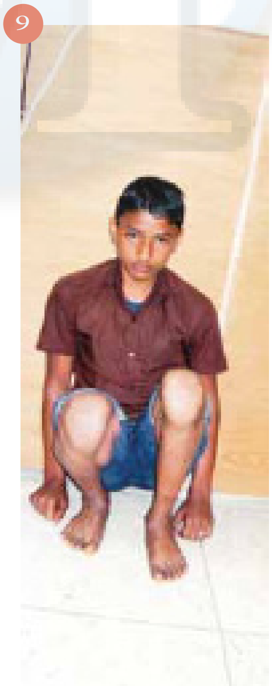

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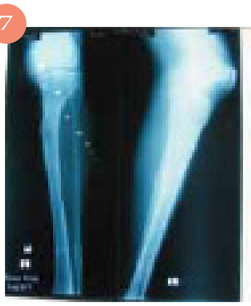

Case Study 20

Right Anteromedial Bowing

1. Age 28 years old man - Right Anteromedial bowing, front view.
2. Right Anteromedial bowing, (back view)
3. Radiograph of right tibia (before treatment)
4. During treatment, with Ilizarov.
5. After removal of Ilizarov fixator, with plaster immobilization.
6. The radiographic result.
7. Final follow up clinical apperance of the patient
8. Patient is happy with the Ilizarov treatment.

Case Study 21

Tibialization

1. Big gap non union of left tibia with uniaxial fixator in situ
2. 27 years old male with Ilizarov in the left leg
3. Patient can walk with the Ilizarov apparatus
4. Radiographic view of tibialization with Ilizarov in situ
5. Radiographic result after the removal of Ilizarov apparatus
6. Just after the removal of the Ilizarov apparatus
7. Radiographic result after 6 months follow up

Case Study 22

Right Anteromedial Bowing

1. Radiographic view of left tibia with very big gap
2. Same patient with uniaxial fixator in situ with bad scur
3. Tibialization of left tibia with Ilizarov
4. Radiographic view of tibialization, left sided after 5 months
5. Radiographic view of tibialization, left sided after 6 months
6. Radiographic result after removal of the Ilizarov apparatus
7. Clinical appearance of the patient.

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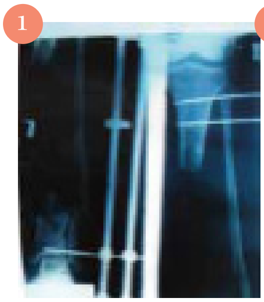

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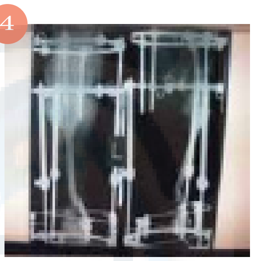

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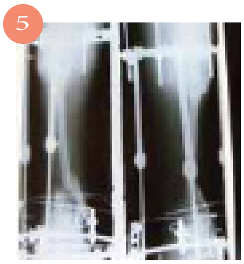

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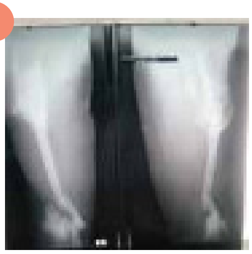

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Case Study 23

Hockey Stick Deformity (C-Type Deformity)

1. Age 18 years old girl – Hockey stick deformity of right ankle with 5 cm shortening.
2. Radiographic view, hockey stick deformity.
3. Right deformed ankle with bad scar.
4. During treatment with Ilizarov ring fixator.
5. During treatment after 2 months.
6. After removal of the Ilizarov apparatus.
7. Deformity is corrected and limb length equalization is achieved.
8. Radiographic result of right ankle deformity.
9. Radiographic view of whole tibia and ankle after correction.

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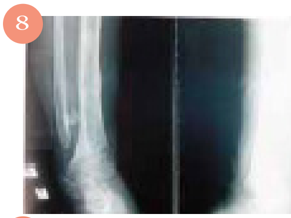

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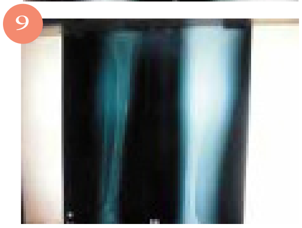

Case Study 24

Anterolateral Bowing

1. Age 9 years old girl – Left Anterolateral bowing with ankle valgus.
2. Age 9 years old girl – Before treatment.
3. Before treatment.
4. Before treatment.
5. Radiograph before treatment.
6. Radiograph before treatment.
7. During treatment.
8. During treatment.
9. During treatment after 4 months.
10. The Radiographic result.
11. The Radiographic result.
12. During treatment.
13. Final follow up.
14. Final follow up.
15. With AFO.

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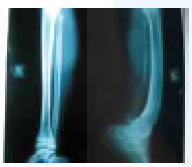
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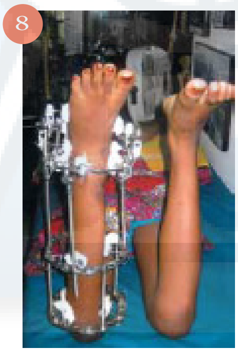
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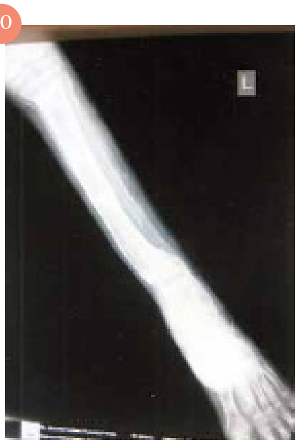

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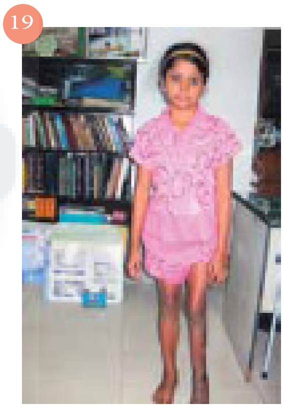

Case Study 25

Left Anteromedial Bowing

1. Age 9 years old boy - Left 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.

Case Study 26

Rt Anteromedial Bowing

1. Age 28 years old man - Right Anteromedial bowing, front view.
2. Right Anteromedial bowing, (back view)
3. Radiograph of right tibia (before treatment)
4. During treatment, with Ilizarov.
5. After removal of Ilizarov fixator, with plaster immobilization.
6. The radiographic result.
7. Final follow up.
8. Patient is happy with the Ilizarov treatment.

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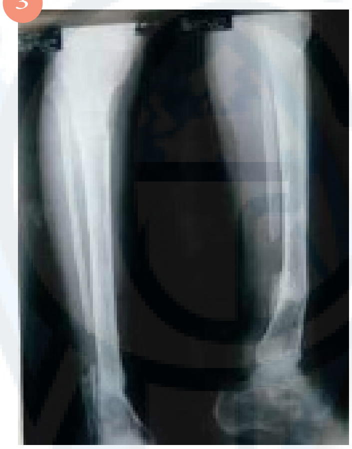

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Case Study 27

Antero Lateral Bowing of Left Tibia

1. 1,2 & 3 12 years old boy Antero Lateral bowing of left tibia
4. Radiographic view of left tibia before surgery
5. External view of left tibia with Ilizarov fixator in situ
6. Final Radiographic view of the left tibia
7. & 8. Clinical appearance of the patient after the surgery (Front & Back View)

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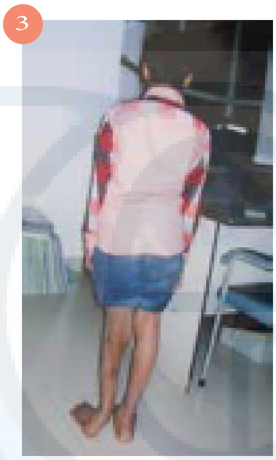

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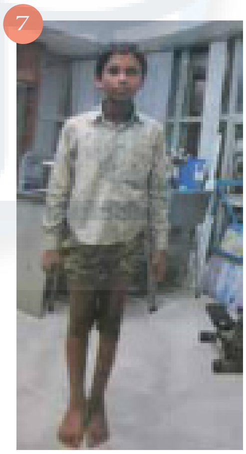

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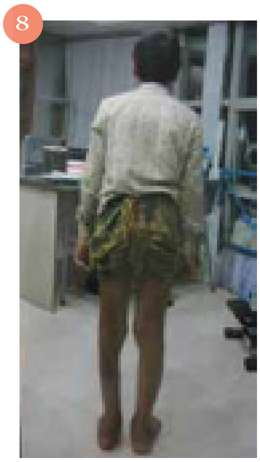

Case Study 28

Congenital Shortening of Left Tibia

1. 2 years old girl, 4 cm (LLD) shortening of lefttibia, (Front view)
2. 12 yers old girl, 4 cm LLD shortening of left tibia, (back view).
3. Galeazzi sign (+) or Alis test (+).
4. 4 cm LLD (left tibia).
5. Radiograph of 4 cm shortening (left side).
6. Before surgery, anxious father (Paedi-atrician) in OR.
7. Tilting to the left side.
8. Distraction osteogenesis with Ilizarov frame, corticotomy was done in th proximal tibia.
9. Surgeon with smiling patient.
10. Patient with Ilizarov frame.
11. Parents (Father Paediatrician and Mother Skin and VD specialist) are happy with their daughter.
12. Clinical appearance of the patient after correction of LLD (4 cm) (side view).
13. Clinical appearance of the patient after correction of LLD (4 cm) front view.
14. Final follow up after 6 months with the Professor M.M. Bari.

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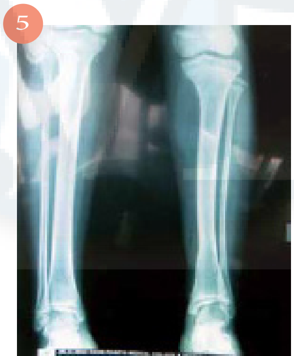
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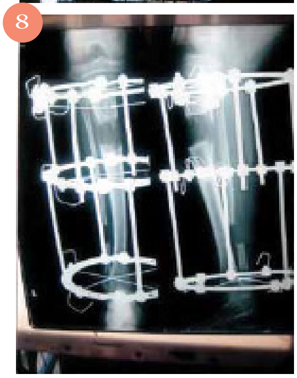
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Cont....

Case Study 28

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Case Study 29

Congenital Shortening of Left Tibia (4.8 cm LLD) with Absence of 2 Digits and Short Foot

1. 11 years old girl with congenital shorting (4.8 cm) left tibia, front view
2. 11 years old girl with congenital shorting (4.8 cm) left tibia, back view
3. 11 years old girl with congenital shorting (4.8 cm) left tibia, lying position
4. 11 years old girl with congenital shorting (4.8 cm) left tibia, gleazzi sign (+)
5. 11years old girl with congenital shorting (4.8 cm) left tibia, with Ilizarov fixator
6. Radiographic view of left tibia fibula with Ilizarov in situ after 3 months follow up
7. Patient can walk with Ilizarov fixator, almostcorected LLD
8. Clincal appearance of the patient after 7 months follow up

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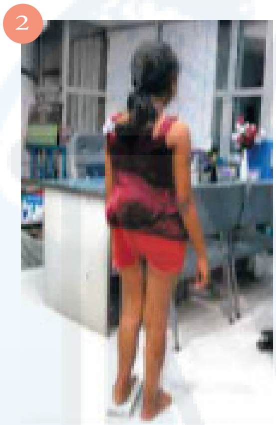

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Case Study 30

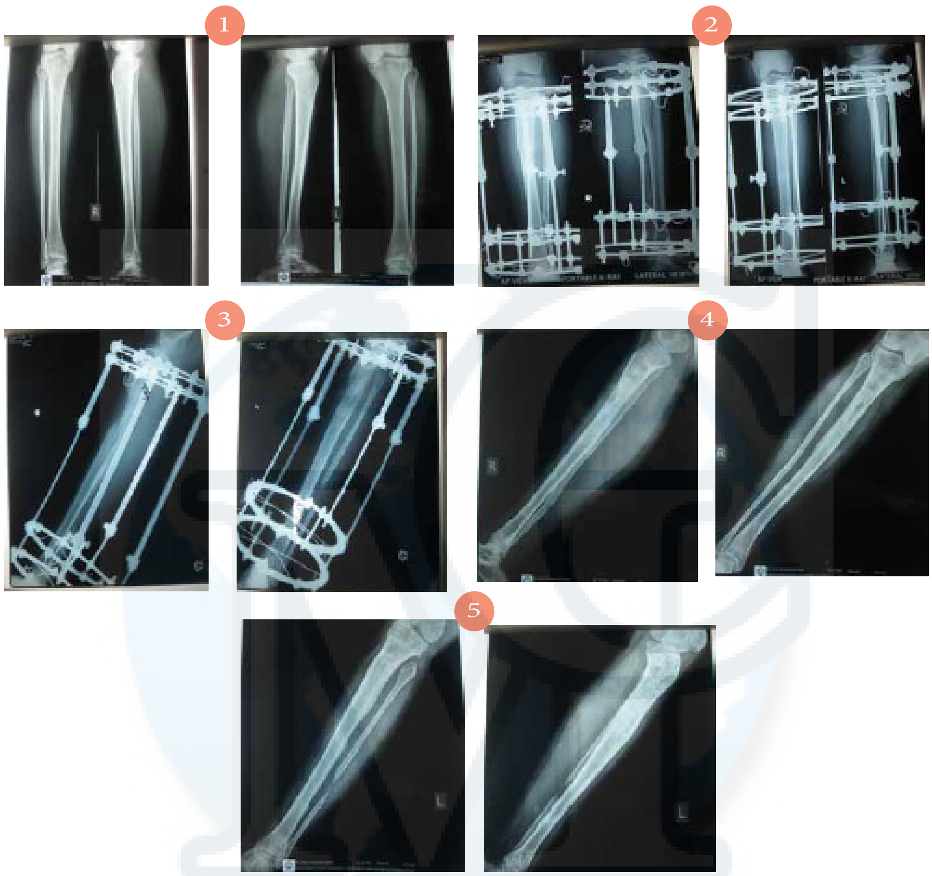
Normal Height Increase of an Individual Using Ilizarov Technique

1. Former avg. height: 5'0'', age 23 years
2. After 7 months of treatment
3. Author is checking the Ilizarov frame
4. After 9 months of treatment
5. After 10 months of treatment
6. Height gained by 4'' after 11 months of treatment
7. Previous Height 5'0''
8. New Height: 5'4''

P.T.O

Case study 1 radiographic follow up:

1. Normal radiograph of both tibia fibula before lengthening,
2. After application of Ilizarov in both the limbs with corticotomy
3. Distraction osteogenesis is seen in both the tibia fibula
4. & 5. Radiographic result after lengthening



Case Study 31

Normal Height Increase

1. & 2. 22 years old girl, normal height 4'8''
before surgery,
3. & 4. Placement of introducing Ilizarov wires.
5. After 3 months follow up with Ilizarov appartus.
6. After 6 months follow up with Ilizarov apparatus.
7. Radiographic result after 11 months.
8. & 9. Clinical appearance of the patient, height is increased upto 5'1''.

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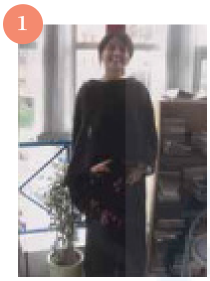
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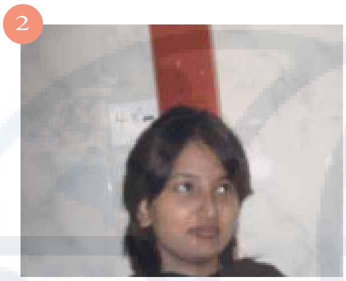
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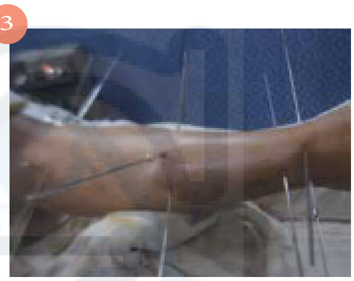
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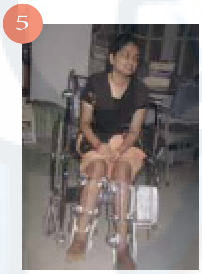
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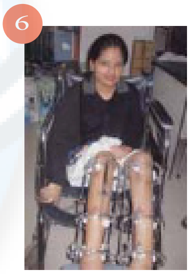
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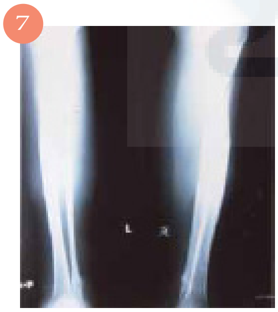
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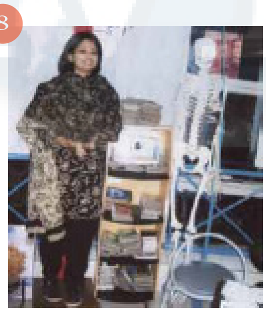
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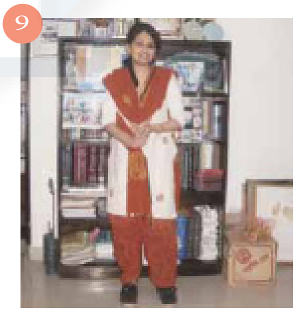

Case Study 32

Post- Polio Residual Deformity - 5.3 cm Shortening

1. 20 years old girl postpolio 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.

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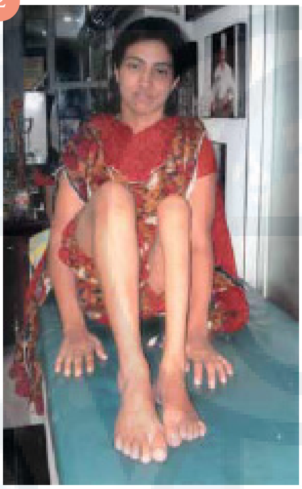

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Case Study 33

Post Polio Residual Deformity - LLD 8 cm

1. 24 years old male, polio residual deformity of left ankle with 8cm LLD.
2. Galeazzi sign (+)
3. 8cm LLD (left) back view.
4. 8cm LLD left front view.
5. Radiographic view of left tibia fibula after 2 months follow up, a good regenerate is seen which is formed by Ilizarov technique.
6. Patient is very happy after 4 monthsfollow up.
7. After full correction 6 months followup, no LLD (front view).
8. Back view.

Case Study 34

Post Polio Residual Deformity - LLD 5 cm

1. 24 years old male – post polio residual deformity; 5cm LLD, unstable knee, ankle with front heal, equino cavo varus deformity.
2. Back view.
3. Walks with hand knee support.
4. In silting position.
5. Flexion position of the knee.
6. In O.R.
7. During treatment with Ilizarov apparatus. After 6 months follow up. Gradual controlled coordinated stretching was done for the correction of the deformity.
8. With thigh, knee, ankle and foot orthosis, patient can walk without any support.stretching was done for the correction of the deformity.
9. With thigh, knee, ankle and foot orthosis, patient can walk without any support.

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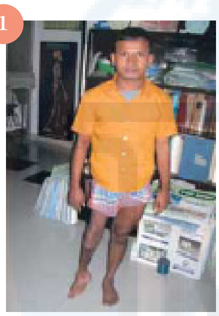

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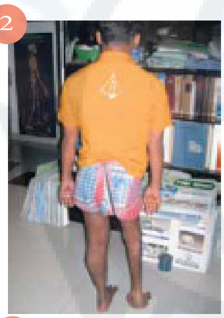

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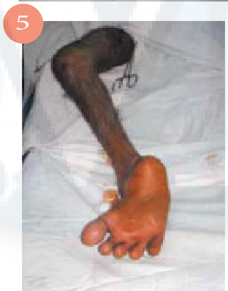

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Case Study 35

Post Polio Residual Deformity

1. 22 years old girl. Post polio residual deformity 4 cm shortening with right ankle valgus.
2. Back view.
3. 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 equal.
10. Clinical appearance of the patient, final outcome after 7 months patient is happy.

Case Study 36

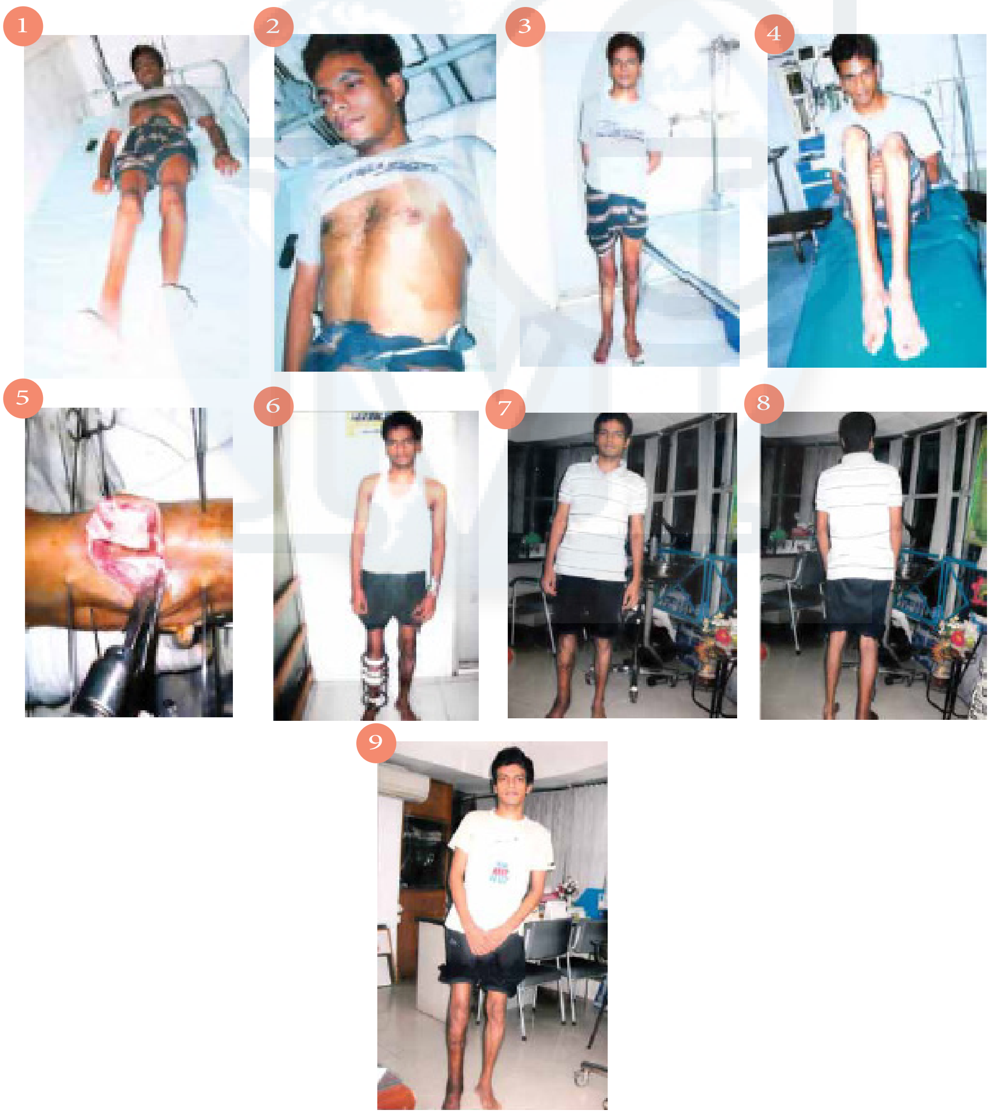
Post Polio Residual Deformity

1. 19 years old girl. Post polio residual deformity of right leg, ankle and foot with external tibial torsion, 2cm 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 2cm shortening.
7. After removal of the Ilizarov apparatus in O.R. Deformity of right leg ankle and foot, external tibial torsion, equino cavo varus deformity corrected.
8. Plaster immobilization.
9. Radiograph result of right tibia fibula with Ilizarov fixator in situ.
10. Clinical appearance of the patient after 11 months follow up. (front view).
11. Clinical appearance of the patient after 11 months follow up (back 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.

Case Study 37

Neurofibromatosis

1. 25 years old male –Neurofibromatosis (Recklen housen's disease) 5 cm LLD, right side is > left side.
2. Big patch in the lateral chest wall.
3. 5cm LLD.
4. Galeazzi sign (+)
5. 5 cm part of tibia and fibula is removed from the right side.
6. During treatment with Ilizarov apparatus.
7. After removal of Ilizarov fixator (Front view).
8. Back view.
9. Final follow up after 2 years.



Case Study 38

Neurofibromatosis

1. 18 cm LLD neurofibromatosis (von Recklinghausens disease)
2. 9 cm removed from tibia
3. 9 cm removed from femur
4. Visible neuroma
5. After removal of the segments from tibia and femur the whole extremity is fixed with Ilizarov fixator, debulking was also done
6. After treatment.

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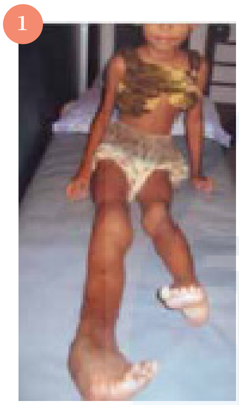

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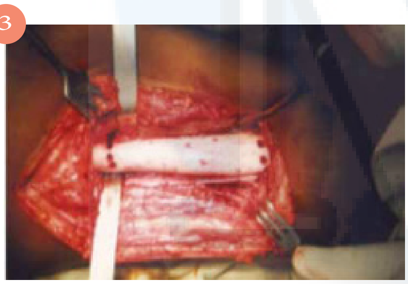

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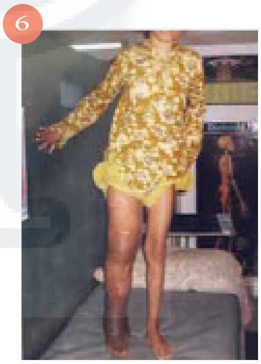

Case Study 39

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 Illizaov 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. & 11. Clinical appearance of the patient after 91/2 months follow up.

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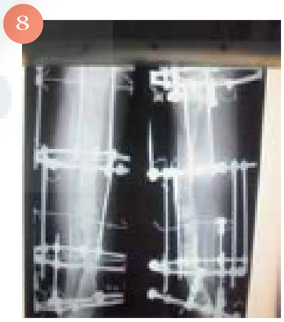
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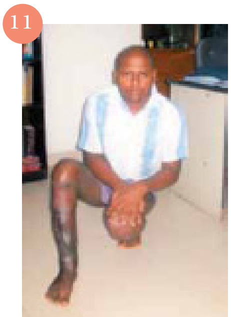

Case Study 40

Hypertrophic Nonunion tibia, Monkey mouth deformity

1. & 2. Radiograph of hypertrophic nonunion of right upper tibia with postereomedial deformity, monkey mouth deformity.

3. & 4. Clinical appearance of 23 years old boy with posteromedial deformity of right tibia.

5. Radiograph of right tibia fibula with almost corrected deformity by gradual distraction with hinges after 3 months follow up.

6. The right leg is almost straight.

7. Lateral view of right leg.

8. Close up view of right leg with Ilizarov in situ.

9. Radiographic result of right tibia fibula after 8 months follow up.

10.11.12. After removal of Ilizarov fixator, happy patient is showing “V” sign.

13. 14. Clinical appearance of the patient after 10 months.

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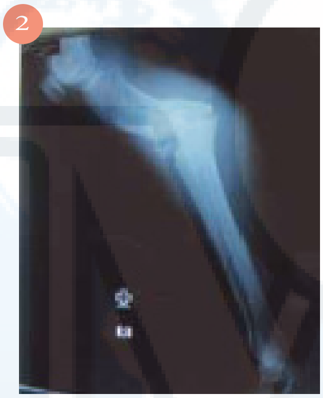

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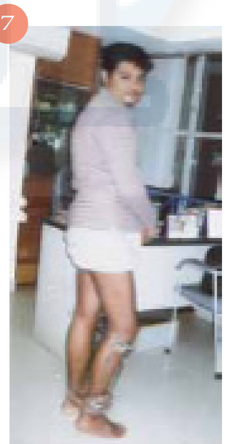

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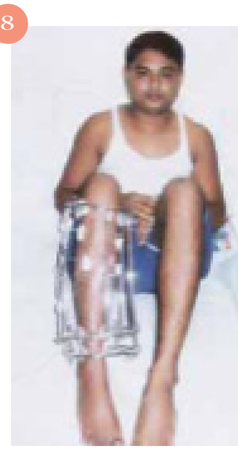

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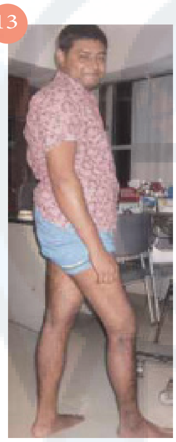

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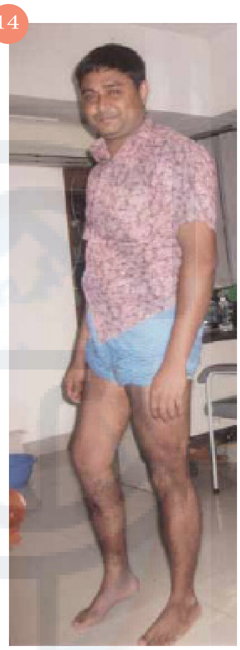

Case Study 41

Post traumatic disorganized knee, ankle valgus and 14 cm LLD.

1. 28 years old male- post traumatic right disorganized knee, bad scar in the leg ankle valgus and, 14 cm LLD. Got injury at the age of 7.
2. Patient is in standing position.
3. In the operation theatre.
4. Knee is disorganized. Radiographic view before treatment.
5. During treatment, after 1 month follow up.
6. During treatment, after 2 months follow up.
7. Smiling treatment after 4 months follow up.
8. After 5 months follow up, distraction of the knee is going on.
9. Radiograph of right tibia and femur after 1 month follow up.
10. Radiograph of right tibia and femur after 2 months follow up.
11. Radiograph of tibia and femur after 3 months follow up.
12. A good regenerate is seen in the lower femur after 3 months.
13. A good regenerate is seen after 4 months.
14. After 1 year of follow up (front view).
15. After 1 year of follow up (Back view).
16. After 13 months of follow up.
17. After 14 months of follow up.
18. Clinical appearance of the patient, final follow up after 16 months. (front view).
19. Clinical appearance of the patient, final follow up after 16 months. (Back view).

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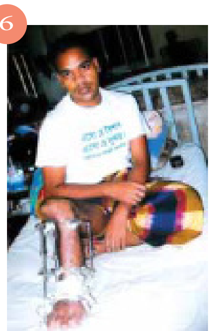

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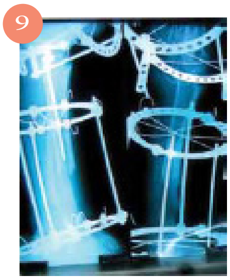

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Case Study 41

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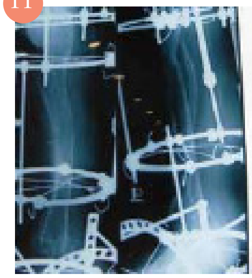

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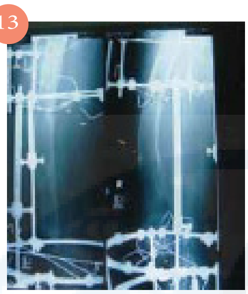

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Case Study 42

Mal United right upper tibia, varus deformity with 4 cm shortening with external rotation accompaynied by equinus deformity>45°

1. External view of the patient, varus deformity with external rotation and 4 cm LLD. (front view) before surgery.
2. External view of the patient, varus deformity with external rotation and 4 cm LLD. (Back view) before surgery.
3. External view of the patient, varus deformity with external rotation and 4 cm LLD. (sitting position) before surgery.
4. Radiographic view of the same patient, mal union of right upper tibia.
5. Radiographic view of the right tibia during treatment with Ilizarov fixator in situ, 4 telescopic rods with 2 rings are seen. follow up after 4 months.
6. Patient is in Ilizarov fixator in the leg and foot (after 5 months follow up).
7. Radiographic view of the right tibia after 6 months follow up.
8. Clinical appearance of the patient. Final out come after 6 months. (Back view)
9. Clinical appearance of the patient. Final out come after 6 months. (Front view)

Case Study 43

Mal Union Right Middle Tibia With Bowing Deformity

1. 29 years old male having right bowing of middle tibia (frontview) before surgery.
2. 29 years old male having right bowing of middle tibia (Back view) before surgery.
3. In sitting position bowing of middle leg is seen.
4. Radiographic view of mal united right tibia fibula with varus deformity.
5. Radiographic view of corrected varus deformity of right tibia fibula with Ilizarov frame in situ.
6. External view of the right leg with Ilizarov frame during treatment, after 4 months follow up.
7. Radiographic result of right tibia fibula after 6 months.
8. Clinical appearance of the patient after 7 months follow up, No Varus deformity is seen.
9. Clinical appearance of the patient after 7 months follow up, patient is in sitting positing. No Varus deformity is seen.

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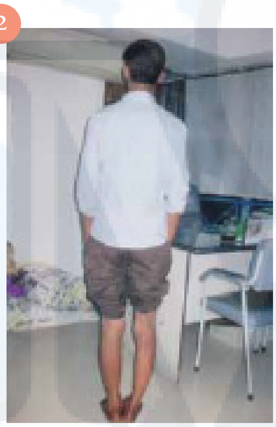
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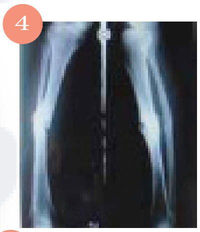
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Case Study 44

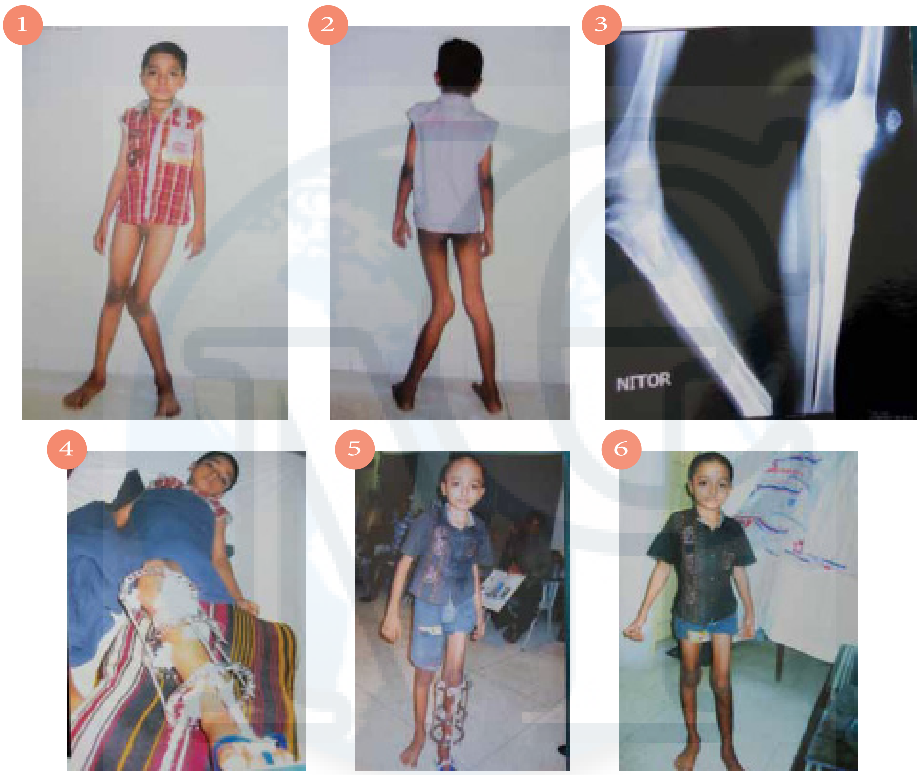
Genu Valgum Deformity

1. &2. 26 years old female with left sided genu valgum deformity, 4 cm shortening.
3. Radiographic view of the left knee before surgery.
4. Radiographic view of the left knee with opening wedge osteotomy with visible hinges.
5. & 6 patient with Ilizarov apparatus, almost corrected genu valgum (Front View & Back View).
7. Final corrected radiographic result of the genu valgum of the same patient.
8. Clinical of the patient, full correction is achieved (Front & Back View).

Case Study 45

Genu Valgum Deformity

1. & 2. 9 Years old boy before surgery, left sided genu valgum deformity (Front & Back View).
3. Radiographic view of the Genu Valgum Deformity before surgery.
4. Patient with Ilizarov apparatus after the surgery.
5. Patient is in standing position with Ilizarov apparatus.
6. Clinical appearance of the patient after 4 months follow up.

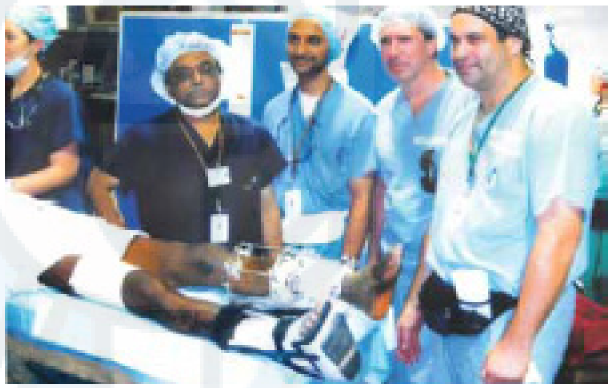


Author with Foreign Dignitaries

Prof. O.V. Oganesyan is teaching his methodology to Dr. M. M. Bari in CITO, Moscow in May 2003.

Prof. G. S. Kulkarni (Ex. IOA President)with Dr. M.M. Bari in Miraj 2003.

Ilizarov workshop in BOSCON 2004; Prof. Milind Kulkarni (Miraj), Prof. B.M. Mirazimov (Tashkent), Dr. Ruta Kulkarni (Miraj) & Dr. M. M. Bari, behind Nabia Bari.

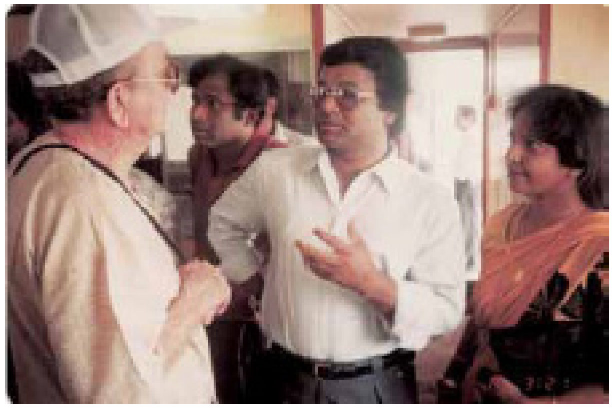


Miami Hospital, Haiti, Feb'2010, Author did the Ilizarov surgery of Earth quake victims.

Prof. R. J. Garst (Founding father of NITOR) and Dr. M. M. Bari in BOSCON conference 1999.

BOSCON February 2004, from left to right: Dr. Ruta Kulkarni (Miraj), Dr. M. M. Bari, Prof. B. M. Mirazimov (Tashkent), Prof Nurul Absar, Prof. K. M. Sirajul Islam.

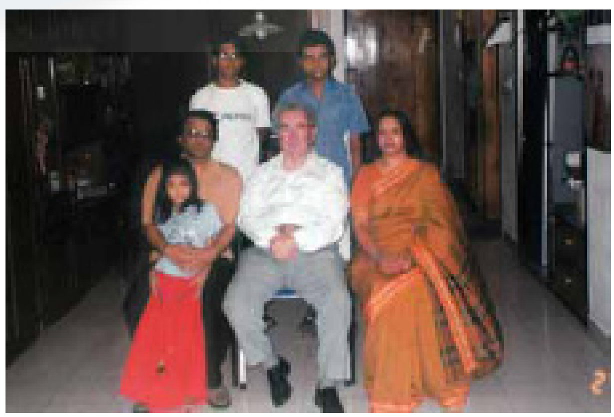
Prof. Dror Paley of Maryland USA with Prof. M. M. Bari in Delhi, APOA conference 2012.



Prof. R. J. Garst author and Nabia Bari, 1997.

Dr. M. M. Bari is presenting scientific paper on non union of humerus by Ilizarov techniques in Golden Jubilee Conference of Indian Orthopaedic Association, December 2005 (Mumbai).

Prof. M. M. Bari with his post-doctoral supervisor Academician Prof. V. I. Shevtsov, Kurgan, Russia 2011.



Prof. B.M. Mirazimov (Former Director of Tashkent Scientific Research Institute of Orthopaedics and Traumatology; PhD supervisor of prof. M. M. Bari) with authors Family in 2004 at Dhaka.

All Ilizarovians from different countries of the world in limb deformity course in Goa April 2005 including Dr. M. M. Bari.

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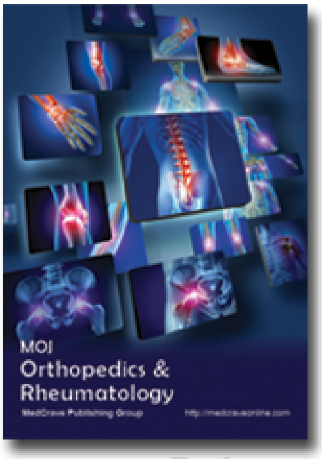

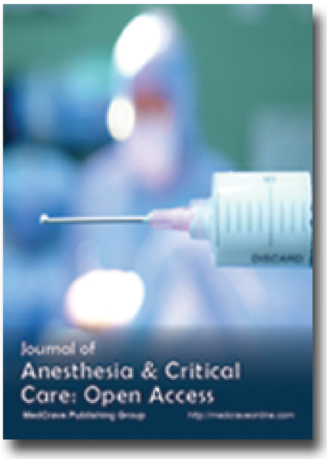

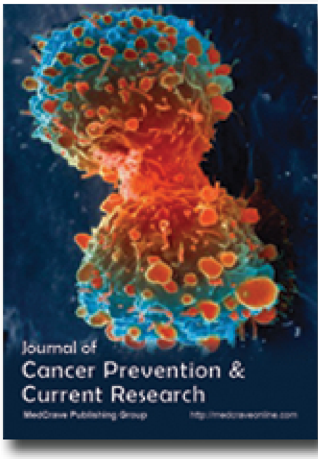

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ISBN 978-0-9967956-0-9
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