FUNCTIONAL OUTCOME OF BOTH BONE FRACTURE FOREARM MANAGED WITH TITANIUM ELASTIC -INTRAMEDULLARY NAIL SYSTEM IN PEDIATRIC AGE GROUP

By

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Introduction

"Functional outcome of both bone fracture forearm managed with titanium elastic - intramedullary nail system in pediatric age group"

MASTER OF SURGERY
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ABSTRACT

BACKGROUND AND OBJECTIVE

Children frequently have orthopaedic injuries, including both bone forearm fractures.They present the medical industry with significant challenges. Additionally, it is important to manage patients appropriately, but it's also essential to comprehend the overall impacts that a child's fracture may have, including potential physical limitations activity. 40% or more of paediatric fractures involves radius ulna fractures[1.]

The majority of these fractures are amenable to conservative care, including closed reduction and immobilisation with a cast. A known failure rate has been estimated to range from 7% to 32%. Currently, open compression plating and flexible intramedullary nailing are the two surgical therapy techniques most frequently used. Each modality has benefits and drawbacks. This study's objective is to evaluate the functional outcome, complications of titanium elastic intramedullary nailing in paediatric patients with radius ulna fractures.

In our study counducted at our institution, for 40 cases, boys made up the bulk of the patients in our study, and their average age was 10-11 years. , and the most common cause was self-fall while playing caused the injury. There was not much dissection required during the surgical procedure.

There was low possibility of intraoperative issues because of the surgery. Patients

got better from forearm functions that were initially close to normal in the weeks it the typical fracture took to heal.

We found no serious post-operative issues during our investigation, all of the patients exhibited wrist movement that was both good and exceptional elbow, radio-ulnar, and other joints.With least post operative comlications like stifness in pronation supination and PTI.

CONCLUSION

Titanium elastic intramedullary nailing system has good functional results with benefits of early fracture union, excellent recovery of function, minimally invasive surgery, with very less bleeding and shortened surgical time in pediatric population for both bone forearm shaft fractures.

INDEX PART A

INDEX PART B

ABBREVATIONS AND ACRONYMS

A/E- Above Elbow
AO -Arbeitsgemeinschaft fur Osteosynthese Fragen
ASIF- Association for the study of internal fixation
BT/CT- Bleeding Time/Clotting Time
BP Blood Pressure
DVT- Deep Vein Thrombosis
DCP- Dynamic Compression Plate
ECG- Electrocardiography
FBS/PPBS- Fasting Blood Sugar/Postprandial Blood Sugar
Fracture
Hb Haemoglobin
HbsAg Hepatitis B Virus Surface Antigen
HIV Human Immunodeficiency Virus
IV Intravenous
Lat. Lateral
LC-DCP Limited Contact Dynamic Compression Plate
LCP-Locking Compression Plate
DCP-Dynamic Compression Plate
ORIF- Open Reduction And Internal Fixation
RTA- Road Traffic Accident
Wks -Weeks
Ant. -Anterior
Post.- Posterior
Prox.- Proximal
Dist.- Distal
TENS- Titanium Elastic Nailing System
DS -Distal 1/3rd Shaft
MS -Middle 1/3rd Shaft
PS- Proximal 1/3rd Shaft
PTI -Pin Tract Infection
ROS- Range of Supination
ROP- Range of Pronation

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INTRODUCTION

Interesting anatomical features like the forearm, which transfers forces from the hand to the upper part of the extremity and allows the hand to rotate, are what give us our arms. The forearm functions as both an axle and a non-synovial joint. [1]

Its skeleton is strangely constructed from the radius and ulna, two distinct bones.

Two light and stable bones offer a good range of rotational motion (ROM)[2]. The

hand's neurovascular structures are fixed on the curved bone the radius,

which is located proximal from the wrist and hand[3]. None of the most advanced robots

have yet been able to mimic the intricate functions of the hand and forearm[4].

The forearm is necessary for the normal operation of the upper limb.
Because the forearm is so complicated and essential to the function of the upper lim b, damage to it might have grave consequences.
Forearm shaft fractures might undoubtedly be hazardous and challenging to treat[5].
They vary from other long bone fractures and may be distinguished from them[6].
This fracture is one of the uncommon paediatric fractures with a genuine risk of com plications and long term morbidity.

It is generally agreed upon that the possibility for remodelling increases with the distance between the fracture and the distal physis. As a result, the distal third of the diaphysis can accommodate more deformity thanthe middle and proximal thirds of theforearm[10.]

The majority of forearm fractures like these managed conservative care, including closed reduction and immobilisation with a cast. Open fractures, irreducible fractures, unstable fractures, pathological fractures, fractures with neurovascular compromise, mal-unions, and re-fractures are some indications for surgical intervention, and there has been a failure rate of up to 7% to 32% reported[11,12].

Currently, open compression plating and flexible intramedullary nailing are the two surgical therapy techniques most frequently used. Each approach has its own benefits and drawbacks[10]. Forearm shaft fractures are reportedly being operated on more frequently.

The procedure known as elastic stable intramedullary nailing (ESIN) has become widely used to repair long bone shaft fractures in children13. French and Spanish surgeons first mentioned it for the treatment of long bones in the late 1970s and early 1980s[14–17]. Research on the surgery is ongoing, and new advancements are being made, such as employing biodegradable implants18. In situations of paediatric forearm shaft fractures, plate and screw fixation is becoming less common and non-operative treatment is becoming less popular[19].

Despite the growing interest in surgical intervention (especially minimally invasive surgery) for forearm shaft fractures, there is significant dispute over the indications for surgical intervention[20].

This study's goal is to evaluate the functional outcome and side effects of titanium elastic intramedullary nailing in fracture of both forearm bone fractures in pediatric age group.

REVIEW OF LITERATURE

.PS Yuan et al. evaluated the frequency of compartment syndrome in paediatric forearm fractures treated with flexible intramedullary nails in their 2004 research of 285 fractures. Compartment syndrome didn't occur in any of the 205 patients who received closed reduction and casting therapy. 80 injuries were treated with intramedullary fixation, including 50 open fractures; 6.5% (6/80) of these patients had surgery to address their compartment syndrome (three closed fractures and three open fractures). All cases of compartment syndrome manifesting within 24 hours of the initial fixation were treated with fasciotomy with delayed wound closure,regular dressing, and none of the patients had long-term neurologic impairment.

According to **V. Kapoor et al. (2005)**[38], flexible intramedullary nailing resulted in early bony union (1 delayed union) at an average 7 weeks (ranging 6 weeks to 4 months) with acceptable bony alignment (pronation restriction of average 20 degrees in 9 patients) in all 47 available patients at final follow up for 50 displaced diaphysial forearm fractures (45 both bone, 4 radius only, and 1 ulna only) in the age group between.

In a retrospective research conducted in 2005, Fernandez et al39 compared the effectiveness of plating and intramedullary treatment in treating children with unstable, diaphyseal fractures of both forearm bones. Of the 64 youngsters they studied, 19 received plating and 45 received intramedullary fixation. The functional result showed no appreciable variation. Regarding surgical method, operation time, frequency and length of hospital stays, and cosmetic outcome, plating produced noticeably inferior results. According to their findings, intramedullary fixation a safe, kid-friendly, minimally invasive procedure that offers early functional treatment with an outstanding functional and cosmetic result for an unstable forearm fracture in cases of skeletally immature patients.

Smith et al[40] retrospectively compared the complication rates in the surgical groups—33% for open reduction internal fixation and 42% for intramedullary nailing—in 50 children with both-bone fractures treated with closed reduction and casting, intramedullary nailing, or open reduction internal fixation in 2005. They examined all 50 patients' treatments, and found that ORIF had a 33% complication rate, 42% complication rate for IMN, and 5% complication rate for casting.

Lewis E. Zionts et al.[41] evaluated 25 older children and adolescents with displaced diaphyseal both-bone forearm fractures who underwent closed reduction and were followed for a mean of 49.6 weeks (mean age 13.3 years and 8.8-15.5) in 2005. All breaks came together. The mean angulation on the final AP radiograph was 8 degrees (0-20 degrees) for the ulna and 9 degrees (0-18 degrees) for the radius. All patients were able to move their wrists and elbows completely. Loss of forearm supination and pronation averaged 4 and 6.8 degrees, respectively, with a range of 0 to 20 degrees. They reached to the conclusion that older children and teenagers may tolerate bayonet apposition and up to 15 degrees of angulation

Lascombes P et al[42] provided a summary of the proper and improper use of flexible titanium and stainless steel nails in 2006. Due to its elastic qualities, titanium (Ti 6A114V) is typically utilised more frequently than stainless steel in the clinical setting since it allows for better insertion and rotation while still providing appropriate strength. stabilisation of a fracture. The possible intramedullary implants' diameters range from1.5 to 4 mm. The medullary canal's diameter affects size selection. Use of a nail with a diameter equal to 40% of the medullary is a well established technique. Under fluoroscopic supervision, the length is measured against the length of the affected forearm's bone. Pre-bent nails should have the most curvature at the fracture point.

In 2008, **Reinhardt et al**[43] evaluated 31 surgically treated patients between the ages of 10 and 16 in a retrospective study. Similar complications and outcomes existed with ORIF and IMN. Finally, they said In skeletally immature patients 10 to 16 years of age, nailing of length-stable forearm fractures is nevertheless an equally successful method of fixation when compared to plating, based on identical functional and radiological outcomes.

In 2009 **Teoh et al.** [44] 17 matched pairs of both bone forearm fractures were examined in retrospect, comparing IMN and ORIF. Functional results were nearly same, however ORIF group participants had worse scarring.

In 2010, **Flynn et al**[45] conducted a retrospective analysis of 149 paediatric forearm fractures treated surgically. The rate of complications for IMN was 14.6%. Children that were older had worse results and more delayed unions. stabilisation of a fracture. The possible intramedullary implants' diameters range from 1.5 to 4 mm. The medullary canal's diameter affects size selection. Use of a nail with a diameter equal to 40% of the medullary is a well established technique. Under fluoroscopic supervision, the length is measured against the length of the affected forearm's bone. Pre-bent nails should have the most curvature at the fracture point. of forearm rotation.

In 2010, **Shah et al**[46] evaluated 61 skeletally immature patients who had had surgery. 83% of patients recovered their complete rotation, while 5% of ORIF group patients experienced problems. No issues in the IMN group. It has been demonstrated that angulation of 15 to 20 degrees in middle third forearm fractures might result in significant loss. A description of the appropriate and incorrect use of flexible titanium and stainless steel nails was given by Lascombes P et al42 in 2006. Since it allows for better insertion and rotation while still providing adequate strength, titanium (Ti 6A114V) is often used more commonly than stainless steel in the therapeutic setting due to its elastic properties.

A single bone IM fixation of the ulna, according to **Jeffrey F. Dietz et al**[47]'s 2010 study, gives sufficient short-term stability of both bone diaphyseal fractures in younger children. Since radial reduction may be lost, it is crucial to carefully check the alignment and stability of the fracture during surgery to determine whether further stabilisation of the radius is necessary. In cases of open fractures or in older children and teenagers, there is a little risk of radial alignment loss that could necessitate further manipulation or surgical stabilisation of the radius. In these situations, considerable consideration should be given to IM fixation of both bones.

. When treating non-operatively for both-bone forearmfractures,**Eric N. Bowman, et al.**[48] in 2011 found that children 10 years of age or older with proximal-third radius fractures and ulna angulation less than 15 degrees appeared to be at highest risk for failure. Early surgical care is advised because the majority of failures happen at an early stage.

In 2011, **Kang et al**[49] assessed 90 kids who had intramedullary nailing treatment, and they reported positive clinical and functional outcomes. The average patient age was 8.4 years, and there was a 6.6-month follow-up. 9% (8/90) of the patients had open fractures, while 86% (77/79) had both-bone fractures. 84% (76/90) of their patients saw excellent or satisfactory results (equal motion on both sides. Forearm fractures treated with intramedullary flexible nailing have been linked to complications.

In 2012, **Antonio Lobo-Escolar et al**[50] came to the conclusion that open reduction is the strongest indicator of a delay in union in cases of paediatric forearm fractures, and they advise patients to avoid it whenever possible.rather than having surgery, use closed reduction and internal fixation with TENS/K-wires.

Even in older children with less capacity for remodelling, **Daniel J. Westacott**[51] in 2012 found no differences in functional outcome between intramedullary nailing and plate and screw treatment in their research of fractures of both bone forearm. Due to its quicker healing period, better cosmetic results, and simplicity of removal, intramedullary nailing may consequently be the best option for treating minor fracture patterns. Even now, plating might still be useful in treating more serious injuries, especially in older kids.

-**Shivanna &Maruthi**. C.V Department of Orthopaedics, CIMS, Chamarajanagara, Karnataka.s: Between 2012 and 2014, children aged 5-15 years with Both bones were fractured in these patients, Underwent Closed reduction and internal fixation with intramedullary TENS NAILING. Flexible tens nail surgicalfixation of the pediatric fractures of forearm revealed several advantages bone healing up to nearly 7weeks post-operatively,minimal invasive surgery, with good clinical and radiological results.

Dr. Harish K. 12 investigated paediatric patients under the age of fifteen who were admitted in a tertiary care hospital between 2014 and 2017 for the purpose of undergoing surgery for a both bone broken forearm. About 42 individuals were admitted, and 27 of those patients were selected to participate in the study. They were chosen in accordance with the inclusion and exclusion standards. These patients were operated on while under general anaesthesia. Six months of follow-up were conducted. Price et al. criteria were used to note the functional outcome of these patients. 27 young individuals with surgically treated double bone forearm fractures participated in the study. The study included 27 pediatric patients having both bone forearm fractures that were operated. In 27 children, 8 were female, and 19 were male. The mean age of patients 10.2 years ranges 4-15 years. Average union time was about 10.5 weeks, with no incidence of nonunion. Complication such as superficial infection at the entry point even though present incidence were low. Based on Price et al., criteria functional outcome was calculated which showed excellent results in 20 (74%) patients, good in 5 (19%), fair in 2(7%) and no poor results.

In 2013, **Jeffrey E. Martus et al.**[52] came to the conclusion that 91% of patients who underwent IMN for paediatric forearm fractures had satisfactory to outstanding outcomes. With this method, problems are common; 17% of them had a grade 2 to 4 severity. Children above the age of 10 had a two-fold increase in the rate of problems. Compartment syndrome affected younger children more frequently. Prior to surgery, patients and their families should receive risk counseling.

In 2014, **Brian A. Kelly et al**[53] came to the conclusion that there were no appreciable differences in the incidence of problems, such as infection and fracture rates, between buried and exposed IM implants. Therefore, in the event of surgical treatment of forearm fractures in paediatric patients, leaving IM implants exposed may be a safe technique. Additionally, this method may allow for removal in-office, sparing the patient from the risk of anaesthesia, and maybe saving money.

In a 2014 systematic analysis, **Akash Patel et al.**[54] showed that IM nails and other devices had similar functional outcomes, radiological outcomes, and comorbidities.

plates used to treat kid patients with both-bone diaphyseal forearm fractures. IM nailing appears to be a successful therapeutic option for these fractures in both bone forearm despite methodological shortcomings of the studies covered, with shorter operating times, improved cosmesis, and simpler hardware removal.

In 2014, **C N Manjappa et al**[.55] discovered that elastic nailing (tens) caused early bone union with favourable bony alignment in all 20 patients who were still alive at the end of the follow-up period. For the treatment of children with unstable diaphyseal forearm fractures, they advise elastic nailing (tens).

In a study by **Mohammad Ruhullah et al. (2016**)[56], 79 patients (3–15 years of age) with displaced fractures of both forearm bone shafts had flexible titanium elastic nails with a 12-month follow-up period. According to his report, 13 patients had minor complications, 74 patients had excellent results, 5 patients had good results, 2 patients had restrictions of 20 degrees of pronation and 10 degrees of supination, 2 patients had restrictions of 15 degrees of pronation, and 1 patient had an 8 degree volar angulation at the radial bone with a limitation of 5 degrees supination. The average time it took to align all fractures was nine weeks, and the average time it took to remove nails was six months. According to his analysis, flexible nailing causes

In 2016, **Rajesh Kapila et al.**[57] came to the conclusion from their study that TENS is a successful, minimally invasive approach of fixing forearm fractures with great outcomes in terms of bone union and functional outcomes and little problems. They advise using TENS to treat paediatric forearm fractures as a result.

Based on their findings, **Abhishek Vaish et al.**[58] came to the conclusion that flexible intramedullary nailing is a successful method of fixing diaphyseal fractures in skeletally immature patients with great functional outcomes and few sequelae.

Christiane **Kruppa et al. (2017)**[59] studied the outcomes based on re-fracture (10 cases), non-union (0 cases), mal union (two cases), infection (one superficial infection), decreased range of motion (two cases), and injury to the Extensor Pollicis Longus Tendon between 2000 and 2015 in a retrospective study of over 201 cases (82.2% of which were both bone forearm fractures) (3 cases). He came to the conclusion that the elastic intramedullary stable nailing method is a safe, dependable, and low-complication approach.

Single bone fixation might be thought of as an appropriate solution for both bone forearm fractures in children, according to **Yong B et al[60] in 2018**, as it requires less time in surgery and less money without sacrificing the patient's final functional outcome when compared to double-bone fixation.

In 2018, **Sahu B et al[62]** agreed that, despite the fact that forearm fractures in children can sometimes be treated conservatively, they frequently result in malunion and restricted motion at the elbow or wrist joint. TENS demonstrated superior outcomes than the traditional approach in terms of bone union, functional outcome with few problems, and cosmesis. Additionally, the operating time was brief. Consequently, this minimally invasive TENS technique may be thought of as a desirable and efficient replacement for paediatric patients with displaced forearm fractures.

K USHA, SOMESHWAR 2020 Postgraduate, Professor and Head of the Orthopedics Department at Santhiram Medical College and General Hospital in NandyalDOI: 10.21474/IJAR01/10919 A diaphyseal fracture of the radius or ulna, which makes up around 40% of all paediatric fractures, is one of the most frequent paediatric fractures. Conservative measures like closed reduction and immobilisation with an above elbow cast may cause malunion. The advent of titanium elastic nailing devices has altered the therapeutic environment. The goal of this study is to evaluate the efficacy of treating both bone forearm fractures with closed reduction and internal fixation using a titanium elastic nail system. Materials and Procedures Internal fixation using titanium elastic nails was used to treat 20 patients with radius and ulna fractures between the ages of 5 and 15.

Harpreeth, beneath aora 2022 Closed reduction and internal fixation with titanium elastic nailing system in pediatric both-bone forearm fractures At our facility, 32 kids between the ages of 5 and 15 who had both-bone forearm fractures underwent closed reduction and internal fixation with TENS. This research covered patients with displaced fractures with angulation more than 10° and rotation greater than 45° or fractures with inadequate reduction following conservative therapy. Upper extremity rating scale (UERS) was used to assess grip strength and range of motion for functional outcome. Six months were spent following up with patients. In every case, the fracture healed without any malunion within the range of 6 to 14 weeks. According to UERS score, the results in all 32 instances were outstanding. Forearm pronation was 10° and 15° below normal in two individuals, respectively. Implant impingement and skin irritation

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ANATOMY OF FOREARMS

An in-depth understanding of the anatomy of the forearm is necessary to prevent neurovascular damage during surgical therapy. The forearm is made up of two bones, the medial radius and lateral ulna, an interosseous membrane, the proximal and distal radio-ulnar joints, as well as soft tissue components including the muscles, nerves, and arteries that are located in the forearm and pass through it. 63-64

EMBRYOLOGY[65]

On the 26th day, limb buds begin to develop. These little bulges may be seen on the lateral body wall between the C5 and C8 level. Limb morphogenesis occurs between the fourth and eighth weeks, and limb rotation happens between the sixth and eighth weeks.

By the eighth week, the elbows and shoulders are set, and the fingers are free. A mesodermal condensation that occurs along the length of a limb gives rise to the skeletal components.

OSTEOLOGY FOREARM

Ulna, radius, and interosseous membrane make up the osseous compartment.

The anterior and posterior compartments of the forearm are therefore separated.

RADIUS:

The lateral bone of the forearm is called the radius. It has widened proximal and distal ends, with the latter being significantly wider. The shaft is convex laterally and concave anteriorly in its distal portion, and it rapidly widens there.p

PROXIMAL END

A head, neck, and tuberosity are present on the proximal end. The proximal surface of the discoid head has a shallow cup for the humeral capitulum. The medial portion of its smooth articular perimeter, which makes contact with the ulnar radial notch, is the deepest vertically. The constrictor that extends distally from the head and drapes over it is the neck. The tuberosity is posterior and distal to the medial neck.

SHAFT

A shaft has three surfaces, three boundaries, and a triangle cross section. With the exception of two locations—proximally, close to the tuberosity, and distally, close to the ulnar notch—the interosseous or medial boundary is sharp. The interosseous membrane joins the radius to the ulna at its distal three-fourths.

Although it is rounded and unclear in the middle, the anterior boundary is apparent at both ends. The only part of the posterior border that can be distinguished clearly is the middle third.

The anterior surface has a distal forward curvature and is transversely concave between the anterior and interosseous boundaries. A foramen and canal for nutrients that are directed nearby are located in the centre of it. The posterior surface is mostly flat between the interosseous and posterior borders, however it may be slightly hollow in the proximal area. On the lateral surface, convexity is minimal. spanning the ANTERO-POSTERIOR boundaries .

THE DISTAL END

It is the widest part. It is four-sided in section.

The lateral surface is slightly rough, projecting distally as a styloid process. The smooth carpal articular surface is divided by a ridge into medial quadrangular and lateral triangular areas.

The anterior surface is a thick, prominent ridge, palpable even through overlying tendons. The medial surface is the ulnar notch, which is smooth and antero-posteriorly concave for articulation with the head of the ulna. The posterior surface displays a palpable dorsal tubercle (Lister's tubercle).

RADIAL BOW

Radial bow has characteristic bow which is demonstrated for forearm roatation,when radius is fractured radial bow has to be restored for forearm function

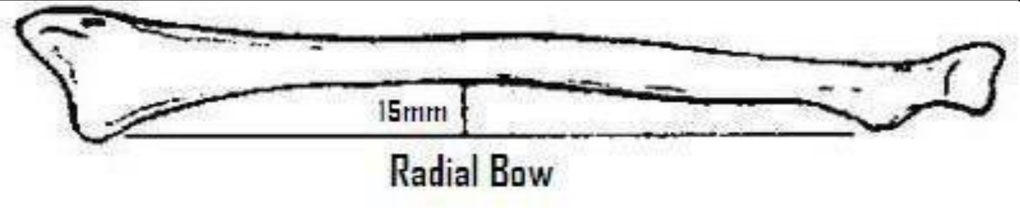


FIGURE1-Radial bow

ULNA

It’s the medial bone of forearm, nearly similar to fibula of lower limb.

PROXIMAL END

The olecranon is closer to the humerus and has a beaked top that bends forward as it extends into the humeral olecranon fossa. Its proximal border sits beneath the elbow's "point," and its posterior surface is smooth, triangular, and subcutaneous. In flexion, the three osseous points form an isosceles triangle and can be felt close to a line connecting the humeral epicondyles when it is extended. The trochlear notch's proximal portion is formed by its anterior, articular surface.

In front of the olecranon, the coronoid process extends distally. The trochlear notch's distal portion is formed by its proximal aspect. There is a small, smooth, oval radial notch on the lateral surface, distal to the trochlear notch, which articulates with the radial head.

The trochlear notch and the trochlea of the humerus articulate. It is restricted where the olecranon and coronoid processes meet, where a thin, rough non-articular strip may exist between their articular surfaces.

The superior radioulnar joint is formed by the radial notch articulating with the head of the radius.

SHAFT

The shaft's proximal three-fourths are triangular in form, but its distal half is virtually cylindrical.

It has anterior, posterior, and medial surfaces. The nutritive foramen is on the anterior surface.

Interosseous, posterior, and anterior borders make up its three sides..

OSSIFICATION

Three centres make up the radius. In the eighth week of foetal development, the primary centre first appears in the middle of the shaft. By the end of the first year, the distal epiphysis, and by the fourth and fifth years, respectively, in the males' and girls' proximal epiphyses. The distal epiphysis fuses in the seventeenth and nineteenth years, respectively, while the proximal- epiphysis of bone fuses in the 14^{th} year in females and the seventeenth year in males.

The ulna bone ossifies from four major centres, two in the olecranon and one each in the shaft and distal end. At the eighth foetal week, the midshaft begins and quickly grows.

It begins during the fifth and sixth years for boys and females, respectively, and spreads into the styloid process.

Distal epiphysis unites with shaft at about 18 years in males and 17 years females.

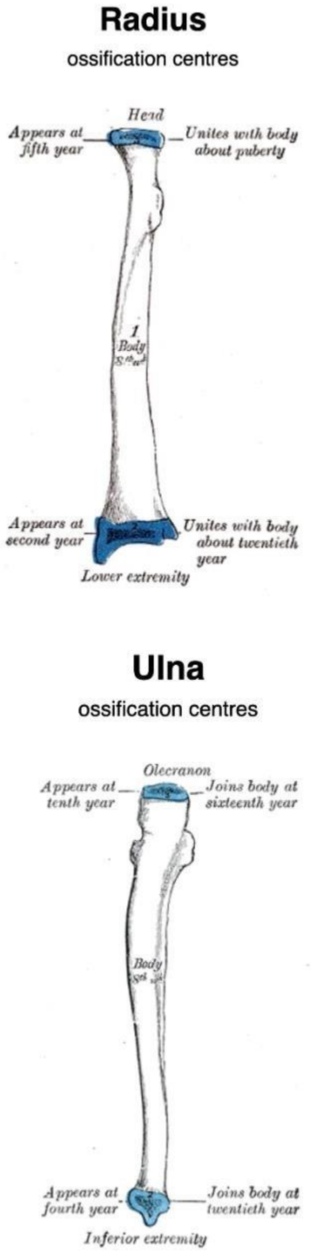


Figure No. 2 : Ossification Centres of Radius and Ulna

PERIOSTEUM[67-68]

Except for the surfaces of the joints, radius ulna bones are completely covered by a thick layer of periosteum. An exterior fibroblast layer and an inner osteogenetic layer make up the periosteum (cambium layer). The periosteum, which contains blood, lymph, and nerve vessels, is essential for bone healing. Children's periosteum has a higher osteogenic capacity than adult periosteum, allowing for more conservative treatment of children's fractures than adult fractures. the periosteum in young children seperates from the bone than it is in adults. Fracture repair is started by the periosteum, which produces new bone quickly. It works well to repair fracture lines when there are bone deficiencies. When damaged, the robust periosteum can function as a hinge, which might worsen alignment. . Contrarily, an unbroken periosteum, which is typically on the concave side, keeps the fractured pieces in contact with one another and may help in closed reduction.

INTEROSSEOUS MEMBRANE[69]

The proximal and distal articulations of the ulna and radius are separated by an oval-shaped gap. The interosseous membrane, which acts as a partition between the anterior and posterior compartments, occupies the majority of the space between the two bones at their maximum distance in full supination. The interosseous ligament, which runs obliquely from the proximal radial to the distal ulnar, is a thick fibrous layer that covers the interosseous membrane.

The space between the oblique cord and the top end of the interosseous membrane is where the posterior interosseous vessels travel. The anterior interosseous vessels might enter the posterior compartment through an aperture in the lower portion of the membrane.

Functions of the interosseous membrane are[64]:

1. Transmit force from the radius to the ulna.
2. Provide firm connection between the radius and ulna
3. Separates and increases surface area of the deep muscles of the anterior and posterior compartments.
4. In the presence of a radius fracture, it acts as a constraint against radial shortening.

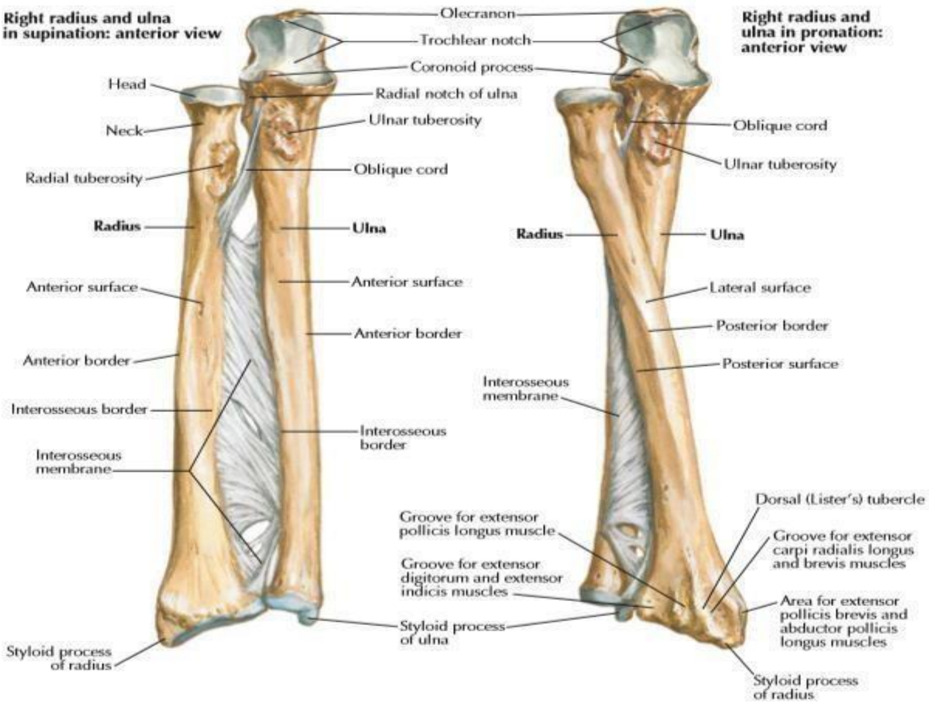


Figure No. 3 : Interosseous Membrane

Figure No. 4 : X – Ray Image of both bone forearm with Marked area suggestive of Interosseous membrane

MUSCLE COMPARTENTS[70-73]

The forearm has three separate compartments for the muscles.

The interosseous membrane, the radius, the ulna, and the antebrachial fascia all encircle the volar compartment. The flexor and pronator muscles are located in the volar compartment, which is separated into superficial and deep sections.

Radius, ulna, fascia, and the interosseous membrane encircle the dorsal compartment. It includes the fingers' and the wrist's extensors. Deep and superficial portions make up the dorsal compartment as well.The dorso-lateral forearm side contains the mobile wad of Henry. In the compartment are a forearm flexor and two wrist extensors.

According to their respective roles, the three groups of forearm muscles are as follows: There are three types of muscles: 1) those inserted to the radius and controlling forearm motions,
2) those that extend to the metacarpal area and allow for wrist motions, and 3) those that help in e xtension to the fingers.

Briefly the forearm muscles are divided as extensor compartment and flexor compartment as shown the figures 5, 6, 7 and 8.

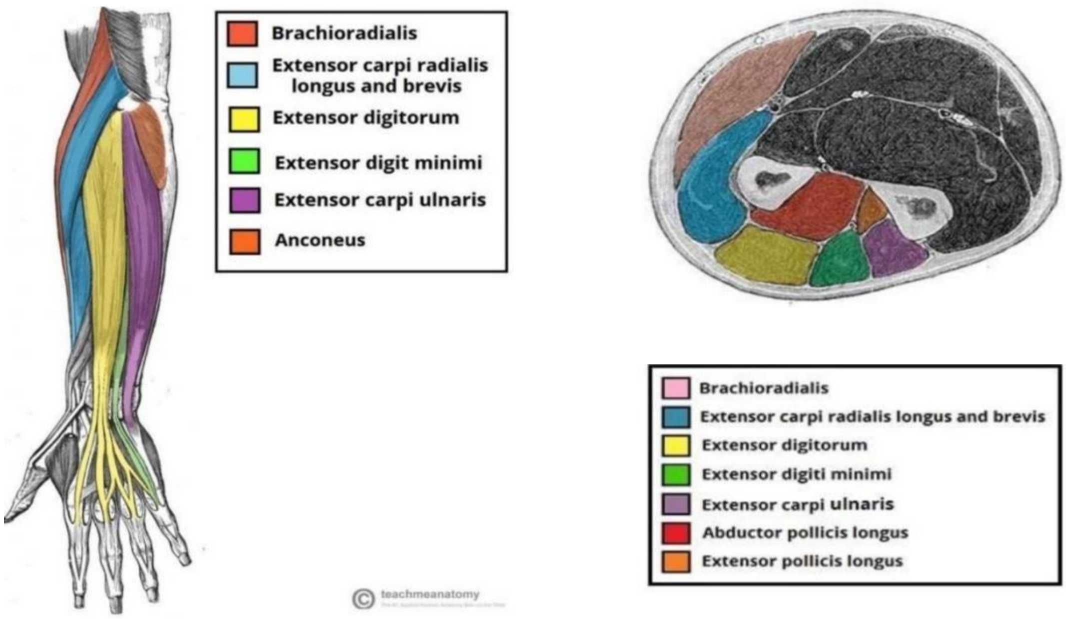


Fig. No. 5: Extensor Comportment of Forearm – Superficial Layer of Muscles

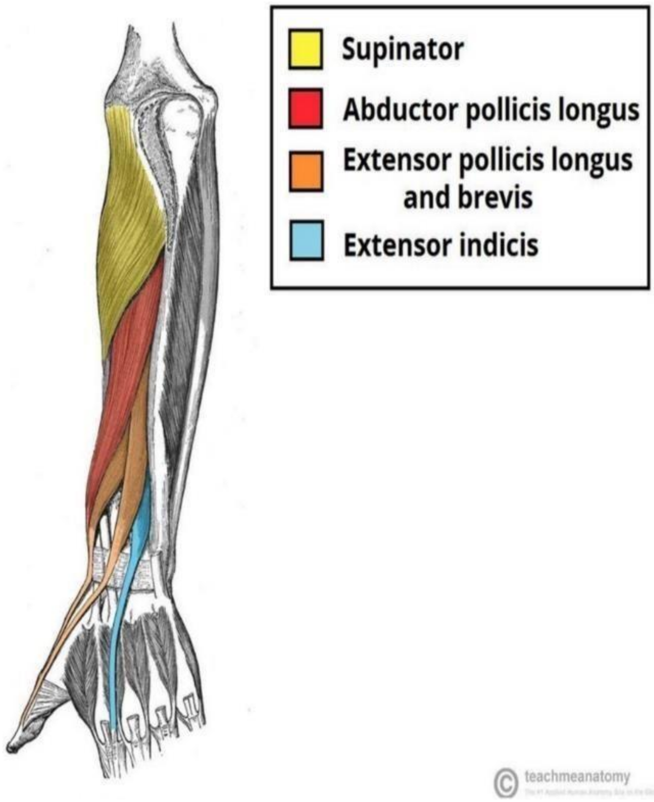


Fig. No. 6: Muscles of Deep Layer of the Extensor Compartment

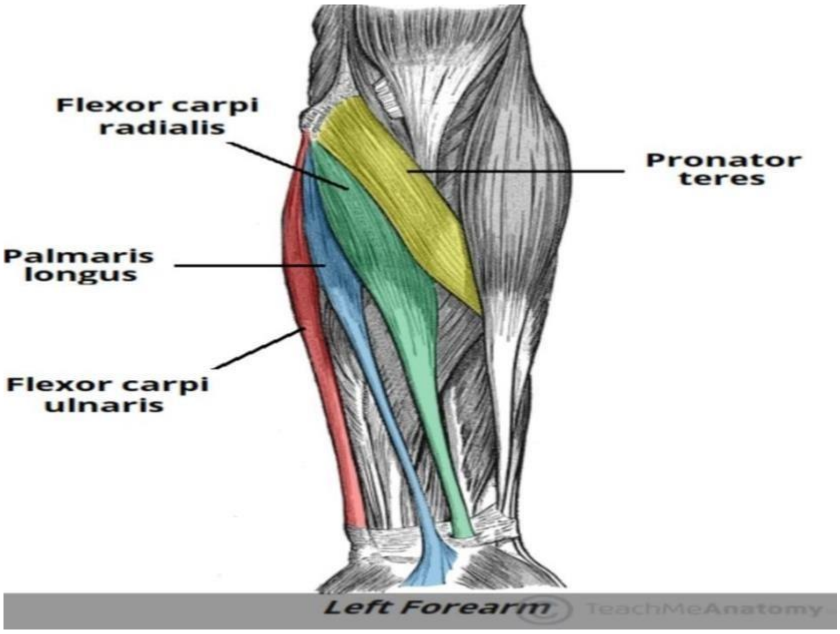


Fig. No. 7: Flexor Conformant Superficial Layer of Muscles

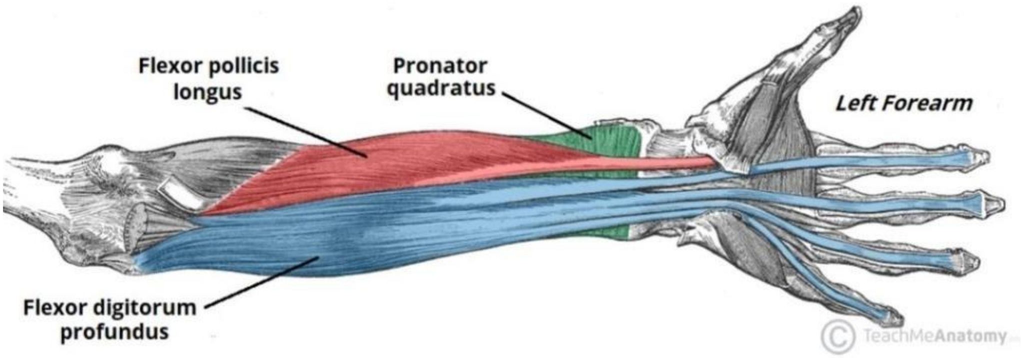


Fig. No. 8: Muscles of Deep Layer of Flexor Compartment of Forearm

ARTERIAL SUPPLY OF FOREARM[74]

RADIAL ARTERY

It begins 1 cm distal to the elbow's flexion crease. From the medial side of the neck of the radius to the wrist, it descends down the lateral side of the forearm, accompanied by paired venae comitantes, and is palpable between the flexor carpi radialis medially and the prominent anterior border of the radius. It curves around the lateral aspect of the radius before crossing the anatomical snuff box and piercing the fascia. It then terminates by combining with the deep branch of the ulnar artery to form the deep palmar arch.

Branches of Radial Artery in the forearm are radial recurrent artery, cutaneous and muscular branches.

ULNAR ARTERY

The bigger terminal branch of the brachial artery, known as the ulnar artery, begins 1 cm distal to the elbow's flexion crease and ends halfway between the elbow and wrist on the medial side of the forearm. The ulnar artery enters the hand by passing via the flexor retinaculum, which is lateral to the ulnar nerve and pisiform bone.

Branches of the forearm's Ulnar Artery:

• The anterior and posterior recurrent arteries of the ulna

- common

Interosseous artery,

- anterior interosseous artery

• Nutrient and muscular branches

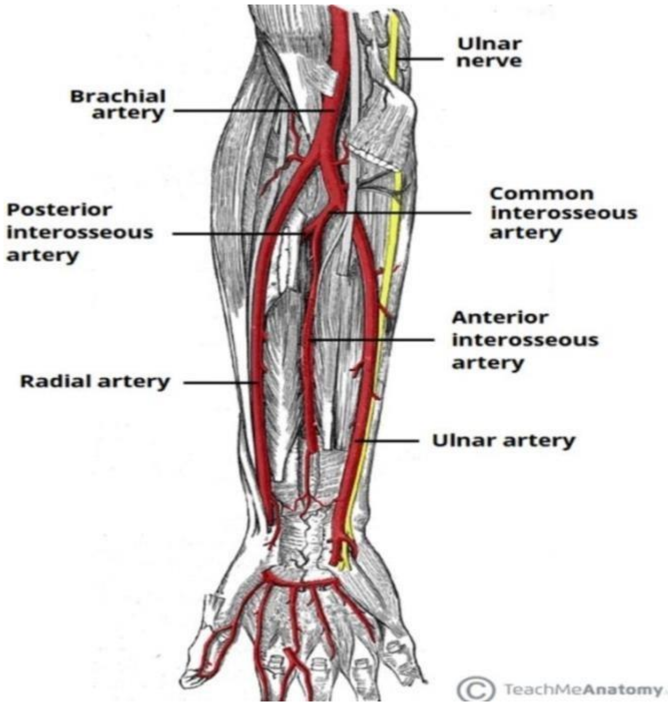


Fig. No. 9: Arterial Supply of Forearm

NERVE SUPPLY OF FOREARM[75]

Nerve Supply of Flexor Compartment:

Median Nerve

Between the two heads of the pronator teres, it enters the forearm. It descends through the forearm posterior and adherent to flexor digitorum superficialis and anterior to flexor digitorum profundus, passing behind a tendinous bridge between the humero-ulnar and radial heads of the flexor digitorum superficialis. It turns superficial to penetrate deep to the flexor retinaculum into the palm around 5 cm proximal to the wrist.

Branches in the Forearm

- anterior interosseous nerve
- Muscular branches to the palmaris longus, pronator teres, and flexor digitorum superficialis.
- articular branches.

The deep fascia above the elbow, lateral to the biceps tendon, is penetrated by the lateral cutaneous nerve of the forearm, the cutaneous continuation of the musculocutaneous nerve, which supplies the anterolateral side of the forearm.

The anterior and posterior part of medial aspect of forearm is supplied by medial cutaneous nerve of forearm

Nerve Supply of Extensor Compartment:

Posterior Interosseous Nerve:

The deep terminal branch of the radial nerve is the posterior interosseous nerve. By navigating the lateral aspect of the forearm, it reaches the back of the forearm.

the distance in between the supinator's two heads. When it reaches the interosseous membrane, it dips down to cross over the origin of the abductor pollicis longus and continues descending between the muscles all the way to the wrist joint.
Branch structures in the forearm The deep muscles of the extensor compartment and muscles deriving from the same extensor origin are supplied by the posterior interosseous nerve.

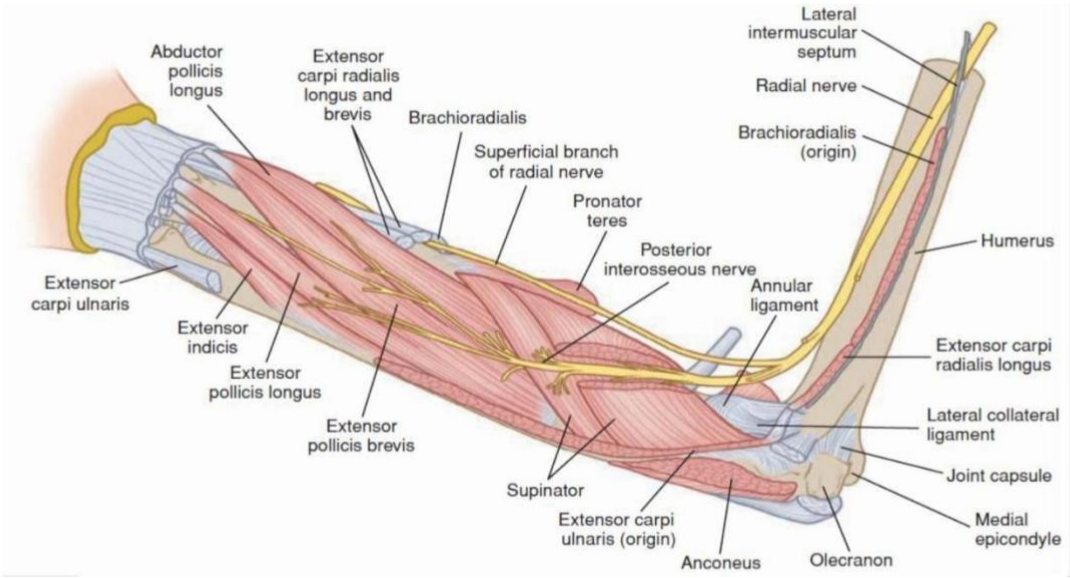


Fig. No. 10: Nerve Supply of Forearm

The Radio-Ulnar articulations[75]:

The superior and inferior radioulnar joints are where the radius and ulna are connected to one another. The inter-osseous membrane, which is occasionally referred to as a middle radio-ulnar joint, also connects the two bones.

A) The superior radioulnar joint

A uni-axial pivot joint is the proximal radioulnar joint. The articulating surfaces are the fibro-osseous ring (ulnar radial notch and annular ligament) and the circumference of the radial head. The crucial component that secures the head of the radius in place is the annular ligament.
Forearm movements include pronation and supination.

a) Inferior radioulnar joint:

A uniaxial pivot joint is the distal radio-ulnar joint. The concave ulnar notch of the radius and the convex distal head of the ulna are the articulating surfaces. An articular disc connects these surfaces. A triangular fibrocartilage that has its base attached to the ulnar notch of the radius and its apex attached to a fossa at the base of the ulnar styloid closes it distally. Pronation and supination of the forearm movements

Forearm Functions:

Movements

The forearm functions as a joint and a mechanical axis. It serves as a lever that transmits force and permits rotational movements of the hand regardless of the elbow's flexion or extension. The motion of the shoulder, elbow, forearm, wrist, and fingers affects how dexterous the upper extremity is.

The movement that mostly affects the forearm and a small portion of the humerus is known as rotation of an extremity. It depends on the radius's bent shape, which modifies the axial rotation at the proximal end and causes the distal end to swing around the distal portion of the ulna[77]. Within the annular ligament, the radius' proximal head pivots. The radius migrates closer when one is fully pronated [(78).]

Rotation may be restricted if the space between the two forearm bones is compressed79.

The forearm's rotational axis is located between the centres of the proximal radial head at the elbow and the ulnar head at the wrist. The ulna and radius' longitudinal anatomic axes are thus perpendicular to the functional axis. Forearm bones must maintain their original form in order to operate properly80

Load Transmission

The radius, the interosseous membrane, and the ulna are all involved in the intricate interaction that occurs when longitudinal load is transmitted from the hand to the elbow. From the proximal radius to the distal ulna, the central band of the IOM distributes load. The membrane transmits compressive pressures from the hand and radius to the ulna for further transmission upward to the humerus due to its oblique construction from the distal part of the ulna to the proximal part of the radius[81,82]. In Figure 6, Normally, the ulna receives the majority (60–95%) of the stress from the distal radius (the wrist), while the radio-humeral joint directly receives modest loads[83,84.]

The carrying angle of the upper extremity affects how weight is transferred from the forearm to the elbow.

The typical carrying angle in children grows with age and spans from 6 to 12 degrees of valgus. As the carrying angle increases, more strain is immediately transmitted from the distal radius to the radiocapitellar joint. When the cubitus is rectus or varus86, direct load transfer between the radius and the humerus is less efficient.

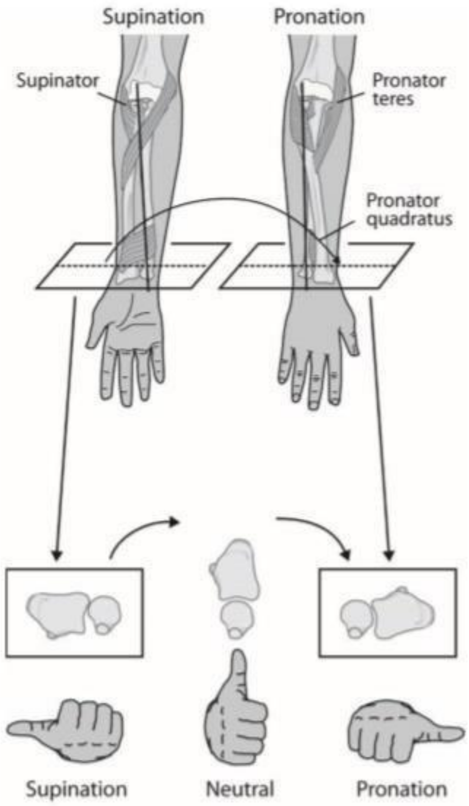


Fig. No. 11: Transmission of Load

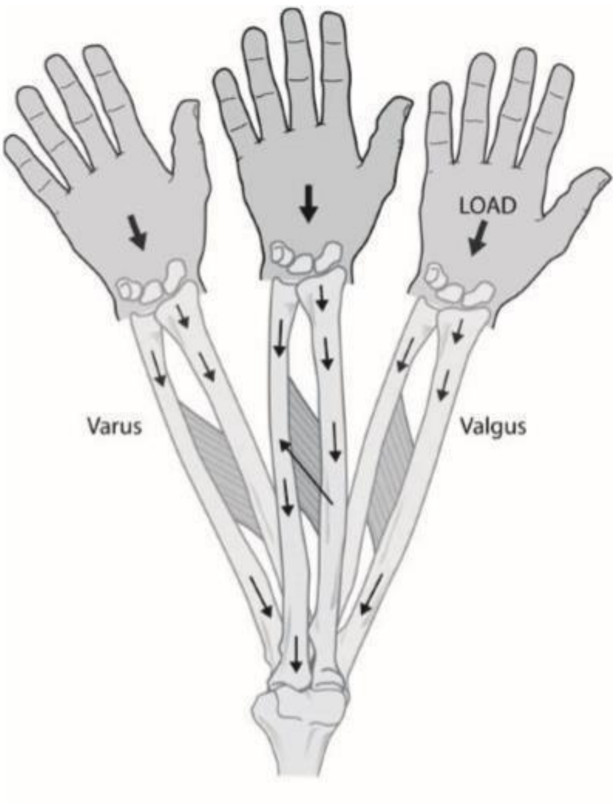


Figure 12 :

According to changes in the upper extremity's carrying angle, transmission of weight is from the wrist to the elbow.

DISPLACEMENTS[87,88]

Both bone forearm fractures must be treated appropriately to restore the function of forearm. The relationship of radiocarpal joint, distal radio-ulnar joint, interosseous membrane, proximal radio-ulnar joint, radio-humeral, ulno-humeral must be anatomical for perfect functioning of forearm.

Three muscles—the supinator, pronator teres, and pronator quadratus—that have their origins on one bone and their inserts on the other attach to the radius and ulna. These muscles tend to approach the radius and ulna and reduce the interosseous gap when there is a fracture.

The biceps and supinator muscles, through their insertions, apply rotational pressures to fractures when they develop in the upper portion of the radius. Pronator quadratus inserts on the distal fourth of the radius, where it exerts rotational and angulatory stresses, while pronator teres inserts on the midshaft.

In fracture of the radius occurring distal to the pronator teres, the combined forces of biceps and supinator is somewhat neutralized on the proximal fragment by the pronator teres and the proximal fragment assumes mid prone position.

The pronator quadratus and the pull of the long forearm muscles cause distal radius fractures, which are distal to the pronator teres, to angle toward the ulna. Therefore, immobilisation in the appropriate position is necessary in closed treatment of fractures of both forearm bones.

Supination should be used to immobilise the forearm in cases with radius fractures in the upper third. The distal third should be immobilised in forearm pronation, while the middle third should be immobilised in mid-pronation. These immobilisation stances aid in a satisfactory union effective outcomes.

Because the proximal fragment frequently displaces toward the radius, ulnar fractures are typically largely influenced by angulatory forces. The proximal forearm's muscle mass makes it challenging to keep the reduction closed.

It is necessary to anatomically correct the double bow of the radius to obtain appropriate pronation and supination. Small contact surfaces at the fracture site impede down bone healing in the radius and ulna, which is why stable fixation of the fragments is crucial.

Therefore, it is anticipated that some loss of pronation will occur in all mid-third radius/ulna fractures and that it will persist for a long period even after union.

Assessment of other factor limiting rotation is thus based on measurement of supination rather than pronation.

BIOMECHANICS OF FRACTURE IN PEDIATRIC BONE[89]:

A childs bone differs from adult bone as it is more porous (areolar tissue), softer (less mineral content) and has more elastic and plastic properties owning to higher water content. It has thicker periosteum and well vascularised.

Owing to these specific bone features four types of

- A buckle fracture (or torus fracture) occurs due to axial compression of bone at the metaphyseal diaphyseal junction.
- A bowing fracture is when the diaphysis appears to be bent without any fracture line evident.
- Greenstick fracture occurs when a bone is angulated beyond the limits of plastic deformity: fracture involving only the convex side of the cortex and its periosteum.
- Hairline fracture (often spiral shaped) with no displacement within its periosteal sleeve.

Other types of fractures, which are also commonly seen in adults:

- Spiral fracture as a result of rotational trauma.
- Pure bending can result in transverse fracture.
- Combination of axial and oblique fracture frequently results in bending and compression.
- A butterfly fragment or a transverse/oblique fracture.
- Comminuted fractures are unusual in youngsters because they absorb a lot of energy before they break.

Diaphyseal Fractures

• The initial trauma results in bone fractures, blood vessel ruptures, and tearing of the nearby soft tissue. Bone and soft tissue bleeding leads to fracture hematoma.

• Histamine and other chemical mediators are released during the early acute inflammatory phase, aggravating the first devitalization of bone and soft tissue.

• Formation of external or periosteal callus actually initiates the repair process by forming encircling collars of callus at proximal and distal fracture fragments, in the

vital bone area. Union is established in a few weeks when these collars gradually approximate each other. This callus is predominant callus which enhances rapidly if the periosteum is intact.

Pediatric fractures heal faster than adult fractures, even though healing mechanisms are identical:

- Damage to bone and soft tissue is less severe since the trauma's energy is released gradually.
- The periosteum is thicker and has better vascular supply, which makes fractures more stable and less likely to dislocate than in adults. The development of external callus is also facilitated.
- Active growth zones support bone remodelling.
- On the other hand, in youngsters, the lengthening of the fractured bone occurs as a result of the growing that follows a bone fracture healing.

DEFORMING MUSCLE FORCES [101]-

Proximal third fractures:

■ **Biceps and supinator:** These function to flex and supinate the proximal fragment.

■ **Pronator teres and pronator quadratus:** These pronate the distal fragment**.**

■ **Middle third fractures:**

■ **Supinator, biceps, and pronator teres**: The proximal fragment is in neutral.

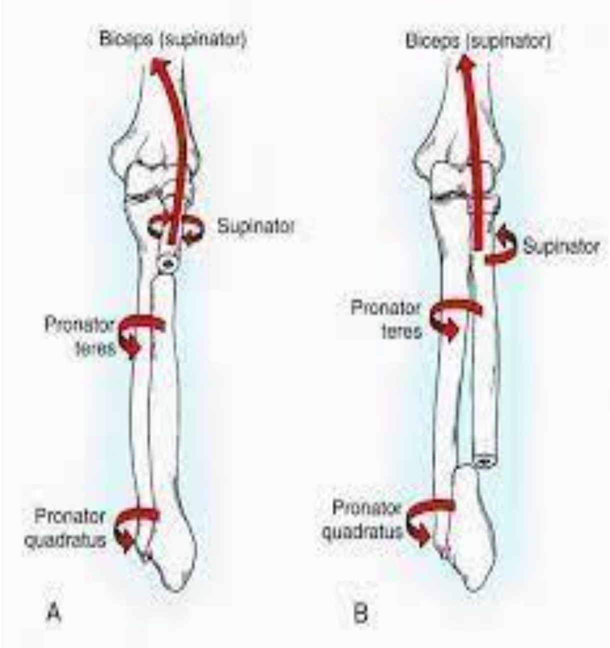
■ **Pronator quadratus:** Pronates the distal fragment.

■ **Distal third fractures:**

■ **Brachioradialis:** Dorsiflexes and radially deviates the distal segment**.**

■ **Pronator quadratus, wrist flexors and extensors, and thumb abductors:** They also cause

fracture deformity



fig;13;deforming muscle forces

FRACTURE CLASSIFICATION

The location, degree of cortical disruption, displacement, angulation, and mal-rotation of fractures are commonly categorised.

The most comprehensive classification of pediatric forearm fractures presently available is the AO classification (Arbeitsgemeinschaft für Osteosynthesefragen). For this study AO classification is considered.

The fracture location comprises of

- The different long bones
- The respective segments
- The sub segments

The morphology of the fracture is documented by a specific child code that stands for

- Fracture pattern (1-9)
- Severity code (.1 .2)
- Additional code (used in case of proximal displaced fractures)

Location

Long Bones are numbered:

Humerus	–	1
Radius / Ulna	–	2
Femur	-	3
Tibia / Fibula	–	4

SEGMENT OF BONE INVOLVED

Proximal	–	1
Diaphyseal	-	2
Distal	-	3

The proximal or distal segment comprises that area of bone covered by a square, the sides of which are equal to the maximal width of the bone at the physeal level.

PAIRED BONES

When, in paired bones both bones are fractured with the same fracture pattern the two fractures should be documented by only one clarification code, severity code will be that of more severely fractured.

When, in paired bones, only one bone is fractured a small letter designates this bone (“u” in case of ulna and “r” in case of radius).

When, in paired bones, both bones are fractured with different fracture patterns, each fracture must be coded separately.

SUBSEGMENT

Within the segments 1 and 3 of each diaphyseal bone, the segment is subdivided into E(epiphysis) or M(metaphysis). The diaphyseal segment is coded D.

MORPHOLOGY

Diaphyseal fracture patterns are coded as below

- Bowing – D/1
- Greenstick – D/2
- Complete transverse < 30 degree – D/4
- Complete oblique/spiral > 30 degree- D/5
- Monteggia – D/6
- Galeazzi –D/7
- Other fractures –D/9

For Our Study we will be considering the below fracture patterns

- 22rD / 4.1
- 22rD /5.1
- 22uD/4.1
- 22uD/5.1

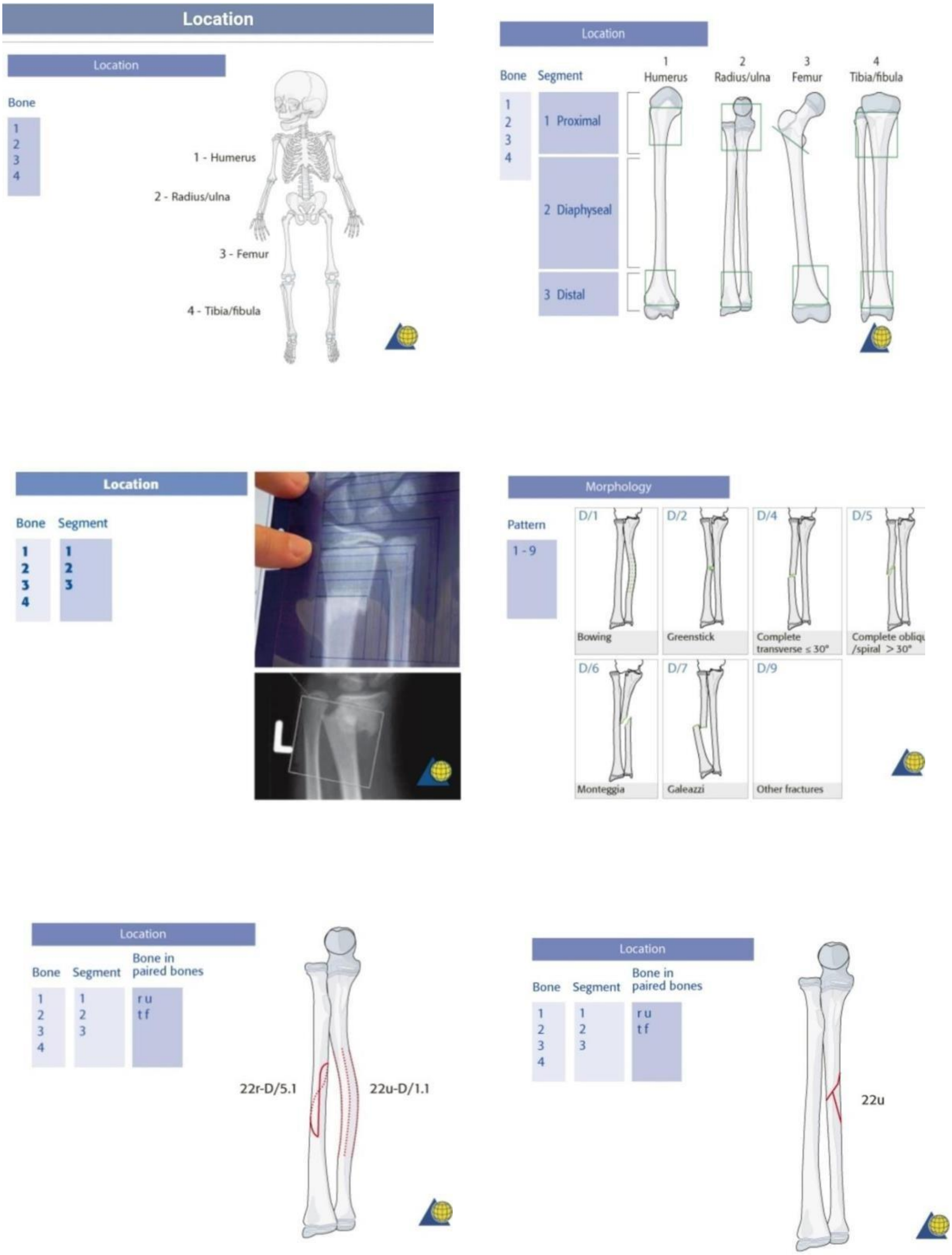


Figure 14 : A O Classification of Both Bone Forearm Fracture in Pediatric Age Group

Mechanism of Injury[90]:

According to Keith L. et al. (1998), the location of the forearm, the structure of the wrist, and the connections between soft tissues all have a role in how weight is transferred from the wrist to the elbow via the radius and ulna. In comparison to supination, pronation enhanced the fracture severity and the contact area with the radial head.

1. **Direct violence**: When a shaft of bone is struck by a hard object during a fall, it can result in a transverse fracture of both bones at the same level, which is rather uncommon. Nowadays, traffic accidents in vehicles are commonly to blame**.**

2.Indirect violence: When a child falls, the radius receives the majority of the force that deforms it. Typically, the radius gives out first, followed by the ulna[71]. Most injuries are caused by forces like landing or falling on an outstretched arm.

A direct hit or angulatory force results in a transverse fracture of both bones at the same level, while a twisting force induces a spiral fracture with the bones shattered at separate levels[73].

. The pattern of displacement of the distal fragment is usually dorsal (apex anterior), because in most falls the wrist is dorsi-flexed. The incidence of volar displaced fractures is small, only about 1%.

The muscles that pull on the radius—the biceps and supinator in the top third, the pronator teres in the middle third, and the pronator quadratus in the lower third—could result in additional rotational deformity.[73]

The angular deformity (dorsal – volar) towards or away from the interosseous membrane determined by the position of the forearm as follows:-

i) Dorsal angulation sustained with forearm in supination.

ii) Volar angulation sustained with forearm in pronation.

2. **New Mechanisms in Modern Society**: Children are exposed to many new recreational and sporting activities such as small wheels attached to shoes increases the forward velocity, children using roller skates - skate boards – in-line skates.

TREATMENT MODALITIES

The orthopaedic surgeon has varieties of options for treating the fractures of shaft of both bones forearm in pediatric population. They are:

Non Operative Management

- Cast immobilisation.
- Closed reduction ,cast immobilisation.

Operative Management

- Closed reduction ,percutaneous fixation using K-wires.
- Open reduction and internal fixation with plating.
- Closed/open reduction and internal fixation with titanium elastic nailing system(TENS)

Indications for Conservative Management

- Bowing and greenstick fractures
- Un-displaced fractures.
- Minimally displaced fractures.
- Age less then 6 year.

CAST APPLICATION[91]

Un-displaced or minimally displaced fractures were immobilized without manipulation. The position of forearm in the plaster was based on the affected level.

Because of deforming muscle forces, the level of the fracture determines forearm rotation of immobilization:

■ Proximal third fractures: Supination

■ Middle third fractures: Neutral

■ Distal third fractures: Pronation

■ Placing the forearm in extremes of supination or pronation should be avoided for any location of fracture

The upper limb is padded with cotton or stockinet and plaster of paris wrapped circumferentially with 50% overlapping of the previous roll. Cast is applied just proximal to the knuckle to just below the level of axilla with elbow in 90 degree flexed position. Measures should be taken not to apply the plaster too tightly nor too loose. The cast should be molded into an oval to increase the width of the interosseous space and bivalved if forearm swelling is a concern. The arm should be elevated.The patient must be given proper instructions regarding the care of cast and danger signs like pain out of proportion, excessive finger swelling, change of finger colour, or numbness for immediate approach to hospital or removal of cast. The cast should be continued for 6-8 weeks till the fracture unites which can be reviewed by check x- ray. During the immobilisation period patient encouraged to do active finger movements, ROM for shoulder joint. After cast is removed physiotherapy for wrist and elbow joint is started.

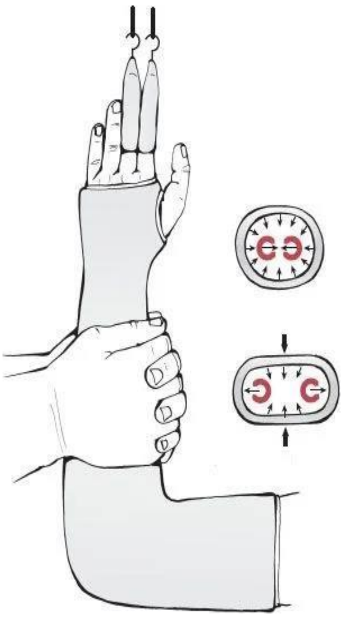


figure14;While the cast hardens, it is pressed together with both hands to form an oval.This increases the width of interroseous space.

Acceptable deformity [101]:

■ **Angular deformities**: Correction of 1 degree per month, or 10 degrees per year, results from physeal growth. Exponential correction occurs over time; therefore, increased correction occurs for greater deformities. The amount of total correction is location and age dependent; for a patient <10 years old, up to 15 degrees of correction may occur at the wrist.

■ **Rotational deformities**: These do not appreciably correct.

■ **Bayonet apposition**: A deformity ≤1 cm is acceptable and will remodel if the patient is <8 to10 years old.

■ In patients >10 years of age, no deformity should be accepted.

■ **Plastic deformation**: Children <4 years or with deformities <20 degrees usually remodel and can be treated with a long arm cast for 4 to 6 weeks until the fracture site is nontender. Any plastic deformation should be corrected that (1) prevents reduction of a concomitant fracture, (2) prevents full rotation in a child >4 years, or (3) exceeds 20 degrees.

■ General anesthesia is typically necessary, because forces of 20 to 30 kg are usually required for correction.

■ The apex of the bow should be placed over a well-padded wedge, with application of a constant force for 2 to 3 minutes followed by application of a well-molded long arm cast.

■ The correction should have less than 10 to 20 degrees of angulation.

CLOSED REDUCTION WITH CAST APPLICATION

Once the swelling subsides this procedure is done under general or regional anaesthesia. Fracture is visualized under image intensifier and manipulative reduction was done by traction and counter traction along the vertical axis of the forearm, the fracture was manipulated using the thenar grip and thumb pressure on the side of deformity. Once satisfactory reduction is achieved cast application is done as described above. Extra care should be given to check about peripheral circulation and compartment syndrome as chances increase due to manipulation. Check x ray to be taken before discharge and at 2,4 and 6 weeks to ensure reduction is maintained and no displacement has occurred and to check for union.

CLOSED REDUCTION WITH PERCUTANEOUS K WIRE FIXATION

In case of distal forearm fractures near to distal epiphysis this procedure is used. This operative procedure is done under general or regional anaesthesia/brachial block. After closed reduction a K-wire was passed from the radial styloid to proximal fragment till it hitches the opposite cortex in case of radius fracture. In sane way ulna can be fixed or can be just left without any fixation. The K wires were bent, cut and left transcutaneous. The forearm was immobilised in above elbow slab. The K- wire and slab was removed after 4-6 weeks depending on fracture union.

OPEN REDUCTION AND PLATE FIXATION

Rarely used in pediatric age group except In older children and there is a need for stable fixation. Radius is approached through Henrys or modified henrys approach depending on the position of fracture. Ulna is approached posteriorly through the subcutaneous border. After anatomic reduction DCP/LCP / LC-DCP is fixed and immobilised in above elbow slab till 3-4 weeks.

Features of Various treatment options for Fracture Both bones

Treatment	Outcome
Conservative management	Good outcome in un-displaced / minimally displaced fractures. No control over fracture fragments. Immobilisation for a longer period. High rate of secondary displacement.
Open reduction with plating	Anatomical reduction Stable fixation with good outcome. Good control over fracture fragments. Needs lots of Soft tissue dissection. Chances of neurovascular damage
Titanium elastic nailing system	Stable fixation with good outcome. Good control over fracture fragments. Minimal soft tissue dissection is needed. Chance of neurovascular damage is very less.

Indications for Flexible Intramedullary Nailing[94]

1) Amount of Displacement

The initial displacement amount (65%) is the criterion that is most usually used. Due of the ruptured periosteum, these fractures are extremely unstable and susceptible to FIN even if there is no contact between the bone fragments. Another element is the amount of time spent in a cast while obtaining non-operative care. Adolescents will need 3 months to recover under these circumstances, which is a long period, especially if the dominant leg is afflicted. Older children require a full reduction with sustained bone contact since they have a limited capacity for remodelling and can only fix 1° of mal-union annually. Isolated greenstick and plastic-bowing fractures must categorically be treated using closed techniques.

2) Age of the Patient

The age of the patient (59%) is the second most important factor. Children under the age of 6 have a bone remodelling capacity of up to 10°, regardless of the severity of the displacement; hence, they are almost usually treated by closed methods [therefore, bone remodelling capacity will be the decisive factor for the final choice]. When anatomic reduction is necessary and cast immobilisation is not preferred, FIN is usually used.

3) Failure of Non-operative Treatment

When appropriate reduction according to age is not achieved by closed reduction.

4) Patients with multiple injuries

Young patients with both-bone forearm fractures are better handled with FIN for simply understood care and monitoring reasons.

5) Compartment Syndrome

Compartment syndrome is best managed with FIN (postoperative skin care is easy).

6) Recurrent Fractures

Adolescents do not tolerate another 2-3 month period of cast immobilisation well, so FIN is justified in this case.

7) Additional Criteria

Few criteries like dominant upper limb,playing sports engaging in sports activities,playing musical instruments must be taken into consideration in adolescents

BIOMECHANISM OF FLEXIBLE INTRAMEDULLARY NAILING[89]

Rapid function restoration is the main objective of FIN, just like it is with rigid fixation. The return of function with FIN is caused by quick bone healing due to excellent periosteal callus growth, whereas with rigid fixation, it is caused by the artificial rigidity the device provides.

Rigid internal fixation: No exterior callus can form since response is completely eliminated due to the rigidity of the construct that is necessary for "primary bone union" and "cortical callus" creation.

Contrary to rigid fixation, elastic fixation requires some relative mobility to encourage the development of the external callus, the physiological callus that forms the fastest and has the most biomechanical strength.

To,promote the formation of external callus.1micro metre displacements can prevent the formation of cortical callus, whereas displacements, one thousand times greater (i.e., of the order of 1 mm),

Basic Principles

FIN uses these basic principles to promote optimal formation of external callus.

1. Tissue Preservation

In order to support the intramedullary construct and encourage fracture healing, FIN relies on bone and soft tissue. As a result, it is necessary to protect the live tissues that are still present at the fracture site. Closed internal fixation prevents additional periosteal and muscle deterioration. It also has the benefit of maintaining the fracture hematoma and its potential for osteogenesis. The periosteum's viability is crucial to the healing process because, as can be shown in some high-energy open fractures, no exterior callus can form where the periosteum has been damaged. Open surgery or periosteal should not be used to further the significant initial injury. The tissues in the immediate area offer

Rotatory Stability

muscles and tendons act in the same way as the shrouds that hold the mast up on a sailboat, and they can resist significant angular deviations, as well as rotational mal-union.

.

2. Elimination of Deleterious Stresses

For the external callus to develop optimally, there must be some degree of mobility. Allowing motions that help establish the bridging callus and avoiding those that could break this bridge is the greatest strategy to encourage the development of the external callus. It is well known that compression-traction stimuli encourage the development of external callus, whereas torsional and shearing stimuli have the opposite effect.

A perfect FIN construct made of two intramedullary nails with opposed curves can change negative stimuli into positive ones in diaphyseal fractures. A well-balanced construct can only be achieved if

1) The angle of curvature must be larger than the actual curvature of the nail in the medullary canal in order to give the nail an appropriate elastic restoring force when subjected to angulation forces.
2) To prevent angular deviation in a construct with two opposing curves, both nails must have the same curve, and the entrance holes must be placed symmetrically on the bone (where possible).

3) The optimal fixation location is the metaphysis across from the entrance hole, where thick cancellous bone offers the highest stability in all three planes. Three-point contact with the bone is crucial. Axial and rotatory stability are always poorer near the entrance location. The key technical challenge is in precisely locating the curve apexes at the fracture site where the spread should be highest; this occasionally necessitates further local contouring. A rare occurrence of forearm fracture involves both bones.

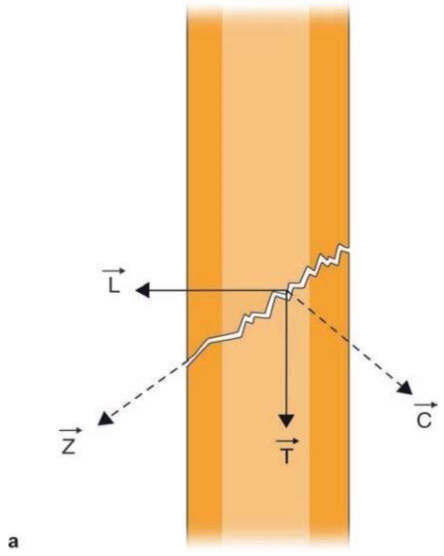


Figure 14 : Distribution of forces vectors according to the type of fracture and the type of construct. (**a**)vector force Along Direction of axial forces (*T* force generated by muscle tone, that resolves into a compression component *C* and a shearing component *Z* . A force *L* is generated that produces displacement which is lateral.

ORDER OF REDUCTION[92]

Because the radius is in a depression and reduction may be more challenging after the ulna has been nailed, the radial fracture is treated first in 80% of cases. Once the radius has been reduced, it is simple to reduce the ulna since its posteromedial border may be felt beneath the skin. Only 20% of the time is the ulna treated initially because it is less complicated or the surgeon prefers it that way.

In case radius reduction is difficult distal ulnar entry point should be used to place both nails in the same direction to the level of fracture site. This allows simultaneous closed manipulation of both fractures and easy imaging(AO)

APPROACHES[93]

Approaches to radius

The radius is always nailed in a retrograde direction. There are two approaches.

1) Radius lateral entry point: Select the proper entry site on the lateral side of the radius, 1 to 1.5 cm from the growth plate, using the image intensifier. Start the incision 2 cm distally from the level of the lateral entry site. If an image intensifier is not accessible, the growth plate must be protected by using an incision that is 3–4 cm proximal to the joint. Avoid hurting the thumb's tendons, cephalic vein, and superficial radial nerve.

2). Radius listers tubercle entry point: Using an image intensifier,mark an entry point around 1 to 1.5 cm away from the growth plate. Locate the listers tubercle on the dorsal portion of the radius.

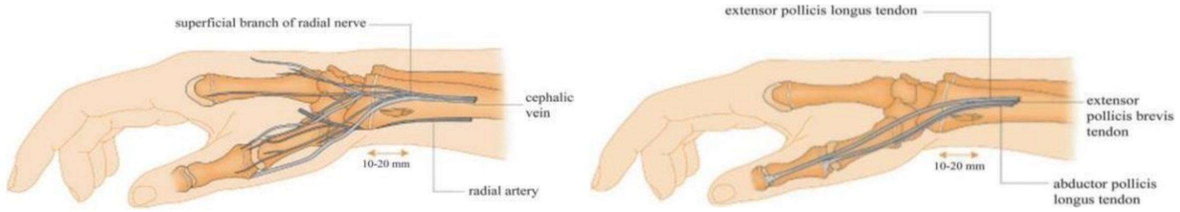


Figure 15 : Entry Point of Radius

Approach to Ulna

To get access, a hole is drilled into the distal radial metaphysis. A 15-20 mm longitudinal incision is made before the intermediate antebrachial vein and the sensory branch of the radial nerve. The hole is carved anterior-posterior in order to safeguard the radial artery.

The input hole is situated 10-15 mm above the physis, distal to the insertion of the brachioradialis tendon and anterior to the extensor pollicis tendons, on the distal side of the anterolateral radius.

1) Antegrade FIN

The ulnar nail enters the body on the posterolateral side of the olecranon. the nail's buried end in the anconeus muscle as a result (short extensor). It is risky because the ulnar nerve is physically near to the posteromedial approach. It is not allowed to put the nail through the top of the olecranon since doing so invariably leads in uncomfortable prominence of the nail tip and even protrusion through the skin whenever the elbow flexes.
The elbow is flexed and the arm is internally rotated to get access to the olecranon. A 20 mm longitudinal incision is made on the posterolateral side of the bone such that its distal end is directly over the planned entry hole. This is carried out 30 mm below the olecranon's point. More area is needed proximally with oblique nail in prevent skin impingement.

Retrograde Entry Point

Distal medial entry point is used when reduction is difficult and simultaneous reduction of both bones is tried.

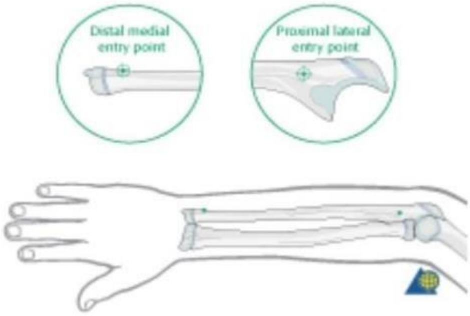
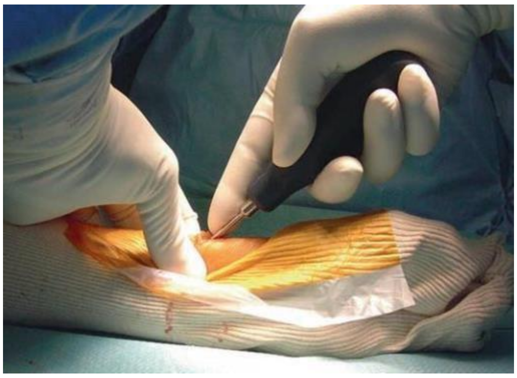


Figure 16 : Entry Points for Ulna

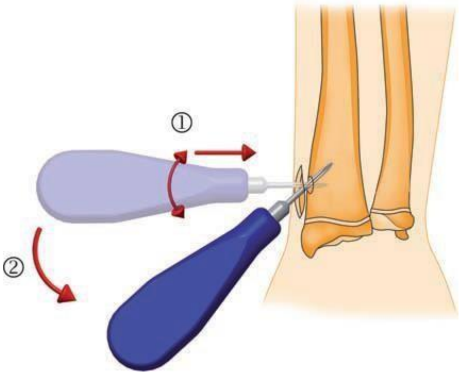
Operative Procedure

For Radius

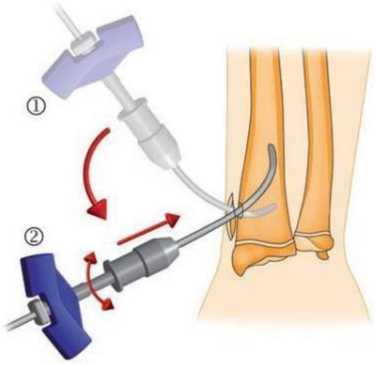
After the incision and soft tissue dissection the proper entry point should be determined as discussed above using fluoroscopy. Short awls with a diameter of 3 mm should be handled as shown in Figure 17a.



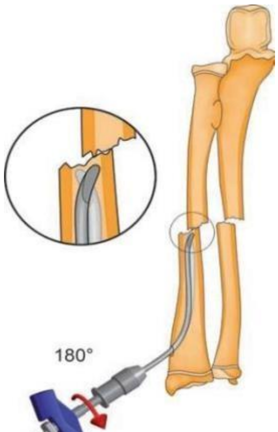
a) Properly positioned awl



b) Fin Entry Hole Created



c. Fin for Radius Inserted



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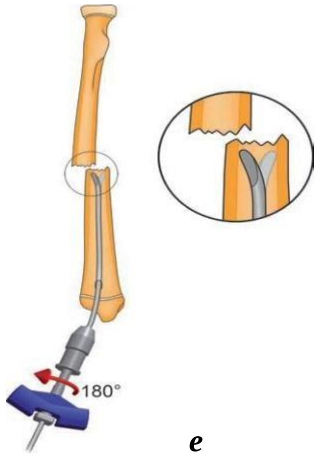
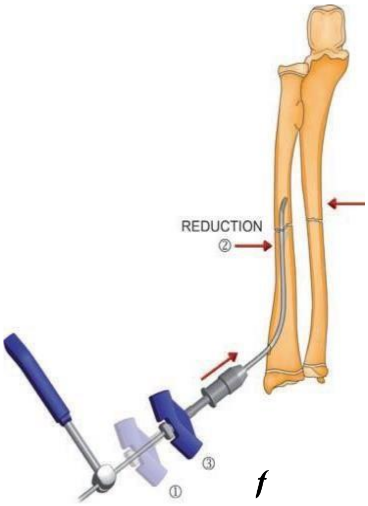
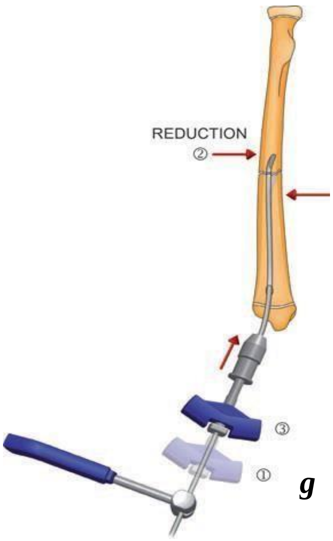


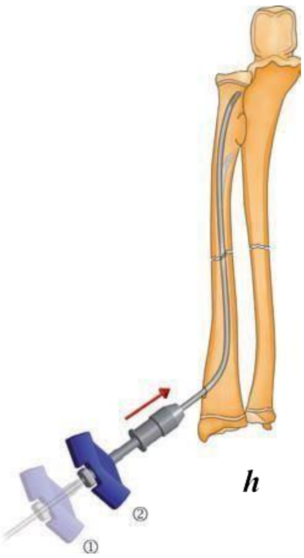
e



f



g

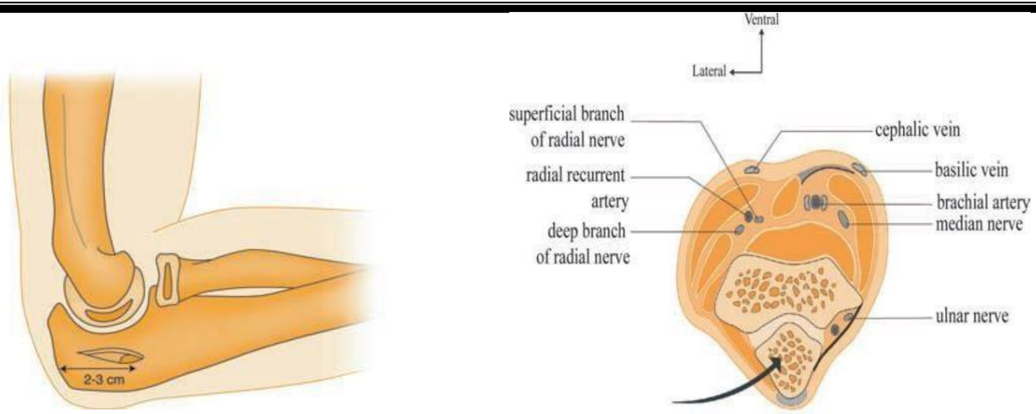


h

Figure 17:

Nail tip is pointed toward the proximal bone fragment as it is moved up to the fracture site: d, e, and f reduction and crossing of the fracture site.

When the g, h nail reaches the radial neck, it is turned 180 degrees so that its concave side is towards the ulna. hammer with a slotted face striking a nail:



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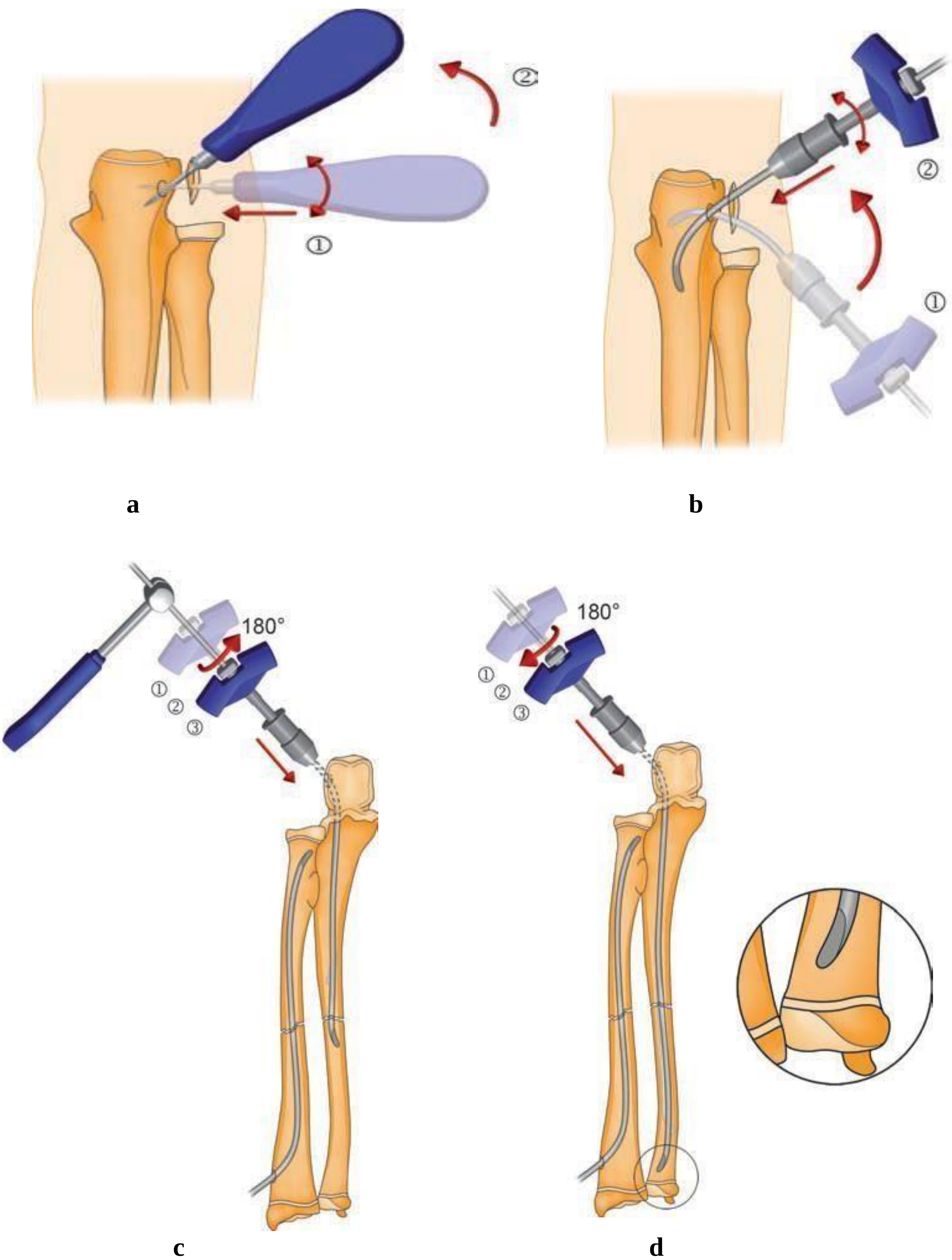
When the nail tip reaches the fracture site on the ulna, reduction is performed. The posteromedial boundary of the ulna, which is immediately felt, serves as a trustworthy reference point for reduction. The ulna is significantly easier to shrink than the radius. It is advised to set the radius first for this reason. As previously noted, the radial nail can be removed to a point around 10–20 mm proximal to the fracture line if relocating the ulna is challenging. Ulnar reduction is facilitated by increased radius movement. Under fluoroscopy, the nail tip is advanced to the distal piece and driven through once there until it reaches the distal metaphysis. The nail's concave side points inside, and the lateral curvature of the tip points outward.

a b

Figure 18: Surgical approach to the ulna: (a)nail insertion point isabout 20–30 mmdistal to the tip of the olecranon on the posterolateral aspect of the bone;

(b) anatomic section of the elbow.



a b c d

Figure 19:

The following steps make up the FIN technique for the ulna: (a) an awl is used to make an entry hole; (b) a nail is inserted; (c) the nail is advanced down to the fracture site and pushed across the fracture with a slotted hammer; and (d) the nail is advanced down to the distal metaphysis with its concave side facing the radius.

Final Reduction

When the medial and lateral tips of the ulnar and radial nails, respectively, point in the same direction, alignment is perfect. Due to the interosseous membrane being tighter, elastic memory stabilises, resulting in the nail having opposing indentations. Once each nail tip is in its ultimate position, give it a solid hammer blow to secure it into the opposing metaphyseal segment. By doing this, the chance of the tip cutting into the Haversian tube is reduced. It also helps the nail resist axial rotation and offers a secure attachment.

Wound Closure

At the end of the procedure, the back edge of the nail is slightly bent away from the bone and carefully trimmed with pliers to make a clean cut without damaging the subcutaneous tissue. It should only protrude 3-5 mm beyond the bone for easy removal later. If the protrusion is too large, you may need to use an impactor to countersink the nail end. The wound is closed and a pressure bandage is applied. Finally, the forearm should be moved through the full range of pronation and supination to ensure proper reduction of the fracture in the horizontal plane. This is further verified with his radiographs in AP and lateral.

Nail Length

Prior to wound closure, the majority of implants need to be trimmed. However, cutaneous and subcutaneous lesions might result from incisions. Because of this, some surgeons employ protective endcaps, which have two significant downsides.
(1) It is somewhat slick. To solve this issue, threaded plugs were created, however they had wider insertion holes and weaker bones when the claws are taken off.

Use of fixed-length nails with non-traumatic ball tips is an additional choice. The contralateral bone is measured to establish the proper length. Increased inventory and higher hospital/clinic fees are two of the main disadvantages. The process's last phase is the most challenging since the nail cannot be turned before the final hammering. Finally, we must precisely calculate the right length.

NAIL DIAMETER

For all the long bones the isthmus diameter is calculated using conventional x ray in antero-posterior and lateral views and 2 nails fitting 80% of the medullary cavity. Forearm bones are exception in which only one nail is used occupying maximum of 60% of isthmus medullary cavity. Most of the times 2 – 3 mm size of nail is sufficient.

Nail Contouring

Doing a FIN is more than hammering nails to achieve correct alignment. The true purpose of FIN is to create corrective power. To achieve this goal, the apex of the curve should be at the fracture site.

COMPLICATIONS[94]

1) Instability and Difficult Reduction

Flexible intramedullary tens is essentially a closed reduction method. Contrary to other therapeutic approaches which frequently employ an open approach, open surgery should only be considered when absolutely required [22]. Nevertheless, 15% of these fractures are displaced.

necessitate a brief incision since, after some time, one or both fractures cannot be reduced by closed techniques. When bone pieces totally cover one another in proximal fractures, this frequently happens.

2) Implant-Related Problems

The most common cause of skin irritation at the entrance site is poor technique. Two things need to be emphasised: (1) Since the nail's tip is typically buried in the anconeus muscle, the olecranon in the ulna should be approached from the postero-lateral side (short extensor) (2) Because residual length is crucial, great attention should be paid to nail trimming in the radius. Depending on how much time has passed, there are two alternatives for dealing with skin impingement or skin perforation: premature nail removal or nail shortening. The youngster is need to wear an orthosis or a detachable splint throughout all activities in the latter scenario.

3) Vascular complications

There are chances of radial artery injury while making a lateral entry point to the radial bone.

4) Joint Stiffness

Joint stiffness in kids and teenagers is nearly often a result of a mal union. Therefore, it is rarely observed with FIN owing to the quality of the original decrease. The loss of the radial bow contour and inability to tension the inter-osseous membrane are the causes of any restrictions in pronation-supination. The postoperative X-ray frequently reveals nail misdirection. There is a 10° range of motion limitation for every degree of mal-union, and no progress is anticipated throughout the remaining growing stage. When the forearm is immobilised for 4 to 6 weeks, stiffness is frequently felt.

5) Compartment Syndrome

Compartment syndrome is typically brought on by underhand methods designed to achieve reduction at any costs. Therefore, one should not step back to open and expose the fracture site for the purpose of inserting the nail if it becomes difficult to decrease the fracture.

6) Infection-

The faulty techniques leading to skin irritation can end up as infection if not treated properly.

7) Delayed Union and Non-union

Although these are very rare, these are encountered in few cases where principles of FIN are not properly followed.

8) Refractures

A trauma to the same limb might lead to fractures at the previous fracture site.

9) Olecrenon bursitis

Due to nail impingement at proximal bent for ulna, was seen in patients who got tens nail removal after 1year , due to persistent irritation for bursal sac.

Exception

Sometimes, surgeons will utilise a plaster cast and just one nail for the ulna or radius. This in no way adheres to the fundamental tenets of FIN, according to which the interosseous membrane's tightening maintains fracture reduction. The displacement of the pieces in the other bone will still occur if a nail is inserted just in one bone. Additionally, this combines the drawbacks of both approaches—incomplete surgical therapy and immobilisation in a cast—without offering any positives outcome

NEED FOR STUDY

Fractures of radius and ulna are the most common diaphyseal injuries in the pediatric age group. It accounts for 5% to 10% of pediatric fractures.

These fractures are more common distally than that of proximally. The reason being proximally both radius and ulna are cylindrical, and they are covered by thick envelope muscle for protection whereas distal is more ovoid and covered by tendons vowing for high risk of injury.

Treating both bone forearm fracture requires both technical and cognitive skills. It is for understanding the nature of fractures and about a selection of ideal treatment. Traditional treatment method of managing both bone fracture forearm is by closed reduction and Plaster of Paris cast immobilization. It has given good and reasonable results. But on the other side; irreducible, more angularly and malrotation displaced fractures shown to be having a poor postoperative functional outcome. The failure rate of these fracture treatment was about 32 per cent. [3, 4]

Operative indications include compartment syndrome, floating elbow, and open fractures Gustilo Anderson's Type 1, 2 with gross displacement and failure of closed reduction. Different operative methods to reduce both bone fracture forearm include intramedullary nail fixation, plate and screw fixation. It will be done using a rush pin or titanium nails and external fixator. Use of titanium elastic nailing system for(10), intramedullary fixation is gaining popularity**(11)**

OBJECTIVES OF THIS STUDY

Study and evaluate functional outcome of Titanium Elastic Intramedullary Nailing System in fractures of both bone forearm shaft in children aged 6-16 years.

To study the duration of union in case of TENS.

To assess the complications associated with fractures of both bone forearm inchildren treated with Titanium Elastic Intramedullary Nailing System.

INDICATIONS :

Both bone forearm fractures in the pediatric age group with titanium elastic intramedullary nail as these fractures are associated with angulations, rotation and displacement.

Titanium elastic nails provide an exceptional mode of fixation providing.

-superior union rates,
- promoting early callus formation
- provides early functional recovery

MATERIALS AND METHODS

40 Patients having fractures of both bones forearm, admitted in Department of Orthopedics in B.L.D.E. (DEEMED TO BE UNIVERSITY) Shri B.M.Patil Medical College, Hospital & Research Centre,VIJAYAPURA, KARANATAKA

with the diagnosis of both bone fracture forearm pediatric age group

The patients will be informed about the study in all respects and informed written consent would be obtained.

Period of study will be from JANUARY 2021- MAY 2022.

Follow up period will be 6 weeks, 3 months and 6 months. were considered for study after obtaining their parents/guardians consent.Our study was a prospective study. Sampling for this study was done by Convenience Sampling Method. Patients were analyzed clinically, radiologically and assessed for functional outcome with TENS application.

Inclusion Criteria:

1. Age below 16 years.
2. Both bone forearm fractures
3. Skeletally immature patients aged between 5-16 years
4. All closed both bone forearm fractures which were displaced.
5. Segmental fractures of both bone forearm with failed closed reduction
6. Open fractures Gustillo Anderson type 1 and type 2
7. Physical fitness for surgery

Exclusion Criteria:

1. Both bone forearm fracture with compartment syndrome needing fasciotomy.
2. Both bone forearm fracture needing vascular repair
3. Age more than16 years
4. Isolated both bone forearm fractures

5.Open fractures Gustillo Anderson&fracture type 3
6.Patient not willing or medically unfit for surgery.

7. Patients with pathological and osteoporotic bone fractures, malignancies, infections, or contractures of the forearm muscles
8. A history of upper limb motor nerve injury on the same side, as well as neurological and vascular diseases.

A thorough history was taken from the patient and/or any attendants at admission in order to determine the mechanism and history of injury and the velocity of the trauma. The patients were subsequently given a clinical evaluation to determine their overall health and the extent of any local injuries.

The vital signs were noted together with the patient's overall state. To rule out fractures at any other sites, clinical examination was made

Local Examination of Injured Forearm:

-Swelling, deformity, and function loss.

- Neuro vascular damage was examined and reported.

-Palpation demonstrated forearm shortening, crepitus, and aberrant movement.

-Fingertip paresthesia, pallor, and radial artery pulsations were used to measure the distal vascularity.

-Anteroposterior and lateral radiographs of the radius and ulna were taken.

-Each view featured the wrist and elbow joints.

-The leg was then immobilised in above elbow Plaster of Paris slab in position according to the fracture level with Sling.

-Following normal tests to determine the patient's fitness for surgery.

-Routine ot investigations, including those for Hb%value, Urine for sugar, FBS, Blood urea, Serum creatinine, HIV, HBSAg, and ECG, were completed before the patient was taken for surgery.

Instruments and Implants used in Titanium Elasting Nailing System (TENS) for Forearm Bones:

1) TENS nails of different diameters starting from 2mm to 4mm (usually upto 3mm size is sufficient in case of forearm bones.)
2) Small bone awl
3) " T" handle for nail insertion
4) "F" tool
5) Nail bender
6) Impactor
7) Hammer
8) Nail cutter
9) General instruments like retractors, periosteal elevators, reduction clamps
10) Bone levers
11) Pneumatic tourniquet

FIGURE 20: TENS Instrument Set

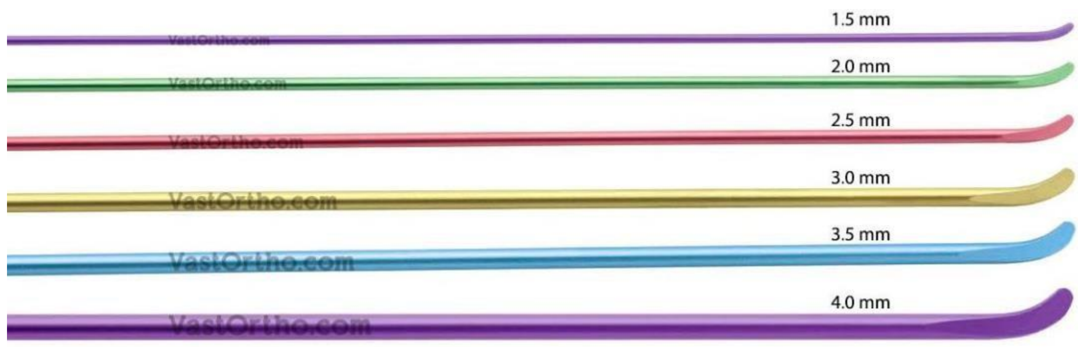


Figure 21: Titanium Elastic Nail

Pre-Operative Planning:

• During the preoperative stage, the fracture level was taken into consideration when positioning the damaged forearm in an above elbow POP slab.

• Before the surgery, parental or guardian consent was obtained.

• Conventional radiography were utilised to determine the proper diameter to be employed. The needed nail diameter is determined by measuring the diameter of the isthmus and dividing it by 60%.

• Prior to the procedure, all the instruments were inspected and sterilised.

• Tetanus toxoid and antibiotics were administered preoperatively, right before surgery, in accordance with weight.

• The portion was prepared the day before operation.

Position:

- Pneumatic tourniquet was applied.
- Patient placed supine on,operating table with a supporting arm-rest placed for
- the arm to be operated on.

OPERATIVE PROCEDURE

- Type of anesthesia: General anesthesia / Brachial block.
- Scrubbing, Painting,drapping of the upper limb done.
- Pneumatic tourniquet was applied for upper arm and inflating time noted.
  - upper limb Draping done.
  -

• In our procedure the entrance points for the ulna and the radius were both obtained retrogradely. The incision was made as previously mentioned. It was really close to listers tubercle in terms of radius.

• The deformity was evaluated clinically and radiographically, and closed reduction was undertaken.

• If reduction was unsuccessful despite 3–4 efforts by closed methods, reduction was eventually achieved after suitable manipulation and nailing with the use of a tiny incision at the fracture sites visualized by FLUOROSCOPY for one or both bones

.

• The ulna was repaired after the radius was corrected..

- .The concept of 3 point fixation should be applied when tens nailing was done.

• After final reduction, it is important to take care to keep the radial form of the bow and the concavity of the radius and ulna facing each other since doing so helps to keep the interosseous membrane taut.

• To avoid damaging the growth plate, the nail tip should be inserted into the subchondral bone rather than the epiphysis.

• The elastic intramedullary nails are partially removed, bent with a nail bender or "T" handle, and then the additional portion of the nail is chopped with a Harrington cutter before the partially removed portion is reinserted, leaving just around 5mm of the nail outside of the bone. The cut end has to be blunt to prevent skin irritation.

• A sterile dressing is applied and non-absorbable sutures are used to close the skin incision site.

• To create compression at the fracture site after the incision has been closed and dressed, mild thumps might occasionally be applied at the elbow.

After Treatment:

Following surgery, an above-elbow POP slab, an arm pouch, and a crepe bandage were placed over the injured forearm. The patient was instructed to keep the afflicted limb elevated while moving the shoulder joint and fingers on that side. The wound was checked and treated on the second post-operative day. A post-operative x-ray was taken on the second day after surgery. IV antibiotics were administered for 2 days following a closed reduction and 5 days following an open reduction. Oral antibiotics were then given till the sutures were taken out. The patient was discharged from the hospital on the second post-operative day for closed reduction and on the fifth post-operative day after wound assessment and dressing with the forearm in the arm pouch.

Follow-up:

Every patient was examined after suture removal at 1st, 2nd,3rd month and every six months, or until the implant was removed, whichever came first. Anteroposterior and lateral images of the forearm were obtained at each follow-up appointment, and they were examined for union, or the presence of bridging periosteol callus in three or four cortices. Clinical examinations were performed on the patients to look for pronation, supination, and w range of movements wrist motions and elbow. Radiological analysis and was done to asses for fracture Union along with

Antero-posterior and lateral radiographs were used to define bone union as the presence of formation of sclerosis by periosteal callus formation in three or four cortices or the primary closure of the fracture line. Delayed Union- union of fracture after 4 months of surgery without any additional procedures.

Non Union- fractures not united even after 4 months requiring additional operative procedure.

The nail was removed after the union was achieved preferably between 16 weeks to 20 weeks.

CRITERIA FOR EVALUATION OF FUNCTIONAL OUTCOME:

ANDERSON et al CRITERIA SCORING SYSTEM (1975)

Anderson et al criteria

RESULTS	UNION	FLEXION/ EXTENSION AT ELBOW JOINT	SUPINATION & PRONATION
EXCELLENT	PRESENT	< 10 degree loss	< 25 loss
SATISFACTORY	PRESENT	< 20 degree loss	>25% - < 50 loss
UNSATISFACTORY	PRESENT	< 30 degree loss	> 50% loss
FAILURE	NON UNION WITH/WITHOUT LOSS OF MOTION		

The patients were analysed based on this grading system. The elbow and wrist movements were observed. Physiotherapy was advised for stiffness of elbow and wrist.

operative trolley

painting of the affected limb

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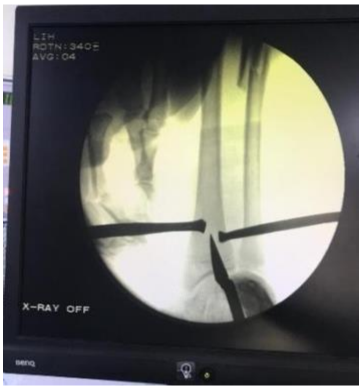
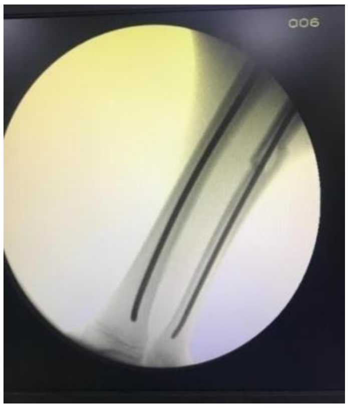
Incision site for radius with entry made with tens nail

Entry point for ulna and entry point made using awl



Fluroscopy image for radial entry point using bone awl.

Fluroscopy image of nail manipulation across # site in radius.



Fluroscopy image after both bone inserted with nail

Figure 22: Operative Images of TENS Nailing

CASE 1

Xray pre op xray post op -day 1

xray pod 3rd week xray pod 14th week

implant removal after 7th month

RANGE OF MOVEMENTS ASSESMENT POST OPERATIVELY

SUPINATION **WRIST DORSI FLEXION**

PRONATION **WRIST PALMAR FLEXION**

CASE 2

Xray pre op

xray post op -day 1

xray pod 3rd week

xray pod 6th week

xray pod 4th month implant removal after 8th month

RANGE OF MOVEMENTS ASSESMENT POST OPERATIVELY


SUPINATION **ELBOW FLEXION**


PRONATION **ELBOW EXTENSION**

Sample Size Calculation

With 95% confidence level and margin of error of ±20%, a sample size of 40 subjects will allow the study to ….. with finite population correction (N=100).

By using the formula:

$$n = \frac{z^2 p(1-p)}{d^2}$$

where

Z = statistic at 5% level of significance

d = is margin of error

p = is anticipated prevalence rate (50%)

Type of Study

A PROSPECTIVE STUDY

Statistical Analysis

All characteristics were summarized descriptively. For continuous variables, the summary statistics of mean± standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries and diagrammatic presentation. Chi-square (χ^2) test was used for association between two categorical variables.

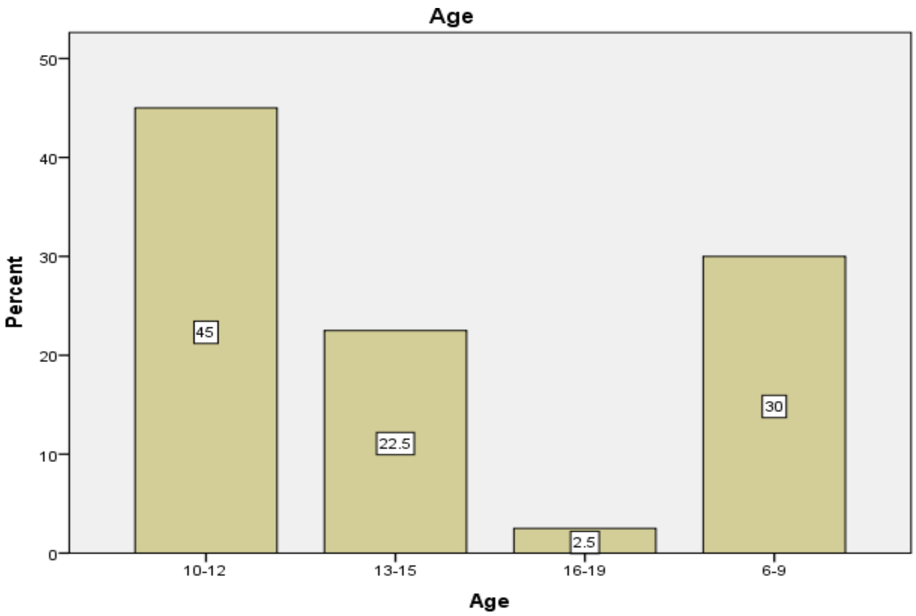
The formula for the chi-square statistic used in the chi square test is:

$$\chi^2_c = \sum \frac{(O_i - E_i)^2}{E_i}$$

The subscript "c" are the degrees of freedom. "O" is observed value and E is expected value.

If the p-value was < 0.05, then the results were considered to be statistically significant otherwise it was considered as not statistically significant. Data were analyzed using SPSS software v.23.0. and Microsoft office 2007.

Age	Frequency	Percent
6-9	12	30.0
10-12	18	45.0
13-15	9	22.5
16-19	1	2.5
Total	40	100.0



Age Distribution

The age of children in our study ranged from 5-16years with most common age group being 10-12 years of age with a mean age of 10.95 years..

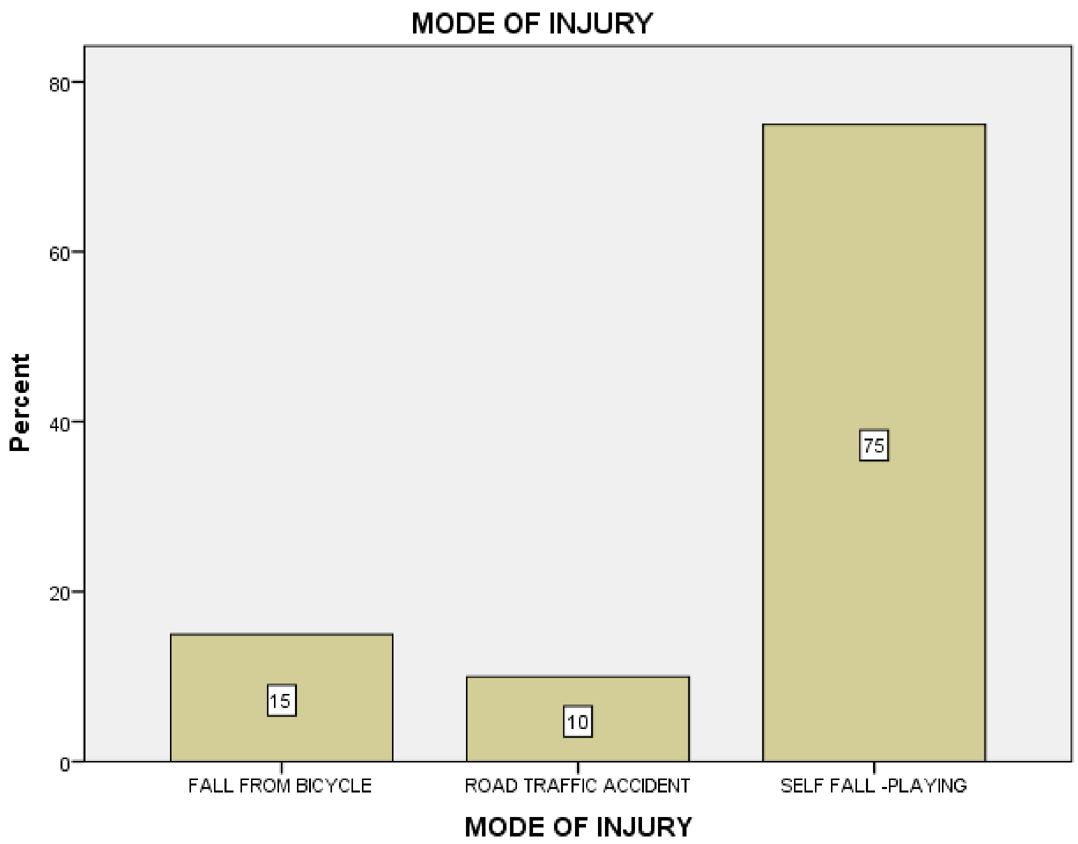
SEX	Frequency	Percent
Female	1	2.5
Male	39	97.5
Total	40	100.0

Sex Distribution

97.5 %of our cases were male among 2.5% cases and the rest were females.

MODE OF INJURY

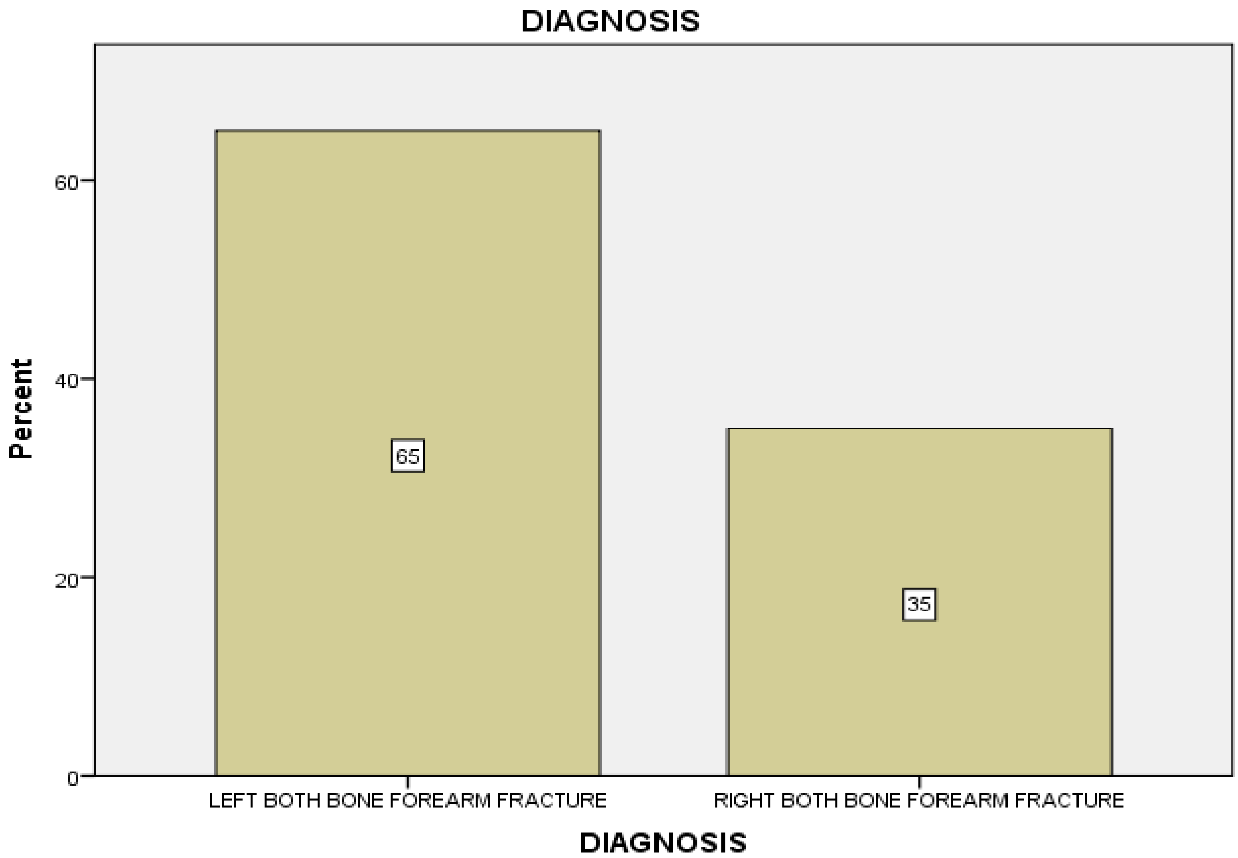
	Frequency	Percent	Percent	Cumulative Percent
FALL FROM BICYCLE	6	15.0	15.0	15.0
ROAD TRAFFIC ACCIDENT	4	10.0	10.0	25.0
SELF FALL -PLAYING	30	75.0	75.0	100.0
Total	40	100.0	100.0	



Mode of Injury

In our study 75% of the cases were due to self-fall while playing, 15% were due to fall from bicycle and rest were due to RTA.

DIAGNOSIS	Frequency	Percent
LEFT BOTH BONE FOREARM FRACTURE	26	65.0
RIGHT BOTH BONE FOREARM FRACTURE	14	35.0
Total	40	100.0

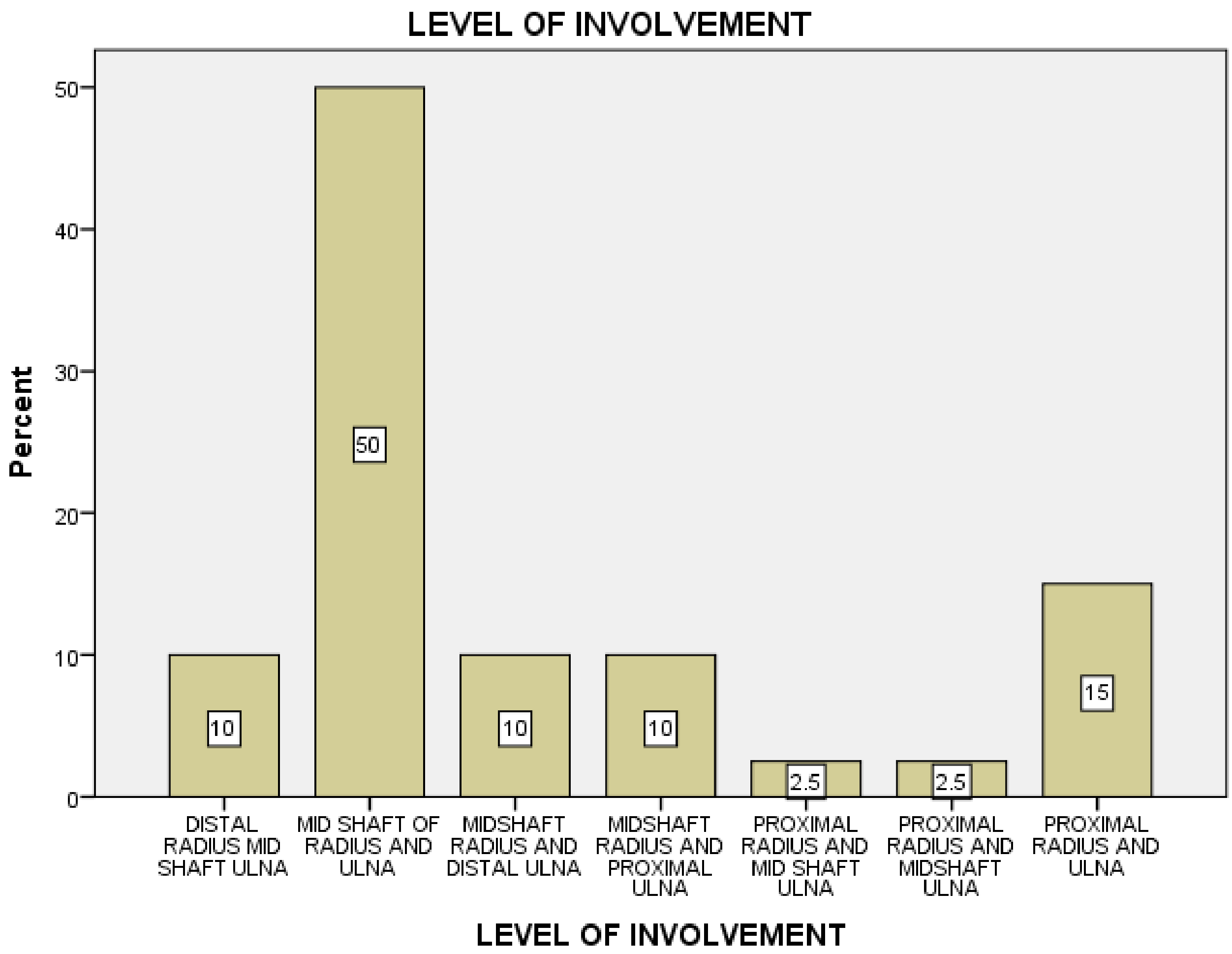


Side Affected

Among 20 cases 65% of cases had left side fracture and remaining 35% had right side fracture.

LEVEL OF INVOLVEMENT

	Frequency	Percent	Percent	Cumulative Percent
DISTAL RADIUS MID SHAFT ULNA	4	10.0	10.0	10.0
MID SHAFT OF RADIUS AND ULNA	20	50.0	50.0	60.0
MIDSHAFT RADIUS AND DISTAL ULNA	4	10.0	10.0	70.0
MIDSHAFT RADIUS AND PROXIMAL ULNA	4	10.0	10.0	80.0
PROXIMAL RADIUS AND MID SHAFT ULNA	1	2.5	2.5	82.5
PROXIMAL RADIUS AND MIDSHAFT ULNA	1	2.5	2.5	85.0
PROXIMAL RADIUS AND ULNA	6	15.0	15.0	100.0
Total	40	100.0	100.0	

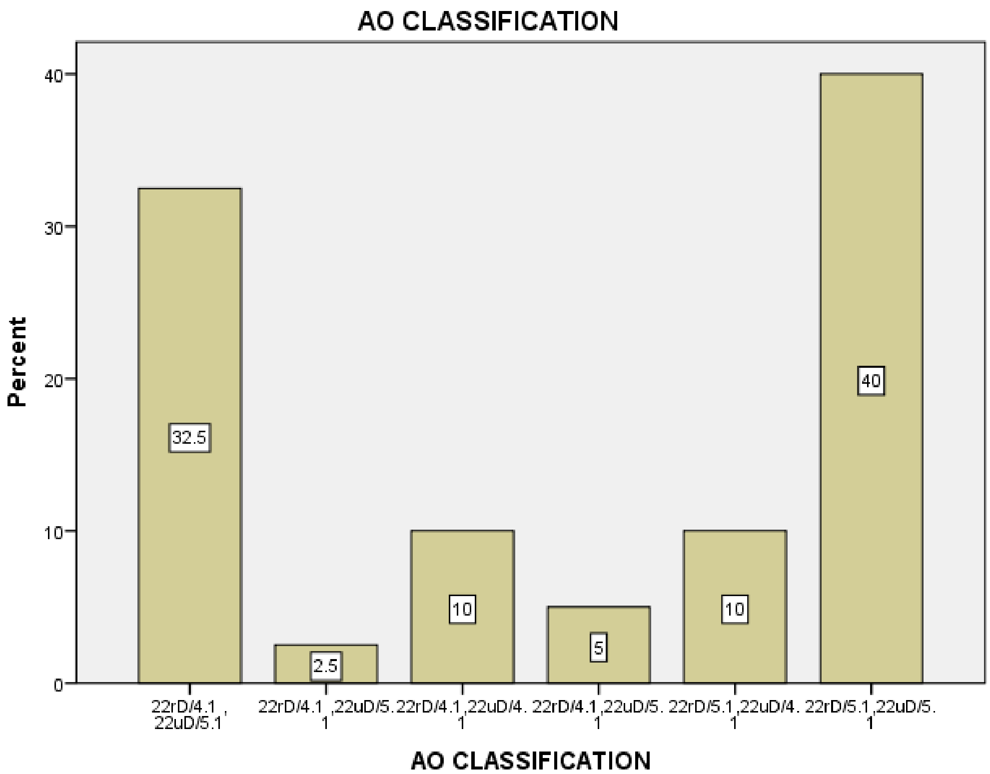


Level of Fracture

Among 40 cases the fracture level in both radius and ulnar mid shaft of radius and ulna fractures were 50%, proximal end radius and ulna fractures were 15%.

AO CLASSIFICATION

	Frequency	Percent	Percent	Cumulative Percent
22rD/4.1 , 22uD/5.1	13	32.5	32.5	32.5
22rD/4.1 ,22uD/5.1	1	2.5	2.5	35.0
22rD/4.1,22uD/4.1	4	10.0	10.0	45.0
22rD/4.1,22uD/5.1	2	5.0	5.0	50.0
22rD/5.1,22uD/4.1	4	10.0	10.0	60.0
22rD/5.1,22uD/5.1	16	40.0	40.0	100.0
Total	40	100.0	100.0	

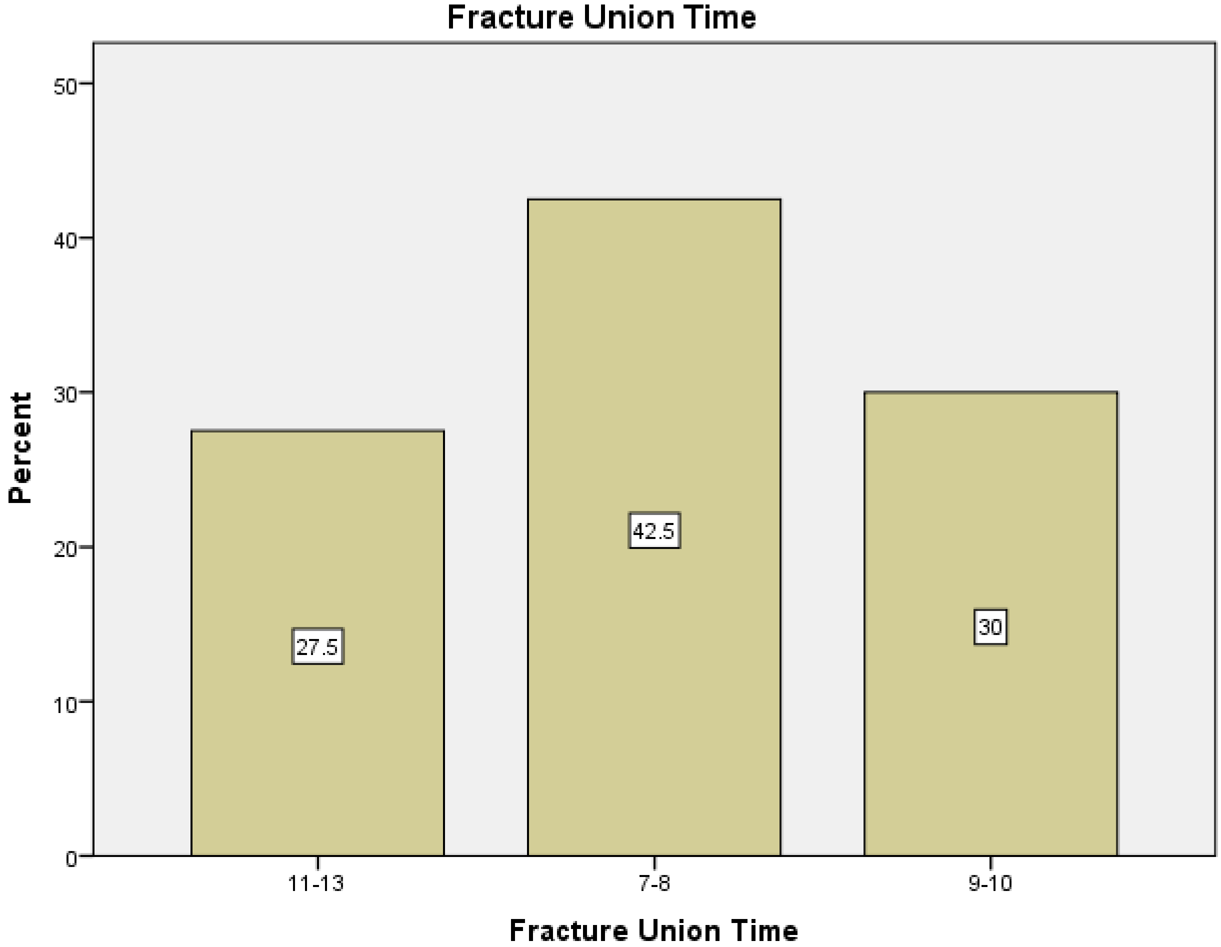


Pattern of Fracture based on AO classification

Among40 cases 22rd/5.1 ,22uD/5 was 40% was the most common pattern of fracture.

Fracture Union Time

weeks	Frequency	Percent	Percent	Cumulative Percent
11-13	11	27.5	27.5	27.5
7-8	17	42.5	42.5	70.0
9-10	12	30.0	30.0	100.0
Total	40	100.0	100.0	

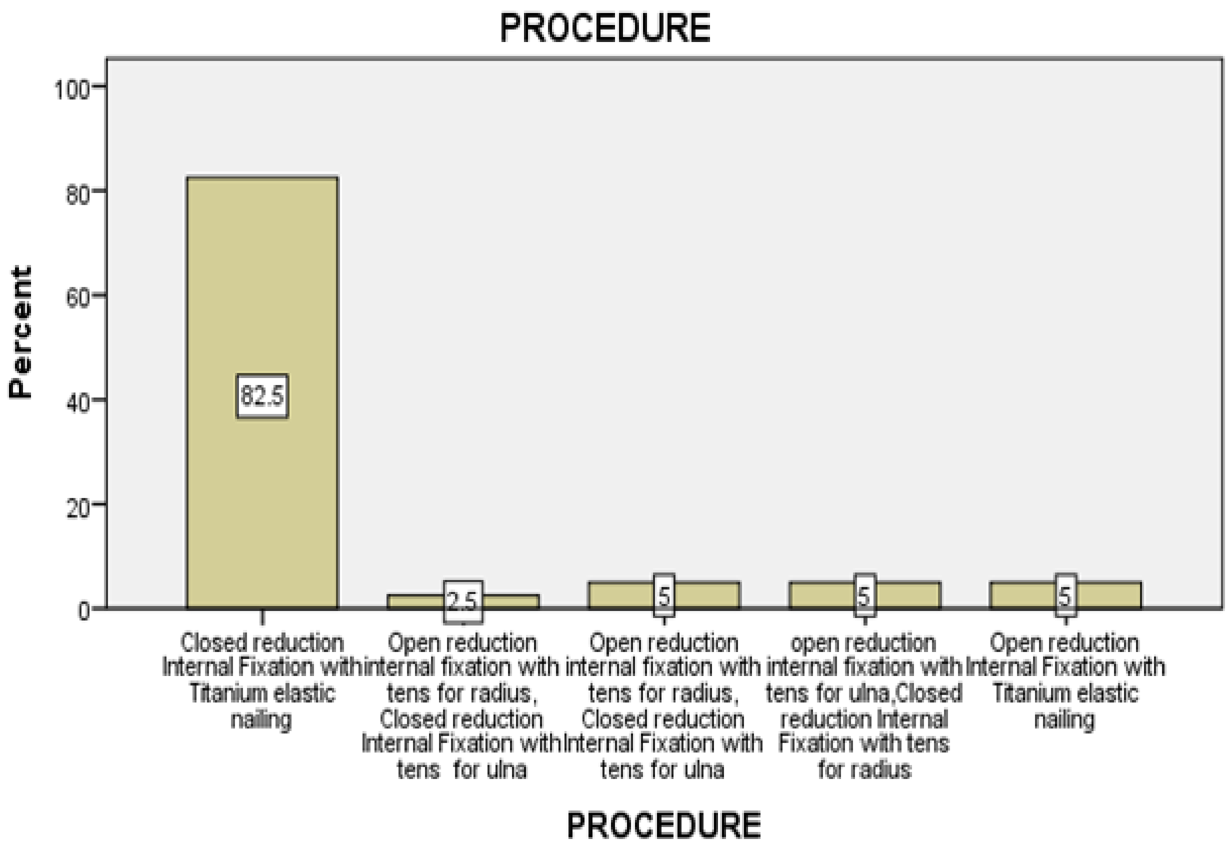


Union time for both bone fracture.

The mean duration of fracture union time was 8.9 weeks with a range of 7-11 weeks.

PROCEDURE

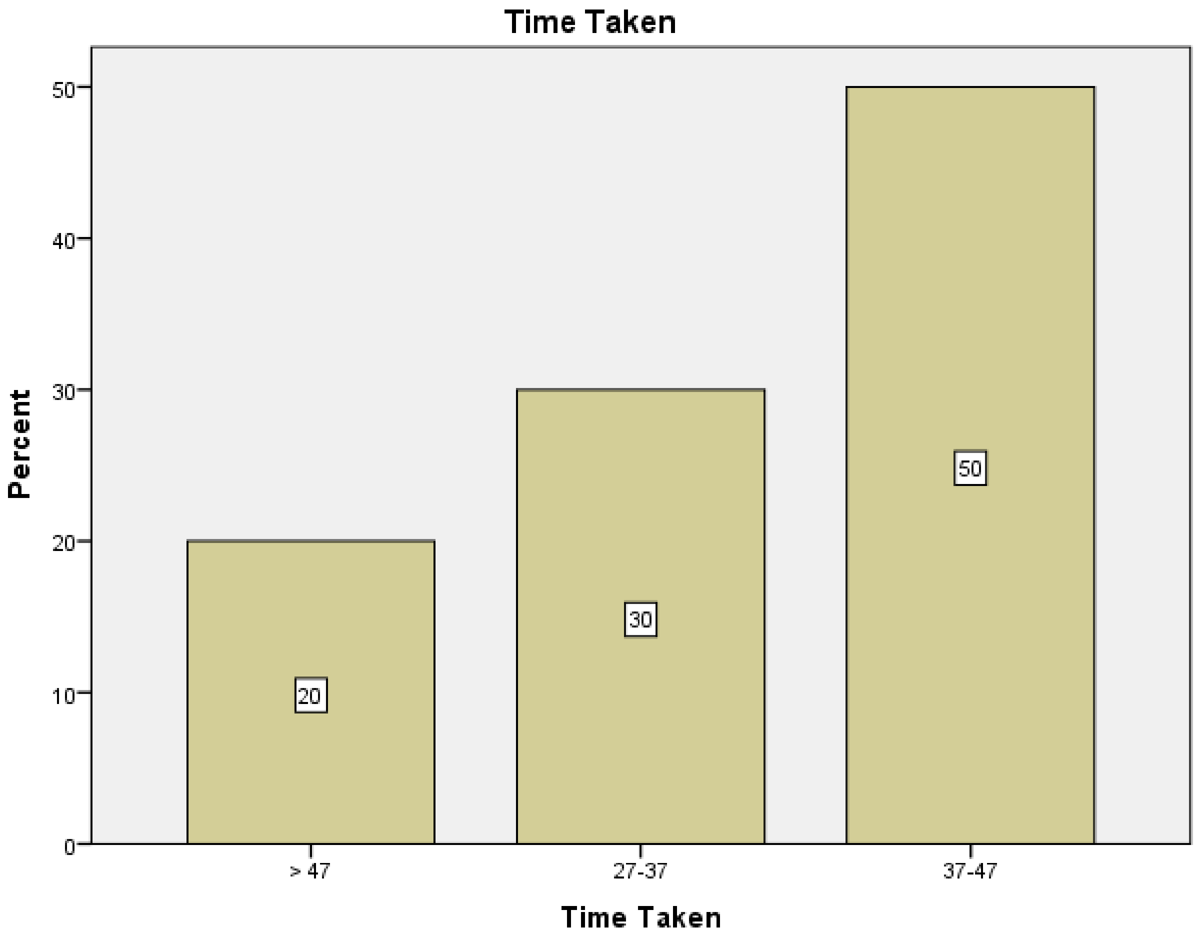
	Frequency	Percent	Percent	Cumulative Percent
Closed reduction Internal Fixation with Titanium elastic nailing	33	82.5	82.5	82.5
Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna	1	2.5	2.5	85.0
Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna	2	5.0	5.0	90.0
open reduction internal fixation with tens for ulna,Closed reduction Internal Fixation with tens for radius	2	5.0	5.0	95.0
Open reduction Internal Fixation with Titanium elastic nailing	2	5.0	5.0	100.0
Total	40	100.0	100.0	



Among 40 cases in our study we were able to achieve close reduction in 82.5% out of cases operated within 5 days of fall. The rest cases we had to go open reduction in cases.

Time Taken for operation in min

	Frequency	Percent	Percent	Cumulative Percent
> 47	8	20.0	20.0	20.0
27-37	12	30.0	30.0	50.0
37-47	20	50.0	50.0	100.0
Total	40	100.0	100.0	

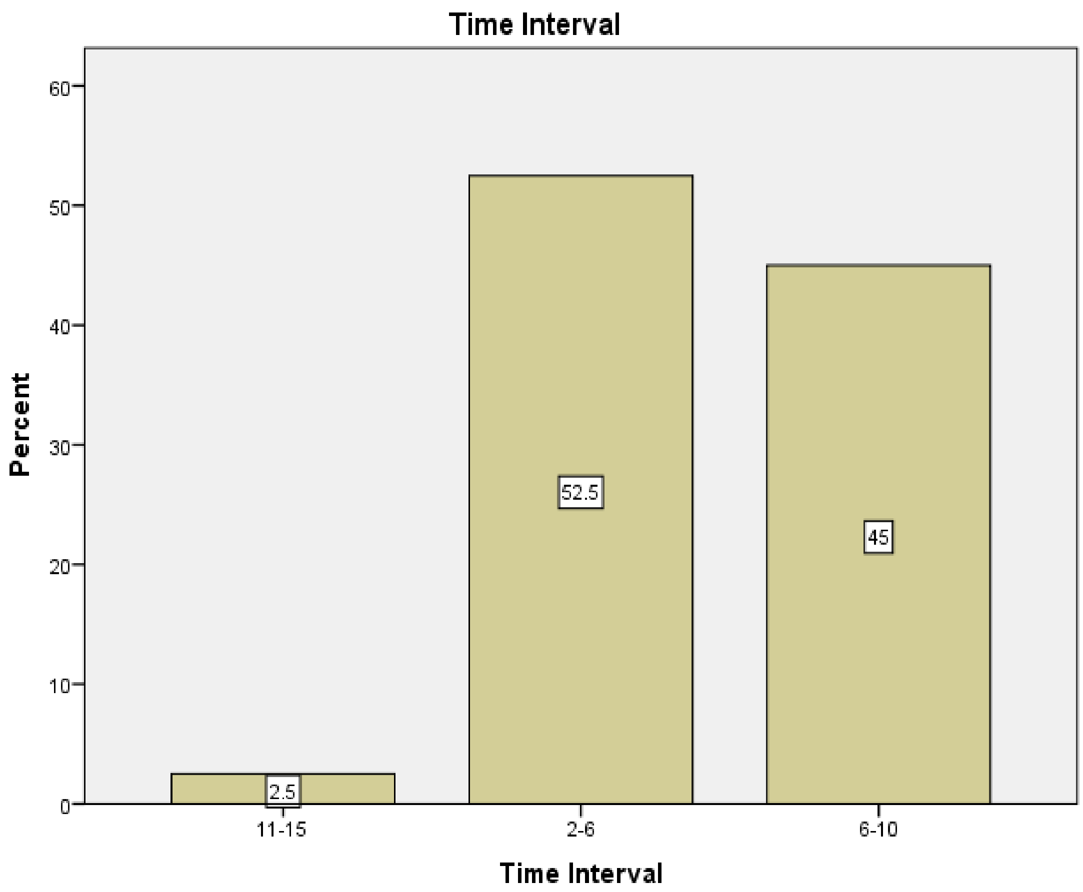


In our study of 40 cases. 80% of cases operated within 47 minutes were fixed by close reduction. In cases which took more than 47 minutes were fixed by open reduction.

Operative time was also increased based on increased days after trauma,which were fixed by open reduction.

Time Interval between trauma and surgery in days

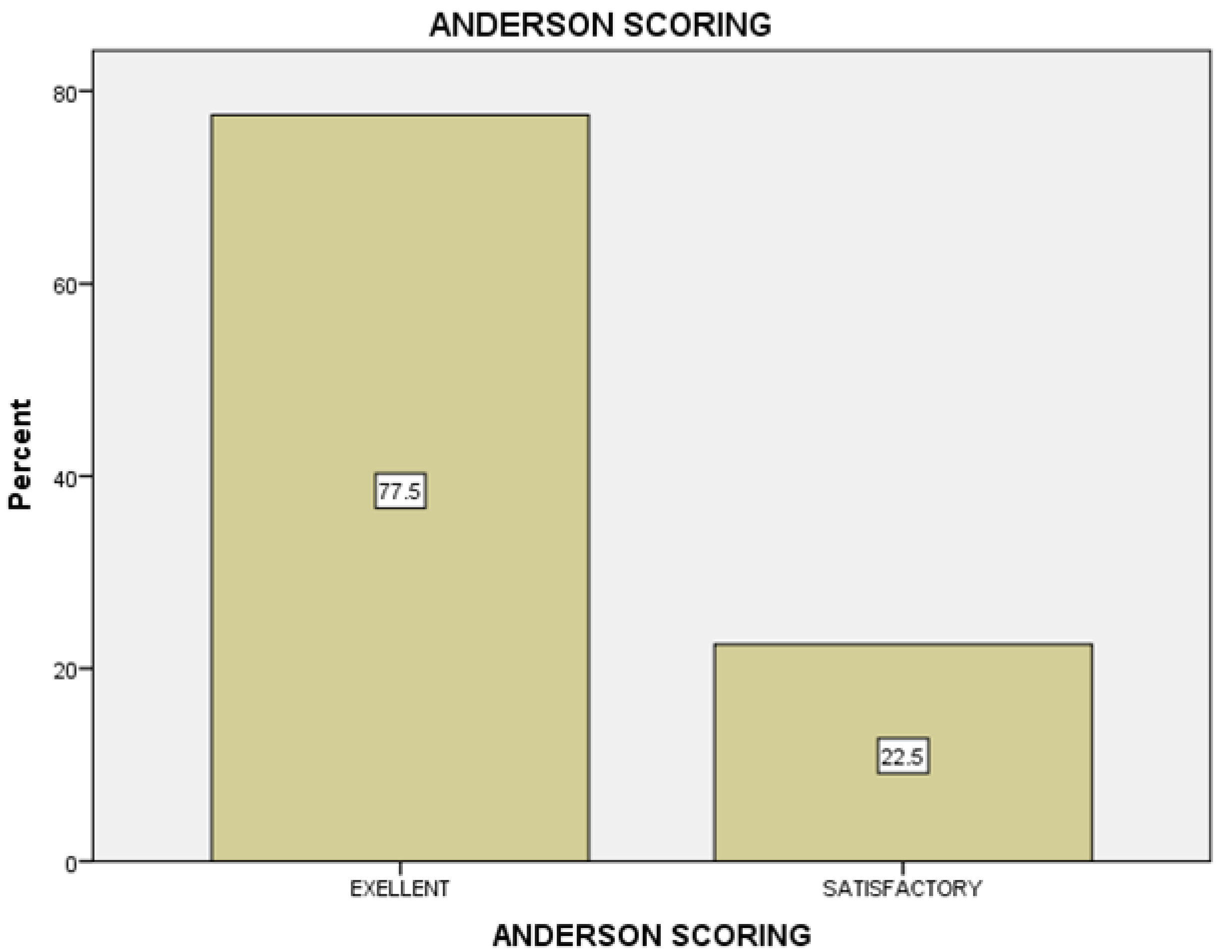
days	Frequency	Percent	Percent	Cumulative Percent
2-6	21	52.5	52.5	55.0
6-10	18	45.0	45.0	100.0
11-15	1	2.5	2.5	2.5
Total	40	100.0	100.0	



In our study we noted that, after 5 days of fall the operation time taken was significantly increased.

ANDERSON SCORING

	Frequency	Percent	Percent	Cumulative Percent
EXELLENT	31	77.5	77.5	77.5
SATISFACTORY	9	22.5	22.5	100.0
Total	40	100.0	100.0	



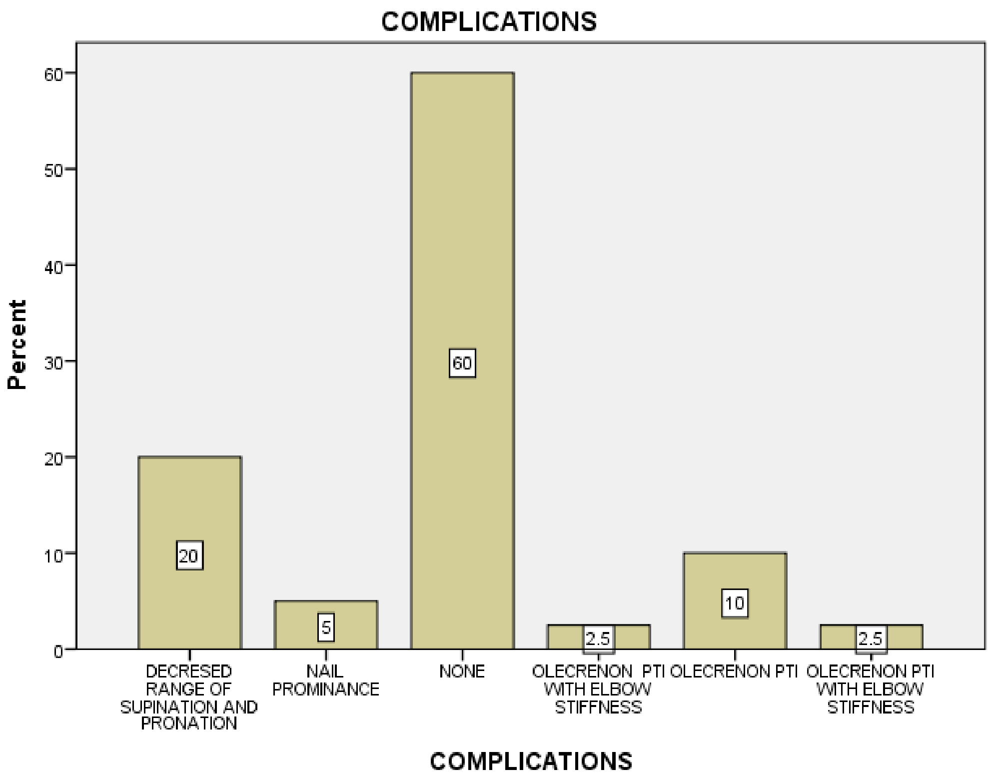
Criteria for evaluation of functional outcome.

Functional evaluation was assessed using Anderson et Al criteria scoring system (1975).

In our study 77.5% patients had excellent and 22.5% patients had satisfactory outcome

COMPLICATIONS

	Frequency	Percent	Percent	Cumulative Percent
DECRESED RANGE OF SUPINATION AND PRONATION	8	20.0	20.0	20.0
NAIL PROMINANCE	2	5.0	5.0	25.0
NONE	24	60.0	60.0	85.0
OLECRENON PTI WITH ELBOW STIFFNESS	1	2.5	2.5	87.5
OLECRENON PTI	4	10.0	10.0	97.5
OLECRENON PTI WITH ELBOW STIFFNESS	1	2.5	2.5	100.0

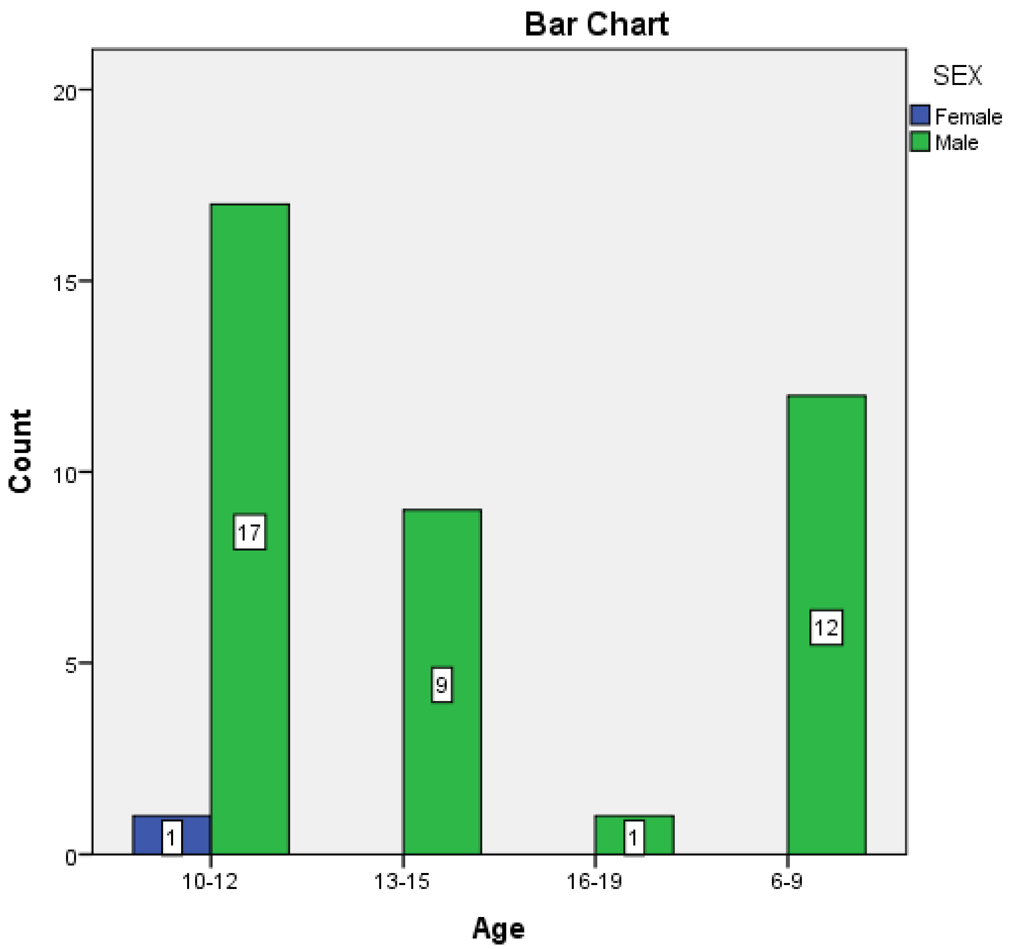


Complications:

Among 40 cases we encountered minor complications with olecranon pin tract infection and decreased range of pronation and supination being the most common.

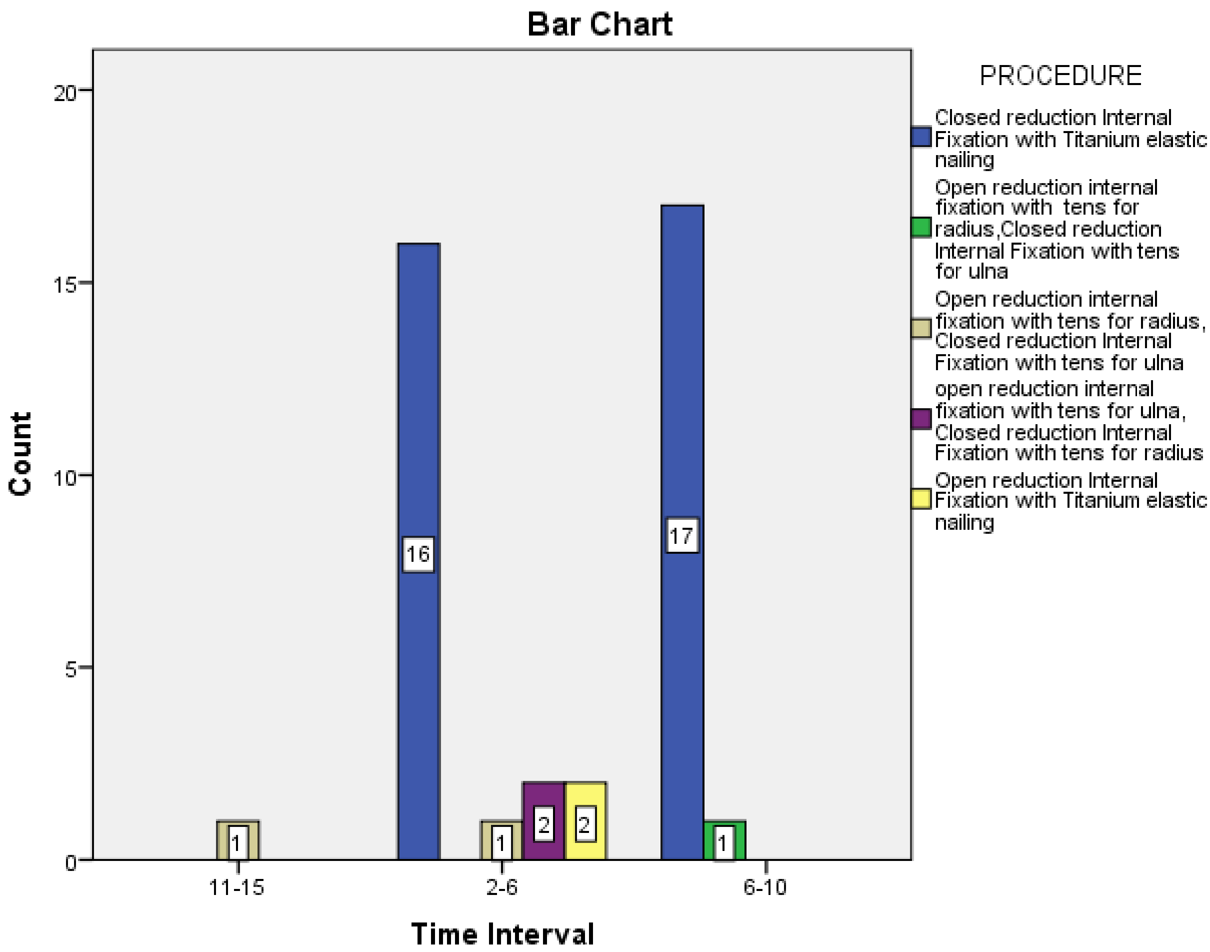
Crosstabs

			SEX		Chi-square value	p-value
			Female	Male		
Age	10-12	Count	1	17	1.254	0.740
		% within SEX	100.0%	43.6%		
	13-15	Count	0	9		
		% within SEX	0.0%	23.1%		
	16-19	Count	0	1		
		% within SEX	0.0%	2.6%		
	6-9	Count	0	12		
		% within SEX	0.0%	30.8%		
Total		Count	1	39		
		% within SEX	100.0%	100.0%		



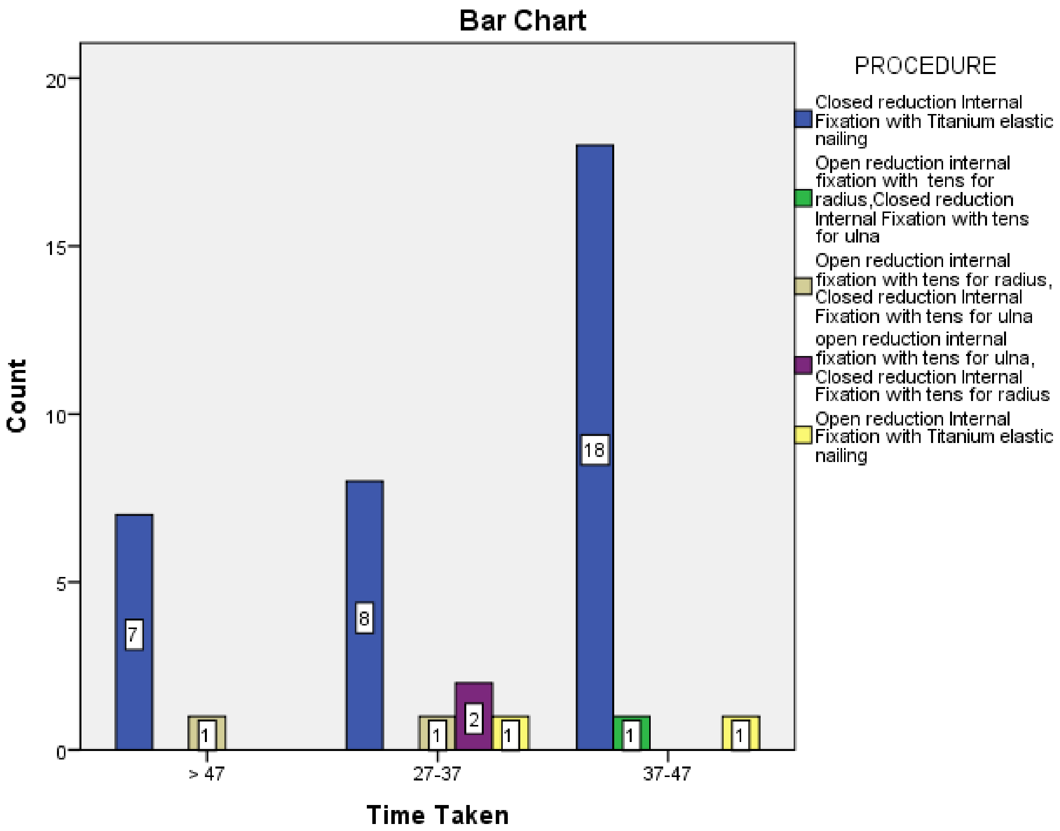
Crosstabs

Time Interval between trauma and operative day		PROCEDURE			PROCEDURE		Chi-square value	p-value
		Closed reduction Internal Fixation with Titanium elastic nailing	Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna	Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna	open reduction internal fixation with tens for ulna,Closed reduction Internal Fixation with tens for radius	Open reduction Internal Fixation with Titanium elastic nailing		
2-6	Count	16	0	1	2	2	25.031	0.002
	% within PROCEDURE	48.50%	0.00%	50.00%	100.00%	100.00%		
6-10	Count	17	1	0	0	0		
	% within PROCEDURE	51.50%	100.00%	0.00%	0.00%	0.00%		
11-15	Count	0	0	1	0	0		
	% within PROCEDURE	0.00%	0.00%	50.00%	0.00%	0.00%		
Total	Count	33	1	2	2	2		
	% within PROCEDURE	100.00%	100.00%	100.00%	100.00%	100.00%		



Time Interval between trauma and operative day increased, open reduction was the need to pass the nail due to soft tissue interposition

Time taken in minutes -procedure			PROCEDURE		Chi-square value	p-value
			open reduction internal fixation with tens for ulna,Closed reduction Internal Fixation with tens for radius	Open reduction Internal Fixation with Titanium elastic nailing		
Time Taken	27-37	Count	2	1	9.025	0.340
		% within PROCEDURE	100.0%	50.0%		
	37-47	Count	0	1		
		% within PROCEDURE	0.0%	50.0%		
	> 47	Count	0	0		
		% within PROCEDURE	0.0%	0.0%		
Total		Count	2	2		
		% within PROCEDURE	100.0%	100.0%		



Operative time was increased more 37 minutes for fractures fixed by open reduction.

DISCUSSION

AGE DISTRIBUTION

In the present study the mean age group of patients with displaced both bone forearm fractures operated with TENS nailing was 10.9 years. The patients were distributed from 5 years to 16 years of age with most common age group being 10-12 years.

Mohammad (2016)[56] study had an average age group nearly 10.04 years.

Shivanna et al (2014)[96] study had an average age group of 9 years.

In case series of Deeptiman James et.al (2010) the average age group was 11.23 years.

DISTRIBUTION OF SAMPLE BY GENDER

In our current study 97.5 % of the patients were boys and remaining 2.5% were girls..

The high rate of involvement of boys might be attributed to the fact that boys of this age group are much more commonly involved in out door activities like sports and bicycling which results in higher percentage of both bone forearm fractures in boys.

Mohammad (2016)[56] in their study had 65.8% boys and 34.2% girls.

In Kapoor et al (1999 to 2002)[38] the study group included 56% of boys rest being girls.

DISTRIBUTION OF SAMPLE BY MODE OF INJURY

In our study we noted 75% of injuries due to accidental self fall at home or while playing, 15 % due to fall from bicycle, and 10% due to RTA.

Kapoor et al (1999 to 2002)[38] the study group ha d 74% sports related injuries, 14% had bicycle injuries, 10% had accidents at home & remaining were road accidents.

Shivanna et al (2014)[97] study had 66.6% of injuries was due to sports related fall, 24.4% were due to fall from height 9% were due to RTA.

DISTRIBUTION OF SAMPLE BY SIDE AFFECTED

In our current study 65 % of patients had left side forearm fractures and 35% had right forearm fractures indicating that there was no such predisposition of sides in both bone forearm fractures in children.

Shivanna et al (2014)[97] study had 56.6% right side and remaining left side forearm injury.

In Kapoor et al (1999 to 2002)[38] had 58 % right side involvement and 42% left side forearm involvement.

Kishorchand Naorem et al[96] during 2015 to 2017 had 63.3% right side involvement and 36.7% left side involvement.

DISTRIBUTION OF SAMPLE BY LEVEL OF FRACTURE

Among 40 cases the fracture level in both radius and ulnar mid shaft of radius and ulna fractures were 50%, proximal end radius and ulna fractures were 15%.

As in other studies in our study also mid 1/3rd shaft was the most commonlevel of involvement.

In Kapoor et al (1999 to 2002)[38] the study group had 88% mid shaft fracture, 8 % had distal shaft fractures and 4 % were in proximal shaft.

Siddaram Patil (2011 -2013)[95] case series had 50% in mid shaft and 25% in distal and proximal shaft.

PATTERN OF FRACTURE

In case of radius fracture 70% were transverse and 30% were oblique. In case of ulna fracture 65% were transverse and 35% were oblique.

Since children are not involved in high velocity injury most of the cases were are transverse in nature.

Our study had excluded the patients with communited fractures.

Kishorchand (2015- 2017)[96] case series had 63.3% had transverse fracture, 23.3% had oblique fracture, 13.3% had segmental fracture.

TIME INTERVAL BETWEEN TRAUMA AND SURGERY

In our study we noted that, after 5 days of fall the operation time taken was significantly increased.

Among 40 patients 52.5% of cases were operated in 2-6 days after trauma

DURATION OF SURGERY

In our study of 40 cases. 80% of cases operated within 47 minutes were fixed by close reduction. In cases which took more than 47 minutes were fixed by open reduction.

Operative time was also increased based on increased days after trauma,which were fixed by open reduction.

DURATION OF IMMOBILISATION AFTER SURGERY

The duration of immobilisation was variable from 3 weeks to 6 weeks depending on patient compatability to follow orders and radiological union. Most of our cases were immobilised for an average time of 4 weeks. This is mainly because TENS provides table fixation but not rigid fixation.

FRACTURE UNION TIME

The mean duration of fracture union time was 8.9 weeks with a range of 7-11 weeks.We did not come through any case of delayed union or non union.

Mohammad Ruhullah et al (2016)[56] in their study had a average union time of 9 weeks.

Shivanna et al (2014)[97] study had a average union time of 7 weeks.

Kishorchand Naorem et al (2015- 2017)[96] series had all fractures united by 16 weeks.

TYPE OF REDUCTION

In our study we were able to fix 8 cases by open reduction, in 3 cases radius fracture site was opened, in 2 case ulna fracture was opened and cases both bones fracture sites were opened to achieve reduction.

It was noted that as the time interval between the trauma and surgery increasedclosed reduction was difficult to achieve and had to be reduced by open method. Operative time was also increased based on increased days after trauma,which were fixed by open reduction.

Shivanna (2014)[97] case study group had 82.2% had closed reduction and remaining were by open reduction.

Kapoor et al (1999 to 2002)[38] case series had 48% closed reduction, 32 % open reduction for a single bone and 20 % had open reduction for both bones.

ASSOCIATION OF TIME INTERVAL FOR OPERATION FROM THE DAY OF FALL WITH TIME TAKEN FOR OPERATION

In our study of 40 cases we noted. In our study we noted that, after 5 days of fall the operation time taken was significantly increased Operative time significantly increased more than 47minutes as the time interval between trauma and the day of operation increased.

ASSOCIATION OF TYPE OF REDUCTION WITH TIME TAKEN FOR OPERATION

In our study we noticed that time duration was comparatively less (<40 minutes) when reduction was by closed method. It significantly increased as we tried open reduction of either of one bone or both bones.

COMPLICATIONS

Among 40 cases we encountered 10 % complications with olecranon pin tract infection and 20% decreased range of pronation and supination being the most common.

One case had elbow stiffness along with olecranon PTI, which improved with physiotherapy. The olecranon pin tract infection was common as pin is superficial and if its not cut near the bone, once the patient starts active ROM of elbow the pin will irritate the skin which might lead to superficial infection.

10% Cases which had olecranon pin tract infection was noted due to late implant removal after 11months. In each of the cases culture sensitivity of the discharge was done and antibiotics were started according to the culture sensitivity report. All the cases with PTI were healed within 2 weeks.

In 20% cases we noticed restriction of supination and pronation at the end of 16 weeks which improved with physiotherapy over the period of next 4-6 weeks.

Kapoor et al (1999 to 2002)[38] case series had a complication rate of 21.2% which included delayed union at 16 weeks, nail prominence, 2 cases had post-operative compartment syndrome, decreased range of supination and pronation and one re-fracture at 6 months.

Siddaram Patil (2011 -2013)[95] case series had a minor complication rate 25%.

FUNCTIONAL OUTCOME

Functional evaluation was assessed using Anderson et Al criteria scoring system (1975).
In our study 77.5% patients had excellent and 22.5% patients had satisfactory outcome

Kapoor et al (1999 to 2002)[38] case series had excellent results in 76% and 18% had good results according to Daruwalla et al criteria.

CONCLUSION

This study was done to assess functional outcome of treating pediatric forearm shaft fractures treated with Titanium Elastic Nailing System. 40 patients with pediatric Both Bones forearm fractures were operated with TENS and the following conclusions were drawn.

The mean age in our group was 10.9 years. Most of the pediatric forearm both bone fractures are treated traditionally by closed reduction and cast application. Most of the younger kids are managed traditionally as the remodelling capacity at younger age group. Operative management is done in cases where conservative management fails.

Our study had male predominance which can be attributed to the mode of injury which is accidental self-fall during out-door activities like playing and bicycling. RTA as a mode of injury was very less in our study. Majority of the fractures in our study were in mid shaft and were transverse followed by oblique in nature which can be attributed to elastic and plastic property of pediatric bone as well as the mode of injury as most of the cases were due to self-fall while paying.

In our study our cases were grossly displaced fractures, unstable fractures and fractures which failed closed reduction. Closed reduction and cast application still remain the primary mode of treatment even if near anatomical reduction is not achieved especially in children with less 10 years of age as in younger children the remodelling capacity was high. Rotational and angular deformity were corrected by remodelling. But in case of older children (12-16 years) we should try to achieve anatomical reduction as much as possible.

These fractures has to be fixed at the earliest as the time interval between the operative procedure and the day of fall increases closed reduction becomes difficult and there might be need for open reduction of single bone or both bone. The operative time also increases as the delay increases.

TENS is a better option considering the short duration of operative time, minimal dissection of soft tissue is required. Since there is minimal soft tissue dissection there is minimal amount of bleeding as well as least chances of neurovascular injury. As the fracture hematoma is not disturbed which helps in early healing of fracture. Even if we go for open reduction, minimal incision at fracture site is sufficient.

Average time of union 8.9 weeks with an average range of 7-11 weeks ,with no incidence of delayed union and non-union with most of the children returning to normal activity by the end of 14 weeks.

The forearm was to be immobilised for average period of 4 weeks as TENS doesn’t provide rigid fixation and it needs immobilisation till sticky callus is formed. Flexion/extension exercises of elbow and wrist were started at 4 weeks and later supination pronation exercise were started. The decreased range of supination and pronation was noticed in most of the cases which improved significantly with physiotherapy for 2-3 weeks.

Pin tract infection at olecranon was most commonly noted as hardware becomes prominent and impinges the soft tissue resulting in superficial infection. So care should be taken while cutting the nail to cut it near the bone and to make it blunt before closing.

Removal of the nail was easy and is minor operative procedure. As the time duration increases the removal becomes difficult. It should be done preferably between 28-32 weeks.

The scar marks are minimal as the incisions are small. So this procedure is cosmetically better.

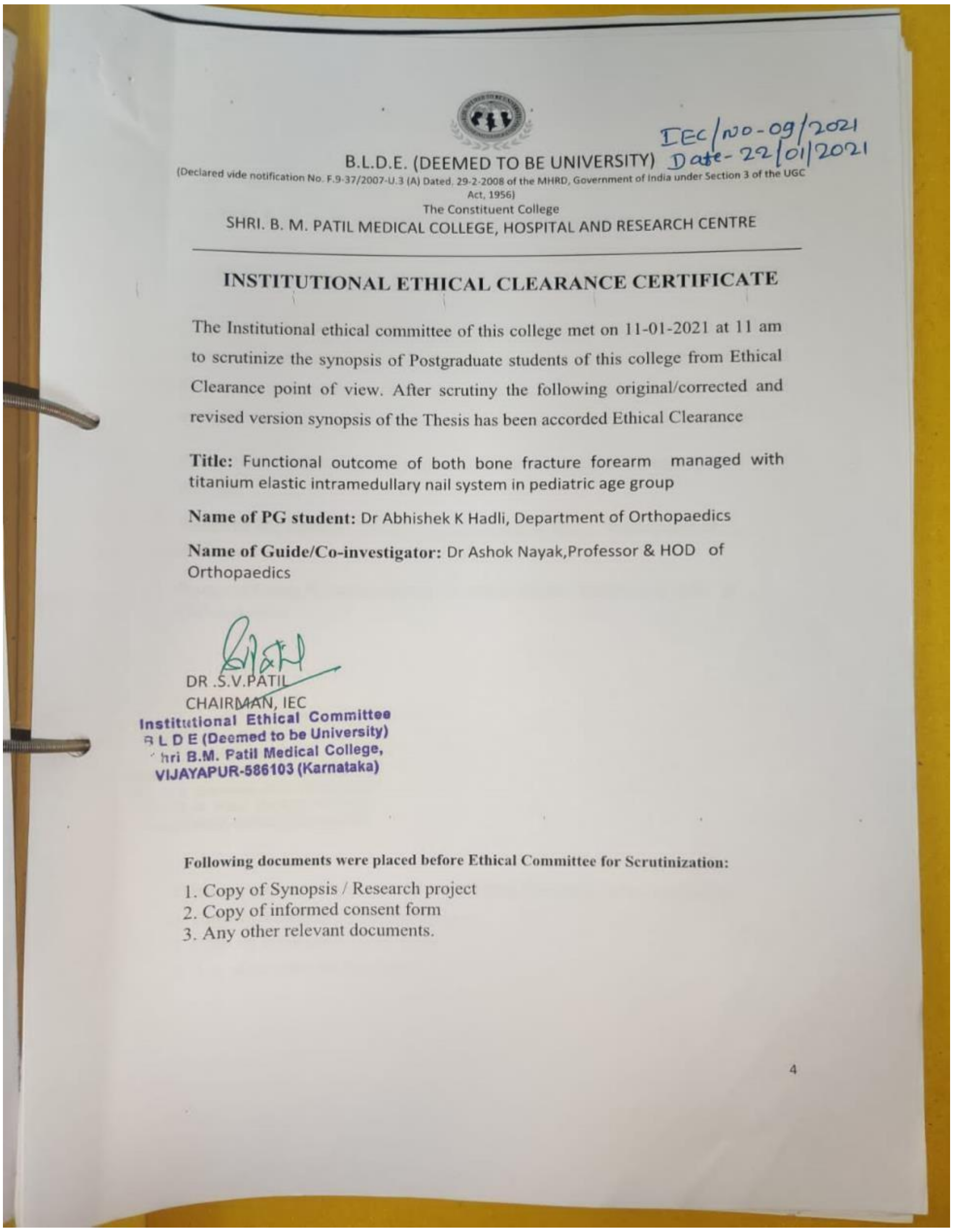
SUMMARY

40cases of pediatric fractures of shaft of radius & ulna were treated with TENS ether by closed/open reduction. The follow up ranged from 3 weeks–6months.

- Boys were predominantly more with left sided forearm affected more than right.
- Majority fractures occurred due to self-fall while playing.
- The average age 10.9 was years.
- Most of the fractures were in middle third (70% for radius and 65% for ulna) with transverse fracture pattern being the commonest with Radius (70%) & ulna(65%) and united within 3 months.
- Our study group results were based on Anderson et al criteria scoring system and in ourstudy, 77.5% patients had excellent and 22.5% patients had satisfactory outcome
- TENS doesn't provide a rigid construct but does provide a stable construct without hampering the fracture hematoma nor the soft tissue which leads to early fracture union.
- Being a stable construct requiring immobilisation for 3-4 weeks resulted in post- operative stiffness which improved with mobilization of the wrist, elbow and radio-ulnar joints.
- TENS provides a minimally invasive method of fracture stabilisation if operated within 3-5 days of fall.
- This surgery is cosmetically better with small incision leading to smaller scar marks.
- Removal needs a minor surgery which should be done at the earliest between 7^{th} to 8^{th} month

ANNEXURE – 1

ETHICAL CERTIFICATE



IEC/NO-09/2021
Date- 22/01/2021

B.L.D.E. (DEEMED TO BE UNIVERSITY)
(Declared vide notification No. F.9-37/2007-U.3 (A) Dated. 29-2-2008 of the MHRD, Government of India under Section 3 of the UGC Act, 1956)
The Constituent College
SHRI. B. M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Institutional ethical committee of this college met on 11-01-2021 at 11 am to scrutinize the synopsis of Postgraduate students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has been accorded Ethical Clearance

Title: Functional outcome of both bone fracture forearm managed with titanium elastic intramedullary nail system in pediatric age group

Name of PG student: Dr Abhishek K Hadli, Department of Orthopaedics

Name of Guide/Co-investigator: Dr Ashok Nayak,Professor & HOD of Orthopaedics

DR .S.V.PATIL
CHAIRMAN, IEC
Institutional Ethical Committee
B L D E (Deemed to be University)
Shri B.M. Patil Medical College,
VIJAYAPUR-586103 (Karnataka)

Following documents were placed before Ethical Committee for Scrutinization:

1. Copy of Synopsis / Research project
2. Copy of informed consent form
3. Any other relevant documents.

4

ANNEXURE

B.L.D.E. (DEEMED TO BE UNIVERSITY) SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTER, VIJAYAPURA-586103

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH

I, the undersigned,_______________, S/O D/O W/O_________________, aged______years, ordinarily resident of_____________do hereby state/declare that Dr. Abhishek K Hadli of Shri. B. M. Patil Medical College Hospital and Research Centre has examined me thoroughly on________________at ______________(place) and it has been explained to me in my own language that I am suffering from ________________ disease (condition) and this disease/condition mimic following diseases. Further DrAbhishek k Hadli informed me that he/she is conducting dissertation/research titled Functional outcome of both bone fracture forearm managed with titanium elastic intramedullary nail system in pediatric age group

.” under the guidance of Dr ASHOK NAYAK . requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in evaluation of the results of the study which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.
The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same time I have been informed that I can withdraw from my participation in this study at any time if I want or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged. After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt_______________________________under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of patient:

Signature of doctor:

Witness: 1.

2.

Date:

Place

ANNEXURE – IX

SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA - 586103

PROFORMA

CASE NO. :

NAME :

AGE/SEX :

I P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized lymphadenopathy:	present/absent
Built:	poor/moderate/well
Nourishment:	poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Right/ Left Hand

Inspection:

a) Attitude/ deformity

b) Abnormal swelling

- Site
- Size
- Shape
- Extent

c) Skin

Palpation:

a) Local tenderness

b) Bony irregularity

c) Abnormal movement

d) Crepitus

e) Swelling

Movements:		Active	Passive
ELBOW Joint:	Flexion		
	Extension		
	Abduction		
	Adduction		

CURRICULUM VITAE

NAME : Dr.ASHOK NAYAK.MS.(ORTHO):

DESIGNATION : PROFESSOR OF ORTHOPAEDICS,
DEPARTMENT OF ORTHOPAEDICS,
B.L.D.E. (DEEMED TO BE UNIVERSITY)
SHRI B. M. PATIL MEDICAL COLLEGE,
VIJAYAPURA.

QUALIFICATIONS : M.B.B.S , M.S.(ORTHO)

M.B.B.S : JAWAHARLAL NEHRU MEDICAL COLLEGE,BELAGAUM

M.S. : **BANGLORE MEDICAL COLLEGE,BANGLORE**

REGISTRATION NUMBER **28172**

PRESENT POST HELD : PROFESSOR
DEPARTMENT OF ORTHOPAEDICS,
B.L.D.E. (DEEMED TO BE UNIVERSITY)
SHRI B. M. PATIL MEDICAL COLLEGE,
VIJAYAPURA.

INVESTIGATOR'S BIO -DATA

NAME : DR. ABHISHEK K.HADLI

QUALIFICATION : M.B.B.S

B.L.D.E. (DEEMED TO BE UNIVERSITY)
SHRI B. M. PATIL MEDICAL COLLEGE
VIJAYAPURA.

KARNATAKA MEDICAL COUNCIL REGISTRATION NUMBER : **123383**

ADDRESS : DEPT OF ORTHOPAEDICS
B.L.D.E. (DEEMED TO BE UNIVERSITY,
SHRI B. M. PATIL MEDICAL COLLEGE
VIJAYAPURA, KARNATAKA.

KEY TO MASTER CHART

SL. NO - Serial Number
IP. NO - In patient number
M - Male
F - Female
R - Right side
L - Left side
RTA - Road traffic accidents
ROM - Range of movement

MASTER CHART OF 40 PATIENTS

Age	AGE(YEARS)	SEX	IP No.	MODE OF INJURY	DIAGNOSIS	LEVEL OF INVOLVEMENT	AO CLASSIFICATION	PROCEDURE
6-9	6	M	214068	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	7	M	10334	FALL FROM BICYCLE	LEFT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND ULNA	22rD/5.1,22uD/5.1	Open reduction Internal Fixation with Titanium elastic nailing
6-9	7	M	116890	ROAD TRAFFIC ACCIDENT	LEFT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND ULNA	22rD/5.1,22uD/5.1	Open reduction Internal Fixation with Titanium elastic nailing
6-9	7	M	147535	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	8	M	178221	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	8	M	255433	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND DISTAL ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	8	M	291682	FALL FROM BICYCLE	LEFT BOTH BONE FOREARM FRACTURE	DISTAL RADIUS MID SHAFT ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	8	M	247076	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND PROXIMAL ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	9	M	157854	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	9	M	250715	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 ,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	9	M	159	FALL FROM BICYCLE	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
6-9	9	M	405549	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	10	M	15/15	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	10	M	187490	ROAD TRAFFIC ACCIDENT	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	10	M	91691	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	10	M	131544	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND DISTAL ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	10	M	16483	FALL FROM BICYCLE	RIGHT BOTH BONE FOREARM FRACTURE	DISTAL RADIUS MID SHAFT ULNA	22rD/5.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	11	M	16020	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND PROXIMAL ULNA	22rD/5.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	11	M	286404	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	11	M	314848	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	11	M	10877	FALL FROM BICYCLE	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	11	M	191332	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	12	M	163342	ROAD TRAFFIC ACCIDENT	LEFT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	12	M	114421	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	12	F	172176	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	open reduction internal fixation with tens for ulna,Closed reduction Internal Fixation w radius
10-12	12	M	305984	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND DISTAL ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	12	M	19870	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	DISTAL RADIUS MID SHAFT ULNA	22rD/5.1,22uD/5.1	Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna
10-12	12	M	33822	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND PROXIMAL ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	12	M	184878	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
10-12	12	M	173482	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
13-15	13	M	255432	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1 , 22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
13-15	13	M	277992	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND MID SHAFT ULNA	22rD/5.1,22uD/5.1	Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna
13-15	14	M	269966	ROAD TRAFFIC ACCIDENT	LEFT BOTH BONE FOREARM FRACTURE	PROXIMAL RADIUS AND MIDSHAFT ULNA	22rD/5.1,22uD/5.1	Open reduction internal fixation with tens for radius,Closed reduction Internal Fixation with tens for ulna
13-15	14	M	37332	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing
13-15	14	M	267795	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing
13-15	14	M	113387	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND DISTAL ULNA	22rD/5.1,22uD/5.1	Closed reduction Internal Fixation with Titanium elastic nailing
13-15	14	M	308539	SELF FALL -PLAYING	RIGHT BOTH BONE FOREARM FRACTURE	DISTAL RADIUS MID SHAFT ULNA	22rD/5.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing
13-15	15	M	33563	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MIDSHAFT RADIUS AND PROXIMAL ULNA	22rD/5.1,22uD/4.1	open reduction internal fixation with tens for ulna,Closed reduction Internal Fixation with tens for radius
13-15	15	M	102239	FALL FROM BICYCLE	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing
16-19	16	M	219284	SELF FALL -PLAYING	LEFT BOTH BONE FOREARM FRACTURE	MID SHAFT OF RADIUS AND ULNA	22rD/4.1,22uD/4.1	Closed reduction Internal Fixation with Titanium elastic nailing

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99.K.Usha and Someshwar reddy Post Graduate, Professor and HOD, Department of Orthopedics, Santhiram Medical College and General Hospital, Nandyal..A Study of both bone forearm fractures In pediatric population -treated by ESIM nailing with TENS

100. Closed reduction and internal fixation with titanium elastic nailing system in pediatric both-bone forearm fractures***Harpreet Singh, Bineet Oza, Kamal Kumar K. Agarwal, Prashant Makadia, Pranjal Jain, Meet Patel*****Published: 2022-04-25**

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