Elastic Stable Intramedullary Nail (ESIN) versus Plating in Adolescent Forearm Fractures: A Randomized Controlled Trial

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Abstract

Background: Paediatric fractures involving both bones of the forearm's diaphysis are often treated using various treatment strategies. Nevertheless, when it comes to the teenage demographic, forearm fractures provide a greater challenge because to their limited ability for remodeling. Consequently, surgical interventions such as Elastic Stable Intramedullary Nail (ESIN) or plating are often used for the treatment of forearm fractures in adolescents.

Objectives*:* The main objective of this prospective study is to compare between fixation of both bone forearm fractures in adolescents using ESIN and Plating.

Patients and methods: Forty patients, aged (10-16 years) presented with both bone forearm fractures, patients with odd numbers (20 patients group A) were treated with ESIN and patients with even numbers (20 patients group B) were treated with plating, the main outcomes measures including fracture reunion time, forearm rotation, site of maximum radial bow, and complications.

Results: A significant difference (p-value < 0.001) was detected between the two procedure regarding mean operative time (55 min in ESIN versus 90 min in plating group), superficial infection (20% ESIN versus 0% plating, p-value =0.05), mean fluoroscopy time (59.5 seconds in ESIN versus 3 seconds in plating group, p-value < 0.001), Insignificant differences between the groups regarding the time of union and range of motion.

Conclusion: We concluded that ESIN and plating in adolescent patients for both-bone forearm fractures are equally effective treatment, each procedure has it's advantages and disadvantages.

Keywords: Forearm fractures; Adolescents; Plates and screws; Intramedullary nail.

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Introduction

In the field of pediatric orthopaedics, there are ongoing debates regarding the optimal timing for surgery, the definition of an acceptable reduction, and the age at which children's ability to remodel fractures becomes less effective. Younger children, who still have more growth potential, generally have a greater capacity for remodeling compared to adolescents. Additionally, it is understood that deformities occurring within the plane of motion are better tolerated and have a higher likelihood of remodeling. Similarly, fractures closer to more active growth plates also exhibit a greater tendency to remodel **(Wilkins, 2005)**.

In the past, both-bone forearm fractures have typically been managed without surgery, and this approach has been successful for most cases. However, there has been an increase in interest and discussion surrounding the standard of care for these types of fractures due to the development of new fixation techniques such as intramedullary nailing and plating **(Abraham et al., 2011)**.

As children approach skeletal maturity, their tolerance for displacement becomes more similar to that of adults. As a result, there is growing trend towards operative management for both-bone fractures in older children **(Flynn et al., 2010).** When there is a decision to proceed with surgery, there is typically a debate over the most suitable fixation method.

Intramedullary nail (IMN) fixation has gained popularity among surgeons for several reasons. These include minimal dissection required during the procedure, shorter anesthesia duration, reliable maintenance of alignment, suitability for both open and closed fractures, and ease of removal when necessary. However, there are some disadvantages to consider, such as the requirement for post-fixation immobilization, inability to treat fractures near the ends of bones due to potential damage to growth plates, and a second surgery is required for nails removal. The utilization of plate fixation demonstrates distinct advantages in instances of comminuted fractures and fractures situated at the apex of the radial bow. It is also recommended when the fracture extends to the metaphysis or involves the articular surface. Additionally, plate fixation allows for open reduction, which can be beneficial in situations where there is a concern for compartment syndrome as it provides direct access to open the relevant compartments. However, it's important to note that when plate removal is necessary, there is a theoretical risk of refracture due to the presence of residual screw holes **(Truntzer et al., 2014)**.

Various studies have described the utilization of single-bone fixation techniques for either the radius or ulna, as well as hybrid fixation methods involving the use of both plates and screws, and intramedullary (IM) nailing **(Bhaskar et al., 2001; Yung et al., 2004)**. our study aims to determine the significant radiological and functional difference between ESIN and ORIF in management of adolescent forearm fractures.

Patients and methods

This prospective randomized comparative study included 40 patients, presented with both bone forearm fractures between July 2022 and August 2023, The patients were randomly categorized into: group A which treated by Elastic Stable Intramedullary Nail (ESIN) fixation. and group B was treated with plates and screws fixation.

This work was approved by the Research Ethics Committee of our institution (Approval code: SVU-MED-ORT017-1-22-10-476), informed and written consent was obtained from all participants and their accompanying adults.

Patient Selection

Inclusion criteria: Patients aged 10-16 years old presented with midshaft both bone forearm fractures with the following criteria:

- More than 10^{o} of angulation after previous closed reduction.
- More than 30^{o} of rotation after previous closed reduction.
- More than 10 mm of displacement after previous closed reduction.

Exclusion criteria:

- Patients aged below 10 and above 16 years old.
- Pathological fractures.

- Single bone fracture.
- Galeazi and Monteggia fractures.
- Associated intra- articular elbow or wrist fractures.

Pre-operative assessment

Initial management and resuscitation: trauma survey and resuscitation measures to stabilize general condition according to advanced trauma life support.

Detailed History taking including: Age, sex, address, phone number, hand dominance , medical co-morbidities and mechanism of injury, duration from injury till operation will be recorded preoperative.

Clinical Examination: Attention should be given to neurovascular status and any skin or soft tissue compromise.

Investigations: Routine Laboratory work up and preoperative fitness. Plain X-ray: Plain radiographs including a preliminary AP and lateral radiographs of the affected forearm will be performed for diagnosis. Posterior above elbow slab was applied, then patients were randomly classified into two groups, group (A) managed by ESIN and group (B) were managed by open reduction and internal fixation by plates and screws (ORIF) as follow: Group A: The patient received a broad spectrum antibiotic via intravenous (IV) administration. Additionally, a well-padded tourniquet was applied to their upper arm, and an image intensifier was positioned parallel to their body. For the anterior-posterior (AP) view, the intensifier was placed directly vertical, while for the lateral view, the patient's upper limb was internally rotated to prevent displacement of the fracture. In all cases, Titanium nails were used and there was no difference in size between radial and ulnar nails. The diameter of the nail was determined based on the rule of the thumb, which suggests that it should be 40% of the diameter of the intramedullary canal. The cases were in a supine posture on the operating table under general anesthesia, with the wounded upper limb positioned on a radiolucent table., Preparation and disinfection of the entire limb was done by betadine, Draping and toweling was performed. *For radial intramedullary fixation*, the entry point was at Lister's tubercle, which Is located along the same line and about 1-1.5 cm closer to the growth plate in the metaphysis. An image intensifier was utilized to ensure that the appropriate entry point was selected **(Fig.1)**.

Fig.1. Lister's tubercle entry point for radius nail

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Skin incision was made and blunt scissors dissection was then performed to skin and subcutaneous tissue, blunt dissection of the retinaculum and blunt dissection of the tendons then direct visual bone contact. The aperture through which the nail was inserted was created by. A short awl with a diameter of 3 mm was inserted perpendicularly to the surface of the bone at the intended level. The nail was then inserted through the incision and located the entry point into the bone. Subsequently, the nail was gradually advanced upwards while applying axial traction to the patient's hand, assisted by rotational movements. **(Fig.2)**.

Fig.2 . The nail was inserted into the incision and find the entry hole into the bone

Fluoroscopy was utilized to verify the accurate placement of the radial nail and ensure the appropriate alignment of its tip. Subsequently, the radial fracture underwent closed reduction and was subsequently assessed using both anteroposterior and lateral imaging perspectives. The assistant utilized mild hammer blows to drive the nail forward and secure the T-handle in place, while the surgeon ensured the maintenance of the reduction. The nail was further inserted, orienting its concave side towards the ulna, to restore the radial bow. The nail was advanced until its tip touched the radial neck **(Fig.3)**.

Fig.3 . Elastic nail technique for radius: nail insertion then advanced up to fracture site

In the procedure of ulnar intramedullary fixation, a surgical incision was performed in the vicinity of the olecranon tip. Subsequently, an entry point was established somewhat lateral and distal to the olecranon apophysis through the use of a bone awl. Subsequently, a titanium nail of suitable dimensions was measured and inserted into the medullary cavity using a comparable technique, starting from the proximal piece and progressing towards the distal fragment. **(Fig. 4)**.

Fig.4. Short awl was inserted into the cancellous bone with fluoroscopic guidance

The assessment of the alignment of the fracture pieces was conducted using a C-arm imaging device. Upon determining the adequacy of the reduction, the protruding ends of the nail were initially bent at an approximate angle of 90 degrees, followed by a further cutting at a distance of 1cm from the bone. In cases when closed reduction proves unsuccessful, a minor surgical procedure is performed including

the creation of a tiny incision at the site of the fracture. Subsequently, the fracture is realigned and stabilized using a titanium nail. The process involves trimming the nails, cleansing the wound, and afterwards closing the subcutaneous tissue and skin **(Fig.5)**. Finally take AP and lateral views on the forearm under C-arm **(Fig. 6)**. .

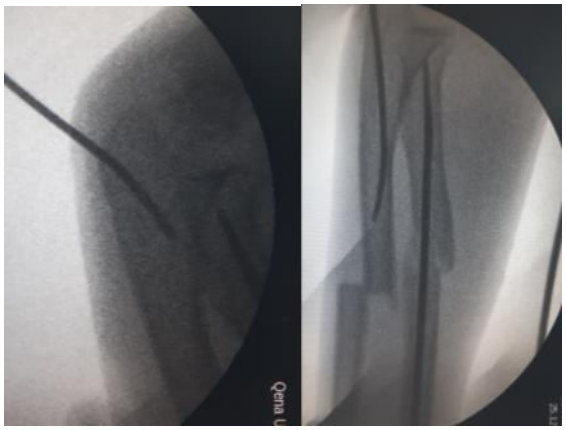

Fig.5. Nail is advanced down to the fracture site

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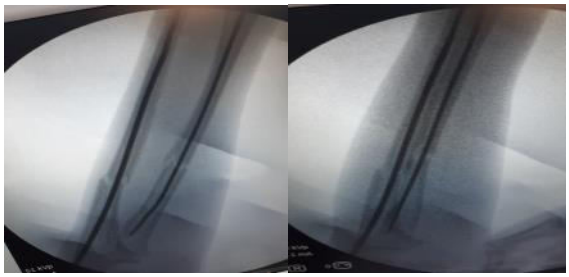

Fig. 6. Final position achieved (C-arm AP and Lateral views).

Group B: Under general anaesthesia, Patient positioning, preparation and disinfection of the entire limb was done as group A, when faced with a fracture of the ulna, a surgical procedure involves creating a longitudinal incision located above the ulna. The presence of the fracture becomes apparent inside the intermuscular gap that is created by the extensor carpi ulnaris and flexor carpi ulnaris muscles. After the implementation of irrigation and the elimination of any fracture hematoma, the fracture is subsequently realigned. Subsequently, a plate of suitable dimensions is chosen to accommodate six cortices on either side of the fracture. The plate is then fixed to the dorsal or dorso-ulnar aspect. In cases when the rotational alignment of a fracture is indeterminate, it is recommended to prioritize the stabilization of the radial fracture. This approach facilitates the restoration of regular pronation and supination movements. The selection of DC plates for Pediatric patients is contingent upon the child's age, with either 3.5 mm or 2.7 mm plates being suitable options. **(Fig.7)**.

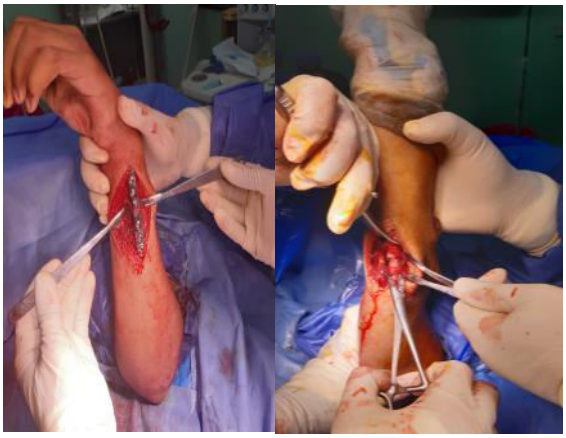

Fig.7. Technique of fracture ulna reduction and fixation using 3.5 mm small DCP

In cases of radius fracture, it is customary to adhere to the radial fracture fixation approach outlined by Thomson. This procedure entails creating a dorsal-lateral skin incision, with a skin bridge measuring approximately 4-5 cm towards the ulnar incision. The fascial layer separating the extensor digitorum communis muscle and the extensor carpi radialis brevis muscle is subsequently incised. Preservation of the distal extensor pollicis longus tendon and superficial radial nerve is important. Subsequently, the fracture is managed in accordance with the treatment protocol, and the operation is finalized by conducting an additional fluoroscopic assessment and evaluating the unrestricted range of motion in the forearm **(Fig. 8, 9)**.

Fig.8. Technique of fracture radius reduction and fixation using 3.5 mm small DCP.

Fig.9 . Intraoperative AP and Lateral images on C-arm

Post-operative care

- In group A patients AE slab or cast was done and was asked to perform active fingers movement.
- Each patient received intravenous antibiotics every 12 hours for a period of two days.
- Limb and circulation care was closely monitored for fear of compartment syndrome and patient advised to active movement of his fingers.
- Following the surgery, a postoperative x-ray was performed to assess fixation and the alignment of the reduction.
- Analgesia was taken until complete resolution of pain.
- Patients were stayed for two or three days then discharged.

Follow-up and Clinical Outcome Evaluation

- The main follow up duration protocol in outpatient clinic visit at 2,6,12 weeks and 6 months after surgery.
- Cast or slab in ESIN group patients was removed after 6 weeks then x-ray done.
- During the final follow-up appointment, patients had an evaluation to determine the extent of motion in the damaged side in comparison to the unaffected side. This evaluation included assessing forearm pronation and supination, as well as flexion and extension of the elbow and wrist.

Statistical analysis

SPSS version 24 was utilized. The data were examined for normalcy with the use of the Kolmogorov-Smirnov and Shapiro-Wilk tests. The qualitative information was shown as a frequency and percentage breakdown. For normally distributed data, mean and SD was used, and for non-normally distributed data, we show the median and a range of values around it called the interquartile range (IQR). $P < 0.05$ was significant.

Results

Forty patients presented with both bone forearm fractures, Twenty patients in each group, Their age ranged between 10 and 16 years old with mean age in ESIN group (11.4 ± 0.96 years) in comparison to plating group (14 ± 1.4 years). Insignificant difference (p-value = 1.0) between groups of study (ESIN group & plating group) regarding gender. There were 18 males (90%) and 2 females (10%) in each studied group

According to mode of trauma In ESIN group , there were 16 patients (80%) injured due to falling on outstretched hand and 4 patients (20%) injured due to motor car accident while in plating group , there were 18 patients (90%) injured due to falling on outstretched hand and 2 patients (10%) injured due to motor car accident.

In ESIN group, there were 14 patients (70%) with closed reduction and 6 patients (30%) with open reduction by small incision over fracture. There was a significant difference between both groups in terms of the use of an intraoperative image intensifier. The mean time of usage in ESIN group was 3 seconds, ranging from 0 to 9 seconds; however, the mean time of usage in plating group was 59.5 seconds, ranging from 47 to 68 seconds ($P<0.001$).Highly statistical significant (p-value < 0.001) decreased surgery time in ESIN group (median = 55 min, IQR = 45 – 60 min) in comparison to plating group (median = 90 min, IQR = 90 – 120 min)**. (Table.1).**

Table 1. Comparison between groups of study regarding surgery time

Variables		**Group A (N = 20)**	**Group B (N = 20)**	**Stat. test**	**P-value**
Surgery time (min)	**Median**	**55**	**90**	**MW = 8**	**< 0.001 HS**
	IQR	**45 - 60**	**90 – 120**		

At final outcome, Insignificant difference (p-value = 0.108) between groups of study regarding flexion, extension (p-value = 0.602)**,**

Pronation: Significantly (p-value = 0.001) decreased pronation at 1st visit in ESIN group (median = 75 min, IQR = 75 – 80) in comparison to plating group (median = 80, IQR = 80 – 85**.**

Insignificant difference (p-value = 0.201) between groups of study regarding pronation at 2nd and 3rd visit. In ESIN group , the median pronation at 2nd and 3rd visit = 85 with IQR = 80 – 85 while in plating group , the median pronation at 2nd and 3rd visit = 85 with IQR = 85 – 85.

Supination: Insignificant difference (p-value = 0.086) between groups of study regarding supination. Location of maximum radial Bow: Highly statistical significance (p-value < 0.001) increased percentage of preserved radial bow location in plating group (20 patients, 100%) in comparison to ESIN group (2 patient, 20%) **(Table. 2)**.

Table 2.Comparison between groups of study regarding location of maximum radial Bow

Variables		Group A (N = 20)		Group B (N = 20)		X^2	P-value
Location of maximum radial Bow	**Preserved**	2	10%	20	100%	**32.7**	**< 0.001 HS**
	Not preserved	18	90%	0	0%		

Union time: Insignificant difference (p-value = 0.529) between groups of study regarding union time. In ESIN group , the median union time = 6.5 weeks with IQR = 5 – 7 weeks while in plating group , the median union time = 7 weeks with IQR = 6 – 7 weeks. **(Table .).**

Table 3.Comparison between groups of study regarding union time

Variables		Group A (N = 20)	Group B (N = 20)	Stat. test	P-value
Union time (weeks)	**Median**	6.5	7	MW = 166	0.369 NS
	IQR	5 – 7	6 – 7		

Complications

- Significantly (p-value = 0.035) increased percentage of superficial infection in ESIN group (4 patients, 20%) in comparison to plating group (0 patients, 0%).
- Insignificant difference (p-value = 0.531) between groups of study regarding delayed union. Delayed union occurred in 2 patients (20%) of ESIN group versus 1 patient (10%) in plating group .
- Insignificant difference (p-value = 0.305) between groups of study regarding neurological deficit. Neurological deficit occurred in 0 patients (0%) of ESIN group versus 1 patient (10%) in plating group (PIN injury with wrist and fingers drop that resolves spontaneously.
- Highly statistical significant (p-value < 0.001) increased percentage of symptomatic hardware in ESIN group (12 patients, 60%) in comparison to plating group (0 patients, 0%).
- Insignificant difference (p-value = 0.305) between groups of study regarding stiffness. Stiffness occurred in 1 patient that improved with physiotherapy (10%) of ESIN group versus 0 patients (0%) in plating group. **(Fig.10)**.

No recorded cases with compartment syndrome, tendon injury, radioulnar synostosis, hardware failure, deep infection , or non-union. The mean hospital stay in both groups was 2 days ranging from (1 to 3 days)

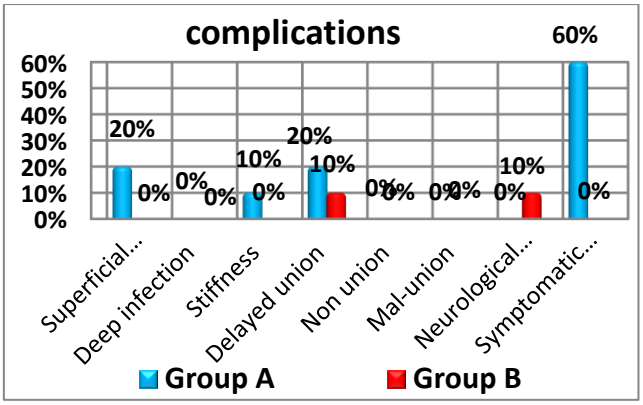

Fig.10 . Comparison between groups of study regarding complications

Discussion

Both-bone forearm fractures can be effectively treated with ESIN and plating techniques. In the case of younger children, non-operative intervention is frequently deemed satisfactory due to the resilient periosteum, open physis, and quick rebuilding capability, which collectively contribute to the restoration of forearm functionality. On the other hand, ORIF with plate and screws is commonly regarded as the preferred surgical intervention for adult patients.. However, the optimal treatment approach for older children and adolescent patients is somewhat controversial due to the unpredictable nature of remodeling capacity in this age group.

Both Elastic Stable Intramedullary Nail (ESIN) and plating can offer advantages and disadvantages as treatment options for forearm fractures. Surgical treatment utilizing ORIF with plate and screws can provide accurate and stable fixation, but unfortunately, it may also result in the opening of the fracture hematoma leads to it's loss, wide periosteal stripping. Additionally, there may be other associated complications, such as intraoperative neurovascular complications and postoperative problems, including delayed union, scarring, infection, and nonunion. These complications may arise due to the loss of the biological environment of factors in the affected area **(Armstrong et al., 2008)**.In addition to the previous complications, it is important to note that the removal of plates can result in significant issues, such as refracture and soft-tissue injury. Conversely, intramedullary fixation is a minimally invasive procedure that is relatively easy to perform and can help maintain proper bony alignment while promoting rapid fracture healing. This approach may be associated with less surgical morbidity and easier hardware removal **(flynn et al., 2010; Lascombes et al., 1990)**. However, it is important to note that there may be potential complications associated with intramedullary fixation, such as compartment syndrome, nonunion due to the persistent gap created by distraction at the fracture ends, and refracture after nail removal.

Our study shows insignificant difference between two groups in forearm range of movement and restoration of forearm function. Other studies also have demonstrated the same results and did not find any significant differences in forearm range of movement **(Reinhardt et al.,2008; Shah et al.,2010; Kose et al.,2008; Thapa et al .,2018).**

Our study shows that the most common mode of trauma causing forearm fracture was FOOSH about 36 patients.

Decreased surgery time in the IMN group (median = 55 min, IQR = 45 – 60 min) in comparison to plate and screws group (median = 90 min, IQR = 90 – 120 min) and this agreed by **Truntzer et al.(2015) and Baldwin et al.(2014)**.

According to **Fernandez et al.(2009)** there is decrease in fluoroscopy time in plating group about 2.2 min in compared to 4.5 min in nail group and this

agreed with our study as the mean time of usage in group A was 59.5 sec, ranging from 47 to 68 sec ; however, the mean time of usage in group B was 3 sec, ranging from 0 to 9 sec (P<0.001).

Our study shows insignificant difference between groups of study (group A & group B) regarding union time. In group A, the median union time = 6.5 weeks with IQR = 5 – 7 weeks while in group B, the median union time = 7 weeks with IQR = 6 – 7 weeks. Other studies also found no difference in union time between two groups **(Reinhardt et al., 2008; Kose et al., 2008; Thapa et al.,2018)**. According to the study conducted by **Shah et al., 2010**; 61 both-bone forearm fractures in patients aged between 11.5-16.9 years were analyzed. These fractures were treated using either flexible intramedullary nailing or ORIF with plating. Interestingly, the study found no difference in the mean time to union between the two groups.

Other study show that the total time required for union was observed to be between 8 to 10 weeks in 93.3% of patients in the DCP (dynamic compression plate) group. In contrast, in the IMN (intramedullary nailing) group, 86.7% of patients experienced unions between 5 to 7 weeks. The difference between the two groups in terms of the time of union was found to be Significantly with a p-value that was considered significant **(Basha et al .,2021)**.Our study found that the nailing group experienced a delay in union in 2 patients and 1 patient in plating group that did not have any significant statistical difference .

In a study conducted by **Schmittenbecher et al. 2008,** a cohort of 532 patients who underwent intramedullary (IM) nailing treatment was examined. The researchers observed 10 instances of delayed union, with an average age of 12.3 years among the affected individuals. **Thapa et al., 2018** Delayed union was seen in three patients treated with nailing for closed bending wedge type of fracture and type 1 open transverse fracture.

In a study conducted by **Flynn et al. 2010,** a total of 149 surgical cases with both-bone forearm fractures were examined, out of which 103 instances were subjected to treatment using intramedullary nailing. The research revealed that the collective incidence of complications related to intramedullary nailing (IMN) amounted to 14.6%. Among the subset of patients aged 10 years or older, delayed union was observed in six out of the 67 individuals. In contrast, there were no instances of delayed union observed in individuals below the age of 10 years. **Baldwin et al., 2014** have also conducted research in this area and It was noted that instances of delayed union and nonunion were infrequent, with a slightly higher occurrence observed in IMN cases. However, it is important to note that this disparity did not reach statistical significance. Previous research has indicated that the occurrence of delayed union following IMN of forearm fractures in pediatric patients may exhibit a higher prevalence in the ulna. This is particularly true in cases involving open reduction, open fracture, and in older patients exceeding the age of 10 years **(Escolar et al., 2012; Kang et al.,2011; Fernandez et al.,2009)**.

In the study conducted by **Venkataraman et al. (2019),** it was shown that both the plating and intramedullary nailing (IMN) groups had instances of delayed union. However, non-union was only observed in 2 participants (6.7%) within the IMN group.

In our study, increased percentage of superficial infection in nail group at site of entry that resolved with antibiotics and dressing (4 patients, 20%) in comparison to plating group.

1 patient in plating group had PIN injury with wrist and fingers drop that resolves spontaneously. No recorded cases with compartment syndrome, tendon injury, radioulnar synostosis, hardware failure, deep infection, or non-union.

In **Truntzer et al. 2014,** study**,** it was determined that both groups exhibited a documented incidence of nonunion and two instances of refracture. Within the cohort of patients who had nailing, an incidence of compartment syndrome was observed in a single individual. Similarly, within the plate fixation group, a solitary occurrence of plate fracture was documented.

According to the study conducted by **Shah et al. 2010**, it was shown that complications occurred in 20% of patients who underwent intramedullary nailing (IMN), with all complications being mild. In comparison, the group of patients who underwent open reduction and internal fixation (ORIF) had a complication rate of 30%, with 19% being minor complications and 11% being serious complications. The study identified many significant problems, namely nonunion in three cases, refracture in one case, and postoperative hematoma in one case. According to **Reinhardt et al. 2008,** the group treated with intramedullary (IM) nailing experienced a total of four severe complications, including two cases of refractures, one case of ulna nonunion, and one case of compartment syndrome. Additionally, the IM nailing group encountered eight minor issues, consisting of four cases of delayed unions, three cases of superficial wound infections, and one case of bursitis over the olecranon. The plating cohort experienced a total of eight problems, consisting of four significant difficulties (two instances of refractures, one case of nonunion, and one occurrence of a broken plate) and four minor complications (four cases of delayed unions). **Kang et al., 2011,** found that in 90 cases who underwent intramedually nailing, compartment syndrome occurred in one case. Other study described extensor pollicis longus rupture and superficial radial nerve injury as potential complications that may arise from dorsal and radial entry of the radial intramedullary nail, respectively **(Cumming et al.,2008 ; Kravel et al.,2007).** In our study, most of patients in plating group complain from scar of operation in comparison with nail group that have smaller scar.

Conclusion

ESIN and plate fixation in adolescent both bone forearm fractures are equally effective treatment options but every modality has its advantages and disadvantages. Nails were found superior to plate fixation in terms of operative, tourniquet time, incision is small and preservation of fracture hematoma. But in the other hand plates were found superior in terms of short time of fluoroscopy, provide rigid fixation, better restoration of the radial bow.

Conflicts of Interest: The authors declare no conflicts of interest regarding the publication of this paper.

References

- **Abraham A, Kumar S, Chaudhry S, Ibrahim T .(2011).** Surgical interventions for diaphyseal fractures of the radius and ulna in children. Cochrane database of systematic reviews. 11(1): 1-14.
- **Armstrong PF, Joughin EC, Clarke HM .(2008).** Pediatric fractures of the forearm wrist and hand. Skeletal Trauma in Children. 3(1): 159-206.
- **Baldwin K, Morrison M, Tomlinson LA, Ramirez R, Flynn JM .(2014).** Both bone forearm fractures in children and adolescents, which fixation strategy is superior - plates or nails? A systematic review and meta-analysis of observational studies. Journal of orthopaedic trauma. 28(1): 8–14.
- **Basha AM, Gajendra G .(2021).** A prospective comparative study of both bone forearm fracture in patients above twelve years of age treated with dynamic compression plating and intramedullary nailing at a tertiary care hospital in Kurnool, Andhra pradesh. Journal of Evolution of Medical and Dental Sciences. 10 (45): 36–38
- **Bhaskar AR, Roberts JA. (2001).** Treatment of unstable fractures of the

forearm in children. Is plating of a single bone adequate?. The Journal of bone and joint surgery: British volume. 83(2): 253–258.

- **Cumming D, Mfula N, Jones JW.(2008).** Paediatric forearm fractures: the increasing use of elastic stable intra-medullary nails. International orthopedics. 32(3): 421-423.
- **Fernandez FF, Eberhardt O, Langendörfer M, Wirth T.(2009).** Nonunion of forearm shaft fractures in children after intramedullary nailing. Journal of pediatric orthopedics. 18 (6): 289-295.
- **Flynn JM, Jones KJ, Garner MR, Goebel J.(2010).** Eleven years' experience in the operative management of pediatric forearm fractures. Journal of pediatric orthopedics. 30 (4): 313–319.
- **Kang SN, Mangwani J, Ramachandran M, Paterson JM, Barry M.(2011).** Elastic intramedullary nailing of paediatric fractures of the forearm: a decade of
- **Reinhardt KR, Feldman DS, Green DW, Sala DA., Widmann RF, Scher DM (2008).** Comparison of intramedullary nailing to plating for both-bone forearm fractures in older children. Journal of Pediatric Orthopedics. 28(4): 403-409.
- **Schmittenbecher PP, Fitze G, Gödeke J, Kraus R, Schneidmüller D .(2008).** Delayed healing of forearm shaft fractures in children after intramedullary nailing. Journal of pediatric orthopedics. 28(3): 303-306.
- **Shah AS, Lesniak BP, Wolter TD, Caird MS, Farley FA, Vander KL .(2010).** Stabilization of adolescent both-bone forearm fractures: a comparison of intramedullary nailing versus open reduction and internal fixation. Journal of orthopaedic trauma. 24(7): 440–447.
- **Thapa U, Wahegaonkar K, Ranjeet N, Sapkota K, Onta P, Thapa P**

experience in a teaching hospital in the United Kingdom. The Journal of bone and joint surgery. 93 (2): 262-265.

- **Kose O, Deniz G, Yanik S, Gungor M, Islam NC .(2008).** Open intramedullary Kirschner wire versus screw and plate fixation for unstable forearm fractures in children. Journal of orthopaedic surgery.16(2): 165–169.
- **Kravel T, Sher-Lurie N, Ganel A .(2007).** Extensor pollicis longus rupture after fixation of radius and ulna fracture with titanium elastic nail (TEN) in a Child: a case report. The Journal of trauma. 63(5): 1169-1170.
- **Lascombes P, Prevot J, Ligier JN, Metaizeau JP, Poncelet T. (1990).** Elastic stable intramedullary nailing in forearm shaft fractures in children: 85 cases. Journal of Pediatric Orthopedics. 10(2): 167-171.
- **Escolar A, Roche A, Bregante J, Gil-Alvaroba J, Sola A, Herrera A .(2012).** Delayed union in pediatric forearm fractures. Journal of pediatric orthopedics. 32(1): 54–57.

.(2018). Comparative study in the outcome of intramedullary nailing to plating for both-bone forearm fracture in early and mid-adolescent age group. Medical Journal. 11(6): 499-502.

- **Truntzer J, Vopat ML, Kane PM, Christino MA, Katarincic J, Vopat BG .(2014).** Forearm diaphyseal fractures in the adolescent population: Treatment and management. European Journal of Orthopedic Surgery and amputation. 25(2): 201–209.
- **Venkataraman S, Ethiraj P, Naik AHS .(2019).** Diaphyseal fractures of the forearm in adults, comparative study of dynamic compression plate versus intramedullary nail. International Journal of Research in Orthopedics. 5(5): 916-20.
- **Wilkins KE (2005).** Principles of fracture remodeling in children. Injury. 36 (1): 3–11.

- **Yung PS, Lam CY, Ng BK, Lam TP, Cheng JC. (2004).** Percutaneous transphyseal intramedullary Kirschner wire pinning: a safe and effective procedure for treatment of displaced diaphyseal forearm fracture in children. Journal of pediatric orthopedics. 24(1): 7–12.