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Original Research Article

A COMPARATIVE ANALYSIS OF FUNCTIONAL OUTCOMES FOLLOWING SURGICAL AND NON-SURGICAL MANAGEMENT OF PAEDIATRIC BOTH-BONE DIAPHYSEAL FOREARM FRACTURES

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ABSTRACT

Background: Diaphyseal forearm fractures (both bones) are frequent in children, and can be treated with either a plaster cast, resulting in immobilization, or with Titanium Elastic Nailing System (TENS) surgery. The decision between the two treatments is controversial, especially concerning union rates, functional outcomes, and complications. **Materials and Methods:** This was a prospective comparative study of 30 patients (aged 5-15) with displaced diaphyseal forearm fractures who were hospitalised between January 2022 and June 2024. The patients were randomly assigned to TENS (surgical fixation) (n=15) or plaster cast (conservative management) (n=15). The baseline and the follow-up clinical and radiological evaluations were conducted. The evaluation of outcomes was done on the basis of radiological union time, the Anderson functional score, and complication profile. **Result:** The mean age in the surgical group was (9.9 years) than the non-surgical group (7.5 years). The leading cause of surgical group was road traffic accidents, and the non-surgical group was mainly related to falls. The radiological union time was lower among the surgical group (8.8 weeks) than the non-surgical group (9.9 weeks). Within 10 weeks, Union was reached in 80% of surgically treated cases as compared to 53.3% of the conservatively treated cases. Functional outcomes were very high or satisfactory in all patients, with slightly higher results in the surgical group (66.7% vs. 60.0%). Surgical complications were observed in one-fifth (20%) of the surgical cases (minor pin tract infection, stiffness, or range restriction) and non-surgical cases (loss of reduction) in 13.3%. **Conclusion:** Non-surgical and surgical management of diaphyseal forearm fractures in children have good results. Nevertheless, TENS fixation has its benefits in promoting reduction, earlier union, and minimizing redisplacement risks, especially in older age and high-energy injuries. The young children with simple fractures and good remodelling potential can still be treated using conservative management.

INTRODUCTION

The overall prevalence of pediatric forearm fractures is approximately 40%.[1] The forearm is an intriguing anatomical feature that allows the hand to rotate and redistributes the forces from the hand to the upper portion of the extremity. Not only is the forearm an axle, but it is also a non-synovial joint. Its skeleton is strangely constructed from two distinct bones, the radius and ulna. These two light and stable bones offer a good range of rotational motion (ROM).[2] The hand's muscles, nerves, and blood vessels are fixed on the turning bone (the radius), which is located far from the wrist and hand. None of the most advanced robots has yet been able to mimic the intricate functions of the hand and forearm.[3] Fractures of the radius and ulna bones of the forearm are common orthopedic injuries in children. It is also important to understand the overall effects fractures might have on a child, which include restricting physical activity. Being so complex and important in relation to the function of the upper limb, forearm injuries can have potentially hazardous consequences.[4] There is no doubt that forearm shaft fractures are potentially harmful and challenging to manage. They are unique and differ from fractures in any other long bones. They are one of the few pediatric fractures that show a real risk of complications and prolonged morbidity.[5] It is generally accepted that the closer the fracture is to the distal physis, the greater the

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potential for remodeling. As a result, more deformity can be accepted in the distal one-third of the diaphysis when compared to the middle and proximal one-third of the forearm.[6] The majority of these fractures can be treated conservatively with closed reduction and cast immobilization of the limb. A recognized failure rate has been reported up to 7% to 32%, and some of the indications for operative intervention are open fractures, irreducible fractures, unstable fractures, pathological fractures, fractures with neurovascular compromise, malunions, and re-fractures.[7] Commonly, two operative treatment modalities are employed at present: open compression plating and flexible intramedullary nailing. Each modality has its own advantages and disadvantages. There have been reports of increasing operative treatment of forearm shaft fractures.[8] Elastic stable intramedullary nailing (ESIN) has become very common in the treatment of long bone shaft fractures in children. It was first reported for the treatment of long bones by French and Spanish surgeons in the late 1970s and early 1980s.[9-11] The procedure is under active research, and innovations, for example, biodegradable implants, are being explored. Plate and screw fixation is becoming rare, and non-operative treatment is less popular in cases of children's forearm shaft fractures. Regardless of the increasing interest in operative treatment (in particular mini-invasive surgery) in forearm shaft fractures, there is great disagreement concerning the indications for operative treatment.[12] The purpose of this study is to assess the outcome of conservative therapy with TENs nailing in children aged 5-15 years with displaced closed diaphyseal forearm fractures.

MATERIALS AND METHODS

This was a prospective study conducted in the Department of Orthopedics, Osmania Medical College and Osmania General Hospital, Afzalgunj, Hyderabad, Telangana. The duration of the study was from January 2022 to June 2024. Institutional ethical approval was obtained for the study after following the protocol for human research. Written consent was obtained from all the parents/guardians. A total of 30 pediatric patients presenting with displaced diaphyseal fractures of both bones of the forearm were enrolled in the study.

Allocation of cases: Patients were allocated to either surgical management with Titanium Elastic Nailing System (TENS) or conservative management with plaster immobilization. Sampling was performed using the convenience sampling method. All patients were evaluated clinically and radiologically, and functional outcomes were assessed at regular intervals.

Inclusion Criteria

1. Age between 5 and 15 years
2. Males and females
3. Simple, displaced diaphyseal fractures of the radius and ulna
4. Fresh fractures (< 1 week old)

Exclusion Criteria

1. Compound fractures
2. Associated neurovascular injury or additional ipsilateral fractures
3. Physeal injuries
4. Fractures with proximal/distal radioulnar joint disruption
5. Patients with systemic or local infection

Clinical Assessment: A comprehensive history was taken on admission that included the mechanism of injury and severity of trauma. General examination included the vital signs and systemic examination to rule out related injuries. The local examination of the forearm was done to record the extent of swelling, deformity, loss of functionality, abnormal movement, crepitus, and shortening. The distal neurovascular status was determined by the pulsation of the radial artery, the capacity of capillary refill, the color of the skin, and the sensory status. All patients underwent radiographs (anteroposterior and lateral positions of the forearm, with the elbow and the wrist).

Conservative Management: Closed reduction was performed under fluoroscopic guidance with traction and counter-traction. Following satisfactory alignment, the limb was immobilized with an above-elbow plaster of Paris (POP) slab, later converted to a full above-elbow cast after one week. Patients were followed with serial radiographs to assess maintenance of reduction and fracture healing. Materials used were POP rolls (4-inch), gauze rolls, and soft cotton padding.

Surgical Management (TENS): Patients selected for operative management underwent TENS fixation following routine preoperative investigations (Hb, blood glucose, renal function tests, HIV, HBsAg, ECG). Preoperative planning included measurement of nail diameter (60% of the isthmus diameter on radiographs).

Instrumentation: TENS nails (2–3 mm), small bone awl, T-handle, “F” tool, nail bender, impactor, hammer, nail cutter, retractors, reduction clamps, periosteal elevators, pneumatic tourniquet.

Procedure (in brief):

1. General anesthesia or brachial block was administered.
2. Patient positioned supine with arm supported.
3. After painting and draping, a pneumatic tourniquet was applied.
4. Retrograde entry point for radius and antegrade entry for ulna were used. Closed reduction was attempted; if unsuccessful, limited open reduction was performed under fluoroscopic guidance.
5. Nails were advanced to achieve three-point fixation while preserving the radial bow. Care was taken to avoid physeal injury.
6. Nails were cut and bent to remain flush with bone, and wounds were sutured.

Postoperative care: The limb was held in an arm pouch and above-elbow POP slab postoperatively.

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The administration of IV antibiotics was done for 4-5 days with open or closed procedure and oral antibiotics up to the time of the removal of the sutures. There was the encouragement of early mobilization of fingers and the shoulder.

Follow-Up and Outcome Assessment: Patients were followed up at 2, 4, 8, and 12 weeks, and then, up to 1 year or until implants are removed. A radiograph was taken at every visit to assess fracture union, which was defined as bridging periosteal callus in 3 or more cortices or elimination of the fracture line. The clinical evaluation of functional outcome included the range of motion of the elbow and wrist (flexion, extension, pronation, and supination).

Statistical analysis: All the available data were refined, segregated, and uploaded to an MS Excel spreadsheet and analyzed by SPSS version 26 in Windows format. The continuous variables were represented as mean, median, standard deviation, frequency, and percentage. The categorical variables were assessed by Student's test for comparison of mean values of two groups. Chi-square test was applied to determine the differences between the two groups. The values of p (<0.05) were considered significant.

RESULTS

A total of 30 pediatric cases of both-bone diaphyseal forearm fractures were included in this study and were divided into two cohorts based on their primary treatment modality: the Surgical group (Group A, n=15) and the Non-Surgical (Conservative) group (Group B, n=15). Table 1 gives the baseline characteristics of the cases included in the study. The mean age of the cohort was slightly higher in the surgical group (9.9 years) as compared to the non-surgical group (7.5 years), and the overall mean was 8.7 years. The distribution characteristics based on age showed that all the cases included for the surgical management were up to 10 years or older (66.7%). The distribution of males appeared to be higher in both groups 53.3% surgical, 86.7% non-surgical) The overall male population in the cohort was 70%. Road traffic accidents were the leading cause of injury in the surgical group, 80% cases, and falls during play were frequently found in the non-surgical group, 66.7% cases. This shows that falls during play could produce less severe injuries, which may be amenable to non-surgical management. Laterality of involvement showed left-sided injuries occurring in 60% of all cases of the surgical group, and right-sided injuries were in 60% of the non-surgical group.

The treatment profile of the cohort is given in [Table 2]. A critical analysis of the table showed that in the surgical group, the majority of cases (73.3%) underwent surgery more than 3 days after injury, and 26.7% of cases were operated on within 3 days. There was a requirement of hospitalization for patients in the surgical group, with a mean duration of hospitalization of 2.4 days. The conservatively managed patients were treated on an outpatient basis. Additional stratification revealed that 60% of the surgical patients were released within 2 days, and 40% took longer before being released. Such results suggest that surgery is linked to a brief but certain inpatient stay, but non-surgical treatment is not linked to hospitalization. Notably, even with a greater initial management duration, surgical patients enjoyed the advantage of a firm fixation, which may have reduced the chances of displacement with a secondary treatment, in comparison to treatment conservatism.

Table 1: Patient Demographics and Injury Characteristics

Characteristic	Surgical Group (n=15)	Non-Surgical Group (n=15)	Total (n=30)
Mean Age (Years)	9.9	7.5	8.7
Age Group, n (%)			
10 years	5 (33.3%)	15 (100.0%)	20 (66.7%)
≥ 10 years	10 (66.7%)	0 (0.0%)	10 (33.3%)
Gender, n (%)			
Male	8 (53.3%)	13 (86.7%)	21 (70.0%)
Female	7 (46.7%)	2 (13.3%)	9 (30.0%)
Mechanism of Injury, n (%)			
Road Traffic Accident (RTA)	12 (80.0%)	5 (33.3%)	17 (56.7%)
Fall	3 (20.0%)	10 (66.7%)	13 (43.3%)
Side Affected, n (%)			
Left	9 (60.0%)	6 (40.0%)	15 (50.0%)
Right	6 (40.0%)	9 (60.0%)	15 (50.0%)

Table 2: Treatment Parameters

Parameter	Surgical Group (n=15)	Non-Surgical Group (n=15)
Injury-to-Surgery Interval, n (%)		
≤ 3 days	4 (26.7%)	Not Applicable
≥ 3 days	11 (73.3%)	Not Applicable
Mean Duration of Hospitalization (Days)	2.4	0
Hospital Stay, n (%)		
≤ 2 days	9 (60.0%)	Not Applicable
≥ 2 days	6 (40.0%)	Not Applicable

[Table 3] compares radiological and functional healing of surgery versus non-surgical treatment. The average radiological time to union was lower in the surgical group (8.8 weeks) than in the non-surgical

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group (9.9 weeks), implying a rapid healing process with TENS fixation. Union was obtained during 10 weeks in 80% of surgically treated patients compared with 53.3% of non-surgical patients, and this supports an earlier trend of union in patients treated by surgery. Functional outcomes measured by means of the Anderson scoring system showed that 66.7 percent of patients who underwent surgery and 60 percent of patients who did not had excellent results, with the rest rated as satisfactory. It is important to note that no unsatisfactory results were reported in any of the groups. The results indicate that both management approaches produce good to excellent functional recovery, but that surgical fixation has slightly higher radiological healing rates and can potentially increase the predictability of union.

Table 3: Radiological and Functional Outcomes

Outcome Measure	Surgical Group (n=15)	Non-Surgical Group (n=15)
Mean Radiological Union Time (Weeks)	8.8	9.9
Union within ≤ 10 weeks, n (%)	12 (80.0%)	8 (53.3%)
Functional Outcome (Anderson Score), n (%)		
Excellent	10 (66.7%)	9 (60.0%)
Satisfactory	5 (33.3%)	6 (40.0%)
Unsatisfactory	0 (0.0%)	0 (0.0%)

[Table 4] presents the observed complications in both groups of treatment. All in all, complications were a bit higher in the surgical cohort (20%) than in the non-surgical one (13.3%). The main complication in the non-surgical group was loss of reduction, which was observed in 2 patients (13.3%), and this indicates the risk of secondary displacement in conservatively broken fractures. On the other hand, the surgical patients reported cases of complications related to implants and procedure, such as pin tract infection (6.7%), elbow stiffness (6.7%), and reduced range of supination/pronation (6.7%). Notably, there were no severe complications of a neurovascular injury or a deep infection among the patients of both groups. The overall frequency of complications was low; however, the trend was different in groups, with conservative therapy being potentially accompanied by the risk of displacement of fractures, and surgical intervention being followed by less serious complications of the procedure. These results indicate that both methods are safe; however, close follow-up should be conducted to identify and address the complications that are unique to each modality.

Table 4: Complications in the cases of the study

Complication	Surgical Group (n=15)	Non-Surgical Group (n=15)
Loss of Reduction	0 (0.0%)	2 (13.3%)
Pin Tract Infection	1 (6.7%)	0 (0.0%)
Elbow Stiffness	1 (6.7%)	0 (0.0%)
Decreased Range of Supination/Pronation	1 (6.7%)	0 (0.0%)
Total Patients with Complications	3 (20.0%)	2 (13.3%)

DISCUSSION

The most frequent long bone fractures in children include both-bone diaphyseal forearm fractures, and their treatment remains controversial between the surgical and non-surgical options, depending on the age of the patient, the displacement of the fracture, and the functional needs.[13,14] The current research study involved a comparison of functional outcomes and complications in patients undergoing Titanium Elastic Nailing System (TENS) fixation versus conservative plaster immobilization, with a specific focus on radiological union, functional scores, and complications in pediatric patients. Demographic profile of our study indicated that surgically treated patients were older, with a mean age of 9.9 years as compared to 7.5 years in non-surgical patients. This is in line with the overall finding that children aged 5 to 10 years, particularly those close to skeletal maturation, are more likely to stabilize via surgery because of reduced forearm remodelling potential. [15,16] The most prevalent mechanism of injury in the surgical group was road traffic accidents (RTAs), and the most prevalent in the non-surgical group was falls. This is probably an increase in the energy of trauma level in older age groups, which requires surgery.[17] Surgically treated patients had a short mean hospitalization (2.4 days), and none of the non-surgical patients needed to stay in the hospital because they were managed on an outpatient basis. Although conservative management does not involve hospitalization, it might involve long-term immobilization and regular radiographic follow-up to detect loss of reduction.[18] Secondary displacement was observed in 13.3% of non-surgical cases in our study, which is similar to previous literature claiming that loss of reduction is among the frequent complications of conservative casting.[19] Radiological results of our study proved that surgical fixation using TENS was slightly better in union, and the average period of healing was faster, with 8.8 weeks and 9.9 weeks in non-surgical patients. Moreover, 80% of surgically treated children had successful union within 10 weeks compared to 53.3% of the conservative group. These results are supported by other researchers who have also indicated that elastic nailing can enhance faster fracture healing and more reliable healing through

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alignment and stability. [20,21] All cases in the current study scored excellent or satisfactory scores in functional outcomes as measured by the Anderson scoring system, and no unsatisfactory results were achieved. Although there were positive functional recovery results in both groups, the surgical group results were slightly greater (66.7% vs. 60%). Previous literature has documented a high union rate and satisfactory functional outcome with both conservative and surgical treatment, although TENS has been linked to earlier forearm mobilization and quicker forearm rotation recovery.[22,23] The complication rate was relatively low in our study. The surgical group had procedure-related problems like pin track infection, elbow stiffness, and slight limitation of supination/pronation in 6.7% of patients each. These are well-recognized and tend to be mild and treatable complications of intramedullary nailing.[24] Compared to non-surgical patients, secondary displacement was at risk since, in two instances, it was recorded. The general complication rates were not high in both groups (20% surgical vs. 13.3% non-surgical), which indicates that both methods are safe when the proper patient selection is conducted. Generally, the current research suggests that TENS fixation and conservative casting are effective in pediatric both-bone forearm fractures with regard to good functional outcomes. Surgical fixation, however, has the advantage of assured maintenance of reduction, earlier radiological union, and reduced risks of secondary displacement, especially in older children, and secondary to high-energy trauma. Younger children with high remodelling potential and with low-energy injuries are still best treated with conservative management.

CONCLUSION

Within the limitations of the current study, we found that both surgical and non-surgical approaches to pediatric both-bone diaphyseal forearm fractures provided favorable functional outcomes. Conservative management remains appropriate for younger children with simple, low-energy fractures due to their higher remodeling potential. However, surgical fixation with Titanium Elastic Nailing System (TENS) demonstrated advantages in maintaining reduction, achieving earlier union, and reducing the risk of secondary displacement, particularly in older children and those sustaining high-energy injuries. Complications were less and manageable in both groups. Overall, TENS offers a safe and reliable option when conservative treatment is unlikely to yield satisfactory results.

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