Surgical management of adolescent both bone forearm fractures using a plate and screws versus an intramedullary elastic nail

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Background
Both bone forearm fractures are common injuries in children and adolescents. In adolescent patients, such fractures may be less frequently amenable to nonoperative management due to the decreased remodeling potential in children approaching skeletal maturity. These fractures are often managed surgically using intramedullary nails (IMNs) or plate fixation. Significant controversy exists between the use of the IMNs and plate fixation for diaphyseal both bone forearm fractures in adolescents.
Objective
This study aimed to evaluate plates and screws versus IMNs in the management of both bone forearm fractures in adolescents.
Patients and methods
Twenty patients were enrolled in a prospective study, 12 males and eight females, their ages ranging from 10 to 14 years (average 11.75). The mean follow-up duration was 13.2 months (ranging from 8 to 18 months). According to our protocol, patients with odd numbers (group A) were treated with plate and screws, and IMNs were used to treat those with even numbers (group B).
Results
The mean operative time in group A was 63.5 min (ranging from 55 to 75 min), while in group B, the mean operative time was 37 min (ranging from 35 to 45 min) ($P<0.001$). The mean time of use of an intraoperative image intensifier in group A was 2 s, ranging from 0 to 7 s. Comparatively, the mean time in group B was 57.5 s, ranging from 45 to 65 s, P value less than 0.001. The union time in both groups ranged from 6 to 8 weeks; the result was statistically nonsignificant. In terms of the supination and pronation range of motion (ROM), group A showed almost no change compared with the other side, at the final follow-up, while group B showed 15° mean loss in the supination ROM, ranging from 5° to 20°, with almost no loss in the pronation ROM ($P=0.032$). In terms of operative time for implant removal, the time needed to remove plates and screws ranged from 30 to 65 min (average 40 min), while the time needed for removal of elastic nails ranged from 10 to 18 min (average 12 min); the result was statistically significant.
Conclusion
IM nailing was found to be superior to plates and screws in the management of adolescent both bone forearm fractures in terms of operative time needed for fixation and removal. However, plates and screws had the advantage that they involved limited intraoperative exposure to the image intensifier.
Level of evidence
Level I.

Keywords:
forearm fractures, intramedullary nails, plates, screws. supination

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Introduction

Both bone forearm fractures are common injuries in children and adolescents. There are many debates about acceptable reduction according to the corresponding age [1].

Younger children, with more growth remaining, have a larger remodeling capacity than adolescents [2]. Most fractures can be treated nonoperatively, with closed reduction and cast application. Less than 10% of pediatric both bone forearm fractures require surgical intervention [3].

As children near skeletal maturity, tolerance for displacement nears adult-like parameters. Over the

last decade, operative management of these fractures has become increasingly more common [3]. Therefore, in adolescent patients, such fractures may be less frequently amenable to nonoperative management due to decreased remodeling potential [4,5]. Irrespective of age, rotational deformities will not correct, and if unacceptable rotational deformity exists, this should be rectified with primary reduction [4].

Successful management of pediatric forearm fractures relies on maintaining a functional forearm range of motion (ROM). The American Academy of Orthopedic Surgeons' standards of normal are 71° for pronation and 84° for supination [4]. Morrey *et al.* [6] set the original standard and suggested that only 50 for both pronation and supination is necessary to function without significant deficit. Difficulty with the activity of daily life can occur with a loss of pronation between 5 and 30 and a loss of supination between 8 and 35° [7,8].

Intramedullary nail (IMN) fixation has been popularized by many surgeons due to limited dissection, shorter duration of anesthesia, reliable maintenance of the alignment, amenability to open and closed fractures, and ease of removal following placement [4]. Disadvantages include the need for immobilization following fixation, inability to treat extreme distal and proximal fractures due to the risk of physeal violation, and the need for a second surgery to remove the nails [4].

Plate fixation is beneficial in comminuted fractures and fractures located on the apex of the radial bow. Fracture extension to the metaphysis or articular surface is also an indication. Moreover, the open reduction can be useful when concern for compartment syndrome exists since the approach provides direct access to open the relevant compartments. However, when plate removal is indicated, residual screw holes theoretically increase the potential of refracture [4].

Significant controversy exists between the use of IM nailing and plate fixation for pediatric diaphyseal fractures. IM nailing is well accepted and is slowly becoming the preferred technique for diaphyseal forearm fracture treatment in young children [9].

Aim

In this study, we aimed to determine the significant difference between both groups and their effects in terms of the time taken to use the image intensifier, hospital stay, union time, final elbow flexion and extension ROM, forearm supination and pronation, and complications.

Patients and methods

This is a prospective randomized study evaluating the results of fixation of the fractured both bone forearms in adolescents using IMNs versus plate and screws. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Aswan University, Aswan, Egypt. In the period between December 2017 and August 2019, 20 patients were enrolled in the study, 12 males and eight females, with their ages ranging from 10 to 14 years, (average 11.75). The mean follow-up duration was 13.2 months (ranging from 8 to 18 months).

According to our protocol, patients with odd numbers (group A) were treated with plate and screws, and IMNs were used to treat those with even numbers (group B). All surgeries were performed by the author in Aswan University Hospital and El-Fayum Insurance Hospital.

All patients fulfilled the inclusion criteria, age between 10 and 15 years, with closed diaphyseal fractures of both bone forearms, completing the protocol of follow-up.

Group A included patients with odd numbers. There were 10 patients, six males and four females; their average age was 11.8 years (ranging from 10 to 14 years). With the patient in the supine position, under pneumatic tourniquet and after an intravenous ceftriaxone antibiotic was administered with induction of general anesthesia, the fractured both bones of the forearm were fixed using small dynamic compression plate (DCPs).

The radius was always fixed using the volar approach, while the ulna was fixed using the direct posterior approach. The plates used had between six and eight holes; they were applied on the volar surface of the radius and the dorsal surface of the ulna. The plates were sometimes mildly precontoured to adapt the radial bow.

The image intensifier was used in five cases before skin closure to ensure adequate reduction and proper screw lengths. A postoperative slab was applied and the stitches were removed after 2–3 weeks. The patient was allowed to return to his or her activities after 6 weeks. The hospital stay ranged from 1 to 3 days (average 2 days).

Group B included patients with even numbers. There were 10 patients, six males and four females; their average age was 11.7 years (ranging from 10 to 14

years). With the patient in the supine position, under pneumatic tourniquet and after an intravenous ceftriaxone antibiotic was administered with induction of general anesthesia, the fractured both bones of the forearm were fixed using elastic IMNs.

The entry to the radius was through the dorsal surface by a small incision, between the third and fourth compartments; the extensor polices longus tendon is protected by direct visualization. The ulna is approached through the tip of the olecranon. Both elastic nails were burden beneath the skin for further removal later on. The image intensifier was used in all cases for proper entry and reduction. Closed reduction was performed in all except two cases. A postoperative slab in the neutral position was applied for 6 weeks. The hospital stay ranged from 1 to 3 days (average 2 days).

All patients (of both groups) were followed up every 2 weeks for 2 months, and then every 2 months for 1 year. No patient needed physiotherapy for ROM. In six patients, the plates and screw were removed after 1 year of fixation, while the others were scheduled for removal.

The date at which full radiological and clinical union were achieved was recorded. In the final follow-up, the supination, pronation, elbow flexion, and extension ROM were recorded. Postoperative complications were recorded in a checkup list including neurovascular injury, tendon injury, nonunion, delayed union, radioulnar synostosis, deep infection, hardware failure, and compartment syndrome.

Statistics

Social Science (SPSS 25) (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) is used for revision of the collected data. The mean and SD were used for parametric numerical data, while the median and interquartile range were used for nonparametric numerical data. The Student *t*-test was used to assess the statistical significance of the difference between the means of the two study groups. The χ^2 test was used to examine the relationship between two qualitative variables. Fisher's exact test was used to examine and test the relationship between two qualitative variables when the expected count is less than 5 in more than 20% of cells.

Results

We studied the operative time starting from the first skin incision to the last skin suture. The mean operative time in group A was 63.5 min (ranging from 55 to 75 min), while in group B, the mean operative time was 37 min (ranging from 35 to 45 min); the difference was statistically significant ($P<0.001$).

There was a statistically significant difference between both groups in terms of the use of an intraoperative image intensifier. The mean time of usage in group A was 2 s, ranging from 0 to 7 s; however, the mean time of usage in group B was 57.5 s, ranging from 45 to 65 s ($P<0.001$).

The average union time in group A was 7.2 weeks, ranging from 6 to 8 weeks (Fig. 1), while the average union time in group B was 7 weeks, ranging from 6 to 8

Figure 1

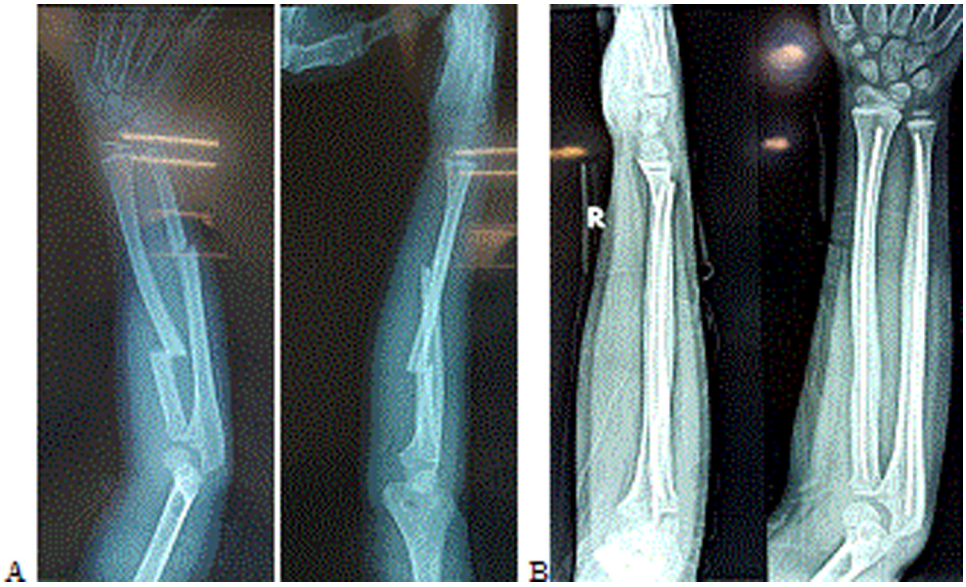
(a) Preoperative radiography of a 13-year-old boy with fractures of both bone forearms. (b) Eight-month postoperative radiography showing complete healing after fixation of fractures with plates and screws. (c–d) Full supination and pronation range compared with the other side.

weeks (Fig. 2); however, the result was statistically nonsignificant.

In group A, the final elbow flexion percentage as compared to the other side ranged from 94 to 100% (mean=98%), while the mean final elbow extension percentage as compared to the other elbow was 97% (ranging from 90 to 100%). In group B, the final mean final elbow flexion and extension were 96 and 97%, respectively, and ranging from 94 to 100% in elbow flexion and from 90 to 98% in elbow extension. However, this mild improvement in ROM favoring the plates and screws was not statistically significant.

There was a statistically significant difference between both groups in terms of the effects on the forearm supination and pronation. Group A showed almost no change in supination or pronation as compared with the other side (Fig. 1), at the final follow-up, while group B showed 15° mean loss in a supination ROM, ranging from 5 to 20°, with almost no loss in the pronation ROM (P=0.032) (Tables 1 and 2).

Figure 2



(a) Preoperative radiography of an 11-year-old boy with fractures of both bone forearms. (b) Two-month postoperative radiography showing almost fracture union after fixation with intramedullary flexible nails.

Table 1 Postoperative follow-up between two methods of operation (nail and P and S groups)

	Method [*n* (%)]		Monte–Carlo Fisher's exact test	
	P and S group	Nail group	*P* value	Significance
Six weeks	3 (30)	2 (20)	1.00	NS
Union time (weeks)				
Seven	4 (40)	4 (40)		
Eight	3 (30)	4 (40)		
Lost degrees of supination				
0	10 (100)	5 (50)	0.032	S
5	0	2 (20)		
10	0	2 (20)		
15	0	1 (10)		
Postoperative splint				
No	6 (60)	0	0.033	S
Above-elbow splint	4 (40)	5 (50)		
Above-elbow cast	0	5 (50)		
Postoperative position				
Neutral	10 (100)	5 (50)	0.002	S
Pronation	0	5 (50)		

S, significant.

The mean hospital stay in both groups was 2 days (ranging from 1 to 3 days). In terms of postoperative complications, there were no recorded cases of neurovascular problems in both groups; however, two patients in group B showed superficial wound infection at the tip of the ulnar nail entry site that responded well to antibiotics and sterile dressings (Table 3).

There was no recorded tendon injury, nonunion, delayed union, radioulnar synostosis, deep infection, hardware failure, or compartment syndrome.

It was the protocol of our institute to remove the plates and screws and the intramedullary nails after 1 year; hence, it was not set as a comparative item. However, we compared the time needed for implant removal in both groups. Plates and screws needed 30–65 min (average 40 min) for removal, while the time needed for removal of elastic nails ranged from 10 to 18 min (average 12 min); the result was statistically significant. Both groups showed no neurovascular complications at the time of implant removal.

Discussion

Many of the studies on pediatric forearm fractures lacked the prospective evaluation of the functional outcome, and operative and postoperative complications [1]. Even those that compared the results of plates and screws versus intramedullary nails in adolescents were either retrospective studies or yielded contradictory results [4]. They found IM nailing to be an effective method of management of fractures of both bones of the forearm, with an equal mean time to the union between IMN and plate-screw fixation [4].

Martus and colleagues studied the complications and outcomes of diaphyseal forearm fracture IM nailing and compared the results in pediatric and adolescent age groups. They found good to excellent outcomes in 91% of pediatric forearm fractures fixed with IMNs, with a twofold increase in the rate of complications in children over the age of 10 years. Compartment syndrome was more common in younger children [10]. However, they lacked a control group to evaluate the results versus those fixed with plates and screws.

Another systemic review and meta-analysis on both bone forearm fractures in children and adolescents favored plating in terms of increasing the odds of an excellent outcome, although the difference was not statistically significant (P=0.13) [1].

In this prospective study, we aimed to evaluate the functional outcomes of plates and screws versus IMNs in fixation of fractures of both bones of the forearm in adolescents.

Table 2 Range of movement between the two groups of postoperative positions within groups that were treated with nails

Lost degrees of supination	Postoperative position in the splint or the cast nail group (10 patients) [*n* (%)]		Monte–Carlo Fisher's exact test	
	Neutral	Pronation	*P* value	Significance
0	5 (100)	0	0.007	S
5	0	2 (40)		
10	0	2 (40)		
15	0	1 (20)		

S, significant.

Table 3 Postoperative complications between the two methods of operation

	Method [*N* (%)]		Monte–Carlo Fisher's exact test	
	P and S group	Nail group	*P* value	Significance
Scar				
No	3 (30)	7 (70)	0.074**c**	NS
Mark	7 (70)	3 (30)		
Infection				
No	9 (90)	9 (90)	1.00	NS
Superficial	1 (10)	1 (10)		
Metal removal				
No	7 (70)	5 (50)	0.65	NS
Removed	3 (30)	5 (50)		

Our study significantly favored the IMNs over plates and screws in terms of the operative time. This result was similar to that of Truntzer *et al.* [4], and Baldwin *et al.* [1]. Baldwin reported that some series reported quicker plating than nailing and considered the operative time to be operator dependent [1].

There was also a significant difference between both groups in use of an intraoperative image intensifier, which ranged in the IMN group from 45 to 65 s (average 57.5 s), while in the group treated with plates and screws, only five patients needed the image intensifier at the end of the surgery to evaluate reduction ranging from 0 to 7 s. Fernandez *et al.* [11] reported that plating was associated with lower fluoroscopy times 2.2 min on average compared to 4.5 min with IMN fixation.

Although the study revealed a statistically significant improvement in supination and pronation ROM in group A (Table 1), compared with decreased supination ROM in group B, we observed that patients who lost degrees in the supination ROM were not strictly adherent to the neutral position of the forearm in the above-elbow slab during the postoperative follow-up period, and they presented to the follow-up clinic with variable degrees of forearm pronation. However, there was no statistically significant variation between both groups in the final elbow extension and flexion ROM (Table 2).

In our study, the nailing group showed a statistically nonsignificant delay in the union than the group treated with plates. Baldwin *et al.* [1] reported that delayed union and nonunion were rare and slightly more common in IMN, although the difference was not statistically significant. In other studies, delayed union after IMN of pediatric forearm fractures has been previously reported to be more common in the ulna with open reduction, open fracture, and in those older than 10 years of age [12–15].

Patel *et al.* [9], in their study, found no statistical difference in functional outcome as measured by the ROM and complication rates. They also reported no study showing a significant difference in time to fracture union. However, the duration of surgery and cosmetic results favored the IMN group [9]. In addition, Firl and Wünsch [16] reported no differences in forearm rotation between the two groups; only the radial bow location when compared with normal values was different in the nailing group and the same in the plate group (69.3% nailing, 62.1% plate, 60.4 normal value).

Kose *et al.* [17], in their rating system, reported that the data of IMN patients in terms of cosmetic outcome were excellent compared with patients who were treated with plating (P=0.001). Teoh *et al.* [18] also found that patients who underwent plating had a worse Manchester scar score. Other studies reported that IMN was associated with improved cosmesis [1].

Another statistically significant variant in this study is the second surgery for implant removal, which favored the nailing group as an easier and faster concerning the plating group. Other studies reported similar results [19,20]. No neurovascular or tendon injuries were documented at the time of primary surgery or implant removal in both groups. Extensor polices longus rupture and superficial radial nerve injury were described in the literature as complications associated with the dorsal and radial entry of the radial IMN, respectively [21,22]

Superficial infection was observed at the tip of the olecranon in the nailing group in two cases.

Our study had no reported cases of refracture or compartment syndrome. Re-fractures were reported in both IMN and plating groups [9]. There were more cases of compartment syndrome in the IMN group than in the plating group [9].

Conclusion

Management of both bone forearm fractures in adolescents using plates and screws was advantageous in terms of the limited intraoperative exposure to an image intensifier, while IMNs were found to be superior to plates and screws in terms of the operative time needed for fixation and removal. However, care should be exercised to secure the postoperative neutral forearm position in the posterior long arm slab, to avoid loss of any degree of forearm supination ROM.

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Conflicts of interest

There are no conflicts of interest.

References

1 Baldwin K, Iii MJM, Tomlinson LA, Ramirez R, Flynn JM. 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. J Orthop Trauma 2014; 19104:8–14.

2 Wilkins KE. Principles of fracture remodeling in children. Injury 2005; 36 (Suppl):3–11.

3 Flynn JM, Jones KJ, Garner MR, Goebel J. Eleven years experience in the operative management of pediatric forearm fractures. J Pediatr Orthop 2010; 30:313–319.

4 Truntzer J, Vopat ML, Kane PM, Christino MA, Katarincic J, Vopat BG. Forearm diaphyseal fractures in the adolescent population: treatment and management. Eur J Orthop Surg Traumatol 2015; 25:201–209.

5 Harrison JWK, Kiely NT, Roberts JA. Treatment of unstable fractures of the forearm in children. J Bone Joint Surg Ser B 2002; 84:147–148.

6 Morrey BF, Askew LJ, Chao EY. A biomechanical study of normal functional elbow motion. J Bone Joint Surg Am 1981; 63:872–877.

7 Rad R, Shwedyk E, Quanbury AOCJ. Normal functional range of motion of upper limb joints during performance of three feeding activities. Arch Phys Med Rehabil 1990; 71:505–509.

8 Raiss P, Rettig O, Wolf S, Loew MKP. Range of motion of shoulder and elbow in activities of daily life in 3D motion analysis. Z Orthop Unfall 2007; 145:493–498.

9 Patel A, Li L, Anand A. Systematic review: Functional outcomes and complications of intramedullary nailing versus plate fixation for both-bone diaphyseal forearm fractures in children. Injury 2014; 45:1135–1143.

10 Martus JE, Preston RK, Schoenecker JG, Lovejoy SA, Green NE, Mencio GA. Complications and outcomes of diaphyseal forearm fracture intramedullary nailing: a comparison of pediatric and adolescent age groups. J Pediatr Orthop 2013; 33:598–607.

11 Fernandez FF, Egenolf M, Carsten C, Holz F, Schneider S, Wentzensen A. Unstable diaphyseal fractures of both bones of the forearm in children: plate fixation versus intramedullary nailing. Injury 2005; 36:1210–1216.

12 Lobo-Escolar A, Roche A, Bregante J, Gil-Alvaroba J, Sola A, Herrera A. Delayed union in pediatric forearm fractures. J Pediatr Orthop 2012; 32:54–57.

13 Kang SN, Mangwani J, Ramachandran M, Paterson JMH, Barry M. Elastic intramedullary nailing of paediatric fractures of the forearm: A decade of experience in a teaching hospital in the United Kingdom. J Bone Joint Surg Ser B 2011; 93 B:262–265.

14 Schmittenbecher PP, Fitze G, Go ÞJ, Kraus R. Delayed healing of forearm shaft fractures in children after intramedullary nailing. J Pediatr Orthop 2008; 28:303–306.

15 Fernandez FF, Eberhardt O, Langendörfer M, Wirth T. Nonunion of forearm shaft fractures in children after intramedullary nailing. J Pediatr Orthop Part B 2009; 18:289–295.

16 Firl M, Wünsch L. Measurement of bowing of the radius. J Bone Joint Surg 2004; 86:1047–1049.

17 Kose O, Deniz G, Yanik S, Gungor M, Islam NC. Open intramedullary Kirschner wire versus screw and plate fixation for unstable forearm fractures in children. J Orthop Surg (Hong Kong) 2008; 16:165–169.

18 Teoh KH, Chee YH, Shortt N, Wilkinson G, Porter DE. An age- and sex-matched comparative study on both-bone diaphyseal paediatric forearm fracture. J Child Orthop 2009; 3:367–373.

19 Carmichael KD, English C. Outcomes assessment of pediatric both-bone forearm fractures treated operatively. Orthopedics 2007; 30:379–383.

20 Shah AS, Lesniak BP, Wolter TD, Caird MS, Farley FA, Vander Have KL. Stabilization of adolescent both-bone forearm fractures: a comparison of intramedullary nailing versus open reduction and internal fixation. J Orthop Trauma 2010; 24:440–447.

21 Cumming D, Mfula N, Jones JWM. Paediatric forearm fractures: the increasing use of elastic stable intra-medullary nails. Int Orthop 2008; 32:421–423.

22 Kravel T, Sher-Lurie N, Ganel A. Extensor pollicis longus rupture after fixation of radius and ulna fracture with titanium elastic nail (TEN) in a child: a case report. J Trauma 2007; 63:1169–1170.