STUDY OF FUNCTIONAL OUTCOMES OF TITANIUM ELASTIC NAILING SYSTEM IN PEDIATRIC BOTH BONE FOREARM FRACTURE

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Abstract:

Background: Pediatric forearm fractures are among the most common cases encountered in Out Patient Department. Successful treatment of both-bone forearm shaft fractures results in restoration of anatomic alignment and full recovery of range of motion. Although closed reduction and casting is the preferred treatment method, outcomes remain variable & it is known for failure despite of good orthopedic casting techniques. This has led to increased use of elastic nails.

Aims: To evaluate the functional & clinico-radiological outcome and complications in forearm fractures in children treated with titanium elastic intramedullary nails. Outcomes were examined in order to formulate the treatment protocol for both bone forearm fracture in pediatric age group.

Material and Methods: 31 children with both bone forearm fracture with mean age 9.5 years were assessed clinically and radiologically pre-operatively & post-operatively and were followed up for 12 months. Mid diaphyseal fractures were more common with 67.7%. Transverse and short oblique fractures were more frequent fracture types than segmental and comminuted types. 41.9% of the patients required mini open procedure for reduction of fracture. There is a significant improvement of symptoms reflected by VAS score for pain and functional scores like DASH Score and Grace-Eversmann scoring. Union was achieved in 30 patients with a rate of 96.8% by 6 weeks’ period. There was no limb length discrepancy, rotational or angular deformity in any patients

Conclusions: TENS is an effective and minimally invasive method of fixation of forearm fractures with excellent results in terms of bony union and functional outcomes with minimal complications. Therefore, we strongly recommend its use in management of pediatric forearm fractures.

Key words: Titanium elastic intramedullary nail, Both bone forearm, paediatric fractures
Introduction

Injuries to the shaft of radius and ulna are among the most common reasons for Children to receive orthopedic care and are among the most challenging Because of their inherent instability and risk of complications. Successful treatment of both-bone forearm shaft fractures results in restoration of anatomic alignment and full recovery of range of motion. Although closed reduction and casting is the preferred treatment method, outcomes remain variable & it is known for failure despite of good orthopedic casting techniques. This has led to increased use of elastic nails.

Methodology

In the above context we have studied 31 patients of 5 to 15 year age group for to determine the rate of union, functional outcome and complications in forearm fractures in children and adolescents treated with titanium elastic intramedullary nails over a period of 1 year. All 31 patients were treated with TENS using standard surgical procedure due to failure of non-operative management. All patients were immobilized in above elbow splint for 4 weeks followed by gradual mobilization exercises. We excluded patients having compound or pathological fracture.

All operated patients were evaluated preoperatively and postoperatively on each subsequent follow-up with Visual Analogue Scale (VAS) for assessment of pain, Disabilities of the arm, shoulder and hand (DASH) Score to assess functional improvement, Grace-Eversmann criteria to evaluate the union and range of motion. Follow-up visits were done at 1, 2, 3, 6 & 12 months after surgery till radiologic healing was seen. Fracture union was defined as bridging callus across the fracture and disappearance of fracture gap in AP and Lateral views of radiograph.

Results

The age of these patients ranged from 5-15 years with an average age of 9.5 Years. Out of 31 patients, 24 patients (77.4%) were males and 7 patients (22.6%) were females male preponderance with sex ratio of 3.4.

In radius and ulna, majority of fractures, 19 (61.3%) were transverse and 10 (32.3%) were short oblique type and 1 (3.2%) was of comminuted variety and 1 (3.2%) was segmental.

21 Patients (67.7%) had mid diaphysis fractures, 3 (9.7%) had fracture at Upper one third level and 7 (22.6) patients had lower one third fracture radius and ulna. Among the 31 patients treated with titanium elastic nailing, 18 (58.1%) Patients required close manipulation for negotiation of nail through fracture Site for both radius and ulna, 6 (19.4%) patients required mini open Procedure for both radius and ulna, 5 (16.1%) patients required only radius Mini open procedure and 2 (6.5%) required ulna to be open reduced.

In our study, we quantified the pain of all 31 patients from preoperative period to 9 months of post-operative period by Visual Analogue Scale. In Pre-operative evaluation mean of VAS score for 31 patients was 8.19 with Standard deviation of 0.946 with minimum score of 6 and maximum score Of 10. In immediate post-operative evaluation mean VAS score was 6.81 With standard deviation of 1.558 with 3 as minimum score and 10 as Maximum score which on progressive evaluation depicted the drop of mean VAS score to 1.13 with standard deviation of 0.499 at 6 months’ post Operative evaluation.

Out of 31 patients treated with titanium elastic nailing system No one had clinically visible residual deformity at the 9 months’ post-operative Evaluation. Mean range of motion for radioulnar joint was 87° supination to 84° Pronation at 6 months and 90° supination to 90° pronation at the end of 9 Months explaining the loss of range of motion for pronation more than Supination. [TABLE-1]

Average duration of radiological union was 6 weeks. The fracture was considered as united when there were no subjective complaints, radiologically when the fracture line was not visible. Arbitrarily, those radial and ulnar fractures which healed in less than 6 months were classified as united; those which required more than 6 months to unite and had no additional operative procedure were classified as delayed union; and those which failed to unite without another operative procedure were classified as non-union. 30 (96.8%) patients had sound union in less than 6 months, 1 patient (3.2%) had a nonunion of ulna.

None of the patients treated with titanium elastic nailing were having any limb length discrepancy at the end of 9 months.

On preoperative evaluation, all 31 patients were having angulation of both radius and ulna, but at 9 months follow up postoperatively, none of the patients had any angular deformity.

All 31 (100%) patients treated with titanium elastic nailing were having radial Bow restored on postoperative evaluation at 12 months.

None of the patients had rotational or translational deformity at the end of 12 months post operatively.

Using the Grace-Eversmann scoring system[6] [TABLE-2] we had
30 patients with Excellent results, 1 patients had an unaccept able result at the end of 9 Months. [TABLE-3] The failure was due to ulnar nonunion which was later treated by Open reduction and internal fixation with bone graft.

For functional outcomes, we used DASH questionnaire. Study shows the mean DASH score at 9 months’ evaluation was 10.6 with Minimum score of 4.6 to maximum score of 22.5 with standard deviation of 4.76. 0 to 100 scale of DASH score represents 0 as least disability and 100 as Maximum disability. According to the DASH score protocol mean DASH score of 10.6 represents the minimal disability at 9 months of evaluation.

Post operatively, complications were seen in only 2 patients. 1 (3.2%) patient had ulnar nail back out, for which reinsertion of nail and above elbow plaster immobilization was done. 1 (3.2%) patient had ulnar non-union for which open reduction and internal fixation with bone grafting was done. [TABLE-4]

Discussion

Historically closed reduction and POP cast immobilisation has been the mainstay of treatment for fractures in both bones of forearm in children. However, fractures tend to re-displace especially in older children. The acceptability criteria in closed reduction have always been a matter of great debate. As mentioned in literature, angular deformity of >10° and complete displacement are not acceptable1–4. Also, younger children due to better remodeling potential, tend to tolerate greater deformity much better than older ones.

Diaphysis fractures of the radius and ulna in children are usually managed by closed reduction and cast immobilization. In contrast, open reduction and internal fixation with plates is recommended in adult forearm fractures to avoid manson and loss of function5,6.

Operative options for internal fixation of pediatric forearm fractures include plating, intramedullary nailing, and pins if indicated. Intramedullary nailing for radius ulna fractures in children offers an alternative form of fixation with few reported complications.

Intramedullary nails function as an internal splint and provide three-point fixation to maintain bony alignment7. End-to-end reduction helps to control rotational alignment, and limited motion at the fracture site promotes formation of external callus by converting shear stress at the fracture site into compressive forces. Intramedullary fixation promotes rapid union, reduces the risk of infection and synostosis, and avoids unsightly incisions that are required with plate fixation and hardware removal8. Patients with longer operative time were at higher risk of developing compartment syndrome. Rod removal is a minor procedure that does not create stress and thus decreases the risk of refracture. Limitation of forearm rotation is comparable with that described in nonoperative treatment series.

In present study, children were in age group of 5-15 years with mean age of 9.5 years. Similar observations were also made by Mohammed H et al. (9.3 years)9, Qidwai SA (11 years)10 and Garg NK et al., (11.8 years)11. In present study, out of 31 patients, 24 patients (77.4%) were males and 7 patients (22.6%) were females showing male preponderance. Sex ratio was 3.4. This is consistent with the study of Landin12 describing that overall risk of fracture in children slowly increases for both male and females until they are 11 or 12 years old and then drops for females and increases further for males.

There was fracture of shaft of forearm bones at proximal 1/3rd in 3 patients (9.7%) all of them were among age group of 11-14 years. There was fracture forearm at middle 1/3rd in 21 (61.7%) and 6 among these were of age group of 11-14 years. Fracture forearm at distal 1/3rd in 7 (22.6%) patients who were in age group of 5-15 years. The mean age of incidence of proximal third fractures in our study was 9.5 years which was similar to study conducted by Celebi L et al.13, in which mean age of patient was 10.6 years. These findings are indicative of the fact that proximal fractures are more likely to occur in older children (>10 years).

Middle 1/3rd fracture is most common (61.7%). This is consistent with the Mohammed H et al14 with 66.7% of fracture incidence in middle third of the forearm.

Among 31 radius fractures, 19 (61.3%) were transverse and 10 (32.3%) short oblique type and 2 (6.3%) was comminuted variety and 1 (3.2%) was segmental among 31 ulna fractures 16 (51.6%) were transverse and 13 (41.9%) short oblique type and 1 (3.2%) was comminuted variety and 1 (3.2%) was segmental showing higher no of simple type transverse or short oblique fractures owing to the fact that the injuries in children are low energy injuries.

Out of 31 patients, 18 were treated with Titanium elastic nailing with closed reduction under fluoroscopy guidance. 13 patients required either both or one of them to be reduced with limited open approach. This is consistent with the study of
Mohammed H et al. “A retrospective review of 21 children with unstable forearm fractures treated with flexible intramedullary nail fixation. Intramedullary nail fixation of both bones was performed in 17 patients, radius in 3 cases, and ulna in one case. A limited open approach to one or both bones was necessary for insertion of the intramedullary nail in 12 cases”.

In this study the mean VAS score for pain in 31 patients in pre-operative Evaluation was 8.19 with standard deviation of 0.946 which on progressive Evaluation depicted the drop of mean VAS score to 1.13 with standard Deviation of 0.499 at 6 months’ post operatively.

All 31 patients on 6 months follow up, had mean supination & pronation range of motion 87⁰ & 83⁰ respectively which on 9 months’ evaluation were 90⁰ & 90⁰ respectively. Similar results have been reported in literature in study by Kapoor V et al.14, in which 16% of patients had some loss of motion at forearm over a 6 months’ follow-up period. (IMAGE-1, 2)

Present study shows average duration of union was 6 weeks & 30 (96.8%) patients had sound union in less than 6 months, 1 patient (3.2%) Had a non-union of ulna. For functional outcomes, we calculated range of motion and presence of union at the end of 9 months with Grace – Eversmann criteria, that evaluated the functional outcomes. Using the Grace-Eversmann scoring system we had 30 (96.8%) patients with excellent results, 1 (3.2%) patient had an unacceptable result. The failure was due to ulnar non-union which was later treated by open reduction and internal fixation with bone graft.[IMAGE-3,4,5].This is consistent with the findings of Amit et al15. Amit et al described the results of treatment of 20 unstable diaphyseal fractures of the forearm in adolescent patients treated with closed intramedullary nailing. All fractures united within 6 weeks.

For functional outcomes we used DASH questionnaire in this study. Study shows the mean DASH score at 9 months’ evaluation was 10.6 with minimum score of 4.6 to maximum score of 22.5 with standard deviation of 4.76. 0 to 100 scale of DASH score represent the 0 as least disability and 100 as maximum disability. As per the DASH score protocol mean DASH score of 10.6 in our study represents the minimal disability at 9 months of evaluation.

**Conclusion**

Forearm fractures are common in pediatric population. Due to high chances of re-displacement internal fixation is preferred over conservative management in older children (more than 11 years old) & in proximal 1/3rd forearm fractures. TENS is a modality which aids in the maintenance of radial bow and interosseous space between forearm bones while sparing the physis, thus achieving good functional results in terms of forearm movements. From the present study, we conclude that TENS is an effective and minimally invasive method of fixation of forearm fractures with excellent results in terms of bony union and functional outcomes with minimal complications. Therefore, we strongly recommend its use in management of paediatric forearm fractures.
Table 1: -Mean Range of Motion at Elbow and Radioulnar joint

<table>
<thead>
<tr>
<th>Mean ROM</th>
<th>Elbow</th>
<th>Radioulnar joint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flexion</td>
<td>Extension</td>
</tr>
<tr>
<td>6 weeks</td>
<td>114°</td>
<td>26°</td>
</tr>
<tr>
<td>3 months</td>
<td>123°</td>
<td>13°</td>
</tr>
<tr>
<td>6 months</td>
<td>135°</td>
<td>1°</td>
</tr>
<tr>
<td>9 months</td>
<td>138°</td>
<td>0°</td>
</tr>
</tbody>
</table>

Table -2: Grace-Eversmann criteria

<table>
<thead>
<tr>
<th>Results</th>
<th>Fracture Union</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Present</td>
<td>≥90%</td>
</tr>
<tr>
<td>Good</td>
<td>Present</td>
<td>≥80%</td>
</tr>
<tr>
<td>Acceptable</td>
<td>Present</td>
<td>≥60%</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>Absent</td>
<td>≥60%</td>
</tr>
</tbody>
</table>

Table -3: Results of Grace-Eversmann criteria at the end of 9 months

<table>
<thead>
<tr>
<th>Results</th>
<th>Number of patient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>30</td>
<td>96.8</td>
</tr>
<tr>
<td>Good</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Acceptable</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>1</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Table – 4: Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Number of patient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial /Deep Infection</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Implant back out-Nailing</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td>Radioulnar synostosis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nerve injury-Posterior interosseous nerve injury</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-union</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td>Delayed union</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>6.4%</td>
</tr>
</tbody>
</table>

References

13. Celebi L, Muratlı HH, Doğan O, Yağmurlu MF, Akşahin E, Biçimoğlu A. The results of intramedullary nailing in children who developed redisplacement during cast treatment of both-bone

