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Safety, efficacy and functional outcome of flexible nailing (ESIN) in unstable fractures of both bones of forearm in children

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Abstract

Background: Elastic intramedullary nailing has been designed and is being used. Elastic intra-medullary nailing, a minimally invasive technique, confers elastic and stable osteo-synthesis. Elastic stable intra-medullary nailing (ESIN) consists of introducing one or two elastic nails through the metaphyseal flare into the medullary canal, advancing them through the fracture site and then impacting them into the opposite meta-physis.

Methods: The prospective descriptive study was carried out in our Hospital from March 2017 to February 2018. The follow-up study continued till October 2018. Thus, the recruitment period was of 12 months and the follow-up period was a mean of 12.8 months (range: 8 to 19 months). Functional outcome was measured according to the Daruwalla's clinical grading, Price *et al.* criteria; and UEF index (46, 64).

Results: The excellent to good results as per UEFI questionnaire was 96.16%. Excellent to good results were obtained using Daruwalla's & Price *et al.* measurements.

Conclusion: Elastic intramedullary nailing gives good results in paediatric forearm fractures.

Keywords: Elastic nailing, forearm fractures, paediatrics

Introduction

Forearm dia-physeal fracture is one of the three common upper limb fractures IN the paediatric population [1, 2, 3]. Unlike the adult forearm dia-physeal fractures, which has undergone tectonic shift in its management concepts [4, 5, 6, 7], its paediatric corollary continues to be viewed more cautiously. Though the concept of instability in forearm diaphyseal fracture is not new, it has acquired better acceptance and understanding with our growing knowledge [6, 13, 18]. This short-term prospective study shall be aimed towards establishing the efficiency of intra-medullary nailing in indicative paediatric forearm fractures as with regards to their functional, clinical and radiological outcomes.

Aims and objectives

To assess Safety, Efficacy and Functional outcome of flexible nailing with (ESIN) in unstable fractures of both bones of forearm in children.

- To determine the clinical spectrum of paediatric patients who shall undergo ESIN for both bones forearm fractures.
- To assess the functional outcome based on clinical parameters, Daruwalla's grading, Price *et al.* [10]; grading and the scores obtained by the Upper Extremity and the Functional Index (UEFI) [11].
- To assess fracture union, time to union, fracture alignment and verify re-establishment of the natural radial bow (based on radiographs).

Materials and Methods

The prospective descriptive study was carried out in the Orthopaedics Department of Sri Muthukumaran Medical College and Hospital, Chennai from March 2017 to February 2018. The follow-up study continued till October 2018. Thus, the recruitment period was of 12

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months and the follow-up period was a mean of 12.8 months (range: 8 to 19 months). The study was approved by the Institutional review board of our hospital.

Inclusion criteria

- a. Completely displaced and unstable dia-physeal fracture of either or both bones of the forearm in children of the age group 5 to 14 years were all included.
- b. Oblique, transverse and short spiral dia-physeal fractures were included.
- c. Fractures presenting within 2 weeks of injury, alone were included.
- d. Closed dia-physeal fracture and Type-I GustilloAnderson open fractures were included.

Exclusion criteria

- a. Pathological fractures were excluded.
- b. Open-fractures were excluded, except for Type-I Gustillo-Anderson.
- c. Nailing done for non-union and delayed-union were excluded.

Results

26 children in the age group of 5 to 14 years of age and conforming to our inclusion criteria, qualified for Titanium Elastic Nailing of the forearm bones, in the ear-marked recruitment period from March 2017 to February 2018. Recruitment of fresh patients stopped by February 2018, in order that the minimum follow-up period would be 8 months [Mean 12.8 months; range: 8 to 19 months]

Thus, the excellent to good results as per UEFI questionnaire was 96.16%

We used the modified Schemitsch and Richard’s method to calculate the location of the radial bow in the children who underwent flexible nailing. The mean distance of the site of the radial bow was located at 66.32% (SD +/- 4.7%) of the radial length. The mean value of maximum radial bow was 5.13% (SD +/- 0.26%). It is comparable to Firl’s criteria which specifies that the mean distance of the radial bow should be around 60% and the maximum radial bow should be less than 10% of the radial length. There was no limb length discrepancy between the operated and non-operated limbs in our group.

The average cost of two intra-medullary nail varied between INR12,000.00 to INR 16,000.00. The analysis revealed that the total expenses incurred during the hospitalization were approximately INR 38,500.00. This cost can be justified considering the fact that the surgery was offered to only carefully selected patients with relevant indications for operative management, who other-wise might have ended up with resultant deformity requiring corrective osteotomy or significant life style modification and altered self-perception. There was no observed case of refracture in our study group.

In the age and sex distribution male to female ratio was 9:4 with a clear male preponderance. Maximum number of children were in the age group of 9 to 10 years at 50% (n=13) and the least were in the age group of 5 to 6 years at 7.7% (n=2) as also in the age group of 13 to 14 again at 7.7% (n=2). Around 77% (n=20) number of cases were those involving the right forearm and 73% (n=19) of cases were those involving the middle third fractures of the forearm. In 65.4% (n=17) of cases, RTA was the main mechanism of injury. Among the total 26 cases 77% (n=20) were of the closed type and remaining 23% (n=6) of cases were of the Gustillo-Anderson Type I open fractures. OA-OTA type 22-D / 5.1 and 5.2

constituted, 46.1% (n=12) of all cases. Nail size range from 1.5mm diameter to 3.0 mm diameter were used to fix the total of 44 bones (22 radius and 24 ulna). 47.7% (n=21) of all cases had their bone fixed with the TENS 2.5 mm diameter nail. The mean average time between injury and surgery was 2.7 days and the mean average stay at hospital after surgery was 7.3 days. The average union period was 6.2 weeks. 88.46% (23/26) of cases achieved union within two months and 11.54% (3/26) of cases within two months and two and a half months.

With regard to clinical and functional outcomes

- As per the Daruwala criteria; we had 92.31% excellent to good outcomes and no poor outcomes.
- As per the price *et al.* criteria; we had 96.16% excellent to good outcomes and no poor outcomes.
- As per the (UEFI) upper extremity functional index questionnaire outcomes; we had again a 96.16% excellent to good outcomes and no poor outcomes.
- The mean average considering all the above criteria and questionnaire, brings the tally of good to excellent results to 94.88%.

Discussion

Our series of 26 patients, 80.82% (n=21) cases were of age group below 10 years of age, remaining 19.18% (n=5) cases were in the age group between 11 to 14 years. The water shed zone! Were rules of acceptability of angulation and mal-rotation take a sweeping change.69.20% (n=18) of these were male and 30.80% (n=8) were females. There was a clear male preponderance in our series as the M:F ratio was 21:5. In 69.23% (n=18) cases, both the radius and ulna were fractured, in 23.08% (n=6) cases ulna alone was fractured and in 7.69% (n=2) cases radius alone was fractured. By far the commonest mode of injury 65.40% (n=17) were due to fall on an outstretched hand. In all, 44 nails were surgically deployed for as many fractured forearm bones. The most widely used nail diameter in 47.70% (n=21) cases were the 2.5mm variant. However, in the entire study range from 1.5mm diameter Tens to 3.0 mm diameter TENS were deployed.

As per the OA-OTA classifications, Type 22-D/5.1 and 5.2 constituted 46.1% (n=12) of all our cases. The mean injury to surgery time was 2.7 days (range: 1 to 6 days) and the mean surgery to discharge time was 7.3 days (range: 5 to 10 days). Radiological union was achieved by 2 and a half months in all cases and within two months in 88.46% (n=23) of cases. The average union period in weeks was 6.2 weeks.

Table 1: Our good to excellent clinical and functional outcomes were as follows

Daruwalla Criteria %age / ‘n’	Price <i>et al.</i> criteria ‘n’ % age	UEFI criteria ‘n’ / % age
92.31 (n=24)	96.16 (n=25)	96.16 (n=25)

Lyons *et al.* in a review of literature involving 68231 children sited a male to female propensity of 63.7%:39.1%. Lyons *et al.* [12] and Ceroni *et al.* [13] cited that the majority of fracture of the paediatric forearm occurred in the distal third. In our study 73.10% (n=19) cases were those of the middle third forearm, 15.38% (n=4) cases were of proximal third forearm and 11.52% (n=3) cases were of the distal third forearm. Ceroni *et al.* [14] and Ryan *et al.* [15] had reported a bimodal peak incidence, one occurring between 5 to 9 years and another occurrence between the age of 10 to 14 years. In our study similarly, 80.77% (n=21) cases were in the age group 5

– 10 yrs.

In the study by Sinikumpu *et al.* [16] and Ryan *et al.* [17] the most common mechanism of injury (83%) was due to a fall, while direct trauma was a distant second (10%). In our series 65.4% (n=17) cases had fall on out-stretched hand as the most common mode of injury and RTA as a cause, constituted a meagre 15.4% (n=4) cases. The gold standard for paediatric forearm fractures as cited by Jones K *et al.* [69] remains closed reduction and casting. In 12 months of recruit period of our study, in all 66 cases of paediatric forearm fracture were addressed, of which 60% (n=40) cases qualified for conservative management and the remaining 39% (n=26) alone qualified as per our inclusion criteria.

Our study had generated 92.31% good and excellent outcome by Daruwala criteria, 96.16% by Price *et al.* criteria and 96.16% as per UEFI questionnaire. Hence the functional end results of operated TENS nailing were credibly good. It has been shown by Shah AS *et al.* [71] that 15 to 20 degree of angulation the middle third of the forearm can lead to a major loss of forearm rotation.

Were open fractures. In our series, 69.23% (n=18) cases were of closed both bones and 23.07% (n=6) cases were of the open Gustillo-Anderson Type 1 injury. In his series too, just like in our study all fractures healed by 3 months. Our good to excellent outcomes of an average of 94.88% was superior to the study by Kang *et al.* [76] where it was reported at 84.44%. There were mild complication and no fracture non-union, compartment syndrome or re-fracture encountered in our series.

Conclusion

Our series is too small to draw high end conclusions for paediatric forearm fracture management. Having said that, the general trends that we witnessed during the course of this study points to the following conclusions:

1. Elastic stable intra-medullary nailing is a safe and reliable method for internal fixation of unstable forearm fractures.
2. Deviation from the basic principles of ESIN which includes choosing the suitable size and material of flexible nail, suitable nail entry point and surgical approach, will lead to avoidable complications
3. Lateral entry point for radial nail puts the superficial radial nerve at risk.
4. The functional results at 1 year are maintained and uncomplicated cases may be discharged from regular follow-up at this period.
5. Immobilization during the immediate post-operative period for 4 to 6 weeks is advisable.
6. Hardware exit is desirable and probably timed at about 6 months from the time of surgery.

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