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A Prospective Study of Functional Outcome of both Bone Forearm Fractures Managed with Titanium Elastic Intramedullary Nail in Pediatric Age Group

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ABSTRACT: Both bone forearm fractures are some of the common orthopedic injuries in children and these are reasons for serious co-morbidities. It is not only crucial to properly treat them, but also critical to understand the overall affects that may have on a child, possibly restricting physical activity. Almost 40% or more of pediatric fractures are forearm fractures. The majority of these fractures are managed by conservative care, including closed reduction and immobilization with a cast. A known failure rate has been estimated to range from 7% to 32%. Currently, open compression plating and flexible intramedullary nailing are the two surgical therapy techniques most frequently used. Each modality has benefits and drawbacks. This study's objective is to evaluate the functional outcome and complications of titanium elastic nailing in pediatric patients with both-bone forearm fractures. In our study, majority of the patients were boys, with an average age of 10.5 years being the most common, and self-fall while playing was the most common mode of injury. The surgery required minimum dissection, short operation time with hardly any risks of intraoperative complications. The average fracture union time was 8.9 weeks with a range of 7 to 11 weeks with patients recovering near normal functions of forearm at the earliest. We didn't encounter any major post-operative complications in our study, and of the patients had excellent range of motion at wrist, elbow and radio-ulnar joints and had satisfactory range of motion. It can be concluded from our study that Titanium elastic nailing system has great results with benefits of early union, excellent recovery of function, minimal invasive surgery, and shortened surgical time in pediatric population for both bone forearm shaft fractures.

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INTRODUCTION

The forearm is an intriguing anatomical feature that allows the hand to rotate and redistributes 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[1]. Its skeleton is strangely constructed from the radius and ulna, two distinct bones. 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[3]. None of the most advanced robots have yet been able to mimic the intricate functions of the hand and forearm[4]. The proper function of the upper limb depends on the forearm. Forearm injuries can have potentially dangerous results since they are so intricate and crucial to the upper limb's function. Without a doubt, forearm shaft fractures can be dangerous and difficult to treat[5]. They are distinct from fractures in other long bones and are different from them[6]. One of the rare pediatric fractures with a real risk of complications and extended morbidity is this one[7]. It is generally agreed upon that the possibility for remodeling increases with the distance between the fracture and the distal physis. As a result, the distal third of the diaphysis can accommodate more deformity than the middle and proximal thirds of theforearm[10]. The majority of these fractures are amenable to conservative care, including closed reduction and immobilization with a cast. Open fractures, irreducible fractures, unstable fractures, pathological fractures, fractures with neurovascular compromise, mal-unions, and re-fractures are some indications for surgical intervention, and there has been a failure rate of up to 7% to 32% reported[11,12]. Currently, open compression plating and flexible intramedullary nailing are the two surgical therapy techniques most frequently used. Each approach has its own benefits and drawbacks[10]. Forearm shaft fractures are reportedly being operated on more frequently. The procedure known as elastic stable intramedullary nailing (ESIN) has become widely used to repair long bone shaft fractures in children13. French and Spanish surgeons first mentioned it for the treatment of long bones in the late 1970s and early 1980s[14–17]. Research on the surgery is ongoing, and new advancements are being made, such as employing biodegradable implants18. In situations of pediatric forearm shaft fractures, plate and screw fixation is becoming less common and non-operative treatment is becoming less popular[19]. Despite the growing interest in surgical intervention (especially minimally invasive surgery) for forearm shaft fractures, there is significant dispute over the indications for surgical intervention[20]. This study's goal is to evaluate the functional outcome and side effects of titanium elastic nailing in fracture of both forearm bone fractures in pediatric population.

MATERIALS AND METHODS

40 Patients having fractures of both bones forearm, admitted in Department of Orthopedics in B.L.D.E. (DEEMED TO BE UNIVERSITY)'s Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, Karnataka with the diagnosis of both bone fracture forearm pediatric age group were informed about the study in all respects and informed written consent were obtained. The Institutional Ethical Clearance Certificate was obtained from BLDE (Deemed to be University) dated 22nd January 2021 ref. IEC/No.9/2021. Period of study was from January 2021 to May 2022 and follow up period were 6 weeks, 3 months and 6 months respectively. Participants were considered for study after obtaining their parent's consent. This was a prospective study and sampling for this study was done by 'Convenience Sampling' method. Patients were analyzed clinically, radiologically and assessed for functional outcome with TENS application. Patients who were skeletally immature with both bone forearm fractures who were physically fit for surgery and belong to an age group of 5 to 16 years and patients of all closed both bone forearm fractures which were displaced and patients with segmental fractures of both bone forearm with failed closed reduction and patients with open fractures of 'Gustillo-Anderson type 1 and 2' were included as participants of the current study. The patients with both bone fracture with compartment syndrome needing fasciotomy or both bone fracture needing vascular repair or isolated both bone forearm fractures or open fractures of 'Gustillo-Anderson fracture type 3' or patients with pathological and osteoporotic bone fractures, malignancies, infections, or contractures of the forearm muscles or patients with history of upper limb motor nerve injury on the same side, as well as neurological and vascular diseases were excluded from the study. After local examination of the injured forearm, a systematic pre-operative planning were done for each of the patients. After surgery, the afflicted forearm was covered with a crepe bandage, an above-elbow POP slab, and an arm pouch. The patient was told to move the shoulder joint and fingers on the affected side while maintaining the affected limb elevated. On the second post-operative day, the wound was examined and treated. On the second post-operative day, a post-operative x-ray was taken. If it was a closed reduction, IV antibiotics were given for 2 days after surgery, and for 5 days if it was an open reduction. After that, oral antibiotics were administered until the sutures were removed. On the second post-operative day for closed reduction and on the fifth post-operative day following wound assessment and dressing with forearm in arm pouch, the patient was discharged from wards. The patient was instructed to move their shoulders and fingers. All the

patients were followed up at 4, 8, 12 weeks and till 6 months, till the implant is removed whichever is earlier. At each follow-up x-rays of forearm in anteroposterior and lateral views were taken and analyzed for union i.e, presence of bridging periosteol callus in three or four cortices. Patients were checked clinically forwrist, elbow Flexion - extension and supination, pronation movements. Union was assessed radiologically. Antero-posterior and lateral radiographs were used to define bone union as the presence of bridging periosteal callus in three or four cortices or the primary closure of the fracture line. Delayed Union- union of fracture after 4 months of surgery without any additional procedures. Non Union- fractures not united even after 4 months requiring additional operative procedure. The nail was removed after the union was achieved preferably between 16 weeks to 20 weeks. The patients were analyzed based on ***ANDERSON et al, 1975 CRITERIA*** grading system. The elbow and wrist movements were observed. Physiotherapy was advised for stiffness of elbow and wrist.

RESULTS

Age and Gender Distribution: The age of children in our study ranged from 5-16years with most common age group being 10-12 years of age with a mean age of 10.95 years. 97.5 %of our cases were male among 2.5% cases and the rest were females.

Mode of Injury and Affected Site: In our study 75% of the cases were due to self-fall while playing, 15% were due to fall from bicycle and rest were due to Road Traffic Accidents. Among 20 cases 65% of cases had left side fracture and remaining 35% had right side fracture.

Level of Fracture: Among 40 cases the fracture level in both radius and ulnar mid shaft of radius. and ulna fractures were 50%, proximal end radius and ulna fractures were 15%.

Pattern of Fracture based on AO classification: Among40 cases, 22rd/5.1, 22uD/5 was 40% was the most common pattern of fracture.

Procedure and Union time for both bone fracture: The mean duration of fracture union time was 8.9 weeks with a range of 7-11 weeks. Among 40 cases in our study we were able to achieve close reduction in 82.5% out of cases operated within 5 days of fall and the rest cases we had to go open reduction in cases. In our study of 40 cases. 80% of cases operated within 47 minutes were fixed by close reduction. In cases which took more than 47 minutes were fixed by open reduction. Operative time was also increased based on increased days after trauma, which were fixed by open reduction. In our study we noted that, after 5 days of fall the operation time taken was significantly increased.

Criteria for evaluation of functional outcome: Functional evaluation was assessed using Anderson et Al criteria scoring system (1975). In our study 77.5% patients had excellent and 22.5% patients had satisfactory outcome.

Complications: Among 40 cases we encountered minor complications with olecranon pin tract infection and decreased range of pronation and supination being the most common. Time Interval between trauma and operative day increased, open reduction was the need to pass the nail due to soft tissue interposition. Operative time was increased more 37 minutes for fractures fixed by open reduction.

DISCUSSION

Age Distribution: In the present study the mean age group of patients with displaced both bone forearm fractures operated with TENS nailing was 10.9 years. The patients were distributed from 5 years to 16 years of age with most common age group being 10-12 years. Mohammad Ruhullah et al. (2016)[21] in their study had an average age group 10.04 years

Distribution of Sample by Gender: In our current study 97.5 % of the patients were boys and remaining 2.5% were girls. The high rate of involvement of boys might be attributed to the fact that boys of this age group are much more commonly involved in out-door activities like sports and bicycling which results in higher percentage of both bone forearm fractures in boys. Siddaram Patil et al. (2011 -2013)[22] case series had 50% in mid shaft and 25% indistal and proximal shaft.

Pattern of Fracture: In case of radius fracture 70% were transverse and 30% were oblique. In case of ulna fracture 65% were transverse and 35% were oblique. Since children are not involved in high velocity injury most of the cases were are transverse in nature. Our study had excluded the patients with communited fractures. Kishorchand Naorem et al (2015- 2017)[23] series had 63.3% had transverse fracture, 23.3% had oblique fracture, 13.3% had segmental fracture.

Procedure: In our study we noted that, after 5 days of fall the operation time taken was significantly increased. Among 40 patients 52.5% of cases were operated in 2-6 days after trauma. In our study of 40 cases. 80% of cases operated within 47 minutes were fixed by close reduction. In cases which took more than 47 minutes were fixed by open reduction. Operative time was also increased based on increased days after trauma, which were fixed by open reduction. The duration of immobilization was variable from 3 weeks to 6 weeks depending on patient compatibility to follow orders and radiological union. Most of our cases were immobilized for an average time of 4 weeks. This is mainly because TENS provides table fixation but not rigid fixation. The mean duration of fracture union time was 8.9 weeks with a range of 7-11 weeks. We did not come through any case of delayed union or non-union. Mohammad Ruhullah et al (2016)[21] in their study had an average union time of 9 weeks. Kishorchand Naorem et al (2015- 2017)[23] series had all fractures united by 16 weeks. In our study, we were able to fix 8 cases by open reduction, in 3 cases radiusfracture site was opened, in 2 case ulna fracture was opened and cases both bonesfracture sites were opened to achieve reduction. It was noted that as the time interval between the trauma and surgery increasedclosed reduction was difficult to achieve and had to be reduced by open method. Operative time was also increased based on increased days after trauma, which were fixed by open reduction. Mohammad Ruhullah et al (2016)[21] in their study had 90% closed reduction and 10% was through open reduction.

Asociation of Time Interval for Operation from The Day of Fall with Time Taken for Operation: In our study of 40 cases we noted that, after 5 days of fall the operation time taken was significantly increased operative time significantly increased more than 47 minutes as the time interval between trauma and the day of operation increased.

Association of Type of Reduction with Time Taken for Operation: In our study we noticed that time duration was comparatively less (<40 minutes) when reduction was by closed method. It significantly increased as we tried open reduction of either of one bone or both bones.

Functional Outcome: Functional evaluation was assessed using Anderson et Al criteria scoring system (1975). In our study 77.5% patients had excellent and 22.5% patients had satisfactory outcome. Mohammad Ruhullah et al (2016)[21] had excellent results in 94% and good in 6% cases by PRICE et al criteria. Kishorchand Naorem et al (2015- 2017)[23] series had excellent results in 80% and 20 % had good results by PRICE et al criteria.

CONCLUSION

This study was done to assess functional outcome of treating pediatric forearm shaft fractures treated with Titanium Elastic Nailing System. We conclude that closed reduction and cast application still remain the primary mode of treatment even if near anatomical reduction is not achieved especially in children with less 10 years of age as in younger children the remodelling capacity was high but in case of older children (12-16 years) we should try to achieve anatomical reduction as much as possible. TENS is a better option considering the short duration of operative time, minimal dissection of soft tissue is required. It can be concluded from our study that Titanium elastic nailing system has great results with benefits of early union, excellent recovery of function, minimal invasive surgery, and shortened surgical time in pediatric population for both bone forearm shaft fractures.

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REFERENCES

[1] Sauerbier M, Unglaub F. Anatomy and biomechanics of forearm rotation. Distal radius fractures and carpal injury: the cutting edge. Elsevier Science, Philadelphia.2009.

[2] Kapandji A. Biomechanics of pronation and supination of the forearm. Hand clinics. 2001 Feb;17(1):111-22.

[3] van der Smagt P, Grebenstein M, Urbanek H, Fligge N, Strohmayr M, Stillfried G, Parrish J, Gustus A. Robotics of human movements. Journal of Physiology- Paris. 2009 May 1;103(3-5):119-32.

[4] Garg NK, Ballal MS, Malek IA, Webster RA, Bruce CE. Use of elastic stable intramedullary nailing for treating unstable forearm fractures in children. Journal of Trauma and Acute Care Surgery. 2008 Jul 1;65(1):109-15.

[5] Droll KP, Perna P, Potter J, Harniman E, Schemitsch EH, McKee MD. Outcomes following plate fixation of fractures of both bones of the forearm in adults. JBJS. 2007 Dec 1;89(12):2619-24.

[6] Landin LA. Epidemiology of children's fractures. Journal of pediatric orthopedics.Part B. 1997 Apr;6(2):79-83.

[7] Sinikumpu JJ, Pokka T, Serlo W. The changing pattern of pediatric both-bone forearm shaft fractures among 86,000 children from 1997 to 2009. European journal of pediatric surgery. 2013 Aug;23(04):289-96.

[8] Jones K, Weiner DS. The management of forearm fractures in children: a plea for conservatism. Journal of Pediatric Orthopaedics. 1999 Nov 1;19(6):811.

[9] Vopat ML, Kane PM, Christino MA, Truntzer J, McClure P, Katarincic J, Vopat BG. Treatment of diaphyseal forearm fractures in children. Orthopedic reviews. 2014 Apr 22;6(2).

[10] Shoemaker SD, Comstock CP, Mubarak SJ, Wenger DR, Chambers HG. Intramedullary Kirschner wire fixation of open or unstable forearm fractures in children. Journal of Pediatric Orthopaedics. 1999 May 1;19(3):329-37.

[11] Fynn JM, Jones KJ, Garner MR, Goebel J. Eleven years experience in operative management of pediatric forearm fracture. JJ Pediatr orthop. 2010;30:313-19.

[12] Barry MJ, Paterson JM. Flexible intramedullary nails for fractures in children. TheJournal of bone and joint surgery. British volume. 2004 Sep;86(7):947-53.

[13] Sinikumpu JJ, Serlo W. Forearm shaft fractures in children. University of Oulu; 2013.

[14] Metaizeau JP, Ligier JN. L'ostéosynthèse chez l'enfant: techniques et indications. Rev Chir Orthop. 1983;69:495-511.

[15] Ligier JN, Metaizeau JP, Prevot J, Lascombes P. Elastic stable intramedullary pinning of long bone shaft fractures in children. Zeitschrift für Kinderchirurgie. 1985 Aug;40(04):209-12.

[16] Ligier JN, Metaizeau JP, Lascombes P, Poncelet T, Prevot J. Treatment of diaphyseal fractures of both bones of the forearm in children using elastic stable pinning. Revue de chirurgie orthopedique et reparatrice de l'appareil moteur. 1987;73:149-51.

[17] Sinikumpu JJ, Keränen J, Haltia AM, Serlo W, Merikanto J. A new mini-invasive technique in treating pediatric diaphyseal forearm fractures by bioabsorbable elastic stable intramedullary nailing: a preliminary technical report. Scandinavian Journal of Surgery. 2013 Dec;102(4):258-64.

[18] Zionts LE, Zalavras CG, Gerhardt MB. Closed treatment of displaced diaphyseal both-bone forearm fractures in older children and adolescents. Journal of PediatricOrthopaedics. 2005 Jul 1;25(4):507-12.

[19] Herman MJ, Marshall ST. Forearm fractures in children and adolescents: a practical approach. Hand clinics. 2006 Feb 1;22(1):55-67.

[20] Peltier LF. Fractures: a history and iconography of their treatment. NormanPublishing; 1990.

[21] Ruhullah M, Singh KK, Shrestha BA, Gupta KM, Jha KR. Flexible intramedullarytitanium elastic nailing of fracture shaft of radius and ulna in children at a tertiary care teaching hospital. Ortho and Rheum Open Acces J. 2016;2(2):555-84.

[22] Satapathy J., Panda J. K., (2026). Integration of Artificial Intelligence in the Regional Media: A Case Study of Odisha Television (OTV). International Journal of Artificial Intelligence, Machine Learning and Data Analytics, 1(1), 13-21. https://www.ijaimda.org/index.php/ijaimda/article/view/6

[23] Nannuri S., Gantla H. R., Ananya D., Vennela A., Bhuvana B., Neha G. (2026). Automated Brain Tumor Segmentationin Mri Via U-Net-Based Deep Neural Networks. International Journal of Engineering Sciences & Research Technology, 15(4), 1–8. https://doi.org/10.64149/j.ijesrt.15.4.1-8

[24] Patil SN, Patil PR. A study of 30 cases of titanium elastic nailing system (TENS) for long bones, and its clinical outcome. International Journal of Orthopaedics. 2018;4(2):328-33.

[25] Naorem K. Treatment of forearm fractures in children and adolescents with titanium elastic nails (TENS): A prospective study. International Journal of Orthopaedics. 2018;4(2):939-42.