

**Study of functional and radiological outcome of humerus diaphyseal displaced fracture in children managed with retrograde Enders nail**

<sup>1</sup>Dr. Rajesh K. Ambulgekar, Professor and head of the department, Department of Orthopedics Dr Shanakarrao Chavan Government Medical College, Vishnupuri, Nanded, Maharashtra.

<sup>2</sup>Dr. Md Zafar Iqbal, Junior Resident, Department of Orthopedics Dr Shanakarrao Chavan Government Medical College, Vishnupuri, Nanded, Maharashtra.

**Corresponding Author:** Dr. Md Zafar Iqbal, Junior Resident, Department of Orthopedics Dr Shanakarrao Chavan Government Medical College, Vishnupuri, Nanded, Maharashtra.

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**Conflicts of Interest:** Nil

**Abstract**

**Objectives:** To study the radiological and functional outcome of displaced humeral diaphyseal fractures in children managed with retrograde Ender nails.

**Material and methods:** This were an observational study conducted between June 2021 and September 2022 in which 50 cases of humeral diaphyseal fractures in children aged between 5 to 15 years were treated with retrograde Enders nails. Clinical follow up evaluation was done and Serial radiographs were taken to look for the time taken for the fracture union and the fracture alignment, positioning and migration of the nails if any. Functional outcome was evaluated using the DASH score for shoulder function and MAYO Elbow score for elbow function.

**Results:** Radio logical union was achieved in 48 cases, whereas 1 had mal-union and another 1 patient had non-

union which was later treated with bone grafting and plate fixation. Elbow stiffness alone was noted in 3 patients while 2 patients had both elbow and shoulder stiffness and 1 patient developed only shoulder stiffness. Radial nerve palsy occurred in 1 patient after surgery. DASH score for shoulder function in majority of patient was Excellent (39[78.0%]), followed by good (10 [ 20. 0%]). DASH score was fair in only 1 out of 50 patient (2%). In most patient MAYO elbow score was excellent (44 [88%]), followed by good (5 [10%]). The score was poor in only 1 out of 50 patients (2%).

**Conclusion:** TENS nailing for fracture shaft of humerus in children is a cost effective, time saving, minimally invasive technique with good radiological and functional outcome comparable with other modalities of treatment.

**Keywords:** Pediatric humerus shaft fracture, TENS, DASH score, MAYO Elbow score, retrograde nailing, Enders nailing

**Introduction**

Humeral shaft fractures comprise approximately 2.5% of all traumatic fractures in children [1,2]. Fractures of humeral shaft result from direct force during a direct impact, traffic accidents or crush injuries. The simplest classification of humeral shaft fractures is based on location of the fracture site in the humeral diaphysis (proximal, middle, and distal), alignment of fragments and appearance of the fracture line [3].

Fractures of the humerus, regardless of their location, are always a matter of intensive discussion, primarily, about conservative or operative therapy. However, remodeling has been clearly identified as being age-dependent and recognized as an important factor in determining the treatment regimen of pediatric humeral fractures [4,5]. Sometimes, reduction cannot be maintained pertaining to excessive shortening, angulation, or malrotation at the fracture site, making surgical intervention necessary. Flexible TENS (Titanium elastic Nailing System) allows stable fixation and good rotational control of pediatric humeral shaft fractures with a low complication rate, and permits early mobilization and return to the normal activities of the patients [6–12]. The aim of this study was to investigate the clinical and radio-logical outcome of humeral shaft fractures treated by TENS Nailing in children.

**Patients and methods**

The case records of 50 children (30 male and 20 female) treated with TENS, from Jan 2021 to June 2022, in our institute. 50 patients participated in the follow-up examination after a mean of 13.42 (+/- 3.4 SD) months. The mean age at surgery was 10.12(+/- 2.6 SD) years.

About 60 %(n=30) children were of the age 6-10 years while 40 %(n=20) were between the age 10-15 years. Inclusion criteria were the diagnosis of humeral shaft displaced fracture in patients of both genders between the age of 5 to 15 years. Exclusion criteria were patients younger than 5 years and older than 15 years of age, patients lost to follow up, patient with severe comorbidities and patient with un-displaced fracture. In all patients information about age, sex, side involved, trauma mechanism, type of fracture, complications, operation time, time duration before surgery and whether the fracture was managed in closed or open method (Table 1). Post operative x ray was done at 6 months and 12 months follow up to see the signs of radiological union and DASH score was used to analyze the shoulder function and MAYO elbow score was used to see the elbow function.

Sr No	Variable	N (%)	
1.	Age	5-10 years	30(60%)
		10-15 years	20(40%)
2.	Sex	Male	30(60%)
		Female	20(40%)
3.	Side	Left	29(58%)
		Right	21(42%)
4.	Mode of trauma	Accidental fall	34(68%)
		Road Traffic Accident	8(16%)
		Fall from tree	7(14%)
		Physical assault	1(2%)
5.	Diaphyseal Location	Proximal 1/3	11(22%)
		Middle 1/3	24(48%)
		Distal 1/3	15(30%)

Table 1: Patients’ data- variables collected preoperatively

### Radiographic assessment

All patient underwent full-length Antero-Posterior (AP) and Lateral radiographs of the involved arm. Displacement was assessed on full-length AP and L radiographs of the injured arm. Angulation is the angle between the axis of the proximal and distal fragments of the fracture. Eleven fractures (22%) were classified as proximal third humeral shaft fracture, twenty-four (48%) as middle third humerus shaft fracture and 24 (30%) as distal third humeral shaft fracture. In 29 patients, the left arm was injured, and 21 fractures occurred on the right side.

### Indications for surgery

Indications for surgery were open fracture, displaced fracture, and impending compartment syndrome, loss of reduction after closed treatment and casting and inability to achieve stable initial reduction with closed treatment.

### Surgical treatment

All the children were treated under supraclavicular block with or without sedation in the supine position on a radiolucent operating table. The fracture was first reduced by external maneuver in the frontal plane with C-arm verification. When reduction was achieved, an incision was made on the lateral and medial side of the distal humerus metaphysis.

Titanium elastic intramedullary nails were used in all patients. The diameter and length of the nails were selected according to bone length and child age. The thickness of the nail was chosen to be approximately one third of the diameter of the humeral marrow cavity. Two nails of the same diameter were introduced into the humeral medullary canal from medial and lateral epicondyle and advanced beyond the fracture site, up to the proximal metaphysis of the humerus (Fig. 1). After

surgery, there were no casting and physical therapy was started on postoperative day two.



Fig. 1: Intraoperative picture of entry from medial and lateral end of humerus; intraoperative C-arm shoot showing reduction.

### Follow-up

All the patients were regularly followed clinically and radio-graphically on Post operative day 2, and then 1, 6 and 12 months. Radiological evaluation was carried out using standard anteroposterior and lateral radiographs at each visit to evaluate the union of the fracture and identify complications such as secondary displacement, shortening, hardware migration, delayed union, nonunion or mal-union, and re-fracture. Subjective data were collected as per DASH score for shoulder function and MAYO elbow score for elbow function.

### Statistics

The presentation of the categorical variable was done in the form of number and percentage (%). Quantitative data were presented as the mean  $\pm$  SD and as median with 25<sup>th</sup> and 75<sup>th</sup> percentile (interquartile range)

The data entry was done in the Microsoft EXCEL spreadsheet and the final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, ver 25.0.

### Result

Most patient were having middle third shaft of humerus fracture (40%), followed by distal third (30%) and lastly proximal third (22%); left side involvement (58%) was more than right (42%); girls (60%) were more to have humerus shaft fracture than boys (40%). Most common

mode of trauma was accidental fall on arm (68%) followed by road traffic accident (16%), followed by fall from tree (14%) and lastly physical assault (2 %). The mean time from trauma till surgery was 47.64 hours (+/- 16.37 SD) and the mean time taken for surgery in all cases were 45.4 minutes (+/- 7.34 SD). In majority (45[90%]) of patients, close reduction was done while in 5 patient (10%) open reduction was needed to achieve desired reduction (Table 2).

Table 2: Distribution of Reduction (Close/Open) of study subjects.

Reduction (Close/Open)	Frequency	Percentage
Close	45	90.00%
Open	5	10.00%
Total	50	100.00%

Outcome on x-ray was evaluated and 96 % had radiological union, while 2% had nonunion and another 2 % had malunion. DASH score for shoulder function for majority patient was Excellent (39 [78.0%]), followed by good (10 [20.0%]). DASH score was fair in only 1 out of 50 patient (2%). In most patient MAYO elbow score was excellent (44[88%]), followed by good (5[10%]). The score was poor in only 1 out of 50 patients (2%) (Fig.2).



Fig. 2: Post operative 6 months assessment for functional and radiological outcome.

Majority (43[86%]) of patient did not had any complications while 3 patients (6%) had only elbow stiffness and 2 patients (4%) had both shoulder and elbow stiffness and 1 patient(2%) had only shoulder

stiffness. 1 out of 50 patient developed radial nerve palsy following surgery (Fig. 3).

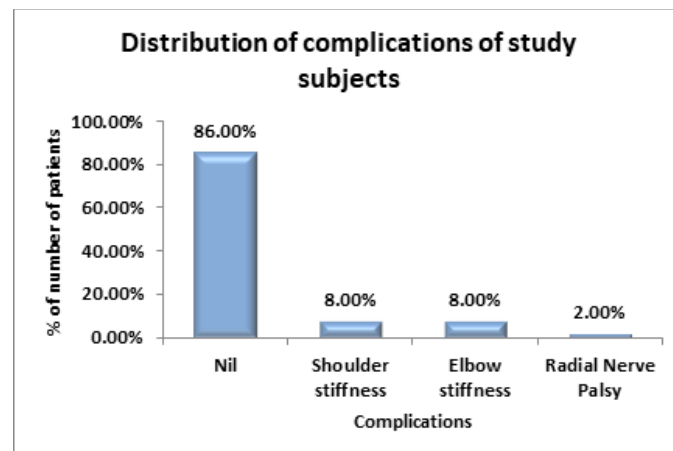


Figure 3: Distribution of complications of study subjects.

### Discussion

Humerus shaft fracture in children mostly occurs due to direct trauma to the arm due to various mode of trauma such as accidental fall, fall from height, road traffic accident or crush injury. Sometimes, indirect forces can cause fracture in cases with fall on elbow or extended elbow or forceful muscle contractions. The most frequent site of the fracture is middle and the distal third of humerus as the bone is narrow, cortical bone is thinner and the forces of torsion are the highest in middle third of the bone [13,14]. Pediatric humerus shaft fracture despite having good outcome with nonoperative methods, surgical treatment is preferred for these fractures as it is associated with early mobilization, low rate of complications and good outcome. The options for stabilization are many, including external fixation, rigid internal fixation with plates and screws, closed manipulation and percutaneous pinning, and intramedullary fixation. External fixation probably is best reserved for fractures severe soft tissue injuries e[which require multiple repeat surgical debridements [5,10,15]. TENS can be a good option for certain situations

based on both fracture-specific factors, such as location and morphology, as well as patient factors, such as age or associated injuries <sup>[5,10,15]</sup>.

In our study, most common mechanism of injury was direct trauma due to accidental fall followed by road traffic accident. Out of 50 patients, 24 had middle third, 15 had distal third and 11 had middle third shaft of humerus fracture. All patients with displaced humerus shaft fracture fulfilling the inclusion criteria were operated with retrograde TENS nailing. Out of 50 cases, 45 were managed with close reduction while 5 patients pertaining to soft tissue interposition and severe angulation. Most cases had complete radiological union while 1 had malunion and another patient went into non union due to severe comminution and soft tissue interposition for which open reduction was needed. While functional outcome as per DASH and MAYO score was excellent for most patient and good for some, it was fair in only one patient who developed non-union. Majority of patient did not have any complication except for 7 patients of which 6 had either or both elbow and shoulder stiffness which was corrected with physiotherapy and 1 had radial nerve injury which was later managed with tendon transfer.

Abasolim et al. reported twenty pediatric patients ranging in age from 6 to 16 years with humeral shaft fracture that were treated surgically using a retrograde single elastic intramedullary nail. All fractures healed in good alignment, and solid union occurred at a median time of eight weeks. There were no intraoperative complications. Postoperatively, the encountered complications were superficial wound infections in two cases, proximal nail migration in one case, and nail entry irritation in one case. The two patients with preoperative radial nerve palsy improved spontaneously after surgery

within 3 months. They concluded that single elastic intramedullary nail fixation for the treatment of humeral shaft fractures in pediatric patients is an adequate technique with a very low complication rate and a favorable final clinical outcome. It has many advantages such as a short hospital stay, no casting, small scar, early rehabilitation and joint motion, no shoulder complications, no growth plate injury recorded, and very good functional and cosmetic results <sup>[16]</sup>. Zivanovic DV et.al. conducted a retrospective analysis of 32 patients aged 5.5-17.8 years who were treated with ESIN for humeral fractures.

The most common cause of injury was fall, followed by traffic accidents. There were 16 proximal, 12 shaft and 4 distal humeral fractures. Twenty-five patients had isolated fractures, while 7 had polytrauma. Most of the patients underwent surgery within 24 hours after injury. Closed reduction of the fracture was achieved in 23 patients. The nails were inserted in a retrograde direction in 28 patients (22 from the lateral and medial sides, 6 only from the lateral side and in an anterograde direction in 4). The mean duration of surgery was 83.13 min. No major complications were observed. All fractures healed without delayed unions or non-unions.

Nail protrusion was encountered in 3 patients, skin irritation in 1 and difficult extraction in 2 patients. The average duration of follow up was 1.2 years. ESIN is a reliable method of treatment for displaced humeral fractures in children and adolescents. Once the patient is under general anesthesia and in the operating theatre for the reduction of humeral fracture, stabilization with ESIN is a better option than any type of plaster immobilization <sup>[17]</sup>.

TENS work by applying a balanced 3-point force on the intramedullary cortical bone <sup>[18]</sup>. This is particularly

powerful in length-stable diaphyseal fractures. The anatomy, particularly related to the location of nail insertion, may not be as familiar to the operating surgeon as the anatomy of other bones where TENS is more commonly used. An understanding of humeral anatomy is of paramount importance as many neurovascular structures lie in close proximity to each of the described nail insertion points and are vulnerable to injury as noted in one of the 50 cases operated in our study.

Conservative treatment in treatment of humerus fractures led to problems like angular deformity, elbow and shoulder stiffness, delayed union, nonunion. Open reduction and internal fixation has been advocated using various implants including flexible intramedullary nails, submuscular plate fixation, intramedullary nail fixation. Thus, we have advanced from the conservative approach to internal fixation in fractures to avoid the complications associated with it. In most centers diaphyseal fractures from 5-15 years have been managed with either stainless steel nails or titanium elastic nail. Flexible intramedullary nailing<sup>[19]</sup>.

In all previous studies, Enders nailing for humerus diaphyseal fracture have shown to be good option for fixation and is associated with good union rate and less complications. In our study we have found the data in line with the previous studies.

### Conclusion

In our study we concluded that Enders nailing for diaphyseal humerus fracture in children give a good radiological and functional outcome with minimal complication rate as can be considered as a good alternate modality of treatment. Proper physiotherapy and rehabilitation postoperatively can help deal with complications.

### References

1. Garg S, Dobbs MB, Schoenecker PL, Luhmann SJ, Gordon JE. Surgical treatment of traumatic pediatric humeral diaphyseal fractures with titanium elastic nails. *J Child Orthop*. 2009;3(2):121-127. doi:10.1007/s11832-009-0166-9
2. Webb L, Mooney J. Fractures and dislocations about the shoulder. In: Green N, Swiontkowski M, editors. *Skeletal trauma in children*. Philadelphia: W.B. Saunders; 2003. pp. 322–343
3. Pogo relic Z, Kadić S, Milunović KP, Pintarić I, Jukić M, Furlan D. Flexible intramedullary nailing for treatment of proximal humeral and humeral shaft fractures in children: A retrospective series of 118 cases. *Orthop Traumatol Surg Res*. 2017;103(5):765-770
4. Knorr P, Joeris A, Lieber J, Schalamon J, Dietz HG. The use of ESIN in humerus fracture: shaft seldom, sub capital sometimes, supracondylar often. *Eur JT trauma* 2005; 31:12–8
5. Fernandez FF, Eberhardt O, Langendorfer M, Wirth T. Treatment of severely displaced proximal humeral fractures in children with retrograde elastic stable intramedullary nailing. *Injury* 2008; 39:1453–9.
6. Furlan D, Pogorelić Z, Biočić M, Jurić I, Budimir D, Todorić J, et al. Elastic stable intramedullary nailing for pediatric long bone fractures: experience with 175fractures. *Scand J Surg* 2011; 100:208–15.
7. Ligier JN, Metaizeau JP, Prevot J. Closed flexible medullary nailing in pediatric traumatology. *Chir Pediatr* 1983; 24:383–5.
8. Canavese F, Marengo L, Samba A, Rousset M, Mansour M, And reacchio A, et al. Evaluation of upper extremity function of displaced diaphyseal humeral fractures in children treated by elastic stable intramedullary

nailing: preliminary results. *J Pediatr Orthop B* 2016; 25:399–405.

9. Lascombes P, Nespola A, Poircuitte JM, Popkov D, de Gheldere A, Haumont T, et al. Early complications with flexible intramedullary nailing in childhood fracture: 100 cases managed with precurved tip and shaft nails. *Orthop Traumatol Surg Res* 2012; 98:369–75.

10. Rajan RA, Hawkins KJ, Metcalfe J, Konstantoulakis C, Jones S, Fernandes J. Elastic stable intramedullary nailing for displaced proximal humeral fractures in older children. *J Child Orthop* 2008; 2:15–9.

11. Bukvić N, Marinović M, Bakota B, Veršić AB, Karlo R, Kvesić A, et al. Complications of ESIN osteosynthesis. Experience in 270 patients. *Injury* 2015; 46:40–3.

12. Lefevre Y, Journeau P, Angelliaume A, Bouty A, Dobremez E. Proximal humerus fractures in children and adolescents. *Orthop Traumatol Surg Res* 2014; 100: S149–56.

13. Slongo TF. Ante- and retrograde intramedullary nailing of humerus fractures. *Oper Orthop Traumatol* 2008; 20:373–86.

14. Jubel A, Andermahr J, Isenberg J, Schiffer G, Prokop A, Rehm KE. Experience with elastic stable intramedullary nailing (ESIN) of shaft fractures in children. *Orthopade* 2004; 33:928–35.

15. Khan A, Athlani L, Rousset M, et al. Functional results of displaced proximal humerus fractures in children treated by elastic stable intramedullary nail. *Eur J Orthop Surg Traumatol*. 2014; 24: 165–172.

16. Abosalim AA, El-Din AF, El-Mowafy HM. Treatment of humeral shaft fractures by a single elastic stable intramedullary nail in children. *Menoufia Med J* 2015; 28:125–32.

17. Zivanovic DV, Slavko Vic AR, Radovanovic ZL,

Marjanovic ZO, Bojovic NM, Djorjdevic IM et.al. Elastic stable intramedullary nailing of humerus fractures in children. *Int J Clin Exp Med* 2018; 11 (4): 2950-2964

18. Huber RI, Keller HW, Huber PM, et al. Flexible intramedullary nailing as fracture treatment in children. *J Pediatr Orthop*. 1996; 16:602–605.

19. Bopst L, Reinberg O, Lutz N, Femur fracture in preschool children: Experience with flexible intramedullary nailing in 72 children *J Pediatr Orthop* 2007; 27 (3) 299-303