

# Comparative Study between using of Single Versus Double Flexible Intramedullary Nails for Fixation of Paediatric Humeral Shaft Fractures

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## Abstracts

### Background

For paediatric humeral shaft fractures, Conservative and surgical treatment options are available. If fractures are unable to be reduced adequately or maintained in adequate alignment by conservative treatment, these should also be treated surgically. Titanium flexible nails are the preferred implant, comparison between using of single flexible intramedullary nail and using of double flexible nails regarding the functional and radiological results will be evaluated.

### Objective

The aim of this work is to compare between results of using single flexible intramedullary nail (titanium type of Nancy group) versus double nails for fixation of paediatric humeral shaft fractures in children between six and sixteen years.

### Patients and methods

Thirty paediatric patients ranging in age from 6 to 16 years (22 males and 8 females) were included in this study. Randomly, fifteen patients treated surgically using a retrograde single elastic intramedullary nail (group 1) and other fifteen (group 2) treated by retrograde double flexible nails (lateral dual entry) Relative surgical indications included open fractures, inability to maintain an acceptable reduction, concomitant lower extremity fractures, and closed head injury.

### Results

All the patients were followed for a mean of 5.33 months, with a range from 4 to 6 months. Radiographically, union started in (group 1) treated by single nail and (group 2) treated by double nails ,with the same mean which was 4,47 (range from 3 to 6 weeks).operative time increased with fixation by double flexible nails. two patients developed superficial wound infections postoperatively, treated by single nail and one patient with superficial wound infection treated by double nails.

### Conclusion

The use of single pre-bent nail achieved good alignment and reduction and acted as an internal splint till fracture healing took place and this decreased the operative time and cost with the same end results and less complication rate than with the double flexible nails.

### Keywords

Children, fracture, humerus, single elastic nail, double flexible nails.

## 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. Indirect forces such as fall on elbow or extended arm or strong muscular contractions can result with a fractured humerus. The most frequent site of the fracture is between the middle and the distal third of humerus.[3,4]

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. [5]

Acceptable alignment of humeral shaft fractures is considered to be 3 cm of shortening, 30° of varus/valgus angulation, and 200 of anterior/posterior angulation.[6,7] Newborns and infants have substantial remodelling capability and deformities up to 45°.(1) Older children also have a certain remodeling potential. Recommended that the deformity should be reduced to <30° for proximal third, <20° for middle third, and <15° for distal third shaft fractures before

proceeding with non-operative treatment. [1,8,9]

Conservative and surgical treatment options are available. The choice of method depends on the extent of primary displacement and on the age, location and stability of the fracture. [10]

Children with traumatic humeral shaft fractures require operative treatment only infrequently, primarily in cases where surgical stabilization of humeral shaft fractures is required to assist with patient mobilization, wound care, or the maintenance of adequate alignment.[11] Over recent years the use of elastic stable intramedullary nails has dramatically increased with the introduction of a variety of nails for paediatric fractures. [12]

The Titanium Elastic Nail (TEN) for Elastic Stable Intra-medullary Nailing (ESIN) is intended for fixation of diaphyseal fractures of long bones where the medullary canal is narrow or flexibility of the implant is paramount. In paediatric applications, the flexibility of the (TEN) allows it to be inserted at a point which avoids disruption of the bone growth plate. The biomechanical principal of the (TEN) is based on the symmetrical bracing action of two elastic nails inserted into the metaphysis each of which bears against the inner bone at three points. [13,14]

Significant contouring is necessary to provide the nail with an adequate elastic restoring force when subjected to angulation forces. The angle of curvature must be greater than the actual curvature of the nail in the medullary canal. Three-point contact with the bone is standard: the preferred anchoring site is the metaphysis opposite the entry hole, where dense cancellous bone provides the best stability in all three planes. The entry site always has less axial and rotatory stability. The main technical difficulty lies in the accurate positioning of the apex of the curve at the fracture site where the spread should be greatest.[15]

In shaft fracture, positioning the nails and selecting their diameters must have stress respect of recommendations. Thus, too great a medullary canal diameter may contraindicate the (FIN) technique. [16, 17] The surgical technique of stabilizing humeral shaft fractures with titanium elastic nails is straightforward. It can be performed in either a retrograde or antegrade manner. [18]

This technique (ESIN) is a well-established technique that is safe, minimally invasive, does not interfere with growth, and is associated with short hospital stays and a rapid return to daily activity. We believe that understanding the principles of this technique is paramount to achieving good results. [19] In addition the complication rates have been reported to be mini-

mal. [20]

A question was raised: Which was better? Use of single or use of double retrograde intramedullary elastic nails for stabilization of diaphyseal fractures of the humerus in children?

In this study, comparison between using of single flexible intramedullary nail and using of double flexible nails regarding the functional and radiological results will be evaluated.

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## Patients and methods

Thirty patients had fracture shaft humerus aged from six to sixteen years. Randomly, fifteen patients of them had been fixed by single flexible intramedullary nail (group 1) and other fifteen patients had been fixed by double flexible nails (group 2).

A written informed consent was obtained from all the parents; they were explained about treatment plan, cost of operation, and hospital stay after surgery, and complications of anaesthesia. They were followed up after surgery was clinically and radiologically assessed for fracture healing, joint movements and implant failure.

## Criteria of inclusion

The inclusion criteria were as follows: humeral shaft fractures of nonpathologic origin, closed fracture, first-degree open fractures, associated with lower extremity fractures to allow early mobility or in polytraumatized patients associated with other injuries (e.g. closed head injury) to facilitate nursing care or to achieve adequate alignment in cases with failed conservative measures (loss of reduction in the follow-up period). The age of the patients ranged from 6 to 16 years.

## Criteria of exclusion

Patients with Pathological fractures as (bone cyst, bone tumour) and open fracture (2nd, 3rd degree).

## Surgical technique

Once the patient was stabilized systemically patient was processed for surgery and the preoperative planning was done. In all cases single prophylactic antibiotic was given 2 hours before operation and this adjusted according to the weight and age of the child, then general anesthesia was given to all cases. The patient was in supine position with the affected upper limb placed on a radiolucent table with the arm ab-

ducted over a hand table and the patient was positioned as close as possible to the edge of the table to allow good visualization of the shoulder and proximal end of the nail, next to the proximal metaphysis. The whole upper limb from hand till axilla and shoulder was sterilized. For single retrograde nail, Start the skin incision 1 cm above the palpable prominence of the lateral epicondyle and progresses proximally up the lateral aspect of the humerus, just overlying the lateral supracondylar region. (Fig.1) The entry hole in the distal portion of the lateral column was made with an awl, 1 cm above the growth plate and at least 0.5 mm greater than the diameter of the planned nail.



**Figure 1:** Lateral supra-epicondylar incision

The appropriate nail diameter was determined by measuring the medullary isthmus which is the narrowest part of the medullary canal; the nail diameter was 60% of the medullary isthmus. The diameter of these nails usually from 2,5 to 4,5 mm.

Each nail was countoured manually in curved C shape to allow optimal resistance to malalignment. The nail was then successively inserted into the medullary canal using a T-handle. Once the nail reached the fracture site, closed reduction was performed under C-arm control. After proper alignment and fracture reduction, the nail was introduced into the proximal fragment.

Multiple and forceful reduction attempts were avoided. Curvature of the nail facilitated some reduction and could be rotated to achieve the best alignment. The nail was driven proximally to within 1–2 cm from the Proximal humeral physis. The protruding distal end of the nail was then trimmed at 0.5 cm from the bone for easy removal later on. Then, the wound was thoroughly irrigated and closed in two layers without drainage. The single nail acted as an internal splint and maintained the alignment until the fracture healed.

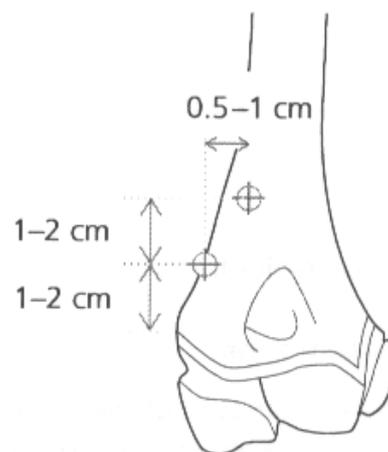
For insertion of double flexible nails the distal insertion point is located 1–2 cm above the epiphyseal plate. The second insertion point is located about 1–2 cm proximal to the first and is displaced medially by

0.5 –1 cm. This procedure is called unipolar FIN.(Fig.2) Two entry holes done in the distal portion of the lateral column made with an awl, for first nail 1 cm above the growth plate and at least 0.5 mm greater than the diameter of the planned nail, and other about 1 cm proximally and medially to first hole.

The nail was then successively inserted into the medullary canal using a T-handle. To facilitate advancement of the curved tip through the lateral column, the nail was inserted in an upward rotational movement (with light hammer blows, if necessary).

Once the first nail reached the fracture site, other nail was introduced by the same manner till reached fracture site we rotated it 180° to be opposite to each other. The first nail follows a direct route with its concavity and leading end turned toward the entry hole side. The second nail must be rotated 180° as soon as it enters the medullary canal, so that its concavity and leading end are turned opposite to the first nail. Direction of nails was dictated by the position of the proximal fragment and the second nail was bent about 30° at its distal part to facilitate easy direction, so it have S shape at lower part. After passing of fracture site and after reduction had been achieved, both nails were impacted into the cancellous bone of the proximal metaphysis to avoid secondary migration.

At the end of the procedure, one should have two nails with opposing curves, the concavities should face each other and the apexes of the curves should be located at the fracture site, thus both nails cross each other proximal and distal to the fracture site. At the end of the operation, the nails were carefully trimmed and the distal ends impacted using impactor with 3\_5 mm cannulated tip and hammer to be hidden under the tegument, To minimize the risk of skin irritation and to be easily visible at the time of ablation. The wound was irrigated carefully and closed in tow layers without drainage.



**Figure 2:** Lateral dual entry(two entry holes) [11]

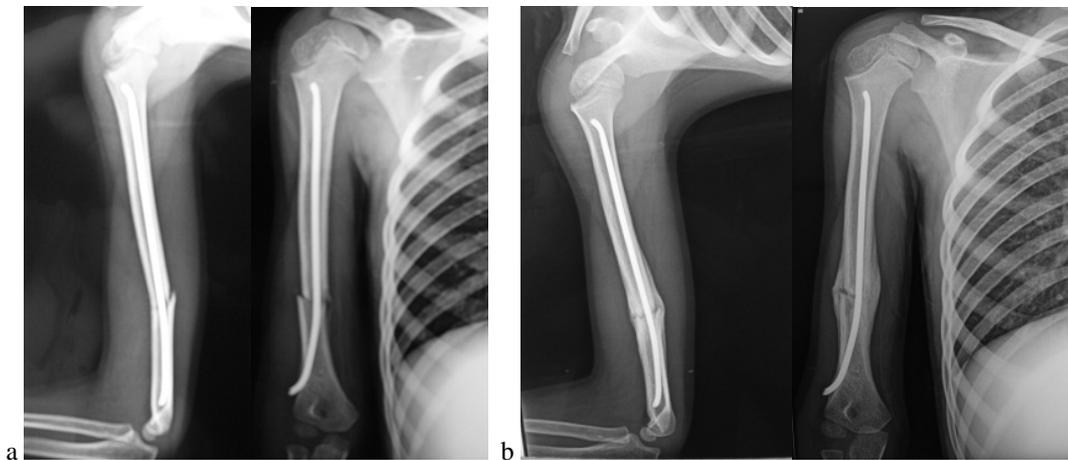
**Postoperative care**

Postoperative monitoring consisted of checking for the presence of postoperative radial nerve palsy and assessment of the peripheral pulsation. U shaped sling done for some cases and functional arm sling was used in other cases, both from 2 \_3 weeks.(Fig.3) From the fourth week onwards, they were encouraged to progress from passive assisted to active exercises as tolerated.



**Figure 3:** Functional arm brace

Radiographs were obtained immediately, 2 weeks postoperatively to check for loss of reduction, and 4,



**Figure 4 a:** Immediate postoperative x ray of single flexible nail. **b:** Eight weeks postoperative x ray of single flexible nails

8, and 12 weeks postoperatively to evaluate healing (Fig.4,5). Solid union was confirmed when at least three cortices showed periosteal new bone formation on standard plain anteroposterior and lateral views, and follow-up was graded according to the system proposed by Stans et al.[21] (grading of callus formation) (Table 1). Although this system was at first designed for the follow-up of the diaphyseal femoral fractures, it was found to be useful and easily applicable for all diaphyseal fractures of long bones.

The functional outcome was evaluated according to the system of Broberg and Morrey.[22,23] for the evaluation of elbow function and the DASH score for the evaluation of shoulder function and disability.(24)The functional outcome was compared with the healthy side. The DASH Outcome Measure is scored in two components: the disability/symptom section (30 items, scored 1-5) and the optional high performance Sport/Music or Work section (4 items, scored 1-5).

**Table 1:** Scale for grading of callus formation [21]

Grade 0	No identifiable fracture healing
Grade 1	Primary bone healing with little or no bone formation
Grade 2	Periosteal new bone formation on two sides of the bone
Grade 3	Periosteal new bone formation on three or four sides



**Figure 5:** a: Immediate postoperative X-ray of double flexible nail. b: Eight weeks postoperative X-ray of double flexible nails

## Results

For all patients included (both groups), following data were documented: operative time, hospital stay, time to bone healing, time of removal of the implant, pain, range of motion, functional status, grip strength of the hand, humeral length discrepancy, whether there were any angulation and/or rotation at the fracture site, and complications.

The duration from trauma to surgery ranged from 6 to 72 h. On both groups, the indications of surgical stabilization included (twenty two cases) could not be maintained in acceptable alignment. The indications for surgery in the remaining eight patients were to allow early mobility in presence of lower extremity fractures (two cases), nursing care in associated abdominal organ injury (three cases) and closed head injury (one case) and wound care in open fractures (two cases with Gustilo and Anderson grade 1).

The mean operative (insertion) time in (group 1) was 25.33 (range 15-45) minutes. The mean operative time in (group 2) was 37.67 minutes (range 30-45) minutes. This demonstrates that there was significant statistical difference p-value ( $<0.05$ ) between studied groups regarding Operation time (minutes).

Callus on both groups was first noted on follow-up radiographs in a mean time of 4.47 (range 3-6) weeks. Return to full activity was possible in a mean time of 9.73 (range 8-12) weeks, so there was no significant statistical difference p-value ( $>0.05$ ) between studied groups regarding time of first callus.

Proximal migration occurred in one case fixed by single nail and protrusion of the nail from lateral cortex occurred in one case fixed by double nail, both without any complaint. Nail entry irritation occurred in

one case fixed by double nails that was treated by early removal of the nail when radiological union was achieved.

One case in (group 1) showed  $10^\circ$  varus, another case showed rotation of the distal fragment about  $15^\circ$ . One case had been fixed by double nails (group 2) showed angulation  $10^\circ$ , all this was accepted and remodeling occurred later at final follow up.

Superficial infection occurred in two cases fixed by single nail and occurred in one case fixed by double nails that was managed by regular dressing and antibiotics.

Two patients fixed by double nails had a preoperative radial nerve injury,

(neuropraxia) that recovered spontaneously within 2 months. One case fixed by single nail had preoperative radial nerve injury, (neuropraxia) that recovered spontaneously within 3 months.

According to the DASH scoring system, there was no difficulty or any residual symptoms related to the shoulder joints and all cases rated no disability level.

## Discussion

This technique (ESIN) is a well-established technique that is safe, minimally invasive, does not interfere with growth, and is associated with short hospital stays and a rapid return to daily activity. We believe that understanding the principles of this technique is paramount to achieving good results. [19] In addition the complication rates have been reported to be minimal. [20]

In the current study, the mean time of first callus noted on follow up radiograph on both groups was 4.47 (range 3 -6) weeks, the mean period of follow up on both groups was 5,33 (range 4 - 6 )months, the mean time of return to full activity in (group 1) 9.73 (range 8-12) weeks, and in (group 2) the mean was 9.67 with (range 8-12) weeks. There was no significant difference between both groups regarding radiological union and return to full activity and time of follow up.

That there was significant statistical difference between both groups regarding operative time. Single nail had short operative time with low cost.

Furlan et al. [12] reported in their study on one patient with preoperative radial neurapraxia involving the superficial radial nerve, which resolved after 12 weeks. Garg et al.[11], in their study in 2009, studied one patient with a radial neuropraxia that recovered function spontaneously within 4 months after injury and another patient with radial nerve injury who was treated with tendon transfers 1 year after the injury to restore wrist extension. Maruthi et al. [25]

On this study two patients fixed by double nails had a preoperative radial nerve injury, (neuropraxia) that recovered spontaneously within 2 months. One case fixed by single nail had preoperative radial nerve injury, neuropraxia that recovered spontaneously within 3 months.

Maruthi et al.[25] used two nails introduced through the distal lateral edge of the humerus above the lateral epicondyle (dual lateral entry portals) and reported that stability is enough to lead to healing without an angular or translational deformity of more than 10° within 12 weeks. On this study, one case in (group 1) showed 10° varus, Another case showed rotation of the distal fragment about 15°. One case had been fixed by double nails (group 2) showed angulation 10o, all this was accepted and remodeling occurred later at final follow up.

Superficial infection occurred in two cases fixed by single nail and occurred in one case fixed by double nails that was managed by regular dressing and antibiotics. Furlan et al. [12] reported in their study one case with a postoperative skin infection. Gordon and Garg [26], in his study, reported that there were no postoperative wound infections. Maruthi et al. [25] reported that there was clinical evidence of a superficial infection in one patient, managed by regular dressing and antibiotics.

Over recent years the use of elastic stable intramedullary nails has dramatically increased with the introduction of a variety of nails for paediatric fractures. [12]

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## Conclusion

Titanium elastic nail fixation is an ideal procedure for treating humeral shaft fractures as it provides stable fixation, with minimal soft tissue stripping at the fracture site, and allows early mobilization of the extremity. In addition, patients with concomitant lower extremity fractures can be mobilized more rapidly because of the increased ability to weight bear through the extremity.

Using of single flexible nail had the same clinical and radiological end results as using of double flexible nails.

Using of single flexible nail is favorable than double nails because it had short operative time with less exposure to radiation, low cost and with no need for a second entry on the lateral side of the humerus. The incidence of nail protrusion increased with using of double nails, In addition, using of single nail decreased the incidence of misdirection of the nail toward posterior soft tissues to avoid damage to the radial nerve.

The main technical points lie in: Significant contouring of nails into a "C" shape construction. One of both nails in (dual lateral entry) had S shape at its lower part.

The concavities of nails should face each other with the apex of the curve at the fracture site to allow for a three point fixation and a stable reduction of the fracture site.

Lateral entry favorable than medial to avoid injury of ulnar nerve.

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