

Retrograde Titanium Elastic Nailing for Diaphyseal Fractures of the Humerus in Children through a Single Central Entry Point: A Case Series with Review of Literature

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Learning Point of the Article:

Retrograde elastic nail fixation of humeral shaft fractures in children with two nails through a central entry point is a reliable technique, with a low risk of complications.

Abstract

Introduction: Almost all paediatric humerus fractures can be managed conservatively with a high rate of union. Surgical intervention may be indicated in a few scenarios. Retrograde nailing with titanium elastic nails through a central entry point proximal to the olecranon fossa offers several advantages when surgical fixation is indicated.

Case Report: Three male patients in the age group of 5–14 years with diaphyseal left humerus fractures were treated with retrograde elastic nailing after failed conservative management. The mean age of the patients was 10 years. All the surgeries were performed under general anaesthesia. The mean operative time was 100 minutes. The mean union time was 12 weeks. The mean follow-up duration was 26.3 months. One patient developed a superficial surgical site infection, and the nails had to be removed 9 weeks after the surgery. The QuickDASH score of all the patients 3 months after surgery was zero, indicating no disability. All patients had excellent outcomes.

Conclusion: When surgical stabilization of paediatric humeral shaft fractures is indicated, retrograde elastic nail fixation with two nails through a central entry point is a reliable technique, with a low risk of complications, offering stable fixation that eliminates the need for uncomfortable immobilization and enables early mobilization of the arm.

Keywords: Retrograde elastic nailing, pediatric humerus fractures, titanium elastic nails.

Introduction

Humeral shaft fractures are uncommon in children, representing 0.4% to 3% of all paediatric fractures and 10% to 20% of humeral fractures. [1]. Almost all paediatric humerus fractures can be managed conservatively with a high rate of union. Authors suggest that before opting for non-operative treatment, the deformity should be reduced to within 30° for fractures of the proximal third, 20° for those in the middle third, and 15° for

fractures of the distal third of the shaft [2]. Surgical intervention may be required in cases of polytrauma to enable early mobilization, in compound fractures for wound management, in patients with head injuries to facilitate nursing care, in pathologic fractures, and in certain instances with unacceptable angulation to preserve proper alignment [3,4].

Several techniques of retrograde nailing with titanium elastic nails for humerus fractures have been described. Antegrade

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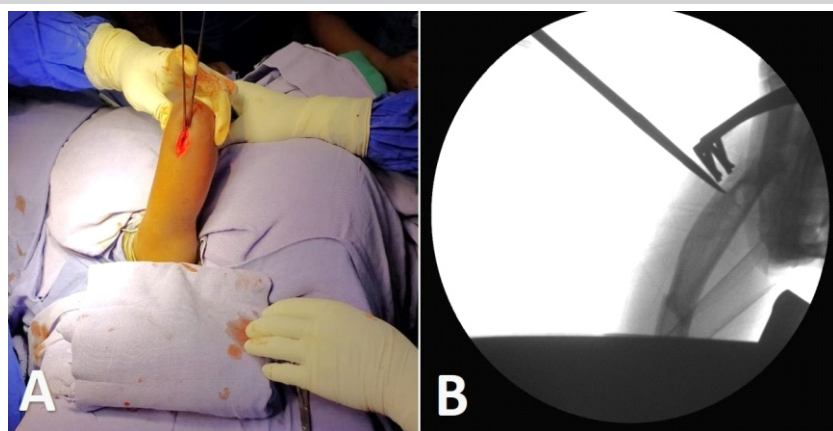


Figure 1: (A) Demonstration of the skin incision, (B) Making an entry point in the humerus using a bone awl proximal to the olecranon fossa.

nailing is not preferred due to violation of the rotator cuff, the possibility of injury to the growth plate, and impingement on the shoulder. Plate osteosynthesis is not recommended for humerus fractures in children.

Retrograde Ender nails may be used [5]. Alternatively, titanium or stainless steel elastic nails may also be used. The most commonly used technique for retrograde nailing involves making a small skin incision and entry over the medial and lateral epicondyles [3]. Skaggs and Frick described another technique where two elastic nails are inserted in a retrograde manner through a central entry point on the posterior aspect of the humerus, slightly proximal to the olecranon fossa [4]. This technique was used to treat three children with humerus shaft fractures in whom conservative methods had failed. Very few studies in the literature have reported the long-term outcomes using this method.

This case series includes three boys aged 7 years, 9 years, and 14 years (Table 1) with closed middle-third fractures of the left humerus who underwent retrograde titanium elastic nailing through a central entry point using the technique described by Skaggs and Frick. None of the patients had neurovascular injury or associated injuries. All the surgeries were done under general anaesthesia by the same surgeon.

Surgical Technique and Post-operative Protocol

This technique has been described in detail in Lovell and Winter's Pediatric Orthopaedics [4]. The patient was kept in a supine position with the arm on a radiolucent table. A posterior midline skin incision was made extending from the olecranon fossa proximally for about 4 to 6 cm, depending on the size

of the patient. The incision was made sharply down through the triceps fascia, and the triceps muscle was split by blunt dissection to expose the posterior surface of the humerus (Fig. 1a). Care was taken to avoid the radial nerve. The radial nerve is located about 10 cm proximal to the lateral epicondyle in adults, but this distance is comparatively lesser in children [4]. An entry point (Fig. 1b) was made with a drill or a straight bone awl above the olecranon fossa to access the medullary canal, with the distance adjusted according to the child's size. Careful attention must be given when creating the entry point to minimize the risk of an iatrogenic fracture with the drill/bone awl.

The size of the elastic nail was determined by placing it next to the humerus and viewing both with an image intensifier. The elastic nail was bent slightly in the distal part. The nail was inserted, driven to the fracture site (Fig. 2a), and passed into the proximal fragment after reduction (Fig. 2b). A second rod was inserted for rotational stability, with one nail directed toward the greater tuberosity and the other toward the humeral head (Fig. 2c). The nails were positioned correctly under

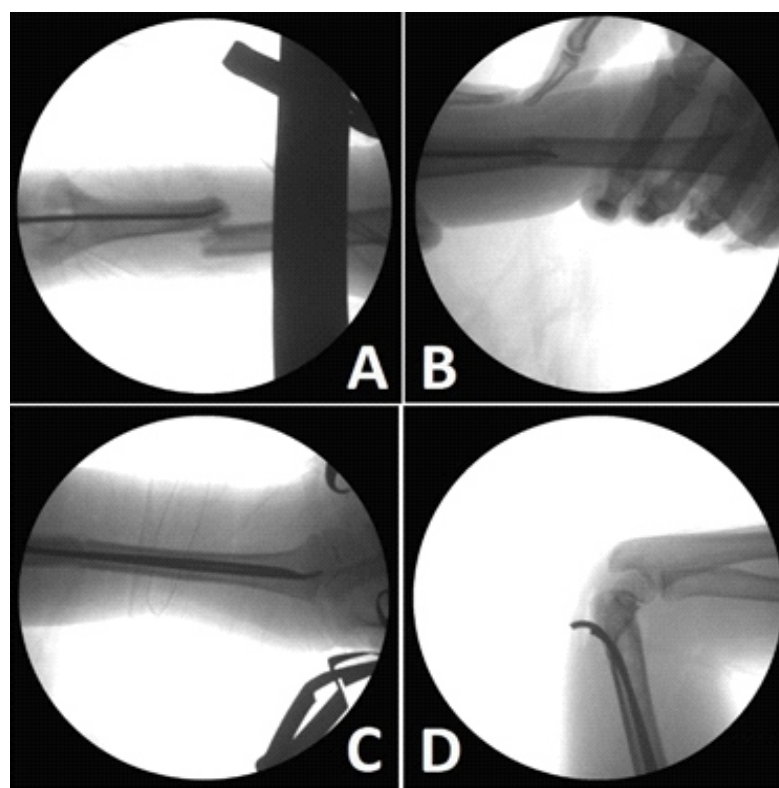


Figure 2: (A) First elastic nail brought to the fracture site, (B) nail passed into the proximal fragment after reducing the fracture, (C) orientation of the nails relative to the greater tuberosity and humeral head, (D) the elastic nails are cut and trimmed at the level of the entry point to avoid soft-tissue irritation and to facilitate their removal.

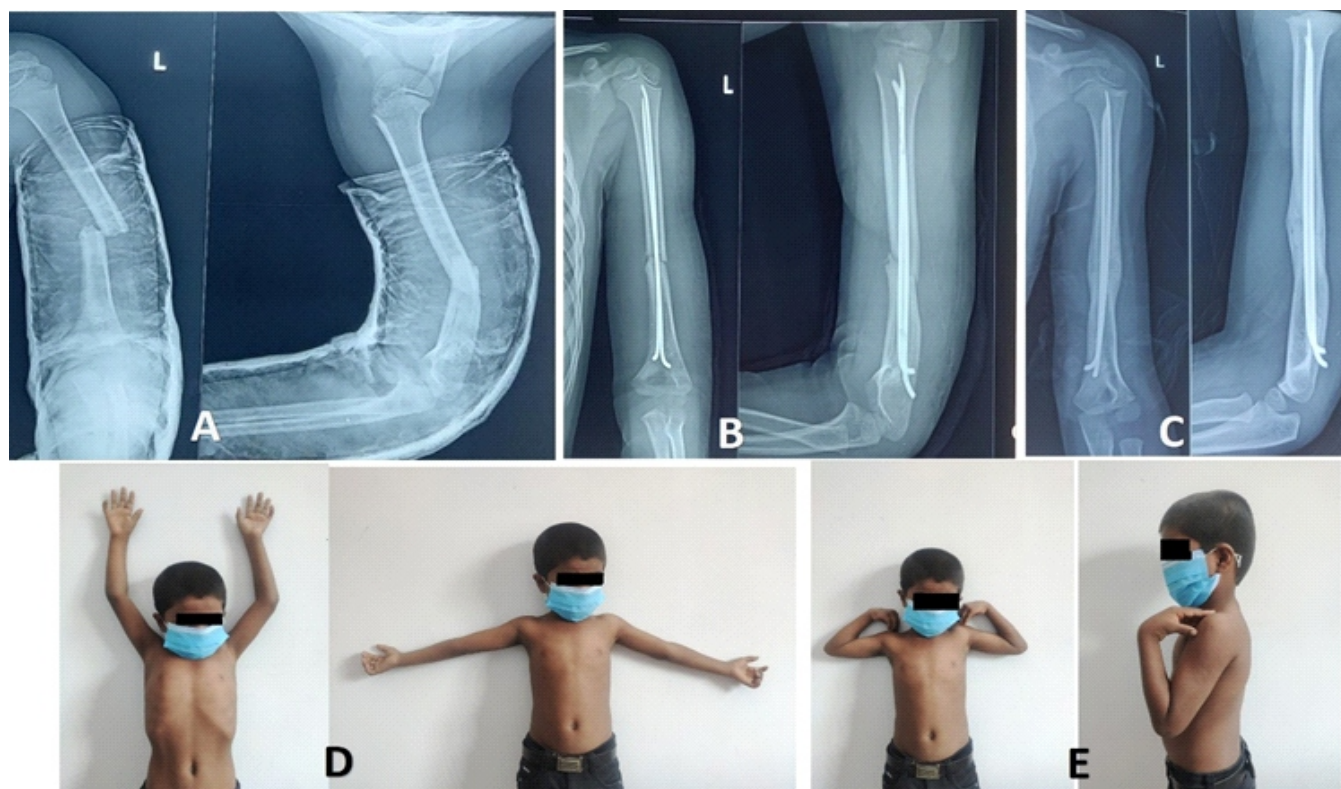


Figure 3: (A) Pre-operative X-ray of Patient 1, (B) Immediate post-operative X-ray of Patient 1, (C) Follow-up X-ray at 8 weeks, (D and E) Full range of motion at the shoulder and elbow after implant removal.

fluoroscopic guidance using an image intensifier. The excess length of the elastic nail was trimmed, leaving sufficient length for easy removal (Fig. 2d). Fluoroscopy ensures proper positioning and fracture reduction.

A sling was provided after surgery for stabilization. Range-of-motion exercises were started after 3–4 weeks, after sufficient healing had occurred. The elastic nails were removed electively after union of the fracture in two patients.

Patient 1

A 7-year-old boy presented with a closed fracture involving the middle third of the left humerus (Fig. 3a), following a fall while

riding as a pillion passenger on a motorcycle. The fracture was irreducible through conservative means, necessitating surgical intervention (Fig. 3b). The fracture united within 8 weeks (Fig. 3c), with no reported complications. Implant removal was done after 3 months. The patient was followed up for 24 months, with excellent recovery and healing with a full range of motion (ROM) at the elbow (Fig. 3d and e).

Patient 2

A 9-year-old boy sustained a closed fracture of the middle third of the left humerus due to an accidental fall in a playground. Initially managed with closed reduction and cast application, the fracture subsequently displaced (Fig. 4a), warranting

Table 1: Demographic, clinical, and surgical details of patients undergoing retrograde elastic nailing for humeral shaft fractures

Patient number	Age at injury (years)	Sex	Open fracture	Site	Side	Mechanism of injury	Associated injury	Indication for surgery	Total operative time	Time for union	Complication	Duration of follow-up
1	7	Male	No	Middle Third	Left Humerus	Road Traffic Accident – fall while riding pillion on a motorcycle	None	Irreducible fracture	45 min	8 weeks	None	24 months
2	9	Male	No	Middle Third	Left Humerus	Accidental fall in the playground	None	Fracture displaced after closed reduction and cast application	35 min	12 weeks	Superficial surgical site infection	29 months
3	14	Male	No	Middle Third	Left Humerus	Road Traffic Accident – fall from a moving auto rickshaw	None	Fracture displaced after closed reduction and cast application	60 min	16 weeks	None	26 months

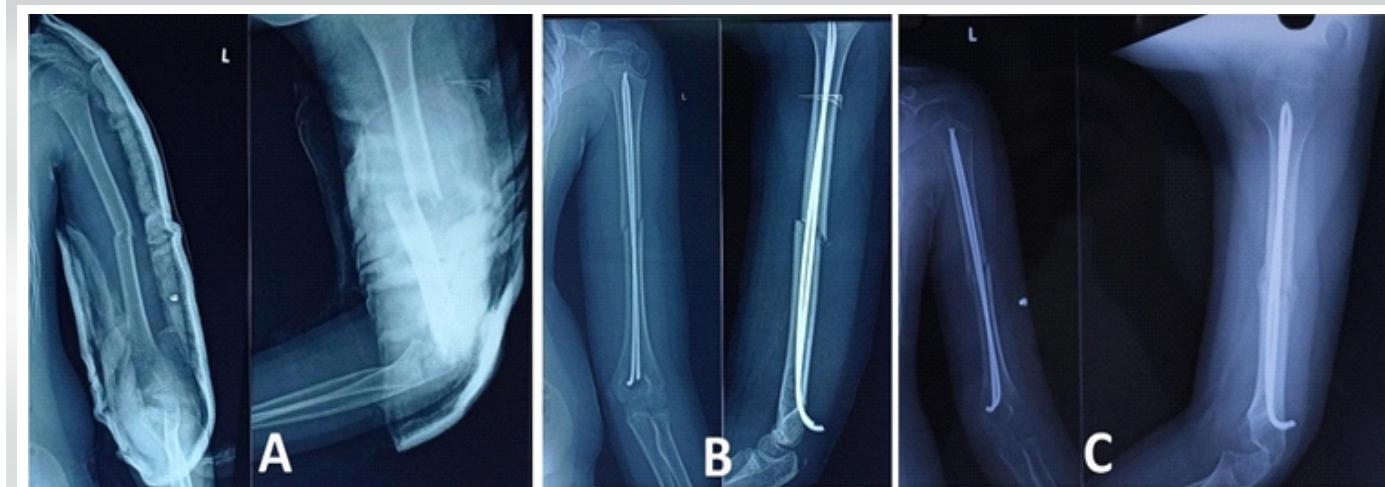


Figure 4: (A) Pre-operative X-ray of Patient 2, (B) Immediate post-operative X-ray of Patient 2, (C) Follow-up X-ray at 6 weeks when implant removal was planned due to superficial infection.

surgical treatment (Fig. 4b). Good callus formation was noted in the follow-up radiographs at 6 weeks (Fig. 4c). However, the patient developed a superficial surgical site infection about 9 weeks after surgery. As sufficient callus was noted in the radiograph, implant removal was done. The child also received IV antibiotics for one week, following which the infection subsided. The fracture united in 12 weeks. Follow-up continued for 29 months, with excellent outcomes and full ROM of the elbow.

Patient 3

A 14-year-old boy suffered a closed fracture of the middle third of the left humerus (Fig. 5a) following a fall from a moving auto rickshaw. Despite initial conservative management with cast application, the fracture was found to be displaced, necessitating surgical intervention (Fig. 5b). Fracture union occurred within 16 weeks, with no reported complications. Implant removal was done at 4 months. Follow-up continued for 26 months, with an excellent outcome, no residual issues, and full ROM in the elbow.

Discussion

We present a case series of three boys aged 7 years, 9 years, and 14 years with closed middle third fractures of the left humerus treated with retrograde titanium elastic nail fixation through a single entry point made proximal to the olecranon fossa. The outcomes in our case series were excellent. All the patients had a full range of motion in the elbow joint. Only one patient had to

undergo implant removal earlier than indicated due to a superficial surgical site infection. In this study, the average age of the patients was 10 years, with a mean fracture union time of 12 weeks and an average follow-up duration of 26.3 months. The QuickDASH score [6] for all patients at 3-month follow-up was 0, indicating no disability. All fractures achieved healing in good alignment, with no intraoperative complications such as neurologic or vascular injuries.

Closed reduction may occasionally fail due to the interposition of muscle or periosteum between the fracture ends. In patients where closed reduction fails, open reduction may be attempted by making a skin incision over the fracture site.

A retrospective study of 13 patients (mean age 12.0 years) by Garg et al. from the USA reported that all fractures healed in good alignment with no intraoperative complications or infections [3]. The dual entry point technique with two nails was followed in 11 patients, whereas antegrade nailing was done for two patients. Two cases of nail migration occurred, including one with skin protrusion, and one patient required



Figure 5: (A) Pre-operative X-ray of Patient 3, (B) Immediate post-operative X-ray of Patient 3.

Table 2: Comparative analysis of outcomes and techniques from various studies on retrograde elastic nailing for humeral shaft fractures in children

Study	Sample size	Mean age	Technique	Mean union time	Complications	Mean operative time	Mean follow-up	Outcomes
Present study (India)	3 patients	10 years	Two retrograde titanium nails, single central entry proximal to the olecranon fossa	12 weeks	1 case of superficial infection, no intraoperative complications	100 min	26.3 months	All fractures healed with excellent alignment; 3-month post-op QuickDASH score 0 (no disability); early implant removal in 1 case due to superficial infection.
Garg et al. (USA) [3]	13 patients	12 years	Antegrade nailing (n=2); dual nails (n=11). Nine had medial and lateral entry portals, and two had dual lateral entry portals.	Mean time not specified. All fractures united within 12 weeks.	2 cases of nail migration (1 with skin protrusion), 1 tendon transfer for radial nerve injury	Not specified	29 months	12/13 returned to full activities; no intraoperative complications
Wang et al. (China) [9]	37 patients	11.8 years	Dual retrograde nails, the entry point from the medial and lateral epicondyles	8 weeks (7–10 weeks)	2 cases of skin irritation from hardware, resolved after implant removal	65 min	24 months	Excellent outcomes
Kwak et al. (South Korea) [10]	12 patients	10.5 years	Dual retrograde nailing (n=9), Dual antegrade nailing (n=3)	6 weeks	4 patients experienced nail site irritation, with 2 requiring early nail removal at 6 weeks due to skin lesions and pain. One boy had a fracture near the proximal nail insertion site.	Not reported	15 months	All patients regained a full range of motion and returned to daily life by the final follow-up.
Samara et al. (Switzerland) [7]	19 patients	12.6 years	Single retrograde nail, entry 10–20 mm proximal to the lateral epicondyle	6 weeks (median)	No cases of infection or neurological damage were encountered.	49 min	6 months	All fractures united on radiographs
Kapil Mani et al. (Nepal) [8]	28 patients	8.85±1.84 years	Single retrograde nail, entry close to the lateral epicondyle	8.28±2.43 weeks	1 case each of malunion, nail migration, superficial infection, radial nerve palsy, nail protrusion	28.21±7.23 min	24.71±9.59 weeks	85.71% excellent results; 14.29% good results

tendon transfer for pre-operative radial nerve injury. Notably, 12 of 13 patients returned to full activities without limitations, aligning with our study's findings.

Samara et al. reported a single nail technique of retrograde nailing for proximal humerus fractures in 19 children, where the entry point was made 10–20 mm proximal to the lateral epicondyle [7]. All fractures appeared united on the radiographs at a median of 6 weeks. A Nepali study that included 28 children reported excellent results in 85.71% of patients and good outcomes in 14.29% [8]. A single retrograde nail was used. The average patient age was 8.85 ± 1.84 years (range: 6–12), and the mean time to fracture union was 8.28 ± 2.43 weeks (range: 6–12). Complications included one case each of malunion ($\sim 10^\circ$), nail migration, superficial infection, transient radial nerve palsy, and nail protrusion.

Wang et al. from China reported excellent outcomes in 37 children using the dual entry point technique for the proximal humerus [9]. They reported skin irritation due to protruding hardware at the distal humerus in two cases. This was resolved after implant removal. The mean union time was 8 weeks (range 7–10 weeks) after surgery.

A Korean study evaluated the antegrade and retrograde two-nail technique in 12 patients [10]. No neurovascular injuries or infections occurred during surgery. However, four patients experienced nail site irritation, with two requiring early nail removal at 6 weeks due to skin lesions and pain. One boy had a fracture near the proximal nail insertion site. All patients regained a full range of motion and returned to daily life by the final follow-up.

The retrograde double nail technique through a central entry

point offers more advantages compared to the single nail technique, though the single nail technique is quicker and more cost-effective. However, the insertion of two nails provides better rotational stability [5,9]. Compared to conservative management, surgical intervention allows quicker recovery, and inconvenient immobilization can be avoided. Surgical fixation allows polytrauma patients with lower limb injuries to be mobilized earlier with the aid of assistive devices such as walkers and crutches. The key findings of all the studies are compared in Table 2. There are a few limitations in this study. The case series included only three patients who were operated on by a single surgeon. Future multicentric studies with a large sample size and longer follow-up duration can provide more insights into how fractures treated by this method remodel over time.

Conclusion

In children where surgery is indicated, retrograde elastic nail fixation of humeral shaft fractures with two nails through a central entry point is a reliable technique, with a low risk of complications, offering stable fixation that eliminates the need for uncomfortable immobilization and enables early mobilization of the arm.

Clinical Message

Fixation of humeral shaft fractures in children with retrograde elastic nails through a central entry point is a reliable technique with several advantages and should be considered when surgical fixation is indicated.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. All the patients were minors. In the forms, the parents of all the patients have given consent for patient images and other clinical information to be reported in the journal. The parents of all the patients understand that children's names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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