

## Elastic Stable Intramedullary Nailing for Closed Diaphyseal Fractures of Humerus in Adults. A Case Series of 28 Patients

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### Abstract

**Aim of study:** To demonstrate clinical and radiological effectiveness of intramedullary fixation of closed diaphyseal humeral fractures in adults using the elastic stable intramedullary nail (ESIN).

**Patients and methods:** Between May 2011 and December 2013, twenty-eight patients (19 males) with closed diaphyseal humeral fractures treated with closed reduction and percutaneous fixation with 2 elastic stable nails. Age from 18 to 56 years (mean, 29 years). Patients with open or pathological fractures, those less than 18 years and medically unfit patients were excluded. Causative injury was pedestrian vehicular accident in 15, fall from height 9 and sport-related activity 4 patients. The time of surgical intervention varied from 24 to 72 hours post-injury.

**Results:** Patients were followed up 12-31 months with an average of 20 months. X-ray films showed that twenty-six fractures united completely at a range 14-20 week (mean, 13.1 weeks). Twenty-Six cases healed in good alignment at a median time of 13.1 weeks (range 14–20 weeks). One case developed delayed union where bone marrow injection and longer immobilization till full healing done. One case developed non-union which was treated by bone grafting and plating. There were no intraoperative complications. One patient with preoperative radial nerve injury recovered spontaneously by eight weeks. Patients followed and assessed using Disabilities of the Arm, Shoulder and Hand score (DASH). At last follow-up, the average DASH score was 90.5 (range 60–100). Final clinical evaluation showed 17 cases Excellent, 8 cases Good, 2 cases fair and one case Poor according to previous score.

**Conclusion:** Elastic stable nail fixation is a good procedure for treating adult humeral shaft fractures in which stabilization is indicated as it provides stable fixation, with minimal soft tissue stripping at the fracture site and allows early mobilization of the extremity.

**Keywords:** Elastic nails; Diaphyseal humeral fractures; Nail fixation; Bone marrow; Injury

### Introduction

Humeral shaft fracture is a common event, and representing between 3% and 5% of all skeletal fractures in adults [1]. The optimal management of these fractures has changed dramatically over the previous three decades from almost universal use of cast immobilization to a variety of operative interventions. Recent trend in most of displaced and segmental fractures is to treat them surgically [2]. Malunion and minor degrees of shortening of humeral shaft fractures can be tolerated owing to the wide range of motion of the shoulder and elbow with minor functional deficit [3]. New implants and recent techniques have been developed to modulate the indications, overcome incidence of treatment failure and to minimize complications and disabilities following injury. One of these implants is elastic stable intramedullary nails [4]. In our study we are going to evaluate the effectiveness, clinical and functional outcome of the diaphyseal humeral fracture treated by elastic stable intramedullary nails.

### Patients and Methods

Ethical clearance was obtained from the institutional ethics committee and written consent from all patients was obtained. Patients were enrolled between May 2010 and December 2013. Twenty-Eight patients (19 males) between ages of 18 to 56 years (average, 29 years) with diaphyseal fracture of humerus had been treated by closed reduction and percutaneous fixation with intramedullary elastic stable nails. All fractures were closed, diaphyseal at different levels of humerus. The right side affected in 17 cases (60.7%). No patient had bilateral fractures. Inclusion criteria involved: Male and female of age between 18 to 56 years with closed diaphyseal fracture of humerus who were medically fit for surgery. Exclusion criteria involved patients who were medically unfit for surgery, less than 18 or over 56 years old, open and pathological fractures, fractures extending to the articular margins of the shoulder or elbow and patients unwilling to participate in the study. Causative trauma was a pedestrian vehicular accident in 15 patients, fall from height 9 and sport-related activity in the remaining four patients. One patient had radial nerve injury and it was neurapraxia which recovered function spontaneously within eight weeks after injury. Patients were evaluated at 2-week, 6 weeks, 3

months, 6 months. Functional evaluation at follow up utilized DASH Score. Distribution of patient's characteristics shown in Table 1.

No.	Age	Gender	Side	Trauma	F-U	Union	Complications	Dash S.
1	20	M	Lt.	M.C.A	26	12 w	-----	100
2	44	M	Rt.	FFH	18	12 w	-----	87
3	30	F	Rt.	Sport. Inj.	20	13 w	-----	98
4	25	M	Lt.	M.C.A	30	28 w	Delayed union, E-pain	65
5	23	M	Rt.	FFH	19	13 w	-----	98
6	33	M	Lt.	M.C.A	20	14 w	Superficial infection-E-pain	96
7	18	M	Rt.	FFH	24	12 w	Radial N.	66
8	37	M	Rt.	M.C.A	20	13 w	-----	93
9	21	F	Lt.	M.C.A	24	12 w	-----	79
10	47	F	Lt.	FFH	25	14 w	Superf. infection	95
11	20	M	Rt.	M.C.A	21	12 w	-----	98
12	38	M	Rt.	Sport. Inj.	20	12 w	Nail migration	86
13	29	M	Lt.	FFH	19	13 w	-----	88
14	56	F	Rt.	M.C.A	18	14 w	-----	100
15	18	M	Rt.	FFH	20	15 w	-----	87
16	19	M	Lt.	M.C.A	25	12 w	Superf, infection	100
17	39	F	Rt.	M.C.A	18	14 w	E-pain	88
18	18	M	Lt.	Sport. Inj.	30	20 M	N-U,E-pain, ROM	60
19	22	M	Rt.	FFH	19	12 w	-----	99
20	26	F	Rt.	M.C.A	22	20 w	Limited ROM elbow, E-pain	88
21	49	M	Lt.	M.C.A	28	14 w	Limited ROM	97
22	19	M	Rt.	Sport. Inj.	18	12 w	-----	96
23	35	F	Lt.	FFH	23	14 w	-----	93
24	21	F	Rt.	M.C.A	21	12 w	E-pain	86
25	29	M	Rt.	M.C.A	23	14 w	-----	95
26	30	M	Lt.	FFH	19	12 w	-----	98
27	21	M	Rt.	M.C.A	17	15 w	E-pain	98
28	25	F	Rt.	M.C.A	29	12 w	-----	100

NO: Number, M: Male, F: Female, Rt.: Right, Lt.: Left, M.C.A: Motor Car Accident, FFH: Fall from Height, Superf.: Superficial, Inj: Injury, W: Week, E-Pain: Elbow Pain, FU: Follow-Up, N.U: Nonunion

**Table 1:** Distribution of patient's characteristics.

The operation was done within 24-72 hours following admission. Operative procedures were carried out under general anesthetic in 19 and regional anesthesia in 9 patients. With the patient in supine position, the affected upper limb was supported by a radiolucent arm table with the shoulder abducted 90° and the elbow flexed to 90°. An image intensifier was positioned so that the long axis of the humerus

was in view and surface markings were made on the skin for the fracture site and proximal and distal fragments. The nail thickness was selected according to the narrowest diameter of the medullary canal on radiographs using the formula  $0.4 \times$  diameter of the canal in mm.

Closed reduction done for all patients through longitudinal traction with abduction and external rotation of the arm. An image intensifier was used to assess quality of reduction.

Two drill holes were done along the lateral supracondylar ridge 2-3 cm proximal to olecranon fossa to get good purchase through the solid columns of bone in the distal humerus. The first nail was introduced through the inferior hole and passed upwards towards the fracture site. The second one introduced and advanced to the fracture site. Once reduction achieved, both nails were advanced across the fracture site up to proximal metaphysis. Bending of the two nails distally was done and cut 1 cm from the cortical surface for easy removal later. The wounds were closed. Post-operatively a collar and cuff sling applied to the operated arm for three weeks during which patients were encouraged to start pendulum exercises of the shoulder as soon as comfortable. Cuff was discarded after 4 weeks.

The average time of hospitalization was 2-5 days. Radiographs were typically obtained immediate postoperative, 2 weeks postoperatively to check for loss of reduction, 6, 12 and 24 weeks postoperatively to evaluate union and alignment status of the fracture. The average follow-up was 22 months (range 18-33 months).

Removal of implant was performed (under general anesthesia as a day case procedure) after complete union of fracture.

### Case Presentation

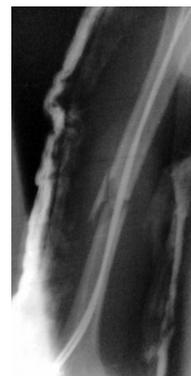
Male patient 35 years. Sustained motor car accident. He got oblique fracture mid shaft left humerus with butterfly fragment (Figures 1 and 2). Closed reduction and 2 elastic stable intramedullary nails via lateral supracondylar ridge approach (Figure 3). Fracture united completely within 14 weeks (Figures 4-8).



**Figure 1:** AP view pre-operative radiography fracture shaft Lt. humerus.



**Figure 2:** Lateral view pre-operative radiography fracture shaft Lt. humerus.



**Figure 3:** Immediate post-operative. Good reduction achieving good alignment.



**Figure 4:** 8 weeks post-operative with good union of fracture.



Figure 5: 10 weeks post-operation with full union of fracture.



Figure 6: After 14 weeks post-operation.



Figure 7: 14 weeks post-op. after extraction of nails (Lateral view).



Figure 8: The three photos demonstrates full functional activity of shoulder and elbow joints.

## Results

All patients had acceptable reduction with less than 10° angulations in either plane. Complete union achieved in twenty-six patients (92.8%) at a mean time of 13.1 weeks (range 14 to 20 weeks). Healing was defined as cortical contiguity in all four cortices seen on standard anteroposterior (AP) and lateral radiographs of the humerus. One patient (3.6%) showed delayed union (case No. 4). Three bone marrow injections with two weeks interval was done and union achieved over 28 weeks. One patient (3.6%) had non-union (case NO.18) and was treated by plating and bone grafting while maintaining the nails *in situ*. Twenty-five patients (89.3%) regained full range of motions for both shoulder and elbow joints. Three patients (10.7%) lacked 10° of extension and 10° of flexion of elbow joint following healing at final evaluation (cases No. 18,20,21). Superficial infection developed in two patients (cases No. 6,10) and managed by daily dressing and antibiotics. No patient developed deep infection. Twenty-two patients (78.6%) had no shoulder or elbow pain at final clinical evaluation. Six patients (21.4%) had some elbow discomfort (cases No. 6, 17, 18, 20, 24, 27) which was tolerable and not affecting daily activities of patient.

One patient (3.6%) had preoperative radial nerve injury (case No. 7) that recovered spontaneously within ten weeks after injury. Distal migration of nails occurred just in one patient (3.6%) (case No. 12). Patient returned back to the operating room and the nails were rehammered to sit flush and trimmed to avoid skin irritation.

Result	No. cases	complication	Case Number
Union	26 united	Delayed-union...1 case Non-union.....1 case	4, 18
Range of Motion	25 full ROM	Limited elbow.....3 Cases	18, 20, 21
Pain	22 No pain	Elbow pain.....6 Cases	6, 17, 18, 20, 24, 27
Superficial Infection	25 No infection	Infection 2 cases	6, 10
Complications: Radial N injury	27 No injury	Radial N injury 1 case	7
Distal Migration	27 without	Distal nail migration 1 case	12

Table 2: Distribution of cases' results.

No patients had implant failure. On final follow-up, the mean DASH score was 90.5 (range 60 to 100) and accordingly we had 17 patients (60.7%) rated Excellent, 8 (28.6%) patients rated Good 2 (7.1%) patients rated Fair and one patients (3.6%) rated poor. distribution of results shown in Table 2.

## Discussion

Management of diaphyseal fractures of humerus in adults remains a challenging issue for orthopedic surgeons. Non-operative treatment still considered an option [5,6] and union rates of more than 90% are often reported [4,5]. Acceptable alignment of humeral shaft fractures is considered to be 3 cm of shortening, 30° of varus/valgus angulation, and 20° of anterior/posterior angulations. Varus/valgus angulation is tolerated better proximally, and more angulations may be tolerated better in patients with obesity [7,8]. There is no universal agreement on optimal modality of fixation when surgical intervention is chosen [9]. Plating carries the risk of infection, neurological insults and non-union [10,11].

Rigid intramedullary nailing whether used via antegrade or retrograde entry still a debatable issue. The proximal entry for antegrade nailing may lead to rotator cuff injury, shoulder impingement, proximal nail migration and impaired shoulder function. On the contrary distal entry portal above olecranon fossa for retrograde nailing may lead to supracondylar fractures, triceps tendon irritation, heterotopic bone formation and elbow pain [12]. A biomechanical study states that distal entry points for retrograde nailing lead to reduction in the torque and energy absorbed to failure and the weakening increases if the entry point is the olecranon fossa compared to the metaphyseal triangle [13].

Elastic internal fixation; contrary to rigid fixation, needs some degree of relative movement to promote formation of the external callus, which is the physiological callus that forms most rapidly, and has the highest biomechanical strength. Also, elastic stable nails preserve the endosteal blood supply and this gives us the option of plating the humerus with non-union in our study without extracting the nails. The minimally invasive procedure with preservation of soft tissues, periosteum and fracture haematoma allows prompt biological union. In our series union achieved in 92.8% of patients by following these rules [14].

A retrospective study treating closed humeral shaft fractures with titanium elastic nail, all the fractures healed in good alignment with no intraoperative complications including neurological injury, vascular injury and infection [15]. In a series of diaphyseal fracture of humerus using titanium elastic nail and at the end of the study the authors concluded that the titanium elastic nails offer a number of potential advantage over traditional way of treating long bone fracture including early immobilization, shorter hospital stay and less risk of loss of fracture position [16]. In two comparative studies treating closed diaphyseal fractures humerus with elastic nail and plate osteosynthesis, the authors concluded that elastic stable nail is applicable for routine use in appropriate selected humerus shaft fracture [17,18].

In our series all the patients were managed by Elastic stable intramedullary nails (ESIN) as a method of fixation and utilizing retrograde lateral epicondylar entry. By this approach, it is possible to avoid supra-olecranon entry complications [1,3,15,16]. Also, neural problems of dual entry through medial and lateral points could be overcome [19]. Great attention should be paid for such entry and

proper opening of the cortex should be done to avoid supracondylar humeral fractures or neural injury.

The results in our series showed almost similar range of movements of the shoulder and elbow joints as compared to the contralateral nonoperated limb in 25 patients (89.3%). The use of lateral epicondylar entry would avoid breaching the elbow joint and preserving the joint motion. The three cases with limited elbow ranges of motion mostly caused by prolonged immobilization due to delayed union (one case), non-union (one case) and the third case due to joint discomfort, rather than joint stiffness. Our series did not have any post-operative nerve injuries or deep infections, and this attributed to the minimal invasive procedure we utilized which respects largely the soft tissues. Also, our series showed low complication rate as we considered well the biomechanical principles of elastic intramedullary nailing principles.

## Conclusion

The use of elastic stable intramedullary nailing (ESIN) for treating closed diaphyseal fractures of humerus is an acceptable method of internal fixation. It presents consistent series of advantages, including: physiological consolidation, flexible stability, and compliance for the patient. Also, it carries a low complication rate if attention is paid to biomechanical principles. The procedure is minimally invasive, simple and well reproducible technique with a steep learning curve. Because of the excellent objective and subjective results, the operative stabilization of humeral shaft fractures with ESIN should be recommended to adult patients.

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