



## Retrograde Ender nailing for humerus shaft fractures

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**Humerus fractures are common ; their management remains controversial. Infection, neurovascular injury, joint problems and non-union are recognised complications of surgical treatment. These complications can be decreased by opting for a surgical treatment that is less invasive and safe. We present a series of 59 patients treated with retrograde Ender nailing ; 56 healed in an average of 9.1 weeks, 2 had delayed union (> 15 weeks) and one went on to non-union, which healed after secondary plate fixation. Nail back out occurred in 8 cases, of which only 3 required nails repositioning. The mean Constant score at final follow-up (mean 19 months) was 91 ; it was significantly lower in patients over 50 years of age and in those with segmental fractures. In this series, Ender retrograde nailing gave overall satisfactory results and appeared as a safe and efficient technique.**

**Keywords :** humeral shaft fracture ; Ender nailing ; retrograde.

batable place in operative treatment of humerus shaft fractures, most acute fractures can be dealt with using less invasive Ender or bundle nailing. This study was performed to assess the overall outcome and complications of retrograde Ender nailing for humerus fractures.

### MATERIALS AND METHODS

This prospective study was carried out at the Government Medical College Hospital, Baroda, India, between June 2002 and June 2005. All patients admitted to the Trauma and Orthopaedic unit with a humeral shaft fracture suitable for Ender nailing were included in the study. Informed consent was obtained from the patients participating in the study. The indications for Ender nailing comprised of failure to obtain reduction, i.e. angulation of more than 20° in any plane, bayoneting of transverse fractures, polytrauma patients, bilateral humeral fractures, open fractures, segmental fractures

### INTRODUCTION

Diaphyseal fractures of the humerus are common ; their management remains controversial. There is no universal consensus on the most appropriate method for management. Infection, neurovascular injury and joint problems are some of the well recognised complications of surgery (1,3,18,20, 25). More patients could be felt suitable for operative intervention if the latter were safe, short, simple and minimally invasive with lesser risks of complications. Although plate fixation has its unde-

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and non compliance with conservative treatment because of obesity or senescence. Patients with a fracture in the distal part of the lower third of the shaft were not considered for retrograde nailing. Also excluded were paediatric patients and patients unwilling to participate in the study, fractures with involvement of the distal or proximal humerus articular surfaces and with neurovascular injuries.

Following the operation, after an initial follow-up at 10 days for wound review, patients were followed up at 4, 8, 12, 20, 28 weeks. Further follow-up was based upon the clinical status. Clinical union was defined as absence of motion or tenderness on movement or manipulation of the arm. Radiographic union was defined as observation of an osseous bridge in both AP and lateral radiographs. All patients were reviewed by the senior author at the final follow-up. Patients were evaluated with the Constant and Murley shoulder scoring system (5). The range of elbow and shoulder motion was also documented in comparison to the respective contralateral joints.

During this period 67 patients were treated with retrograde multiple flexible nails. Eight patients were lost to full follow-up. Results of the remaining 59 patients were available for analysis. As this was the standard management provided in our unit, approval from the ethics committee was not required.

The fractures were classified on the basis of the anatomic location and pattern using the AO classification (table I). On admission the arm was splinted in a plaster back slab. Open fractures were treated with intravenous antibiotics, minimal initial debridement in casualty followed by urgent surgical debridement and internal fixation.

### Surgical technique

The operation was performed under brachial block or general anaesthesia. All patients received three doses of prophylactic intravenous antibiotics. A careful pre-operative planning to assess the medullary canal diameter on radiographic films was made to anticipate the appropriate number and size of nails, in a good spatial distribution. Before antiseptic preparation, the fracture was manipulated under fluoroscopy to assess the reducibility and maneuvers required therefore. The patient was positioned supine with the arm placed on an arm rest. The image intensifier was positioned so as to enable easy screening of the fracture site, elbow joint and humerus head. Incisions were placed on the palpable subcutaneous lateral and medial epicondyles. The ulnar nerve was carefully protected on the medial side. The tips of

Table I. — Patient numbers as per AO classification

Fracture configuration	Number of patients
12A2	08
12A3	33
12B1	04
12B2	06
12B3	03
12C2	05

the epicondyles were used as entry portals. The elbow was maintained at 90° flexion to facilitate palpation of the epicondyles and for insertion of a curved awl under imaging. The curved awl directed the track well into the medullary canal. First a C or S shaped Ender nail was inserted from either entry portals depending on the fracture geometry, and was advanced to the fracture site. After appropriate manipulation under fluoroscopy, the nail was advanced to the subchondral part of the humerus head. Similarly, a nail from the other epicondyle was inserted as well, with an aim to spatially distribute it in the proximal humerus. Length of the nails was confirmed with imaging before the final hammering. If the medullary cavity permitted, a third nail was inserted, usually from the lateral condyle. The tip of the nail was buried completely into the epicondyle. Depending upon the fracture geometry and stability achieved, the decision to provide a humerus brace was made. The brace supported the upper arm only and the patients were encouraged to move the elbow and shoulder joints.

### Statistical analysis

Statistical analysis was performed using Student's t test for comparison of means and Fischer's exact test for comparison of proportions. ANOVA (analysis of variance) was used to determine the level of significance of continuous variables. Calculations were performed using the Statistical Package for the Social Sciences (SPSS Windows package), version 12. Ninety five percent confidence interval was considered hence, a 'p' value less than 0.05 was considered as significant.

## RESULTS

During the study period 67 patients, 38 male and 21 female, were treated with retrograde multiple flexible nails. Eight patients were lost to full follow-up. Results of the remaining 59 patients were



**Fig. 1.** — Trauma radiographs, AP (a) and lateral (b) views.

available for analysis. The mean duration of follow-up was 19 months with a range of 15 to 31 months. The mean age of patients was 36 years (range, 18 to 71 years). The mechanism of injury was a motor vehicle accident for 17 patients, a fall while walking/cycling for 19 patients, a fall from a height/tree for 14 patients, an assault with a stick (lathi) for 7 patients and occupational injuries for 2 patients. Thirty four patients had a left humerus fracture while 25 had fractures of the right arm. Eight patients had open fractures, of which one was Gustilo Anderson Grade 3. Sixteen patients had other injuries as well. Twenty three patients had midshaft humerus fractures, 31 had upper or lower third fractures and 5 fractures were segmental. Thirty three patients had transverse or short oblique fractures, 8 had a long oblique configuration while 13 had butterfly or comminuted fragments. The mean time from injury to surgery was 1.7 days (range 7 hours to 13 days). The average duration of hospitalisation was 3.6 days (range 2 to 19 days). There was no peri-operative mortality.

Median healing time was 9.1 weeks (range 6.3 to 19.4 weeks). Two patients showed delayed union with union achieved in over 15 weeks. One patient had non-union and was treated by extraction of the Ender nails followed by plating with bone grafting.

At final follow-up, 52 patients had no shoulder or elbow pain. Six patients had some elbow discom-



**Fig. 2.** — Post-operative radiographs: AP (a) and lateral (b) views showing retrograde Ender nails *in situ*, inserted from epicondylar entry points.

fort and one had severe pain. Fifty three patients had acceptable reduction with less than 5° angulation in either plane. The remaining 6 patients had varus or valgus alignment between 5° to 10°. Three patients had the entry portal proximal to the tip of the epicondyles. This led to varus or valgus angulation. Eight patients had back out of the nails. Of these, 5 underwent extraction of the nail as fractures had united by then. In the remaining three patients, the back out of the nails occurred at 2.5, 3 and 4 weeks respectively. The nails were rehammered to sit flush to the epicondyles. There were no problems with union in these patients. All the nail back-outs and non union occurred in patients treated with two 3.5 mm flexible nails. Of the 27 patients who had fixation with either 4 mm nails or three nails of 3.5 mm size, no complication during healing was seen. A significant association was found between the nail size/ number used to fix the fracture and the complications like back out and delayed/ non-union ( $p = 0.03$ ). No patients had implant failure.

On final follow-up (mean 19 months), the mean Constant and Morley shoulder score (5) was 91 (range 62 to 100). The mean score was 95 for patients below 50 years of age, versus 79 in patients above 50 years ; the difference was statistically significant ( $p < 0.05$ ). Patients with a segmental fracture had a mean Constant score of 74 in comparison to 93 in the rest of the patients ; this difference was statistically significant ( $p = 0.026$ ). Presence of a wound associated with the fracture and the time from admission to operation showed no statistical significance. Thirteen patients underwent supervised shoulder and elbow physiotherapy for over 2 months duration. They had a mean Constant score of 82 in comparison to 94 in the rest. This difference was statistically significant. The range of movements of elbow and shoulder were as per table II.

## DISCUSSION

Non-operative treatment still remains the first option for most humerus diaphyseal fractures (7,16, 22). There is no consensus on the optimal modality of fixation when surgery is indicated (3,15,16,29). Internal fixation with plates carries risks of infection, neurological injury and non-union. Antegrade and retrograde insertion of nails is a matter of debate in itself.

In our series all the patients were operated with retrograde epicondylar entry, thus avoiding the complications associated with antegrade nailing. The proximal entry for antegrade nailing may lead to rotator cuff injury, shoulder impingement, proximal nail migration and impaired shoulder func-

tion (1,3,11,18-20,23,29). The results in our series showed almost similar range of movements of the shoulder joint as compared to the contralateral non-operated limb. The elbow range of movement was only marginally affected. The epicondylar entry ensures that no joint is breached, and preserves the joint motion. Small restriction of the elbow motion was probably due to a generalised early discomfort, rather than joint stiffness. Similar restriction of elbow movements is expected in antegrade nailing as well (23). Nails inserted in a retrograde manner with an entry portal in the olecranon fossa may lead to supracondylar fractures, triceps tendon irritation, heterotopic bone formation and elbow pain (23,25). Strothman *et al* concluded from their biomechanical study that distal entry points for retrograde nailing lead to reduction in the torque and energy absorbed to failure ; the weakening was more if the entry point was the olecranon fossa as compared to the metaphyseal triangle (27). This is especially important when prescribing postoperative mobilisation in elderly patients in whom the upper extremities will be used for weight-bearing in either transfer or ambulation (26,27).

Ender nailing relies on configuration and spatial orientation of the nails to achieve rotational stability (8). Accuracy of the entry portals is the key in achieving good reduction and fixation. With reamed interlocking nails, locking screws may be used to provide rotational stability. They rely on bone quality and hence achieve poor fixation in osteopenic bones (4,8). Insertion of locking screws can sometimes be tedious, time consuming and may lead to neurovascular complications. By not relying on interlocking screws for stability, nerve damage

Table II. — Shoulder and elbow movements of affected and contralateral limbs

Joint movement		Mean (operated)	Range (operated)	Mean (contralateral)
<i>Elbow</i>	Extension lack	3°	0° to 10°	1°
	Flexion	134°	90° to 150°	138°
<i>Shoulder</i>	Abduction	109°	90° to 125°	115°
	Flexion	120°	90° to 130°	122°
	Int rotation	74°	60° to 85°	78°
	Ext rotation	62°	55° to 75°	67°



**Fig. 3.** — Final follow-up radiographs at 14 weeks : AP (a) and lateral (b) views showing signs of union.

associated with the screw placement is eliminated in Ender's nailing (3,6). Our series did not have any post operative nerve injuries or deep infections. Ender nailing does not require reaming. Reaming for interlocking nails may have deleterious effects on fracture union. It destroys the residual endosteal blood supply (29). Although being intramedullary implants, Ender nails relatively preserve the endosteal blood supply. This gave us the option of plating the humerus of the patient with non-union in our study. The minimally invasive procedure for Ender nailing with preservation of soft tissues, periosteum and fracture haematoma provides flexible stability for biological union. It offers internal bracing, helping in maintenance of the fracture fragments in acceptable alignment. This decreases the necessity of plaster immobilisation and allows early return to normal activity (13,21). The use of Ender or bundle nails in elderly and paediatric (pathological fractures following unicameral bone cysts) age groups has been shown to be minimally invasive and safe, and to produce excellent functional and cosmetic results (2,8,10,13,14,17,26). The literature suggests that this technique gives minimal x ray exposure, short operative time and causes less soft tissue insult (9,13-15). This decreases the overall morbidity in elderly and poly traumatised patients.

In our series 8 patients (10.1%) had nail back out. This is usually a minor complication warranting re-

hammering or extraction of the nails. Fastening of the eyelets of the nails with a wire eliminates this complication (12). End caps to prevent back out of Ender nails have now been designed by various manufacturers. All our patients who had nail back out achieved fracture union. Nail back out is, indeed, perceived as a potential complication with the use of Ender nails, but even if this occurs it can be resolved with minor procedures. The long term ill effects of this complication are much more benign than the complications associated with other surgical options as discussed earlier. Our results show significant increase in complications viz. back out and delayed or non-union with the use of an inappropriate number and size of implants. Overall stability of the construct depends on the number and size of implants and their spatial distribution with adequate jamming in the medullary canal. Meticulous preoperative planning and intra-operative execution is the key to this operation.

The patient with a non-union in our series had a Gustilo Anderson grade 2 open fracture on presentation. Two 3.5 mm Ender nails were used for fracture fixation ; they failed to achieve sufficient stability, as there was unsatisfactory jamming in the wide medullary canal with osteoporosis, and this led to non-union. There was a statistically significant difference between the mean Constant score of patients below 50 years in age in comparison to those above that age : the mean scores were 95 and 79 respectively. This probably was due to the pre-injury shoulder joint status and associated problems like arthritis or rotator cuff pathology in the older group. In the younger age group, overall shoulder and limb function was not adversely affected as they had no significant deterioration of the Constant score. Similar observations were made by Wachtl *et al* following their study on the use of multiple flexible nails for proximal humerus fractures (28). Patients with a segmental fracture had a mean Constant score of 74 in comparison to 93 in the rest of the patients ; this difference was statistically significant ( $p = 0.026$ ). These patients were provided with a humerus brace and mobilisation was delayed. The segmental geometry of these fractures suggested high-energy trauma and hence the amount of associated soft tissue injury in these

patients was probably more ; this could explain the poor shoulder function in this group. The group of patients who underwent supervised shoulder and elbow physiotherapy had a mean Constant score of 82 in comparison to 94 in the rest. The difference was statistically not significant but this was probably due to a type II error. The group referred had a worse range of movements on the initial referral. We did not assess the improvement in the patients' range of movements in comparison to their pre-physiotherapy movements.

Intramedullary flexible nailing presents a consistent series of advantages, including advantages of a biological (physiological consolidation), mechanical (flexible stability), and practical (comfort for the patient) nature (24). This simple and safe surgical technique provided good overall outcome for humerus diaphyseal fractures in our study. With the above advantages, the indications of operative intervention can be extended to include a wider group of patients for surgical intervention. Elderly patients should be considered for this surgery, thus giving them less potential surgical risks, but advantages of ability to use the limb soon after surgery for routine activities and for mobilisation support.

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