Treatment of Closed Humeral Shaft Fractures with Intramedullary Elastic Nails

[Article]

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Abstract

Purpose: Our purpose is a retrospective study of the results of diaphyseal humeral fracture treatment by elastic intramedullary nailing in comparison with plate osteosynthesis.

Methods: Thirty cases were reviewed, with an average follow-up of 2 years. In 14 cases, flexible nails were used, and in the remaining 16 cases, A-O plates were used. We considered patients' sex and age, fracture type according to the A-O classification, type of treatment, consolidation defects, additional therapeutic procedures, healing time, and functional recovery. The surgical technique of elastic nailing appeared very simple, safe, and rather atraumatic because the nail is introduced in a retrograde manner and does not need proximal interlocking.

Results: The results of elastic nailing, in terms of fracture healing time and functional recovery, appeared comparable with the results of plating, and complications appeared milder.

Conclusion: We conclude that intramedullary elastic nailing is valid for routine use in appropriately selected humeral shaft fractures.

Key Words: Humeral shaft fracture, Internal fixation, Elastic nailing.

Nonoperative treatment is considered the first choice in humeral shaft fractures (HSFs). [1,2] Splints, hanging casts, functional braces, and skeletal traction are all used. Shoulder and elbow stiffness, nonunion, and malunion are observed with such conservative methods, although reported union rates and good results are greater than 90%. [3-6]

An increasing number of HSFs are currently treated surgically, not only in cases of open fractures, [7] fractures complicated by neurovascular damage, [8] improper reduction and nonunion, [5,9] or in patients with multiple injuries,

[10] but also every time early mobilization of the shoulder and elbow is necessary, e.g., in the active young patient and the elderly patient. [6] The most widely used devices are plates, [10,11] intramedullary nails, [12-16] and external fixators. [7]

The reported complications of this type of surgery are radial nerve injury, [17,18] posterior cutaneous antebrachial nerve damage, [13] rotator cuff lesion and shoulder pain with proximally inserted nails, [12,14] cosmetically poor scars, shoulder stiffness, [14] nonunion, [13] and infection. [6] The results of the surgical treatment of HSFs at our clinic with intramedullary elastic nails (IEN; Zimmer, Inc., Warsaw, Ind) are reported and compared with the results of the treatment of a control group with A-O plates.

PATIENTS AND METHODS

Fifty-one patients with HSFs were surgically treated from June 1992 to June 1996. We reviewed all cases: 2 patients (admitted because of pathologic fractures) died of tumoral disease, and 19 patients were excluded because they were treated with different devices (14 with Seidel nails and 5 with external fixators for open fractures). Of the 30 remaining patients, 19 were males and 11 were females. Mean age was 47 years (range, 16-84 years). Average follow-up was 25 months (range, 12-50 months).

Fractures, as shown in Table 1, are classified according to the A-O scheme: [19] 14 were treated with IENs (47%) and 16 with A-O plates (53%). All fractures were closed. We treated three fractures in patients with multiple injuries (U.G., G.R., L.G.; Table 2). Two patients (G.L., G.C.; Table 2) previously treated conservatively (hanging casts) had delayed union, and nailing was performed. Two other patients (A.G., P.S.; Table 2) had failure of surgical treatment: in the first, we observed early mobilization of a Seidel nail (revised with a plate); in the second, a distal shaft fracture incorrectly treated with an IEN was revised with a plate and bone graft 3 months later. No vascular lesion and five preoperative radial nerve deficits (B.M., A.B., S.P., U.B., O.B.; Table 2) were observed; early radial nerve exploration was performed in two of the five patients (A.B, U.B.; Table 2).

Fracture Type	Fractures (n)	Plates (n)	IENs (n)
A1	2	1	1
A2	8	3	5
A3	7	5	2
B1	3	2	1
B2	2	1	1
B3	5	3	2
C1	3	1	2
C2	-	-	-
C3	-	-	-
Total	30	16	14

Table 1. Type of fractures and treatment

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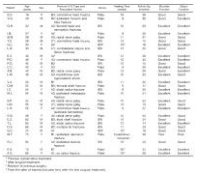

Table 2. Details of patients

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The clinical criteria for healing time assessment were painless and free shoulder and elbow activity; radiographic criteria were the presence of a bone bridging the callus and a remarkable reduction of fracture line lucency in the case of A-O plates. The functional results were recorded according to the Constant shoulder evaluation form and the Morrey, An and Chao elbow evaluation sheet: excellent (95-100 points), good (80-94 points), fair (50-79 points), and poor (<50 points) (Table 2). The overall results were graded according to the sum of the scores recorded on each form: excellent (190-200 points), good (160-189 points), fair (100-159 points), and poor (<100 points).

Surgical Technique: IEN

The Marchetti-Vicenzi nail features a cylindrical part of 8 or 9 mm in diameter, linked to four or five diverging pins of 2.5 mm diameter each (Figure 1A). The pins are precharged by an elastic diverging force and are held in a closed position by a metallic rod, passing from the proximal cylindrical part through a distal ring linked to each pin (Figure 1B). Total nail length ranges from 210 to 310 mm.

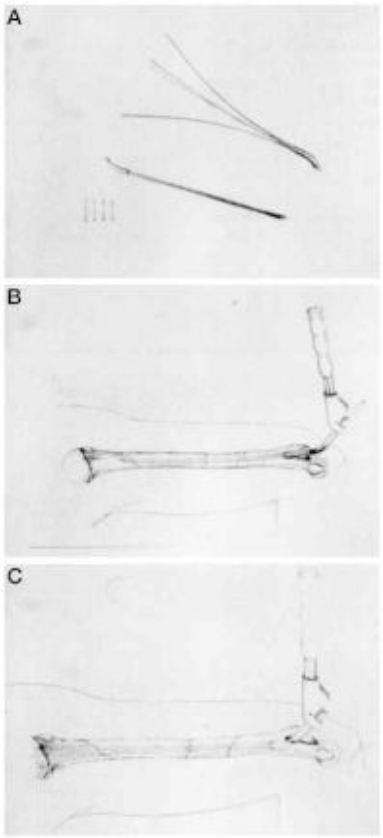

Figure 1. (A) Design of the humeral intramedullary elastic nail. (B) Central rod holding the pins in the closed position. (C) Opening of the humeral intramedullary elastic nail. (Reproduced by kind permission of Zimmer, Inc.)

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The patient is positioned prone, with the affected arm abducted at 90 degrees lying on a radiolucent Table andthe elbow flexed at 90 degrees hanging at the end of the table. If the prone position must be avoided, e.g., in cases of multiple trauma or if the patient is in respiratory distress, the patient will lay supine with the affected arm flexed at 90 degrees and the forearm lying horizontally on a support. The nail is introduced in a retrograde fashion by a distal approach.

A straight skin incision, about 7 cm long, is made toward the tip of the olecranon. The triceps tendon is split just above the olecranon fossa, and the posterior aspect of the humeral palette is then skeletized. An elliptic hole just proximal and lateral to the olecranon fossa is carefully prepared with drills and burrs. Nail length is determined by a radiopaque ruler. About 7 cm of the distal canal is reamed.

Elbow flexion, until the forearm impinges on the edge of the table, allows distraction of the fracture site. The nail is fixed to a handle, which can be used as a joystick for manipulation and reduction of the fracture under an image intensifier. When the tip of the nail is 2 or 3 cm beyond the fracture line, the pin-release rod is withdrawn to free the bundle of pins (see Figure 1C). Pins can now be hammered into the cancellous bone of the humeral head to achieve

proximal stabilization. Distal locking is achieved with a posteroanterior 3.5-mm screw, angulated 45 degrees, inserted through the distal end of the nail.

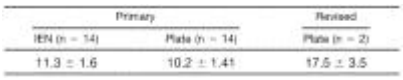
Surgical Technique: A-O Plate

The standard lateral approach and surgical technique were used. [6] In both groups, the arm was maintained in a sling for the postoperative period. Elbow and wrist active movements were encouraged from the first postoperative days. Shoulder pendulum active-assisted movements started as soon as pain subsided sufficiently. Shoulder active motion was allowed after 1 month.

RESULTS

Surgery was performed on average 1.9 days after admission. Mean hospital stay was 7.5 days. The longest delay for surgery was in patients with multiple injuries. We were unable to retrospectively study the average surgical time.

The mean healing time and SDs were calculated for single groups. Data do not show statistically significant differences ($p > 0.05$, t test) between primary fixations with IENs and A-O plates (Table 3), although a wider series could have shown some difference. Table 3 also shows the results of revised fixations. Overall functional outcome of primary and revised fixations is shown in Table 4: similar results were obtained with IENs and A-O plates.



Primary		Revised
IEN (n = 14)	Plate (n = 14)	Plate (n = 2)
11.3 ± 1.6	10.2 ± 1.41	17.5 ± 3.5

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Table 3. Healing time (weeks) of primary and revised fixations

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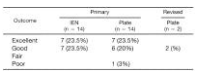

Outcome	Primary		Revised
	IEN (n = 14)	Plate (n = 14)	Plate (n = 2)
Excellent	7 (23.5%)	7 (23.5%)	
Good	7 (23.5%)	6 (20%)	2 (%)
Fair			
Poor		1 (3%)	

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Table 4. Functional outcome of primary and revised fixations

Two patients had revisions of previous procedures, one for loss of fixation and one for delayed union. In the first patient (A.G.; Table 2), a Seidel nail showed mobilization 7 days after insertion because of loss of distal locking; in the

second patient (P.S.; Table 2), a B1 fracture, which was too distal, was incorrectly treated with an IEN and did not show evidence of even initial repair at 3 months. Both fixations were successfully revised with the use of A-O plates, with autogenous bone graft in the latter, and these patients are included among the plate-treated patients.

Complications

A 75-year-old woman (M.F.; Table 2) treated with an A-O plate developed pseudoarthrosis even after Gauss field therapy; her arm was finally splinted in a functional brace after she refused further operations. Among the five preoperative radial nerve deficits, two appeared complete and were surgically explored; in both, which were treated with plates (A.B., U.B.; Table 2), the nerve was contused but continuous. Three nerve deficits were partial and were not explored. At the last follow-up, we observed full clinical recovery in all of these patients, and no postoperative nerve deficits were observed. There was one case of superficial infection (S.P.; Table 2), and no deep infections were recorded. A painful, hypertrophic scar was observed in a young girl treated with plating (E.D.; Table 2).

DISCUSSION

Surgical treatment of humeral shaft fractures (Figure 2A and Figure 3A) must be compared with the satisfying results of conservative treatment, which is considered by many authors the first-choice therapy. [1,6,20,21] On the other hand, because among surgical options plates are widely accepted as the gold standard in humeral shaft fractures, [6,20-24] in this retrospective study we compared the results of a group of patients treated with IENs and a control group of patients treated with A-O plates. We obtained comparable, overall good functional results with both IENs and A-O plates (Table 4).

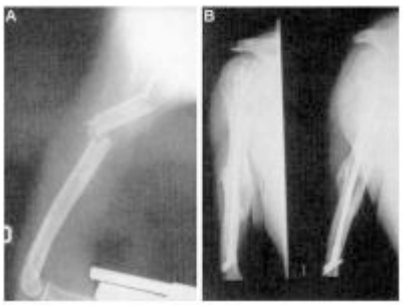

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Figure 2. Preoperative (A) and follow-up radiographs (B; at 15 weeks) of a patient treated with IEN (G.R.; Table 2).

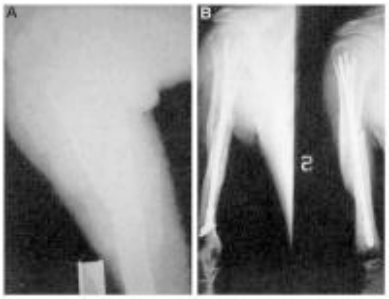

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Figure 3. Preoperative (A) and follow-up radiographs (B; at 16 weeks) of a patient treated with IEN (L.M.; Table 2).

The mean healing time for both devices was 11 weeks (Table 3). This is not shorter than nonsurgical procedures, [6,20] but surgically treated patients maintain nearly normal lives during most of this period-without limitations by splints, casts, or braces-and can return to work even sooner. Furthermore, in our experience patients treated conservatively usually need additional physical therapy after fracture healing and are frequently troubled by joint pain and stiffness.

Because of these factors, we can observe a trend toward operative treatment with broader indications than in the past. [6,20,21,24] It is our opinion that the surgical treatment of even isolated humeral shaft fractures, in active young patients and elderly patients, could lead to overall better functional results and lower morbidity compared with conservative treatment.

Reported rates and types of complications (infection, extensive approach and scar, nerve injuries) limit routine surgery in HSFs, and a completely satisfying device is not yet available. Plates offer an optimal primary stability, allowing early mobilization and recovery. The surgical approach allows radial nerve exploration; on the other hand, exposure is wide, with resulting cosmetically undesirable scars and greater risk of infection, and radial nerve lesion is possible. [11]

Antegrade nails can cause shoulder pain and require a sometimes difficult distal interlocking, which can be unreliable with Seidel nails. [12] These factors led us to give up the latter device after a personal experience with 14 patients; of these patients, 4 (29%) developed shoulder pain and 2 (14%) had distal locking failure.

Retrograde, rigid nails avoid rotator cuff lesions but possibly cause additional comminution, both at the entry and at the fracture site, and need proximal interlocking, [14] which is especially troublesome in obese patients and carries risks of damage to the axillary nerve. External fixators, suited for widely exposed and highly comminuted fractures, can damage the radial nerve, and

their use is limited by possible pin-track infection, uneasy fracture alignment, and patient compliance. [7,25]

IEN has a retrograde insertion, thus avoiding rotator cuff lesions, and its elasticity reduces risks of fractures or additional comminution at the introduction site. The most critical step in its application is the accurate shaping of the elliptic entry hole, proximally and laterally to the olecranon fossa, in the direction of the medullary canal. Proximal locking is achieved by impacting the diverging pins in the metadiaphyseal bone of the humeral head (after extraction of the locking wire), and distal locking by driving a screw through the cylindrical portion of the nail toward the anterior cortex. Each of these procedures appears simple and safe. Rotational stability is the greatest concern with the IEN. In our experience, it appeared sufficient for early mobilization and fracture healing, with an abundant periosteal callus (Figure 2B and Figure 3B).

In our opinion, plate osteosynthesis remains indicated in cases of distal diaphyseal fractures, i.e., 10 cm or less from the articular line, proximal fractures, and complete radial nerve palsies requiring exploration and repair. On the other hand, isolated long, spiral, comminuted fractures with little dislocation are better treated by nonoperative means. Because with retrograde elastic nails the main concerns about plates and antegrade rigid nails are apparently avoided, we currently use IENs routinely for appropriately selected HSFs.

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