Feature Article

The Use of Elastic Nails for Intramedullary Fixation of Humeral Fractures and Nonunions

P.G. Marchetti, MD*  S. Landi, MD*
G. Vicenzi, MD*  V. Surdo, MD†
C. Impallomeni, MD*

ABSTRACT

From May 1993 to January 1997, a total of 130 humeral fractures and nonunions were treated using an “elastic” unreamed nail. The elastic nail consists of a cylindrical proximal component tapered for the application of the impactor-extractor, distally containing the proximal ends of four or five secondary nails preloaded to diverge and held together by a retaining system. The surgical approach is through the olecranal fossa apex. Once introduced, the proximal end of the nail locks automatically by diverging the secondary nails in the proximal humeral epiphysis. Distally, the elastic nail is locked with a crossbolt. The elastic nail enables stable fixation of fractures or nonunions and allows early rehabilitation.

The surgical treatment of humeral fractures and nonunions differs from the treatment of fractures and nonunions in the lower limb.1-4 Intraoperative reduction is usually easier in humeral fractures, especially compared to femoral fractures. Furthermore, as the humerus does not bear body weight, slight axial or rotational malalignment are generally acceptable, thus making treatment of humeral fractures technically easier.

Today, it is generally accepted that treatment of humeral fractures should be as “biological” as possible, by avoiding open surgery and rigid fixation.5-17 These concepts have made closed intramedullary nailing of humeral fractures popular over the past several years.

The most widely used intramedullary nailing systems can be divided into two major groups: nails for proximal insertion12,14,16,18 and nails for distal insertion.17,19 The major drawback of proximal nails is that they can damage the delicate periarticular structures of the shoulder20-21 and fail to guarantee rotational stability. Distal nails are often unstable with a tendency to back out and do not always guarantee rotational stability and control of shortening. Moreover, rigid nails (eg, Kuntscher, Seidel, etc) often require reaming of the medullary canal, which is a nonbiological procedure, and locking which may cause serious technical and surgical problems such as vascular and nervous damages.22

To address these problems, we designed an “elastic” humeral nail that allows distal insertion, does not require reaming of the medullary canal, and offers rotational and shortening control. Additionally, being an “elastic” nail, it favors multiplanar micromovements at the fracture site to foster callus formation.13,14,23-27

This article describes the use of the elastic nail for intramedullary fixation of humeral fractures and nonunions in 170 patients. The features of the nail and the surgical technique also are described.

MATERIALS AND METHODS

Elastic Nail

The humeral nail is constituted by a proximal cylindrical tapered component, inclined by 45° and proximally treated to host the impactor or extractor. The distal part of the cylindrical component encloses the proximal ends of four or five strongly embedded “secondary” nails (Figure 1).

The distal ends of the secondary nails are kept firmly in place by an inner wire protruding from the proxi-
Lesion of the radial nerve is not in itself a contraindication to the use of the elastic nail, which can be inserted before or after nerve repair or exploration at the surgeon's discretion.

In our experience, the use of the elastic nail alone may be contraindicated in fractures where the medullary canal is wide. In such cases, stability should be implemented by the use of a well-molded brace for 3-5 weeks. Another contraindication for nailing alone is mobile and atrophic nonunions; in these cases, after reaming (which is routinely performed in all nonunions) and nailing, it is advisable to open the nonunion site and perform an accurate decortication (Judet’s technique) with or without bone graft.

**Surgical Technique**

The patient lies prone and the affected limb is abducted 70°-90° resting on a radiolucent plane with the elbow flexed at 90° and the forearm hanging. For patients who will require traction, a subaxillary bandage fixed at the opposite side of the surgical table can be applied.

A 4.5 cm straight incision is made at the level of the olecranon fossa (Figure 2A), which is then fully exposed after retracting the fibers of the triceps tendon (Figure 2B). With a 3-mm drill, a hole is drilled 1 cm proximally from the tip of the olecranon fossa down to the medullary canal; the hole is then enlarged with a 4- to 5-mm drill and an awl up to 6-7 mm.

A guide wire is inserted 10-12 cm into the medullary canal (Figure 2C). Only the distal 5-6 cm of the medullary canal is reamed, first with a 6-mm reamer and then with a 7- and 8-mm reamer when a 4-element nail is used or a 9-mm reamer for a 5-element nail. Reaming whole or part of the shaft is required only in rare cases when the medullary canal is smaller than approximately 7 mm and in all nonunions.

The length of the nail is usually established in the surgical field by the image intensifier. The contralateral humerus can be used as a length referral in severely comminuted fractures. An 8-mm diameter nail (5 secondary nails) is indicated for medullary canals ≥8 mm, and the 7-mm diameter nail (4 secondary nails) is indicated for medullary canals <8 mm. Whenever possible, it is preferable to use the nail with 5 secondary nails to fit the medullary canal better.

The nail is connected to the impactor with a screw and inserted in the medullary canal (Figure 2D). The procedure is monitored with the image intensifier. The impactor can be adequately maneuvered to reduce the fracture and enable the nail to pass the fracture site. Opening of the fracture site should be performed only when reduction is impossible to achieve by closed manipulation.

Once the fracture or the most proximal fracture line is exceeded, the retaining wire is pulled out (Figure 2D) and the secondary nails released so they can diverge and become firmly anchored to the proximal meta-epiphysial cancellous bone of the humerus when the nail is further inserted (Figure 2E).

Once the nail insertion is completed, a 2.5-mm drill hole is made in the anterior cortex, drilling through the impactor guide. A self-tapping 3.2-mm cancellous screw of the proper length is inserted to fix the nail to the anterior cortex, providing distal locking.

Postoperatively, if the limb is swollen, it can be placed in a soft-type bandage with the elbow flexed 90° for 10-12 days. Alternatively, the arm can be placed in a sling to allow early hand, wrist, and elbow active movement. In severely comminuted fractures or in mobile and atrophic nonunions, functional bracing or a soft bandage may be used for 3-4 weeks.

Progressive active and passive mobilization of the elbow and shoulder is started 6-8 days after surgery and gradually increased. Three to 4 weeks after surgery, the patient is instructed to perform gradual active flexion-extension movements of the elbow against resistance to foster multiplanar micromovements at the fracture site, thus stimulat-
ing healing callus formation. Nail removal is usually straightforward, especially if the device is removed early, i.e., 3-4 months after fracture consolidation.

**Patient Population**

Between May 1993 and January 1997, a total of 130 patients (71 men and 59 women) with fractures or nonunions of the humeral shaft were treated with the elastic humeral nail. One hundred thirteen were fractures and 17 were nonunions. Average follow-up was 21 months (range: 6-32 months).

Open or partially open nailing was performed in 12 patients. Two of these patients had a proximal-third fracture with soft-tissue impingement, and 10 patients had nonunions.

Fractures (113 cases) were classified according to the fracture location and pattern. Twenty-seven fractures were in the proximal third, 35 fractures were in the proximal third-middle third, 21 fractures were in the middle third, 16 fractures were in the middle-third-distal third, and 14 fractures were in the distal third of the humeral shaft. There were 47 oblique, spiral, and transverse simple fractures (type A according to AO classification); 56 spiral, bending, or fragmented wedge fractures (type B); and 10 comminuted or segmental fractures (type C).

Criteria used to evaluate results included fracture healing time (radiographic), alignment, and shoulder and elbow range of motion.

**RESULTS**

No general complications were observed in any of the patients. Two patients with comminuted fractures of the mid-third shaft developed a radial nerve palsy that completely resolved by 3 months postoperatively.

**Fractures**

Average time to radiographic healing was 9.5 weeks (range: 6-12 weeks) in 107 (94.6%) patients. In 2 (1.7%) patients, healing took >4 months to heal. Nonunion occurred in 4 (3.5%) patients.

Alignment was evaluated by comparing postoperative radiographs with radiographs taken after healing had occurred. One hundred (88.4%) of the healed ones did not demonstrate any significant loss of reduction. In particular, 60 patients had <5° of angulation in every plane; 28 patients had between 5° and 10°, and 14 patients had >10°. Thirteen (11.6%) patients had significant modifications to the postoperative reduction: 5 patients had 5°-10° of alignment improvement and 8 patients had 5°-12° loss of reduction; all 13 of these patients had unstable proximal third fractures.

Functional results were evaluated according to the Shazar protocol, concerning the shoulder, >120° abduction and >180° internal-external rotation was considered a good functional result; between 90° and 120° abduction and 120°-180° internal-external rota-
tion was considered a fair result, and <90° abduction and <120° rotation was considered a poor result. A loss of <10° elbow extension was considered a good result, between 10° and 30° was considered a fair result, and >30° was considered a poor result.

Ninety-seven (85.8%) patients had good, 10 (8.8%) patients had fair, and 6 (5.4%) patients had poor range of motion. In 2 of the 10 fair patients, shoulder range of motion was limited by an associated fracture of the great tuberosity; in the remaining 8 cases, the fair result was determined by loss of elbow extension (associated with heterotopic bone formation at the nail entry site in 2 patients). The 6 patients with poor range of motion were 4 nonunions and by 2 delayed unions that healed in >4 months.

Combining all of the parameters (healing, alignment, and range of motion) with clinical factors (general and local symptoms and overall patient satisfaction), 101 (89.2%) patients were rated as good, 6 (5.4%) patients were rated as fair, and 6 (5.4%) patients were rated as poor results.

Nonunions

Nonunions (17 patients) were classified as hypertrophic (13 patients) and atrophic (4 patients). Bone graft was not used in any patient.

Seven nonunions were opened and the internal fixation devices were removed to achieve better alignment. In 7 of these patients, decortication (Jude’s technique) was carried out.

The average time to union was 16 weeks (range: 12-20 weeks). Eleven (64.7%) patients were considered good results and 6 (35.3%) patients were considered poor results (no consolidation). The 6 patients with poor results were treated by closed, simple nailing after reaming of atrophic and mobile nonunions.

No poor results occurred in patients treated with reaming, open nailing, and local decortication.

**DISCUSSION**

The elastic nail for intramedullary fixation of humeral fractures and nonunions can be considered a significant step forward compared with the existing locking and nonlocking nailing systems. This nail provides stable but “elastic” internal fixation, requires reaming only in nonunions, is fixed at both ends to prevent rotation, shortening, or pull out, requires an easy and quick surgical technique (especially when compared to the surgical technique required by locking nails), does not damage the periarticular structures of the shoulder and elbow, fosters rapid endosteal and periosteal bone forma-

![Figure 3: Preoperative radiograph of a 50-year-old man shows a comminuted fracture of the distal third of humeral shaft (A). Postoperative radiograph shows complete consolidation at 2 months (B).](Image)

![Figure 4: Preoperative radiograph of a 34-year-old man demonstrates a humeral neck fracture (A). Postoperative radiograph shows complete union at 2 months (B).](Image)
wide medullary canal we do not use the elastic nail or external protection (soft type) for at least 3-4 weeks.

The high incidence of poor results (35%) in the treatment of nonunions must be discussed. Most of these cases were mobile, atrophic nonunions that were treated closed with reaming and nailing; for this type of nonunion, this treatment evidently is not effective enough. On the other hand, all of the nonunions that were treated open (i.e., to remove screws, broken plates, etc.) with local decortication healed well. Based on our experience, mobile and atrophic nonunions should be treated with reaming, nailing, and local decortication and/or grafting; in severe cases, immobilization (with a soft bandage) for at least 3 weeks could also be indicated.

REFERENCES

11. Perren SM. The biomechanics and biol-

![Figure 5: Preoperative radiograph of a 67-year-old man shows a midshaft fracture and a large medullary canal (A). Postoperative radiograph shows a Rush nail, which was inserted intraoperatively after elastic nailing to achieve better stability (B). Ten months postoperatively, radiographs demonstrated nonunion and initial deformation of both nails.](image)