

TREATMENT OF HUMERAL DIAPHYSEAL NONUNIONS BY INTERLOCKED NAILING AND AUTOLOGOUS BONE GRAFTING

C. C. KESEMENLI, M. SUBASI, H. ARSLAN, S. NECMIOĞLU, A. KAPUKAYA

Twenty seven patients with humeral diaphyseal nonunion treated with interlocked nailing and autogenous bone grafting were retrospectively assessed. The mean age was 37 years (28 to 59 years). There were 16 women and 11 men. An average of 11 months (8 to 36 months) had elapsed between the initial trauma or treatment and presentation in our clinic. The nonunion site was in the distal third of the humerus in 18 patients (66%) and in the middle third in 9 (34%). Seventeen (73%) had hypertrophic and 10 (37%) atrophic nonunion. Patients were treated with locked intramedullary nailing and autogenous cancellous bone grafting.

The mean follow-up was 42 months (28 to 62 months), and the mean time to union was 4.8 months (2.5 to 11 months). Three patients developed superficial infection. Union was achieved in all cases but one, in which there was multiple nerve injury. According to Steward and Hundley's scoring, results were good in 24 patients, fair in 2, and poor in one.

Interlocked nailing and autologous bone grafting has a good rate of union provided nails of appropriate diameter are used and distal and proximal locking is performed correctly. We think that its low rate of infection, low risk of injury to the radial nerve, and low requirement for soft tissue dissection make it a suitable choice in the treatment of nonunions of the humeral diaphysis.

Keywords : nonunion, humerus ; interlocked nailing ; autologous grafting.

Mots-clés : pseudarthrose, humérus ; enclouage verrouillé ; autogreffe.

INTRODUCTION

Humeral diaphyseal fractures often result from high-energy trauma. Traditional treatment is con-

servative, and surgical intervention is generally not necessary. Cases of humeral nonunion are accordingly rare (9).

The treatment of humeral nonunions is problematic. Nonoperative methods require prolonged immobilization and fail to achieve sufficient stabilization. Methods such as electric stimulation and extracorporeal shock waves are only practicable in a limited number of selected cases. Decortication, cancellous bone graft, and rigid fixation have been recommended in surgical treatment. Major complications may arise, such as restricted joint movement and radial nerve paralysis, which may necessitate one or more further operations. Intramedullary nails and external fixators may be used as fixation materials (9, 10). Insufficiently rigid stabilization is currently one of the greatest problems faced by the orthopedist in the surgical treatment of ununited fractures of the humeral shaft (9, 11).

Intramedullary nailing has gained popularity because of its low requirement for soft tissue dissection, low risk of complications, and ease of application. Nonetheless, intramedullary materials such as the Rush pin and Ender or Kuntscher nails have failed to achieve rotational stability (11). This problem has been solved by the recent development of locked intramedullary nails, now widely used in

Department of Orthopedics and Trauma Surgery of the University of Dicle Medical School.

Correspondence and reprints : Cumhuriyet Kesemenli, Department of Orthopedic and Trauma Surgery, University of Dicle Medical School, Diyarbakir, Turkey. E-mail : ccevdet@dicle.edu.tr.

the treatment of both fractures and nonunions. Literature data on their use in humeral nonunions, however, are scant (11).

In the present study, the outcomes of patients treated for humeral nonunion by locked intramedullary nailing combined with autogenous bone grafting were assessed.

PATIENTS AND METHODS

Twenty-seven patients comprising 16 women (59%) and 11 men (41%) with a mean age of 37 years (range : 28-59 years) who were treated with locked intramedullary nailing for humeral diaphyseal nonunion between 1994 and 1999 were retrospectively assessed. Complaints included pain, abnormal movement in the fracture, and restriction of daily activities. Nonunion criteria were sclerotic fracture ends and a persistent radiolucent interval on xrays taken 6 months after the fracture (9, 11).

Two patients (7%) had received no initial treatment for their fractures, 3 (11%) who had open fractures were initially treated with external fixators, 5 (19%) were treated with intramedullary nails, 14 (51%) were treated with plate osteosynthesis and 3 (11%) were treated conservatively. Fifteen (55%) had nonunion on the right side and 12 (45%) on the left. The mean time from the initial treatment or trauma to presentation at our clinic was 11 months (range : 8 to 36 months). One patient treated for open fracture had radial, ulnar, and median nerve paralysis. One patient treated initially with plate fixation underwent this procedure a second time, and sought new treatment for plate failure and nonunion. Fracture locations were as follows : 18 (66%) at the junction of the medial and distal third of the humerus, and 9 (34%) in the medial third of the diaphysis. Sixteen fractures (59%) were transverse, and 11 (41%) were comminuted or oblique. Seventeen patients (73%) had hypertrophic and 10 atrophic nonunion (37%).

Management

Patients treated with external fixators were started on antibiotic prophylaxis after removal of the fixator, and surgery was performed after a minimum waiting period of 15 days. The operation was carried out under general anesthesia in all patients, and first-generation cephalosporin and other antibiotic prophylaxis was used. First, implant material from any previous surgery was removed. The fragment ends were decorticated. Closed

sclerotic medullae were reamed, and antegrade intramedullary nailing was then performed (Biomet nails). If the patient already had an intramedullary nail, it was replaced with one that was one size thicker. After locking distally and proximally, autogenous cancellous grafting was done on all patients with no distinction made between atrophic or hypertrophic nonunion. Bones were fixed in long-arm plaster casts until the soft tissue had healed (at least 2 weeks). After removal of the plaster cast, shoulder and elbow exercises were begun under the supervision of a physiotherapist.

Patients were discharged, and were examined at 4 to 6-week intervals. Bone union was defined as the absence of movement at the fracture site, absence of pain, and solid callus formation on xray (11).

The results were assessed according to Steward and Hundley's scoring (table I).

RESULTS

The mean follow-up was 42 months (range : 28-62 months) and the mean time to union was 4.8 months (range : 2.5-11 months). Complete union was observed in 26 cases (96%). Union was not achieved in one patient initially treated with an external fixator for a type IIIC open fracture. The patient refused further treatment and withdrew from medical care. Three patients (11%) developed superficial infection and were treated with oral antibiotics. None developed deep infection. One patient had restricted movement and shoulder pain owing to the abnormal position of the proximal end of the nail, which had not been inserted sufficiently far. During nail insertion, a fracture in the distal fragment occurred in one patient, and there was difficulty opening a sclerotic medullary canal in another. No refracture, implant failure, or nail breakage occurred.

Shoulder and elbow movements, which were initially restricted after fixation, returned to normal range with exercise in all patients. Shoulder abduction improved from 90° preoperatively to 160° postoperatively. Adduction, flexion, extension, and internal and external rotations were within normal range. An average loss of 15° in elbow flexion occurred, but there was no restriction in extension, supination, or rotation. According to Steward and Hundley's scoring, results were good in 24 (89%)



Fig. 1a. — Nonunion of the humerus in a 42-year-old man ; **b.** — after treatment with intramedullary nailing ; **c.** — 26 months after treatment.

Table I. — Steward and Hundley's scoring system
Functional results

Patients	Score	Pain	Limitation of elbow or shoulder mobility (°)	Angulation(°)
24	Good	None	< 20	<10
2	Fair	After efforts or fatigue	20-40	>10
1	Poor	Permanent	> 40	Radiologic nonunion

patients (fig. 1 a, b, c), fair in 2 (7%), and poor in 1 (4%) (table I).

DISCUSSION

Fractures of the humeral diaphysis tend to result from high-energy trauma, and are generally treated conservatively (7, 8, 11). While the nonunion rate in cases treated nonoperatively is 5%, it is as high as 25% in cases treated operatively (1). Of the patients we operated on for nonunion, 88% had been treated surgically.

The treatment of humerus nonunions is very difficult, and repeat surgery may be necessary (9). Electric stimulation and extracorporeal shock waves are in use as conservative treatment methods,

and successful outcomes have been reported. However, these methods should only be used in a few special cases which do not have any severe deformities (3). Other conservative treatment modalities such as casting, splinting, functional bracing, and traction provide insufficient stability and restrict joint movements, and thus are not suitable for the treatment of humerus nonunions (3, 9, 11).

Decortication, cancellous bone graft, and rigid fixation are traditionally recommended. One of the most significant problems in surgical intervention is fixation failure. Plates, intramedullary nails, and external fixators may be used as fixation devices (2, 11).

Plate fixation has been recommended as the best treatment modality (2, 11). However, osteoporosis

and the risk of damaging the radial nerve complicate the use of plates. The incidence of nerve injury in plate fixation is 0 to 5.6% (9), and there is a risk of refracture both because of the potential for failure and because of stress concentration at the extremity of the plate (11). Another disadvantage is that it requires exposure, which is associated with increased rates of infection and nonunion (11). Circular external fixators have advantages such as not requiring a postoperative plaster cast immobilization (4, 10), but they have disadvantages as well, such as difficulty of application, the technical difficulty, the possibility of injury to blood vessels and nerves, restricted movement, pin-tract infections, and septic arthritis (9, 4).

Treatment with intramedullary nailing has advantages such as requiring less soft tissue dissection, a small area of exposure, a low rate of infection, relative ease of use, and a low rate of radial nerve paralysis. However, it also has disadvantages, such as inapplicability in cases where the distal fragment is short, or where there is rotational instability, or lack of compression. Traditional nonreamed nails, such as Ender and Rush nails, and reamed Kuntscher nails do not achieve sufficient stability, particularly in rotation. Stability, rotational stability in particular, can be achieved with locked intramedullary nails if the distal and proximal screws are correctly inserted. Gupta *et al.* (6) obtained good rotational stability with intramedullary nails, with a functional improvement rate of 89%. Successful outcome rates of 87.5 to 100% have been reported in nonunions treated with locked intramedullary nails (5, 11). In our patients, nails appropriate to the width of the medulla were locked at the distal and proximal ends; rotational stability was achieved in all patients, and complete consolidation in 96%.

It is claimed in the literature that compression is not achieved when locked intramedullary nails are used in nonunions or primary fractures, and hence that treatment may be unsuccessful (11). Nonetheless, 100% successful results have been reported with the achievement of rotational stability (6). In all of our patients who were treated with intramedullary nails after the primary fracture, the cause of nonunion was rotational instability. This

suggests that achieving the rotational stability of intramedullary nails increases the success rate. The rate of nonunions caused by lack of compression may be reduced by achieving sufficient contact between fracture fragments intraoperatively.

In nonunions occurring after primary treatment with intramedullary nailing, removal of the intramedullary nail followed by plate osteosynthesis has been recommended (11). Five of our patients had undergone intramedullary nailing as initial treatment but had developed nonunion. These patients were treated a second time with intramedullary nailing. The fact that complete consolidation was achieved in all these patients suggests that proper distal and proximal locking and the use of an intramedullary nail of a diameter appropriate for the humerus canal increase the success rate, in both fresh fractures and nonunions.

In conclusion, intramedullary nailing and autogenous bone grafting increases the union rate provided that a nail with a diameter appropriate to the width of the medulla is used and that distal and proximal locking are performed correctly. In addition, we think that the low infection rate, low risk of radial nerve injury, and the need for only limited surgical exposure make this a suitable choice in the treatment of nonunions.

REFERENCES

1. Beguin J. M., Plenevaux P., Poilvache G. Considerations concerning the treatment of pseudarthrosis of the humerus. *Acta Orthop. Belg.*, 1991, 57, 114-123.
2. Billings A., Coleman S. S. Long-term follow-up of persistent humeral shaft nonunions treated with three-cortical bone grafting and compression plating. *Iowa Orthop. J.*, 1999, 19, 31-34.
3. Bosh U., Skutek M., Kasperczyk W. J., Tscherme H. Nonunion of the humeral diaphysis-operative and nonoperative treatment. *Chirurg.*, 1999, 70, 1202-1208.
4. Cattaneo R., Catagni M. A., Guerreschi F. Applications of the Ilizarov method in the humerus lengthenings and nonunions. *Hand Clin.*, 1993, 9, 729-739.
5. Corradi M., Retriccioli D., Panno B., Mrenghi P. Seidel locked nailing for the treatment of unstable fractures and nonunion of the humerus. *Chir. Organi Mov.*, 1996, 81, 189-195.
6. Gupta R. C., Gaur S. C., Tiwari R. C., Varma B., Gupta R. Treatment of ununited fractures of the shaft of the humerus with bent nail. *Injury*, 1985, 16, 276-280.

7. Holm C. L. Management of humeral shaft fractures. Fundamental nonoperative techniques. Clin. Orthop., 1970, 71, 132-139.
8. Hunter S. G. The closed treatment of fractures of the humeral shaft. Clin. Orthop., 1982, 164, 192-198.
9. Lammens J., Bauduin G., Driesen R., Maens P., Stuyck J., De Smet L. *et al.* Treatment of nonunion of the humerus using the Ilizarov external fixator. Clin. Orthop., 1998, 353, 223-230.
10. Patel V. R., Menon D. K., Pool R. D., Simonis R. B. Nonunion of the humerus after failure of surgical treatment Management using the Ilizarov circular fixator. J. Bone Joint Surg., 2000, 82-B, 977-983.
11. Wu C. C., Shih C. H. Treatment for nonunion of the shaft of the humerus. Comparison of plates and Seidel interlocking nails. Can. J. Surg., 1992, 35, 661-665.

SAMENVATTING

C. C. KESEMENLI, M. SUBASI, H. ARSLAN, S. NECMIOĞLU, A. KAPUKAYA. *Behandeling van humerus schaft pseudarthroses met een verankerde intramedullaire nagel en autogreffen.*

Retrospectieve studie van 27 humerus schaft pseudarthroses behandeld met verankerde nageling en autologe sponsiosagreffes. De gemiddelde leeftijd bedroeg 37 jaar (28 tot 59 jaar). Er waren 12 vrouwen en 11 mannen. Er verliep gemiddeld 11 maand tussen het initieel trauma of de initiële behandeling en het eerste contact met ons ziekenhuis. De pseudarthrosis was gelokaliseerd distaal in 18 gevallen (66%) en in het middenste derde bij 9 gevallen (34%). De pseudarthrosis was hypertrofisch in 17 (73%) en atrophisch in 10 (37%) gevallen.

De gemiddelde opvolging bedroeg 42 maanden (28 tot 62 maanden). De overbruggingstijd bedroeg gemiddeld 4.8 maand (2.5 tot 11 maand). Oppervlakkige infectie werd 3 maal vastgesteld. In één geval met multiple zenuwletsels bleef overbrugging uit. De resultaten waren goed in 24, matig in 2 en slecht in één geval volgens de Steward en Hundley score.

Verankerde nageling met autologe botgreffen heeft een goede helingsratio als men tenminste de juiste nageldiameter gebruikt en correct distaal en proximaal verankert. Het laag risico voor infectie en voor letsel aan de n. radialis, en de beperkte weekdeel dissectie betekenen pluspunten bij de beslissing tot de wijze van behandelen van humerus schaft pseudarthroses.

RÉSUMÉ

C. C. KESEMENLI, M. SUBASI, H. ARSLAN, S. NECMIOĞLU, A. KAPUKAYA. *Traitement des pseudarthroses diaphysaires de l'humérus par enclouage verrouillé et autogreffe spongieuse.*

Les auteurs ont évalué rétrospectivement 27 patients présentant une pseudarthrose diaphysaire de l'humérus traitée par enclouage verrouillé et autogreffe spongieuse. Leur âge moyen était de 37 ans (28 à 59 ans) ; il y avait 16 femmes et 11 hommes.

Le délai moyen entre le traumatisme ou le traitement initial et la prise en charge était de 11 mois (8 à 36 mois). La pseudarthrose siégeait au tiers distal dans 18 cas (66%) et au tiers moyen dans 9 cas (34%). Il s'agissait de 17 pseudarthroses hypertrophiques (73%) et 10 atrophiques (37%). Le traitement a associé un enclouage verrouillé et une autogreffe spongieuse. Le suivi moyen était de 42 mois (28 à 62 mois). Le délai de consolidation moyen a été de 4, 8 mois (2, 5 à 11 mois). Trois patients ont présenté une infection superficielle. La consolidation a été obtenue dans tous les cas, à l'exception d'un patient qui présentait des lésions nerveuses multiples. Sur base des critères de Steward et Hundley, il y avait 24 bons résultats, deux médiocres et un mauvais. L'enclouage verrouillé associé à une autogreffe spongieuse donne un bon taux de consolidation à condition d'utiliser des clous de diamètre approprié et de faire un verrouillage correct en proximal et en distal. Les auteurs pensent que c'est un traitement adéquat des pseudarthroses diaphysaires de l'humérus, du fait de son faible taux d'infection, du risque réduit de lésion du nerf radial et de son abord chirurgical limité.