Flexible Unreamed Locked Nailing in the Treatment of Diaphyseal Humerus Fractures

Abstract

A modified implant using unreamed locked intramedullary nailing of the humerus allows a stable fixation of humeral shaft fractures and immediate postoperative functional recovery. The type of nail used has angulations at its two ends: between them there is a long cleaved flexible shaft. The implant has two forms: the thicker form is canullated and the thinner one is solid. This type of nail was used to stabilize fractures 2 cm below the surgical neck and 4 cm proximal to the olecranon fossa. This nail was used on 74 patients who had suffered humeral shaft fractures. This type of nail can be inserted by either antegrade or retrograde methods. All of the fractures operated on, healed in an average of 6 months with excellent postoperative shoulder and elbow function. In cases of pathological fractures, stability was maintained up to the end of the patient's life. There were no occurrences of vascular and nerve iatrogenic injury, septic complications, or implant failure. Postoperative radial nerve palsy was temporarily displayed in 3 patients, all of whom showed spontaneous recovery.

Key words

Humeral shaft fractures · intramedullary flexible nailing · statically locked nailing · antegrade-retrograde method

Introduction

Uncomplicated humeral shaft fractures with no primary radial nerve palsy can be treated conservatively. Conservative therapies include hanging casts, functional casts, overhead-traction, Samiento brace, Valpeau dressing or a sling and swathe dressing [26]. Acceptable alignment of humeral shaft fractures is considered to be a 3 cm shortening, 30° of varus-valgus angulation, and 20° of anterior/posterior angulations [4, 10]. This misalignment is well tolerated cosmetically and functionally. Operative treatment of humeral shaft fractures is appropriate in patients who cannot tolerate closed management, or in those who cannot be placed in a functional brace because of obesity, body habitus, or non-cooperation (drug abusers, alcoholism, dementia). Other conditions, such as closed reposition problems, secondary displacement, misalignment, malunion or pseudoarthrosis, are considered to be operative indications [1, 2, 5, 13, 19, 21, 22].

Published works have indicated the operation in open fractures, fractures associated with vascular and nerve injury, pathological fractures, polytrauma, multitrauma, bilateral humeral shaft fractures and in some cases at the patient's special request [11, 17, 18, 21, 22]. When radial nerve palsy is diagnosed primarily, it is preferable to explore the nerve, and then to insert the intramedullary nail or plating under direct observation [12]. 90–100% of patients usually recover spontaneously after postoperative palsy. Spontaneous recovery occurs within 3–4 months. If there is no spontaneous recovery, EMG should be performed to determine whether exploration is necessary or not. In open fractures with radial nerve palsy the surgical exploration of the nerve is an absolute indication [17, 19–21].

When stabilization of the humeral shaft fracture is indicated, the choices for fixation are open reduction and plating, intramedullary nailing, or fixateur externe.
Plate osteosynthesis – according to most traumatologists – is considered to be the “golden standard” for fixation of humeral shaft fractures. It allows anatomic repositioning with stable fixation. However, it has a lot of disadvantages, such as a high rate of infection (3–10%) and iatrogenic radial nerve injury (3–29%); and the blood supply of the periosteum and fracture fragments can easily be harmed [15, 18].

Fixateur externe is indicated in firearm (high-energy) injuries, and fractures with very serious soft tissue injuries. The risk of iatrogenic vessel and nerve injury in pin infection is high. In addition it is uncomfortable.

The older generation of intramedullary nails (Hacketal, Rush, Ender nails) has been used for a long time. Due to their frequent postoperative infection, secondary displacement and rotational instability, they are now used only in a narrow range of indications.

The new generation of unlocked, intramedullary nails for unstable humeral shaft fractures is attributed to Kuntscher. Because of the absence of soft tissue and nerve damage and reduction of the periosteal blood supply this technique has developed rapidly. Seidel in 1985 [23] developed his locked intramedullary nail with low rotational stability [5, 24]. The first locked, intramedullary nail for humerus fractures was developed in 1986 by Russel-Taylor: This nail cannot be locked statically because it has two oval locking holes at its two ends. Russel-Taylor used it in tibial fractures first, then in pathological humeral shaft fractures [9, 17]. These nails are variable in their axial and torsional stability. Therefore, in 1995 the Synthes unreamed, locked intramedullary nail was developed (UHN), which can be inserted by antegrade and retrograde techniques. In some cases it can provide an interfragmental compression which was proved to be useful in transverse shaft fractures [5, 11, 14, 15]. Later, other nails using a similar technique, such as the Marchetti-Vicenzì, were developed.

Because of the risk of migration of the screws in poor cancellous, osteoporotic bones (the “cutting-out” phenomenon) the angle-stable third generation of unreamed, locked intramedullary nails was developed (T2-PHN, TargonH) [6]. These nails have threaded locking holes that correspond to the thread of the interlocking screws. They can be interlocked in more than one direction, so more fragments can be stabilized. The short version of these nails can be locked distally with the help of the arming device. Another advantage of these nails is that they can provide interfragmental compression. Their disadvantages are similar to the other types of intramedullary nails, such as infection, pseudoarthrosis, entry hole infraction, radial and axillary nerve and blood vessel injury. All the new generations of intramedullary nails vary in their torsional and axial stability.

Many published works have mentioned the intraoperative entry hole infraction in retrograde nail insertion with a reported rate of 3.9% of cases [24, 25], so to decrease the risk of entry hole infraction the flexible unreamed intramedullary nail was developed [2, 5, 13, 16]. The nail shaft is cleaved, flexible and compressible so its insertion is easier than the rigid nail but it is also necessary to prepare the entry hole with care.

**Patients and Methods**

The retrospective study reported here covered the period from 1st November 2000 to 31st July 2005. Out of 84 patients who had suffered humerus diaphyseal fractures, 74 patients (38 male, 36 female) were operated on using the new implant.

Mean age was 59.5 years (range: 21–79 years). The average follow-up period was 11.5 months (range: 6–18 months). Antegrade insertion was performed in cases of fractures of the middle and distal third of the humeral shaft, involving 38 patients (51.4% of cases). Retrograde insertion was carried out in cases of fractures of the proximal and middle third of the humeral shaft in 36 patients (48.6% of cases) [16].

These fractures were classified as follows: four (5.4%) with malunion, two (2.7%) showing pseudoarthrosis; 8 (10.8%) with pathological fractures; and 60 (81.3%) suffering fresh trauma. Patients suffering fresh trauma were classified as: closed fracture (A00–A03) in 46 patients (76.2%), open fracture (Gustillo III/a) in 4 patients (6.7%); bilateral humeral shaft fractures in three patients (5%); and multiple injury in 7 patients (11.5%). Among those patients who suffered closed fracture, 3 patients were operated at their own request to avoid the need for plaster fixation. All of the patients who suffered fresh trauma were operated on within 24–48 hours, and those who suffered pathological fractures within a week [2].

The modified flexible unreamed, locked intramedullary humerus nail can be inserted either by antegrade or retrograde techniques. The nail has two angulations (10° and 5°) at its two ends and in between there is a long, cleaved, compressible and flexible shaft. The nail is available in lengths ranging from 180 mm to 300 mm, in increments of 15 mm; the diameters are 6.5 mm in the case of the solid and either 7 or 8 mm in the case of the camuflage version (Fig. 1). The nail is made of a steel and titanium alloy. It is inserted with the help of an arming arch, near to which are two locking holes, while at the other end there are three locking holes. The locking holes near the arming arch are locked lateromedially with the help of a targeting device and drill-sleeves. Both holes are in one line but diverge when locked up.

It is advisable to close the flanged nut to fix the drill-sleeves on to the bone surface to increase the accuracy of targeting and to prevent the sleeves from sliding out. Under the image intensifier the targeting device is positioned until the hole in the nail shows a complete circle. Then both the drill-sleeves and the trocar are inserted and drilling can start. A 3.8 mm fully threaded cortical screw was used for interlocking the nail (Fig. 2).

The antegrade procedure was performed either in a supine or “beach chair” position. When it is performed, the entrance hole trepanation – under the control of the image intensifier – is car-
ried out with an awl from the edge of the tuberculum majus medially someway anterioventrally at the edge of the cartilage disc, thus avoiding iatrogenic injury of the rotator cuff, which may occur at the insertion site of the supraspinatus muscle. If the rotator cuff must somehow be divided, careful suturing of it is a prerequisite to avoid both permanent lesions of the rotator cuff and shoulder pain [2, 9].

Furthermore, the tip of the nail must be countersunk below the cartilage level at the entrance point, otherwise it will cause shoulder pain and impingement syndrome [2, 9]. As previously mentioned, the other end of the nail has three locking holes (2 lateromedially and one dorsoventrally). They are locked under control of an image intensifier by a freehand technique. The lateralmedial locking screws are first put into the nail. The muscle fibers are then separated bluntly after incising through the skin and fascia. It is then essential either to touch or to check by inspection that the radial nerve is not under the freehand targeting device. The device can then be directly strained onto the bone. Sagittal locking is performed dorsoventrally through the triceps muscle after internal rotation of the arm (Fig. 3).

The retrograde procedure is done either in a supine or prone position. The latter position should be avoided in case of injuries to the thorax and abdomen in polytraumatic patients. The oval entrance hole is prepared by longitudinally dissecting the triceps muscle fibers extra-articularly about 1.5 cm above the olecranon fossa edge. The entrance hole must be prepared as obliquely as possible at an angle of approximately 30° inclination, carefully approaching the elbow with a 3.2 mm drill, then using a front drill. The oblique oval canal is placed exactly in the centre of the triangle of the dorsal surface of the distal metaphysis. The distal edge of the oval entrance hole must be tilted to avoid the entrance hole infraction [2, 13, 16] (Fig. 4).

The tip of the nail should not be more proximal than the surgical neck (if uninjured), so that the locking screw can be inserted without danger to the axillary nerve [16] (Fig. 5).

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Follow-up

A triangular sling was placed postoperatively for 24–48 hours. After that shoulder and elbow mobilization was started. Rotational movement was avoided until cancellous healing was seen. The implant was removed in young patients after at least 6 months when cancellous healing was seen on the radiographic inspection.

Results

The average hospital stay was 7.5 days and the mean healing time of all fractures was 6 months.

All the pathological fractures treated had been caused by metases. They were operated to relieve pain, restore function, facilitate nursing, and to improve the patient’s quality of life. In such cases it is important to stabilize the whole length of the humeral shaft and not to ream, so as to avoid the dissemination of tumorous cells [3, 8]. In the case of pathological fractures, the stability lasted up to the end of the patient’s life [2].

Intraoperatively 3 iatrogenic entry hole infraction were encountered where in one case a full coracoid wire was necessary. Postoperatively there were 3 cases of partial radial nerve palsy. All showed spontaneous recovery. There were no septic complications, iatrogenic injury to blood vessels or nerves, implant failure or pseudoarthrosis. Complete cancellous healing of all of the operated fractures was seen on average at 6 months at the X-ray examination. Postoperatively external fixation was not needed.

Postoperatively and after cancellous healing of the fracture, one of the 74 patients (1.4%) had significant shoulder pain and one patient (1.4%) reported significant pain at the elbow joint. Shoulder abduction and adduction range of motion (ROM), shoulder extension and flexion ROM, shoulder external and internal rotation ROM, elbow extension and flexion ROM, and elbow pronation and supination ROM were measured on the fractured arm in comparison to the contralateral unfractured arm [16, 24].

Shoulder and elbow function was evaluated as excellent when there was < 10° loss of ROM in any direction, moderate when the loss of ROM was between 10° and 30°, and poor when the loss of ROM was > 30° [16, 24]. Of 74 patients, 61 (82.4%) had an excellent result for their shoulder, 11 (14.9%) had a moderate result, and two (2.7%) had a poor result. Meanwhile 63 (85.1%) had an excellent result for their elbow, 8 (10.8%) a moderate result, and 3 (4.1%) a poor result [16, 24] (Table 1).

Discussion and Conclusion

Management of humeral shaft fractures requires a very careful and precise evaluation and measurement of the benefits and risks of each procedure.

Although plating can give an exact reduction, has high union rates and involves less shoulder pain compared with the antegrade nailing of the humeral shaft fractures, there is a high risk of radial nerve injury and infection associated with the surgical exposure. In addition, plating destroys the blood supply of the fracture fragments due to open reduction.

The AR-humeral nails can be inserted by antegrade and retrograde techniques. Their biomechanical properties and flexibility make their insertion easy and give good stability. The insertion technique can be chosen depending on the site and type of the fracture. The nail’s insertion and locking site need small skin incisions.

Although there was no uniformity in surgical indications, the most important absolute indications were in cases of closed fractures (A00–A03), open fractures (up to Gustillo IIIa), pseudoarthrosis, bilateral humeral shaft fractures, polytrauma and multiple injury. Relative indications were in cases of pathological fractures, malunion, patient’s special request, obesity, and in some non-cooperative patients (alcoholism, drug abusers). The intramedullary nailing is contraindicated in septic cases, paediatric fractures (open growth plate), and in special anatomic anomalies (narrow bone marrow) [1, 2].

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<th>Shoulder and elbow function after cancellous humeral shaft fracture healing</th>
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<td>result</td>
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The closed reduction of the fracture does not destroy the blood supply of fracture fragments. The absence of reaming avoids damage to the endosteal blood supply. The most important advantages of the retrograde type of insertion are that the nail is inserted extra-articularly, with no rotator cuff injury or impingement syndrome, and radial nerve injury is avoided, when the nail is locked up distally. The disadvantages are iatrogenic entry hole frictions, proximally when the nail is locked up, sagittally the axillary nerve can be injured; also difficulties in freehand locking in obese, or heavily muscular patients and screw migration in the humerus head [1, 2, 16].

In addition, elbow pain and stiffness (teardrop ossification), periarticular ossification in polytraumatic cases, and in cerebrally damaged patients have also been reported [16].

In the antegrade type of insertions, the most important advantages are that the entry hole is easily prepared, proximal locking holes are easily drilled with the help of a targeting device, and the proximal end of the nail is well countersunk in the entry hole. The most important disadvantages are rotator cuff injury, adhesive capsulitis and impingement syndrome (caused by nail protrusion into the subcapsular space). Furthermore, the radial nerve can be injured easily when the nail is locked up lateromedially in the distal end by the freehand technique. On the other hand, when the nail is interlocked anteroposteriorly, blood vessels can be injured and proximally the nail is locked up only lateromedially; thus the circumflex nerve and the long head of the biceps muscle can be injured [9]. Both procedures guarantee the stability of the whole length of the shaft in fragmental, segmental, and pathological fractures.

There is no clear consensus on which operation procedure is preferred. Careful and precise surgical techniques in all methods can help to avoid complications. The decision on how to treat a humeral shaft fracture must be made individually, with both surgeon and patient aware of the necessary precautions and interventions required to minimize complications and further injury [7].

In conclusion, the A/N-humeral nail is a new implant for interlocking the humerus shaft fractures. Intramedullary nailing allows a stable fixation and due to its flexibility the risk of entry hole fracture is low. On the basis of these results its application is recommended.

References