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Cerclage wiring and intramedullary nailing, a helpful and safe option specially in proximal fractures. A multicentric study

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ABSTRACT

Purpose: Antegrade intramedullary nailing is an alternative for humeral shaft fracture treatment. This surgical technique can be especially demanding in some fracture patterns, leading to problems like malunion and non-union. The purpose of our study is to demonstrate that the use of a nail with cerclage wires could be a safe procedure that facilitate reduction, specially in fractures with abduction of the proximal fragment.

Materials and methods: Fifty-six patients were included, from January 2007 to March 2016. In this cohort forty-two patients were females and eighteen males; mean age was sixty-seven (32–89). The fractures were reduced using a cerclage wire through a small lateral or anterior approach, then, antegrade intramedullary nailing was performed. Fracture healing was established by clinical and radiographic evaluation. Shoulder function was assessed using the Constant Score.

Results: Fifty-three patients healed (94.6%) adequately. Two patients developed a non-union (3.5%). One patient developed an infection (1.8%). Transient radial nerve palsy was observed in two patients (3.5%). The mean Constant Score at the end of the study was 70 points (range from 34 to 98 points).

Conclusions: Surgical treatment of humeral shaft fractures with cerclage wire and intramedullary nailing is a safe technique to improve fracture reduction. The use of cerclage wires leads to better bone contact while minimizing malunions. The rate of non-union in our study is lower than the rate reported in the literature for humeral shaft fractures treated by intramedullary nailing alone.

Introduction

Fractures of the humeral shaft account for approximately 3% of all musculoskeletal injuries [1]. Several treatment modalities have been described, however non-operative management continues as the mainstay for treatment of the majority of these fractures with high healing rates [2,3]. Recent publications has stablished an increased rate of complications with conservative treatment, with a nonunion rate near 20, even high in proximal third fractures with abduction deformity of the proximal fragment [4].

Surgical treatment is recommended for some fracture patterns, or in those situations where patients do not to tolerate conservative treatment, or when maintaining alignment is not possible with conservative alternatives [5].

Nowadays, plate osteosynthesis and intramedullary nailing are the most common methods of fixation for humeral shaft fractures [6,7]. Plate fixation remains the most used fixation method, although closed humeral nailing is considered an alternative treatment with successful clinical and radiological results [5,8].

Rotator cuff function impair due to intramedullary nailing has been reported [5,9,10] however, once this complication was recognized, greater care was taken into adequately inserting the nail and ensure careful repair of rotator cuff disruption at the end of surgery. Recent publications support that intramedullary nailing leads to similar shoulder function, as does plating, when the rotator cuff is properly managed [8,11–13].

Malrotation of the humeral shaft is another important issue related to intramedullary treatment. Surgical technique is demanding in some fracture patterns, ending up with problems like malunion and non-union. In these cases, the use of a cerclage

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wire with a minimally invasive approach could improve fracture reduction, alignment and stability [13].

Simple pattern fractures were classically treated with absolute stability. This was usually achieved using lag screws with a neutralization or compression plate. In oblique or spiral fractures. this usually requires very extensive and harmful approaches, that lead to wide soft tissue damage, bone stripping and impaired healing. Treating these fractures with a relative stability method (as nailing is), with the use of minimally invasive approaches, to avoid bone blood supply damage, can be tricky because strain proper modulation is sometimes impossible if fracture gap is too large. In these cases a better reduction will diminish fracture gap, so the strain remains within callus formation limits, improving fracture healing [14,15].

The use of cerclage wires has been reported in the literature for treatment of complex subtrochanteric femoral fractures. It allows the surgeon to obtain and maintain an anatomic reduction, leading to better fracture healing with the advantage of starting point optimization, minimizing inappropriate reduction, and improving forces distribution and transmission [16]. Comparatives have been stablished between subtrocanteric fractures and proximal third humeral fractures, highlighting the importance of the muscular forces through the humeral shaft [17].

We hypothesized that open reduction through a minimally invasive approach, and nailing of humeral shaft fractures will improve healing and postoperative complications (non-union, secondary displacement and malunion) because of the improvement of fracture gap, optimizing strain and proving forces transmission (especially because of neutralizing abduction forces of the deltoid). We designed a retrospective descriptive study with the purpose of demonstrate that the use of a nail with cerclage wires could be a safe procedure that facilitate reduction, especially in fractures with abduction of the proximal fragment.

Materials and methods

The study and procedures were approved by the institutional review board and ethics committee.

Patients

Inclusion criteria were: Patient operated in the two institutions who performed the study, from January 2007 to March 2016, who sustained a closed, isolated humeral shaft fracture with a long oblique (simple or multifragmentary) or spiral pattern

Exclusion criteria were: Lack of data, incomplete follow-up (patients who died during the first year of follow-up were also excluded, except if the death was a surgical complication within the first month postoperative) and the presence of preoperative radial nerve palsy.

From all the patients treated at our institutions because of a humeral shat fracture, sixty full fit the inclusion criteria but four were excluded because of death during the first-year follow-up. Fifty-six shaft fractures were operated by minimally invasive reduction with the help of a cerclage wire, and stabilization with an antegrade intramedullary nail, and were included in our study.

Fractures were classified according to the AO classification system: 36 type 12A1, 9 type 12B1, 1 type 12B3, 7 type 12C1, 3 type 12C2 and 4 type 12C3. (Table 1).

Other fracture patterns unsuitable to reduction using cerclage wires where not included.

Surgical technique

Surgery was performed with the patient in a beach-chair position with the fractured extremity draped free and the shoulder over the edge of the table.

Table 1
Cohort description.

Number of patients enrolled (n)	60
Sex	42 Female 18 Male
Age	Mean 67 Range 32–89
AO Classification	12A1: 36 12B1: 9 12B3: 1 12C1: 7 12C2: 3 12C3 : 4

Patients where operated under general anaesthesia with interscalene brachial plexus block.

All patients received antibiotic prophylaxis according to each institution's protocol.

Intraoperative fluoroscopy was used in all procedures.

First, the fracture was reduced using a minimally invasive lateral or anterior approach at the level of fracture site, checked by fluoroscopy.

In the mini lateral approach, the lateral fascia of the triceps was opened lengthwise, followed by blunt circumferential dissection around the humeral shaft to avoid radial nerve entrapment.

In the mini anterior approach, fascia over de biceps brachii was opened lengthwise. The biceps brachii was retracted medially and brachialis muscle was divided allowing access to fracture site. Blunt circumferential dissection was then performed to ensure that any neurovascular structure was compromised.

The fracture was then directly reduced under fluoroscopic and direct touch control and stabilized with a cerclage wire.

The second step of surgery was the intramedullary fixation of the fracture with an anterograde nail. A correct entry point was selected based on nail design avoiding any damage to the rotator cuff insertion. A guidewire could be used for reaming or insertion of the nail. Care was taken to avoid any protrusion of the proximal end of the nail to prevent rotator cuff impingement. Proximal and distal locking were then performed to avoid any rotatory instability. Surgery ended up with careful rotator cuff repair in all patients (Fig. 1).

Materials

Intramedullary nails used in this cohort were: Trigen humeral nail, manufactured by Smith and Nephew -Memphis USA- (48 patients); Multilock humeral nail, manufactured by Synthes -Oberdorf, Switzerland- (5 patients); Polarus humeral nail, manufactured by Acumed -Hillsboro USA- (7 patients).

Cerclages used were manufactured by Smith and Nephew (39 patients), Synthes (21 patients).

Follow-up

Early postoperative complications and surgical incidents were recorded during the hospital admission.

Patients were evaluated routinely in the outpatient's clinics after discharge, at two weeks, one month, two months, four months, six months and one year, with X-rays.

Fracture healing was established when the patient reported no pain at fracture site, in conjunction with evidence of callus formation on standard plain x-rays (two orthogonal views where obtained and radiographic bone union was stablished when at least 3 of 4 cortices where bridged by callus). A standard-ray in neutral rotation was obtained routinely of the uninjured side to confirm rotation (also assed clinically) and individual parameters.

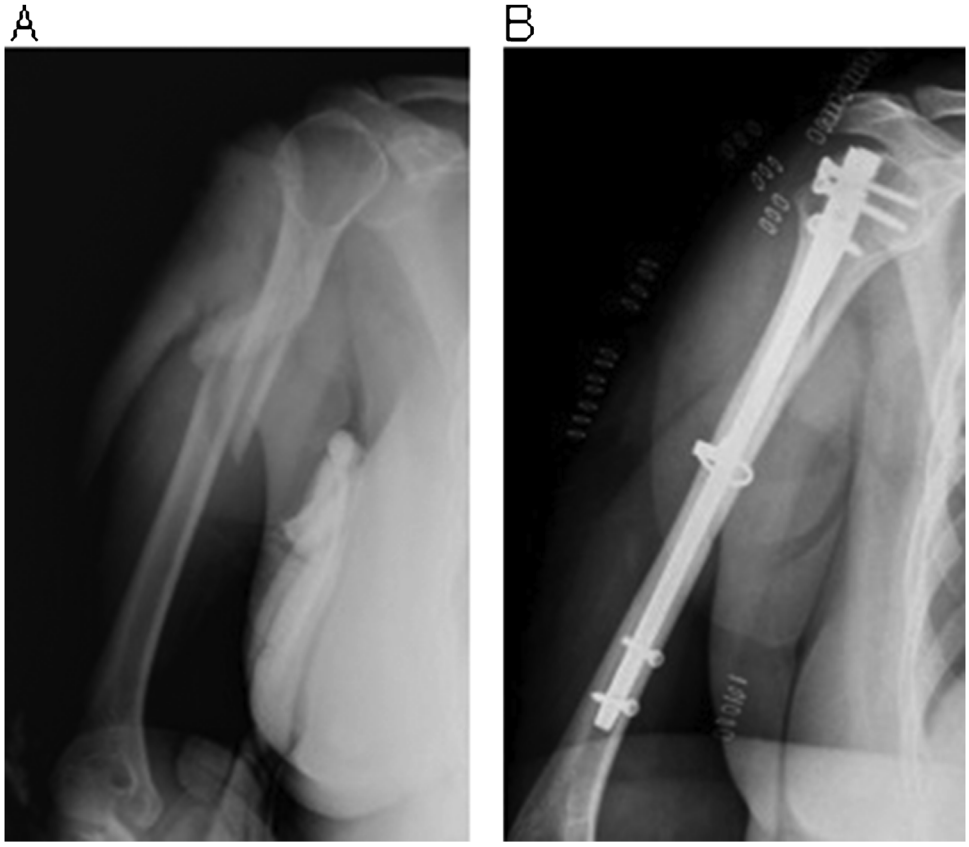

Fig. 1. 12A1 Humeral shaft fracture treated with direct reduction and cerclage through a mini lateral approach followed by intramedullary nailing.

Shoulder function was assessed using the Constant Score.

All complications were recorded during the follow-up. We defined infection as any situation in the surgical site/incision that require the use of antibiotics. We defined radial nerve palsy as any deficit in its function. We defined malunion as any deformity that exceeds 20° anterior angulation, 20° of varus or valgus, 15° of malrotation or 1 cm of length discrepancy.

Results

The mean age of the patients enrolled in the study was 67 (range, 32–89 years). There were 42 females and 18 males.

Fifty-six patients completed a follow-up of a minimum of 12 months. Four patients died before during the first year, so their data was not included in the analysis.

Healing rates

The healing rate without complication (and secondary procedures) in our cohort was 94.6% (53 of 56 patients). Two patients developed a non-union (3.5%) and another an infection (1,8%).

Mean healing time was 3.5 months.

Healing rate within the first 16 weeks was 82.1% and 92.8% within the first 24 weeks

One patient with a nonunion had no pain or functional limitation so was treated conservatively. The other patient underwent nail removal, fracture site debridement and plate osteosynthesis with autologous bone grafting and healed without further complications.

Complications

Fifty-one patients healed uneventfully (91%).

Transient radial nerve palsy was observed in 2 patients (3.5%). Full recovery was observed within 3 months in both of them.

As previously described, two patients developed a non-union.

There were no malunions or secondary displacements.

One patient developed an infection (1.8%) and was treated with debridement, nail removal, temporary external fixation and antibiotic therapy, followed by plate osteosynthesis and bone grafting. Infection was ruled out with cultures in the secondary procedure.

Functional scores

Mean Constant Score obtained by the patients of the cohort in the last follow-up (one year) was 70 points (range from 34 to 98 points) (Table 2).

Table 2
Results.

n complete follow up	56
Healed	53 (94.6%)
Healed uneventfully	51 (91%)
Transient radial nerve palsy	2 (3.5%)
Infection	1 (1.8%)
Non-Union	2 (3.5%)
Time to heal	Mean 3.49 months Range 1.5–8 months
Constant score	Mean 69.60 Range 34–98

Discussion

As purposed we have demonstrated that intramedullary nailing is an adequate and acceptable treatment for humeral shaft fractures. We obtained a high rate of consolidation without secondary interventions (53 of 56 patients), who obtained good functional outcomes. In our series with this technique, the addition of a cerclage wire has minimally complications, and radial nerve palsy seem not to be increased compared to other fixation methods (only two temporary palsies).

In some fracture patterns anatomical reduction with intramedullary nailing could be demanding, ending up with problems like malunion that can lead to non-union or unsatisfactory functional results [13]. Minimally invasive fracture site approach and reduction with cerclage wires minimizes malunion and improves bone contact improving healing rates. The time expected for healing in this fractures was 3,5 months, similar to those reported by other series that published a time to union between 13 and 15 weeks comparing open or minimally invasive techniques [18].

Reduction is essential in simple fracture patterns, diminishing the fracture gap. According to basic orthopaedic principles, well described by Perren, a large fracture gap in these fractures will lead to a non-union, and be improved using a cerclage as described in our series [14,15]. This may be one of the causes of lower healing rates reported by humeral nails, especially in proximal fractures with abduction in the proximal fragment [18].

In multifragmentary fractures, where shaft anatomy is disturbed, and in the proximal humerus the nail entry point is hidden due to displacement (the vast majority of times with varus and external rotation [17]), intramedullary nailing is more difficult [19]. Humeral shaft reconstruction with a cerclage wire makes the anterograde intramedullary nailing easier, minimizing complications. We have not reported malunion with the described technique.

The radial nerve is at risk in humeral shaft fractures, and blind intramedullary nailing can be dangerous. Radial nerve injuries have been reported in up to 152% of all humeral shaft fractures [20]. Circumferential blunt dissection around the humeral shaft and fracture avoids radial nerve entrapment. We described two cases of neuro-apraxia after surgery, but we confirm intraoperatively that the nerve was not entrapped or damaged in the cerclage area or fracture site in the danger zone. Both patients recovered without any other intervention. From this point we have demonstrate that the technique is safe, as previously established by Greching et al. [21].

Disrupting fracture hematomas can be controversial when performing an open reduction, and some evidence prevent their removal because it increases the risk of non-union [6]. There is also a trend to perform minimally invasive plating, because it seems to accelerate healing compared to classic open reduction and internal fixation [22]. In our series the non-union rate (2/56, 3,6%) is similar to the overall published rates for humeral shaft fractures treated surgically with MIPO [19], and depending on the series, superior compared to classic intramedullary nailing and open reduction and internal fixation [18].

When we look for the functional outcomes, our patients had a mean constant score of 70 (34–98), score that represents a retired patient with no paint, a ROM near to complete, able to develop a strength of 15 pound in abductions. Normal population at the mean age of our population study has a Constant score of 82 points [23], so we have to expect a loose of 12 points in the CS in the first year postoperative. We can find series of minimally invasive plating for humeral shaft fractures, that reach a mean of 83 points in the CS [24], but in a population of 43 year, with 2/3 of males (who obtained better scores). In these population the CS for healthy patients is stablished in more than 90 points. There are also series, that include patients with similar demographic characteristics than ours, with humeral fractures treated with a plate through an anterior approach that described a mean final CS of 76 [25]. We can also find a comparative study between nail and plate [26] with a CS of 71 for patients treated with a nail and 82 in those treated with a plate, but in a younger population with higher basal constant scores. Our patients have obtained scores comparable to other techniques for the fixation of humeral shaft fractures.

The weakness of this study relies on its retrospective and non-randomized nature, along with the small number of patients. We cannot establish a recommendation for the treatment of oblique and spiral humeral shaft fractures or other complex fracture patterns, but we have demonstrated that nailing with minimally open reduction and cerclage wiring is safe and facilitates nailing, but further prospective, controlled, randomized, multi-centric studies are needed.

Conclusions

Treatment of humeral shaft fractures with minimally invasive direct reduction and cerclage wires followed by antegrade intramedullary nailing is a useful and safe surgical technique that leads to improved reduction, bone contact and stability. It makes intramedullary nailing technically easier and allows a safer and less harmful approach for soft tissues.

Conflict ofinterest and source of funding

None declared

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