Lateral minimally invasive percutaneous osteosynthesis in humeral fractures

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Abstract

Introduction: The aim of this study is to evaluate retrospectively the functional and radiological results and the immediate and long-term post-operative complications in a series of patients with humeral fracture treated with osteosynthesis with minimally invasive techniques.

Materials and methods: Retrospective multi-center study. We evaluated 14 patients (7 females and 7 males aged 48.7 years old on average [ranging from 21 to 73]) with humeral fracture that was subject to lateral minimally invasive osteosynthesis techniques with plates between 2007 and 2013. As stated by the AO classification, fractures were 12A1 (n = 1), 12B1 (n = 1), 12B2 (n = 3), 12C1 (n = 6), 12C2 (n = 1), and 12C3 (n = 2). We performed two lateral approaches, one proximal and the other one distal; the plate was slid through a submuscular canal, and the radial nerve was protected.

Results: Average follow-up was 30 years. We got fracture healing in 13 cases (92.85%); average time before fracture healing was 3 months (ranging from 2 to 6). Average shoulder flexion was 174.8º; external rotation, 67.2º; abduction, 173.8º; and internal rotation, 72.1º. The average elbow flexion-extension arch was of 140.5º. Average Constant test was 82.66 marcks. Average DASH was 15.27 marks. Four patients (23.5%) showed radial neuropraxia.

Conclusions: Osteosynthesis with percutaneous plating by minimally invasive approach has proved to be an efficient method for the treatment of humeral diaphyseal fractures applying the principle of bridge plating. It is a biological, technically demanding and not-free from complications procedure.

Key words: Humeral fractures; minimally invasive osteoshynthesis; percutaneous.
Level of evidence: IV

Osteosíntesis percutánea mínimamente invasiva lateral en fracturas de húmero

Resumen

Introducción: El objetivo de este estudio es evaluar retrospectivamente los resultados funcionales, radiológicos y las complicaciones posquirúrgicas inmediatas y a largo plazo de una serie de pacientes con fracturas de húmero tratados mediante osteosíntesis con técnica mínimamente invasiva.

Materiales y Métodos: Estudio multicéntrico retrospectivo. Se evaluó a 14 pacientes (7 mujeres y 7 hombres; edad promedio 48.7 años [rango, 21-73]) con fracturas de húmero, que fueron tratados con técnica de osteosíntesis mínimamente invasiva lateral con placas, entre 2007 y 2013. Según la clasificación AO, las fracturas eran 12A1 (n = 1), 12B1 (n = 1), 12B2 (n = 3), 12C1 (n = 6), 12C2 (n = 1), 12C3 (n = 2). Se efectuaron dos incisiones laterales, una proximal y otra distal; se deslizó la placa por un canal submuscular y se protegió el nervio radial.

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Resultados: El seguimiento promedio fue de 30 meses. Se obtuvo la consolidación en 13 casos (92,85%), el tiempo promedio hasta la consolidación fue de 3 meses (rango, 2-6). La flexión promedio fue de 174,8°; la rotación externa, de 67,2°; la abducción, de 173,8º y la rotación interna, de 72,1°. El arco de flexo-extensión del codo promedió los 140,5°. El promedio de la prueba de Constant fue de 82,66 puntos; el puntaje DASH promedio fue de 15,27. Cuatro pacientes (23,5%) presentaron neuropraxia radial.
Conclusiones: La osteosíntesis con placas percutáneas mediante un abordaje mínimamente invasivo ha demostrado su eficacia para el tratamiento de fracturas diafisarias de húmero aplicando el principio de placa puente. Es un procedimiento biológico, técnicamente demandante, no exento de complicaciones.

Palabras clave: Fractura de húmero; osteosíntesis mínimamente invasiva; percutánea.
Nivel de Evidencia: IV

Introducción

Humeral diaphyseal fractures represent 3-5% of all fractures.[1] Most of them can be treated well conservatively.[2,3] If surgical treatment is necessary, intramedullary nailing and plating have given good results when the surgical technique is appropriate.[4] Minimally invasive percutaneous osteosynthesis combines some advantages of plate fixation with some of intramedullary nailing: early functional rehabilitation,[5] lesser injury of soft tissues and preservation of the fracture hematoma.[6] This technique has been widely applied in the lower limbs.[7,8]

The aim of this study is to evaluate retrospectively functional and radiologic results and immediate and long-term post-operative complications in a series of patients with humeral fracture treated with osteosynthesis with minimally invasive technique by lateral approach.

Materials and methods

We evaluated retrospectively 14 patients with humeral fracture who were treated with internal fixation with plating using a minimally invasive technique by lateral approaches, at three orthopedic centers, between November 2007 and February 2013. The patients were seven females (50%) and seven males (50%), aged, on average, 4.7 years old (ranging from 21 to 73). As stated by the AO/ASIF classification, the fractures were: 12A1 (one case), 12B1 (one case), 12B2 (three cases), 12C1 (six cases), 12C2 (one case), 12C3 (2 cases) (Table). Mechanisms of trauma were car crash (11 cases) and fall from standing height (3 cases).

Procedures were performed with patients in a semi-beach-chair position under supraclavicular block anesthesia. They were given 1 g pre-operative i.v. cephazolin. We performed two 4 cm- and 7 cm-length approaches: the proximal one was a deltoid splitting approach lateral to the bicipital groove, and the distal one was also on the lateral aspect of the humerus. While using this approach, it is necessary to identify two nervous structures: the axilar nerve proximally and the radial nerve distally (Figure 1); both nerves were acknowledged and protected throughout the procedure. With a periosteal elevator we formed a sub-muscle tunnel along the humeral diaphysis, along which we slid the plate watching the axilar nerve for it to remain superficial to the plate. The elbow was kept 90º flexed, with alignment of the fragments by traction. The whole process was performed under fluoroscopy. We used the following implants: locking 90º nail-plates (3 cases), locking 4.5 mm compression plates (7 cases) and locking 3.5 mm compression plates (four cases). In most cases we used national plates with six proximal cortexes and 6 distal cortexes.

Patients were subject to radiologic check-ups immediately after the surgery, at week 6, at months 3, 9, 12 and at the last follow-up consultation. The objective analysis was carried out measuring the range of motion with a goniometer; all the patients were evaluated using the Constant test. For subjective evaluation, we used the DASH (Disabilities of the Arm, Shoulder and Hand) scale.[9] Measurements and questionnaires were given at the last follow-up consultation.

Results

Follow-up averaged 30 months (ranging from 10 to 69). We verified fracture healing in 13 of the 14 patients (92.85%), in an average time of three months (ranging from two to six) (Figure 2). In one case, at month 14 we did not see signs of fracture healing; the patient showed no pain and was able to perform daily activities normally; therefore, it was decided to wait and see, evaluating the patient on a regular basis. Patients showed neither radiologic signs of loosening nor rupture of the osteosynthesis material. Average ranges of motion at the last follow-up consultation were: flexion, 174.8º (ranging from 152º to 180º), external rotation, 67.2º (ranging from 46º to 81º), abduction, 173.8º (ranging from 131.4º to 180º), and internal rotation, 72.1º (ranging from 52º to 84º). The average elbow flexion-extension arch was of 140.5º (ranging from 132º to 145.3º). The average Constant test at last follow-up consultation was of 87.66 marks (ranging from 78 to88), and the DASH at the last follow-up consultation was of 17.27 marks (ranging from 9.2 to 21.3). Four pa-

Table. Patients' characteristics

Case	Sex	Age	Classification	Complications	Follow-up	Fracture healing
1	F	33	12A1	No	60 meses	Yes
2	F	40	12C1	No	60 meses	Yes
3	F	49	12C1	No	69 meses	Yes
4	M	67	12C1	Radial deficit	19 meses	No
5	M	67	12C2	Radial deficit	18 meses	Yes
6	M	71	12C3	No	13 meses	Yes
7	M	73	12C3	No	13 meses	Yes
8	F	39	12C1	No	13 meses	Yes
9	M	54	12B2	Radial deficit	12 meses	Yes
10	F	55	12B2	Radial deficit	10 meses	Yes
11	F	45	12C1	No	14 meses	Yes
12	F	62	12B1	No	10 meses	Yes
13	M	72	12C1	No	58 meses	Yes
14	F	46	12B2	No	56 meses	Yes

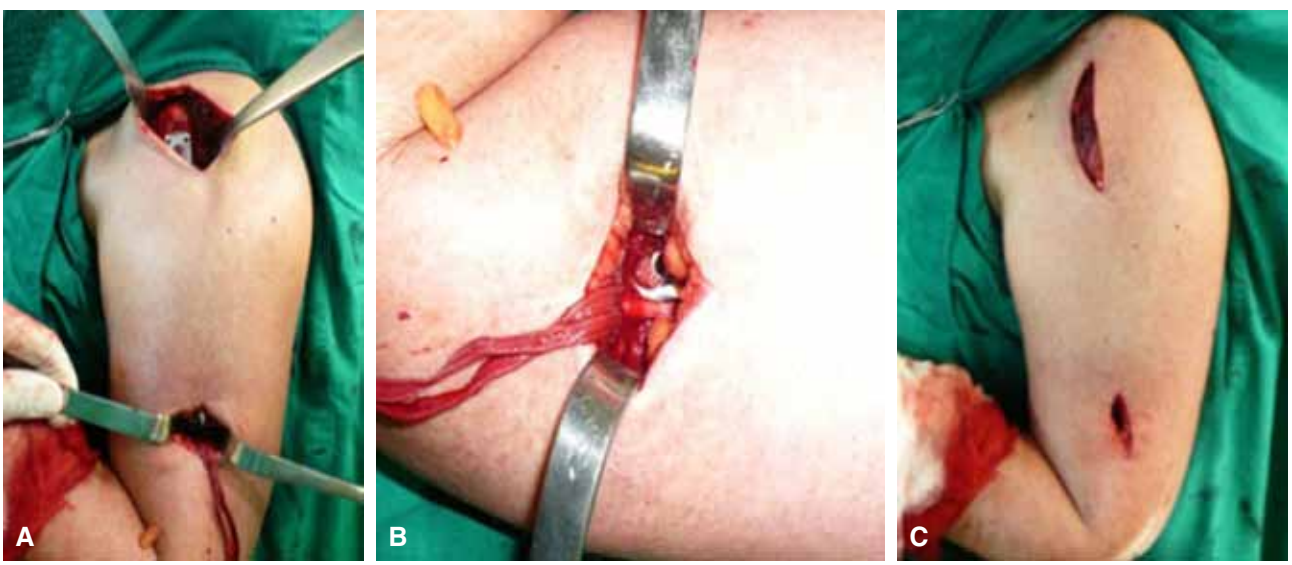

Figure 1 **A.** Minimally invasive technique. Plate already inserted. **B.** Release and protection of the radial nerve.

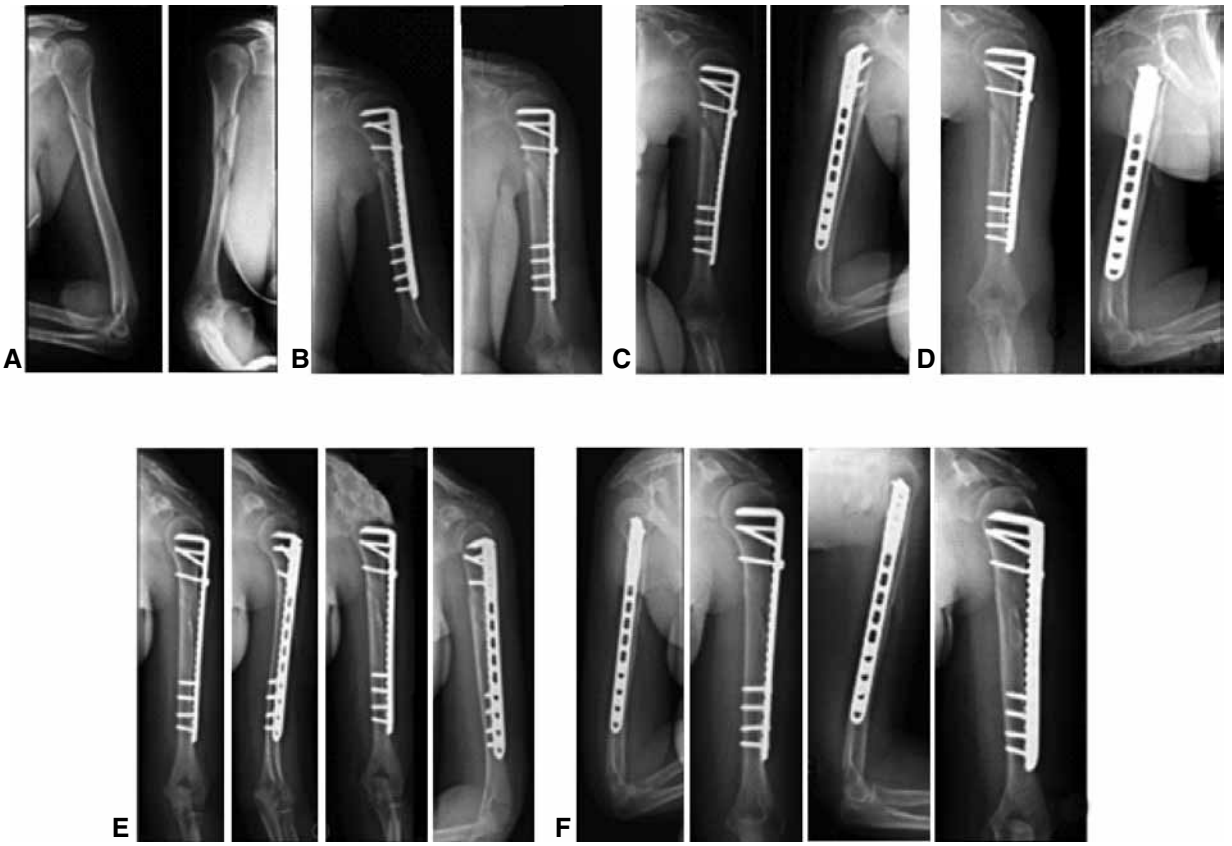

Figure 2. A. Type 12C1 humeral fracture. **B.** Immediate post-operative X-ray. **C.** Anterior-posterior and lateral X-rays at week six **D.** Three-month post-operative X-ray **E.** Nine-month post-operative X-ray **F.** Anterior-posterior, lateral and oblique X-rays at month 12.

tients (23.5%) showed post-operative radial nerve neuropraxia, but all recovered motion before the post-operative month 7 with no need of surgical revision. There were no cases of axilar nerve injury; in no case was it necessary to remove the osteosynthesis material.

Discussion

What the best stabilization method is for humeral fractures requiring surgical treatment is still controversial. Although conservative treatment is successful in most cases, several surgical options have been suggested.[10,11] Stabilization options include plating, intramedullary nailing, and external fixation. Osteosynthesis with locking intramedullary nails is also a minimally invasive procedure that preserves soft tissues around the fracture site and that has given good results in humeral fractures; the most frequent complication is the injury at the level of the nail insertion point, both anterogradely and retrogradely. The drawbacks to humerus osteosynthesis with intramedullary nailing verified so far are lack of stability in fractures that involve the bone metaphysis and the need of both compression systems and locking at both proximal and distal levels.[4]

As new implants keep coming, minimally invasive techniques have gained popularity over the past few years because they highlight the biological aspects of the treatment of fractures.[6,12,13]

The interpretation of the results, however, is often difficult, due to the low number of patients, the different fracture patterns, the diverse kinds of implants used and the different surgical approaches. The objective of minimally invasive procedures is to cause as little soft tissues injuries as possible and preserve the fracture's biology by means of more flexible fixations.[14,15] The term "biological" suggests fracture setting that is not *that* anatomical and that is performed indirectly with a plate, applying the principle of bridge plating;[17,18] this way, infection rates and fracture healing time decrease. In this series, we did not detect any case of infection. Indirect fracture setting implies not visualizing the bone fragments; sometimes, perfect bone alignment is complex and some degree of misalignment remains.

One technical advantage of minimally invasive procedures in the humerus is that, contrarily to the lower limbs, the humerus tolerates greater degrees of angular deformities. Indirect reduction through minimal approaches is technically more demanding; therefore, it is essential to

have fluoroscopy to control every step in bone setting so as to preserve the bone axis and rotation.[19]

Neurovascular injuries represent a risk in the surgical treatment of humeral fractures—the axilar nerve proximally and the radial nerve distally. In this study, we did not have axilar nerve injuries. While performing the lateral approach, this nerve is 6 cm distal to the acromion on the lateral aspect of the humerus;[20,21] it is important to identify it and protect it placing one's index finger on the nerve while inserting the plate in the proximal humerus.[22] In this series, in the fractures that involved the distal third of the humeral diaphysis and when the plate was going to be inserted near the radial nerve, we visualized the nerve directly during the surgery and we protected it while sliding the plate so as to decrease the risk of nerve injury. Ji et al.[23,] in an anatomic corpse study showed that it is possible, safe and convenient to perform osteosynthesis with a minimally invasive technique in humerus distal fractures in which lateral approaching is used. Four patients, however, showed post-operative radial deficit that subsided completely before seven months. Zhiquan et al.[10] compared groups of patients with percutaneous osteosynthesis by anterior approach to osteosynthesis with open fracture setting and found greater incidence of nerve injury and more time before fracture healing in the second group. In a group of 17 patients with proximal humerus fracture, Jiang et al.[24] found three cases of radial nerve neuropraxia with average recovery time of 6 months, results which are similar to ours. Galluci et al.[25] present a series of 11 cases treated by percutaneous osteosynthesis by dorsal approach, with good functional results and a DASH score lower than that we got in our study.

The limitations of this study were the retrospective design and the limited number of patients (14 cases). Although we have not proved that this technique is better than the other alternative methods, including conservative treatment, this procedure gives good results if the surgical technique is adequate and appropriate implants are available. The patient should be warned that the surgical approaches might be widened if it is not possible to set the fracture appropriately or due to any other surgical complication.

Conclusions

Osteosynthesis with percutaneous plating by minimally invasive lateral approach has proved to be an efficient method for humeral diaphyseal fractures, because it is a biological procedure with lesser soft tissues injuries and that allows early functional rehabilitation. Although it is a procedure that is not-free from complications, involving a demanding surgical technique, it results a good option for this type of conditions.

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