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Clinical Impact on the Shoulder after Intramedullary Nailing for the Treatment of Humeral Shaft Fractures

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Corresponding Author:	Luisa Fernanda García-Guerrero, MD Hospital Universitario de la Samaritana Bogotá, Bogotá COLOMBIA
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Hospital Universitario de la Samaritana
Corresponding Author's Secondary Institution:	
First Author:	Daniela Gutierrez, MD
First Author Secondary Information:	
Order of Authors:	Daniela Gutierrez, MD
	Luisa Fernanda García-Guerrero, M.D
	Raul Ernesto Gonzalez, MD
	Felipe José Valbuena, MD, Med
Order of Authors Secondary Information:	
Funding Information:	
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Suggested Reviewers:	

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Abstract

Introduction: Intramedullary fixation is a frequently used option for the management of proximal and diaphyseal humeral fractures. The biomechanical advantages of this fixation method are known, in addition to the preservation of soft tissues and periosteal irrigation. However, in clinical practice, the postoperative follow-up reveals that some patients develop symptoms associated with shoulder pathology, such as subacromial pain, decreased flexion and abduction strength.

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Conclusions: We conclude that in this group of patients, osteosynthesis with humeral intramedullary nails did not have a significant clinical impact on the shoulder in terms of range of motion and symptoms of impingement.

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Level of evidence: IV

Introduction

Humeral shaft fractures comprise approximately 3% of fractures (1,2). When the treatment of the fracture has indication for surgery, one of the fixation options are intramedullary nails. This method has theoretical

biomechanical advantages, in addition to soft tissue preservation and periosteal irrigation, compared to stabilization with open plate osteosynthesis. When comparing these two fixation methods, intramedullary nails offer comparable results compared to plates, in terms of the union rates, deep infection, iatrogenic radial nerve palsy, return to labor and functionality (3,4). However, when approaching the shoulder joint to insert the nail, violating the integrity of the rotator cuff tendons and articular cartilage, could result in residual symptoms of shoulder, associated with pain and restricted range of motion. Moreover, during postoperative follow-up many of these patients develop symptoms associated with shoulder pathology, such as subacromial pain, and decreased flexion and abduction strength. The evidence on the effects of intramedullary nails on the shoulder is contradictory so far, with some studies reporting good shoulder function in patients undergoing humeral intramedullary nailing and others where the functional consequences of the shoulder are significant. So far, the evidence on these effects is conflicting, with authors indicating adequate shoulder function after humeral nailing(1,5,6), finding by ultrasound partial rotator cuff tears that are generally asymptomatic(7,8), and others where postoperative symptoms of the shoulder associated with the use of intramedullary nails suggest that fixation with plates is preferable(9-11). This study evaluates, in a group of patients, the clinical impact of antegrade intramedullary nailing for humeral shaft fractures in shoulder symptoms.

Materials and methods

A retrospective descriptive observational study was performed in an orthopedics and traumatology reference center in Bogotá, Colombia. The subjects where adult patients,18 to 70-year-old with humeral shaft fractures undergoing surgical treatment with antegrade humeral intramedullary nailing by 4 orthopedic surgeons from the same institution from 2017 to 2020. Patients excluded were those with a history of rotator cuff syndrome or experiencing previous shoulder pain, pathological fractures, glenohumeral or acromioclavicular osteoarthritis and patients with a history of neuromuscular pathologies or concomitant neurological lesions. All subjects underwent closed reduction and antegrade intramedullary fixation (Figure 1) with 2 types of nails (Smith & Nephew TRIGEN® Humeral Nail and Synthes MultiLoc® Humeral Nail).

2 examiners performed follow-ups 6 to 12 months after the procedure, including completion of questionnaires, physical examination, and evaluation of radiographs. Outcomes were defined as functionality by QuickDASH

score, shoulder pain by visual analogue score (VAS), active and passive range of motion (anterior flexion, elevation in the scapular plane, external and internal rotation) and 3 signs of subacromial impingement (Yokum, Neer and Hawkins-Kennedy). Additionally, demographic data of the patients such as age, sex, laterality, comorbidities, and the date of the surgical procedure were taken from the evaluations and medical records. The union of humeral shaft fractures was evaluated clinically and radiographically at the time of assessment. The results were analyzed, correlating the frequencies and percentages of the recorded demographic data and the results in scores of the aforementioned scales, as well as the findings on physical examination. The JASP statistical analysis system was used.

Results

In total, 31 adult patients underwent surgery in our hospital for diaphyseal humerus fractures with intramedullary nails from 2017 to 2020. Of these, 2 patients died, 1 patient had not yet completed the follow-up time necessary for the study, and 4 patients did not attend assessment for demographic difficulties. A total of 25 patients were evaluated, with a mean age of 57.8 years: 11 men and 14 women (Table 1). 18% had some comorbidity, the most frequent being high blood pressure (Table 2). All the patients, in the 6 to 12 postoperative months controls, presented a complete consolidation of the diaphyseal humerus fracture on clinical and radiological evaluation. Data analysis indicated preserved range of shoulder movement with 145° (+-31.6) of mean anterior flexion, active external rotation of 42.8°(+-10.2), and most patients achieving internal rotation between T10 and T12 vertebral level (40% of patients). Regarding the functional outcomes on QuickDASH score, most had little disability associated with shoulder symptoms with a mean score of 6.1 (+-8.5). In terms of symptoms, most of the patients did not experience significant pain with a mean of 2 points for VAS (Table 3). Clinical signs of subacromial impingement were infrequent, where 64% of patients presented no clinical sign of impingement, 25% of patients with 1 sign, 8% with 2 signs (Table 4). One patient with a history of type 2 diabetes mellitus had shoulder stiffness with limited elevation above 90 degrees and 3 signs of positive subacromial impingement.

Discussion

The selection of implant for stabilization of diaphyseal humeral fractures between intramedullary nails and plates is still controversial. Intramedullary nails have the advantage of preserving periosteal irrigation and fracture hematoma and allow minimally invasive soft tissue management. However, its use by shoulder surgeons is often met with considerable wariness because of the invasion and potential injury to the rotator cuff tendons. In addition, in clinical practice, some of these patients develop symptoms associated with shoulder pathology, such as subacromial pain, and decreased force in flexion and abduction.

Initially, the Cochrane systematic review conducted in 2011 (12) compared the results of fixation with intramedullary plates or nails of diaphyseal humerus fractures. Analyzing results from 5 randomized clinical trials, it was found that there were no statistically significant differences between the use of both fixation methods when comparing factors such as fracture non-unions, surgical time, radial nerve palsy, blood loss and patients' return to work. However, it was reported that in patients managed with intramedullary nailing, there was a significant increase in symptoms of subacromial impingement and a decrease in shoulder range of motion. Later, in 2013, systematic reviews carried out by the Ouyang(10) and Ma(11) demonstrated that the use of intramedullary nails generated greater symptoms of subacromial impingement and restriction of shoulder mobility. Ma's group also found an association between intramedullary nails and greater implant failure and reoperations. They concluded that the quality of the evidence was low, requiring larger controlled clinical studies to confirm these differences. In 2015, the meta-analysis published by Zhao(9), concluded that due to similarities in functional outcomes and complications, and considering the repercussions on the shoulder associated with the use of intramedullary nails, plaque fixation can be considered a superior treatment for humeral diaphyseal fractures. Gottschalk(3) compared the characteristics of the patients who underwent plaque fixation or intramedullary nail, indicating that patients managed with intramedullary nails may present a higher mortality rate, explained by the use of intramedullary nails in pathological fractures due to oncological pathology. Patiño(13), in 2015, evaluated 30 patients at 35 months measuring range of shoulder movement and radiological position of the nails, finding an overall decrease in range of movement and shoulder symptoms related to subacromial impingement by prominence of nail.

However, there is conflicting evidence in some clinical studies showing good functional results in the shoulder of patients with intramedullary nails. In 2004, Flinkkla(14) evaluated 29 patients at 6 years on average, finding limitation for flexion as the only repercussion on the shoulder, without recording differences in pain or functional scores. In 2008, Pogliacomi(5), analyzing results from 40 patients at 62 months, found excellent results on a Constant score, concluding that performing an appropriate approach and avoiding technical errors can reduce repercussions on the shoulder when performing intramedullary nailing. García-Bógalo(8) also found that with adequate dissection and a correct nail entry point, the functional outcomes and ultrasound results are adequate. Studies supplemented by ultrasound analysis of the rotator cuff, such as Verdano's(2), who also evaluated functionality using the Constant scale and the Simple Shoulder Test, found that 79% of patients undergoing intramedullary nailing of the humerus had good functional results, and if there are rotator cuff injuries, most of them are partial supraspinatus tears, less than 30 mm, without significant long-term clinical effect. Ferreira Neto(7) studied results in fractures of the proximal humerus managed with intramedullary nails, finding that there is a high rate of rotator cuff injury by ultrasound (32% of patients with partial tears of the supraspinatus and 13% with full thickness tears), but these tears do not have a significant clinical impact when evaluating patients with functional scores over time. Baltov(15), analyzing results from 111 patients managed with intramedullary nails for diaphyseal fractures, presented very good and excellent results on the Constant score in 83.7% of patients, and chronic pain in 10% of patients, most of whom presented technical errors in surgery such as prominent nails. Boileau(16) recently reported outcomes of patients with stabilized humeral diaphyseal fractures with third-generation humeral nails, finding that the associated supraspinatus injuries are infrequent (12.% of patients) and asymptomatic, not greater than those presented in the general population by clinical and ultrasound findings. However, they report that 20% of patients may present symptomatic biceps tendinopathy, associated with technical errors due to the prominence of the nail.

In this study, we found that patients in our center treated with osteosynthesis due to antegrade humeral intramedullary nails did not present significant impairment of the shoulder functionality or range of motion, nor chronic shoulder pain. The majority of patients also did not present symptoms suggestive of subacromial impingement. In general, the results in terms of shoulder functionality evaluated by range of motion and by DASH score were satisfactory. In all patients, the goal of fracture consolidation at the diaphysis level was

achieved. One of the patients with other comorbidities and advanced age developed stiffness of the shoulder, which limited the specific assessment of symptoms of impingement.

Current limitations are inherent to the design of the study (descriptive and retrospective), without a comparative group with other fixation methods, in addition to a limited number of patients, which does not allow generalizing these results or generalizing the outcomes to other population groups. Other factors that may influence clinical outcomes at the shoulder level, such as physical therapy, were not standardized for all patients.

Conclusions

In this group of patients, osteosynthesis with humeral intramedullary nailing of the humeral shaft achieved radiological and clinical consolidation in all cases. Intramedullary nailing of humeral diaphyseal fractures with antegrade technique can achieve satisfactory outcomes, generating little or no significant clinical impact at the shoulder level.

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Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Figure 1.

Figure 1. (A) Preoperative radiograph of a patient with a spiroid diaphyseal fracture of the left humerus. (B) Radiography after reduction and antegrade intramedullary nailing of the humerus.

Table 1

Variable	Number of patients (n=25)
Age (years)	57.8 (+-17.98)
• Under 30 years old	3 (12%)
• 30-49 years	4 (16%)
• 50-64 years	8 (32%)
• Over 65 years old	10 (40%)
Men	11 (44%)
Women	14 (56%)

Table 1. Demographic characterization of patients by sex and age. The number of patients in absolute numbers is in the right column with the percentages in parentheses.

Table 2

Comorbidities	**Number of patients**
ACV	2 (8%)
DM with neuropathy	1 (4%)
HTA	3 (12%)
Obesity	1 (4%)
None	18 (72%)
Total	25

Table 2. Demographic characterization of patients describing comorbidities. The number of patients in absolute numbers is in the right column with the percentages in parentheses.

Table 3

Variable	Mean	Standard Dev.
VAS	2.32	2.06
DASH	7.93	8.54
FlexAct (degrees)	148.08	31.68
FlexPas (degrees)	154.92	27.54
REAct (degrees)	42.84	10.23
REPas (degrees)	58.08	10.25
ElevAct (degrees)	146.16	20.26
ElevPas (grados)	155.28	17.93

Vertebral level	Frequency
T5	5 (20%)
T6	3 (12%)
T8	1 (4%)
T9	4 (16%)
T10	2 (8%)
T11	2 (8%)
T12	6 (24%)
L1	1 (4%)
L2	1 (4%)

Table 3. Functional, symptomatic results and range of movement. The number of patients in absolute numbers is in the right column with the percentages in parentheses.

Table 4

Clinical signs of subacromial impingement	
	Frequency
No sign	16 (64%)
1 sign	6 (24%)
2 signs	2 (8%)
3 signs	1 (4%)

Table 4. Symptoms of subacromial impingement evaluated by the clinical signs of Neer, Yokum and Hawkins-Kennedy. The number of patients in absolute numbers is in the right column with the percentages in parentheses.

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Authors

Daniela Gutiérrez Zúñiga M.D.[1] 0000-0001-6852-0350

Luisa Fernanda García M.D., M.S.[2] 0000-0002-7609-3675

Raúl Ernesto González M.D.[3] 0000-0003-2939-3891

Felipe José Valbuena Bernal M.D., MEd[4]* 0000-0002-1993-3797

* Correspondence author

Address: Cr 8 #0-29 south, third floor, Bogotá – Colombia

Phone: (+57) 14077075, ext 10372

Mail: ortopedia.medico@hus.org.co

[1] Resident, Orthopedic Surgery and Traumatology. Pontificia Universidad Javeriana. Hospital Universitario de la Samaritana. Bogotá, Colombia.
[2] Physician and Surgeon. Masters in bioethics. Hospital Universitario de la Samaritana. Bogotá, Colombia.
[3] Orthopedist and Traumatologist. Fellow of Hand and Upper Extremity Surgery. Pontificia Universidad Javeriana, Hospital Universitario de la Samaritana. Bogotá, Colombia.
[4] Orthopedist and Traumatologist. Shoulder and elbow surgery. Masters in education. Hospital Universitario de la Samaritana. Professor Pontificia Universidad Javeriana. Bogotá, Colombia.

Abstract

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Key words: Humeral diaphyseal fracture, Antegrade intramedullary nail, Subacromial impingement, Rotator cuff

Funding: This research has not received any specific grant from agencies in the public, commercial, or non-profit sectors.

Conflict of interest: none.

Ethics approval: Comité de ética de investigación del Hospital Universitario de la Samaritana – CIEHUS

Consent to participate: All patients has signed an informed consent in which we informed them the risk and the pros of being part of the study.

Consent for publication: All patients has signed an informed consent in which we informed them the possibility of published the manuscript.

Availability of data and material: Not applicable

Level of evidence: IV