

CASE REPORT

Clinical impact on the shoulder after antegrade intramedullary nailing in humeral shaft fractures

Impacto en el hombro del enclavijamiento endomedular anterógrado en el tratamiento de fracturas de la diáfisis humeral

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Abstract

Introduction: Intramedullary nailing (IN) is a common therapeutic option for humeral shaft fractures. However, some patients treated with IN develop signs of subacromial impingement and decreased strength in flexion and abduction movements.

Objective: To evaluate the clinical impact of the use of antegrade IN on the shoulder for the treatment of humeral shaft fractures in terms of pain, functionality, and subacromial impingement symptoms.

Methodology: Retrospective observational study carried out in 25 adult patients with humeral shaft fractures treated with antegrade IN. Follow-up was performed 6 to 12 months after the procedure, assessing functionality (arcs of motion and QuickDASH scale), as well as the presence of pain (visual analog scale [VAS]) and signs of subacromial impingement (according to Yocum, Neer and Hawkins-Kennedy). Data are described using absolute and relative frequencies for qualitative variables and means and standard deviations for quantitative variables.

Results: Mean anterior flexion, QuickDASH score, and VAS score were 145° (±31.6), 6.1 (±8.5), and 2.32 (±2.06), respectively. One or more signs of subacromial impingement were observed in 32% of the patients. In addition, complete fracture healing occurred in all cases.

Conclusion: Given that no significant impact on the shoulder was evidenced in terms of mobility, pain or signs of subacromial impingement and that fracture healing occurred in all cases, IN was adequate for the treatment of humeral shaft fractures.

Keywords: Fracture Fixation; Intramedullary; Rotator Cuff; Subacromial Impingement Syndrome; Humeral Fracture (MeSH).

Resumen

Introducción: el enclavijamiento endomedular (EE) es una opción terapéutica para fracturas de la diáfisis humeral; sin embargo, algunos pacientes tratados con EE desarrollan signos de pinzamiento subacromial y disminución de la fuerza en movimientos de flexión y abducción.

Objetivo: evaluar el impacto en el hombro del uso del EE anterógrado para el tratamiento de fracturas de la diáfisis humeral en términos de dolor, funcionalidad y signos de pinzamiento subacromial.

Metodología: estudio observacional retrospectivo realizado en 25 pacientes adultos con fracturas de la diáfisis humeral tratadas con EE anterógrado. Se realizó seguimiento entre 6 y 12 meses después del procedimiento, valorando la funcionalidad (arcos de movimiento y escala QuickDASH) y la presencia de dolor (escala visual análoga [EVA]) y signos de pinzamiento subacromial (según Yocum, Neer y Hawkins-Kennedy). Los datos se describen utilizando frecuencias absolutas y relativas para las variables cualitativas, y medias y desviaciones estándar para las cuantitativas.

Resultados: las medias de la flexión anterior, puntaje en la escala QuickDASH y escala EVA fueron 145° (±31,6), 6,1 (±8,5) y 2,32 (±2,06), respectivamente. El 32% de los pacientes presentó uno o más signos de pinzamiento subacromial. Además, la consolidación completa de la fractura ocurrió en todos los casos.

Conclusiones: dado que no se evidenció un impacto significativo en el hombro en términos de movilidad, dolor o signos de pinzamiento subacromial y que la consolidación de la fractura ocurrió en todos los casos, el EE fue adecuado para el tratamiento de fracturas de la diáfisis humeral.

Palabras clave: Fijación intramedular de fracturas; Manguito de los rotadores; Síndrome de pinzamiento subacromial; Fracturas del húmero (DeCS).

Introduction

Humeral shaft fractures account for 1% to 3% of all fractures seen in the emergency department and represent approximately 20% of all humeral fractures.^{1,2} One of the treatment options available for this type of fracture is intramedullary nail fixation. From the biomechanical and biological point of view, intramedullary nailing (IN) has advantages over plate osteosynthesis, since it preserves bone hematoma and periosteal irrigation, resulting in less soft tissue disruption, as well as a higher rate of healing. Also, IN potentially reduces complications such as infection and radial nerve palsy.^{3,4} However, if the integrity of the rotator cuff tendons and articular cartilage is compromised while using the shoulder joint approach, pain and function limitation may occur.

During postoperative follow-up, it has been observed that some of these patients develop symptoms and signs associated with shoulder injuries and diseases such as pain and decreased strength in flexion and abduction movements. However, available evidence on these effects is contradictory. In this regard, some studies report that function after shoulder surgery is good and that patients with rotator cuff tears are usually asymptomatic,^{1,5,6} but other studies report changes in shoulder function.^{7,8} Hence, some authors report that plate osteosynthesis has a superior performance due to the possible effects of IN in the shoulder.⁹⁻¹¹

Considering the above, the objective of the present study was to evaluate the impact of using antegrade IN on the shoulder for the treatment of humeral shaft fractures in terms of shoulder pain, functionality, and signs of subacromial impingement.

Methodology

Type of study, population, and sample

A retrospective observational study was conducted in a quaternary care hospital in Bogotá, Colombia, which is a referral center for orthopedic and trauma treatment by specialists in the city. The study population comprised all adult patients (18 to 70 years old) with humeral shaft fractures who underwent surgery with antegrade IN in the humerus, performed by four orthopedic surgeons, between January 2017 and January 2020. Patients with a history of rotator cuff injury, shoulder pain, pathologic fractures, osteoarthritis of the glenohumeral or acromioclavicular joints, and/or neuromuscular or neurological diseases were excluded, as well as patients with no follow-up data.

It should be noted that all patients underwent closed reduction and antegrade intramedullary fixation with two types of third-generation nails from two different manufacturers.

Procedures

Between 6 and 12 months after surgery, patients were followed up by means of anamnesis, administration of a questionnaire, physical examination, and x-ray assessment. Functionality was assessed using the QuickDASH arm, shoulder and hand disability score and considering shoulder range of motion (active and passive arcs of motion [anterior flexion, scapular plane elevation, and external and internal rotation]). In addition, the presence of the three signs of subacromial impingement reported by Yocum, Neer & Hawkins-Kennedy was assessed, and pain was evaluated using the visual analog scale (VAS). Finally, humeral shaft fracture healing was evaluated clinically and radiologically

at the time of the follow-up assessment. Moreover, patients' medical records were reviewed to collect demographic (age and sex) and clinical data (comorbidities and date when the surgical procedure was performed).

Statistical analysis

Data were entered into a database created in *Microsoft Excel* for subsequent analysis in JASP statistical analysis software. Qualitative variables are described using absolute and relative frequencies, and quantitative variables using means and standard deviations.

Ethical considerations

This study followed the ethical principles for the performance of biomedical studies involving human subjects established in the Declaration of Helsinki¹² and the scientific, technical and administrative standards for health research set forth in Resolution 8430 of 1993 issued by the Colombian Ministry of Health.¹³ In addition, the study was approved by the Research Ethics Committee of the Hospital Universitario de La Samaritana E.S.E., as recorded in Minutes 05IC10-V1 of November 22, 2018.

Results

During the study period, 31 adult patients underwent IN for the treatment of humeral shaft fractures, two of whom had died by the time of follow-up, one had undergone surgery within the last six months, and four did not attend the follow-up visit. Thus, 25 patients were included in the study. The mean age was 57.8 years, and the majority were women (56%). Moreover, 18% had some comorbidity, with the most frequent being high blood pressure (Table 1).

Table 1. Demographic characteristics and comorbidities of the patients included in the study.

Variable	n (n=25)
Age (mean, SD)	57.8 ($\pm$ 17.98)
Under 30 years of age	3 (12%)
30-49 years old	4 (16%)
50-64 years old	8 (32%)
Over 65 years of age	10 (40%)
Sex	
Male	11 (44%)
Female	14 (56%)
Comorbidities	
Stroke	2 (8%)
Diabetes mellitus type 2	1 (4%)
High blood pressure	3 (12%)
Obesity	1 (4%)
None	18 (72%)

SD: standard deviation.

Source: Own elaboration.

Based on clinical and x-ray findings, complete healing of the humeral shaft fracture occurred in all patients by the time of the follow-up assessment. Regarding shoulder arcs of motion, the mean anterior flexion was 145° (± 31.6) and the mean active external rotation was 42.84° (± 10.25). Also, the majority of patients achieved internal rotation between the T10 and T12 vertebrae (40%). Regarding shoulder functionality, most patients presented a low degree of disability and the mean QuickDASH score was 6.1 (± 8.5). Finally, the mean VAS was 2.32 points (± 2.06), thus the majority of patients did not experience any significant pain (Table 2).

Table 2. Presence of pain and functionality in patients included in the study.

Variable	Media (DS)
Pain (VAS)	2.32 (± 2.06)
Functionality (QuickDASH)	7.93 (± 8.54)
Shoulder arcs of motion	
Active anterior flexion	148.08° (± 31.68)
Passive anterior flexion	154.92° (± 27.54)
Active external rotation	42.84° (± 10.23)
Passive external rotation	58.08° (± 10.25)
Active elevation	146.16° (± 20.26)
Passive elevation	155.28° (± 17.93)
Active internal rotation (Vertebra)	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%)

SD: standard deviation.

Source: Own elaboration.

Finally, clinical signs of subacromial impingement were rare, with 24% of patients showing one sign, 8% showing two signs, and 4% showing three signs (Table 3). It should be noted that one patient with a history of type 2 diabetes mellitus presented limitation of shoulder mobility on arm elevation above 90 degrees and three signs of subacromial impingement.

Table 3. Signs of subacromial impingement evaluated in accordance with the Neer, Yokum & Hawkins-Kennedy approach.

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

Source: Own elaboration.

Discussion

At present, the use of IN as a treatment for humeral shaft fractures is a controversial issue among shoulder surgery experts, since it can cause shoulder pain and functional limitation. This treatment has advantages such as preservation of the periosteal arteries and fracture hematoma and allows minimally invasive soft tissue management.³ However, IN may cause injury to the rotator cuff tendons and it has been reported that many of the operated patients develop symptoms and signs associated with shoulder injuries and diseases, such as pain and decreased strength in flexion and abduction movements.

In this regard, the *Cochrane* systematic review,¹⁴ conducted in 2011, compared the results of fixation of humeral shaft fractures using dynamic compression plates or intramedullary nailing. Said review included five small clinical trials and found no statistically significant differences between the two methods when comparing factors such as fracture healing time, operation time, nerve injury, blood loss, and resumption of work activity. On the contrary, it identified significant differences with respect to a greater presence of subacromial impingement signs and a decrease in shoulder motion arcs in patients treated with IN. Importantly, the review did not find sufficient evidence on functional outcomes.

Later, in 2013, systematic reviews by Ouyang *et al.*¹⁰ and Ma *et al.*¹¹ reported that the use of intramedullary nailing resulted in the presence of more subacromial impingement signs, as well as greater restriction of shoulder mobility. Ma *et al.*¹¹ also found an association between the performance of IN and a higher occurrence of implant failures and reinterventions; however, because the quality of evidence was low, they concluded that more controlled clinical trials evaluating these differences are necessary to corroborate these findings.

In turn, Zhao *et al.*⁹ concluded in a meta-analysis that plate osteosynthesis is superior to IN, as they found that, although functional outcomes and complications were similar, patients who underwent IN experienced clinical involvement at the shoulder level. Likewise, Gottschalk *et al.*,³ in a study comparing these two fixation methods, reported a higher mortality in patients treated with IN; however, it should be pointed out that their study included oncologic patients with pathologic fractures.

Furthermore, Patiño¹⁵ evaluated shoulder range of motion and intramedullary nail positioning based on radiology in 30 patients over a period of 35 months, and found an overall decrease in range of motion, as well as the presence of signs of subacromial impingement caused by nail protrusion.

Regarding shoulder involvement in patients who underwent surgery with IN, Flinkkla *et al.*,¹⁶ in a study in which 29 patients were followed up 6.2 years after the procedure, identified that the only impact on the shoulder was limitation of flexion. Moreover, Pogliacomì *et al.*,⁵ in a study in which a 62-month follow-up of the IN was performed in 40 patients, concluded that a proper approach and avoiding technical errors during surgery can reduce the occurrence of tendon injuries in the shoulder. Similarly, García-Bógalo⁸ reported good functional and ultrasound outcomes in patients who underwent procedures where adequate dissection was performed and a correct nail entry point was established.

Other studies reported complementary tests, such as ultrasound, to evaluate rotator cuff. For instance, Verdano *et al.*² reported that most rotator cuff injuries in these patients were partial-thickness rotator cuff tear, which do not lead to significant long-term involvement. It is worth mentioning that these authors also evaluated functionality using the Constant score and the Simple Shoulder Test and found that 79% of patients treated with IN had a good functional outcome. Likewise, Gracitelli *et al.*⁷ evaluated the

management of proximal humerus fractures with IN and, based on ultrasound, reported a high rate of rotator cuff injury (32% with partial tears and 13% with complete tears); however, evaluation of long-term function in these patients indicates that these tears did not have a clinically significant impact.

The study by Baltov *et al.*¹⁷ in 111 patients with diaphyseal fractures treated with IN found good results on the Constant score in 83.7% of these patients. In addition, that study reported the presence of chronic shoulder pain in 10% of the cases, most of which resulted from technical errors during surgery, such as intramedullary nail prominence. Finally, Muccioli *et al.*¹⁸ evaluated the outcomes of patients with humeral shaft fractures treated with third-generation humeral nails and found that rotator cuff injuries were rare (12%), so there is no evidence of a difference in the prevalence of these injuries with respect to the population that has not undergone IN. However, these authors reported that 20% of patients presented symptomatic biceps tendinitis caused by errors in surgical technique (nail protrusion).

Since one of the concerns pointed out in the literature is the presence of rotator cuff injuries, the use of arthroscopy during this procedure has been proposed and described in order to have a direct view of the entry point through the rotator interval, evaluate concomitant injuries, and determine a pin height, avoiding its prominence.¹⁹ For example, after using this technique and assessing mobility and functionality up to 1 year after surgery, Antoni *et al.*¹⁹ reported good functionality (average Constant score: 73.9; when adjusted for age, the average was 93.5). However, that study does not report the symptomatic presence of subacromial impingement or rotator cuff injuries.

According to a meta-analysis and systematic literature review²⁰ comparing minimally invasive plate osteosynthesis (MIPO) and IN in the humerus based on data reported in seven randomized, observational clinical trials (325 patients treated with MIPO and 357 with IN), the MIPO technique shows significantly lower risks of nonunion or reoperation, leading to better functional outcomes. It should be noted that the authors point out that the learning curve of the MIPO technique should be considered when interpreting the results.

In the present study, patients with humeral shaft fractures treated with antegrade IN had no pain or significant impairment of function. Moreover, most patients showed no signs of subacromial impingement. Overall, the results of shoulder functionality, as assessed by range of motion and QuickDASH score, were satisfactory. On the other hand, fracture healing was observed in all patients. It is worth mentioning that one of the patients who had comorbidities and advanced age presented shoulder stiffness at the time of the follow-up assessment, which limited the evaluation of signs of subacromial impingement.

The reason for the good results achieved and the strengths of this study include the use of third generation intramedullary nailing, the performance of surgeries by expert orthopedists specialized in major trauma and shoulder surgery, the precise length of the nails in the subacromial space, the meticulous management of the soft tissues, as well as the careful dissection and suturing of the rotator cuff.

Regarding limitations, the study design (observational and retrospective), the lack of comparisons with other fracture fixation methods, and the small sample size do not allow extrapolating the results or generalizing the outcomes observed to the context of other population groups. In addition, it should be noted that other factors that may influence outcomes, such as the need of physical therapy interventions, were not standardized for all patients. Finally, it should be considered that it was not possible to follow up 22% of the patients since many of them resided in rural areas, so they were not able to go to health care centers.

Conclusions

In the present study, the fixation of humeral shaft fractures by means of IN resulted in satisfactory outcomes, with a low frequency of shoulder pain and clinical signs of subacromial impingement.

Conflicts of interest

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References

1. Wong J, Newman JM, Gruson KI. Outcomes of intramedullary nailing for acute proximal humerus fractures: a systematic review. *J Orthop Traumatol.* 2016;17(2):113–22. <https://doi.org/jvkn>.
2. Verdano MA, Pellegrini A, Schiavi P, Somenzi L, Concari G, Ceccarelli F. Humeral shaft fractures treated with antegrade intramedullary nailing: What are the consequences for the rotator cuff? *Int Orthop.* 2013;37(10):2001–7. <https://doi.org/f5bjf7>.
3. Gottschalk MB, Carpenter W, Hiza E, Reisman W, Roberson J. Humeral shaft fracture fixation: Incidence rates and complications as reported by American board of orthopaedic surgery part II candidates. *J Bone Joint Surg Am.* 2016;98(17):e71. <https://doi.org/jvft>.
4. Dai J, Chai Y, Wang C, Wen G. Dynamic compression plating versus locked intramedullary nailing for humeral shaft fractures: A meta-analysis of RCTs and nonrandomized studies. *J Orthop Sci.* 2014;19(2):282–91. <https://doi.org/f5vrxy>.
5. Pogliacomini F, Devecchi A, Costantino C, Vaianti E. Functional long-term outcome of the shoulder after antegrade intramedullary nailing in humeral diaphyseal fractures. *Chir Organi Mov.* 2008;92(1):11–6. <https://doi.org/cksftv>.
6. Grossterlinden L, Ueblacker P, Rueger JM. Arthroscopical findings after antegrade nailing of a proximal humeral fracture : Case report and review of the literature. *Eur J Trauma Emerg Surg.* 2007;33(4):383–7. <https://doi.org/cfjj4p>.
7. Gracitelli MEC, Malavolta EA, Assunção JH, Matsumura BA, Kojima KE, Ferreira Neto AA. Ultrasound evaluation of the rotator cuff after osteosynthesis of proximal humeral fractures with locking intramedullary nail. *Rev Bras Ortop.* 2017;52(5):601–7. <https://doi.org/jvkn>.
8. García-Bógalo R, Larrainzar-Garijo R, Díez-Nicolás E, Llanos-Alcázar LF. Clinical and Sonographic Assessment of Rotator Cuff Damage During Antegrade Humeral Nailing. *Rev Esp Cir Ortop Traumatol.* 2008;52(1):2–8. <https://doi.org/cdvpxn>.
9. Zhao JG, Wang J, Wang C, Kan SL. Intramedullary nail versus plate fixation for humeral shaft fractures: a systematic review of overlapping meta-analyses. *Medicine (Baltimore).* 2015;94(11):e599. <https://doi.org/jvkq>.
10. Ouyang H, Xiong J, Xiang P, Cui Z, Chen L, Yu B. Plate versus intramedullary nail fixation in the treatment of humeral shaft fractures: an updated meta-analysis. *J Shoulder Elbow Surg.* 2013;22(3):387–95. <https://doi.org/f2fvwn>.
11. Ma J, Xing D, Ma X, Gao F, Wei Q, Jia H, et al. Intramedullary Nail versus Dynamic Compression Plate Fixation in Treating Humeral Shaft Fractures: Grading the Evidence through a Meta-Analysis. *PLoS One.* 2013;8(12):e82075. <https://doi.org/jvkr>.
12. World Medical Association (WMA). WMA Declaration of Helsinki – Ethical principles for medical research involving human subjects. Fortaleza: 64th WMA General Assembly; 2013.

13. Colombia. Ministerio de Salud. Resolución 8430 de 1993 (octubre 4): Por la cual se establecen las normas científicas, técnicas y administrativas para la investigación en salud. Bogotá D.C.; octubre 4 de 1993 [cited 2022 Feb 03]. Available from: <https://bit.ly/31gu7do>.
14. Kurup H, Hossain M, Andrew JG. Dynamic compression plating versus locked intramedullary nailing for humeral shaft fractures in adults. *Cochrane Database Syst Rev*. 2011;(6):CD005959. <https://doi.org/d7v46j>.
15. Patiño JM. Treatment of humeral shaft fractures using antegrade nailing: functional outcome in the shoulder. *J Shoulder Elbow Surg*. 2015;24(8):1302–6. <https://doi.org/f3g9rr>.
16. Flinkkilä T, Hyvönen P, Siira P, Hämäläinen M. Recovery of shoulder joint function after humeral shaft fracture: a comparative study between antegrade intramedullary nailing and plate fixation. *Arch Orthop Trauma Surg*. 2004;124(8):537–41. <https://doi.org/cbj3vh>.
17. Baltov A, Mihail R, Dian E. Complications after interlocking intramedullary nailing of humeral shaft fractures. *Injury*. 2014;45(Suppl. 1):S9–15. <https://doi.org/f5pcc9>.
18. Muccioli C, Chelli M, Caudal A, Andreani O, Elhor H, Gauci M-O, et al. Rotator cuff integrity and shoulder function after intra-medullary humerus nailing. *Orthop Traumatol Surg Res*. 2020;106(1):17–23. <https://doi.org/jvks>.
19. Antoni M, Lazarus P, Kempf JF, Clavert P. Arthroscopic intramedullary nailing of humeral fractures through the rotator interval. *Orthop Traumatol Surg Res*. 2021;107(1):102750. <https://doi.org/jvkt>.
20. van de Wall BJM, Baumgärtner R, Houwert RM, Link BC, Heng M, Knobe M, et al. MIPO versus nailing for humeral shaft fractures: a meta-analysis and systematic review of randomised clinical trials and observational studies. *Eur J Trauma Emerg Surg*. 2022;48(1):47–59. <https://doi.org/jvkv>.