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The right path of scientific evidence

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What is wisdom? We could define it as practical wisdom, doing what has to be done well and not doing what does not need to be done, rightly or erroneously. Wisdom is good judgment,yet it is well recognized that beliefs frequently obstruct it.

Similarly, it is difficult to contradict beliefs that provide benefits; this applies to doctors and everyone else in the medical-industrial complex.

Current scientific evidence is divided into two strands: one scientific and one commercial. The current body of scientific evidence is separated into two strands: scientific and commercial. The second lurches between a proclaimed coherence—scientific in appearance—which is confirmed by the multiplicity of visible evidence of scientificity and a hidden coherence, in theory, "well-intentioned." There is scientific rhetoric that contributes to the efficacy and strength of the imposed mythos.

As physicians, we must be able to ask skeptical questions, to cast doubt on the unquestionable certainty of the "great representatives" and current charismatic leaders of modern medicine, who appear to be the fathers of institutionalized truth and who frequently reproduce hegemonic thought while subordinating to private interests. I encourage young professionals to emulate their (excellent) instructors while maintaining critical judgment and, ultimately, not succumbing to the Cartesian ideal of purity worthy of emulation or unquestioning obedience. I believe that we must dissect, gut, and scrutinize scientific evidence that is offered as a finished truth, packaged, canned, and ready to be crowned as the absolute surgical indication that supports and justifies the use of a particular implant or trendy approach. Let us avoid becoming part of an iatrogenic vanguard marked by fanaticism. Let us remember that most revered novelties have been, are, and will be rapidly buried and forgotten.

On the other hand, it is important to remember that the entire history of science is a graveyard of failed attempts to achieve absolute and unshakeable certainty. However, we owe ourselves as eternal students to that graveyard of failed attempts. The researchers who have taken responsibility for these failed attempts are not the fathers of failure, but rather the opposite. They are the ones who prevailed despite their failure. In this sense, Evidence-Based Medicine provides the physician with the evidence that validates certain diagnostic-therapeutic actions over others. This invites them to articulate the evidence to substantiate an action. Thus, in medicine, a technique called convergence of evidence is used, but the underlying problem is both the validity and legitimacy of such imprecise evidence. Finally, in critical skepticism, the strength and imperfection of that evidence are called into question, and that means reasoning.

This act of reasoning about one's own conclusions and looking for potential flaws in the process is known as reflection; it displays an awareness of the existence of error and that uncertainty is always present.

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As surgeons, we not only process information, but also create our own paradigms. As a result, both the context we live in and the profession we carry out are not external to us but are active developers of scientific evidence and current knowledge. Blessed are those researchers who seek to deepen our grasp of orthopedics and traumatology. However small and ephemeral their discoveries and contributions may seem, they have been, since ancient times, the most eminent reflection of the sense of scientific curiosity that fuels the culture and art of our specialty.

Suprascapular and Interscalene Nerve Block as Analgesia After Arthroscopic Rotator Cuff Repair: a Retrospective Comparative Cohort Study

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ABSTRACT

Introduction: This study aimed to compare the efficacy of interscalene block (ISB) and suprascapular nerve block (SSNB), individually and in combination (ISB+SSNB), used as postoperative analgesia within the first 3 hours after arthroscopic rotator cuff repair. **Materials and Methods:** Retrospective comparative cohort study, conducted between 2019 and 2021. The primary endpoint was shoulder pain score in the immediate postoperative period as reported on a visual analog scale (VAS) by the patient. Secondary endpoints were opioid use in the recovery room (first 3 hours) and locoregional anesthesia complications. **Results:** 175 patients were included; 13 in the ISB group, 61 in the ISB+ SSNB group, and 101 in the SSNB group. The ISB group and the ISB+ SSNB group had significantly less pain in the recovery room than the SSNB group ($p = 0.001$ and $p < 0.001$, respectively). The percentage of patients who required at least one dose of opioid and the total number of opioids consumed in milligrams of morphine equivalent were significantly lower for the ISB and ISB+ SSNB groups than for the SSNB group ($p < 0.001$). There were no significant differences in pain or opioid use between ISB alone or combined with SSNB (ISB+SSNB). **Conclusions:** In this retrospective comparative study, ISB was more effective in relieving pain and reducing opioid use in the recovery room after arthroscopic rotator cuff repair than SSNB. The ISB+SSNB combination did not increase effectiveness, and therefore it is suggested not to combine these two techniques.

Keywords: Rotator cuff tear; interscalene block; suprascapular nerve block; arthroscopic repair.

Level of Evidence: III

Bloqueos supraescapular e interescalénico como analgesia después de la reparación artroscópica del manguito rotador: estudio de cohorte comparativo retrospectivo

RESUMEN

Introducción: El objetivo de este estudio fue comparar la eficacia de los bloqueos interescalénico y supraescapular, solos y combinados, como analgesia posoperatoria en las primeras 3 horas tras la reparación artroscópica del manguito rotador. **Materiales y Métodos:** Estudio de cohorte comparativo retrospectivo, realizado entre 2019 y 2021. El criterio de valoración principal fue el puntaje del dolor de hombro en la sala de recuperación evaluado con una escala analógica visual por el paciente. Los criterios de valoración secundarios fueron el consumo de opioides en la sala de recuperación y las complicaciones de la anestesia locorregional. **Resultados:** Se incluyó a 175 pacientes, 13 en el grupo de bloqueo interescalénico, 61 en el grupo de bloqueos interescalénico más supraescapular y 101 en el grupo de bloqueo supraescapular. Los grupos de bloqueo interescalénico y de bloqueo interescalénico más supraescapular tuvieron significativamente menos dolor en la sala de recuperación y una tasa total menor de opioides consumidos en miligramos equivalentes de morfina que el grupo de bloqueo supraescapular ($p = 0,001$ y $p <0,01$, respectivamente). No hubo diferencias significativas en el dolor ni el consumo de opioides entre el bloqueo interescalénico solo o combinado con bloqueo supraescapular. **Conclusiones:** El bloqueo interescalénico fue más eficaz que el bloqueo supraescapu-

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lar para aliviar el dolor y disminuir el consumo de opioides en la sala de recuperación tras la reparación artroscópica del manguito rotador. La combinación de bloqueo interescalénico más bloqueo supraescapular no resultó en un incremento en la eficacia, y se sugiere no combinar estas dos técnicas.
Palabras clave: Rotura del manguito rotador; bloqueo interescalénico; bloqueo supraescapular; reparación artroscópica.
Nivel de Evidencia: III

INTRODUCTION

Arthroscopic rotator cuff surgery is a minimally invasive procedure that is currently conducted primarily on an outpatient basis.[1] However, arthroscopic rotator cuff repair is associated with moderate or severe postoperative pain, and adequate pain management is key to successful outpatient surgery. [1-4]

Multiple strategies have been proposed to treat pain after rotator cuff repair surgery that decrease opioid use, such as cryotherapy, intralesional anesthesia, nerve block, continuous nerve block with catheters, and multimodal analgesia. [2] Interscalene block (ISB) has been shown to be an optimal analgesic option in arthroscopic shoulder surgery, with success rates of 87% to 100%.[5] However, it can be associated with potentially serious adverse effects and there are relative contraindications in patients with severe chronic obstructive pulmonary disease due to the almost inevitable diaphragmatic paralysis it causes.[6]

For this reason, peripheral blocks have been considered to reduce these risks, such as suprascapular nerve block (SSNB). The efficacy and safety of SSNB has been proven to control pain and reduce the need for opioids after rotator cuff repair surgery.[7] Multiple studies compared the efficacy of ISB versus SSNB.[2,5,8-10] Although, in some, the ISB is reported to be superior in controlling postoperative pain,[2] in others, the non-inferiority of SSNB was demonstrated.[7]

In a previous study of our group, we evaluated the efficacy of a multimodal analgesia protocol that included intralesional anesthesia and SSNB, without ISB, in patients undergoing mini-open or arthroscopic rotator cuff repair.[1] The results showed that the protocol was highly effective for pain management after mini-open surgery; however, in the arthroscopic surgery group, the protocol was not optimal, resulting in significantly greater pain averages than in the mini-open surgery group. Based on the results of this study, we consider that the multimodal analgesia protocol that includes only SSNB could be insufficient for pain management after arthroscopic surgery. Therefore, with these results in mind, we decided to add an ISB in patients undergoing arthroscopic rotator cuff repair. The objective was to compare the efficacy of ISB (alone or in combination with SSNB) with that of the multimodal protocol of the historical cohort that included only SSNB as postoperative analgesia within the first three hours of arthroscopic rotator cuff repair. Our hypothesis was that ISB, alone or combined, would be superior to SSNB in managing pain within the first few hours after surgery.

MATERIALS AND METHODS

Patient selection

A retrospective study was carried out with patients who had undergone arthroscopic rotator cuff repair and who were included, prospectively, in the registry of the Rotator Cuff Clinical Care Center at our institution, between January 2019 and April 2021. This study was approved by our institutional ethics committee.

The inclusion criteria were: 1) >18 years old; 2) with complete or partial rotator cuff tears that had undergone arthroscopic repair with associated procedures on the biceps, acromion or acromioclavicular joint, or without procedures; 3) with an SSNB, an ISB, or a combination of both (ISB plus SSNB) for the management of postoperative pain, and 4) with a complete record of pain and analgesia administered during anesthesia and the first three hours in the recovery room. Patients who were administered regional anesthesia other than ISB or SSNB were excluded from the study. Likewise, those with physical or psychological incapacity to assess pain on a visual analog scale (VAS) and with a known allergy to local anesthetics (bupivacaine, lidocaine) were excluded.

Surgical technique

Arthroscopic surgery was performed by only one surgeon (GF). General anesthesia was administered with the patient in the lateral decubitus position with upper limb traction. The repair was performed using bone anchors with the repair configuration selected by the surgeon according to the morphology of the injury.

Anesthetic procedures

All patients underwent surgery under general anesthesia with a combination of inhaled and intravenous anesthetic. An anesthesiologist performed all ISBs under ultrasound guidance (Sonosite M-Turbo or Mindray with a linear transducer of 7.5 to 15 MHz) and a neurostimulator at 0.4 mA. After identifying the anatomical landmarks, 1 ml of 2% lidocaine without epinephrine was infiltrated into the skin and subcutaneous cellular tissue, and then the puncture was carried out using an ultrasound-guided 50-mm Pajunk needle, visualizing its entire journey as it progressed to the proximity of the C5-C6-C7 nerve roots. Using the neurostimulator and avoiding sensory or motor responses at 0.4 mA, after negative aspiration, and with an injection pressure of 15 psi, between 10 and 15 ml of 0.375% levobupivacaine were administered, the adequate distribution of the local anesthetic was observed, and the adequate motor and sensory block was verified

The SSNB was performed based on specific anatomical landmarks according to the surgeon, after general anesthesia and with the patient in the lateral decubitus, using 10 cc of 0.5% bupivacaine dissolved in 10 cc of saline solution.

Analgesia Protocol

The same analgesic protocol was used for all patients. During anesthesia and before going to the recovery room, all patients received 1 g of paracetamol and a dose of anti-inflammatory drugs (75 mg diclofenac, 30 mg ketorolac or 40 mg parecoxib), intravenously, to prevent pain. In the recovery room, if the pain score on the VAS was >3, the ward staff administered a dose of an opioid that included oxycodone, hydromorphone, or morphine. The pain was evaluated again after 5 minutes. If the score was >3, another dose of opioid was administered.

Endpoints and variables analyzed

The primary endpoint was the postoperative shoulder pain score, evaluated by the patient in the VAS (from 0 to 10). Pain was assessed when the patient woke up in the recovery room (before administering any opioid). The secondary endpoints were: the use of opioids standardized in morphine equivalents until discharge from the recovery room and complications.

The variables analyzed were: 1) demographic data, 2) type of block (ISB, SSNB or a combination of both); 3) pain during recovery according to the VAS; 4) the administration of opioid and non-opioid medications by the anesthesiologist, during surgery and in the recovery room; 5) the dose in mg of each medication administered; 6) the number of doses required to control pain in the recovery room.

To facilitate data analysis, all opioids were converted to milligram equivalents of oral morphine.

Statistical Analysis

The patients were divided into three groups: 1) ISB only, 2) ISB plus SSNB, and 3) SSNB only. Demographic variables and surgical variables were compared between groups using analysis of variance for continuous variables and the chi-squared test or Fisher's exact test for categorical variables. A one-way analysis of variance (one-way ANOVA) was performed to compare pain and opioid use between groups with *post-hoc* tests comparing all groups with each other and correcting the p-value for multiple comparisons using the Bonferroni method. All statistical tests were bilateral and the significance was set at alpha = 0.05.

The analyses were carried out with the Stata 14 program (StataCorp. 2015. Stata Statistical Software: version 14. College Station, TX: StataCorp LP).

RESULTS

Study population

After applying the eligibility criteria, data from 175 patients were analyzed. It included 94 women and 81 men, with an average age of 59 ± 9.7 years, who were divided into three groups: 13 in the ISB group, 61 in the ISB plus SSNB group and 101 in the SSNB group. The demographic characteristics and surgical variables of the three groups are detailed in the Table.

Table. Demographic information, characteristics of the injury and surgical variables

	ISB Group (n = 13)	ISB + SSNB group (n = 61)	SSNB Group (n = 101)	p
Demographics				
Age	60 ± 9.1	58 ± 10	59 ± 9.6	0.79
Sex (female)	8 (61)	30 (49)	56 (55)	0.62
Characteristics of the injury				
Operated side: right, n (%)	12 (92)	46 (75)	82 (81)	0.35
Pre-surgical ASES score	48.7 ± 15.5	42.3 ± 16.7	39.4 ± 18.3	0.26
Size of the anteroposterior injury (mm)	24.8 ± 13.9	20.5 ± 10.9	24.2 ± 12.5	0.23
Size of the mediolateral injury (mm)	25.3 ± 15.2	20.2 ± 11	23.5 ± 13.7	0.29
Intraoperative variables				
Surgical time (min)	93.6 ± 56.3	90.8 ± 40.2	88.8 ± 51.8	0.93
Number of anchors (range)	2 (1-4)	2 (1-5)	2 (1-4)	0.84
Associated procedures[†]				
Biceps				0.27
Tenotomy	3 (30)	9 (17)	33 (35)	
Tenotomy and tenodesis	5 (50)	28 (54)	42 (44)	
Resection of the distal end of the clavicle	0 (0)	9 (17)	5 (5.3)	0.05
Other Procedures [‡]	2 (20)	3 (5.8%)	4 (4.2%)	0.13

Data are expressed as number, number (%), or mean ± standard deviation, unless otherwise indicated.
[†]Data on associated procedures were missing in 3 patients in the ISB group, 9 in the ISB plus SSNB group, and 6 in the SSNB group.
[‡]Other procedures include superior capsular reconstruction with biceps or subacromial balloon spacer.
ISB = interscalene block; SSNB = subscapular nerve block; ASES = American Shoulder and Elbow Surgeons Score.

Pain and opioid use

The ISB group had significantly less pain in the recovery room than the SSNB group (0.9 ± 2.1 for ISB vs. 4.8 ± 3.8 for SSNB, p = 0.001). Similarly, the ISB plus SSNB group suffered significantly less pain than the SSNB group (1.3 ± 2.8 for ISB plus SSNB vs. 4.8 ± 3.8 for SSNB, p < 0.001). There was no significant difference in pain between the ISB group and the ISB plus SSNB group (0.9 ± 2.1 for ISB vs. 1.3 ± 2.8 for ISB plus SSNB, p = 1.0).

The percentage of patients requiring at least one dose of opioids in the recovery room was significantly higher in the SSNB group (54%) than in the ISB (7.7%) and ISB plus SSNB (13%) groups (p <0.001). Among patients who required at least one dose of opioids, the SSNB group had a significantly higher consumption of equivalent milligrams of morphine than the ISB group (8.9 ± 6 for SSNB vs. 2.4 ± 3.4 for ISB, p = 0.04). Although it did

not reach statistical significance, opioid consumption in milligrams equivalent of morphine was also higher in the SSNB group than in the ISB plus SSNB group (8.9 ± 6 for SSNB vs. 4.9 ± 4 for ISB plus SSNB, p = 0.125). Opioid use, both in terms of the percentage of patients requiring at least one dose, and in equivalent milligrams of morphine, was similar in the ISB and ISB plus SSNB groups.

Complications

There were no early complications in any of the three groups. No patient with an ISB had serious complications, such as pneumothorax.

DISCUSSION

Adequate pain management after rotator cuff repair is a key aspect of achieving successful outpatient surgery. To this end, locoregional anesthesia is a method that has been used in recent decades with the aim of reducing pain and opioid use.[2,6] Among locoregional anesthesia options, ISB is considered the gold standard given its effectiveness for pain management in shoulder surgery.[2] However, the application of ISB requires trained personnel and can be associated with complications, such as diaphragmatic paralysis, vertebral artery injection, pneumothorax, brachial plexus injury, dysphonia, dysphonia, dyspnea, Horner syndrome, among others.[2,6] For this reason, other alternatives have been considered that have similar efficacy, are easy to apply and pose a lower risk of complications, such as SSNB. SSNB is an effective alternative for controlling pain after rotator cuff surgery considering that the suprascapular nerve provides sensory fibers to around 70% of the shoulder joint and directly innervates the supraspinatus and infraspinatus muscles.[6,10] The surgeon performed the SSNB based on anatomical landmarks because this is the procedure widely utilized in clinical practice for this type of block. In addition, there are anatomical studies that demonstrate the efficacy of SSNB performed blindly, guided by anatomical landmarks.[11] Therefore, we do not consider it necessary for the block to be in the hands of an anesthesiologist or guided by ultrasound.

The efficacy of SSNB versus ISB has been addressed, as well as whether these two locoregional anesthetic procedures provide equivalent analgesia and safety.[2,5,7-9] Koga et al. compared SSNB and ISB after rotator cuff repair and reported that they did not find significant differences between these two methods in terms of the duration of analgesia and pain in VAS. In a randomized controlled clinical trial, on the other hand, it was determined that SSNB was as effective as ISB for pain control in the first 24 hours after surgery, but ISB was more successful in managing pain in the immediate postoperative period.[8] In addition, according to a meta-analysis, patients with SSNB consumed more opioids than those with ISB in the immediate postoperative period.[2]

Postoperative pain control in the group of patients undergoing arthroscopic repair was not optimal in a previous study by our group that evaluated the efficacy of a multimodal analgesia protocol with local anesthesia and SSNB, with pain averages in the VAS significantly higher than in patients undergoing mini-open surgery.[1] Although the direct causes for this difference cannot be established, we consider that the hydration and edema of the soft tissues that occur after arthroscopic surgery could play an important role that can condition pain that is difficult to manage with local anesthesia and SSNB because of its extension to areas distant from the glenohumeral joint. For this reason, after these results, we decided to use ISB in patients undergoing arthroscopic rotator cuff surgery and the objective of this study was to compare the efficacy of the ISB and the SSNB used in the multimodal protocol of the historical cohort.

The findings of this study show that ISB was more effective than SSNB in controlling post-operative pain during the first three hours in the recovery room, with a significant decrease in opioid use. None of the patients with ISB suffered serious early complications. In one of the groups evaluated, a combination of ISB plus SSNB was used to determine if there was an additive effect on the effectiveness of these blocks. Our results show that the combination of the two blocks does not seem to offer a significant increase in efficacy and, therefore, we do not recommend the combined use of these blocks. Based on these results, we have changed our practice and routinely use ISB for post-operative pain management in patients undergoing arthroscopic rotator cuff repair.

This study has several limitations and the results presented should be viewed in light of these limitations. First, this is a retrospective study and the assignment to the type of block was not random. This retrospective study,

on the other hand, is integrated in a prospective cohort as part of a clinical care facility where data is collected prospectively and standardized surgical, anesthetic, and analgesic procedures are performed. This allows for a reasonable comparison between patients with ISB and the historical cohort treated with the multimodal SSNB protocol. Likewise, there were no significant differences in the demographic, preoperative and intraoperative variables between the three groups. Second, although pain management was standardized, the type of anti-inflammatory and opioid medications administered was variable. However, the analgesic potency of the anti-inflammatory drugs administered was similar and opioid consumption was standardized to equivalent milligrams of morphine during the analysis to make the comparisons more valid. Third, the number of patients included, especially in some of the groups, is not large and this may affect the estimates, and could explain the absence of complications. Because ISB complications are rare, a considerable sample size is required to accurately estimate their frequency. Finally, our study only assessed pain and opioid use during the first three hours in the recovery room and, therefore, it is not possible to discuss whether the superiority of ISB extends beyond the immediate postoperative period.

CONCLUSIONS

In this retrospective comparative study, ISB was more effective than SSNB in relieving pain and reducing opioid use in the recovery room after arthroscopic rotator cuff repair. The combination of ISB plus SSNB did not increase efficacy and, therefore, it is not considered necessary to combine these two techniques.

Conflict of interest: The authors declare no conflicts of interest.

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Oral Versus Intra-articular Corticosteroid in the Treatment of Adhesive Capsulitis

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ABSTRACT
Introduction: Adhesive capsulitis is a condition defined by thickening of the shoulder joint capsule, which clinically translates into discomfort and progressive loss of range of motion, with conservative therapy being the initial option. In this study, we evaluate the use of intra-articular corticosteroid injections for the treatment of this condition. **Materials and Methods:** A retrospective analysis was conducted between 2015 and 2020, assessing the outpatient records of patients diagnosed with adhesive capsulitis or frozen shoulder and treated with corticosteroids either orally or intra-articularly. **Results:** A total of 19 patients were analyzed, 8 received oral treatment and 11 received intra-articular injection, with both groups showing considerable improvement, with the difference that the patients in the articular corticosteroid group reported long-term improvement. **Conclusion:** Corticosteroids have been found to be effective in the treatment of adhesive capsulitis both orally and by intra-articular injection; however, intra-articular corticosteroids have proved to be more effective in the long term.
Keywords: Adhesive capsulitis of the shoulder; oral corticosteroid; corticosteroid injection; pain; range of motion.
Level of Evidence: III

Corticoesteroide oral vs. intrarticular en el tratamiento de la capsulitis adhesiva

RESUMEN
Introducción: La capsulitis adhesiva es una enfermedad que se caracteriza por el engrosamiento de la cápsula articular del hombro, lo que se traduce clínicamente en dolor y una pérdida progresiva de la movilidad. El tratamiento conservador es la primera opción. En este estudio, se evaluó el uso de corticoesteroides articulares para el manejo de este cuadro. **Materiales y Métodos:** Se llevó a cabo un estudio retrospectivo entre 2015 y 2020. Se evaluaron los registros de consulta externa de pacientes con diagnóstico de capsulitis adhesiva u hombro congelado, que recibieron tratamiento con corticoesteroides por vía oral o articular. **Resultados:** Se analizó a 19 pacientes, 8 recibieron tratamiento por vía oral y 11, por vía articular. Hubo una mejoría importante en ambos grupos, pero los pacientes que recibieron corticoesteroides articulares comunicaron una mejoría a largo plazo. **Conclusiones:** La administración de corticoesteroides tanto por vía oral como intrarticular para tratar la capsulitis adhesiva fue eficaz; sin embargo, a largo plazo, los corticoesteroides articulares resultaron más eficaces.
Palabras clave: Capsulitis adhesiva del hombro; corticoesteroide oral; inyección de corticoesteroide; dolor; rango de movilidad.
Nivel de Evidencia: III

INTRODUCTION

The term adhesive capsulitis or frozen shoulder refers to a condition characterized by thickening of the joint capsule resulting in progressive loss of both active and passive range of motion.[1,2] The degree of thickening is directly related to the loss of range of motion; however, it is not related to the perception of pain.[3]

This disease does not have a specific cause; in general, it has an idiopathic origin, and it is a self-limiting condition. It begins with a "freezing" phase in which joint pain and stiffness increase, which may last for several months, followed by a stable stage in which it remains "frozen", after which it progresses to a "thawing" phase, and it tends to resolve spontaneously.[4,5]

Received on August 8th, 2022. Accepted after evaluation on February 17th, 2023 • Dr. BYRON TORRES • byrontorres78@gmail.com https://orcid.org/0000-0002-7365-5927
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Some diseases may predispose to the development of adhesive capsulitis, such as a contralateral shoulder condition, immobilization, hypothyroidism and hyperthyroidism, diabetes, obesity, Parkinson's disease, cerebrovascular events, Parsonage-Turner syndrome or Dupuytren's disease, and should be taken into account when diagnosing this condition.[6]

Adhesive capsulitis has been classified on the basis of arthroscopic and histological evaluation, as described by Neviaser and Hannafin, and comprises four stages:[7]

- Stage 1: pre-adhesive phase, with fibroblast proliferation without adhesion formation, without alteration of ranges of motion, but with the appearance of pain.
- Stage 2: acute adhesive synovitis, characterized by synovial hypertrophy and early adhesion formation, pain and mild loss of range of motion.
- Stage 3: maturation phase, the transition from synovitis to fibrosis occurs, the axillary recess adheres to the joint capsule.
- Stage 4: chronic phase, significant loss of range of motion and dense adhesions, but with mild or no pain.

In order to facilitate patient understanding, the natural course of the disease has been divided into three phases that correlate with the findings described in the Neviaser and Hannafin classification.[7] Phase 1 correlates with stage 1 and is characterized by the onset of pain, with no ROM restriction; in phase 2, a combination of acute pain and loss of ROM correlating with Neviaser and Hannafin stages 2 and 3 is detected; and phase 3 correlates with stage 4, there is a frank loss of ROM, albeit with mild pain or no pain at rest.[8]

The usual clinical presentation of this condition includes pain of insidious onset, lasting several months. Once symptoms are established, they tend to occur in increasingly frequent episodes.[9] The pain is typically nocturnal and the patient describes being unable to sleep on the affected side; loss of range of motion appears with the natural evolution of the condition and rarely precedes the typical clinical presentation.[10,11]

Imaging studies are inconclusive in diagnosing adhesive capsulitis. Conventional radiographs tend to be normal, MRI may reveal thickening of the coracohumeral ligament, poor capsular distension, contrast media extravasation, synovial hypertrophy, and scar formation in the rotator interval.[12,13]

Although the condition is known to be self-limiting and tends to heal spontaneously, this is not always the case, so numerous types of treatments have been proposed, ranging from pharmacological and non-pharmacological options to the surgical alternative.[14] Treatment can be symptomatic with the administration of analgesics and anti-inflammatory drugs or corticosteroids to modify the natural evolution of the disease.[7,15] Physical therapy has been indicated as the first line of treatment, alone or concomitantly, and has been effective in alleviating this condition.[16]

The administration of intra-articular corticosteroids produces significant relief of pain and restoration of ROM on the affected side after 12 weeks when compared to placebo.[17,18]

Surgery is considered if pain or limited range of motion persists after a minimum of 3-6 months of conservative management including medication, local injections or physical therapy.[19]

MATERIALS AND METHODS

A retrospective study was conducted to identify all patients with a diagnosis of adhesive capsulitis or frozen shoulder seen in the outpatient area of the Orthopedic Specialty Center, between 2015 and 2020. An electronic interview was conducted. Patients gave their consent to participate in the study.

Demographic data, such as age and sex, were collected and patients who received an oral corticosteroid were compared with those treated with an intra-articular corticosteroid for the management of adhesive capsulitis. A pre-treatment and post-treatment evaluation was performed using the Simple Shoulder Test (SST). Follow-up was up to 12 months.

The oral corticosteroid protocol included methylprednisolone 4 mg, one dose daily, for 15 days, followed by 2 mg daily, for 15 days and finally a dose of 2 mg, every 48 h, until completing two months of treatment.

The intra-articular corticosteroid protocol consisted of methylprednisolone 80 mg plus 8 ml lidocaine without epinephrine, one dose every week, for three weeks, via a posterior, ultrasound-guided route.

All patients treated at our center underwent physical therapy at approximately the third or fourth week after diagnosis, once relief of pain had been achieved, for a period of 2-4 months. This consisted of progressive work on passive range of motion, assisted active range of motion, and active range of motion against resistance.

Inclusion criteria were: clinical records mentioning the diagnosis of adhesive capsulitis, no age range, conservative treatment with oral or intra-articular corticosteroid.

Patients with previous surgery, those who refused to participate in this study, or who were not interested in taking part in scientific research were excluded.

A sample of 92 patients was obtained and, after applying the exclusion criteria, a final sample of 19 patients was obtained.

The SST is a subjective scale consisting of 12 questions with Yes/No answers, including daily activities. It is easy to apply and it must be completed by the patient, which allows eliminating biases. The answer 'Yes' adds up to one point, and the final result is multiplied by 100 and divided by the number of questions, thus obtaining a result in percentage.[20]

RESULTS

Nineteen patients met the inclusion criteria, eight of them had been treated with oral corticosteroids and 11 with intra-articular corticosteroids.

Physical therapy alone is not referred to, as our treatment is followed by a physical therapy protocol, and is mentioned more as an adjunctive treatment in the management of adhesive capsulitis.[21]

The eight orally treated patients had a baseline SST score of 4.16%. Two of them improved within three months, with an average of approximately 95.8% six months after starting treatment; in one, symptoms improved completely (100% in SST); the remaining five patients required more time to obtain a positive result, the average value in SST was 66.66% after one year of treatment (Figure 1).

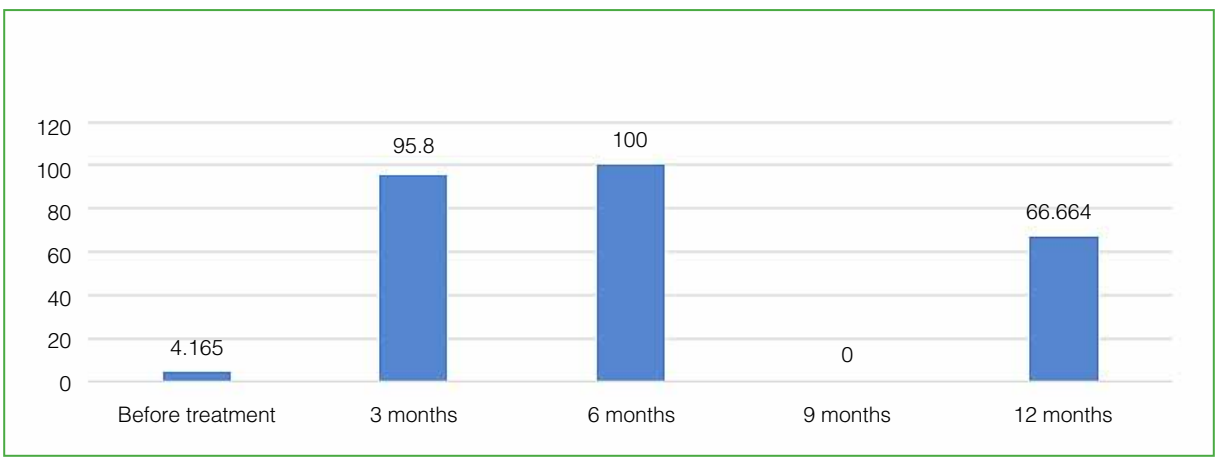

Figure 1. Simple Shoulder Test in the group treated with oral corticosteroid.

In the group treated by the intra-articular route (11 patients), the average SST was 11.36% at the first consultation. Eight of them had substantial improvement over a three-month period, with an average SST value of approximately 93.74%. The remaining three obtained 97.22% in the SST after one year of treatment (Figure 2).

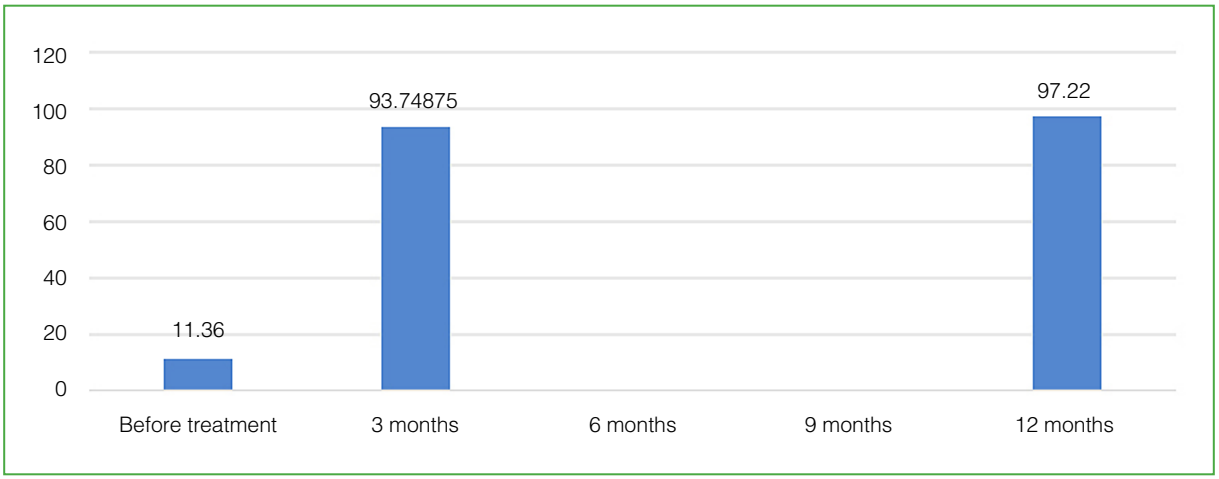

Figure 2. Simple Shoulder Test in the group treated with intraarticular corticosteroid.

As mentioned above, patients undergoing surgery were excluded; however, it would be important to assess the specific indications for surgery because, as has been indicated in international series, this type of treatment is reserved for young, high-demand individuals or those who need to return to work quickly, as well as for those suffering from metabolic diseases that have been shown to respond poorly to conservative treatment.[11,12]

No psychological assessment had been performed prior to the start of this study, despite the fact that it has been demonstrated that this disease has a significant emotional component, and that inadequate management can lead to a slow progression or noncompliance with therapy.

DISCUSSION

Our literature review showed that multiple therapeutic options are available for adhesive capsulitis and one of the best known and effective is the use of oral or intra-articular corticosteroids, as described by Redler et al. in 2019.[3] These authors report a significant improvement in perceived pain in patients with adhesive capsulitis treated with intra-articular corticosteroids; the drug begins to work after six weeks. Pain intensity improves significantly, as well as rotations, especially external rotation. They also point out that the success rate increases if ultrasound is used to perform the infiltration.

In 2017, Wang et al.[5] demonstrated the efficacy of intra-articular corticosteroids for pain management in the short term, with no difference in the long term, and noted that they achieve substantial improvement in passive and active ranges of motion in the short and long term.

A systematic review by Koh[17] compared the efficacy of corticosteroid injection with various types of treatment, such as placebo, physiotherapy alone, and non-steroidal anti-inflammatory drugs, and concluded that intra-articular corticosteroids have proven efficacy, relieving pain at 12 weeks and improving ranges of motion, although we know that, because of their self-limiting nature, they make no difference to the long-term course of the disease. However, the application of corticosteroids at an early stage of the disease helps to greatly improve its natural evolution.

In 2019, Shang et al.[14] conducted a systematic review comparing the efficacy of intra-articular or subacromial corticosteroid injection to treat adhesive capsulitis. They found no significant differences in terms of site of application. Pain was relieved in an average of three weeks and ranges of motion increased at approximately 12 weeks, although the authors reported that there was no long-term evaluation and follow-up. In addition, they mentioned the probable advantages of subacromial application that avoids the adverse side effects of joint application of corticosteroids.

We are aware that a retrospective study may have limitations, such as lack of data or recall bias; however, we take this study as a starting point for future research, to strengthen research in our field and to be able to provide findings with greater scientific weight to our daily practice.

CONCLUSIONS

According to the results of our study, it is suggested that the best option for the management of adhesive capsulitis is the application of intra-articular corticosteroids, which achieves a higher recovery rate in less time; in addition, the functional scale yielded a better score in the group treated with intra-articular corticosteroids.

Although the results indicate that corticosteroid therapy is effective in the management of adhesive capsulitis, this is a retrospective study with a small sample size; however, it correlates well with larger studies.

Finally, this study incorporates an adequate clinical perspective comparing the two treatment methods used, and shows that the most effective option is intra-articular corticosteroids.

Conflict of interest: The authors declare no conflicts of interest.

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Recalcitrant Humeral Nonunion: Biological Reconstruction Technique

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ABSTRACT

Introduction: Nonunion of the humeral shaft occurs in between 2% and 10% of non-surgically treated fractures and up to 15% of fractures treated with initial open reduction and internal fixation. The definition of recalcitrant nonunion is still under debate. The purpose of this study is to present the outcomes of a series of patients with recalcitrant pseudarthrosis of the humerus who were treated with stable osteosynthesis combined with biological reconstruction using allograft utilizing a novel surgical approach. **Materials and Methods:** The series included 33 patients treated between 2012 and 2021. 20 women and 13 men, with a mean age of 65.4 years. The evolution time of recalcitrant pseudarthrosis was 33.3 months. The mean follow-up was 33.2 months. **Results:** Out of a total of 33 patients treated with this technique, 32 (97%) achieved a complete consolidation and one patient had a partial consolidation. The average consolidation period was 4.6 months and the complete osseointegration of the allograft was 8.1 months. For the functional evaluation, the visual analog scale (VAS), ASES score, Constant score and elbow motion arcs were taken into account. **Conclusions:** Even among experienced surgeons, the treatment of recalcitrant pseudarthrosis of the humerus remains an obstacle and an unsolved challenge. The use of a specialized osteosynthesis material added to a bone allograft fixed with screws significantly increases mechanical stability, allowing early range of motion, and works as an osteoinductive and osteoconductive scaffold, all of which are essential for consolidation.

Keywords: Nonunion; recalcitrant; allograft; humeral fractures.

Level of Evidence: IV

Seudoartrosis recalcitrante de húmero: técnica de reconstrucción biológica

RESUMEN

Introducción: La incidencia de seudoartrosis en las fracturas de húmero tratadas de forma conservadora es del 2-10%, y del 15% en aquellas operadas. La definición de seudoartrosis recalcitrante es aún tema de debate. El objetivo es comunicar los resultados de una serie de pacientes con seudoartrosis recalcitrante de húmero tratados con osteosíntesis estable y reconstrucción biológica con aloinjerto mediante una nueva técnica de montaje. **Materiales y Métodos:** La serie incluyó a 33 pacientes evaluados entre 2012 y 2021, 20 mujeres y 13 hombres (edad promedio 65.4 años). El tiempo de evolución de la seudoartrosis recalcitrante era de 33.3 meses. Todos tuvieron un seguimiento promedio de 33.2 meses. **Resultados:** Treinta y dos de los 33 pacientes tratados con esta técnica (97%) tuvieron una consolidación completa y uno, una parcial. El período de consolidación promedio fue de 4.6 meses y el de osteointegración completa del aloinjerto, de 8.1 meses. Para la evaluación funcional se consideraron la escala analógica visual, el puntaje ASES, el puntaje de Constant-Murley y los arcos de movilidad del codo. **Conclusiones:** El manejo de las seudoartrosis recalcitrantes de húmero sigue siendo un dilema y un problema no resuelto aún para los cirujanos experimentados. La combinación entre el uso de un material de osteosíntesis específico sumado al aloinjerto óseo fijado con tornillos aumenta considerablemente la estabilidad mecánica, permite una movilidad precoz, y actúa como un andamio osteoinductor y osteoconductor vital para la consolidación.

Palabras clave: Húmero; seudoartrosis recalcitrante; aloinjerto; diáfisis.

Nivel de Evidencia: IV

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INTRODUCTION

Humeral diaphysis fractures occur between the upper edge of insertion of the pectoralis major proximally and the supracondylar ridge distally. These injuries constitute 1.2% of all fractures in adults,[1] and have an annual incidence of between 10 and 20 per 100,000 inhabitants.[2-5] In published studies, the incidence of nonunion in humerus fractures varies considerably, from 2% to 10% of conservatively treated fractures, and 15% of operated fractures.[6-8] This variance is attributed, in large part, to the unusual vascular contribution of the humeral diaphyseal area, which in 93.8% of cases is represented by a nutrient foramen.[9] Most foramina are located in three-fifths of the humerus and have a downward direction towards the elbow joint.[10,11] Fractures located in this segment can damage the nutrient supply and bring problems for consolidation, especially when extrinsic factors or morbidities, or intrinsic factors related to the type of immobilization or fixation used, coexist, altering the 'diamond concept' of Giannoudis et al.[12] needed for healing. In this way, the evolution of the fracture can be towards hypertrophic or atrophic nonunion, the latter is the most frequent. Pseudarthrosis of long bones remains a major problem worldwide and that of the humerus is no exception, it is a condition difficult to treat even in expert hands. The term nonunion has been defined in several ways, and there is up to 55% disagreement about the right time to consider it.[13]

The US Food and Drug Administration defines it as a "fracture that is at least 9 months old and has not shown any signs of healing for 3 consecutive months." Others have recommended that, for long bones, the entity should be considered within a period of six months, during which no signs of radiological consolidation of the fracture are evident.[14] Accordingly, the definition of 'recalcitrant nonunion' is even more difficult. According to some authors, it refers to nonunion that does not respond to conventional treatment in any of its variants in patients who have had surgery at least three times over a two-year period.[15] Others, on the other hand, consider them as those that require more than one intervention to heal.[16] In their study of 125 patients, Wiss and Garlich argue that the main risk factors for this type of condition are the number of previous procedures (2 or more), the history of infection and the initial treatment of the fracture.[16] We define recalcitrant nonunion as a fracture that does not respond to conservative or surgical treatment with at least one of the following characteristics:

- for conservative treatment, we take into account the lack of consolidation over a period of two years, in patients without major risk factors, and one year in those with two or more risk factors (mentioned below);
- pfor surgical treatment, a minimum of two previous operations without clinical and radiological signs of consolidation.

Although numerous studies have been published on the treatment of nonunion when there is no diaphyseal consolidation of the humerus, where surgical reduction and osteosynthesis combined with autologous bone graft is considered the gold standard, little has been written about the difficult scenario that represents the management of recalcitrant nonunion.

The objective of this article is to communicate the clinical and radiological outcomes obtained in a consecutive series of patients with recalcitrant nonunion of the humerus evaluated retrospectively, by prospective treatment with stable internal osteosynthesis associated with biological reconstruction with non-irradiated frozen structured allograft using a telescope technique or a novel 'Onlay 90°- 90°' technique of placement, according to the deficit of bone stock and the type of nonunion to be rescued.

MATERIALS AND METHODS

It is a series of 37 patients with recalcitrant nonunion of the humerus, evaluated retrospectively, analytically and descriptively, between 2012 and 2021, in the Hand and Reconstructive Upper Limb Surgery Service, operated on by a level V expert surgeon and a level IV advanced surgeon, from the same surgical team, according to the Tang classification.[17]

The following inclusion criteria were considered: 1) patients with recalcitrant nonunion of the humerus, with previous failed conservative treatment or surgery including those with a history of infection, 2) patients with definitive failed treatment by our surgical team and 3) patients with a postoperative follow-up of at least one year. The exclusion criteria were: treatment of nonunion with a different technique from that proposed.

This reduced the sample to 33 patients. In the first evaluation, all consulted for pain and functional impairment.

The series consisted of 20 women and 13 men, with an average age of 65.4 years (range 27-80) They were grouped according to the kinematics of trauma into high-energy (patients <50 years) and low-energy accidents, such as falls from own height (patients >50 years). The progression time of recalcitrant nonunion was 33.3 months (range 3-120). The average number of previous surgeries was 3.28. Patients treated conservatively (15.15%) averaged 31.2 months until surgery (range 12-51) (Tables 1 and 2).

Table 1. Patient demographics

Patient	Age	Time of evolution (months)	Previous interventions	Allograft	Consolidation
CE	79	120	6	Onlay + intercalary	Yes
CO	73	76	3	Onlay	Yes
EA	66	66	2	Onlay	Yes
VO	65	64	5 (Infection)	Onlay	Yes
EI	66	66	9	Onlay + intercalary	Yes
DA	75	51	0	Onlay	Yes
AN	71	59	1	Onlay	Yes
CC	73	59	2	Onlay	Yes
LI	68	59	2 (Infection)	Onlay	Yes
NR	66	52	6 (Infection)	Onlay + Intercalary	Yes
RS	77	50	0	Onlay	Yes
MP	65	36	1	Onlay	Yes
RE	70	72	1	Onlay	Yes
SE	80	19	0	Onlay	Yes
BM	69	24	0	Onlay	Yes
CE	65	14	5	Onlay + Intercalary	Yes
NR	69	12	7	Onlay + Intercalary	Yes
CA	66	12	0	Onlay	Yes
PA	69	12	1	Onlay	Yes
LE	72	4	3	Onlay	Partial
MR	27	11	2	Onlay	Yes
SR	34	3	2	Onlay	Yes
RS	77	24	4	Onlay	Yes
BJ	45	15	2	Onlay	Yes
DJ	46	10	3	Onlay	Yes
MS	47	7	5	Onlay	Yes
TS	68	18	3	Onlay	Yes
BZ	74	16	2	Onlay	Yes
MM	62	18	2	Onlay	Yes
MA	67	14	6	Onlay	Yes
CS	63	12	2	Onlay	Yes
MRI	75	21	5	Onlay + Intercalary	Yes

Table 2. Analysis of data

Quantity	33		
Sex	Female: 20 (60.6%)	Male: 13 (39.4%)	
Type of trauma	Low energy: 28 (85%)	High energy (15%)	
Laterality	Right: 19 (57.6%)	Left: (42.4%)	
Dominance	Dominant: 18 (54.5%)	Non-dominant: 15 (45.5%)	
Location	Proximal: 7 (21.2%)	Shaft: 20 (60.6%)	Distal: 6 (18.2%)
Consolidation time	Minimum: 4 months	Average: 4.6 months	Maximum: 7 months
Osseointegration:	Minimum: 7 months	Average: 8.1 months	Maximum: 11 months
Follow-up	Minimum: 12 months	Average: 33.2 months	Maximum: 75 months

The mean follow-up of all patients was 33.2 months (range 12-75) and the clinical evaluation included the Constant-Murley score, visual analog scale (VAS), *American Shoulder and Elbow Surgeons Score* (ASES) and elbow functionality using goniometry. In the treated patient population, different risk factors for the development of this condition were identified (Table 3).

Table 3. Risk factors for recalcitrant nonunion of the humerus

Inherent to the patient	Inherent to the fracture	Treatment
Obesity	Fracture pattern*	Functional Brace*****
Smoking	Location**	Insufficient fixation
Alcoholism	Deforming forces	Number of previous surgeries
Diabetes	Open fractures***	
Use of corticosteroids	Infections***	
Osteoporosis	Third fragment***	
Prior shoulder/elbow stiffness	Pathological fractures***	
Advanced age	Homolateral forearm fracture	
	Magnitude of separation between bone fragments****	

*Ring et al., 2007; Papasoulis et al., 2010; Rutgers and Rings, 2006. **Ekholm et al., 2010. ***Modaber and Jupiter, 1998. ****Neuhaus et al., 2014. *****Toivanen et al., 2005.

The following studies were requested as routine and preoperative planning: comparative anteroposterior and lateral humerus radiographs, preferably digital; computed tomography with 3D reconstruction and 'skip' punch biopsy of the affected segment in cases of doubt or history of infection. In four patients with several previous surgeries (more than 4) and more than one osteosynthesis plate, rapid printing 3D models were used for preoperative planning in order to quantify the bone defect zone and correctly choose the implant and the exact length of the bone graft or non-irradiated frozen structural intercalary allograft. In the remainder, the measurement was performed with the routine preoperative studies requested. If a larger bone resection was necessary because of the infeasibility or doubtful vitality of the ends observed during surgery, planning was modified during the surgical procedure. It should be noted that this *in situ* modification does not create a complication, since, in all cases, a homolateral total humerus allograft is requested.

Radiological evolution was analyzed with digital anteroposterior, lateral and oblique radiographs and computed tomography at 6 weeks, 3, 6 and 9 months.

On the other hand, for rescue surgery with the proposed technique to be successful, we believe that several fundamental factors must be taken into account in planning. For this, we developed the 'hexagon rule' which is very useful for diagnosis and preoperative planning in these difficult scenarios (Figure 1). This scheme takes into account the patient's inherent risk factors, joint stiffness, disuse bone atrophy, range of motion and resorption at the level of the nonunion focus and operculum closure. We believe that the previous analysis of this hexagon allows us to evaluate therapeutic possibilities, choose the best reconstruction technique for each particular case and assemble an intraoperative logical sequence during the technique.

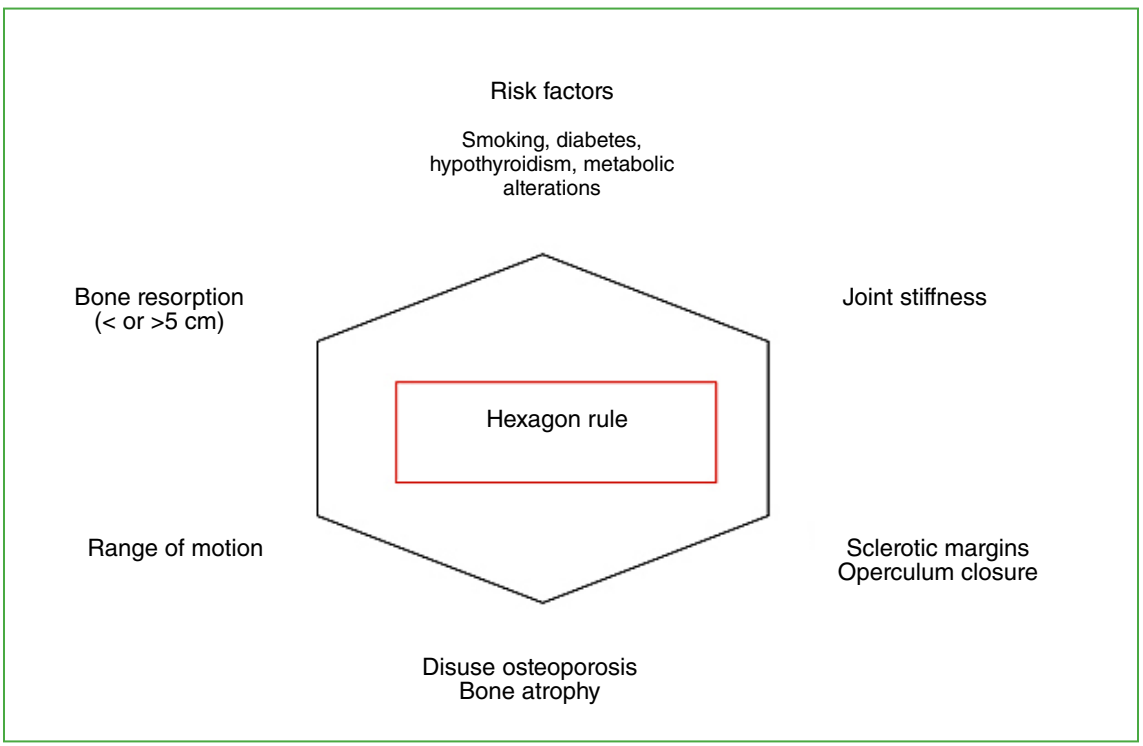

Figure 1. Hexagon rule.

We propose a technique based on three essential principles of fracture treatment:

- Rigid stabilization of fragments
- Stimulation of the osteogenesis process
- Early range of motion exercises.

To these principles, we add Giannoudis' diamond concept.[18,19]

Surgical technique

As already mentioned, this technique was designed based, firstly, on the classic concepts of diamond healing described by Giannoudis, [18,19] where the presence of osteogenic cells, osteoinductive mediators and an osteoconductive matrix in the focus is necessary; and secondly, risk factors (summarized with the hexagon rule), where bone stock, disuse osteoporosis and the stiffness of neighboring joints (shoulder and elbow) produce, biomechanically, greater stress at the level of the focus and are common causes of failures in traditional methods. Some published complications due to morbidity of the autologous bone donor zone, such as pain,

functional impairment and bruising, were also considered, especially if the bone stock requirements were large and required hospitalization of certain patients. Through meticulous preoperative planning, two modalities of biological reconstruction can be used as an adjunct to stable internal osteosynthesis according to bone stock deficit and bone quality at the time of intervention. We chose 5 cm of bone defect as a cutting point because we can shorten the limb to that extent without compromising neurovascular structures and obtain a rigid assembly with the technique used, facilitating soft tissue healing and patient tolerance, even though we prefer to maintain anatomical length whenever possible.

Deficit <5 cm in length: biological plate or strut cortical frozen non-irradiated humerus allograft placed in an arrangement we call 'Onlay 90°- 90°' associated with ground allograft (canopy technique).

Deficit >5 cm in length: non-irradiated frozen structured allograft of the humerus, intercalary or 'telescope' associated with intramedullary ground allograft.

A correct preoperative planning can minimize errors and speed up surgical times (Figure 2).

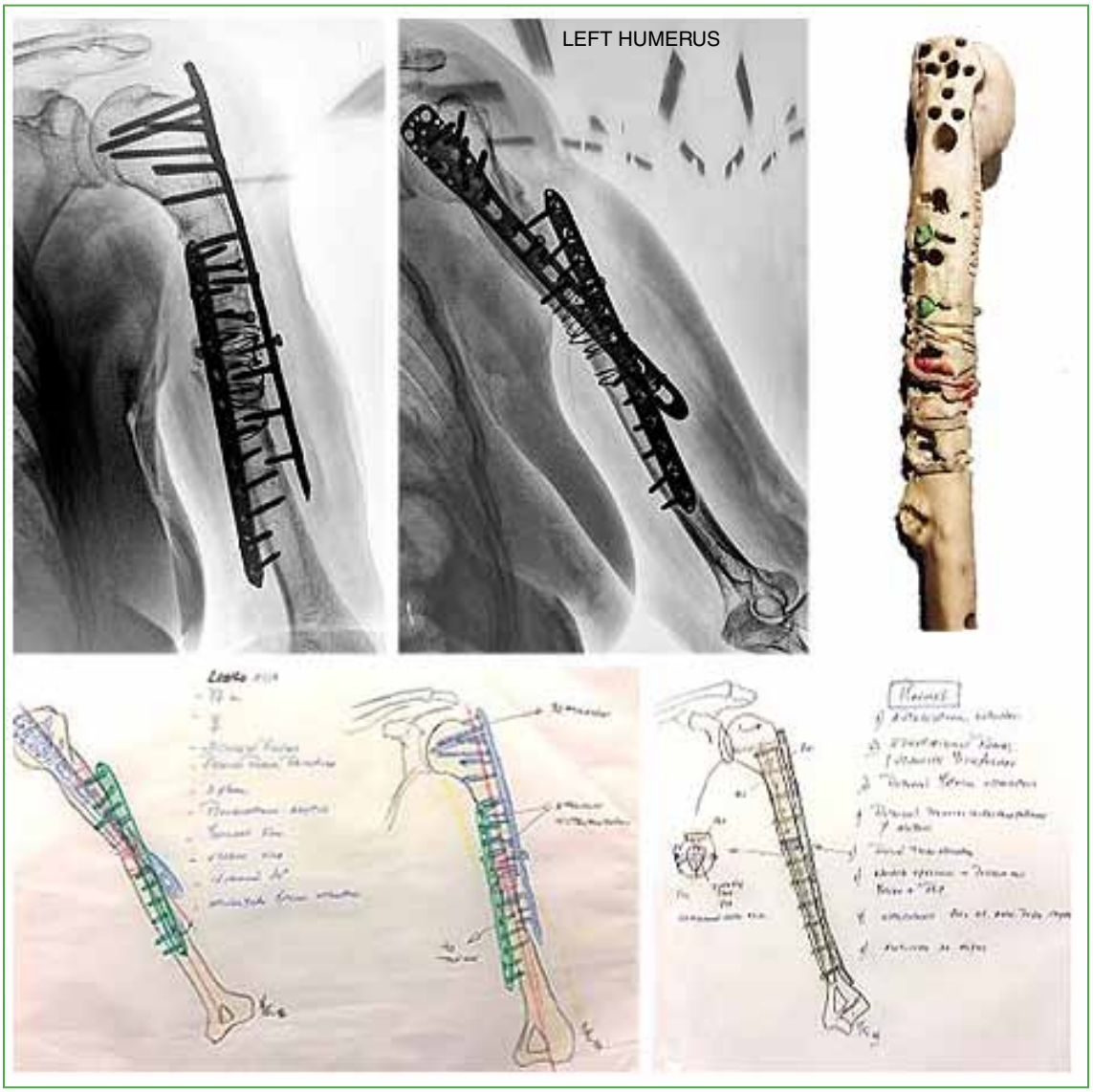

Figure 2. Preoperative planning.

Key sequence and steps

- General anesthesia or plexus block assisted by ultrasound and sedation. Positioning of the patient in the dorsal position at 45° (beach chair position), with the exception of the distal third performed in the ventral or lateral position with a support at elbow level.
- Expanded or posterior deltopectoral approach when nonunion is near the supracondylar region with electroscalpel (Covidien®) to reduce bleeding and pain, and improve skin aesthetics.
- Frozen or punch biopsy when there is doubt or history of infection (in cases with >5 polymorphonuclear leukocytes per field a cement spacer is made with antibiotic - Masquelet technique).
- Antibiotic prophylaxis 30 min before surgery with 2 g IV cefazolin, followed by a booster dose within 2 hours of starting the procedure.
- Resection of keloid scars, if any.
- Neurolysis and repair of the radial or ulnar nerve under microsurgical magnification. This step can be time consuming especially if the patient has had several previous surgeries or radial nerve neuropraxia.
- Treatment of the nonunion focus: decortication, saucerization of the site without consolidation, resection of bone tissue with macroscopic aspect of necrosis, regularization of ends, alignment (Figure 3).

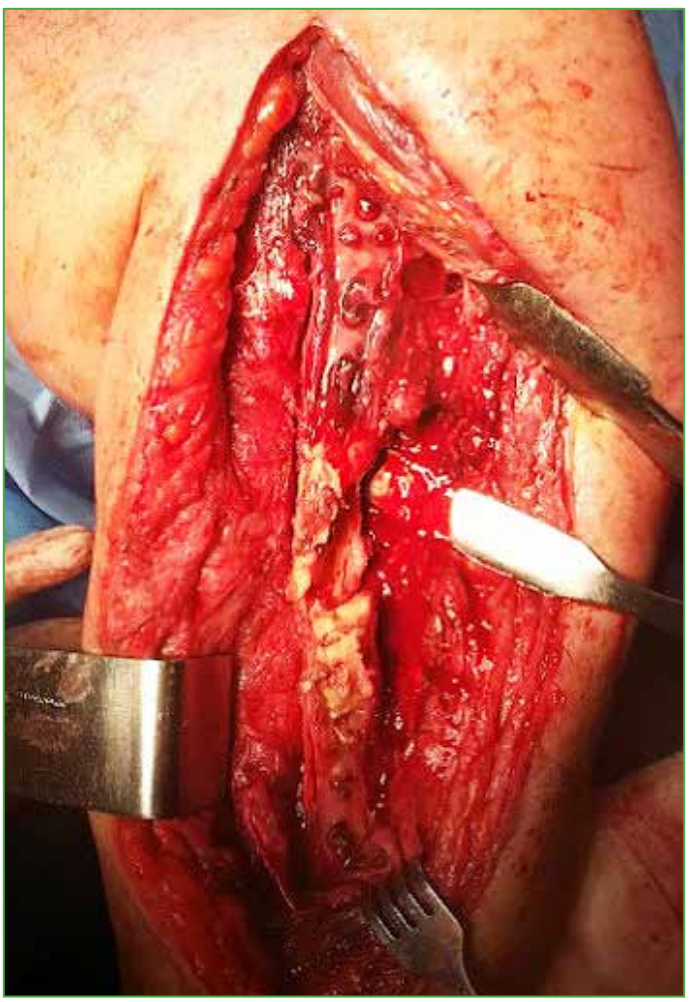

Figure 3. Visualization of the mid-shaft humerus bone stock defect after removal of osteosynthesis material.

- Osteosynthesis: with 3.5/4.5 LC-DCP plate with at least four bicortical screws at each end; Phylos® type plates or anatomical plates for the lower end of the humerus according to the topography of the recalcitrant nonunion to be treated (Figure 4).

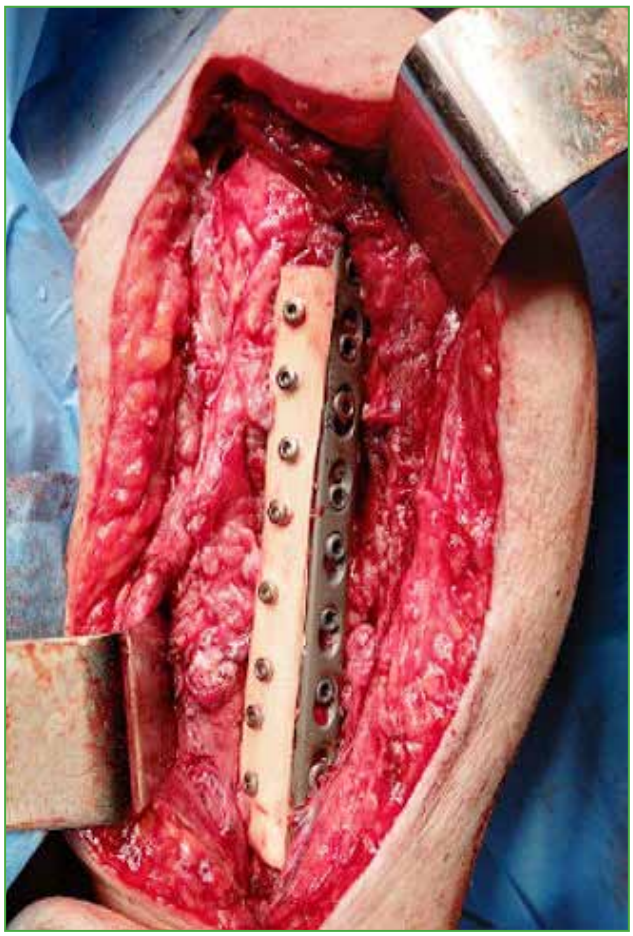

Figure 4. Onlay 90-90° technique. The arrangement of the DCP plate and the structural allograft is observed, which is fixed to the bone with 4.5 mm screws.

In defects <5 cm in length, structural humerus allograft (biological plate) struts of equal length to that of the osteosynthesis plate are used, fixed to the native bone by 3.5/4.5 mm compression screws placed anterior to 90° of the plate that is usually located on the lateral face acquiring a fixation system of 90°-90° ('Onlay 90°-90°'). In this way, a rigid and stable assembly is obtained that allows early range of motion, favors the incorporation of the allograft and prevents its reabsorption (Figure 4). At the native bone-structural allograft interface, a ground allograft is placed in the form of a 'canopy' (Figure 5) to generate greater osseointegration and fill the spaces that may remain at that interface. Figure 6 shows a schematic of the surgical technique when the defects measure <5 cm.

Figure 5. Canopy preparation: arrangement of the ground allograft within the structural allograft in the form of a 'canopy'.

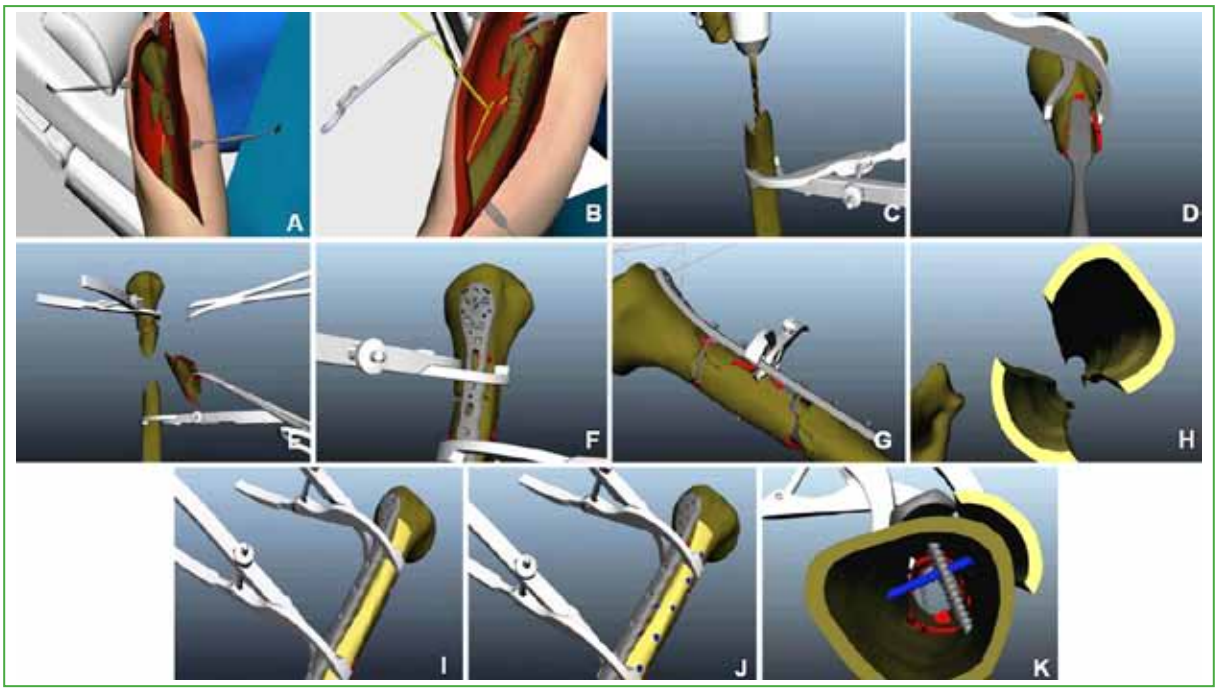

Figure 6. Scheme of the surgical technique. Bone stock deficit <5 cm. 90-90° Technique. **A.** Exposure of the nonunion focus. **B.** Nerve identification. **C.** Treatment of the nonunion focus. **D.** Multiple decortications. **E.** End regularization – Removal of devitalized tissues. **F.** Locking plate placement according to the segment to be treated. **G.** Fixation. **H.** Allograft preparation. **I.** Presentation of the preparation on native bone. **J.** Fixation of the allograft strut to the native bone using screws. **K.** 90°-90° arrangement of screws from an intramedullary view.

In defects >5 cm in length, a frozen non-irradiated humerus allograft is placed in structural intercalary or 'telescope' form to increase the rigidity of the assembly, associated with osteosynthesis in lateral compression of the same characteristics as those used for defects <5 cm and placement of ground allograft in an intramedullary way (Figure 7).

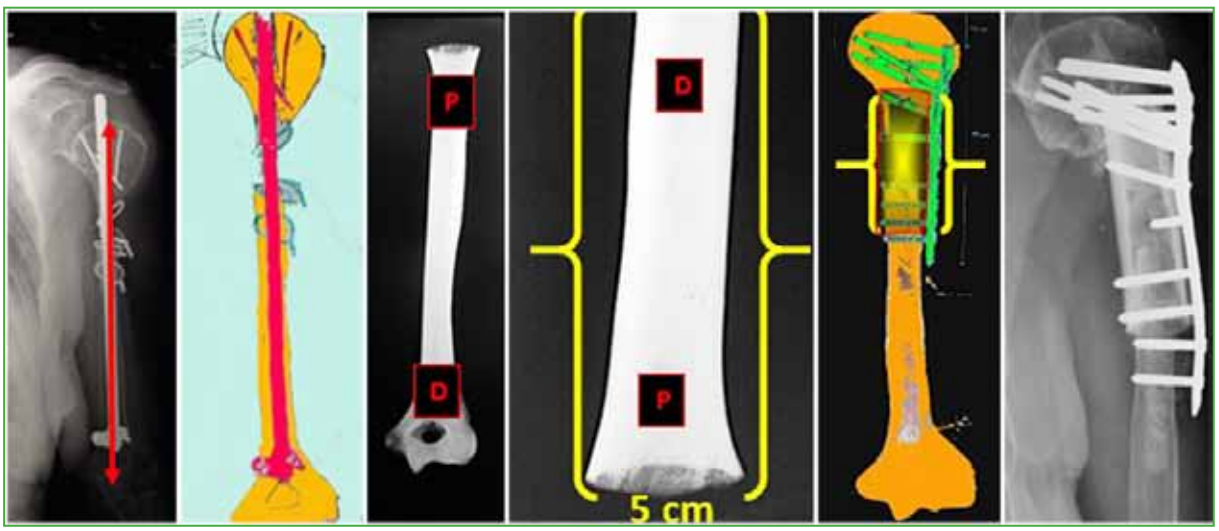

Figure 7. Scheme of the surgical technique. Bone stock deficit >5 cm. 90-90° Technique.

In both techniques, vancomycin 2 g powder is always added to the allograft.

If there is joint stiffness due to immobilization or previous surgeries (shoulder-elbow), an arthrolysis of the glenohumeral or distal joint is performed at the elbow level, a key step to achieve a normal distribution of forces and avoid overloads at the repair site.

Intradermal skin closure is performed, without drainage and usually without static immobilization.

Postoperative antibiotic prophylaxis is not administered.

Rehabilitation protocol

After one week, the protocol of assisted passive range of motion of the shoulder and elbow joint, and treatment of surgical scarring are initiated. From the third week onwards, active range of motion and increased muscle toning exercises are indicated, the exercises should have a progressive controlled load until corroborating the osseointegration by CT scan with metal suppression.

RESULTS

At the last evaluation, 32 of the 33 patients (97%) treated with this technique had complete consolidation; six (18.18%) had been treated with intercalary graft in the 'telescope' form and 27 (81.81%), by allograft strut; in one case, partial consolidation was achieved that did not require a new procedure, because the patient had no symptoms (Table 2).

The period of consolidation observed on CT scan for the presence of bridges of bone trabeculae across the focus of nonunion was 4.6 months (range 4-9). The time required for complete allograft osseointegration is even longer and is around 8.1 months on average (range 7-11) (Figure 8). The average follow-up was 33.2 months (minimum 12, maximum 75).

In two cases, platelet-rich plasma was used as an adjuvant. One was intercalary and the other 'Onlay 90°-90°'. This method was chosen due to the poor bone quality of the region of the humerus near the focus of consolidation and the number of previous surgeries (more than 7). There was no difference from treatment without platelet-rich plasma in terms of consolidation times, although we believe it is an additional biological contribution.

Patients with more rapid consolidation had fewer previous surgeries (<2), no history of infections and fewer or no comorbidities (<3 risk factors [Table 1]).

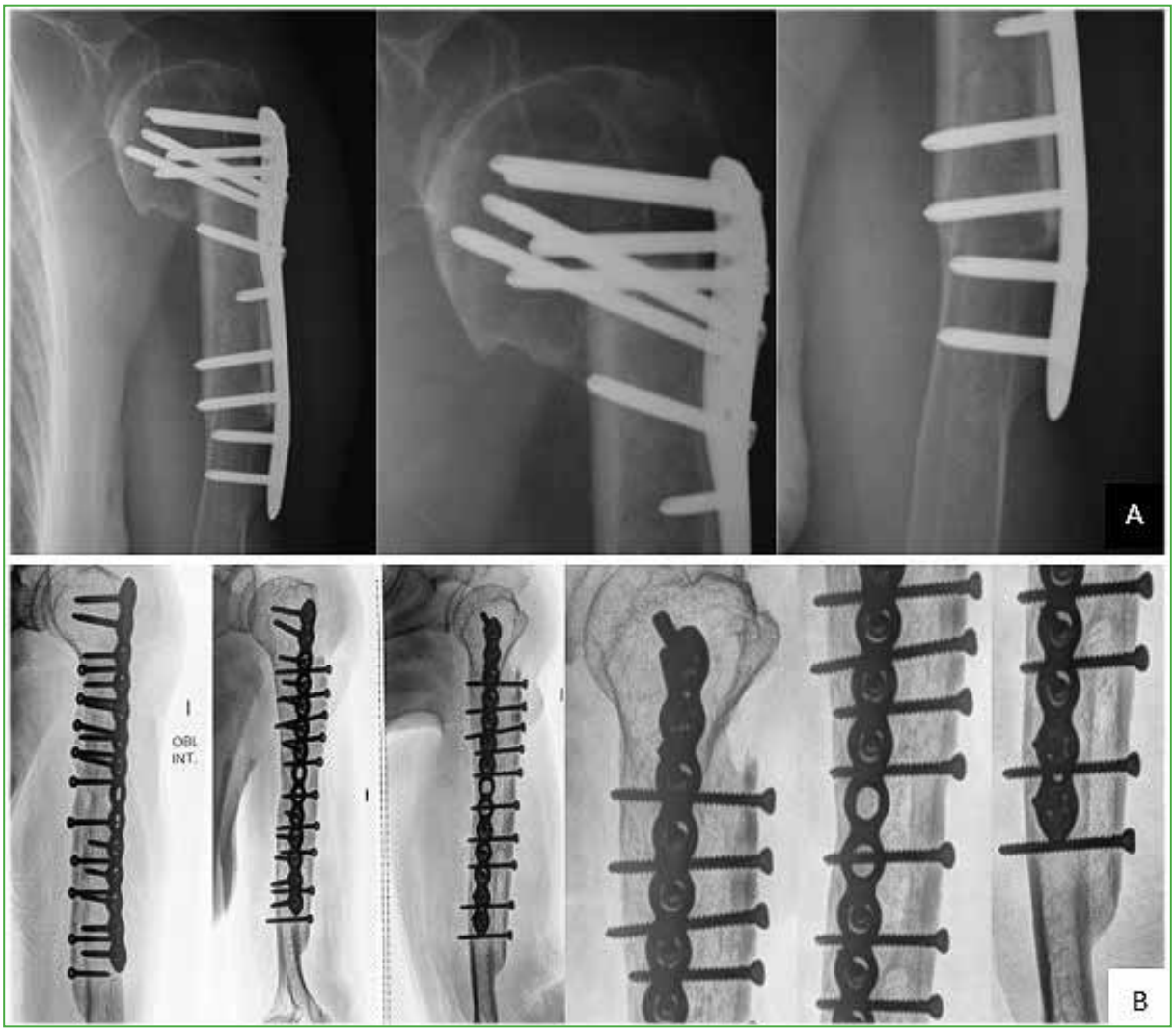

Figure 8. Postoperative control a year after surgery. **A.** Telescope technique for defects >5 cm. **B.** Onlay 90°-90° technique. In both cases, consolidation of the nonunion and complete allograft osseointegration are observed.

Shoulder arthrolysis was performed in seven cases (6 in the proximal humerus and the remaining in the diaphyseal location) and elbow arthrolysis was performed in four cases (distal humerus), no post-surgical infections or radial nerve palsy were recorded. Three patients had suffered a previous infectious condition treated with surgical debridement and intravenous antibiotics. In no case was resection of more than 1 cm of nonunion focus necessary. One patient required a second intervention for material breakage ("Onlay 90°-90°" technique) after a fall from his own height, two months after surgery. The material was removed and a new osteosynthesis was performed with the same reconstruction technique and the final consolidation occurred after nine months. There were no major complications, such as deep or superficial infection, loosening of osteosynthesis material or nerve lesions (radial paralysis), reabsorption or allograft fracture, with any of the aforementioned techniques. As negative outcomes, we must mention the aesthetic defect in some patients, which is directly proportional to the number of previous surgeries but has no impact on interpersonal life; the transient postoperative pain referred to the volume of the implant, which disappears after the ninth month of rehabilitation; and the postoperative hematoma, which may appear with the consequent increased risk of infection if a thorough hemostasis is not performed.

Visual analog scale (VAS), ASES score, Constant-Murley scale and elbow arcs of motion were considered for the functional assessment (Table 4).

Table 4. Preoperative and postoperative clinical evaluation

Clinical evaluation						
	Before surgery	1 month post-op	3 months post-op	6 months post-op	9 months post-op	12 months post-op
VAS	Min.: 7 Max.: 10 Mean: 8.7.	Min.: 3 Max.: 8 Mean: 5.2.	Min.: 2 Max.: 6 Mean: 4.1	Min.: 1 Max.: 5 Mean: 2.2.	Min.: 1 Max.: 3 Mean: 1.3.	Min.: 1 Max.: 3 Mean: 0.9
ASES	Min.: 7 Max.: 15 Mean: 12.3.	Min.: 11 Max.: 19 Mean: 17.1.	Min.: 16 Max.: 23 Mean: 20.2.	Min.: 20 Max.: 25 Mean: 22.5.	Min.: 22 Max.: 27 Mean: 25.4.	Min.: 24 Max.: 30 Mean: 27.1
Clinical evaluation one year after surgery						
Constant-Murley Scale	Excellent: 14 (42.4%)		Good: 13 (39.4%)		Fair: 6 (18.2%)	
Elbow functionality	10-130° 22 patients (66.6%)	15-130° 5 patients (15.1%)	20-115° 3 patients (9%)	30-115°: 2 patients (6%)	40-105°: 1 patient (3%)	

VAS = visual analog scale; ASES = American Shoulder and Elbow Surgeons Score.

According to the VAS, the average preoperative score was 8.7 (range 7-10). One month after the operation, it was 5.2 (range 3-8); at six months, 2.2 (range 1-5); and at 12 months, 0.9 (range 1-3).

Regarding the ASES score, only the patient-reported section was used. The average score was 12.3 (range 7-15) before surgery; 17.1 (range 11-19) after the first month; 22.5 (range 20-25) at 6 months; and 27.1 (range 24-30) after a year.

The postoperative evaluation of shoulder function according to the Constant-Murley scale was performed after one year and yielded the following results: excellent (14 patients; 42.4%), good (13 cases; 39.3%) and fair (6 cases; 18.1%) (Figure 9).

Regarding elbow function, the range of motion was also evaluated at one year, and the results were: 10-130° (22 patients; 66.6%), 15-130° (5 cases; 15.1%), 20-115° (3 cases; 9%), 30-115° (2 cases; 6%) and 40-105° (1 case; 3%).

The poorer outcomes were obtained in those patients whose focus of nonunion was closer to the joint (shoulder/elbow), and when the evolution time was >4 years, with extensive soft tissue compromise or previous infectious process.

Figure 9. Functional evaluation.

DISCUSSION

Even among experienced surgeons, the treatment of recalcitrant pseudarthrosis of the humerus remains an obstacle and an unsolved challenge. The personal history, the time of disease evolution, and the condition of the soft tissue and bone quality as a result of previous surgeries or disuse make preoperative planning and surgical technique difficult, and the results unpredictable, resulting in a not insignificant rate of complications.

Stable internal fixation and autologous bone grafting remains, for many, the gold standard procedure for the management of humeral nonunion with satisfactory outcomes in terms of consolidation. Its use is not without complications or morbidity, especially from the donor area when grafting is performed in large numbers; in addition, some of these patients require hospitalization to control pain.

At the same time, the allograft has been shown to be useful as a structural and biological contribution, especially advantageous if there are large bone defects, avoiding the morbidity of the donor zone, [20,21] but with possible risks of infection or reabsorption.

Several authors have described the use of autologous and heterologous grafting in the treatment of humerus nonunion with very good outcomes.

Garbayo Marturet et al. presented five patients >65 years with diaphyseal nonunion of the humerus of more than 18 months of evolution, treated with LCP locking plates, decortication, and ground allograft or autograft, with a 100% consolidation rate. They define recalcitrant nonunion as a major bone defect caused by implant mobilization, a biological factor significantly altered by the loss of vascular supply as a result of multiple in-

terventions, and a functional loss characterized by joint stiffness and muscle and tendon alterations, similar to the Giannoudis diamond concept, regardless of the time since nonunion or the number of previous operations.[22]

Campochiaro et al. added the use of platelet-rich plasma to the treatment of nonunion using LCP locking plates and structural allograft, treating nine patients and achieving complete consolidation in an average of seven months.[23]

Gogus et al. use structural bone allograft for complex primary fractures of the humerus and femur in patients with osteopenia (mostly elderly) and describe it as a novel idea.[24] Unlike in this study, stabilization is performed in parallel. We believe that the "Onlay 90°-90°" arrangement gives more rigidity and better mounting for fixing.

Van Houwelingen et al. treated six patients with a technique similar to one of our suggestions (structural allograft plus rigid osteosynthesis), with the exception that the graft was fixed with plate screws as a 180° 'sandwich' (lateral plate plus medial structural allograft) with 100% consolidation in an average of three months.[9] The difficulty of this technique lies in the placement of the allograft at the level of the medial face of the humerus, since the humeral artery and vein, and the median and ulnar nerves run through this zone. Also, as already mentioned, the parallel placement and not at 90° could be less rigid in certain circumstances.

In a series of 10 patients with humeral diaphyseal nonunion treated similarly to Van Houwelingen, Hornicek et al. obtained a 100% consolidation rate at three months, except for one case at six months, and established that cortical allograft struts provided the structural support and osteoinduction to improve healing of fracture nonunion.[25]

Marinelli et al. treated 57 patients with diaphyseal nonunion of the humerus using locking plates associated with structural allograft with 93% consolidation. The comparison of the success rates of the various bone fixation techniques is limited by the fact that, in the relatively few published studies, the series are small and heterogeneous; in addition, the highly variable clinical and radiographic presentation of nonunion (mobile-rigid, atrophic-hypertrophic), surgical difficulties (osteoporosis, maintenance of bone stock, presence of fixation devices, shortage of soft tissue and previous scarring) and comorbidities (smoking, alcoholism and obesity) prevent comparison of the different series.[26]

The association between the use of a special osteosynthesis material for the humerus (Phylos® type plate for the proximal extremity, LC-DCP for the diaphysis and anatomical for the lower end of the humerus), added to the structured bone allograft, either in the form of a bone strut or intercalary telescope, fixed with screws, considerably increases the mechanical stability, this allows an early range of motion, and acts as an osteoinductive and osteoconductive scaffold, helping to reconstruct bone defects and eliminate the increases in tension in the osteosynthesis material that could lead to a failure in the case of a native bone of poor bone quality, and thus has a more even distribution of loads.

The stable internal fixation and lack of irradiation of the bank allograft used in the processing not only prevent reabsorption, but also favor the integration usually observed in our casuistry eight months after the operation. We have not observed infections or rejections in treated patients, but reports of a low rate of disease transmission have been published, and would therefore be one of the weaknesses of using this type of biological input, although we think that this variable has a direct relationship with the quality of processing of the tissue bank. We think that the addition of vancomycin as perioperative prophylaxis along with allograft placement could explain this result in addition to what has already been mentioned. Although levels of consolidation are high with the technique used, functional outcomes vary depending on the location of nonunion, they are poorer the closer it is to the joint, especially the glenohumeral. Despite this, patients have marked symptom relief, the VAS score drops significantly and they resume independence for daily living tasks.

Recalcitrant nonunion of the humerus usually occurs at the diaphyseal level.[8,16,19,22] There are several risk factors that predispose patients to this type of condition, some of them more preponderant than others. In most cases, it is due to incorrect management of conservative treatment or defects in the surgical technique used in the management of the initial fracture added to the type of patient to be treated. It is critical to consider the 'hexagon rule,' which is extremely useful for preoperative planning since it allows for the consideration of aspects that could lead surgical rescues to fail in the approach of this entity.

We present a new surgical technique of biological reconstruction with frozen non-irradiated allograft that has achieved encouraging outcomes, which could address the adverse scenario represented by recalcitrant humeral nonunion.

Like other authors,[21] we observed that younger patients have a lower consolidation time rate than older patients. Another advantage of allograft use is the possibility of doing it on an outpatient basis. 87.8% of our cases were done under this modality, with immediate monitoring the next day of the procedure. This could be considered an advantage of the method as it reduces hospitalization time and costs, and the possibility of resolution in times such as the recent SARS-CoV-2 pandemic. The use of locking plates in the treatment of this condition is of vital importance, because many cases of nonunion present with poor bone quality, as well as the use of structural allograft that provides additional rigid support.

As strengths of the study, we believe that our sample size is considerable in relation to the prevalence of the disease treated. The results in terms of consolidation and postoperative function are encouraging. The technique proposed in its two modalities is reproducible and offers certain advantages, such as avoiding the morbidity of the patient's own grafting and, in this way, being able to carry out the procedure on an outpatient basis and thus have the possibility of reducing hospitalization costs. In addition, the rigidity of the assembly obtained in the nonunion focus allows to quickly recover the mobility of the limb and thus improve the quality of life of patients, especially those who have been immobilized for more than a year.

On the other hand, it is important to mention that the study has certain weaknesses, such as its retrospective nature, without a control group of patients treated as standard and with a heterogeneous sample, although we think that, due to its frequency, it is difficult to find published comparative studies.

CONCLUSIONS

We present a new technique to treat the difficult and unusual recalcitrant nonunion of the humerus using a non-irradiated frozen structured allograft of the homolateral humerus, by means of two forms of assembly, according to the defect to be treated, associated with a rigid and stable internal osteosynthesis.

In our experience, the addition of ground allograft when using a 'strut' ('canopy technique') in the 'Onlay 90°-90°' configuration or in the 'telescope' form has allowed us to obtain a high rate of osseointegration and, therefore, consolidation, with a rate of excellent and good outcomes in 81.7% of patients. When the location was close to either the glenohumeral or elbow joint, the outcomes were poorer.

The 'hexagon rule' provides relevant information that assists the surgeon in preoperative planning, and that could explain the rate of good outcomes achieved combined with a refined surgical technique.

Conflict of interest: The authors declare no conflicts of interest.

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Surgical Treatment in Maresca Type A2 Bifocal Humeral Fractures

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ABSTRACT
Bifocal humeral fractures are infrequent injuries, and fractures involving the proximal and diaphyseal humerus are even rarer. We present four patients with bifocal humeral fractures of the Maresca type A2 classification. We detail the surgical plan, technical pearls, and functional outcomes.
Keywords: Bifocal fractures; humerus fractures; surgical treatment.
Level of Evidence: IV

Tratamiento quirúrgico para fracturas bifocales de húmero tipo Maresca A2

RESUMEN
Las fracturas bifocales de húmero son lesiones infrecuentes, más aun las que ocurren asociadas con fracturas en el húmero proximal y diafisario. Presentamos a cuatro pacientes con fracturas bifocales de húmero proximal y diafisario (Maresca A2), la planificación quirúrgica, los detalles técnicos y sus resultados funcionales.
Palabras clave: Fracturas bifocales; fracturas de húmero; tratamiento quirúrgico.
Nivel de Evidencia: IV

INTRODUCTION

Humerus fractures are injuries that any orthopedist treats frequently. Experience and indications are extensive for fractures of either the proximal end, diaphysis or distal end.[1] However, bifocal or multifocal fractures of the upper limb are very rare, accounting for 4.8% of humerus fractures. Fractures specifically involving the proximal humerus and diaphysis are even less frequent (0.4%).[2]

There is no consensus on the ideal method of stabilization of bifocal humerus fractures and, as they are infrequent, only isolated case series have been published.[1,2]

The aim of this article is to describe the surgical planning, technical details and functional outcomes in four adult patients operated on for bifocal humerus fractures type A2 of the Maresca classification, with the goal of optimizing healing in a functional position with early rehabilitation; a literature review on the injury is also provided.

MATERIALS AND METHODS

A retrospective series of four consecutive adult patients with bifocal fractures of the humerus, operated on at two highly complex medical centers by surgeons with experience[3] in the surgical treatment of upper limb pathology, was evaluated. The descriptive AO[4] classification was used for each fracture pattern, and the Maresca[1] classification was used for bifocal humerus fractures (Table).

Surgery was the treatment of choice due to marked instability in all cases, with open reduction and internal fixation with plates and screws (3 cases) or intramedullary nail (1 case).

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Table. Classification of bifocal fractures of the humerus (Maresca)

Type	Description		
A	Proximal humerus + diaphysis	Subtypes	
		1	Nondisplaced proximal fracture + displaced diaphysis
		2	Displaced proximal fracture + displaced diaphysis
		3	Proximal fracture with extension to diaphysis
B	Diaphysis		
C	Diaphysis + distal humerus		

Surgical technique

Plates with screws

Patient in beach chair position and under regional anesthesia; in three of the four cases, open reduction and internal fixation with an anatomic extra-long proximal humerus plate and screws, with a screw diameter of 3.5 mm, was planned.

A double approach was performed. The first was an anterolateral shoulder mini-approach in the intramuscular plane between the anterior and middle deltoid, always stopping proximal to the axillary nerve safe zone 6 cm from the anterolateral edge of the acromion.[5] The second was a distal lateral approach between the triceps muscle bellies and the brachialis muscle with careful management of the radial nerve. This is followed by radial nerve neurolysis and reduction of the diaphyseal fracture site using a distal approach with forceps. According to the pattern, absolute stability is provided to the distal focus (Case 3). The length of the implant is selected according to the radiographic planning. The extra-long proximal humerus plate is introduced from the proximal mini-approach in the submuscular plane, through the deltoid, respecting the safe zone. The plate is slid across both fractures. Provisional proximal and distal pins are placed to corroborate correct implant placement and provide temporary stability. This is followed by the indirect reduction and screw placement in the holes proximal and distal from the plate to the proximal fracture. Finally, the distal focus is fixed with the plate providing a mixed fracture stability system (Figure 1).

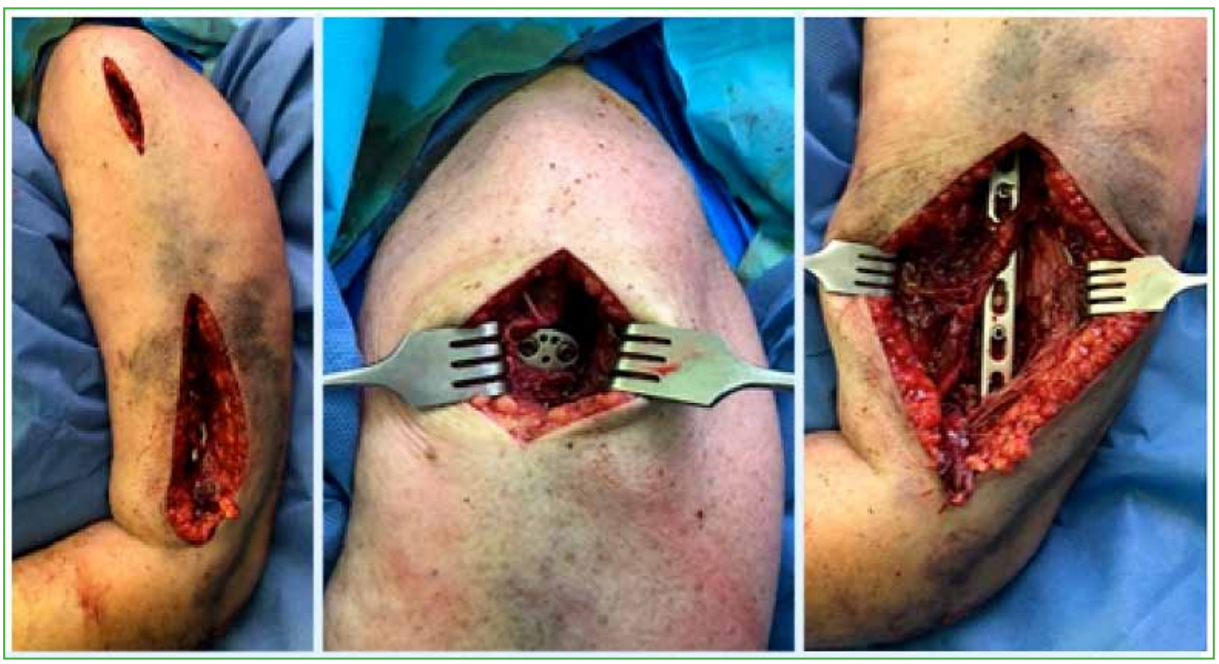

Figure 1. Surgical details.

Intramedullary nail

Under radioscopic control, a 2.5 mm diameter pin was placed at the level of the humeral head and transverse to the shaft of the diaphysis, to control the axes as a *joystick*. An anterolateral mini-approach is performed on the shoulder. This is followed by dissection of the deltoid and supraspinatus or remnants. The anterograde nail is inserted according to the traditional technique. It can be used in association with the pin described above as a *joystick* for reduction and stabilization of the proximal focus. The distal focus is reduced and stabilized with traction and external maneuvers according to the usual technique.

Postoperative controls were performed 7, 15 and 30 days after surgery. Except for one patient who was lost to follow-up at the fifth month, patients were examined once a month until consolidation and then once a year for remote clinical follow-up.

Clinical and radiological parameters[6] were used to verify fracture healing, as well as the Constant-Murley score[7] to assess function. The usual complications related to the surgical procedure (infection, radial palsy, omalgia) were investigated.

RESULTS

Four bifocal humerus fractures were documented in adult patients from 2018 to 2021 at two high-complexity medical centers. These were type A2 fractures of the Maresca classification, with involvement of the proximal humerus and diaphysis. All four patients underwent surgery and the clinical and radiological outcomes were favorable.

CLINICAL CASE 1

A 70-year-old woman with bifocal fracture of the left humerus, Maresca type A2, 11B2 and 12A1 of the AO[4] classification (Figure 2); trauma of three days of evolution. Based on the clinical-radiological picture, open reduction and internal fixation were indicated. The technique previously described was performed.

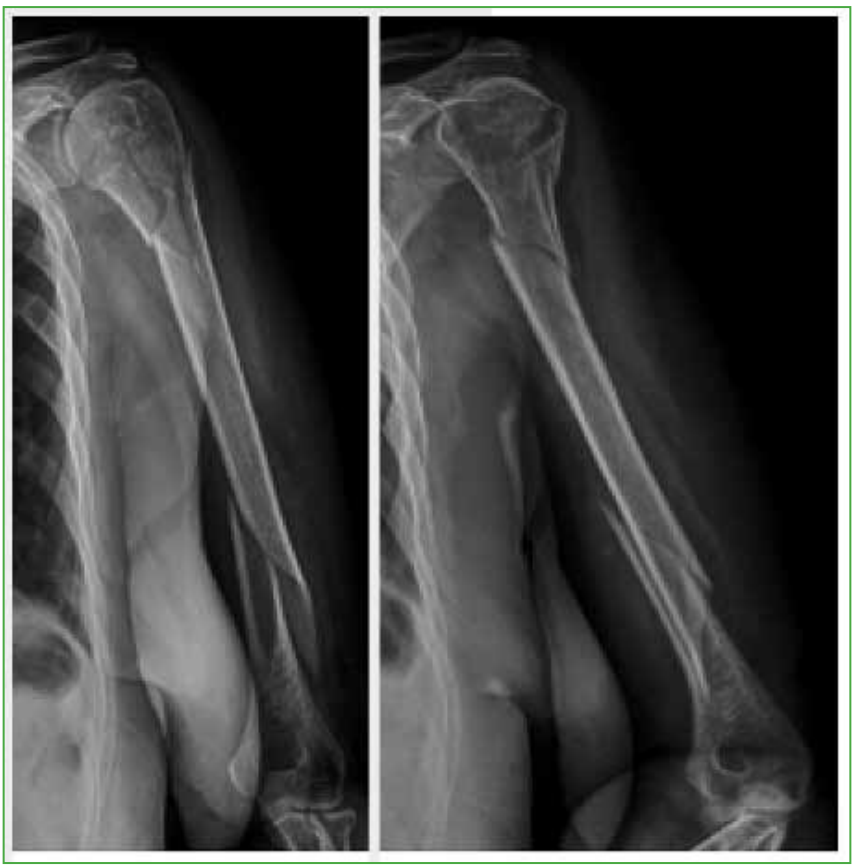

Figure 2. Fracture 11B2 and 12A1 of the AO classification.

At the control two years after surgery, both fractures were found to have healed, with complete restoration of range of motion, without pain or weakness of the limb. The functional score on the Constant-Murley scale was 91. The described complications were not observed (Figure 3).

Figure 3. Radiographs and clinical outcomes two years after surgery.

CLINICAL CASE 2

A 68-year-old woman with bifocal fracture of the right humerus Maresca type A2, 11A1 and 12A2 of the AO[4] classification (Figure 4); trauma of six days of evolution. Surgery was indicated with the same detailed surgical tactics.

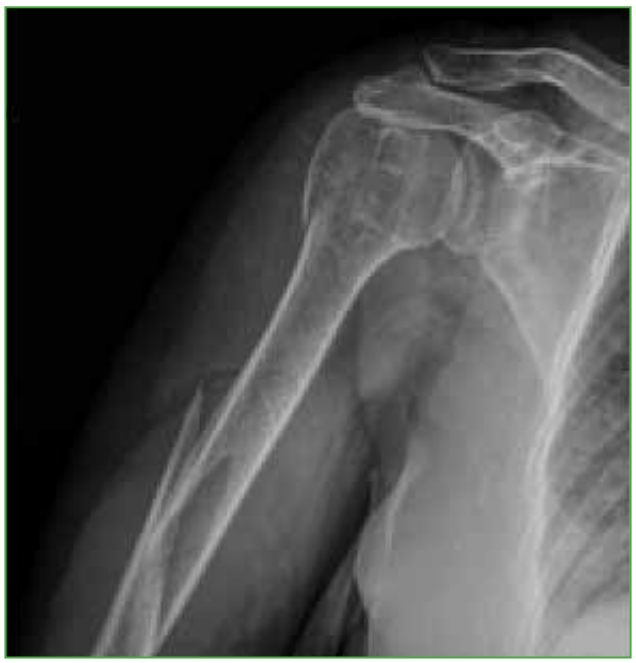

Figure 4. Fracture 11A1 and 12A2 of the AO classification.

Clinical-radiological consolidation was reached at five weeks. At the 1-year distant control, functional restoration of the limb was verified with a functional score on the Constant-Murley scale of 85. No complications were observed (Figure 5).

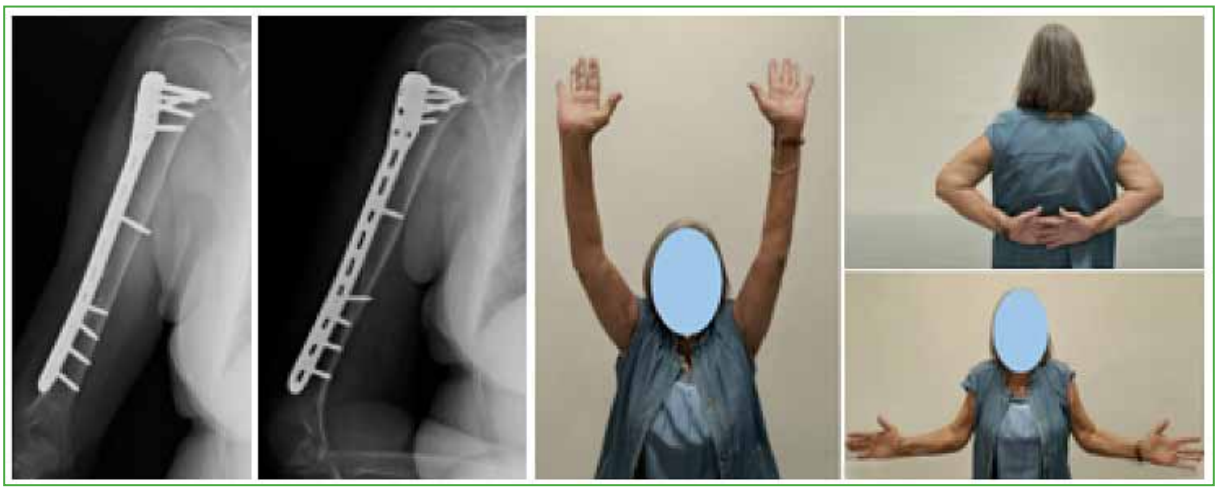

Figure 5. Radiographs and clinical outcomes two years after surgery.

CLINICAL CASE 3

A 71-year-old woman, with bifocal fracture of the right humerus Maresca type A2, 11A2 and 12A1 of the AO[4] classification (Figure 6); trauma with one month of evolution. The surgical tactics described above were followed.

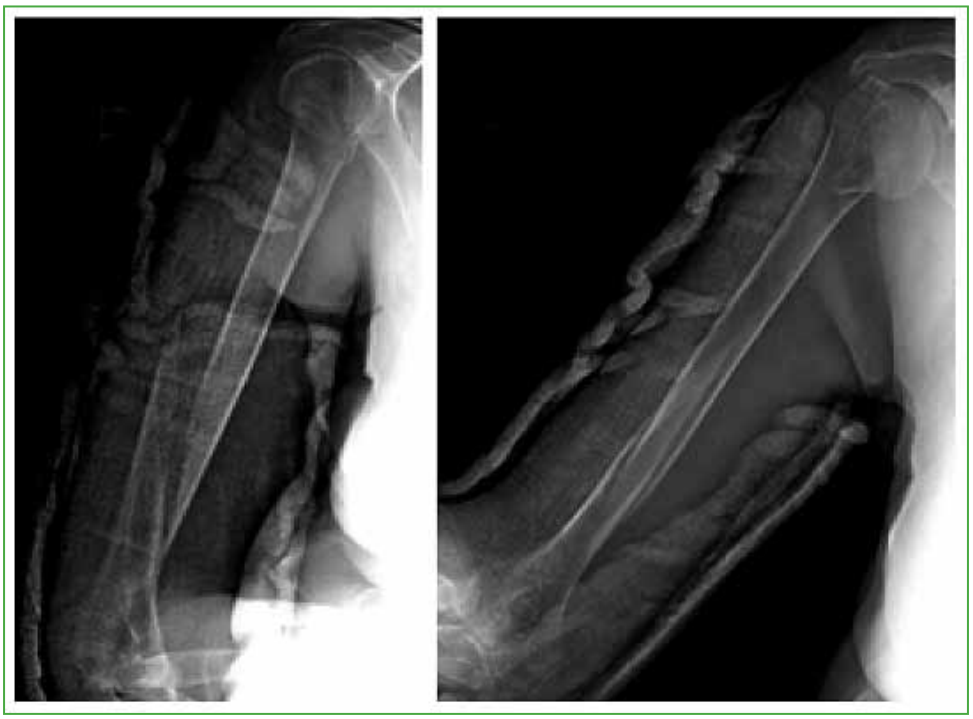

Figure 6. Fracture 11A2 and 12A1 of the AO classification.

As a valuable technical detail, the provisional reduction and stabilization of the distal trace was performed with extra-strength wires (Fiberwire®) using the Nice point[8] for blocking (Figure 7), definitively synthesizing the focus with two transfracture screws and with the extra-long plate of the proximal humerus as a bridge as in the previous cases.

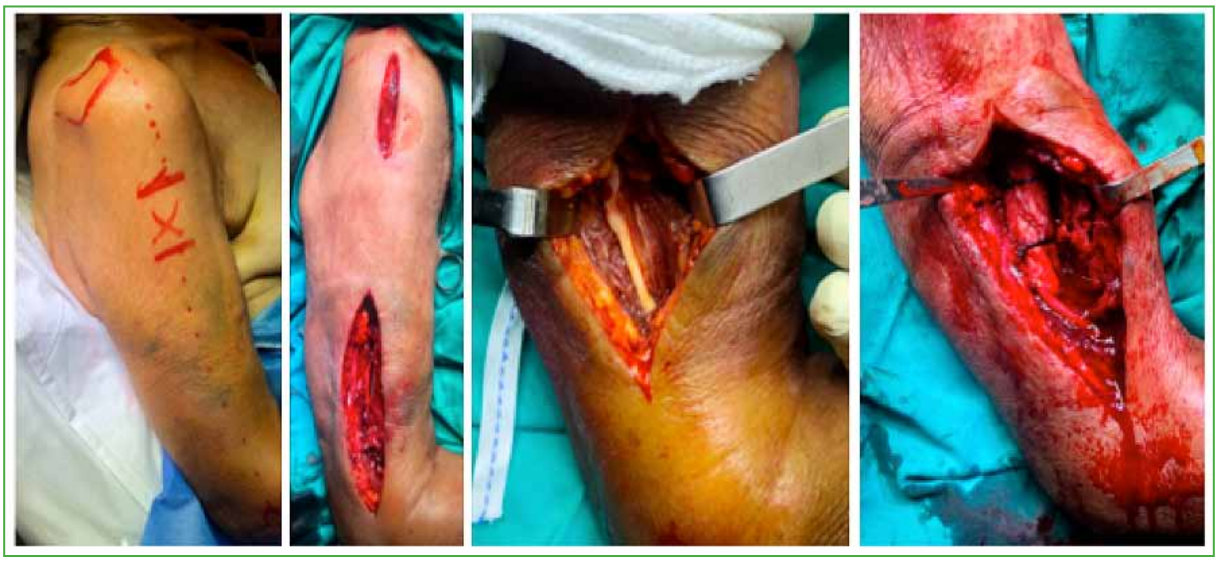

Figure 7. Surgical details.

The result four months postoperatively was satisfactory with fracture healing, no pain and a Constant-Murley functional (provisional) score of 50 (Figure 8). It was not possible to locate the patient at the controls after the fifth month for a final functional evaluation.

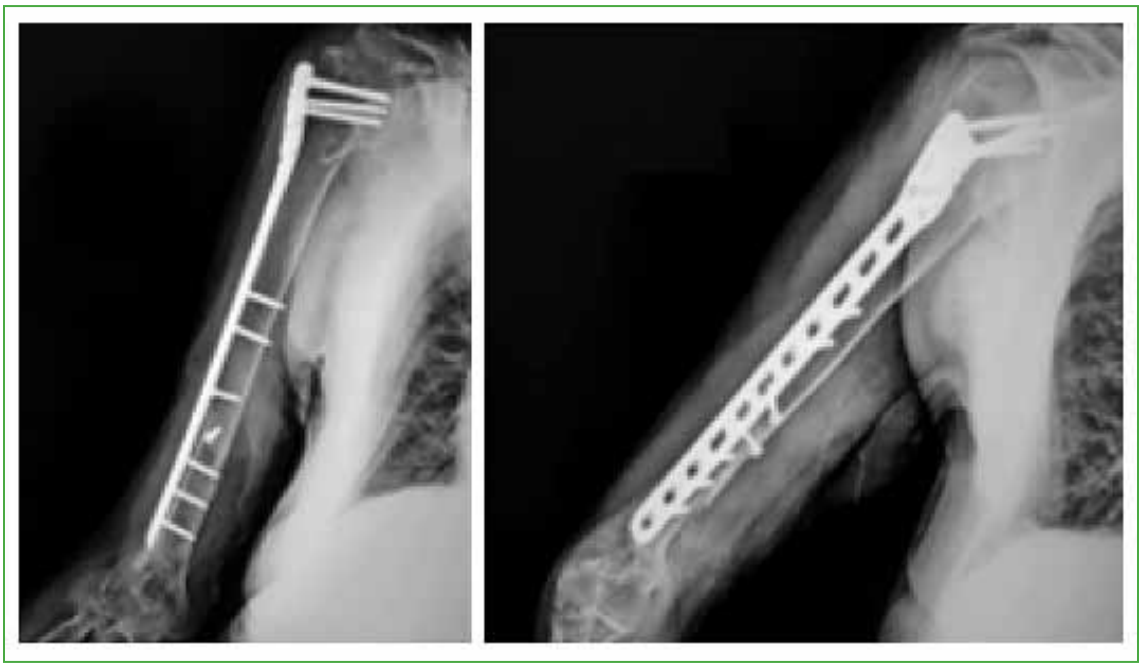

Figure 8. Radiographs four months after surgery.

CLINICAL CASE 4

A 96-year-old man, active and independent. Radiographs showed a bifocal fracture of the right humerus Maresca type A2, 11A3 and 12B1 of the AO[4] classification (Figure 9).

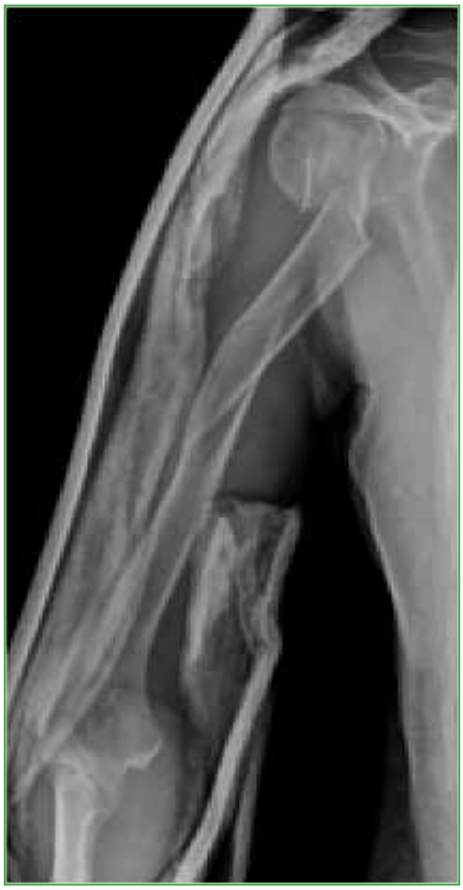

Figure 9. Fracture 11A3 and 12B1 of the AO classification.

Given the functional demands of the patient, which were unrelated to his chronological age, mini-invasive surgery with intramedullary nailing was chosen to relieve pain and improve the functionality of the limb.

Surgical details: With the patient in the beach chair position and under regional anesthesia, an anterograde anchored intramedullary nail (Polarus Acumed^{R}) was placed using an anterolateral mini-approach, joining both fractures. The restoration of the axis, the contact between fragments and the relative stability of the traces was achieved.

The immediate evolution was good; fracture consolidation was verified at three months. The patient was performing activities of daily living three years after the intervention, with a Constant-Murley score of 65, and no early or distant complications (Figure 10).

Figure 10. Radiographic and clinical control three years after surgery.

DISCUSSION

Bifocal fractures of the humerus are very rare. Broadbent et al. found only seven cases of bifocal humerus fractures in 13,560 fractures recorded over eight years in patients >13 years of age. Four of them corresponded to the association of the proximal humerus and diaphysis; two, to the proximal and distal humerus, and one, to the diaphysis and distal humerus.[2]

In 2014, Maresca found 35 bifocal humerus fractures out of 717 which had been surgically treated (4.8%). In a case series, the author developed a descriptive classification for bifocal or multifocal fractures of the humerus that is still the only one available. Thus, he divided them into three types: A, fractures involving the proximal humerus and diaphysis; B, fractures in the humeral diaphysis; and C, fractures of the diaphysis associated with the distal humerus.[1] Type A was further divided into three subgroups: 1, nondisplaced fractures of the proximal humerus associated with displaced fractures of the diaphysis; 2, displaced fractures of the proximal humerus and diaphysis; and 3, multifragmentary fractures of the proximal humerus with extension to the diaphysis. In his series of 35 patients, all fractures were type A, and the most frequent group was subgroup 1 (20 cases), and group 2 was very infrequent (3 cases).[1]

The four cases in our study belonged to type A, subgroup 2.

When planning the treatment of this type and group of fractures, we are faced with the controversy that sometimes some fractures are associated with indications for surgical and non-surgical treatment, and secondly, it is possible that the method of surgical stabilization of one of the fractures does not resolve the other.

Regarding the first situation, we consider it advisable to be guided by the treatment of the more complex fracture, stabilizing both fractures to allow early mobilization of the limb. In the case of the second, the ideal stabilization should include both fractures avoiding a zone of mechanical stress between the implants with a risk of refracture.

Published surgical options generally include the use of the anterograde intramedullary nail or plate with screws for isolated proximal humerus or diaphyseal humerus fractures.[9,10]

However, the method of choice for bifocal fractures of this type and group is still debated. The advantage of the intramedullary nail is that its placement requires less soft tissue dissection when compared to plate osteosynthesis, and it allows both fractures to be joined with very little dissection. However, omalgia related to nail insertion through the supraspinatus is a known complication. The benefits of the use of plates and screws or nails on the rate of consolidation have been discussed.[11-16]

Plates with screws allow stabilization of both fractures with an anatomical reduction and use of bone graft, if necessary. In addition, through the same approach, the radial nerve can be explored if a neural lesion is suspected. However, it leads to opening of the fracture hematoma, deperiostization and a theoretical increase in the infection rate due to exposure. The introduction of the MIPO (minimally invasive plate osteosynthesis) technique conceptually decreases these complications.[17]

In 2008, Levy et al. published the results of treatment of a long segmental (bifocal) humerus fracture stabilized with a 4.5 mm straight plate using two approaches and submuscular gliding, with excellent outcomes.[18]

Meanwhile, in 2018, Toulopakis et al. published a series of 11 patients with multifocal fractures of the proximal humerus with diaphyseal extension treated with extra-long anatomic proximal humerus plates and MIPO technique. It should be clarified that, in this series, there were no type A2 fractures (published in our series), and their cases represent diaphyseal extensions of fractures of the proximal humerus. Consolidation was achieved in all patients and the complications were four radial nerve neuropraxias.[19]

In 2010, Garnavos and Lasanianos reported the outcomes of 18 patients with fractures of the proximal humerus extended or combined to the humeral diaphysis, treated with locking intramedullary nails. In this series, eight corresponded to Maresca type A2 and consolidation was achieved in all of them with good functional outcomes.[20]

In our series of Maresca type A2 fractures, due to the lack of consensus guidelines and the scarce published literature, we customized surgical tactics according to the clinical characteristics and functional demand of each patient.

However, as a guideline, we rely on opening the distal fracture site prioritizing absolute reduction and stabilization of the main fracture line, adding an anterolateral mini shoulder approach to allow an anterograde submuscular sliding of an anatomic extra-long proximal humerus screw plate. In this way, we achieve firm stabilization of the distal line with a more elastic stabilization of the proximal line. We only modified the technique in one case due to the advanced age of the patient, and with the objective of reducing the surgical and anesthetic risk.

When deciding on open reduction and stabilization with plate and screws, it is essential to recognize and carefully repair the radial nerve in the distal approach and to recognize the axillary nerve passing through the deep epimysium of the deltoid 6 cm from the acromion for its protection.

In the four cases presented, the fracture healed, on average, within eight weeks. Patients returned to their activities without functional limitations and limb range of motion was restored at the time of the remote control (Constant-Murley >65 in all cases). One of the patients did not continue with the follow-up, which prevented evaluation of the final functional outcome.

CONCLUSIONS

We do not have a sufficient number of cases to reach relevant conclusions. However, we have observed that, for bifocal humerus fractures with involvement of the proximal humerus and diaphysis (Maresca type A2), surgery with extra-long proximal humerus plates and screws using a double approach, as well as the use of the anterograde intramedullary nail for an elderly patient or with a higher surgical risk, achieved fracture healing in all cases. The patients had a good overall functional outcome and returned to their usual pre-trauma activities.

Conflicts of interest: The authors declare no conflicts of interest.

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Subjective Evaluation of Subclavicular Hypoesthesia After Open Reduction and Internal Fixation of Clavicle Fractures

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ABSTRACT

Introduction: Clavicle fractures account for 4% of adult fractures, with mid-shaft fractures accounting for 80%. Although surgical treatment reduces the risk of pseudarthrosis, malunion, and residual pain, it is not without complications such as regional hypoesthesia (12-29%). **Objective:** To determine the prevalence of subclavicular hypoesthesia following open reduction and internal fixation for clavicle fracture, as well as if and how it impacts the patient's quality of life. **Materials and Methods:** A prospective cross-sectional analytical study of patients with displaced clavicle midshaft fractures treated with ORIF between 2018-2021 was performed. The research team used a questionnaire with six items that were completed anonymously. The presence of infraclavicular hypoesthesia, regional pain, and daily life interference was assessed. **Results:** Twenty-nine patients treated surgically with a longitudinal approach and with a minimum postoperative follow-up of one year were evaluated. Twenty-two patients (76%) had altered sensitivity, whereas seven (24%) denied the existence of the symptom. In 97% of individuals with subclavicular hypoesthesia, quality of life was impaired minimally or not at all. **Conclusions:** Before undergoing surgery, it is important to inform the patient about the risk of cutaneous numbness as a postoperative consequence due to its high frequency but improbable impact on daily activities.

Keywords: Clavicle fracture; internal fixation; numbness; supraclavicular nerve.
Level of Evidence: IV

Evaluación subjetiva de la hipoestesia subclavicular luego de una reducción abierta y fijación interna de fracturas de clavícula

RESUMEN

Introducción: Las fracturas de clavícula representan el 4% de las fracturas del adulto; el 80% son mediodiafisarias. Se ha demostrado que el tratamiento quirúrgico disminuye el riesgo de seudoartrosis, consolidación viciosa y dolor residual, aunque no está exento de complicaciones, como la hipoestesia regional (12-29%), entre otras. **Objetivo:** Evaluar la incidencia de hipoestesia subclavicular luego de una reducción abierta y fijación interna para una fractura de clavícula, si afecta la calidad de vida del paciente y cómo la afecta. **Materiales y Métodos:** Se realizó un estudio transversal analítico prospectivo de pacientes con una fractura mediodiafisaria desplazada de clavícula tratados con reducción abierta y fijación interna entre 2018 y 2021. Se utilizó un cuestionario elaborado por el equipo, que consistió en 6 preguntas para responder de forma anónima. Se evaluó la presencia de hipoestesia infraclavicular, dolor regional y afectación de la vida cotidiana. **Resultados:** Se evaluó a 29 pacientes con un seguimiento posoperatorio mínimo de un año, operados mediante un abordaje longitudinal. Veintidós (76%) tenían alteración de la sensibilidad y siete (24%) negaron este síntoma. La hipoestesia subclavicular afectó la calidad de vida de manera leve o nula del 97% de los pacientes con hipoestesia subclavicular. **Conclusión:** Es importante advertirle al paciente antes de la cirugía sobre la posibilidad de hipoestesia cutánea como complicación posoperatoria, debido a su alta frecuencia, aunque es poco probable que dicha complicación afecte la calidad de vida.

Palabras clave: Fractura de clavícula; fijación interna; hipoestesia cutánea; nervio supraclavicular.
Nivel de Evidencia: IV

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INTRODUCTION

Clavicle fractures account for 4% of adult fractures and 44% of shoulder region fractures, and represent one of the most common bone injuries in young adults.[1] They are classified, according to Allman, into three types according to their location: 80% are fractures of the middle third of the clavicle (Allman type 1).[2] The injury mechanism is usually indirect trauma after a fall on the shoulder, and is common in contact sports and road traffic accidents.

For years, the treatment of choice has been conservative; however, in the last decade, surgery has been shown to decrease the risk of pseudarthrosis, malunion, residual pain and achieve better short-term functional rates, allowing the patient an early return to work.[3] However, surgery causes complications and one of the most frequent is regional hypoesthesia (12-29% incidence).[3,4]

The objective of this study was to evaluate the incidence of subclavicular hypoesthesia after open reduction and internal fixation (ORIF) for a clavicle fracture using an anterior superior longitudinal approach, whether it affects the patient's quality of life and how it affects it.

MATERIALS AND METHODS

A prospective analytical cross-sectional study of patients with a mid-shaft clavicle fracture treated with ORIF by the same team of hospital surgeons was conducted between January 1, 2018 and June 30, 2021.

The inclusion criteria were: 1) age >16 years, 2) Allman type 1 fractures with >100% displacement of clavicle width or shortening >1.5 cm, 3) postoperative follow-up of at least one year, 4) ORIF with plates and screws.

The exclusion criteria were: 1) open fractures, 2) fractures with neurovascular injury on admission, 3) refractures, 4) floating shoulder, 5) loss of follow-up within one year of surgery.

Surgical technique

Antibiotic prophylaxis with 1 g of cephalexin was administered intravenously 30 min before the skin incision. Surgery was performed with the patient under general anesthesia and regional block, in the beach chair position. Antisepsis of the corresponding hemithorax and upper limb was performed with povidone-iodine. The sterile drapes were placed according to the surgical technique. A longitudinal approach was performed on the corresponding clavicle. Resection by planes, repair and identification of the superficial cervical plexus branches were performed. If the cutaneous branch interfered with reduction or plate placement, it was cauterized and severed (Figure 1).

The fracture was identified and anatomical reduction and osteosynthesis were performed. Subsequently, radioscopic monitoring, wound washing and layered closure were performed.

Patients who met the inclusion criteria were contacted via WhatsApp or phone call. The purpose of the contact was explained and each patient was requested to verbally consent to participate in the study. A questionnaire was sent using the QuestionPro application and patients answered all six questions anonymously (Appendix). During the follow-up of the first postoperative year, the presence of infraclavicular hypoesthesia, its impact on activities of daily living, and the presence of psychological effects and pain were assessed.

RESULTS

After applying the inclusion and exclusion criteria, 29 patients formed the study group. Twenty-seven were male (93%) and two were female (7%). The average age was 39.8 years (range 19-63).

Twenty-two (76%) reported having regional hypoesthesia and seven (24%) denied having this symptom. This finding is noteworthy because, according to published studies, regional hypoesthesia affects 12-29% of patients.

Three of the 22 patients with altered sensation reported hyperesthesia of the surgical wound site, with no associated pain.

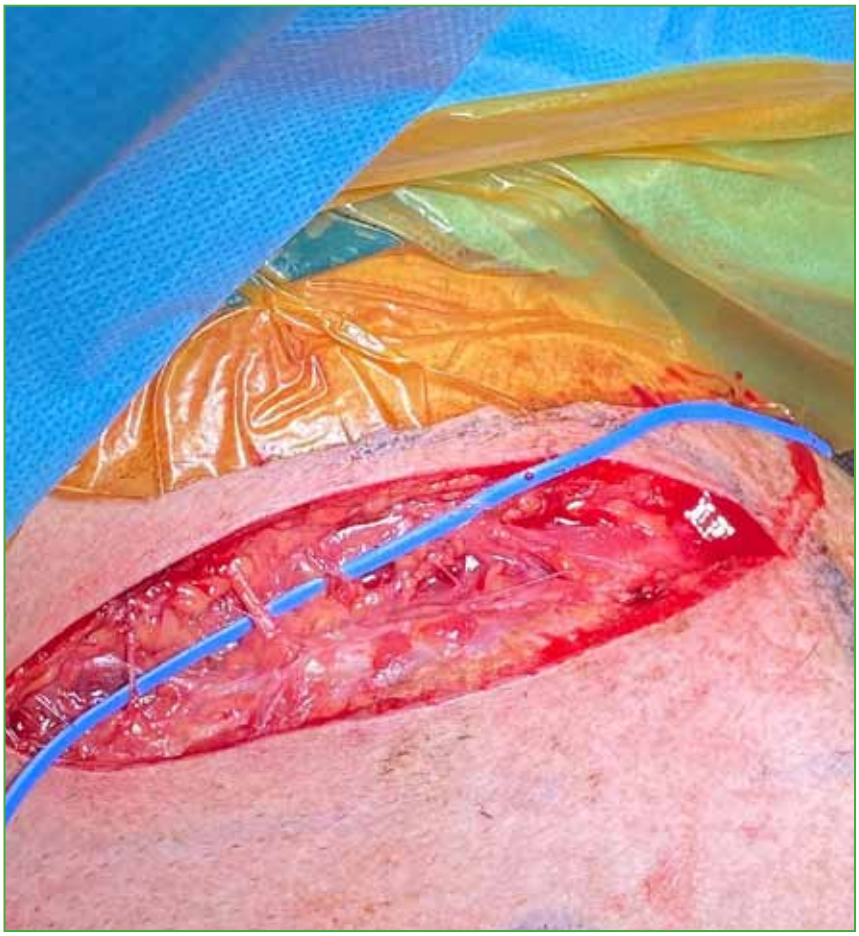

Figure 1. Illustration of the supraclavicular nerve with its superficial sensory branches.

Figure 2 shows the severity of hypoesthesia after the first year of surgery.

Twenty-four patients (83%) reported no discomfort due to hypoesthesia during their daily activities; four (14%) reported a mild grade and only one (3%) a moderate grade.

Regarding the evolution of hypoesthesia during the first year of rehabilitation, 13 patients (45%) reported no improvement. On the other hand, two (7%) reported excellent outcomes after the first year of rehabilitation, while the remaining 14 (48%) reported a slight improvement.

Only four (14%) experienced psychological effects and pain in the surgical wound region during the postoperative period.

DISCUSSION

The incidence of clavicle fractures is high in young adults and their surgical treatment with plate and screw ORIF achieves good outcomes with high success rates and low complication rates.[5] Regional hypoesthesia is one of the most frequent complications due to injury to the superficial sensory branches of the supraclavicular nerve.[2,6] This complication has not been taken into account for many years and is an important factor to discuss with the patient before the operation.

The supraclavicular nerve is a sensitive cutaneous nerve that originates from the C3-C4 nerve roots of the superficial cervical plexus. Its innervation zone includes the anteromedial region of the shoulder and the proximal region of the chest under the clavicle. The nerve divides into two branches, one medial and one lateral, and may occasionally present a third intermediate branch. The medial branch crosses the medial third of the clavicle and the lateral branch crosses the lateral third, each divided into 2-3 superficial branches (Figure 3).[7]

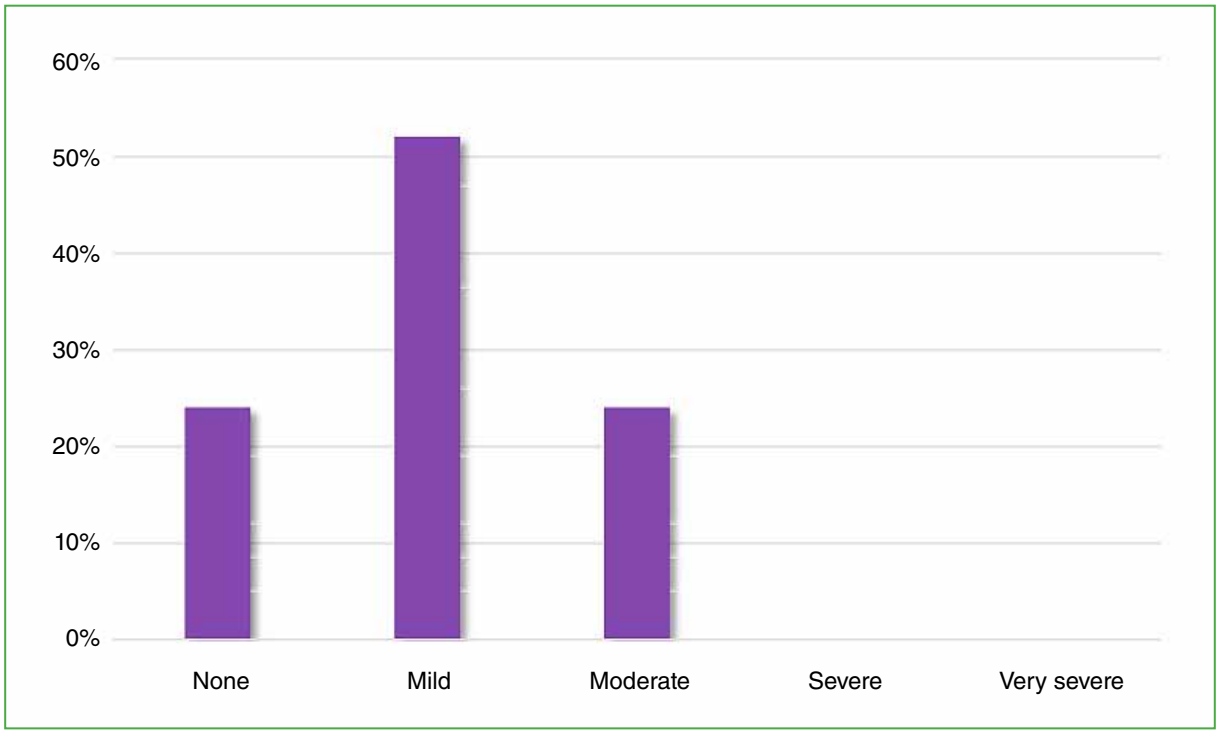

Figure 2. Severity of hypoesthesia after the first year of surgery.

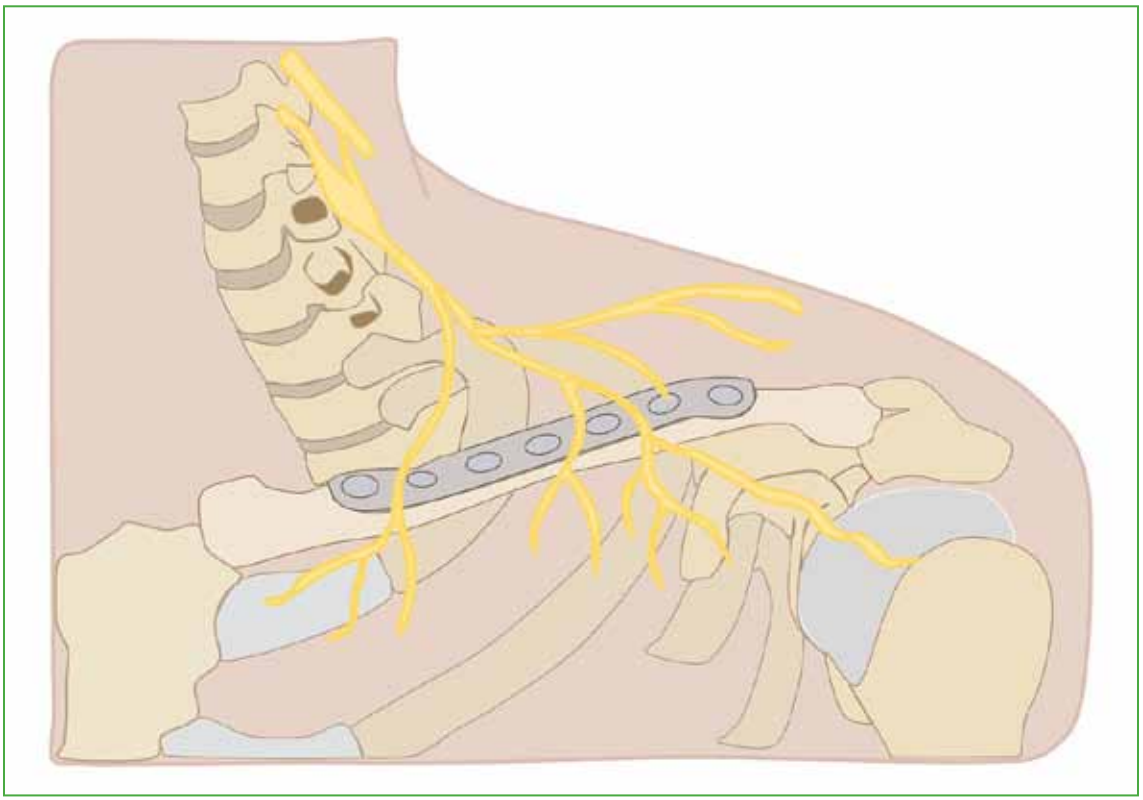

Figure 3. Supraclavicular nerve and its branches.

Two main approaches have been described for the surgery of clavicle fractures with plates and screws: one longitudinal and one vertical (Figure 4). In our institution, the longitudinal approach that runs over the anterosuperior edge of the clavicle is used. Such an approach may compromise the superficial sensory branches of the supraclavicular nerve, generating regional hypoesthesia if severed. They can be preserved and better identified using microsurgery loupes. Repair and care of these sensitive branches may require a longer surgical time and therefore more exposure time with the risk of infection and surgical discomfort for the surgeon when performing reduction and osteosynthesis.[4,8,9]

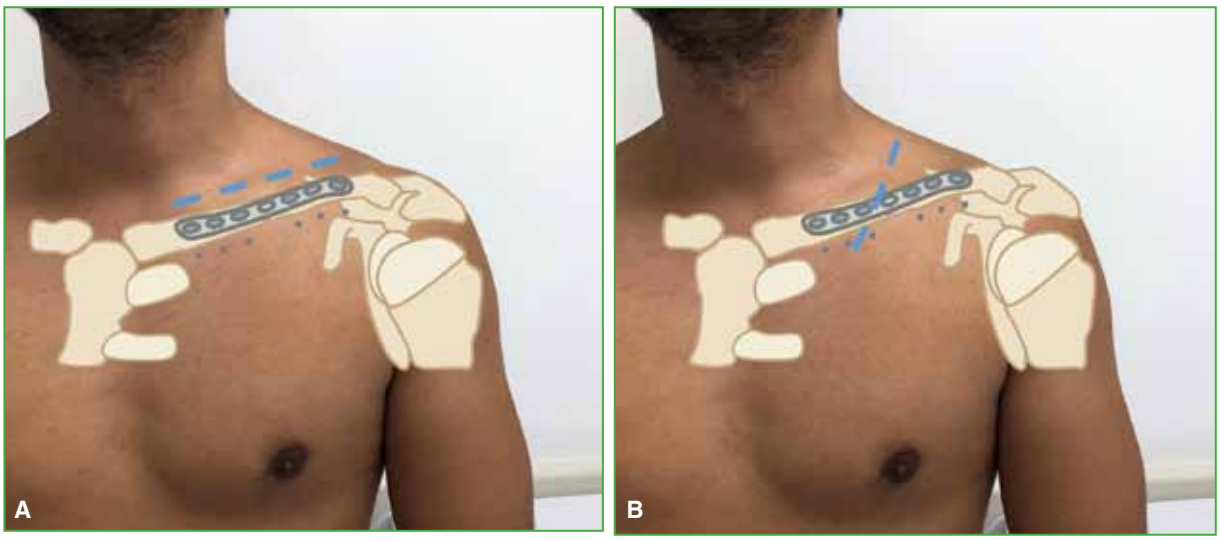

Figure 4. A. Longitudinal approach. **B.** Oblique approach.

Minimally invasive surgery has recently been described as a successful surgical technique for mid-shaft clavicle fractures, which allows for the reduction of complications associated with the open approach. It involves making small approaches away from the fracture focus that cause less bleeding and dissection, thus decreasing the risk of injury to supraclavicular nerves.[10]

There are few comparative studies between the minimally invasive technique and ORIF. So far, no significant differences have been found in radiological and functional outcomes, or in consolidation time.[10,11] However, the minimally invasive technique causes a lower rate of surgical wound complications and especially a lower rate of regional hypoesthesia.[11,12]

Studies comparing the longitudinal to the oblique or vertical approach were conducted in the literature.[3,5] The vertical or oblique approach avoids compromising the sensory branches of the supraclavicular nerve; however, it may cause more discomfort for the surgeon, it exposes less of the clavicular fracture and has similar long-term functional outcomes to the longitudinal method. According to published studies, there is no statistically significant difference in complications in both groups of patients. It has been concluded that patients felt more satisfied with the aesthetic results of the longitudinal approach.[5]

Iatrogenic neuromas are a rare complication of clavicle fractures. Injury to the cutaneous branches of the supraclavicular nerve or compression with osteosynthesis material or a fracture callus can generate pain and hyperesthesia in and around the scar region. In such a case, a surgical examination and nerve decompression or stellate ganglion block should be performed as a technique of choice.[8,13]

In this study, only 13% of patients felt pain in the wound area and 10% reported hyperesthesia, but none reported that these symptoms interfered with their daily activities or generated a psychological condition.

According to our findings, hypoesthesia is a frequent complication in the postoperative period of clavicle fractures treated with a longitudinal approach, however, it does not appear to impact quality of life. 97% of patients reported no discomfort or mild discomfort during daily activities. On the other hand, this alteration of sensation is more severe during the first months after surgery and, with the course of rehabilitation, the improvement is progressive. 76% of our patients reported a decrease in the severity of hypoesthesia after the first year.

The limitation of our study was the relatively low number of cases. This was a retrospective study in which patients provided a subjective opinion without an objective assessment of regional hypoesthesia; an objective regional examination should include neurophysiological and instrumental studies beyond the scope of our research. However, we believe that the patient's opinion and satisfaction largely reflect the success or failure of the outcome.

CONCLUSIONS

Injury to the supraclavicular nerve or its branches is a common complication during internal fixation of clavicle fractures. According to our results, 76% of patients had regional hypoesthesia that decreased over months and did not influence their daily activities or affect them psychologically. However, it is important to discuss the possibility of this complication before surgery to avoid the patient's affliction.

Given that complications or discomfort from regional hypoesthesia do not affect the quality of life of patients operated on using a longitudinal approach, the surgeon should operate comfortably and use the approach with which they have more experience and can perform the best reduction and desired osteosynthesis.

APPENDIX. Questionnaire sent to the patients

1. Do you have altered sensitivity in the region of the operated clavicle?

☐ Yes.

☐ No.

2. Degree of severity of hypoesthesia one-year after surgery.

☐ 1: None.

☐ 2: Mild.

☐ 3: Moderate.

☐ 4: Severe.

☐ 5: Very severe.

3. Do you have discomfort in your daily activities due to hypoesthesia?

☐ 1: None.

☐ 2: Mild.

☐ 3: Moderate.

☐ 4: Severe.

☐ 5: Very severe.

4. Were there improvements in hypoesthesia throughout rehabilitation?

- ☐ 1: None.
- ☐ 2: Mild.
- ☐ 3: Moderate.
- ☐ 4: Severe.
- ☐ 5: Very severe.

5. Have you experienced psychological effects due to regional hypoesthesia?

- ☐ 1: None.
- ☐ 2: Mild.
- ☐ 3: Moderate.
- ☐ 4: Severe.
- ☐ 5: Very severe.

6. Do you have pain in the scar or wound area?

- ☐ 1: None.
- ☐ 2: Mild.
- ☐ 3: Moderate.
- ☐ 4: Severe.
- ☐ 5: Very severe.

Conflict of interest: The authors declare no conflicts of interest.

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Intraoperative Iatrogenic Injury of the Radial Nerve in Humerus Osteosynthesis

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ABSTRACT

Introduction: The purpose of this study is to determine the incidence of intraoperative iatrogenic radial nerve injury after osteosynthesis of the diaphysis and distal end of the humerus, identify associated risk factors, and determine the prognostic factors involved in its recovery. **Materials and Methods:** We retrospectively assessed 82 humerus osteosynthesis cases between 2005 and 2021 who had normal radial nerve function before surgery. We evaluated the fixation systems used, the type of surgery (primary versus revision), and the intervals between surgeries. The diagnosis of postoperative radial palsy was made by clinical examination. All patients were treated with wrist extension splint, physiotherapy, and vitamins B1, B6, and B12. **Results:** After humerus fixation, 9 patients developed motor palsy. Seven cases were fixed with plates, one with a cable-plate system, and one with an anterograde locking intramedullary nail. Seven cases (22%) occurred after primary procedures, while two occurred during revisions. Within 6 months, 88% had regained full motor function. In the remaining 22% of patients with definite palsy, electromyography revealed no excitability of the radial nerve. **Conclusions:** The use of an osteosynthesis plate, as well as intraoperative dissection and neu-rolysis of the radial nerve, were identified as risk factors for the development of radial palsy. Reoperations on the humerus, on the other hand, are a risk factor that increases the likelihood of postoperative radial nerve palsy. A radial nerve with no excitability on the postoperative electromyogram has a poor prognosis of spontaneous radial nerve function recovery.

Keywords: iatrogenic; radial nerve; humerus fracture
Level of Evidence: IV

Lesiones iatrogénicas del nervio radial en la osteosíntesis de la diáfisis humeral

RESUMEN

Introducción: Los objetivos de este estudio fueron determinar la incidencia de lesión iatrogénica intraquirúrgica del nervio radial durante la osteosíntesis de la diáfisis y el extremo distal del húmero, distinguir factores de riesgos asociados y reconocer ele-mentos pronósticos que participan de su recuperación. **Materiales y Métodos:** Se evaluaron, en forma retrospectiva, 82 osteo-síntesis de húmero entre 2005 y 2021, sin parálisis radial preoperatoria. Se consideraron los sistemas de fijación utilizados, y se compararon las cirugías primarias con las reoperaciones y el tiempo transcurrido entre estas. El diagnóstico de parálisis radial posoperatorio fue clínico. Todos los pacientes fueron tratados con férula en extensión de muñeca, electroestimulación, kinesio-logía y vitaminas B1, B6, B12. La electromiografía se solicitó a los fines del pronóstico. **Resultados:** Nueve pacientes tuvieron déficit motor del nervio radial en el posoperatorio inmediato. El sistema de fijación era una placa (7 casos), sistema de cable-placa (1 caso) y clavo endomedular acerrojado anterógrado (1 caso). Siete ocurrieron en cirugías primarias y dos en reoperaciones. El 88% recuperó su función motora completamente antes de los 6 meses después de la parálisis. La electromiografía reveló un nervio radial no excitable en el 22% restante con parálisis definitiva. **Conclusiones:** El uso de placa de osteosíntesis, la disección intraoperatoria del nervio radial y las reoperaciones aumentan la incidencia de parálisis. Un nervio radial no excitable se relaciona con un peor pronóstico de recuperación espontánea.

Palabras clave: Iatrogenia; nervio radial; fractura de húmero.
Nivel de Evidencia: IV

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INTRODUCTION

As indications for surgical treatment of both fractures and pseudarthrosis of the humerus increase, cases of postsurgical iatrogenic paralysis are becoming more frequent. The incidence of post-surgical radial nerve palsy has been reported to be 5.1%.[1]

Radial nerve injuries in humerus fractures are very disabling for performing activities of daily living. Once established, recovery either by conservative treatment or surgery takes no less than six months.[2]

There is still no consensus on how to approach the treatment of these complications given the diverse responsiveness of the nerve. The multiplicity of implants available today, the large number of techniques for fracture reduction and pseudarthrosis correction, as well as the different approach routes determine that the approach to iatrogenic radial nerve injury is also very dissimilar.

Causes of iatrogenic radial nerve palsy include manipulative trauma during fracture surgery (Figure 1), impingement of the nerve by fragments of the fracture itself, entrapment by the fracture callus, and scar tissue formation.[3]

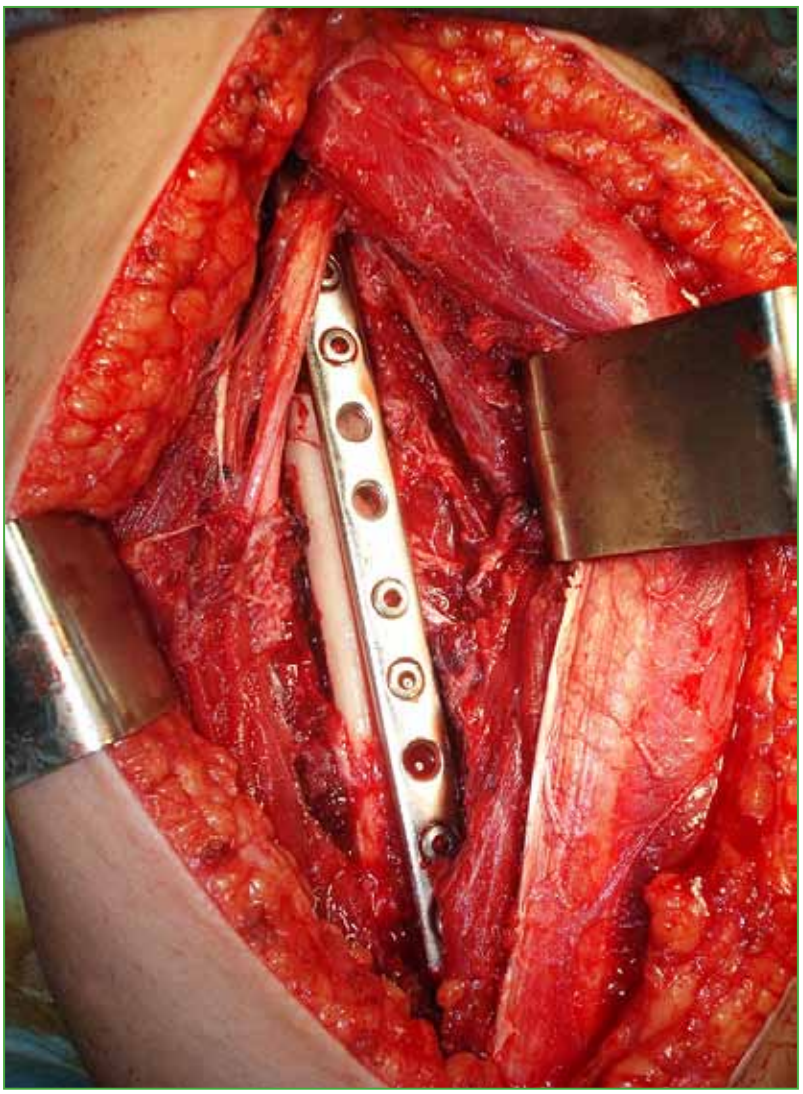

Figure 1. Relationship of the radial nerve with the straight plate on the posterior aspect of the humerus. Treatment of a diaphyseal fracture of the humerus.

The aim of this study was to determine the incidence of intraoperative iatrogenic radial nerve injury in osteosynthesis of the humeral shaft, to distinguish associated risk factors and to recognize the prognostic elements involved in its recovery.

MATERIALS AND METHODS

We retrospectively evaluated 82 osteosyntheses of the humeral diaphysis performed by the same surgeon in 74 adults (mean age 47 years; range 19-89) between June 2005 and March 2023.

Inclusion criteria were: reduction and osteosynthesis of the humerus diaphysis in adults without previous motor injury to the radial nerve. Pediatric patients and those with previous motor injury to the radial nerve were excluded.

The diagnoses were: acute traumatic fractures (63 cases), loosening of the osteosynthesis within 4 months after primary surgery (3 cases), nonunion (14 cases), pathological fracture (1 case) and humerus malunion (1 case).

Traumatic fractures were classified according to the AO classification system.

Twenty-eight acute traumatic fractures corresponded to group A; 27 to group B and eight to group C. In the case of the pathological fracture, the anatomic pathology analysis showed breast cancer metastasis. The malunion had an imbalance of 28° antecurvatum and 18° varus.

The fixation systems used were: plates with screws (57 cases), intramedullary nails (21 cases), spacer with antibiotic cement (2 cases) and cable-plate system (2 cases). Nineteen of the 59 fractures fixed with plates had also been fixed with screws using an out-of-plate compression technique.

Three traumatic fractures were open. The degree of exposure according to Gustilo's classification was: Gustilo I (1 case), Gustilo II (1 case) and Gustilo IIIA (1 case).

The choice of surgical approach and implant was based on patient activity, arm volume and soft tissue status in each particular case.

No osteosynthesis protocol or approach was followed for a particular type of fracture. The wide age range of the patients, the diverse occupational factors, the wide range of surrounding soft tissue injuries, the different medical insurances, the diverse socioeconomic level and, therefore, the access to osteosynthesis elements determined a wide variety of surgical techniques and implants that were chosen by the treating physician according to each patient.

The approaches used for the cases fixed with plates and screws were: trans-tricipital (30 cases), paratricipital (3 cases), deltopectoral extended to the distal third of the arm (14 cases) and lateral MIPO (minimally invasive plate osteosynthesis) (9 cases).

The intramedullary nails were placed anterogradely (17 cases) and retrogradely (4 cases).

The radial nerve was dissected during surgery in 28 cases and there was no evidence of macroscopic injury. Twenty-one surgeries were reoperations (26%).

Radial nerve injury was diagnosed by physical examination when the patient was unable to voluntarily perform wrist and finger extension and thumb abduction (Figure 2).

All patients were prescribed a wrist extension splint (Figure 3), electrostimulation, passive range of motion of the wrist and fingers, and pharmacological treatment with vitamin B1, B6, and B12 tablets once a day for 30 days, as soon as the diagnosis was confirmed.

Until 2014, electromyography was not requested, as this study was only advised if the patient showed no evidence of motor recovery after the third month, which did not occur in the four cases at the time. From then on, it was routinely requested within month after the paralysis occurred. In the evaluation, muscle values of M4 or more of the muscles innervated by the radial nerve were taken as the recovery parameter.

RESULTS

Nine patients (11%) suffered radial nerve motor deficits in the immediate postoperative period after reversal of surgical anesthesia. Four were men and five were women, and the average age was 44 years (range 22-82). The median follow-up was 7.9 months (range 5-15).

The distribution of these nine cases of postoperative paralysis was: seven for primary surgeries (6 operated after acute fractures and 1 for malunion) and two for reoperations (1 for nonunion and 1 for loss of reduction of an acute fracture) (Figure 4). All nine patients reported hypoesthesia in the sensitive territory of the radial nerve.

Figure 2. Wrist drop. A characteristic sign of radial nerve palsy.

Figure 3. Thermoplastic splint for the rehabilitation of radial paralysis.

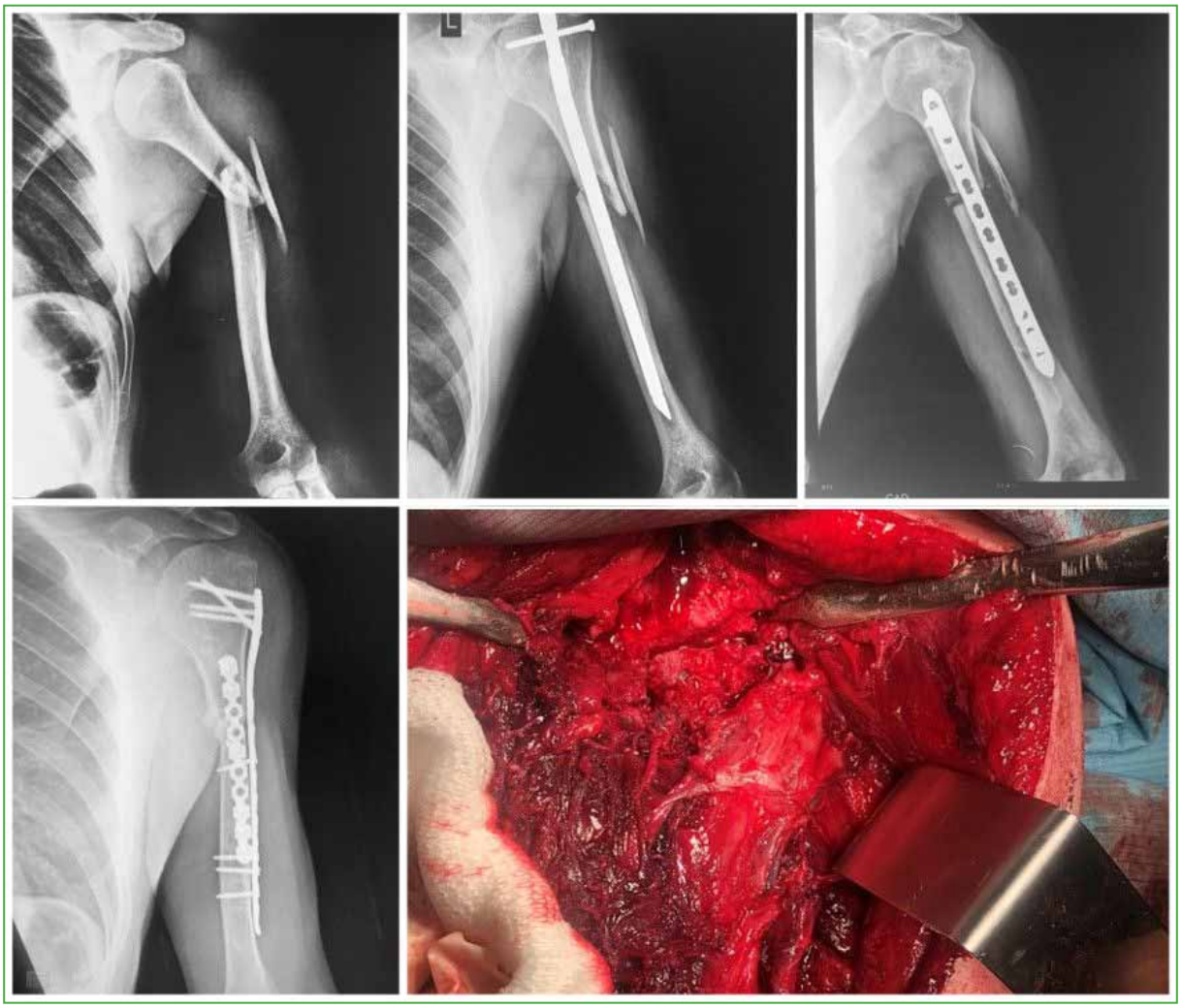

Figure 4. Fibrosis surrounding the radial nerve in a patient with recalcitrant pseudarthrosis of the humerus in whom three methods of osteosynthesis were performed.

As for the cases operated on for acute fractures, five plate osteosyntheses were performed: three with posterior approaches (2 paratricipital, 1 trans-tricipital) and two with mininvasive lateral approaches with an extra large proximal humerus regional locking plate. The remaining case was fixed by means of antegrade locked intramedullary nailing. In two of these patients, the screws were placed using the fragmentary compression technique, which requires greater traction on the soft tissues surrounding the humerus.

Nonunion and malunion occurred after osteosynthesis with a straight plate and a trans-tricipital approach.

On the other hand, in the patient with paralysis after revision osteosynthesis, an extended deltopectoral approach had been performed through the anterolateral aspect of the arm between the anterior and posterior compartments.

The only open fracture without preoperative radial nerve injury and radial nerve palsy after osteosynthesis was a transverse single-pattern diaphyseal fracture, Gustilo and Anderson type 1 (Table 1).

Table 1. Patients diagnosed with iatrogenic radial nerve injury.

Case	Diagnosis	Osteosynthesis used	Approach	Reoperation
1	Malunion	Straight 3.5 mm DCP plate	Trans-tricipital	No
2	Fracture	Extra-long proximal regional plate	Lateral MIPO	No
3	Fracture	Extra-long proximal regional plate	Lateral MIPO	No
4	Open fracture	Regional distal humerus plates	Trans-tricipital	No
5	Fracture	Intramedullary nail	Anterograde	No
6	Fracture	Plates + compression screw	Paratricipital	No
7	Reduction displacement	Cable-plate system	Expanded deltopectoral	Yes
8	Fracture	Plates + compression screw	Paratricipital	No
9	Infected pseudarthrosis	Straight 3.5 mm DCP plate	Trans-tricipital	Yes

MIPO (*minimally invasive plate osteosynthesis*).

Electromyography results one month after injury showed no radial nerve excitability in two cases and moderate radial nerve injury with partial reinnervation in the remaining four cases. Electromyography was not repeated when any of these patients showed any sign of motor recovery.

Four of the nine patients with postoperative paralysis had undergone primary surgery for radial nerve exploration and neurolysis, in which nerve indemnity was found (cases 2, 3, 8 and 9). These four patients recovered full motor and sensory function after electrostimulation treatment at 5, 3, 6 and 8 months, respectively (Table 2).

Table 2. Prognostic factors for recovery from iatrogenic radial nerve injury.

Patient	Intraoperative examination of the radial nerve	Electromyography	Recovery
1	No	No	Yes
2	No	No	Yes
3	Yes	No	Yes
4	No	Non-excitable radial nerve	No
5	No	Non-excitable radial nerve	No
6	No	Moderate radial nerve injury	Yes
7	No	Moderate radial nerve injury	Yes
8	Yes	Moderate radial nerve injury	Yes
9	Yes	Moderate radial nerve injury	Yes

The nine patients with iatrogenic radial nerve palsy were evaluated over a period of eight months (range 5-15). Seven recovered nerve function in an average of 6.5 months (range 3-9) by treatment with electrostimulation, joint mobility and vitamin B, with a value of M4 (6 cases) and M5 (1 case). Radial nerve exploration and neurolysis was not performed in any of the nine cases as treatment of postoperative paralysis.

Motor recovery began at 1.71 months (range 1-3). Two patients had no motor recovery at the time of follow-up. One underwent tendon transfers, but the other, who was already over the age of 80, declined such treatment.

DISCUSSION

At follow-up, 78% of iatrogenic radial nerve palsies reversed spontaneously. Plate osteosynthesis of the humerus diaphysis, intraoperative radial nerve neurolysis and reoperations represent a risk factor for the development of radial nerve motor palsy.

The radial groove is a crucial region of the radial nerve for the development of paralysis. In this segment, the nerve changes its location from posterior to lateral, makes intimate contact with the diaphysis of the humerus and the aponeurosis of the vastus lateralis, and thus decreases its elongation capacity. In this segment, the nerve is less mobile. Therefore, any elongation produced there will cause a sudden stretching of its neural sheath and its inner fascicles, thus producing, depending on the intensity, a greater or lesser interruption in the transmission of motor electrical impulses, which manifests itself in paralysis.[4]

Osteosynthesis of the humerus raises the risk of radial nerve injury, usually due to traction, but sometimes also due to pressure from a spacer, exposure or damage of a wick or the implant itself. The radial nerve is at risk in the middle third of the humerus with a posterior or lateral approach to the radius and in the distal third of the humerus with an anterolateral exposure. When the paralyzed radial nerve is anatomically intact, the chances of total restitution are high.[5]

In multiple studies, the rate of iatrogenic radial nerve palsy has been found to be higher with diaphyseal plate fixation compared to nail fixation.[5,6]

In terms of treatment, there is no agreement on whether and when it is advisable to surgically examine the nerve.[7]

In other series, a high rate of spontaneous recovery has been reported in patients with primary iatrogenic injury: the expectant management strategy seems to be widely accepted, and early nerve exploration is only recommended in special situations, for example, if the fracture is open.

In contrast, opinions differ on the need for early nerve exploration in patients suffering from radial nerve palsy after initial surgical fixation of the humerus. While some authors recommend early exploration, others advocate an observation period of 4-6 months.[7] Following the latter concept, surgical exploration was not performed in those patients who developed postoperative paralysis. Seventy-eight percent of the patients in our sample who developed iatrogenic radial nerve palsy recovered their motor function completely. The first sign of wrist extensor contraction was observed between the first and third month after the diagnosis of paralysis, without the need for further surgery.

The placement of a screw with an interfragmentary compression technique for humerus diaphyseal fractures requires the use of instruments (drill bit, soft tissue protector and motor) which, due to their dimensions, can cause traction of the radial nerve and the subsequent development of neuropraxia. Nineteen of the 59 fractures fixed with plates and screws were also fixed with screws using a compression technique. Two of these 19 cases (10.5%) developed radial nerve neuropraxia.

Because of scar tissue formation, the development of postoperative paralysis is less likely after revision surgery performed, at most, 10-14 days after initial surgery than 3-4 months after primary surgery.[8] The rate of postoperative paralysis in our patients undergoing reoperations was 11% (2 cases in 21 reoperations) at an average of 224.55 days from primary surgery. These two patients were reoperated 458 and 53 days, respectively, after surgery.

Beyond the evolution of the implants, the rate of development of paralysis after osteosynthesis remains considerable (11%).

A factor in the development of such paralysis is the use of a plate compared to any other method of osteosynthesis, as well as the dissection and intraoperative neurolysis of the radial nerve. Secondly, reoperations on the humerus are a risk factor that increases the possibility of developing postoperative radial nerve palsy.

We did not find a relationship with age, type of fracture, presence of pseudarthrosis, or compressive screw placement.

The absence of clinical signs of motor recovery after three months of established paralysis, combined with a non-excitable radial nerve on postoperative electromyography, is associated with a poor prognosis for spontaneous radial nerve function recovery. We suggest nerve exploration in these cases.

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Arthroscopic Decompression in Suprascapular Neuropathy. Case Report and Anatomical Review

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ABSTRACT
Suprascapular neuropathy is a rare cause of shoulder pain and weakness and is therefore often misdiagnosed. As a consequence, misdiagnosis may lead to inappropriate conservative treatment or a failed surgical procedure. A case of a 55-year-old man suffering from suprascapular nerve entrapment syndrome is presented. The patient underwent shoulder arthroscopy, where the compression of the suprascapular nerve by the superior transverse scapular ligament was diagnosed. Arthroscopic release of the suprascapular nerve relieved pain, weakness, and atrophy of the supraspinatus and infraspinatus muscles.
Keywords: Suprascapular neuropathy; decompression; entrapment.
Level of Evidence: IV

Descompresión artroscópica para la neuropatía de nervio supraescapular. Reporte de un caso y revisión anatómica

RESUMEN
La neuropatía del nervio supraescapular es una causa poco común de dolor y debilidad en el hombro y, por lo tanto, a menudo, es mal diagnosticada. Como consecuencia, el diagnóstico erróneo puede llevar a indicar un tratamiento conservador inapropiado o un procedimiento quirúrgico fallido. Se presenta el caso de un hombre de 55 años con síndrome de atrapamiento del nervio supraescapular. El paciente fue sometido a una artroscopia de hombro y se le diagnosticó una compresión del nervio supraescapular por el ligamento transverso escapular superior. La liberación artroscópica del nervio supraescapular alivió el dolor, la debilidad y la atrofia de los músculos supraespinoso e infraespinoso.
Palabras clave: Neuropatía supraescapular; descompresión artroscópica; atrapamiento nervioso.
Nivel de Evidencia: IV

INTRODUCTION

Suprascapular neuropathy is a rare condition,[1] first described in 1959 by Thompson and Koppel.[2] The most common etiology is compression of the nerve in the suprascapular notch by the superior transverse scapular ligament or spinoglenoid compression by a ganglion cyst.[3]

Clinically, it may present as localized pain on the posterior and lateral sides of the shoulder, or as weakness, with little or no pain, and it may also cause no symptoms.[1,4]

The diagnosis of neuropathy is based primarily on clinical history and physical examination.[5] Conventional radiography is usually normal. Magnetic resonance imaging (MRI) can reveal acute changes related to denervation, such as edema and muscle hypotrophy, depending on the time of evolution of the compression.[6] In the subacute stage, edema and the onset of hypotrophy can be observed, and in the chronic stage, hypotrophy and fatty infiltration as a result of denervation. Other useful studies include electromyography, which should show the denervation of both the supraspinatus and infraspinatus muscles,[7] and MRI neurography, which allows the compression to be visualized and guides the specific treatment.

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The treatment of compressive neuropathy is based on nerve decompression, preferably arthroscopically, depending on the cause of compression.[8]

Anatomical review

The suprascapular nerve is a mixed nerve that emerges from the ventral ramus of the spinal nerve (C5) or from the upper trunk of the brachial plexus (C5-C6) and often receives an additional supply from C4.[3] From its origin, the nerve runs, covered by the trapezius and omohyoid muscles, through the posterior triangle of the neck, following the course of the suprascapular artery, until it reaches the scapular notch, converted into an osteofibrous hole by the superior transverse scapular ligament. In certain cases, the notch is observed to be almost or completely closed by bone tissue and it turns, then, into a bone hole (Figure 1), these are enthesopathic changes in the lateral and medial insertions of the superior transverse scapular ligament.[6,9]

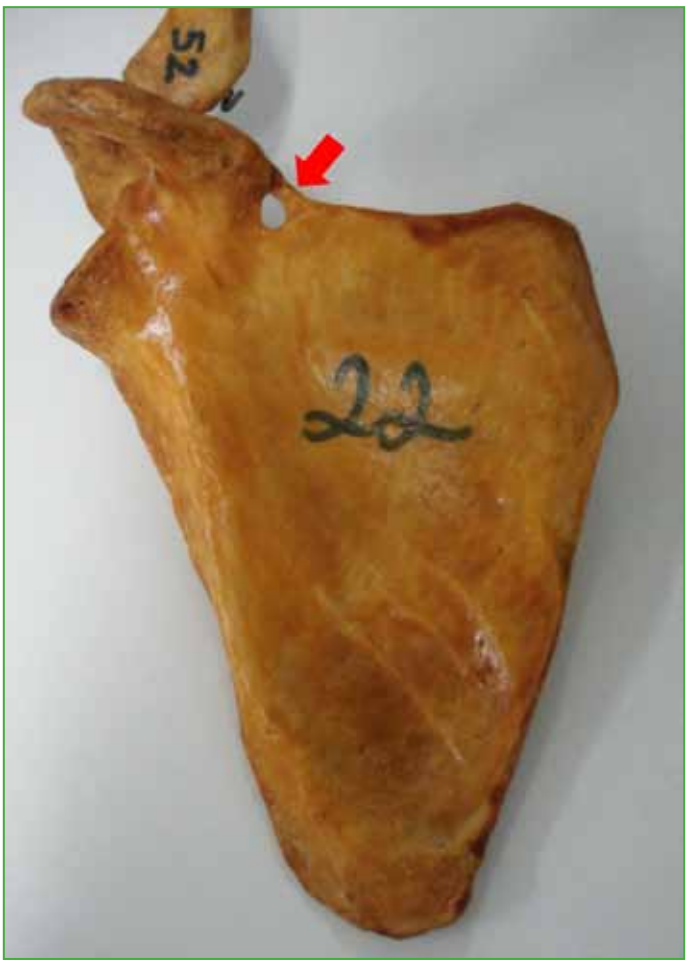

Figure 1. Anterior view of the right scapula. The red arrow indicates the ossified transverse scapular ligament.

The nerve thus reaches the supraspinatus fossa where it provides two motor branches for the supraspinatus muscle, while providing a sensory branch for the coracoclavicular and coracohumeral ligaments, the acromioclavicular joint and the subacromial bursa.[8] Following these branches, the nerve runs deep into the supraspinatus muscle, in the direction of the emergence of the spine of the scapula, to surround it and thus reach the infraspinatus fossa, ending in 2-4 motor branches that innervate the infraspinatus muscle.[10] Due to its long and complex

anatomical path, the suprascapular nerve is highly susceptible to entrapment, which usually occurs at the level of the scapular notch.[3]

Depending on the morphology of the notch, the movements of the shoulder can cause the nerve to angle, pressing it against the superior scapular ligament or against the edge of the bone that limits the notch, causing nerve irritation.[3] This possible mechanism was proposed by Rengachary et al., under the name of the 'hammock effect'.[11,12]

The morphological variations of the superior transverse scapular ligament consist of the number of bands that make up the ligament (two, three or multiple in the proximal-distal direction) and that decrease the passage space of the suprascapular nerve at the level of the scapular notch, thus contributing to increasing the possibility of compression or entrapment.[6,11]

CLINICAL CASE

A 55-year-old man who practiced field hockey and had no relevant pathology history. He had developed a dull pain in his shoulder and scapula three months prior to the consultation. The pain had permanently increased (7/10 according to the visual analog scale) and, after a few weeks, was associated with hypotrophy of the supraspinatus and infraspinatus muscles. This caused severe external rotation paresis (M3 according to the Daniels scale). It is important to mention that he did not have a limited range of motion, but rather pain and motor weakness. Initially, an MRI of the shoulder and scapular region without contrast medium was requested, which showed subacute changes in muscle denervation with an increase in signal in the STIR sequence related to changes in edema (Figure 2).

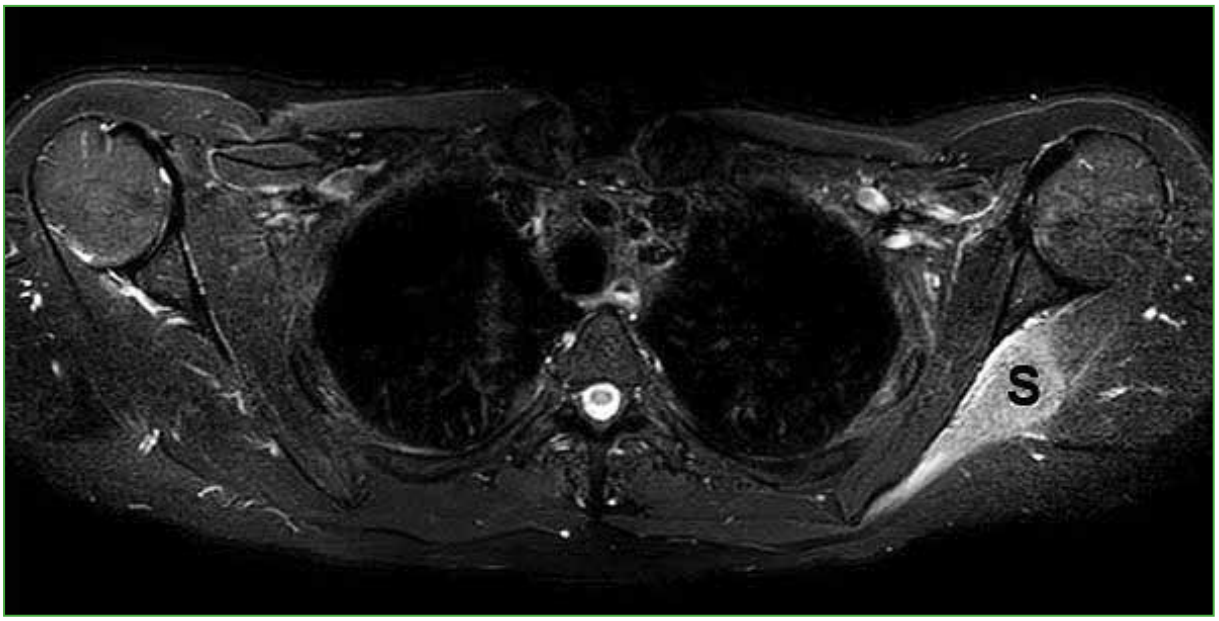

Figure 2. MRI of the left shoulder, axial section, STIR sequence. Edema is observed in relation to the supraspinatus muscle (S).

The rest of the rotator cuff muscles showed a normal signal. Electromyography showed involvement of the suprascapular nerve in isolation (Figure 3).

MRI neurography revealed that the suprascapular nerve branch was diffusely thickened reaching the supraspinatus notch. In this way, the diagnosis of suprascapular nerve entrapment was confirmed.

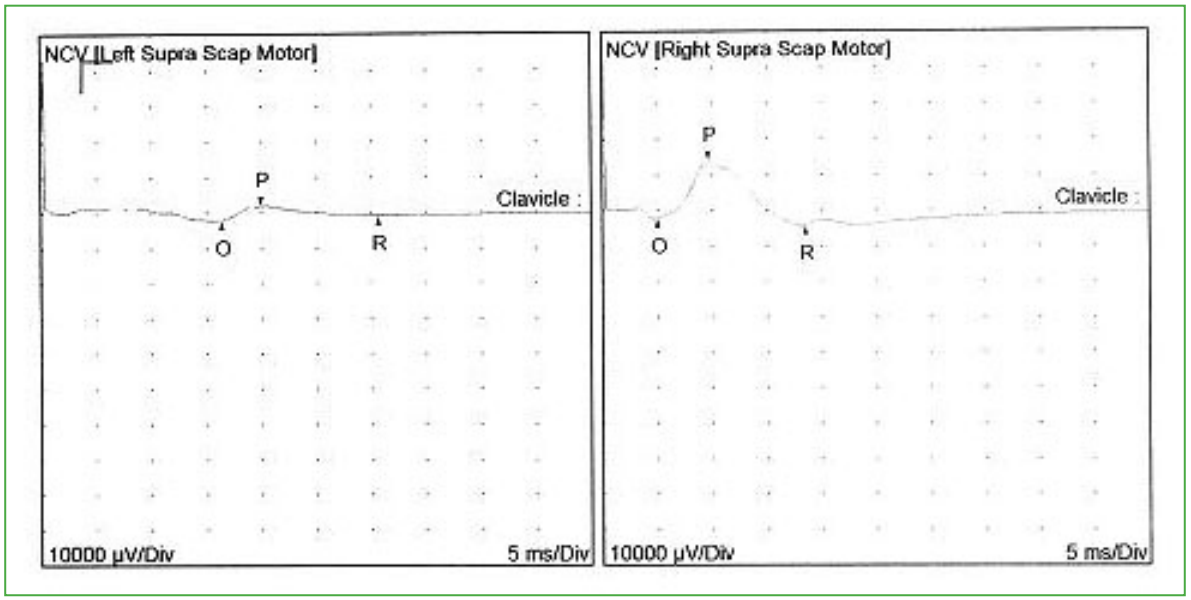

Figure 3. Electromyography of both suprascapular nerves. The reduction in the motor amplitude of the left suprascapular nerve compared to the contralateral one can be observed.

At first, the patient refused surgical treatment and underwent kinesiotherapy. After 12 months without improvement, he consulted again. A new MRI and neurography were indicated, and signs of subacute denervation with fatty infiltration and a decrease in the volume of the supraspinatus-infraspinatus muscle (hypotrophy) were detected in the T1-weighted sequence (Figure 4).

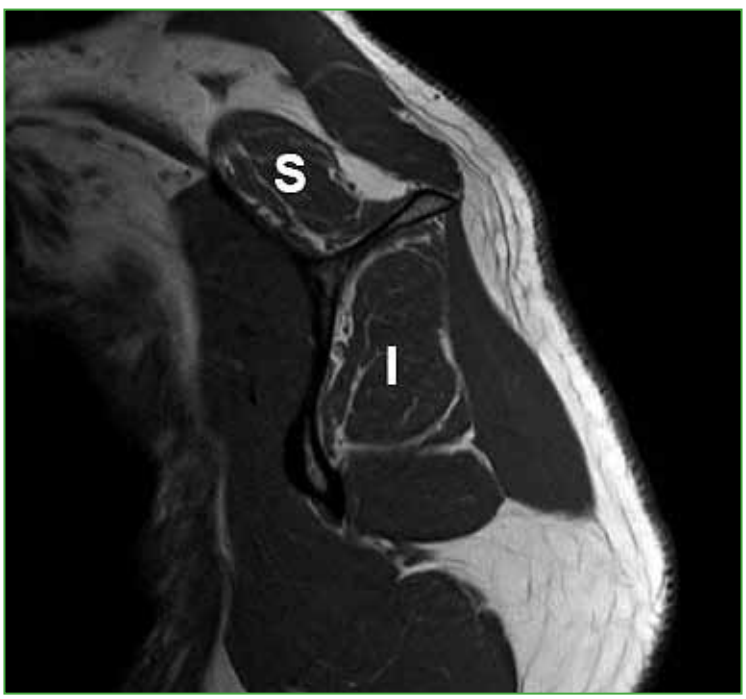

Figure 4. MRI of the left shoulder, sagittal view, T1-weighted sequence. Fatty infiltration of the supraspinatus (S) and infraspinatus (I) muscles can be observed.

Finally, arthroscopic decompression of the suprascapular nerve in the notch was performed.

The patient had no postoperative complications and was discharged within 24 hours. 14 days after surgery, kinesiology rehabilitation began. Scapular pain disappeared (1/10 according to the visual analog scale). After one month, a gradual recovery of muscle strength for external rotation was observed and, after three months, a partial recovery of muscle tropism was observed.

Surgical technique

Arthroscopic decompression was performed based on the original Lafosse technique.[13] The patient was placed in a modified beach chair position, under general anesthesia and interscalene block. The initial visualization was carried out through a posterior portal and an anterolateral work portal. An extensive bursectomy was performed, identifying the anterior border of the supraspinatus, using it as a guide to move forward with the medial dissection, until the base of the coracoid was identified. The body and base of the coracoid were then cleaned. Then, the conoid ligament was identified medially and posteriorly to the trapezoid ligament. At the base of the conoid, a retroclavicular portal was created with the help of a spinal needle, called the 'suprascapular nerve portal'. This portal was created 7 cm from the acromial and retroclavicular region. A trocar was then used as a retractor and a second suprascapular nerve portal was created 1.5 cm lateral to the first. The transverse ligament shares an insertion at the base of the coracoid with the conoid ligament, approximately 3.5 cm from the acromioclavicular joint. Using the medial suprascapular nerve portal, the base of the conoid and the transverse ligament were cleaned with a blunt tip trocar, taking care not to injure the suprascapular artery that runs above the ligament and the nerve below it. In this step, nerve compression between the suprascapular notch and the superior transverse ligament was observed (Figure 5).

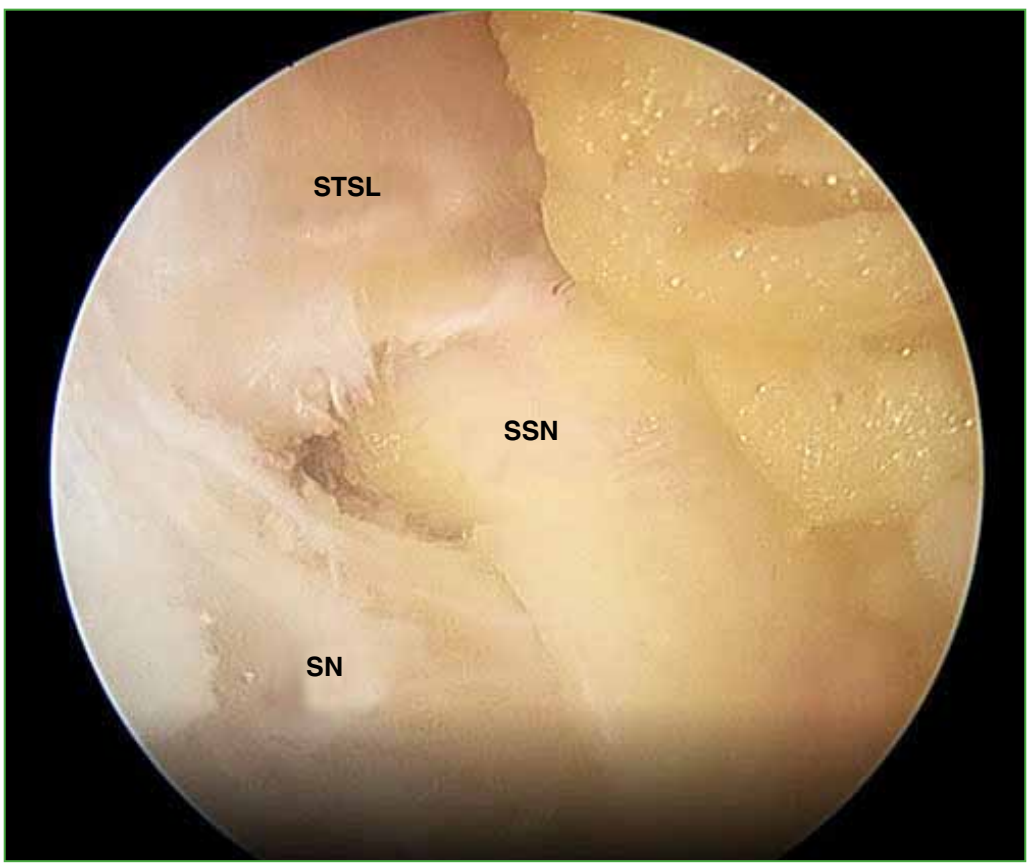

Figure 5. Arthroscopic image of the suprascapular nerve compressed by the superior transverse scapular ligament. SSN = suprascapular nerve; STSL = superior transverse scapular ligament. SN = suprascapular notch.

Using a blunt trocar through the medial suprascapular nerve portal, as a retractor of the trapezius muscle, the transverse ligament was cut with arthroscopic scissors through the lateral suprascapular nerve portal. Then, it was possible to visualize the released and uncompressed suprascapular nerve (Figure 6).

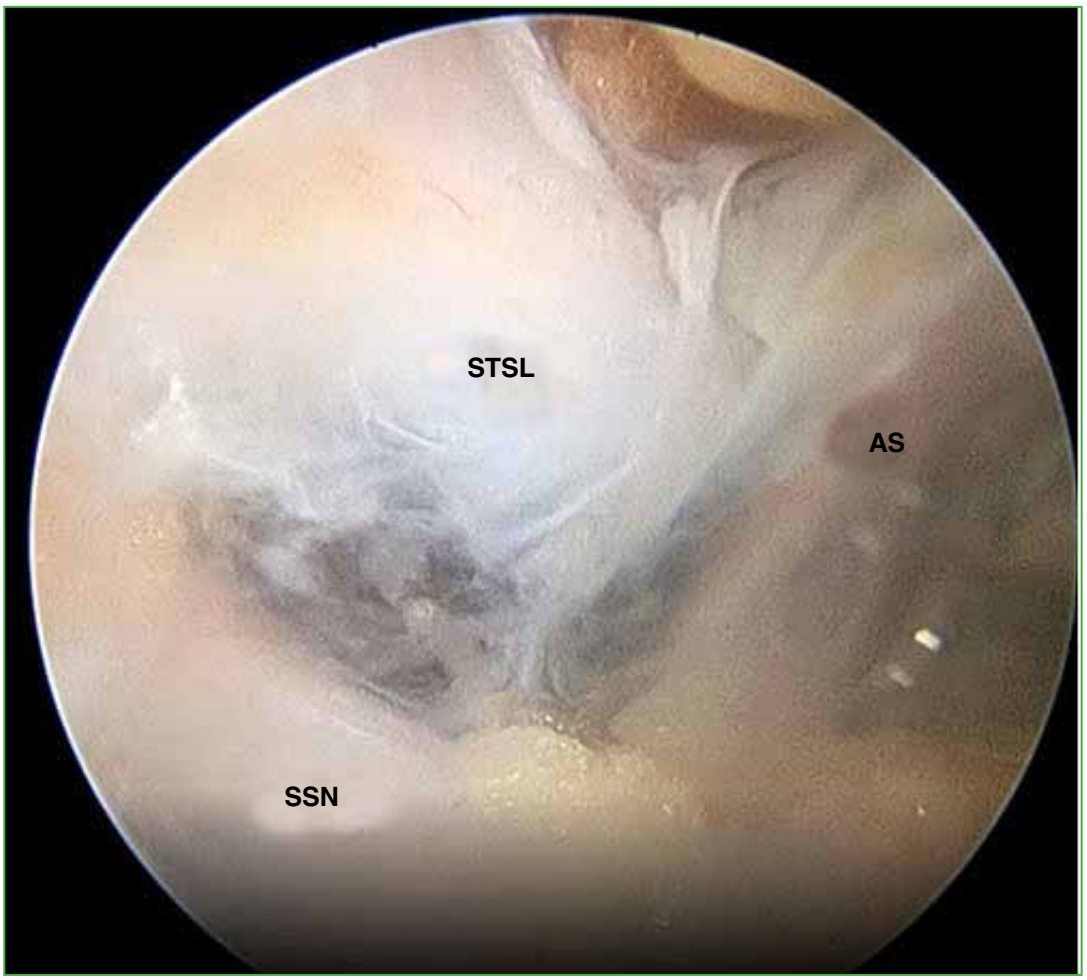

Figure 6. Arthroscopic imaging. Arthroscopic scissors were used to cut the transverse scapular ligament. SSN = suprascapular nerve; STSL = superior transverse scapular ligament. AS = arthroscopic scissors.

Adequate nerve decompression was confirmed by careful mobilization of the nerve outside the scapular notch (Figure 7).[14] We believe it is important to perform this maneuver, especially because of presence of the anterior coracoscapular ligament identified by Avery et al.[15]

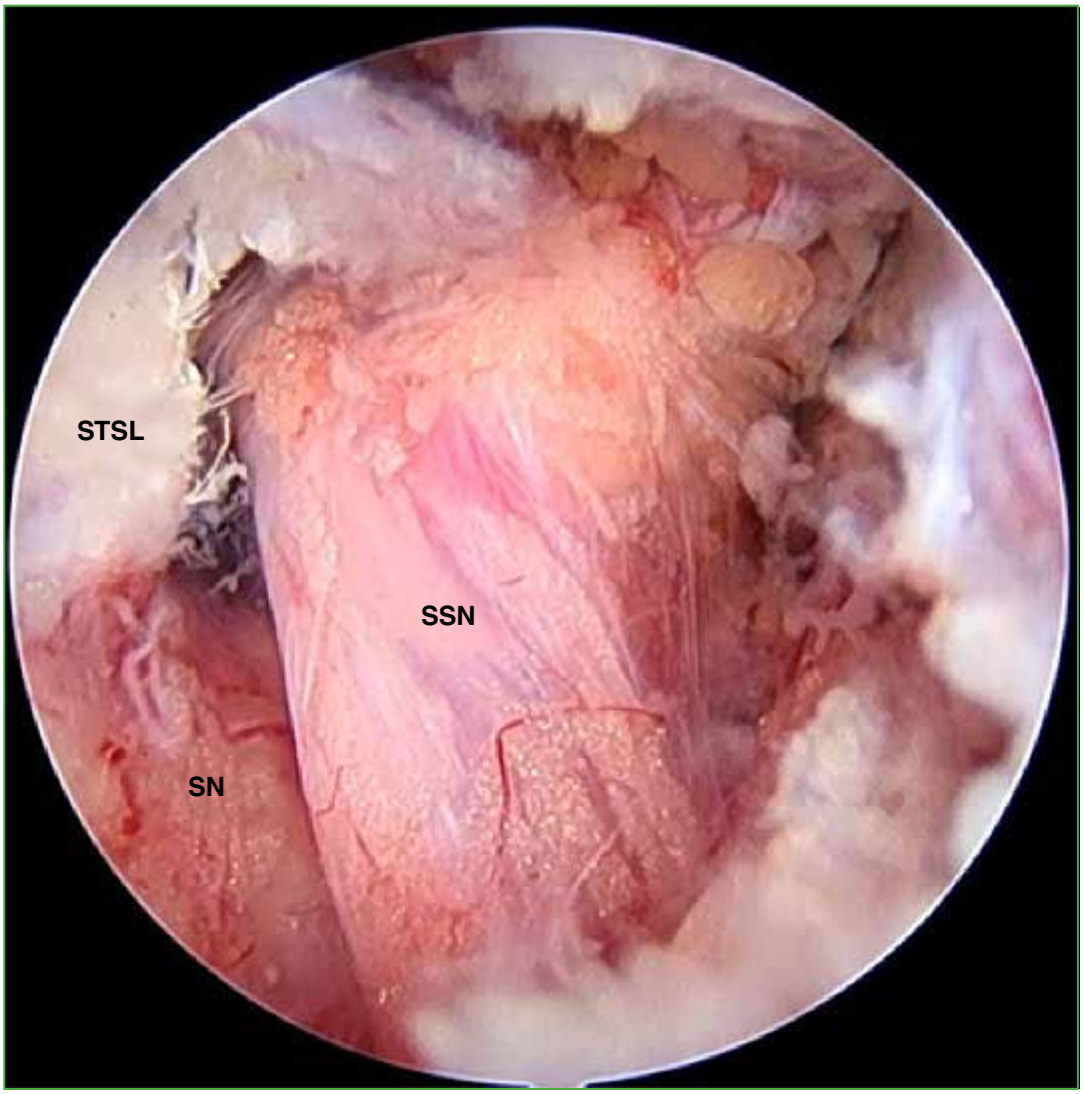

Figure 7. Arthroscopic imaging. The fully released suprascapular nerve can be visualized. SSN = suprascapular nerve; STSL = superior transverse scapular ligament; SN = suprascapular notch.

DISCUSSION

Suprascapular nerve entrapment in the suprascapular notch is a rare condition that is difficult to diagnose clinically and requires a high level of suspicion.[16,17] Most cases are idiopathic, but it commonly affects athletes who perform overhead activities. The sequelae of scapular fracture and ossified suprascapular ligament are also factors that increase the likelihood of nerve entrapment. Although there are several open and arthroscopic approaches to decompress the suprascapular nerve, all depend on the location of the coracoclavicular ligaments that lead to the superior transverse scapular ligament. The study by Harris et al.[18] provided insight into the importance of the coracoclavicular ligaments as a landmark to the superior transverse scapular ligament. These authors evaluated the variation of the coracoclavicular ligaments and found that, despite the variability of the shape, length and insertion area of the coracoclavicular ligaments, the conoid ligament and the supraspinatus muscle tendon shared, in all their studied cases, the same insertion site on the coracoid process. In addition, they found that the fibers of the conoid component blend with the fibers of the supraspinatus tendon.[18] The potential space surrounding the

suprascapular nerve and coracoclavicular ligaments is a fatty connective plane, which makes arthroscopic visualization technically demanding. This step is usually the most time-consuming in surgery, prioritizing at all times the protection of the suprascapular artery to avoid bleeding.

CONCLUSION

Suprascapular neuropathy is a rare disease whose diagnosis is usually delayed. Maintaining a high index of suspicion is possibly the most important aspect of the treatment of this condition. Arthroscopic decompression offers a valid therapeutic alternative.

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Subscapularis Fibromatosis as a Cause of Winged Scapula. Case Report and Literature Review

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ABSTRACT
Winged scapula is usually caused by neurological injuries to both the spinal nerve and the long thoracic nerve. Its presence as a result of a ventral scapular tumor makes initial diagnosis difficult. We present the case of a young woman with limited external shoulder rotation, no known traumatic history, and images consistent with a soft tissue lesion dependent on subscapular muscle aponeurosis, which was confirmed by biopsy as a desmoid tumor. Although it is a benign, self-limiting tumor, it has an alarmingly high rate of relapse after resection, so many treatments are available, and many teams choose to closely monitor the patient's prognostic factors and functional limitations, obtaining satisfactory outcomes and, in some series, superior to those of surgical treatment.
Keywords: winged scapula, desmoid tumor, treatment.
Level of Evidence: IV

Fibromatosis subescapular como causa de escápula alada. Presentación de un caso y revisión bibliográfica

RESUMEN
La escápula alada suele producirse por lesiones neurológicas tanto del nervio espinal como del nervio torácico largo. La aparición a causa de un tumor ventral de la escápula dificulta su diagnóstico inicial. Presentamos el caso de una mujer joven, con limitación para la rotación externa del hombro, sin antecedentes traumáticos conocidos, evolución progresiva e imagen compatible con una lesión de partes blandas dependiente de la aponeurosis del músculo subescapular confirmada por biopsia como un tumor desmoide. Aunque se trata de un tumor benigno y autolimitado, tiene una inquietante alta tasa de recidivas después de la resección, por lo que se dispone de numerosos tratamientos y muchos grupos optan por hacer un seguimiento médico estrecho de los factores pronósticos y las limitaciones funcionales del paciente, con lo que obtienen resultados satisfactorios y, en algunas series, superiores a los del tratamiento quirúrgico.
Palabras clave: Escápula alada; tumor desmoide; tratamiento.
Nivel de Evidencia: IV

INTRODUCTION

Extra-abdominal fibromatosis is a rare aggressive monoclonal fibroblastic proliferation of musculoaponeurotic tissues. Two types are distinguished: superficial ones, such as Dupuytren's contracture, Ledderhose disease or penile fibromatosis, and deep ones, which are called aggressive desmoid tumors because of their local behavior.[1] The term desmoid, derived from the Greek 'desmos' meaning 'band', was initially applied by Müller because of its consistency similar to that of tendons. They have a slight prevalence in the population between the ages of 25 and 35, although, in many series, no differences are observed according to age; it represents about 0.03% of all skin and soft tissue neoplasms, and the risk increases if the patient has a genetic condition, such as Gardner syndrome. The prevalence of extra-abdominal desmoid tumors increases to 15% if associated with familial adenomatous pol-

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yposis,[2] which, in addition, determines that those with desmoid tumors are more prone to malignancy than those without this condition.[3]

Desmoid tumors do not metastasize, but they have irregular limits because they are not contained in a capsule, this factor is associated with greater aggressiveness and recurrence after surgery.

Periscapular tumors and, even more so, desmoid tumors, are a rare cause of scapulothoracic dissociation, making them difficult to diagnose. In this regard, winged scapula is usually due to paralysis of the serratus anterior or trapezius muscles due to nerve injury to the long thoracic or accessory nerves, but these injuries are dynamic and must be differentiated from static ones that do not occur due to neuromuscular causes, which means that this type of winged scapula is present at rest and does not increase with anterior flexion of the arm.[4]

CLINICAL CASE

A 28-year-old woman with a history of idiopathic adult scoliosis and with an active job that involved carrying material. She was referred to the trauma outpatient clinic for post-traumatic left omalgia of eight months of evolution and limitation for external rotation, contracture and trapezius pain, with no improvement after rehabilitation. On physical examination, relative hypotrophy of the left scapulohumeral musculature compared to the contralateral scapulohumeral musculature was detected. No masses were palpated or inflammatory signs were observed. Active and passive range of motion were preserved, except for an external rotation of 0º for the left shoulder and 75º for the right shoulder. In addition, scapulothoracic dyskinesia compatible with a left winged scapula was found, so different complementary studies were requested. With the CT scan, bone disease was ruled out. On electromyography, a lesion of the long thoracic nerve, with chronic characteristics and of moderate intensity, was detected, which impeded the mobility of the scapula. In addition, magnetic resonance imaging revealed a lesion in the subscapularis muscle of about 5 cm, with poorly differentiated margins, discrete heterogeneity and a slight signal hyperintensity in the T2-weighted sequence, compatible with a fibromatous process (Figures 1 and 2).

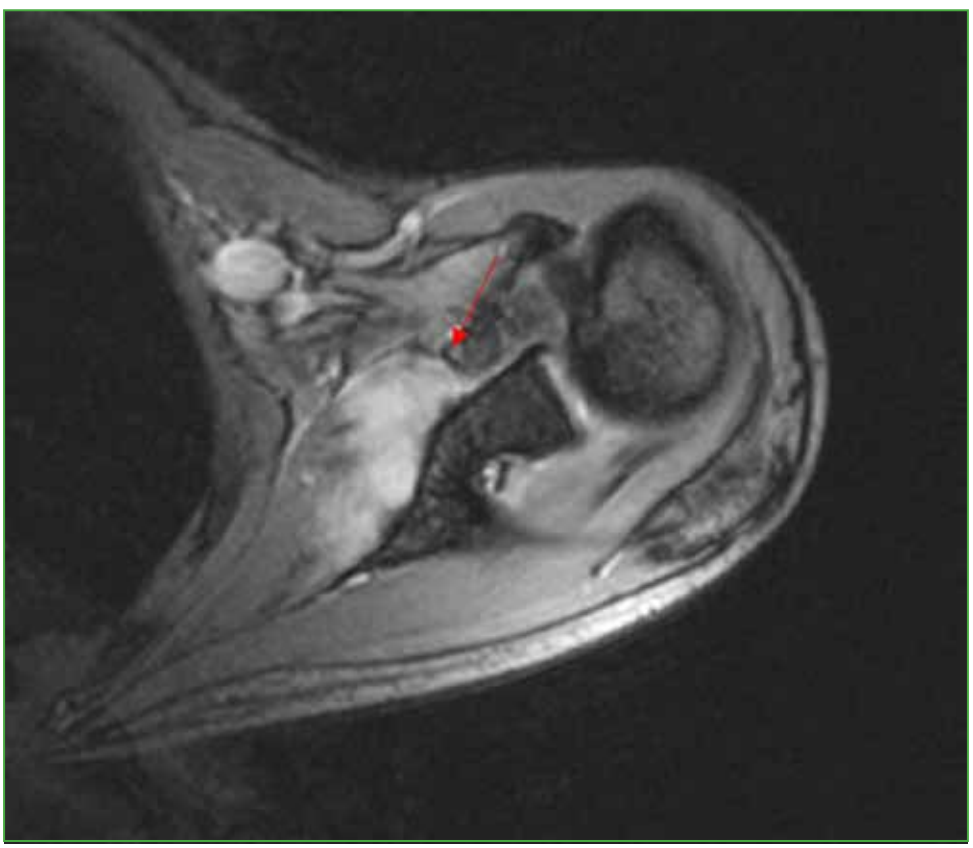

Figure 1. MRI of the left shoulder, axial section, STIR sequence. The red arrow indicates the subscapular tumor.

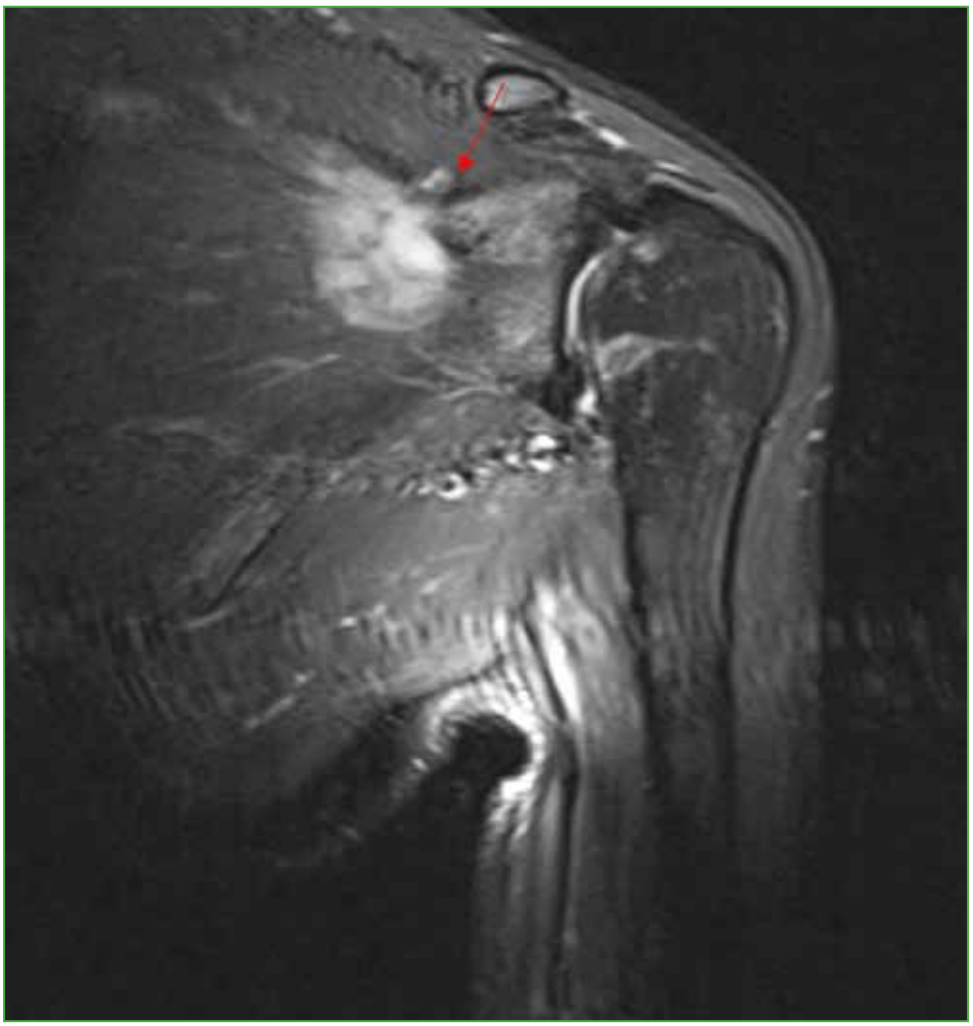

Figure 2. Magnetic resonance imaging of the left shoulder, coronal section. The red arrow points to the subscapular tumor.

To confirm the diagnosis, a thick needle biopsy was performed under sedation and guided by computed tomography. The sample was kept fresh until it arrived at the pathological anatomy laboratory where it was processed. Histological analysis showed a low-grade mesenchymal spindle cell proliferation, suggestive of desmoid-type fibromatosis that locally infiltrates the subscapularis muscle. Therefore, the case was treated in conjunction with a tumor unit, and it was decided to complete the evaluation with a scan that showed the absence of tumor activity.

In the evaluation of the specialized unit, it was decided to manage the inflammatory disease by controlling the symptoms through radiotherapy and hormonal suppressive therapy. Surgical intervention was ruled out due to the high morbidity of the procedure, the difficulty in performing an extensive resection, and the high rate of relapses after surgery.

The patient received radiotherapy sessions and started hormonal treatment with tamoxifen 40 mg daily. After a year of work leave, she was told that she could return to her activities and she resumed her work with moderate-severe pain, both during active range of motion and at rest. This required monitoring by the chronic pain unit, where analgesia was reinforced at the third level of the World Health Organization pain scale and trigger point injections were indicated, first, with local anesthetics on a diagnostic basis and then with botulinum toxin, in order to improve the reflex contracture associated with the muscles of the shoulder girdle.

The patient underwent biannual monitoring with magnetic resonance imaging, which showed a decrease in tumor size of 10 mm since diagnosis. Cryo-sclerotherapy was contemplated, but the patient decided to continue symptomatic medical treatment because of the risk of a possible reported nerve injury.

Tumor growth and functional impairment were stabilized from diagnosis to 20 months of follow-up. Periodic checks were carried out every six months, using magnetic resonances without contrast medium and with the usual sequences, which showed that the mass had not grown. In addition, clinical examinations were carried out every three months to assess the progression or improvement of symptoms. The doctors in the chronic pain unit administered ultrasound-guided injections of extended-release betamethasone (2 ml) combined with mepivacaine 2% (6 ml) into the underlying muscles, which achieved good pain control. Three years after the diagnosis, the patient was discharged because the injury had not progressed.

DISCUSSION

Currently, the treatment of extra-abdominal desmoid tumors remains a controversial topic, mainly due to the difficult local control of the disease and the high rate of recurrence in published case series. In a study of 194 patients with extra-abdominal desmoid tumors, most of which were in the extremities, attempts to control the disease locally through surgery with intralesional resection, whether marginal or extensive, had a recurrence rate of up to 76%, 70% within the first two years, and 60% if radiotherapy was used.[5] In another study, a series of 83 cases were evaluated. Most had been treated only with surgery and the local recurrence rate was 45%, with no difference with a small group that could not be properly resected and was prescribed radiotherapy.[6] More recently, a study of a series of 234 operated patients has been published, with a success rate of 83% in primary surgeries; these results include 10 recurrences in a group of 39 patients with radiotherapy and four in one of eight with chemotherapy only. In addition, a higher rate of recurrence of tumors located in the upper limb is reported, which is probably due to the limitation to perform more aggressive surgeries.[7]

The authors of most of the studies on these tumors highlight the importance of controlling tumor margins and their relationship with local relapse. For this reason, radiotherapy is incorporated into the therapeutic approach, both as an adjunct treatment to surgery and as a single treatment when surgery is not possible. In this regard, some studies have obtained good outcomes with adjuvant radiotherapy in patients with affected resection margins and neoadjuvant radiotherapy during a six-year follow-up.[8,9] The case presented is based on these results to justify the choice of radiotherapy at the beginning of the therapeutic regimen.

Systemic treatment is recognized as a line of therapy for extra-abdominal desmoid tumors. It may include nonsteroidal anti-inflammatory drugs, hormonal response-modulating drugs, and chemotherapy drugs. In this regard, in some studies of patients with desmoid tumors, the response to meloxicam has been good, stabilizing the disease and even making it remit.[10] Although up to 80% of sporadic desmoid tumors have mutations in the gene coding β-catenin, a specific study on mutations in this gene with a series of 145 samples found no relationship between the variants and the risk of recurrence.[11]

According to the European Soft Tissue and Bone Sarcoma Group, patients with clearly progressive, unresectable conditions, such as that of our patient, or in whom extensive resection leads to impairment or loss of limb function, are candidates for systemic therapy.[12] Despite correct case selection, there is currently no standardized treatment, which must be adapted to each patient. Specifically, and clearly considering these inclusion criteria, in the study by Mankin et al.,[7] only 4% of patients were treated with chemotherapy from the beginning, unlike other series in which these rates triple.

With regard to the treatment of desmoid tumors through chemotherapy, the use of doxorubicin associated with dacarbazine and vinorelbine stands out, with significant clinical response rates, without adverse reactions due to serious toxic effects.[13,14]

In the last decade, interest has grown in the use of molecules that interact, in a specific way, in the cell cycle, such as the tyrosine kinase inhibitors, imatinib and sunitinib. In several clinical studies, a reduction in radiological size has been detected in symptomatic patients treated exclusively with sorafenib,[15] and even a two-year progression-free survival of 81% of patients with advanced, treatment-resistant disease. [16]

On the other hand, it is believed that desmoid tumors may be related to hormones, since 80% have been found to affect women and their progression related to pregnancy has even been observed.[17] In 2003, a compilation of 34 reports of primary and recurrent cases with an average follow-up of 17 months was published. Three of them had a complete response; 15, a partial response and 12 showed no change in response to tamoxifen during follow-up.[18] In another study, similar outcomes were obtained with toremifene.[19] As for testolactone, an enzyme that controls the conversion of testosterone to estrogen, the largest published series is of 17 patients. The disease control rate was 40% and reached 70% if it was combined with a non-steroidal anti-inflammatory drug, such as sulindac or indomethacin.[20]

Conservative treatment — *wait-and-see* policy

Conservative management of the disease through symptomatic medical treatment to avoid the morbidity associated with surgery and radiotherapy is defined as serial magnetic resonance imaging monitoring combined with symptomatic treatment with or without nonsteroidal anti-inflammatory drugs. This therapeutic option is receiving increasing support even as a first-line treatment for primary tumors.[19] Specifically, in a retrospective series of 87 patients analyzed based on the management of their primary desmoid tumor, either with surgery or through symptomatic treatment and periodic magnetic resonance, no significant difference was found in disease-free survival between the two groups.[21] Along these lines, in 2017, the French Sarcoma Group published a prospective study with 771 patients that compared event-free survival in an operated subgroup and another treated symptomatically. It was concluded that there are no statistically significant differences between the two options. It was also reported that, after a univariate analysis, the location of the desmoid tumor is the isolated parameter that most influences event-free survival.[22]

Currently, sarcoma research groups recommend conservative symptomatic management (*wait-and-see policy*) for extra-abdominal desmoid tumors with periodic magnetic resonances, especially during the first year, since only a very small amount grows beyond the first 36 months of diagnosis.[23] This avoids overtreatment and the excessive indication of surgery in these patients and helps to reduce the rate of sequelae.

CONCLUSIONS

Because the etiology of desmoid tumors is multifactorial and their nature is unclear, it is difficult to determine a specific treatment and its possible evolution if no treatment is indicated. Many factors influence the poor outcome, such as the size, location and age of the patient. On the other hand, the factors that favor spontaneous resolution are still unknown.

Conservative treatment as the first line of treatment for extra-abdominal desmoid tumors is a completely valid option, although, in most studies, the abandonment of this therapeutic option remains a problem that may alter the results. A high percentage of patients achieve the spontaneous stabilization of the tumor in an average of two years. Therefore, according to our criteria and following the consensus of the Soft Tissue and Bone Sarcoma Group, we have chosen this line of treatment with the predictability of obtaining good outcomes in tumors that are unresectable—due to the high comorbidity that resection may entail, especially in the limbs—as well as in patients without risk factors for progression with tumors with few symptoms. We choose surgery for patients who do not respond to medical treatment after two years of follow-up, provided that the resection of the tumor does not entail a loss of relevant functionality and in cases where the surgical management of these tumors may not result in greater morbidity due to their location, such as those that settle in the neck or on the walls of the abdomen, and always reserving limb amputation for patients with a significant functional compromise present or expected after resection.

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Median Nerve Compression Syndromes. Literature Review and Update

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ABSTRACT

The median nerve is a nervous structure that begins to cross structures at the level of the elbow that might cause compression. The Struthers ligament, lacertus fibrosus, pronator teres, and flexor digitorum superficialis are among them. Finally, the transverse carpal ligament creates another compression site in the wrist. All these structures can develop pathological signs and symptoms of nerve entrapment, which favors nerve functional degradation. Our objective is to provide an update on these median nerve entrapment sites, as well as information on how to establish an accurate diagnosis and provide adequate treatment.

Keywords: Nerve compression; median nerve; pronator teres syndrome; carpal tunnel syndrome; surgical decompression.

Level of Evidence: IV

Síndromes compresivos del nervio mediano. Revisión y actualización de la bibliografía

RESUMEN

El nervio mediano desciende por el brazo y, en el codo, comienza a atravesar estructuras que pueden generar compresión, como el ligamento de Struthers, el lacertus fibrosus, el pronador redondo, el flexor superficial de los dedos. Finalmente, en la muñeca, se encuentra otro sitio de compresión producido por el ligamento transverso del carpo. Todas estas estructuras pueden provocar signos y síntomas de atrapamiento nervioso y favorecer el deterioro funcional del nervio. Nuestro objetivo es dar a conocer una actualización sobre estos sitios de atrapamiento del nervio mediano, y cómo realizar un diagnóstico preciso e indicar un tratamiento adecuado.

Palabras clave: Compresión nerviosa; nervio mediano; síndrome del pronador redondo; síndrome del túnel carpiano; descompresión quirúrgica.

Nivel de Evidencia: IV

ANATOMY

The median nerve is constituted by the nerve roots of C5-C7 that form the lateral cord and of C8-T1 that generate the medial cord.[1] These roots coalesce forming the median nerve, which descends through the medial arm to the humeral artery and medial to the biceps and the brachii, without emitting collateral branches during this journey.[1-3]

In the elbow, it has been observed that the median nerve passes through a number of structures. Initially is the medial spur of the humerus, from where the Struthers ligament that extends to the medial epicondyle can originate. It then enters the cubital fossa in the depth of the bicipital aponeurosis and the pronator teres (PT) (both heads, humeral and ulnar). Running distally, it enters below the flexor digitorum superficialis (FDS). In this level, the motor branch or anterior interosseous nerve emerges, which runs in the forearm through the anterior region of the interosseous membrane and innervates the pronator quadratus, flexor pollicis longus, and flexor digitorum profundus muscles. The median nerve then continues its path in the forearm between the FDS and the flexor carpi radialis. 7 cm from the wrist, the palmar cutaneous branch of the median nerve emerges, which gives sensitivity to the thenar

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eminence. Finally, the nerve enters the carpal tunnel where the thenar motor branch emerges and ends up dividing to distal in the sensitive finger branches.[1-4]

CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome is a compressive mononeuropathy of the median nerve in the wrist.[5] From the pathophysiological point of view, it generates edema in the nerve, with demyelination and axonal damage.[6,7] It is characterized by paresthesia or tingling in the sensitive region of the median nerve (radial edge of the hand), as well as pain that is usually exacerbated at night.[5,6]

Diagnosis

We describe a case associated with pain, numbness, hypotrophy of the thenar eminence, etc. Such symptomatology can be assessed using the CTS-6 questionnaire (6-item carpal tunnel syndrome symptoms scale), where a score of 5 indicates a low likelihood of having the syndrome, while a score of 12 or more indicates a high likelihood.[8,9]

A review by the American Academy of Orthopedic Surgeons identified certain features associated with the diagnosis of carpal tunnel syndrome, including the presence of thenar eminence atrophy, which is strongly related to the disease.[9]

Clinically, Phalen's test and Tinel's sign, and altered conduction nerve studies (taking into account that electromyography can give 10% false negatives) were markedly associated with this disease. It should be noted that these factors have no diagnostic value when considered separately.

On the other hand, there are also diagnostic tests that are moderately related to the diagnosis of the disease, such as the scratch collapse test, alterations in sensitivity through two-point discrimination or the monofilament test. In addition, there is a moderate association with other diseases, such as diabetes, repetitive manual activities, and vibrational activities.[9]

Treatment

Initial conservative treatment only provides benefits if wrist immobilizers are used to prevent flexion and corticosteroid infiltrations are administered, which achieve improvement in up to one third of patients.[5]

However, in the absence of a response, surgery is indicated. The objective is to decompress the tunnel by opening the transverse carpal ligament.[10]

Currently, both open and endoscopic techniques are the two surgical options.

In systematic reviews, it has been shown that there are no statistically significant differences between the techniques in terms of surgical time, improved grip strength, improved sensitivity at three months with the monofilament test or at one year with two-point discrimination.[10,11]

On the contrary, benefits of endoscopic treatment were found, with statistically significant differences in patient satisfaction, return to work and the absence of complications related to the skin wound (the open technique is associated with infections, pillar pain, and hypertrophic scarring).[11] However, certain complications may occur, such as neuropraxia (not with permanent damage, in this sense, both are similar) and has the disadvantage of being more expensive.[5,6,10,11]

Persistence, recurrence or new symptoms

In the absence of symptom improvement, the possible scenarios are:[6,12]

- *Persistence:* symptoms are never relieved. In 58% of cases, it is attributed to incomplete release and in 37% to another compression site (such as the PT).[12]

- *Recurrence:* symptoms are relieved for a period >6 months and then the same symptoms reappear. In 88% of cases, it is usually associated with perineural adhesions, fibrosis and scarring. In these situations, revisions are indicated. It is recommended to improve the environment of the nerve including vein coverage, hypothenar fat pad flaps, etc.[12]

- *New symptoms after surgery:* up to 67% of the cases are related to iatrogenic complications. Revision with nerve repair or reconstruction is recommended.[12]

COMPRESSIONS OF THE MEDIAN NERVE AROUND THE ELBOW

While the incidence of elbow compressions is low, Hagert et al. indicate that this may be due to failure to diagnose this disease.[13-16]

From an anatomical point of view, compressions can be produced by:

1. The pronator teres. It is the most frequently documented site. The causes are usually thickened fibrous and tendon bands of the deep fascia (76% of reported cases).[1,3,15,17,18]

2. Bicipital aponeurosis It is the second most reported site. Hagert et al. report that this is the main constricting structure. In their study, to corroborate proper decompression, they measure the strength of the flexor pollicis longus and the flexor profundus digitorum before release and after. It has been reported as a cause in up to 42% of cases.[1,3,17,18]

3. The FDS. It forms aponeurotic arches. It accounts for up to 36% of cases.[1,3,17,18]

4. Other less common causes, such as Struthers' ligament or Gantzer muscle (accessory head of the flexor pollicis longus).[1,7]

Tang et al. pointed out that it is almost impossible to differentiate between compressions produced by the PT and the FDS; therefore they considered and treated both causes at the same time. The bicipital aponeurosis, which would be the other frequent etiology capable of generating such compression, is released by the closeness and ease provided by the 3.5 cm approach performed 6 cm from the elbow crease.[19]

Diagnosis

Currently, there is no consensus to establish diagnostic criteria for median nerve compression around the elbow.[20] However, clinical symptoms and signs, and complementary studies are described.

Clinical signs and symptoms

Tinel's sign on the forearm: only 50%.[1,3,21]

Compression test: usually generates pain: being deep structures, Tang et al. emphasize that it may be nonspecific or absent.[1,5,19,21] Compression should be performed 6 cm from the elbow crease and 4 cm lateral to the medial epicondyle.[22]

Pain in the forearm and paresthesia in the forearm and the thenar eminence: they are associated with this etiology, because the palmar cutaneous branch of the median nerve is compromised.[1,2,4,5,17,20,23]

Thenar eminence weakness: it has been linked to compressions in the elbow, while nocturnal symptoms as well as thenar atrophy are more common in carpal tunnel syndrome (distal compressions).[4,20]

Scratch collapse test: it has been proposed as a method to reveal compression sites. It is more accurate if, in addition, the test is carried out with ethyl chloride, as it achieves a similar sensitivity and specificity as other provocation diagnostic tests.[6]

Dynamic tests: they are considered positive if they produce paresthesia. The effectiveness (sensitivity and specificity) of diagnostic tests that evaluate the force against resistance to reproduce symptoms of neuropathies is about 90%.[16] These include:

1. Pronation against resistance with the elbow at 45°: positive for the PT.

2. Flexion against resistance with the supinated forearm: positive for compressions where the constricting structure is the bicipital aponeurosis.

3. FDS flexion: third/middle finger against resistance for 1 minute: positive for FDS.[1-3,22]

Complementary studies

1. Radiography: this is useful for testing for a humeral spur.[3]

2. Electromyography: it has been positive in only 30% (low sensitivity).[3,20] However, it is requested to evaluate secondary causes of compression (such as a cervical condition, which is the most common).[3,6,16,18] Specifically in the forearm, it evaluates for positive fibrillations or waves, polyphasic or long-lasting, indicative of compression of the median nerve.[20]

3. Magnetic resonance imaging: it has low sensitivity to detect nerve lesions (5% according to Özdemir et al.).[16,20,24] In acute and subacute stages, the presence of edema in the STIR sequence could indicate nerve compression, and appears earlier than nerve changes, which usually develop after at least three weeks. In chronic stages, it is associated with fatty degeneration of the muscles innervated by the median nerve.[4,6,20,24,25]

4. Ultrasound: it may show hypoechogenicity before the compression site, which is due to perineural edema.[4-6,20,26] Özdemir et al. observed changes in up to 57% of cases, for example, alterations such as decreased median nerve cross-sectional area with maneuvers, such as supination.[20] The median nerve cross-sectional area is normally 7-9.8 mm at the carpal tunnel level. In the forearm, ultrasound signs may not be evident, as the compressive bands are often too small to be visualized with this study.[26] However, it is operator-dependent and should not be used in isolation to diagnose compressive neuropathy.[27] Even with all limitations, Özdemir et al. note that ultrasound is the most sensitive study to diagnose median nerve compression in the forearm.[20]

Treatment

Conservative treatment

It is the initial treatment to be instituted and should last at least three to six months. It is based on non-steroidal anti-inflammatory drugs, changes in activities to avoid exercises that require prolonged elbow flexion, forearm pronation and prolonged grip strength with the hands. In addition, kinesiotherapy is indicated for the stretching of the muscles of the forearm. It has also been proposed to administer corticosteroid injections, which achieve good therapeutic outcomes.[2,3,17,19]

In some cases, conservative treatment may need to be prolonged for up to one year to achieve a favorable response. This occurs with compressions that generate only motor symptoms with the impossibility of performing the OK sign (Kiloh-Nevin sign) in which anterior interosseous nerve syndrome should be considered as a diagnosis. This may be part of Parsonage-Turner syndrome (a brachial plexus neuritis secondary to a viral infection that presents with omalgia, symptoms of irritative nerve disease, and is usually associated with anterior interosseous nerve syndrome). In these cases, conservative treatment should be prolonged for up to one year.[2-5] In the presence of this syndrome, decompression is only recommended if there is associated severe neurological damage.[5]

Surgical treatment

Surgery has historically been based on an anterior S-shaped approach to the elbow, which allowed all structures that might be involved to be explored and released.[5]

Then, selective releases started to be performed through smaller incisions of the structures that were most often related to compression, and that achieved similar improvement rates of up to 70-90%.[1,3,5]

Surgical options

1. Hagert proposes a 3 cm approach in the elbow crease, with the WALANT technique (Wide Awake Local Anesthesia No Tourniquet) to perform preoperative and intraoperative measurements of the force of the flexor pollicis longus and the flexor digitorum profundus. With their mini-invasive technique, they operated on 82 patients and the DASH score improved from 35 to 12.7 (a statistically significant value). In addition, pain and numbness measured with the visual analog scale improved to 1 after 6 months, and patient satisfaction in their series was 8.8.[16,18,21]

2. Zancolli et al. reported that the cause of compression was PT and FDS in 44 patients in their series. For nerve decompression, they performed an oblique approach of 3.5 cm to 6 cm of the elbow crease, deeply dissecting the septum between the flexor carpi radialis and the PT. Then, they released the deep fascia of the PT. In addition, if FDS symptoms were present, they also resected its arch. These authors reported that all treated patients also had carpal tunnel syndrome, which was also released. As a result, 93% improved.[5,22]

3. Tang argues that it is very difficult to differentiate clinically between the PT and FDS. When physical examination reveals that the bicipital aponeurosis is the cause of compression, the author uses the WALANT technique for its release, as in the technique of Hagert et al. If the clinical presentation is nerve entrapment secondary to FDS/PT, the author chooses a distal 3 to 4 cm elbow crease approach. The PT and the arch of the FDS are released, and the bicipital aponeurosis is also released due to the proximity and ease of the approach.[19]

4. Lee and Barnett et al. have proposed endoscopic techniques. They make a 3 cm incision at the level of the bicipital aponeurosis, dissecting by planes to the level of the median nerve in relation to the PT. Through a probe and direct visualization, they extend to proximal, releasing with scissors and performing hemostasis with a bipolar probe. They then proceed to release with distal decompression.[17,28] In a 13-patient series, Lee reported resolution of paresthesia and a >50% improvement in the DASH score.[3,5,28]

5. Ultrasound-guided hydrodissection. It is performed under local anesthesia placed proximal to the compression site. Then, with the injection of 5 ml of 1% lidocaine, it is attempted to generate a 360° decompression in the compression zone determined by ultrasound. Following decompression, the site is immobilized for four weeks before the patient can resume normal activities. The limitation is the need to visualize the compression site by ultrasound (present in only 50% of cases. It is visible as fascicular edema, epineural thickening, and changes in nerve gauge). In some case series, symptoms are reported to have improved more than 75% in 70% of patients treated with this technique.[26]

FINAL CONSIDERATIONS

Compression of the median nerve can occur at different levels in the upper limb. The lack of an accurate and proper diagnosis can lead to the persistence of symptoms; therefore, we believe that a detailed and thorough physical examination can help reduce errors due to the lack of proper treatment. Finally, initial treatment is usually conservative. If this fails, surgical resolution techniques can be chosen, supported by reports of satisfactory outcomes in symptom improvement when treated with any of the multiple surgical options and techniques currently available.

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Standardized Rotator Cuff Repair. Classification of Fundación Santa Fe de Bogotá

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ABSTRACT
Rotator cuff surgery has become more popular in recent years, transitioning from an open technique to arthroscopic surgery. Although multiple techniques for bone fixation have been described, the steps to perform this repair have not been standardized, leading to inconsistencies and heterogeneity in the outcomes. This article proposes a new classification of rotator cuff injuries that will help surgeons make decisions during arthroscopic rotator cuff repair surgery.
Keywords: Rotator cuff repair; arthroscopy; classification; surgery.
Level of Evidence: IV

Reparación sistemática del manguito rotador: Clasificación de la Fundación Santa Fe de Bogotá

RESUMEN
La cirugía de manguito rotador se ha popularizado en los últimos años y pasó de realizarse mediante una técnica abierta, en la mayoría de los casos, a la reparación artroscópica. Se han descrito múltiples técnicas para la fijación del hueso, pero no se han estandarizado el orden y los pasos para llevar a cabo esta reparación, lo que generó inconsistencias y heterogeneidad en los resultados de la reparación. En este artículo, se propone una nueva clasificación de las lesiones del manguito rotador que les permitirá a los cirujanos tomar decisiones durante la cirugía de reparación artroscópica del manguito rotador.
Palabras clave: Reparación del manguito rotador; artroscopia; clasificación; cirugía.
Nivel de Evidencia: IV

INTRODUCTION

Rotator cuff surgery has grown in popularity in recent years, transitioning from an open procedure to arthroscopic treatment in the majority of patients.[1] Multiple techniques for bone fixation have been described,[2-5] but the order and steps for repair have not been standardized, leading to inconsistencies and heterogeneity in repair outcomes.

This article proposes a new classification of rotator cuff injuries that will allow surgeons to make decisions during arthroscopic rotator cuff repair surgery.

CURRENT CLASSIFICATIONS

The current classifications of rotator cuff injury are based on its morphology, size, number of tendons affected, location of the tear, degree of atrophy, and degree of compromise in the insertion (partial/complete) of the tendon, and have been used as a reference to compare results between studies.[6-13] These classifications described do not guide the surgeon during the operation, they do not allow the repair to be standardized for the vast majority of patients, and they do not describe the degree of repair achieved at the end of the surgery, since, in many cases, total repair of the defect is not possible.

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Classification of Fundación Santa Fe de Bogotá (FSFB)

The FSFB classification seeks to standardize rotator cuff repair by providing the orthopedist with management guidance according to the type of injury and describing the degree of repair achieved (Table). It is based on two principles. The first is the repair of the limits of the rotator interval (proximal limit: most anterior portion of the supraspinatus tendon and distal limit: most superior portion of the subscapularis tendon). The second is to achieve an anatomic rotator cuff repair (tension-free tendon repair without folds plus converging sutures in the rotator cuff traction vector; from posteromedial to anterolateral).[14,15]

Table. Classification of Fundación Santa Fe de Bogotá for complete rotator cuff injuries

Type	Definition	Treatment
0	All the tendons are inserted into the bone	Do not repair/End of surgery
I	Tendon disinserted from bone Anteroposterior diameter greater than medial-lateral diameter Crescent-shaped lesion/No apex	Bring the tendon directly to the bone. Use anchors or tunnels Does not require convergence sutures
II	Identifiable apex Proximal rotator interval limit identifiable and inserted into the bone	Requires convergence sutures Posteromedial to anterolateral or anteromedial to posterolateral convergence sutures to close the injury apex Then repair as a type I lesion
III	Injury to the proximal limit of the rotator interval The distal rotator interval limit is inserted into the bone	Fix the apex of the proximal limit to the most superior and lateral part of the subscapularis or to its insertion zone in the most anterior portion of the greater tuberosity Then repair as a type II lesion Then repair as a type I lesion
IV	Injury to the distal limit of the rotator interval	Fix the apex of the distal limit to the lesser tuberosity Then repair as a type III lesion Then repair as a type II lesion Then repair as a type I lesion

The FSFB classification does not refer to the fixation method used (single or double row, anchors or bone tunnels) and is considered an intraoperative classification, which can be extrapolated to pre-surgical magnetic resonance imaging findings.

During surgery, it is possible to classify injuries into five types according to their characteristics and the arthroscopic repair that should be performed. Type 0 injuries refer to a rotator cuff without injury or with all tendons repaired, that is, the injury has already been repaired. Complete repairs with an anchor or repairs to the medial half of the footprint are considered type 0 injuries. An injury is classified as type I when the supraspinatus or infraspinatus tendon is not attached to the greater tuberosity, the anterior portion of the supraspinatus tendon is intact, and there is no apex in the area of tendon injury. In type I lesions, the anteroposterior diameter is usually larger than the mediolateral diameter and they have a crescent shape. The treatment of type I injuries involves bringing the tendon to the bone, and fixing it. It does not require additional convergences or releases (Figure 1).

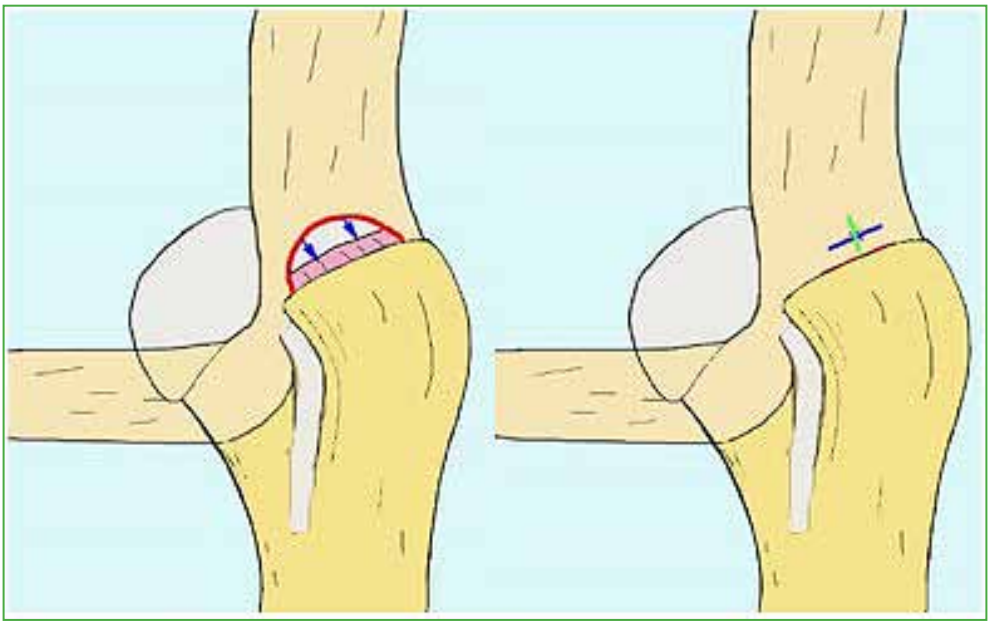

Figure 1. Type I injury: The supraspinatus or infraspinatus tendon is not attached to the greater tuberosity, the proximal limit is intact, and there is no apex in the area of tendon injury (crescent shape). Treatment: bring the tendon to the bone, and fix it.

Type II injuries have an apex in the tendon lesion and the limits of the rotator interval remain intact. Treatment of type II lesions is based on convergence from posteromedial to anterolateral, which converts the lesion to type I and allows it to be repaired as if it were type I (Figure 2).

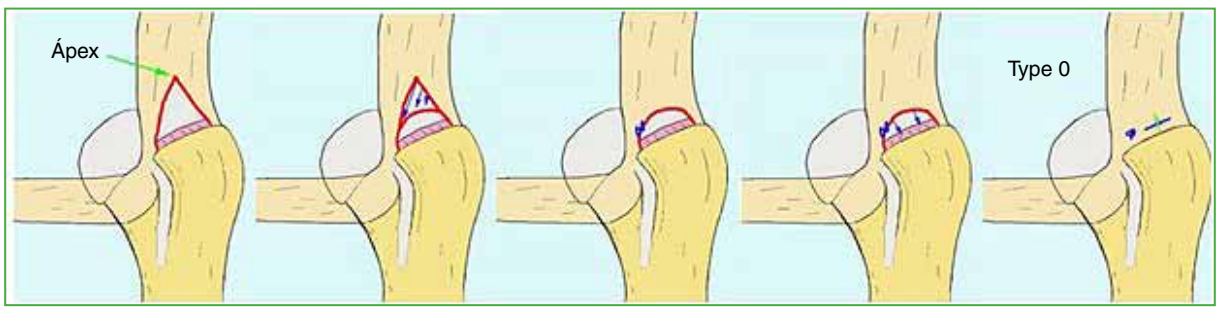

Figure 2. Type II injury: there is an apex in the tendon injury and the limits of the rotator interval are intact. Treatment: converge from posteromedial to anterolateral, making the lesion type I, then repair it as a type I lesion.

Type III injuries are those with a tear in the proximal limit of the rotator interval and with the distal limit attached to the bone. Treatment consists of fixation of the proximal limit, then, it is treated as a type II injury. If there is no apex in the lesion after fixation of the proximal limit, the injury is treated as type I (Figure 3). A type IV lesion is considered when there is a tear of the distal limit of the rotator interval and also isolated injuries to the subscapularis tendon. Management of type IV injuries consists of repairing the subscapularis tendon to the lesser tuberosity and then repairing it as a type III injury (Figure 4). There is not enough evidence to support the separation of the supraspinatus tendon from the subscapularis when they are attached.[16]

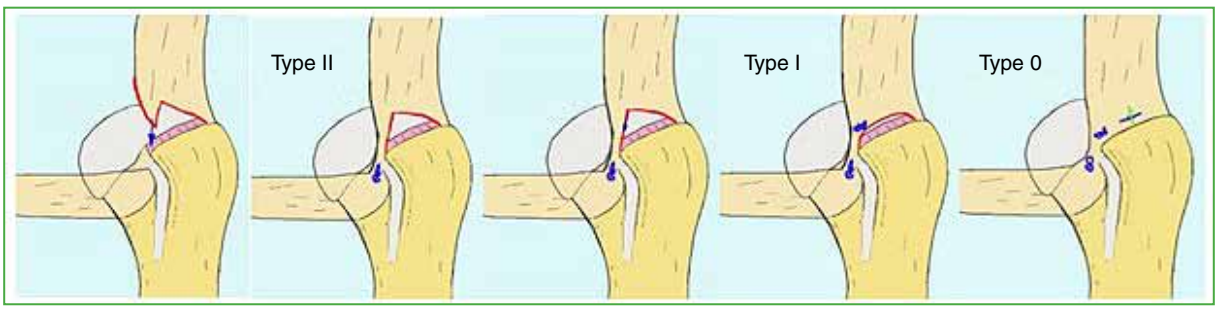

Figure 3. Type III injury: tear of the proximal limit of the rotator interval with the distal limit attached to the bone. Treatment: fixation of the proximal limit, then repair as a type II lesion. If there is no apex in the lesion after fixation of the proximal limit, it is repaired as a type I lesion.

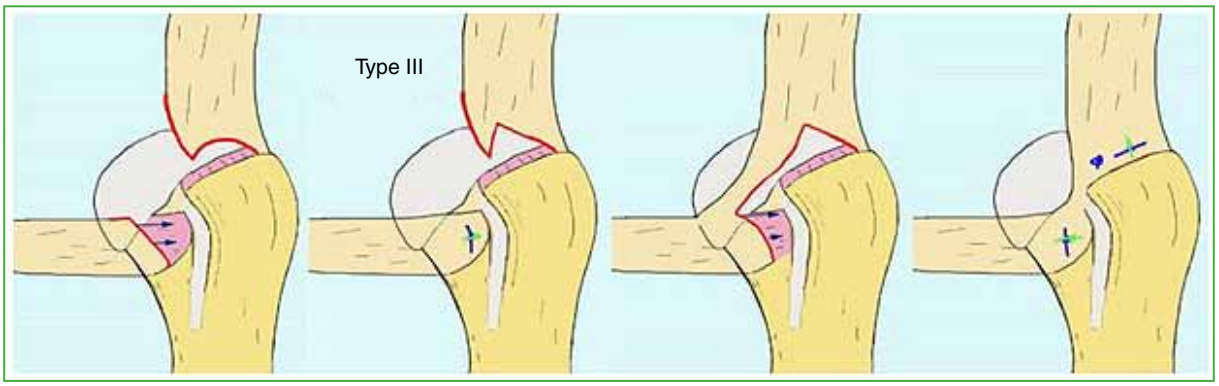

Figure 4. Type IV injury: lesion of the distal limit of the rotator interval. Includes isolated injuries to the subscapularis tendon. Treatment: repair the subscapularis tendon to the lesser tuberosity, then repair as a type III injury.

Surgical procedure

To systematically repair the rotator cuff, surgery can be divided into two components: "non-cuff" and "rotator cuff".

"Non-cuff" components of rotator cuff surgery

The "non-cuff" component refers to all the different procedures for bringing the tendon to the bone. Among the "non-cuff" components, we find the following procedures:

- Tenotomy or tenodesis of the long head of the biceps, includes all types of tenodesis described. The decision between performing a tenotomy or a tenodesis depends on the surgeon's preference for each patient.[17-19]
  - Rotator interval release, which includes resection of the capsule and bursa in the anterior region of the rotator interval, allows better access and facilitates procedures in FSFB type III and IV lesions.[20]
  - Synovitis associated with rotator cuff injuries may increase the likelihood of postoperative stiffness; therefore, in patients with synovitis, we recommend partial or total synovectomy. [21]
  - The joint capsule plays a fundamental role in rotator cuff disease. Its release allows an excursion of the tendon to the footprint with less tension.[22] For type II lesions, we recommend superior, posterior, and inferior capsulotomy and, for type IV lesions, anterior capsule release.

- The subacromial, subdeltoid, and subscapular bursae have a protective and nutritious function, and their dissection is required to perform cuff repair surgery. As a result, we urge that the amount of bursa resected be as minimal as possible unless the patient has extensive bursitis, in which case the release should be substantial.[23]
- In order to allow the excursion of the retracted tendon to the footprint, it must be released at the spine of the scapula in type II injuries and at the lateral aspect of the coracoid, at the level of the coracohumeral ligament, in type IV injuries.
- The decision to modify the shape of the acromion and the amount of acromion resected is chosen based on the patient. There is no solid evidence to support the routine use of acromioplasty in patients with rotator cuff injuries undergoing repair surgery.[24]
- The objective of the debridement of the cuff's footprint on the humerus is to provide a bleeding bed in which to repair the tendon, as this promotes healing. In some published articles,a perforation of the footprint with more than 1 cm depth and less than 2 mm of diameter is suggested for each perforation to promote tendon healing. However, recent studies have not found a statistically significant difference from the above.[25]
- In patients with symptomatic acromioclavicular osteoarthritis, distal clavicle resection surgery is associated with rotator cuff repair.[26]

Once the "non-cuff" component of rotator cuff surgery has been completed, we proceed with the "rotator cuff" component, which consists of planning its repair and fixation to the bone, depending on the characteristics of the lesion.

DISCUSSION

Recent anatomy studies have shown, in more detail, the form of insertion of the rotator cuff tendons, which has allowed us to understand the patterns of retraction and progression of the disease.[27] The distribution of the rotator cuff fibers is not exclusively medial to lateral, but rather fan-shaped with a posteromedial to anterolateral distribution. The repair must reproduce the anatomy of the cuff, so the direction of convergence must be from posteromedial to anterolateral before attaching the tendon to the bone.[14,15]

Numerous studies have been published on techniques for fixing the injured tendon to the bone, but there are no studies that standardize the repair sequence of the rotator cuff tendon, partly because of the extensive variation in tear morphologies and the surgeon's level of skill.[2-5] The current classifications on which the available studies are based do not guide the surgeon during the operation,resulting in very variable decisions made during the operation.[6-13] For this reason, the external validity of the studies is low, given that patients with the same type of injury are treated differently, with varying results from one center to another. Integrative classifications have been described, such as the one proposed by the *International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine* (ISAKOS), in which the classifications described above are grouped in order to better describe the injury, [13] but it does not guide the surgeon during the operation or standardize the way in which rotator cuff repair should be performed.

The FSFB classification emerged in response to the need for a classification that would allow for a systematic and standardized surgical approach to rotator cuff injuries. This classification was designed to guide the surgeon during rotator cuff repair in a homogeneous and standardized way based on the morphology and involvement of the tendons in rotator cuff injuries.

CONCLUSION

The FSFB classification, which is based on the morphology of the injury and tendon involvement, aims to provide the surgeon with a repair process that is simple and standardized, and thus guarantees external validity, allowing the results of the medical literature to be homogenized.

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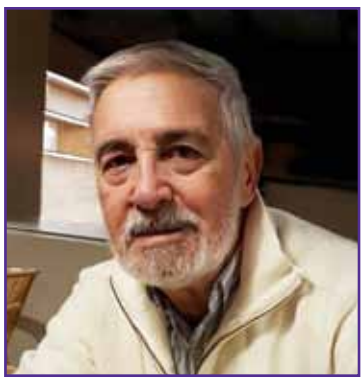
Dr. Gastón Maignon (1950-2023)



I met Gastón Maignon over 30 years ago. In Argentina, our subspecialty was beginning to develop. The concepts being used in our country were, in many cases, outdated, whereas in other parts of the world, there was an "explosion of interest" in shoulder pathology, as Charles Rockwood characterized it.

Gastón had just completed his training with Rockwood and Louis Bigliani. Together, we began taking the first institutional steps in the *Asociación Argentina de Cirugía de Hombro y Codo*. At the same time, we met once a month in my father's office with the participation of Hugo Senes and Pablo Zapata, who was unfortunately disappeared. In those meetings, we shared our experiences, discussed our cases, and tried to find the best solution together. When the situation got the better of us, we would write to Charles Rockwood, knowing that it would take at least two weeks for the letter to reach him. We always received his answers and advice.

Gaston was Head of the Shoulder Team of the Orthopedic Service of Hospital Italiano, President of the Asociación Argentina de Hombro y Codo in 2002 and President of the Sociedad Latinoamericana de Hombro y Codo in 2007. During that year's international congress in Costa do Sauipe, Brazil, he approached me with great enthusiasm, saying that Louis Bigliani had suggested he apply to host the international congress in Buenos Aires.

Together, we began the long road that led to the organization of this event. In 2010, we applied in Edinburgh and were unsuccessful. The Korean Association was the winner.

We decided to persist in our attempt. In 2013, we applied again in Osaka. We were confident, but 20 minutes into the presentation, we learned that, in addition to India, South Africa, and Australia, the United States, a candidate who had never lost, would apply. We were pleasantly surprised to win by a considerable margin as finalists against the United States.

It would be impossible to comment on all the experiences shared during the process of organizing the congress. As a result, many consider this to be the most successful event since the inaugural International Congress in 1980. After that, Gastón continued to participate actively in our meetings of the International Board of Shoulder and Elbow Surgery.

I received his phone call a few weeks ago, apologizing for being unable to attend the Advanced Shoulder Surgery Techniques Course in April due to complications with his health. I asked him to take part in the following one and he agreed. He never lost his collected nature or his optimism, and he was always eager to contribute. His dedication to the subspecialty was unwavering.

Today, I bid this great man, husband, father, and colleague farewell with sadness, admiration, and affection. His memory and legacy will live on in the Asociación Argentina de Cirugía de Hombro y Codo.

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