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Journal of the Argentine Shoulder and Elbow Association Special Issue 2025

Dr. Guido Fierro
President, Latin-American Shoulder and Elbow Society (SLAHOC)

Thirty years ago, the Latin American Shoulder and Elbow Society (SLAHOC) was founded with a clear purpose: to promote excellence in research, education, and patient care while fostering collegiality among surgeons throughout the region. Three decades on, we remain steadfast in our pillars of integrity, collaboration, and innovation, always grounded in ethics and free from personal or commercial interests.

SLAHOC's strength lies in its continental network of societies and national chapters united by a shared banner and common vision. This integration has enabled multicenter projects, the open exchange of knowledge, and mentoring networks that elevate surgical practice across countries. We invite research groups to leverage this network to generate new collaborative, prospective studies that strengthen Latin American clinical evidence. SLAHOC will continue to build the institutional and academic bridges that make this possible.

With the XXVIII SLAHOC Congress (Cartagena de Indias, October 1–4, 2025) just weeks away, this special issue presents reviews and clinical experiences that reflect the vigor of our community. We are confident that the discussions in Cartagena will spark alliances that translate into high-impact projects.

That same vitality is reflected in the pages before you. This special volume brings together original articles, reviews, and clinical experiences that showcase the best of Latin American scholarship in shoulder and elbow surgery. Each contribution has been carefully selected to inform, challenge, and enrich daily practice.

As President of SLAHOC, I encourage you to immerse yourself in this issue, share it with your teams, and let the ideas within inspire you. Reading, debating, and applying this knowledge is one of the most direct ways to improve our patients' lives and keep the flame of innovation burning in our specialty.

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Case Presentation

Nicolás Rabello, J. Javier Masquijo, Lucas D. Marangoni
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Resolution on page 405.

Shoulder Trauma in an Adolescent Patient

ABSTRACT
Differentiating normal ossification variants from fractures in children and adolescents with shoulder trauma is a common diagnostic challenge. We report the case of a 14-year-old male who, after a sports-related injury, was initially diagnosed with a glenoid fracture based on radiographs and computed tomography (CT). Subsequent evaluation, including a detailed physical examination and contralateral shoulder radiographs, showed that the suspected fracture represented normal ossification of the scapular growth centers. This case underscores the importance of a solid understanding of developmental anatomy, a thorough clinical examination, and the use of comparative imaging to avoid misdiagnosis and unnecessary treatment in this population.
Keywords: Ossification; fracture; pediatrics; shoulder; diagnosis.
Level of Evidence: IV

Traumatismo de hombro en un adolescente

RESUMEN
La diferenciación entre las variantes normales de la osificación y las fracturas en pacientes pediátricos y adolescentes con traumatismos de hombro es un desafío diagnóstico común. Presentamos el caso de un varón de 14 años que, tras un traumatismo deportivo, fue inicialmente diagnosticado con una fractura glenoidea sobre la base de estudios radiográficos y tomográficos. Una evaluación posterior, que incluyó un examen físico detallado y radiografías contralaterales, reveló que la supuesta fractura correspondía a la osificación normal de los centros de crecimiento escapulares. Este caso subraya la importancia de un conocimiento profundo de la anatomía del desarrollo, un examen clínico exhaustivo y el uso de estudios comparativos para evitar diagnósticos erróneos y tratamientos innecesarios en esta población.
Palabras clave: Osificación; fractura; pediatría; hombro; diagnóstico.
Nivel de Evidencia: IV

INTRODUCTION

A 14-year-old boy (14 years 11 months) presented to the Department of Orthopedics and Traumatology with a sling on the right arm and a prior diagnosis of glenoid cavity fracture. The injury followed a ground-level fall while playing rugby. At the initial Emergency Department evaluation, shoulder radiographs (Figure 1) and multidetector CT with multiplanar reformats and 3-D reconstructions (Figure 2) were obtained.

FINDINGS AND INTERPRETATION OF THE IMAGING STUDIES.

The CT report stated: “A glenoid fracture is observed in the superior region extending toward the base of the coracoid process,” and the patient was prescribed immobilization, analgesics, and specialist follow-up.

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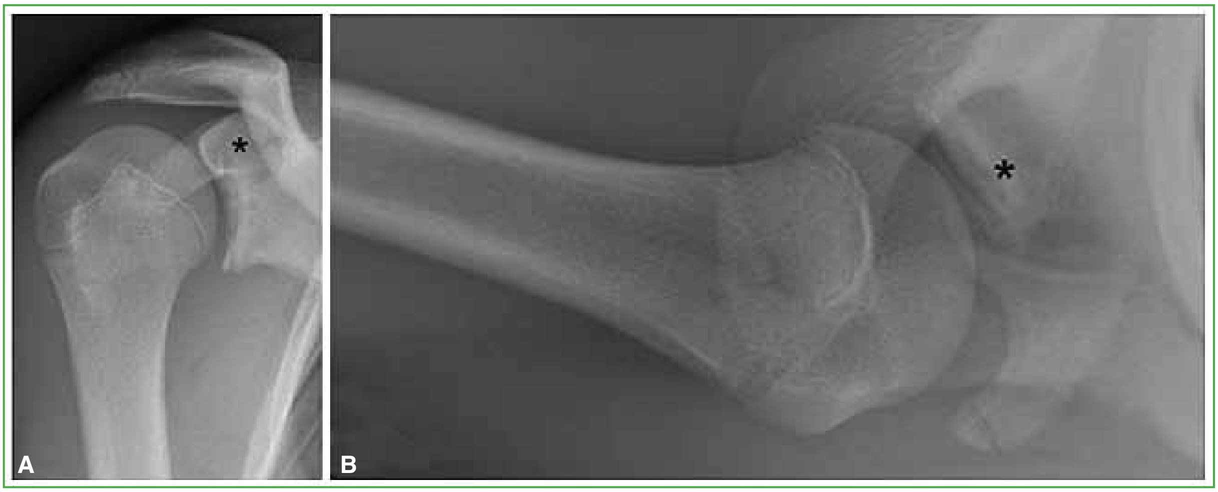

Figure 1. Shoulder radiographs, anteroposterior (**A**) and axial (**B**) views. Linear lucency at the superior glenoid articular surface (*) compatible with a fracture line. Joint spaces preserved.

Figure 2. CT of the right shoulder. Although initially reported as a fracture of the glenoid surface extending into the coracoid ossification center, the images are consistent with the normal secondary ossification centers of the coracoid and the inferior glenoid in a 14-year-old boy, shown on axial (**A**), coronal (**B**), and 3-D reconstruction (**C**).

At 48 hours post-injury, he was assessed by a sports shoulder specialist. Examination showed mild swelling in the anterior shoulder, localized tenderness on palpation (VAS 3/10), and full range of motion without meaningful asymmetry compared with the contralateral side.

Clinical questions. Given the preliminary diagnosis and these initial findings, is the information sufficient to establish a definitive diagnosis and treatment plan? What additional studies would you obtain and why?

To corroborate the suspected glenoid fracture and identify any associated injuries, a shoulder MRI was requested.

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

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Stemless Humeral Prosthesis and Meniscal Allograft: Should We Abandon This Technique?

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ABSTRACT

Introduction: Managing advanced glenohumeral osteoarthritis in young, active patients is complex and controversial. This study reports outcomes after humeral resurfacing arthroplasty combined with meniscal allograft. **Materials and Methods:** Twenty-five patients (mean age, 47.3 years) were included, with a mean follow-up of 66.1 months. Pre- and postoperative assessments included imaging, range of motion, and functional scores (VAS, ASES, and Simple Shoulder Test). In a subgroup of 10 patients, the same variables were reassessed at 6 years postoperatively. **Results:** One-year outcomes improved significantly versus baseline: VAS decreased from 7.3 to 2.8; ASES increased from 31.3 to 70.5; SST from 3.6 to 7.3; forward elevation improved from 70° to 135°; abduction from 57° to 103°; external rotation with the arm at side from 25° to 55°; and internal rotation from 1.4 to 4 points (0–5 scale). In the 10 patients evaluated at 6 years, there was a statistically significant deterioration across all variables relative to the 1-year results, although values remained substantially better than preoperative levels. Radiographs showed progressive glenohumeral joint-space narrowing in all patients. **Conclusions:** This surgical technique yielded meaningful improvements in pain, mobility, and quality of life and proved safe, with no major complications.

Keywords: Prosthesis; humeral head; osteoarthritis; allograft; meniscus; hemiarthroplasty.

Level of Evidence: IV

Prótesis humeral sin vástago y aloinjerto meniscal: ¿se debe abandonar?

RESUMEN

Introducción: El tratamiento de la artrosis glenohumeral avanzada en pacientes jóvenes y activos es complejo y controvertido. El objetivo de esta presentación es comunicar los resultados de una serie de pacientes sometidos a artroplastia humeral de superficie y aloinjerto de menisco. **Materiales y Métodos:** Se incluyó a 25 pacientes (edad promedio 47.3 años) con un seguimiento promedio de 66.1 meses. Antes de la cirugía y después, se evaluaron los estudios por imágenes, el rango de movilidad y las escalas funcionales (EAV, ASES y *Simple Shoulder Test*). Se analizaron las mismas variables en un subgrupo de 10 pacientes a los 6 años de la operación. **Resultados:** Los valores preoperatorios mejoraron significativamente al año de seguimiento: EAV de 7,3 a 2,8; ASES de 31,3 a 70,5; *Simple Shoulder Test* de 3,6 a 7,3; elevación anterior de 70° a 135°, abducción de 57° a 103°, rotación externa con el brazo aducido de 25° a 55° y rotación interna de 1,4 a 4 puntos (evaluada con un puntaje de 0 a 5). En los 10 pacientes evaluados a los 6 años de la cirugía, los resultados mostraron un deterioro estadísticamente significativo en todas las variables, aunque con una mejora sustancial respecto a los valores preoperatorios. En las radiografías, se observó una pérdida progresiva de la luz articular glenohumeral en todos los pacientes. **Conclusiones:** Con esta técnica quirúrgica hemos obtenido buenos resultados en cuanto a la mejoría del dolor, la movilidad y la calidad de vida, fue un procedimiento seguro y sin complicaciones mayores.

Palabras clave: Prótesis; cabeza humeral; artrosis; aloinjerto; menisco; hemiartroplastia.

Nivel de Evidencia: IV

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INTRODUCTION

Advanced glenohumeral osteoarthritis in young, active patients is a difficult clinical problem with no ideal solution. Management is especially challenging when conservative treatment fails and there is extensive joint damage. Progressive pain, restricted motion, and high functional demands in this population often limit the effectiveness of nonoperative care.[1,2]

Traditionally, numerous options have been described: arthroscopic debridement, glenoplasty, arthrodesis, partial or total shoulder arthroplasty, and more recently, biologic therapies.[3,4] Although hemiarthroplasty has been the most frequently indicated procedure, its results have been inferior to total arthroplasty because of long-term glenoid erosion and frequent conversion to total prosthesis.[5,6] Total arthroplasty relieves pain and improves function, but complications such as wear, glenoid loosening, and periprosthetic fracture limit its use in young, active patients.[2]

Concerns about polyethylene durability at the glenoid have fueled interest in biologic materials for non-prosthetic reconstruction. Interposition using joint capsule, autogenous fascia lata, Achilles tendon allograft, and meniscal allograft has been reported with variable success.[7-10]

Meniscal allograft in young patients with knee osteoarthritis has shown healing potential and durability.[7,9] Cementless humeral resurfacing prostheses yield outcomes comparable to stemmed implants in active young patients, with fewer complications, and they facilitate future revisions by preserving humeral bone stock.[8]

With these concepts in mind, the aim of this study was to retrospectively evaluate short- and mid-term functional outcomes in a group of active patients with glenohumeral osteoarthritis treated with humeral resurfacing hemiarthroplasty and biologic interposition using a cryopreserved, non-irradiated lateral meniscal allograft from our tissue bank.

MATERIALS AND METHODS

From June 2003 to June 2023, 30 patients with symptomatic, advanced glenohumeral osteoarthritis underwent hemiarthroplasty with a humeral surface prosthesis (Copeland Mark III®, MacroBond, Biomet, Warsaw, IN, USA) combined with a non-irradiated frozen lateral meniscal allograft from our institutional tissue bank. All procedures were performed by the same experienced surgeon (level V on Tang's expertise scale).[11] Retrospective assessments were carried out by Upper Limb Surgery staff who were not involved in the cases.

Inclusion criteria: 1) symptomatic glenohumeral osteoarthritis, grade 3 (severe) per the Samilson–Prieto radiographic classification[12] (Table 1); 2) age ≤55 years; 3) treatment with humeral resurfacing plus meniscal allograft; 4) pain (visual analog scale [VAS] ≥6) and functional limitation refractory to at least 8 months of conservative treatment (NSAIDs, activity modification, rehabilitation, injections) or prior arthroscopic synovectomy and lavage.

Table 1. Samilson–Prieto radiographic classification of osteoarthritis.

Grade 1 (Mild)	- Osteophytes < 3 mm at the humeral head or glenoid. - Normal or slightly decreased joint space.
Grade 2 (Moderate)	- Osteophytes 3-7 mm at the humeral head or the glenoid. - Moderately decreased joint space. - Mild subchondral sclerosis may be present.
Grade 3 (Severe)	- Osteophytes > 7 mm at the humeral head or glenoid. - Significant joint-space loss. - Subchondral sclerosis and cysts may be present.

Exclusion criteria: 1) follow-up <1 year; 2) rheumatoid arthritis or signs of active infection; 3) previous hemiarthroplasty; 4) tears of two or more rotator cuff tendons.

Bipolar osteoarthritis (involvement of both articular surfaces) was diagnosed based on 1) clinical history, 2) radiographs to stage osteoarthritis per Samilson–Prieto,[12] and 3) intraoperative findings in patients who had previously undergone arthroscopy. Glenoid cartilage damage (degeneration, erosions, asymmetric wear, and cartilage loss) was confirmed intraoperatively before proceeding. All patients were carefully evaluated with radiographs (AP, axillary, and AP with internal and external rotation), CT with 3D reconstruction and image suppression, and non-contrast MRI. These studies were used to select the lateral meniscal allograft best suited to resurface the glenoid according to morphotype and glenoid erosion (Walch criteria[13]) and to assess the presence of rotator cuff injuries. CT was also obtained postoperatively (immediate, 6 months, 1 year, then annually) to document the glenohumeral joint space achieved at surgery and to monitor allograft wear over time.

Function was assessed preoperatively and at 1, 3, 6, and 12 months postoperatively during the first year, then annually. Outcomes included VAS and active range of motion (abduction, forward elevation, internal rotation, and external rotation with the arm adducted). Internal rotation was graded by the highest vertebral level reached with the thumb extended (Table 2).

Table 2. Scale used to measure internal rotation.

Level reached for internal rotation	Score
Greater trochanter	0
Posterior superior iliac spine	1
Sacroiliac joint	2
L4-L5	3
L1-T12	4
T12-T9	5

The ASES (*American Shoulder and Elbow Surgeons*) score and the *Simple Shoulder Test* (SST) were also collected.

Twenty-five of the 30 operated patients met inclusion criteria. Twenty were men and five were women. Mean age was 47.3 years (range, 35–55). Twenty had right-sided involvement, and the dominant limb was affected in 17 cases (Table 3).

Diagnoses included: sequelae of humeral fracture-dislocation (2 cases) and prior surgery for anterior glenohumeral instability (20 cases): seven had open procedures (Putti-Platt [4], Bristow [2], and unspecified anterior capsular plication [1]) and 13 had arthroscopic procedures (Bankart repair, 10 with metal anchors and 3 with biodegradable implants). In seven instability cases (open and arthroscopic), osteoarthritis was accompanied by glenoid bone defects due to malpositioned implants (incorrectly placed 3.5-mm screws or anchors). Five of these seven had undergone exploratory arthroscopy with debridement for pain relief. The remaining three cases were idiopathic primary osteoarthritis with concentric joint narrowing. All patients were considered active and high demand based on work or sport (Table 4).

Table 3. Demographic data

Patients	Age	Sex	Laterality	Dominant side	Follow-up (months)
1	35	F	Right	Yes	21
2	46	M	Right	Yes	30
3	41	F	Right	Yes	27
4	47	M	Right	Yes	79
5	50	M	Right	No	97
6	51	M	Left	No	66
7	39	F	Left	Yes	42
8	41	M	Right	No	50
9	46	M	Right	Yes	28
10	47	F	Left	No	27
11	46	M	Right	Yes	60
12	48	M	Right	Yes	78
13	49	M	Right	No	80
14	43	M	Right	Yes	47
15	50	M	Left	Yes	77
16	52	M	Right	No	85
17	47	M	Right	Yes	90
18	55	M	Right	No	120
19	49	M	Right	Yes	133
20	45	F	Right	Yes	64
21	42	M	Left	Yes	66
22	49	M	Right	No	156
23	54	M	Right	Yes	57
24	55	M	Right	Yes	40
25	55	M	Right	Yes	33
Average	47.28	Male (80%)	Right side (80%)	Dominant side (70%)	66.12

M = male; F = female

Table 4. Cause of glenohumeral osteoarthritis and previous surgeries.

Patients	Cause of osteoarthritis	Previous interventions	Joint impingement
1	Humerus fracture-dislocation	ORIF, material removal and arthroscopic debridement	Concentric
2	Instability	Arthroscopic surgery, arthroscopic debridement	B1 glenoid bone defect
3	Instability	Arthroscopic surgery, arthroscopic debridement	Glenoid B1 bone defect
4	Instability	Arthroscopic surgery	Concentric
5	Instability	Open surgery	Concentric
6	Instability	Open surgery	Concentric
7	Instability	Arthroscopic surgery	Concentric
8	Instability	Arthroscopic surgery	B1 glenoid bone defect
9	Instability	Arthroscopic surgery	Concentric
10	Instability	Arthroscopic surgery	Concentric
11	Instability	Open surgery	Concentric
12	Instability	Arthroscopic surgery	Concentric
13	Instability	Arthroscopic surgery, arthroscopic debridement	Glenoid bone defect B2
14	Idiopathic	Arthroscopic debridement	Concentric
15	Instability	Open surgery	Concentric
16	Idiopathic	No	Concentric
17	Idiopathic	Arthroscopic debridement	Concentric
18	Instability	Open surgery, arthroscopic debridement	Glenoid bone defect B2
19	Instability	Arthroscopic surgery	Concentric
20	Instability	Arthroscopic surgery	Concentric
21	Humerus fracture-dislocation	ORIF, material removal and arthroscopic debridement	Concentric
22	Instability	Arthroscopic surgery	Concentric
23	Instability	Open surgery	Concentric
24	Instability	Arthroscopic surgery	B2 glenoid bone defect
25	Instability	Open surgery, arthroscopic debridement	B1 glenoid bone defect

ORIF = open reduction, internal fixation.

Statistical Analysis

Continuous variables are presented as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. To compare VAS, ASES, and SST scores before surgery, after surgery, and across follow-up in the full cohort, the nonparametric Friedman test was used given the longitudinal, non-normal data. A p value <0.05 was considered significant.

A specific subgroup of 10 patients who completed a minimum of 6 years (72 months) of follow-up was analyzed for mid-term outcomes. Paired comparisons in this subgroup were performed with the Wilcoxon signed-rank test. Analyses were conducted with SPSS version 25.0 (IBM Corp., Armonk, NY, USA).

Surgical Technique (Figure 1)

All procedures were performed under brachial plexus block plus general anesthesia in the beach-chair position. A deltopectoral approach was used in all cases. When necessary, the subscapularis and anteroinferior capsule were elevated to obtain adequate tendon excursion, including release of adhesions in the subcoracoid space. The anterior capsule and subscapularis were elevated as a single layer to facilitate reattachment to the greater tuberosity. If external rotation was markedly limited, priority was given to repositioning the subscapularis by medializing it. Excessive posterior excursion of the humeral head was addressed by closing the rotator interval with simple Vicryl® sutures. Tenotomy and tenodesis of the long head of the biceps at the superior aspect of the subscapularis were routinely performed. The intra-articular biceps and the superior labrum were resected.

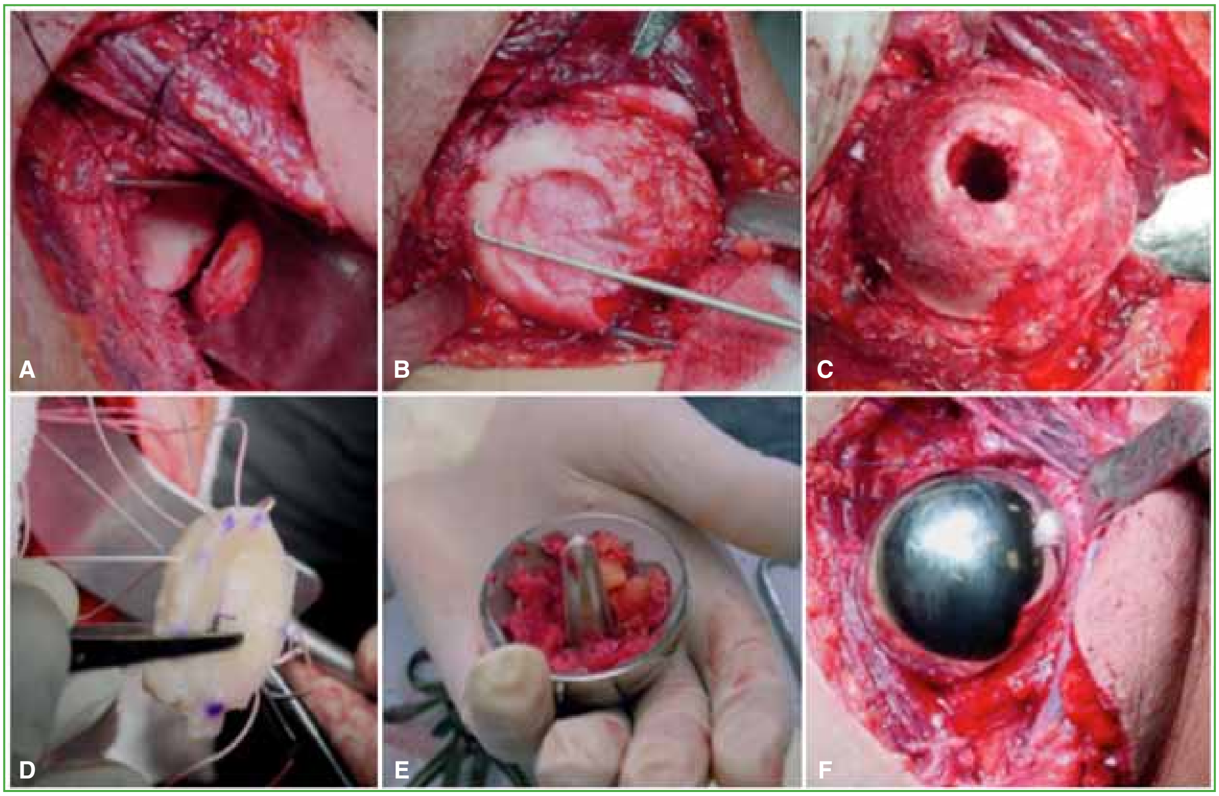

Figure 1. Key steps during surgery. **A.** Glenoid preparation. **B, C.** Humeral head preparation. **D.** Presentation and fixation of the meniscal allograft with suture anchors. **E, F.** Placement of a surface prosthesis with cancellous bone graft.

Glenoid step: to ensure allograft viability and avoid rupture, fixation strategy was meticulous. Based on intraoperative cartilage defects and asymmetric wear, the glenoid was reamed to a bleeding bed with complete labral debridement. Asymmetric reaming was performed when needed to correct deformity. The lateral meniscus, previously resected from a cadaveric tibial plateau, was prepared on a side table (Figure 2).

Leaving sufficient tissue for reinforcement, the anterior and posterior horns were sutured together and the graft was positioned according to the defects encountered, especially in Walch type B1 or B2 glenoids.13 Fixation was achieved with suture anchors, borrowing concepts from heart-valve prosthesis fixation: the glenoid was divided into quadrants and at least two anchors were placed in each quadrant (Figure 3).

Figure 2. Humeral resurfacing prosthesis with meniscal allograft.

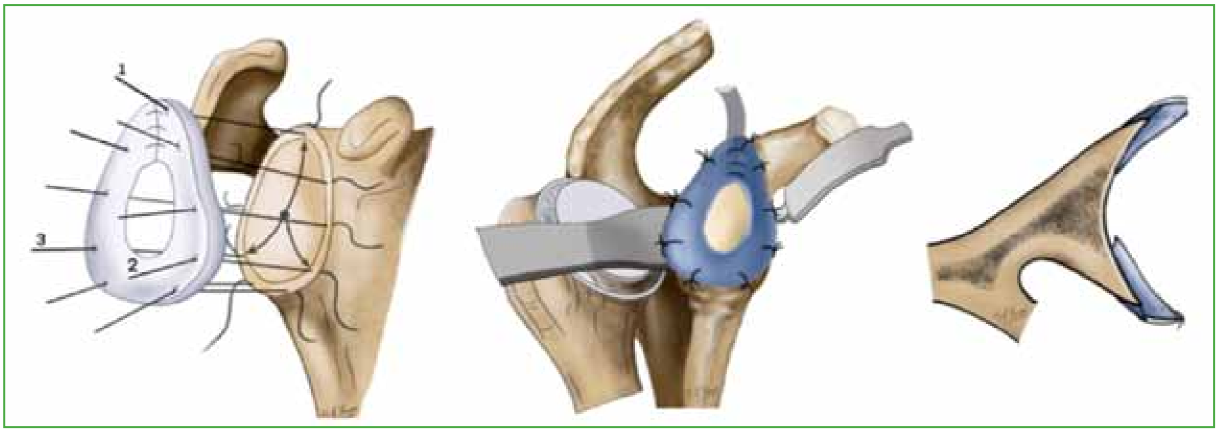

Figure 3. Preparation of the lateral meniscus on the back table.

Eight anchors were used. Early in the series these were metallic (2.8-mm FASTak, Arthrex®), later biodegradable (Bio-SutureTak®, Arthrex®), all with high-strength sutures (FiberWire®). The meniscus was trialed and all sutures placed prior to final fixation.

Humeral step: after controlled dislocation and humeral head preparation, an uncemented humeral resurfacing prosthesis was implanted in all cases (Copeland Mark III®, MacroBond; Biomet, Warsaw, IN, USA) (Figure 4).

Humeral bone defects larger than 5 mm in diameter were filled with cancellous bone allograft plus 1 g of vancomycin powder. When humeral head deformity was substantial, an image intensifier was used to determine the cervicodiaphyseal angle and humeral version. Small rotator cuff lesions were repaired with sutures; no procedures were performed on the acromioclavicular joint or the subacromial space. After meniscal fixation and prosthesis implantation, the subscapularis was reattached to the greater tuberosity with 5.5-mm anchors, with the arm adducted and 10° of external rotation. Layered closure and intradermal skin closure were performed. No drains were used. Mean operative time was 135 ± 13.95 minutes (range, 120–180).

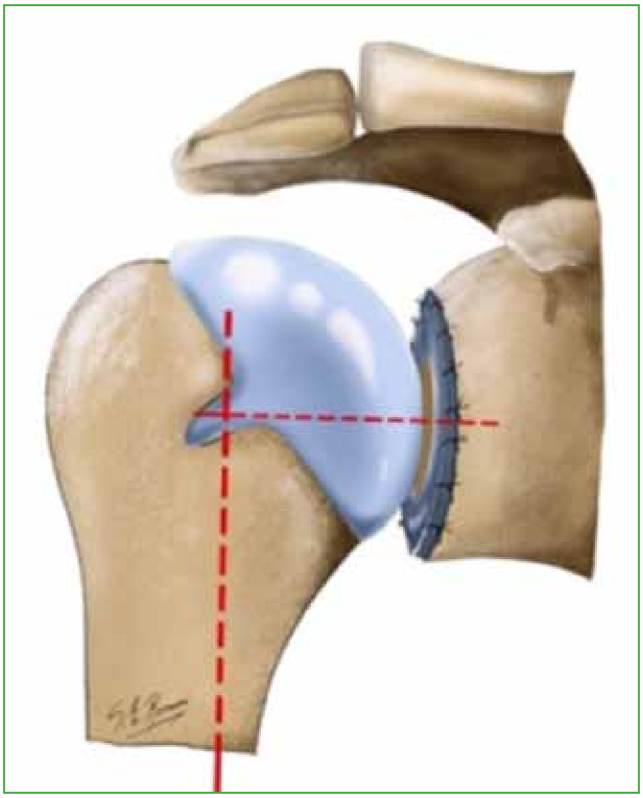

Figure 4. Schematic of glenoid fixation of the lateral meniscal allograft with suture anchors.

Postoperative Rehabilitation Protocol

Weeks 1-6 (protection and passive motion): continuous sling use (20° elevation in the scapular plane). From day 1, elbow and wrist exercises and Codman pendulums were started. At 2 weeks, physical therapy began; full passive flexion, adduction, and internal rotation were allowed, while external rotation was limited to 45° to protect the meniscal allograft.

From Week 7 (active motion and progressive strengthening): full passive stretching of external rotation and active motion were initiated. Progressive strengthening began at 12 weeks. Return to sport was individualized according to each patient's progress and tolerance.

RESULTS

Twenty-five patients were evaluated with a mean follow-up of 66.1 months (range, 21–156). Functional outcomes improved progressively and significantly across all clinical scores.

Mean VAS pain decreased from 7.32 ± 1.31 preoperatively to 2.76 ± 1.14 at 12 months ($p < 0.00001$; Friedman test). ASES improved from 31.32 ± 5.54 to 70.52 ± 11.84 ($p < 0.00001$), indicating significant functional recovery. SST increased from 3.64 ± 1.02 to 7.28 ± 1.40 over the same period ($p < 0.00001$), this indicates an improvement in functional perception by the patient (Figure 5).

Figure 5. Functional evaluation 8 years after surgery. Forty-six-year-old man with primary glenohumeral osteoarthritis treated with humeral resurfacing and lateral meniscal allograft interposition.

Active range of motion also improved. Forward elevation increased from 70.0° ± 25.0° preoperatively to 135.3° ± 24.8° at 12 months. Abduction rose from 57.2° ± 5.8° to 103.4° ± 9.0°. External rotation with the arm adducted improved from 25.1° ± 2.5° to 55.0° ± 4.6°. Internal rotation, graded on an ordinal scale, improved from 1.48 ± 0.50 to 4.04 ± 0.72 over the same period (Figures 6 and 7).

With appropriate rehabilitation, 20 patients returned to work or sport; 13 without restriction and seven at a lower level than expected because of concern about trauma affecting durability.

Mid-term outcomes (6 years): in the subgroup of 10 patients with at least 6 years of follow-up, we compared 12-month versus 6-year outcomes regarding pain and function scores, as well as active ranges of motion (Table 5) .

There was a statistically significant decline in pain and function scores (VAS, ASES, SST) and in active range of motion (forward elevation, abduction, external and internal rotation) at 6 years relative to 12 months. Despite this decline, mean 6-year values still represented substantial improvement over preoperative baselines.

Table 5. Functional values in the subgroup evaluated 6 years after surgery.

Parameter	Mean ± SD at 12 months	Mean ± SD at 6 years	p (Wilcoxon)
VAS	2.6 ± 1.2	3.2 ± 1.0	0.038
ASES	75.0 ± 10.4	69.0 ± 9.4	0.007
SST	7.8 ± 1.6	6.8 ± 1.6	0.008
Forward elevation	147.5 ± 18.0	139.3 ± 18.0	0.005
Abduction	105.5 ± 8.2	97.4 ± 9.6	0.005
External rotation	55.4 ± 3.9	49.9 ± 4.4	0.005
Internal rotation	4.1 ± 0.7	3.8 ± 0.6	0.025

VAS = visual analog scale; ASES = *American Shoulder and Elbow Surgeons*; SST = *simple shoulder test*.

Radiographic findings: preoperatively, all 25 shoulders had Samilson–Prieto[12] grade-3 osteoarthritis (loss of joint space, cysts, and osteophytes) (Figures 6 and 7).

Figure 6. Preoperative radiographs and CT of the patient in Figure 5.

Figure 7. Postoperative radiographs of the patient in Figure 6. **A.** Immediate postoperative. **B.** Two years after surgery. **C.** Eight years after surgery.

Seven had asymmetric glenoid wear (Walch type B1 in 4 and B2 in 3[13]). In addition, seven shoulders had moderate subluxation and one had severe subluxation. Postoperatively, subluxation resolved in 22 shoulders and persisted mildly in three. Mean glenohumeral joint space increased from 1.2 mm (range, 0–3) to 3.4 mm (range, 1–5) (Figure 8).

Follow-up CT demonstrated progressive joint-space reduction due to meniscal allograft wear, correlated with time. On last-follow-up CTs, glenoid erosion was classified as minimal/none in 15 patients (60%), moderate in 7 (28%), and severe in 3 (12%). These qualitative findings confirm long-term glenoid wear despite meniscal interposition; erosion was an anticipated complication.

Intraoperative notes included rotator cuff repair with nonabsorbable sutures in two patients with prior humeral fracture-dislocation (one supraspinatus tear, one subscapularis tear). Five patients had variable numbers of loose bodies.[1-3] No infections occurred. One patient had an uncomplicated postoperative hematoma, and one woman with osteonecrosis from fracture-dislocation had poor functional outcome but marked pain improvement.

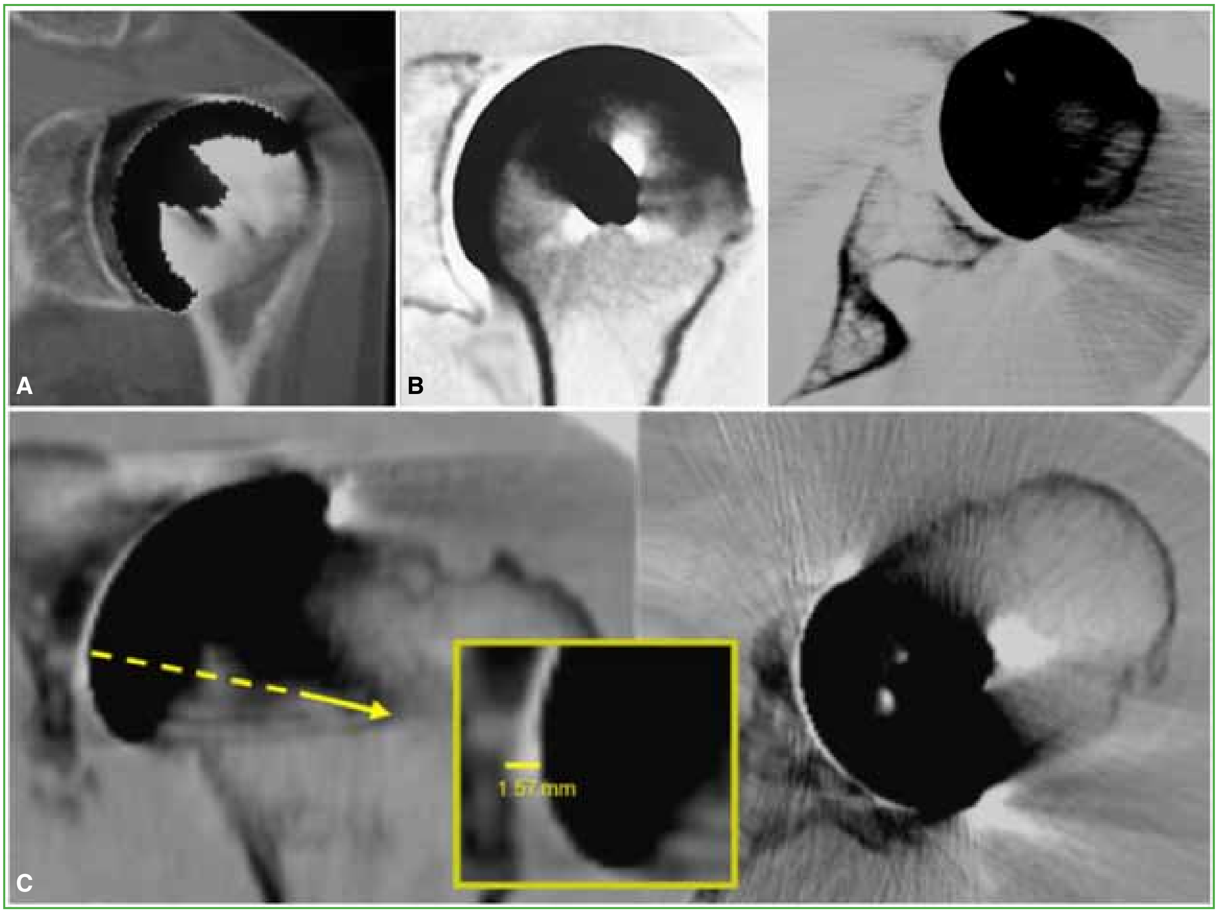

Figure 8. Progressive decrease in joint space on CT due to meniscal allograft wear. **A.** Immediate postoperative joint space 6.0 mm. **B.** Two years after surgery, 4.0 mm. **C.** Eight years after surgery, 1.57 mm (same patient as Figures 5–7).

DISCUSSION

Treating glenohumeral osteoarthritis in young, active patients is complex and controversial. Primary wear is uncommon; secondary causes after arthroscopic instability surgery are more frequent.[14] Conservative care may help initially but is insufficient in advanced stages. Current literature favors total shoulder arthroplasty for short- and mid-term clinical outcomes,[15] yet higher complication and revision rates have been reported in younger patients, mainly due to glenoid component wear.[16,17] A systematic review found high revision (17.4%) and complication (9.4%) rates in patients younger than 65 years, with glenoid lucency in 54% at 9.4 years.[16] A Mayo Clinic study of more than 5000 cases showed that older age is associated with lower risks of reoperation, revision, mechanical failure, and infection.[17] The risk of revision decreased 3% per year after age 50, and infection risk decreased 1% after age 55. Patients aged 50–65 years had 35% fewer revisions, and those older than 65 had 55% fewer, compared with patients younger than 50. Other studies also report increased revisions in younger patients, with significant glenoid failures at 10 years.[18,19]

In response, the concept of "buying time and quality of life" has been proposed,[20] based on biologic interposition options that delay joint deterioration without compromising future surgery. One of the pioneers in proposing this technique was Burkhead,[9] who paired hemiarthroplasty with autografts (capsule, fascia lata) or allografts (Achilles), reporting variable but encouraging results. In this study, we chose meniscal interposition—tailored to the articular surface—based on favorable survivorship in young knees and its mechanical advantages: load transmission, reduced cartilage stress, shock absorption, stability, lubrication, and chondrocyte nutrition.[21] The shape of the lateral meniscus, with the anterior and posterior horns sutured together, allows an excellent fit to the glenoid and humeral head, decreasing glenohumeral pressure by about 10% through force dispersion.[22,23] Meniscal interposition aims to improve congruence and act as a biologic articular spacer. Among preservation methods, frozen, frozen plus gamma irradiation, and cryopreservation are most used.[24] Several studies report that cadaveric meniscus should be cryopreserved, not lyophilized or irradiated, to preserve structure and biomechanics.[21,24-26] Many reports do not specify preservation method. In all our patients we used non-irradiated cryopreserved lateral meniscal allograft, which may help explain our clinical results by maintaining microstructure. We also favored humeral resurfacing for several advantages: it better recreates normal biomechanics by preserving the humeral center of rotation compared with stemmed hemiarthroplasty, reduces operative time, and preserves bone for future reResults of interposition arthroplasty are variable.[20] Results of interposition arthroplasty are variable. Puskas et al.[6] reported unacceptably high early failure in 17 hemiarthroplasties with various biologic glenoid resurfacings; three of five meniscal cases required revision within 22 months. Lee et al.[10] reported complications in 32% of 19 patients treated with hemiarthroplasty and meniscal allograft, with reoperation in six (32%) at 4.25 years. Both groups favored total shoulder arthroplasty as a more predictable option with lower failure. Others have reported positive outcomes.

Wirth[2] treated 27 patients with hemiarthroplasty and lateral meniscal allograft, observing pain relief and improved function at 2–5 years despite radiographic joint narrowing. In long-term follow-up (mean 8.3 years), the same group[27] reported very good functional outcomes, though with a 30% revision rate. Despite narrowing, the humeral head remained centered, possibly due to capsular release, soft-tissue balancing, rotator cuff preservation, and glenoid reaming.

Direct comparative studies between interposition and isolated hemiarthroplasty are scarce. In young patients, one study found unfavorable results in both groups, with hemiarthroplasty alone superior for pain relief and lower revision rates.[28] Notably, interposition tissues varied (human acellular dermal matrix and lateral meniscal allograft) and sterilization methods were not specified. More comparative research is needed to determine optimal treatment.

Recently, hemiarthroplasty using a pyrocarbon humeral head has emerged as a promising option for young, active patients.[29,30] Pyrocarbon has an elastic modulus similar to bone, offers durability and antimicrobial properties, and virtually eliminates risk of stem loosening by avoiding intramedullary fixation.[29] In a retrospective series, Barret et al.[29] evaluated 62 active patients (mean age, 60 years) and reported 87% 10-year survivorship, with best results in type-A glenoids. It is not recommended for type-B2 glenoids or subscapularis insufficiency given high revision rates (44%). Garret et al.[30] reported satisfactory clinical scores with minimal glenoid erosion results in

37 patients treated with pyrocarbon humeral heads at mid-term follow-up (5-9 years). At the end of follow-up, glenoid erosion was minimal (moderate in 24% and severe in 8%), with satisfactory clinical scores. Although not yet available in our setting, this alternative represents meaningful progress toward durable solutions for young patients.

Despite the favorable early results in our series, this retrospective case series without a control group has inherent limitations, and findings should be interpreted accordingly. Strict inclusion criteria yielded a limited sample, constraining statistical power. While we observed significant mid-term improvements in pain and function, our 6-year subgroup analysis showed a statistically significant decline in functional scores and motion, and meniscal wear, although values remained substantially better than preoperative baselines, indicating preserved function. Patients with a history of fracture-dislocation fared worse than those with prior instability, suggesting that altered tuberosities may impair biomechanics and allograft viability, making such patients less suitable for this technique. Strengths include sample homogeneity, systematic clinical and radiographic follow-up, and a single high-experience surgeon, which ensures technical consistency. The 6-year functional analysis, though small, is a valuable and uncommon contribution for this intervention.

CONCLUSIONS

Humeral resurfacing with lateral meniscal allograft remains a valuable option in young, active patients. With strict patient selection and sound surgical technique, we achieved good improvements in pain, motion, and quality of life. Bone-stock preservation is a significant advantage that facilitates future revision if required.

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Sex Differences in Recovery After Brachial Plexus Injuries: Anatomical and Physiological Basis and Clinical Study

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ABSTRACT

Introduction: Brachial plexus injuries (BPIs) are severe, disabling, and impose a high socioeconomic burden. Restoring elbow flexion is paramount to functional recovery. Anatomical and physiological characteristics of peripheral nerves in males and the peripheral effects of testosterone may contribute to better recovery in men than in women. **Materials and Methods:** Observational, retrospective case series. Thirty-nine patients with BPI who underwent musculocutaneous nerve neurotization were included. **Results:** In males, the mean BMRC score was 4; the functional reinnervation rate (BMRC ≥3) was 89%, and the surgical failure rate (BMRC <3) was 11%. In females, the mean BMRC score was 3.5; functional reinnervation was achieved in 67%, with a surgical failure rate of 33%, and there was a greater tendency to failure with increasing patient age. Differences in strength achieved by subgroup according to the BMRC scale were statistically significant (p = 0.05). **Conclusions:** Men show a greater capacity for motor recovery than women after musculocutaneous nerve neurotization. Additionally, the risk of surgical failure increases with age in females. These findings may be explained by sex-related differences in peripheral nerve anatomy and physiology and by testosterone-related mechanisms acting on the nervous system and muscle.

Keywords: Brachial plexus injuries; neurotization; nerve transfers; testosterone.

Level of Evidence: IV

Diferencias entre los sexos en la recuperación de las lesiones del plexo braquial. Bases anatómicas, fisiológicas y estudio clínico

RESUMEN

Introducción: Las lesiones del plexo braquial son graves, incapacitantes y generan un alto costo socioeconómico. Restaurar la flexión del codo resulta primordial para la recuperación. Las características anatomofisiológicas de los nervios de los varones y los efectos periféricos de la testosterona podrían jugar un papel en la mejor recuperación de los hombres sobre las mujeres. **Materiales y Métodos:** Estudio observacional, retrospectivo, tipo serie de casos. Se incluyó a 39 pacientes con lesiones del plexo braquial sometidos a neurotizaciones del nervio musculocutáneo. **Resultados:** En el sexo masculino, el puntaje promedio de la escala BMRC fue 4; la tasa de reinervación funcional (BMRC ≥3), del 89% y la tasa de falla quirúrgica (BMRC <3), del 11%. En el sexo femenino, el puntaje promedio de la escala del BMRC fue 3,5; se logró la reinervación funcional en el 67%, con una tasa de falla quirúrgica del 33%, hubo una mayor tendencia a la falla conforme aumentaba la edad de la paciente. Las diferencias de fuerza lograda por subgrupo según la escala del BMRC fueron estadísticamente significativas (p = 0,05). **Conclusiones:** Los hombres tienen una capacidad de recuperación motora mayor que las mujeres luego de las neurotizaciones del nervio musculocutáneo. Además, existe una mayor tendencia a la falla quirúrgica en el sexo femenino conforme aumenta la edad. Esto podría explicarse por las diferencias anatomofisiológicas del nervio periférico entre los sexos y por mecanismos ligados a la testosterona tanto sobre el sistema nervioso como en los músculos.

Palabras clave: Lesiones del plexo braquial; neurotizaciones; transferencias nerviosas; testosterona.

Nivel de Evidencia: IV

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INTRODUCTION

Brachial plexus injuries (BPI) are severe, highly disabling, and impose a substantial socioeconomic burden on the health system. Their incidence, although difficult to quantify precisely, has increased in recent years due to improved survival after severe motor vehicle accidents.[1] The mean patient age at the time of injury is 26.4 years, and 90.5% of cases occur in males.[2]

Restoring elbow flexion is a critical first step toward final function and recovery of the affected limb. Neurotization of the musculocutaneous nerve or its branches using different techniques has been established as the reference procedure to achieve this goal.

In this study, two neurotization strategies were used according to the pattern of BPI to be reconstructed: Oberlin type I (ulnar nerve fascicle to the biceps branch of the musculocutaneous nerve) for upper BPI (C5–C6) and transfer of the spinal accessory nerve (XI) to the musculocutaneous nerve with an autologous sural graft for total BPI.

The main hypothesis was that men would have greater functional recovery potential after peripheral nerve injuries, including BPI, and would therefore obtain better results after nerve transfers for BPI. This was based on the following considerations:

- Male axons have up to 80% greater cross-sectional area and up to 55% more microtubules, which makes them more resistant to stretch injury.3
- After trauma, intracellular calcium rises rapidly in female axons, which reduces excitability; this response is less pronounced in males.[3]
- Testosterone appears to play a key role in two effector systems:[3-6]
  - In neurons: it promotes axonal growth and repair after peripheral nerve injury and protects neurons in the injured pathway from dendritic atrophy through interactions with androgen receptors in the central nervous system.4,5
  - In muscle: it delays degeneration after denervation and reduces the shift from type I to type II fibers.6 This is crucial in neurotization because it prolongs the time during which a denervated muscle remains amenable to reinnervation.

In published BPI neurotization series,[1,2,7,8] we did not find clear reports of sex-based differences in recovery. Given our sample size, extended follow-up, and a relatively higher proportion of women than in most series, we conducted this study to assess whether sex-related differences in recovery potential truly exist. Our findings may help set realistic goals and prognoses for postoperative recovery.

MATERIALS AND METHODS

The primary objective was to determine whether there were significant differences in recovery of bíceps strength between men and women operated on for BPI. The secondary objective was to identify other factors associated with biceps strength recovery after BPI surgery.

Study Design

We conducted an observational, retrospective case series of patients operated on between January 2009 and July 2022 at one public and one private institution in Córdoba. The surgical techniques were the Oberlin procedure and XI-to-musculocutaneous nerve transfer with a sural nerve graft. All surgeries were performed by the senior author (FJC).

Patient Selection

We included consecutive patients with traumatic BPI and loss of elbow flexion who underwent surgery during the study period. Exclusion criteria were follow-up shorter than 6 months, conditions that delayed or precluded proper surgical technique or rehabilitation (more than 1 year from injury), and irreparable complete BPI.

Selection of the Surgical Technique

Technique selection depended on the BPI pattern. For upper BPI (C5–C6 or C5–C7), the ulnar nerve was available as an intraplexal donor and the Oberlin procedure was chosen. For total BPI (C5–T1), intraplexal donors were not available and the spinal accessory nerve was used as an extraplexal donor.

Data Collection

From electronic medical records we extracted age, sex, date of birth, cause and type of injury, affected limb, time from injury to first specialist visit, type of surgery, time from injury to surgery, motor recovery after surgery, length of follow-up, and postoperative biceps strength according to the British Medical Research Council (BMRC) scale.[9]

Outcome Measurement

The primary outcome was improvement in biceps strength measured with the BMRC scale.[10] Several publications report excellent correlation between dynamometer-measured torque and electromyographic activity when compared with BMRC functional grades.[11] A BMRC score lower than 3 was considered surgical failure.

Statistical Analysis

Because variables were not normally distributed, nonparametric tests were used. For comparisons of numerical variables we applied the Wilcoxon rank-sum test, Fisher's exact test, and the exact Wilcoxon test. A p value lower than 0.05 was considered significant. Analyses were performed with RStudio Version 1.4.1106.

RESULTS

Thirty-nine patients were included: 33 men (84.6%) and 6 women (15.4%). Demographic characteristics are shown in Table 1.

Six of the 33 men did not meet inclusion criteria; no women were excluded. The statistical analysis included 27 men (81.8% of included patients) and 6 women (18.2%) (Figure 1).

The two groups were homogeneous with respect to age, time from BPI to surgery, and length of follow-up (Table 2).

Overall mean age was 25 years. The mean interval from injury to surgery was 211 days and mean follow-up was 1043 days. Fourteen patients (42%) underwent XI-to-musculocutaneous nerve transfer and 19 (58%) underwent the Oberlin procedure. The mean BMRC score was 4. Surgical failure occurred in 5 patients (15%).

When techniques were compared regardless of sex, the XI-to-musculocutaneous group had a mean BMRC score of 3.1 and a failure rate of 21%. In the Oberlin group, the mean BMRC score was 3.5 with a failure rate of 11% (Table 3).

Table 1. Demographic characteristics of the study patients.

Patient	Type of surgery	Age (years)	Sex	Time to surgery (days)	Follow-up (days)	BMRC Scale
1	SAN-TO-MCN TRANSFER	30	M	300	3476	3
2	SAN-TO-MCN TRANSFER	22	F	280	1572	4
3	SAN-TO-MCN TRANSFER	19	M	145	2621	4
4	SAN-TO-MCN TRANSFER	44	M	215	1700	3
5	SAN-TO-MCN TRANSFER	21	M	317	1880	5
6	SAN-TO-MCN TRANSFER	31	M	241	1981	3
7	SAN-TO-MCN TRANSFER	27	F	280	361	2
8	SAN-TO-MCN TRANSFER	38	M	143	850	4
9	SAN-TO-MCN TRANSFER	19	M	241	220	0
10	SAN-TO-MCN TRANSFER	43	M	158	740	4
11	SAN-TO-MCN TRANSFER	28	M	148	373	3
12	SAN-TO-MCN TRANSFER	23	M	311	1687	0
13	SAN-TO-MCN TRANSFER	19	M	167	616	4
14	SAN-TO-MCN TRANSFER	17	M	211	1435	4
15	Oberlin	23	M	538	1314	3
16	Oberlin	28	M	623	4296	3
17	Oberlin	23	M	338	1735	4
18	Oberlin	18	M	180	1043	5
19	Oberlin	49	M	305	169	3
20	Oberlin	25	F	101	435	4
21	Oberlin	33	M	204	988	4
22	Oberlin	50	F	260	1145	2
23	Oberlin	22	M	240	337	4
24	Oberlin	25	M	185	1411	3
25	Oberlin	24	F	234	945	5
26	Oberlin	33	M	287	1376	4
27	Oberlin	29	M	149	387	4
28	Oberlin	20	M	130	1686	4
29	Oberlin	28	M	195	848	4
30	Oberlin	25	F	200	322	3
31	Oberlin	38	M	130	1433	0
32	Oberlin	17	M	136	989	4
33	Oberlin	30	M	122	424	3
34	SAN-TO-MCN TRANSFER	25	M	321	0	-
35	SAN-TO-MCN TRANSFER	28	M	162	0	-
36	Oberlin	53	M	631	0	-
37	Oberlin	39	M	185	0	-
38	Oberlin	21	M	163	0	-
39	Oberlin	28	M	s/d	0	-

SAN-TO-MCN TRANSFER = spinal accessory nerve to musculocutaneous nerve transfer; F = female; M = male; BMRC = *British Medical Research Council*.

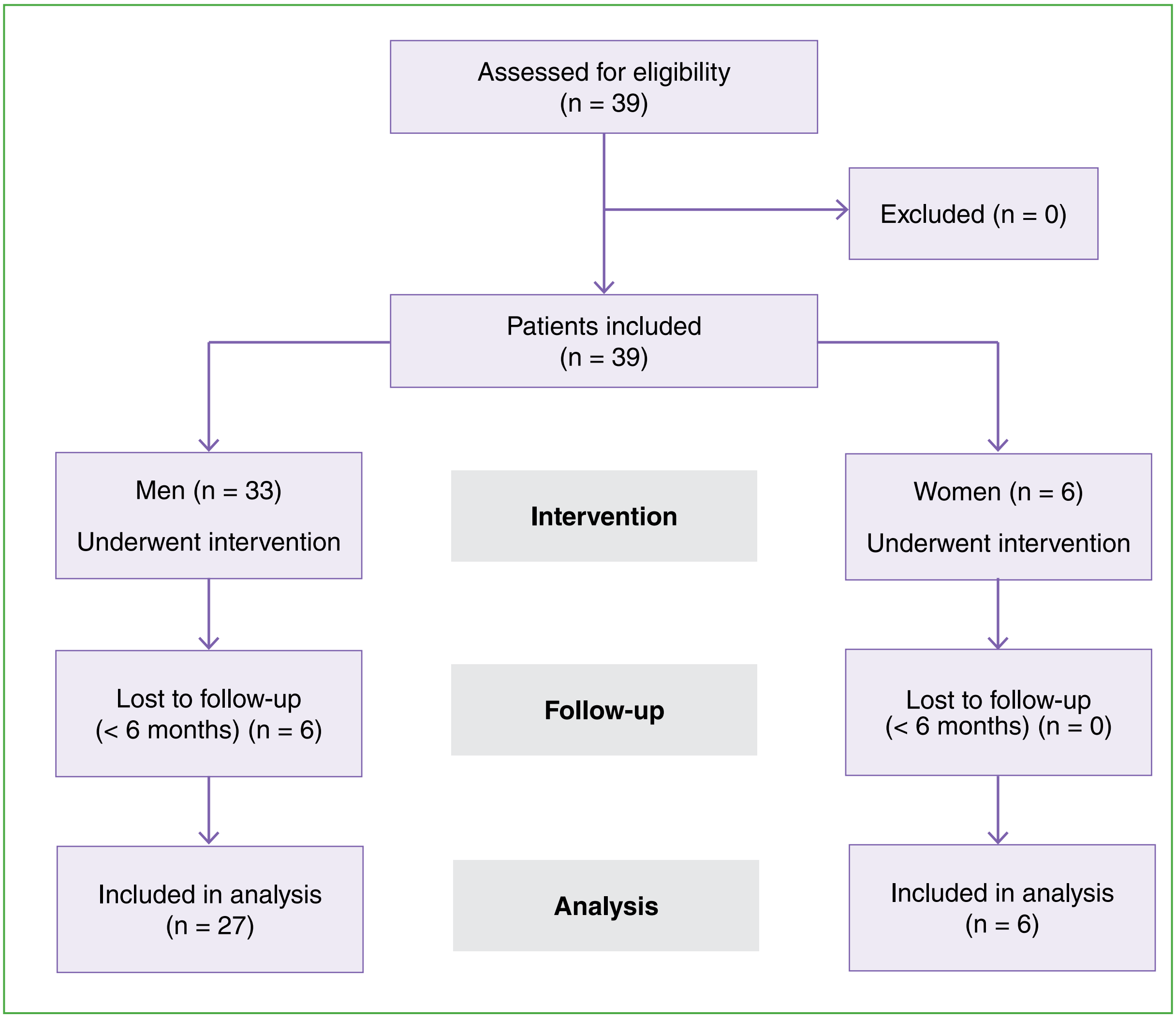

Figure 1. Flow diagram showing the distribution of the overall patient sample.

In women, mean age was 25 years (range 22–50), mean time from injury to surgery was 247 days, and mean follow-up was 690 days. Sixty-seven percent underwent the Oberlin procedure. The mean BMRC score was 3.5 and there were 2 failures (33%).

In men, mean age was 28 years (range 17–53), mean time from injury to surgery was 204 days, and mean follow-up was 1314 days. Fifty-six percent underwent the Oberlin procedure. The mean BMRC score was 4 with 3 failures (11%).

Within BMRC strength subgroups, 24 of 27 men (89%) and 4 of 6 women (66%) achieved M3 or greater. Overall surgical failure (BMRC ≤ 2) occurred in 5 of 33 patients (15%): 2 women (33% of women) and 3 men (11% of men) (Table 2; Figure 2). These subgroup differences on the BMRC scale were statistically significant ($p = 0.05$) (Table 2).

On multivariate analysis correlating age and sex with functional outcomes, age was not related to failure rate among men. In women there was a greater tendency toward failure with increasing age (Figure 3). The two failures in this group occurred in the two oldest women in the series.

Table 2. Overall sample results

Characteristic	Population (n= 33)*	Female sex (n= 6)*	Male sex (n= 27)*	p**
Age	25 (17-53) (IQR 22-31)	25 (22-50) (IQR 24-27)	28 (17-53) (IQR 21-32)	0.9
Time of evolution (days)	211 (149-280)	247 (209-275)	204 (149-294)	0.8
Time of evolution (months)	7.03 (4.97-9.33)	8.23 (6.95-9.17)	6.8 (4.95-9.78)	0.8
Surgery				
SAN-TO-MCN TRANSFER	14 (42%)	2 (33%)	12 (44%)	
Oberlin	19 (58%)	4 (67%)	15 (56%)	
Follow-up (days)	1043 (435-1686)	690 (380-1095)	1314 (678-1694)	0.2
Follow-up (months)	35 (15-56)	23 (13-37)	44 (23-56)	0.2
BMRC scale (categorical)				0.05
0	3 (9.1%)	0 (0%)	3 (11%)	
2	2 (6.1%)	2 (33%)	0 (0%)	
3	10 (30%)	1 (17%)	9 (33%)	
4	15 (45%)	2 (33%)	13 (48%)	
5	3 (9.1%)	1 (17%)	2 (7.4%)	
Average BMRC scale (numerical)	4 (3-4)	3.5 (2.25-4)	4 (3-4)	0.8
Surgical failure	5 (15%)	2 (33%)	3 (11%)	0.2

*Mean (range); IQR = interquartile range; n (%)
**Wilcoxon rank sum test, Fisher's exact test and Wilcoxon exact test.
SAN-TO-MCN TRANSFER = spinal accessory nerve to musculocutaneous nerve transfer; BMRC = *British Medical Research Council*.

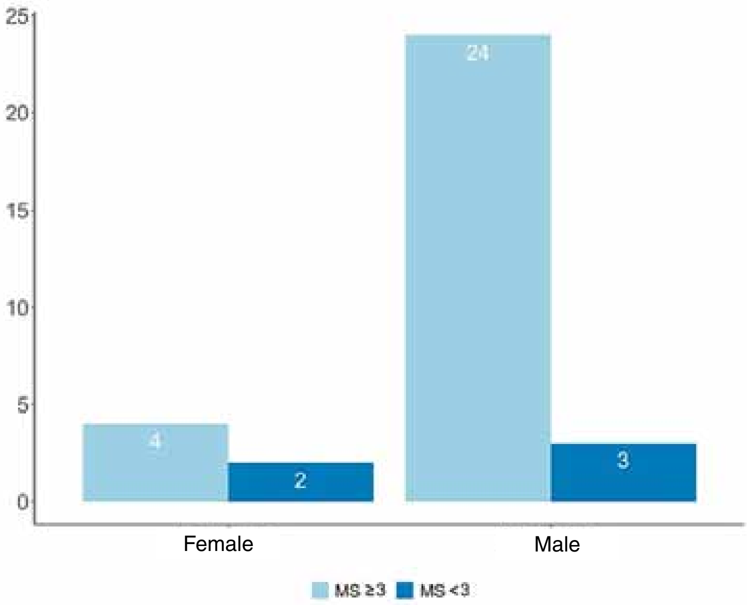

Figure 2. Distribution of surgical outcomes by sex.

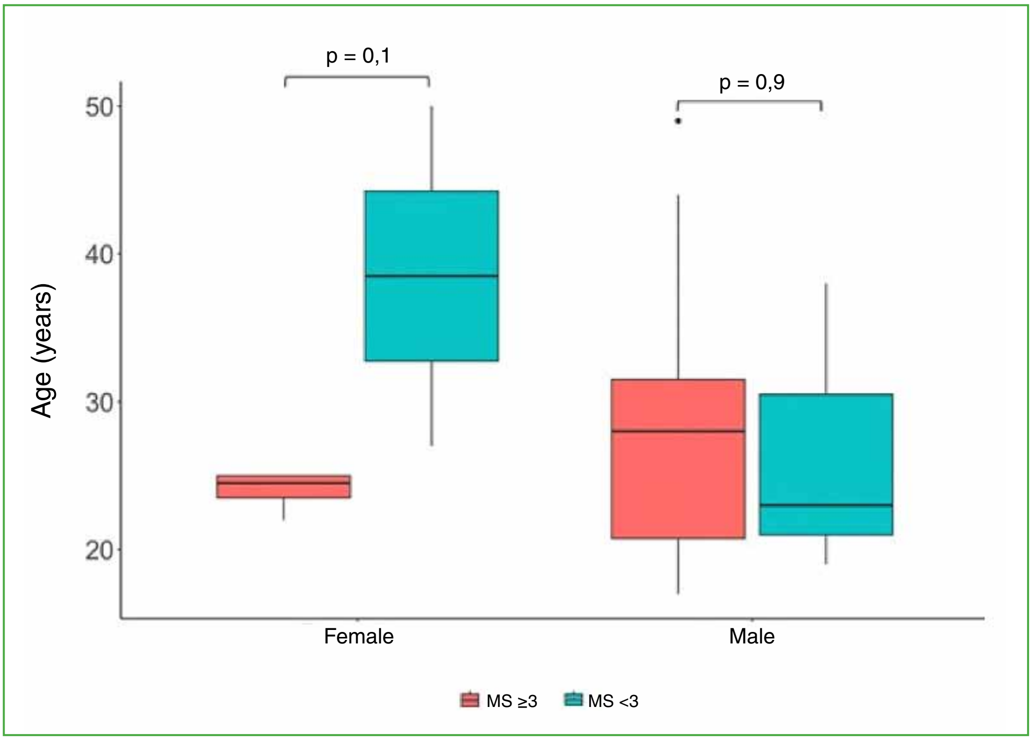

Figure 3. Relationship between functional outcome by sex and age.

Table 3. Functional outcomes and failures according to the technique used.

	SAN-TO-MCN TRANSFER (14)	Oberlin (19)	p
BMRC, mean ± SD	3.1 ± 1	3.5 ± 1	0.4
Failure, n (%)	3 (21)	2(11)	0.4

SAN-TO-MCN TRANSFER = spinal accessory nerve to musculocutaneous nerve transfer; BMRC = *British Medical Research Council*; SD = standard deviation.

DISCUSSION

Our literature search found no relevant reports addressing sex-based differences in postoperative biceps strength after neurotization. Even published meta-analyses do not mention such differences.[8-10] This likely reflects the predominance of BPI in men, which leaves most case series with too few women for meaningful comparison.

Overall, strength outcomes were better with the Oberlin procedure than with XI-to-musculocutaneous transfer, and failure rates were lower with the former. This can be explained by procedural features. In Oberlin type I, the nerve impulse crosses a single neurorrhaphy and travels a shorter distance to the target muscle. In XI-to-musculocutaneous transfer, the distance is longer and the impulse crosses two neurorrhaphies. This is critical because between 6 and 12 months after injury, the motor end plate undergoes progressive degeneration and loss of function. Axonal regeneration advances about 1 mm per day and requires roughly 30 days to cross each neurorrhaphy.[12] To date, there are no direct comparative studies of recovery between these two techniques. Our results align with expectations for the reasons noted.

In our series, men achieved significantly higher BMRC strength subgrades than women after musculocutaneous nerve neurotization ($p = 0.05$).

The mean BMRC score was also higher in men than in women (4 vs 3.5; $p = 0.8$), and functional reinnervation defined as BMRC ≥ 3 was achieved in 89% of men versus 67% of women ($p = 0.2$).

These differences may be attributable to sex-related anatomical and physiological characteristics of peripheral nerves and to the protective and regenerative effects of testosterone after nerve injury. The hormone may also slow muscle degeneration after surgery. Further research into these mechanisms would help clarify these findings.

We also observed an age-related trend toward surgical failure in women, which is important when counseling patients about prognosis and recovery. This may relate to progressive declines in endogenous estrogens and androgens with age and to physiologic loss of muscle mass associated with postmenopausal changes. This trend was not observed in men.

A strength of this study is the proportion of women, nearly 20%, which is higher than the approximately 10% reported in many series. Limitations include a mean interval from injury to surgery greater than 6 months, which reflects delays to specialist evaluation in the public health setting, and the use of two different surgical techniques according to BPI type, each with distinct technical features and reinnervation timelines.

CONCLUSIONS

Men had better functional outcomes and a lower failure rate than women after musculocutaneous nerve neurotization for BPI. There was also a greater tendency toward surgical failure in women as age increased. These findings may be explained by sex-related anatomical and physiological differences in peripheral nerves and by testosterone-linked mechanisms acting on both the nervous system and muscle. Larger series and deeper investigation of these mechanisms are needed to support these observations.

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

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Displaced Midshaft Clavicle Fractures in Adolescents: Outcomes with Flexible Intramedullary Nail Fixation

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ABSTRACT

Introduction: This study reports radiological and functional outcomes, surgical times, and intraoperative radiation exposure in patients aged 10–18 years with simple displaced midshaft clavicle fractures treated with flexible intramedullary nails, stratified by reduction type (open vs closed). **Materials and Methods:** Retrospective analysis of prospectively collected electronic medical record data. Adolescents with acute, displaced, noncomminuted clavicular shaft fractures treated with flexible intramedullary nails and with 1-year follow-up were included. **Results:** Sixteen patients were included (mean age, 14 years). Mean time from injury to surgery was 9.3 days. Seven patients required open reduction, mainly when delays exceeded 11 days. Procedures using closed reduction had longer intraoperative radiation exposure times. Fracture union occurred by 6 weeks. The Constant–Murley score improved from 83.35 at 6 weeks to 95.88 at 1 year. Osseous adaptation was observed in some patients, with an increase in clavicular diameter. **Conclusions:** Flexible intramedullary nailing is an acceptable option for treating simple displaced midshaft clavicle fractures in adolescents. When time from injury exceeds 10 days, open reduction should be considered to reduce intraoperative radiation exposure.

Keywords: Clavicle fracture; intramedullary nail.
Level of Evidence: IV

Fracturas diafisarias desplazadas de clavícula en adolescentes. Resultados con clavos elásticos endomedulares

RESUMEN

Introducción: El objetivo de este estudio fue evaluar los resultados obtenidos en adolescentes con fractura completas simples desplazadas del tercio medio de la clavícula tratados con clavos elásticos endomedulares, la evolución clínico-radiológica, la complicaciones, la duración del procedimiento y de la exposición a la radiación según el tipo de reducción. **Materiales y Métodos:** Análisis retrospectivo de datos recopilados prospectivamente de las historias clínicas electrónicas. Se incluyó a adolescentes con fracturas agudas desplazadas no conminutas de la diáfisis clavicular que habían sido tratados con clavos endomedulares flexibles y tenían un seguimiento de 1 año. **Resultados:** El estudio incluyó a 16 pacientes. La edad promedio era de 14 años. El tiempo promedio hasta la cirugía fue de 9.3 días. Siete pacientes necesitaron reducción abierta, principalmente debido a retrasos superiores a 11 días. El tiempo de exposición a la radiación intraoperatoria fue mayor en los procedimientos que incluyeron reducciones cerradas. La consolidación ósea ocurrió en 6 semanas. El puntaje de la escala de Constant-Murley mejoró de 83,35 a las 6 semanas a 95,88 al año. Se observó una adaptación ósea en algunos pacientes, con un aumento del diámetro de la clavícula. **Conclusiones:** Los clavos endomedulares son una alternativa aceptable para el tratamiento de las fracturas simples desplazadas del tercio medio de la clavícula en la población adolescente. Para reducir el tiempo de exposición a la radiación intraoperatoria, es recomendable considerar la reducción abierta cuando el tiempo de evolución sea >10 días.

Palabras clave: Fractura de clavícula; clavo endomedular.
Nivel de Evidencia: IV

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INTRODUCTION

Clavicle fractures account for about 15% of fractures in childhood and adolescence, most commonly at the midshaft.[1,2] In this population, nonoperative care remains the first-line treatment because simple fractures rarely progress to nonunion and even malunions often remodel owing to late medial and lateral physeal closure.[3,4] However, remodeling potential depends on skeletal (bone) age: approximately 80% of clavicular growth is achieved by age 9 in girls and by age 12 in boys, so remodeling after adolescence is limited.[5] Together with recent reports showing poor tolerance of nonunion and malunion in this group, especially in athletically active adolescents, this has shifted some indications toward reduction and internal fixation.[1,4,6-9]

Loss of bone length is a common complication of conservative treatment and can significantly impair function.[3,10-15] Plate-and-screw fixation is widely used but carries risks such as neurovascular injury and peri-implant fracture, particularly in children and adolescents.[3,11,12,16,17] These concerns have increased interest in elastic intramedullary nailing in this population, given lower complication rates.

The aim of this study was to report outcomes in adolescents treated with flexible intramedullary nails, including clinical and radiographic evolution, complications, and the effect of approach and implant diameter on operative time and fluoroscopy time.

MATERIALS AND METHODS

We performed a retrospective study of patients operated on between June 2021 and June 2023 by the same surgeon at two clinics. Inclusion criteria: complete midshaft clavicle fractures (Allman Group I), simple closed traumatic fractures with >2 cm displacement (overlap/shortening or diastasis) in any radiographic plane (Robinson type 2B1) despite figure-of-eight bandage or sling, age 10–18 years.[18] Exclusion criteria: fractures >3 weeks old; comminuted fractures (Robinson 2B2); open, pathologic, or insufficiency fractures; buckle or greenstick fractures; prior clavicle fracture or refracture; and <1 year of clinical–radiographic follow-up.

The variables analyzed were: age; complications; need for an incision at the fracture site (open reduction); days to surgery; operative time and intraoperative fluoroscopy time; nail diameter; Constant–Murley score (6 weeks, 3 months, 1 year); and radiographic evolution (union and adaptive changes) at 1 year.

Because the minimal clinically important difference for Constant–Murley in diaphyseal clavicle fractures is unknown, we referenced the general shoulder literature value of 10.4 points.[19]

Surgical Technique

Patients were positioned beach-chair with a Philadelphia collar and eye protection. Combined anesthesia (sedation plus brachial plexus block) and antibiotic prophylaxis were administered per protocol. The operative field (hemithorax and affected upper limb) was prepared with double preoperative washing using 4% chlorhexidine soap and antisepsis with chlorhexidine digluconate plus alcohol (20 mg chlorhexidine digluconate and 0.49 ml ethyl alcohol [Laboratorio Bohm S.A., Madrid, Spain]); sterile drapes and an arm holder (Trimano Fortis® Support Arm, Arthrex®) were used. A 1.5-cm incision was made along Langer's lines, 3 cm medial to the fracture site. Closed reduction and internal fixation with a flexible intramedullary nail (Stryker® T2 Kids; titanium Ti-6Al-4V ELI, ASTM F136; ISO 5832-3; Type II anodized; laser-etched diameter bands; diameters 1.5, 1.75, 2.0, 2.25 mm) were performed under direct fluoroscopy with the C-arm contralateral to the operative side. Nail diameter was selected at ~40% of the intramedullary canal measured on preoperative AP radiographs; if not exact, the larger diameter was chosen to avoid an overly flexible construct. Nails were inserted straight (without prebending). An entry portal was created in the anterior cortex 4–6 cm medial to the fracture with a 3.2-mm awl and soft-tissue cannula. After closed reduction with two reduction forceps, the chosen nail was advanced under fluoroscopy using a universal T-handle driver. The nail was cut with a pin cutter and seated into cancellous bone of the lateral fragment using an impactor and slotted hammer, leaving 5–7 mm of the nail proud at the medial fragment cortex. No end caps were used.

If closed reduction could not be achieved (with forceps or terminal bending), a 3-cm incision at the fracture site was made for open reduction.

Postoperative care: sling for 3 weeks (removed for home exercises: passive forward flexion to 90°, external and internal rotation). At 3 weeks, the sling and wound sutures/staples were removed; from week 4, passive and active motion were progressed.

RESULTS

According to the inclusion criteria, nineteen patients underwent elastic intramedullary nailing during the study period; three were excluded (two lost to 1-year follow-up; one refracture operated after 2 months following initial conservative care of an angulated fracture, Robinson 2A2). Sixteen patients were analyzed (Figure 1).

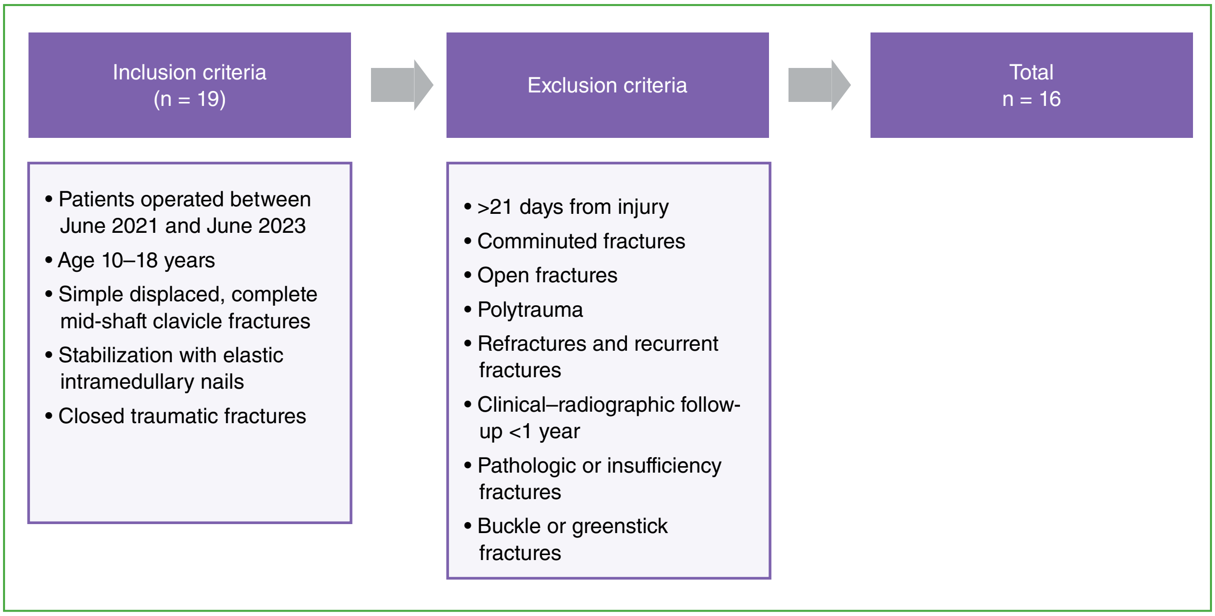

Figure 1. Flowchart showing progression from 19 initially treated patients to the 16 included in the analysis.

Mean age was 14 years (range 13–16; SD 0.99). Mean time from injury to surgery was 9.3 days (range 4–17; SD 4.7). All cases requiring a second approach (n = 7) for open reduction had ≥11 days of evolution, except one 5-day case in which a 1.5-mm nail could not cross the fracture due to excessive flexibility; this did not occur with larger nails in patients operated before day 10. Twelve 2.0-mm nails, four 1.75-mm nails, and one 1.5-mm nail were used.

To evaluate the statistical significance of the difference in times between the two groups, Student's t-test was used for independent samples with unequal variances.

Confidence intervals were calculated using Student's t distribution because the sample size was small (n = 16). The critical t-value corresponding to a 95% confidence level and 15 degrees of freedom is approximately 2.131. Operative and fluoroscopy times by technique are shown in the Table.

Table. Operative and fluoroscopy times by technique.

Category	Mean	Standard deviation	95% confidence interval	Sample size	p
Overall operative time	53 min	± 17.3 min	43.79-62.21 min	16	-
Overall fluoroscopy time	149 s	± 138.5 s	75.21-222.79 s	16	-
Closed reduction					
Operative time	63 min	± 11.3 min	54.30-71.70 min	9	0.005
Fluoroscopy time	240 s	± 122.5 s	145.86-334.14 s	9	0.001
Open reduction					
Operative time	40 min	± 14.4 min	26.71-53.29 min	7	0.005
Fluoroscopy time	33.8 s	± 9.59 s	24.95-42.65 s	7	0.001

There were significant differences in operative time (t = 3.475, p = 0.005) and fluoroscopy time (t = 5.030, p = 0.001)

Clinical and Functional Outcomes

The mean Constant-Murley scale score at 6 weeks was 83.35 (SD ± 3.70), and reached 94.47 (SD ± 2.03) at 3 months, time of medical discharge. This score remained at 95.88 (SD ± 2.49) at 12 months (Figure 2). From month 3 onward, no patient reported pain with activities of daily living, sports, or at end-range motion.

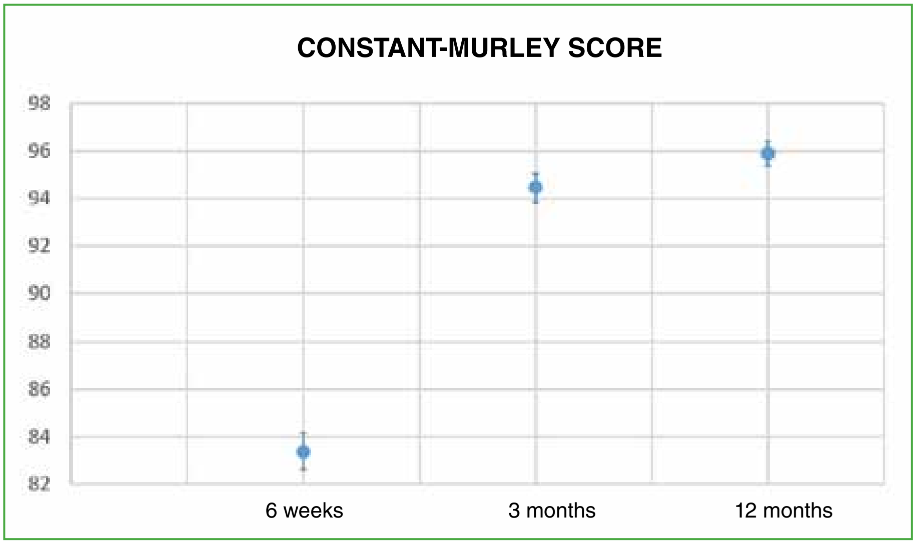

Figure 2. Constant-Murley scores at 6 weeks and at 3 and 12 months.

Bone Union and Adaptive Changes

Mean time to radiographic union, defined as bridging callus across at least two thirds of cortical contact in two views (AP clavicle and 45° caudo-cephalic), was 6 weeks. No hardware removal was required. There were no nonunions, delayed unions, infections, hardware migration, or discomfort associated with it.

Fracture healing and adaptive remodeling were documented at all follow-ups. Although union averaged 6 weeks, an increase in clavicular diameter outside the callus, consistent with periosteal reaction, was noted in 7 cases at 3 months and persisted at 12 months; the clavicle had not returned to preinjury diameter during this interval as part of the bone remodeling process (Figure 3). A single incision was used in 4 cases and a dual-incision approach in 3.

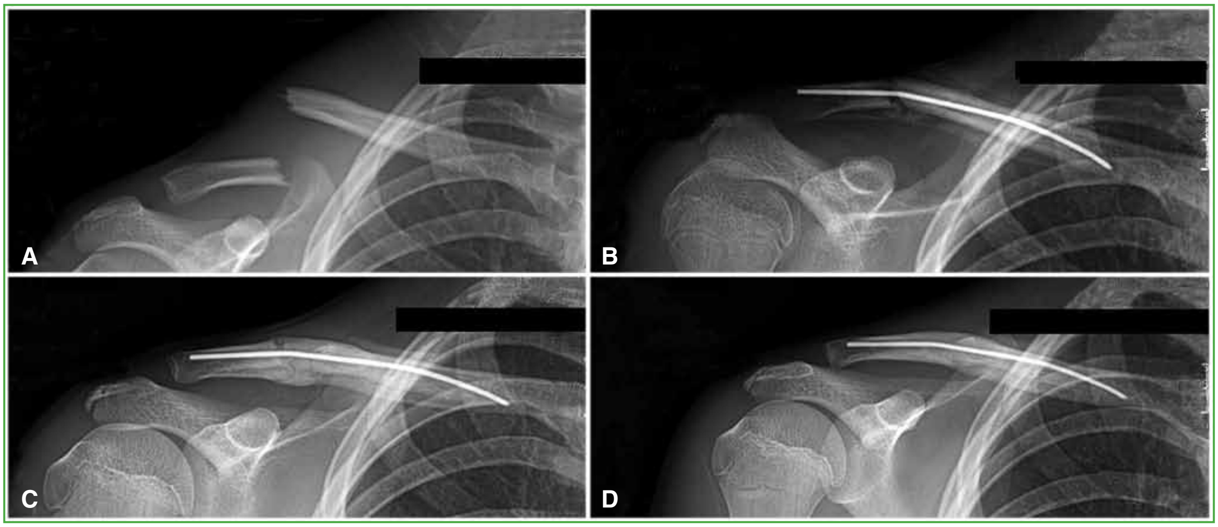

Figure 3. AP radiographs of the right clavicle. **A.** Simple midshaft fracture in a 13-year-old boy. **B.** Two weeks post-op via medial incision. Periosteal reaction not attributable to fracture callus. **C.** Nine weeks: partial ossification of the periosteal reaction with increased cortical thickness. **D.** One year: advanced remodeling without full return to original diameter.

Complications

One patient had nail angulation without breakage or other associated complication (Figure 4). Clinical evolution matched the cohort (Constant–Murley: 84 at 6 weeks; 95 at 6 months; 97 at 12 months).

DISCUSSION

The diameter of the intramedullary nail determined the need to open the fracture site. A 1.5-mm nail often necessitated opening the fracture site due to implant flexibility. Although some authors have performed a second incision and open reduction of the fracture when using nails larger than 2 mm, we have not had the need to use diameters > 2 mm, so this has not been our experience. Rapp et al. placed 2-2.5 mm nails in 24 adolescents.[7] Frigg et al. used 2-3 mm nails in 34 patients; however, the sample included both adolescents and adults.[20] Frye et al. used 2.8-4.5 mm nails in 17 adolescents.[21]

A medial entry facilitates identifying the medial clavicle, eases manipulation compared with a lateral entry, and minimizes risk to adjacent neurovascular structures. A single-incision technique has cosmetic appeal but increases intraoperative fluoroscopy time eightfold, substantially increasing radiation exposure to the patient and surgical team. While fluoroscopy times have been reported across many orthopedic procedures, specific data for clavicle fractures are lacking.[22] This is relevant, as cumulative radiation exposure increases surgeons' cancer risk.[23,24]

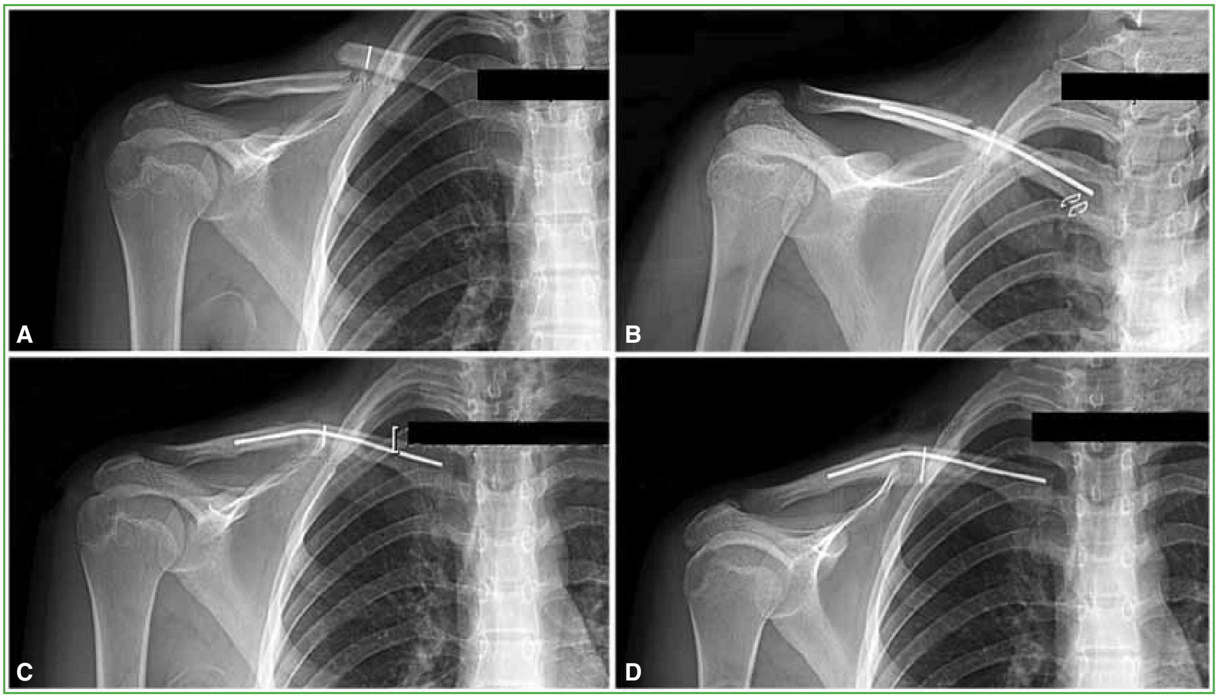

Figure 4. AP radiographs of the right clavicle. **A.** Simple midshaft fracture in a 14-year-old girl. **B.** Immediate post-op (note staples from single medial approach). **C.** Nine weeks: union signs without periosteal reaction, but nail angulation. **D.** One year: advanced adaptive remodeling with mature compact bone formation (predominantly inferior, compression side) and completed union.

With early postoperative shoulder motion after stabilization with intramedullary nailing, a malunion rate of 7% (95%CI 4-11) has been reported.[25]

We observed one nail angulation without malunion (angle <30°), delayed union, or nonunion. This occurred because, at the fracture ends, four times of loads are present: axial load, two bending moments (AP and lateral), and torsion. With a single intramedullary nail, typical in the clavicle's narrow canal, the construct chiefly controls axial load. For this reason, we indicate the use of a sling for 3 weeks (to limit bending) and no forward flexion >90° before week 4 (to limit torsion).

Although traditionally diaphyseal clavicle fractures in children were thought not to progress to nonunion and to remodel completely if malunited, recent evidence shows that painful nonunion and symptomatic shortening malunion can follow nonoperative care.[4,14] The most common clinical and radiographic expression of malunion is loss of bone length, which is inherent to conservative treatment, and occurs in 71% of displaced fractures, with shortening> 2 cm in most cases.[3] In adolescents, both weakness and dissatisfaction have been associated with ≥18 mm shortening in males and ≥14 mm in females, reflecting poorer tolerance than in adults.[10] Another complication of conservative treatment of displaced fractures with malunion is refracture, which may occur up to 6 months after the index injury.[15]

Bone shortening may also occur with elastic intramedullary nail stabilization. Shortening of 1 cm has been reported in 5-50% of cases.[26-28] This was due to the inclusion of comminuted fractures in the studies. Our series comprised simple patterns; therefore, shortening was not expected after reduction.

Some authors advise not advancing the nail beyond 3 cm past the fracture to avoid distal lateral migration[3,13] In our series, we advanced to this distance in most cases, impacting the nail in the lateral segment without cortical breach.

In adults, the most commonly used fixation method to stabilize midshaft fractures is anatomical plating with screws. However, beyond already known complications of this implant (neurovascular injury during screw placement, hypoesthesia inferior to the incision, hematoma), specifically in children and adolescents, fixation with plate and screws can cause complications, such as peri-implant fracture in patients who practice contact or collision sports, pain, growth restriction, postoperative discomfort in the soft tissue adjacent to the plate, and the consequent need for removal (close to 100% in this population).[3,11,12,16,17] For these reasons, there is increasing interest in the use of elastic nailing in this population.[13]

Implant-related complications (nail migration, soft tissue irritation) are the most documented in the literature and mostly occur in the first 3 months after surgery.[25] However, the patients in our series did not have complications that required hardware removal. We believe that this was due to the fact that, in our sample, we excluded both comminuted and lateral clavicle fractures, which are prone to this complication when treated with an elastic intramedullary nail.[29] We consider that one year of radiographic follow-up is sufficient to rule out loosening of the osteosynthesis material or its migration.

Elastic intramedullary nailing generates a predominantly periosteal callus that can be more exuberant inferiorly (compression side) than superiorly (tension side). In children and adolescents, osteoblasts in the inner cellular layer of the thick periosteum are able to generate neoformed bone tissue more rapidly. The increase in bone thickness as a consequence of the periosteal reaction (and outside the area of the bony callus) that we have documented in this study is not a feature that has been evaluated in previous studies on clavicle fractures. Our 1-year follow-up cannot determine whether later remodeling restores preinjury diameter; additional imaging would add unnecessary radiation.

In our case series, Constant–Murley scores improved by 6 weeks, consistent with prior reports,[30] likely related to restricting forward elevation beyond 90° for 6 weeks, given the nail's limited rotational stability compared with plates.

One limitation of our study is that it did not include patients <12 years, because, in this population, we indicated conservative treatment due to the high residual remodeling potential in the face of eventual malunion. On the other hand, the 1-year follow-up in skeletally immature patients may be too short to evaluate the outcomes and complications in the medium and long term. Another limitation is its retrospective design and lack of control group. Its strengths are that it includes a homogeneous cohort and that the patients were operated on by the same surgeon.

CONCLUSIONS

Flexible intramedullary nails are a valid option for simple, displaced midshaft clavicle fractures in adolescents. Periosteal reaction with increased cortical thickness after elastic intramedullary nailing had no clinical or functional consequences.

Open reduction should be considered when time from injury exceeds 10 days or when a 1.5-mm nail is required; although it adds an incision, it shortens operative time and, crucially, reduces fluoroscopy exposure.

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

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Posterior Shoulder Instability Treated with Arthroscopic Bankart and McLaughlin Techniques

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ABSTRACT

Introduction: Traumatic posterior shoulder dislocations are uncommon and often produce anterior humeral head defects (reverse Hill–Sachs lesions) and posterior labral injuries (reverse Bankart lesions) due to abrupt posterior translation of the humeral head. These injuries frequently involve engagement between the humeral head and the glenoid. Although nonoperative management is often favorable, recurrent dislocation episodes may persist in 65–80% of patients who do not undergo surgery. Both open and arthroscopic surgical procedures have been described for persistent dislocations. **Objective:** To describe an arthroscopic technique adapted from the open McLaughlin procedure, compare it with approaches reported in the literature, and present outcomes from three consecutive cases. **Materials and Methods:** Three patients (ages 26, 30, and 45) were operated on by the same surgeon. Mean follow-up was 7 months. Outcomes were assessed using the Visual Analog Scale (VAS) for pain and the Western Ontario Shoulder Instability Index (WOSI). **Results:** Shoulder stability was documented at approximately 3 months. No redislocations, subjective instability, or infections were reported during follow-up. **Conclusion:** The arthroscopic technique achieved joint stability with full range of motion while avoiding extensive open approaches and their associated complications. This arthroscopic variant represents a minimally invasive alternative for managing posterior shoulder instability.

Keywords: Posterior instability; reverse Bankart; reverse Hill–Sachs; remplissage; arthroscopic McLaughlin.
Level of Evidence: IV

Inestabilidad posterior de hombro tratada con la técnica de Bankart y McLaughlin artroscópica

RESUMEN

Introducción: La luxación posterior de hombro traumática es una lesión poco frecuente que puede provocar defectos óseos en la cara anterior del húmero (lesión de Hill-Sachs invertida) y lesión del labrum (lesión de Bankart invertida) por la traslación posterior brusca de la cabeza humeral que suele involucrar un enganche entre la cabeza humeral y la glena. Si bien el tratamiento conservador suele ser favorable, en el 65-80% de los pacientes, pueden persistir los episodios de luxaciones, si no se someten a cirugía. Se han descrito tratamientos quirúrgicos, tanto abierto como artroscópicos, para las luxaciones persistentes. **Objetivo:** Describir la técnica artroscópica, una variante de la técnica abierta de McLaughlin, y compararla con otras publicadas, y comunicar el seguimiento de 3 casos tratados. **Materiales y Métodos:** Se incluyó a 3 pacientes operados por el mismo cirujano. El seguimiento promedio fue de 7 meses. Se utilizó la escala analógica visual para dolor y el cuestionario WOSI. **Resultados:** Se constató la estabilidad del hombro en un tiempo variable de 3 meses. No hubo reluxaciones, sensación de inestabilidad ni infecciones. **Conclusiones:** Se obtuvo la estabilidad y la movilidad completa, evitando grandes abordajes y complicaciones asociadas. Esta variante de técnica artroscópica se puede utilizar como opción para evitar técnicas de reparación a cielo abierto.

Palabras clave: Inestabilidad posterior; técnica de Bankart inversa; lesión de Hill-Sachs invertida; *remplissage*; técnica de McLaughlin inversa.
Nivel de Evidencia: IV

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INTRODUCTION

Posterior shoulder dislocation is a rare injury. Most cases have a traumatic origin, although seizures are another possible etiology.[1]

Traumatic posterior translation of the humeral head often produces associated injuries, such as impaction of the anteromedial humeral head (reverse Hill–Sachs lesion), fracture of the posterior glenoid rim (posterior bony Bankart lesion), and detachment of the posteroinferior capsulolabral complex (reverse Bankart lesion).[1,2]

Up to 86% of patients may sustain a reverse Hill–Sachs lesion that affects joint congruence and can lead to instability.[2,3]

In the Emergency Department, diagnosis may be missed; however, the clinical presentation should raise suspicion—external rotation is limited because the humeral head rests against the posterior glenoid rim, as described by Cicak.[4] Magnetic resonance imaging and computed tomography are useful for diagnosis and for determining the definitive treatment.

Once diagnosed, reduction is usually performed closed, under general anesthesia, although an open approach may be necessary.[4,5]

Dislocation may resolve favorably with conservative treatment; however, 65–80% of cases may remain unstable if not managed surgically. In most patients with posterior dislocation, and those with posterior instability, nonoperative treatment with physical therapy is effective; however, when a bony defect increases instability, surgery is indicated.[1-4]

Surgical repair of isolated capsulolabral lesions yields good outcomes, but when these lesions are associated with a humeral head defect, outcomes are better if the defect is filled.[5,6]

Various treatments have been described and can be divided into anatomic techniques, which restore the native humeral head anatomy, and nonanatomic techniques, which fill the defect.

McLaughlin first described tendon transfer in 1952 as a nonanatomic open technique to fill the humeral head defect.[7] Hawkins later modified the procedure by transferring an osteotomized portion of the lesser tuberosity, and Krackhardt subsequently reported the first arthroscopic variant. Over time, several modifications have been proposed.[7-9]

The objective of this report is to describe an arthroscopic surgical technique— a variant of the McLaughlin procedure—report 9-month outcomes, and compare the approach with previously published techniques.

MATERIALS AND METHODS

Three patients (26, 30, and 45 years old) were operated on by the same surgeon. Follow-up for the first patient was 9 months, and for the other two, 6 months. The Visual Analog Scale (VAS) for pain and the Western Ontario Shoulder Instability Index (WOSI) were used. Details of each patient are given in the Table.

Table. Patient data.

Patient	Sex/Age	Mechanism	Dominant Hand	Treatment of dislocation	Time until surgery	Compromise Reverse Hill-Sach
1	Male/ 26 years	Fall with shoulder internal rotation	Yes	Closed reduction in the ED	10 days	15%
2	Male/ 30 years	Fall with adducted shoulder plus internal rotation	Yes	Closed reduction in the ED	9 days	10%
3	Male/ 45 years	Fall with adducted shoulder plus internal rotation	No	Closed reduction in the ED	12 days	20%

Inclusion criteria were: acute dislocations reduced in the Emergency Department; treatment of instability within the second or third week after the episode; reverse Bankart lesion; and a reverse Hill–Sachs lesion involving up to 30% of the humeral head (Figures 1 and 2).

Figure 1. A. Shoulder radiograph, anteroposterior view. Cast immobilization and the light bulb sign are visible. **B.** Scapular radiograph, lateral view, showing posterior subluxation of the humeral head.

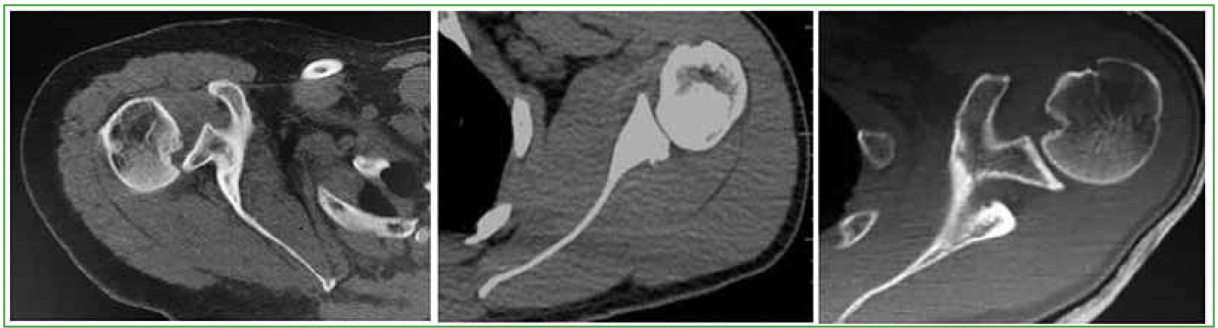

Figure 2. Axial CT scans of the shoulder for the 3 patients: reverse Hill–Sachs lesion involving <30% of the humeral head.

Surgical Technique

The patient was placed in the lateral decubitus position, with 3-kg arm traction, the table tilted 25°, and two anterior bolsters. The usual portals were marked: a posterior viewing portal and an anterior working portal.

The joint was entered through the posterior intra-articular portal with a 30° arthroscope, and an initial diagnostic arthroscopy was performed to identify labral and glenohumeral lesions.

After placing cannulas in the anterosuperior and inferior portals, the anterosuperior portal was used for visualization.

First, we assessed decentering of the humeral head relative to the glenoid axis and the extent of the reverse Hill–Sachs lesion (Figure 3).

Depending on its length, one or two 3.5-mm titanium suture anchors were selected. The subscapularis tendon was then grasped with forceps to pass the sutures, but the knots were not tied at this stage (Figure 4).

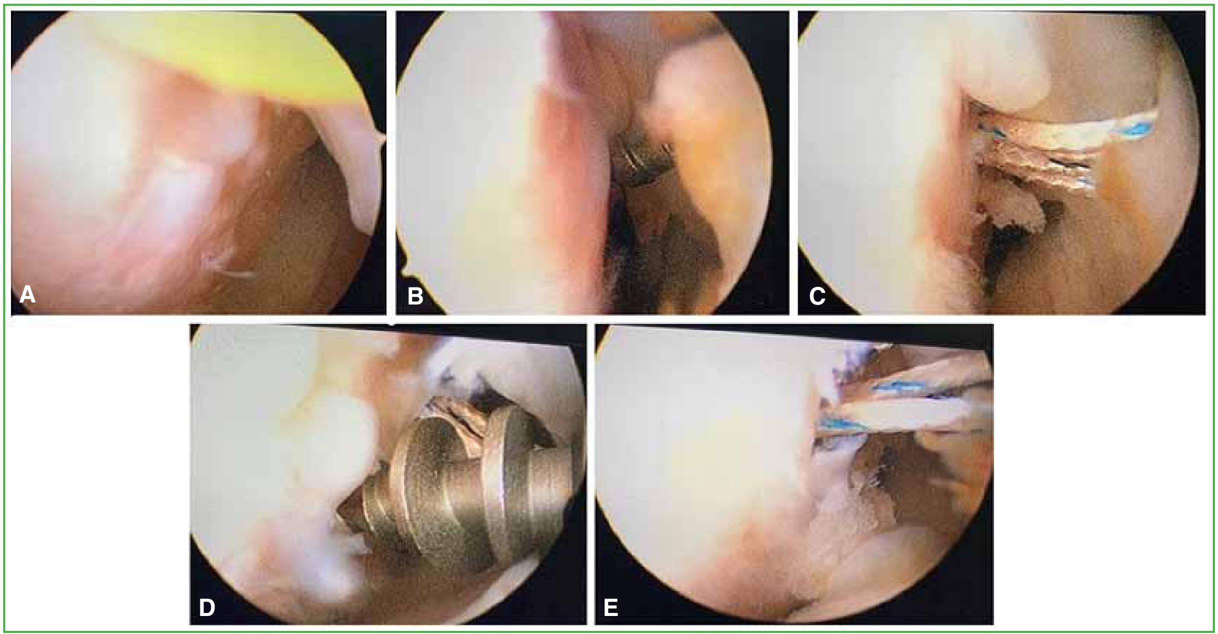

Figure 3. Arthroscopic view. **A.** Reverse Hill-Sachs defect. **B and C.** Placement of the first titanium suture anchor. **D and E.** Placement of the second anchor.

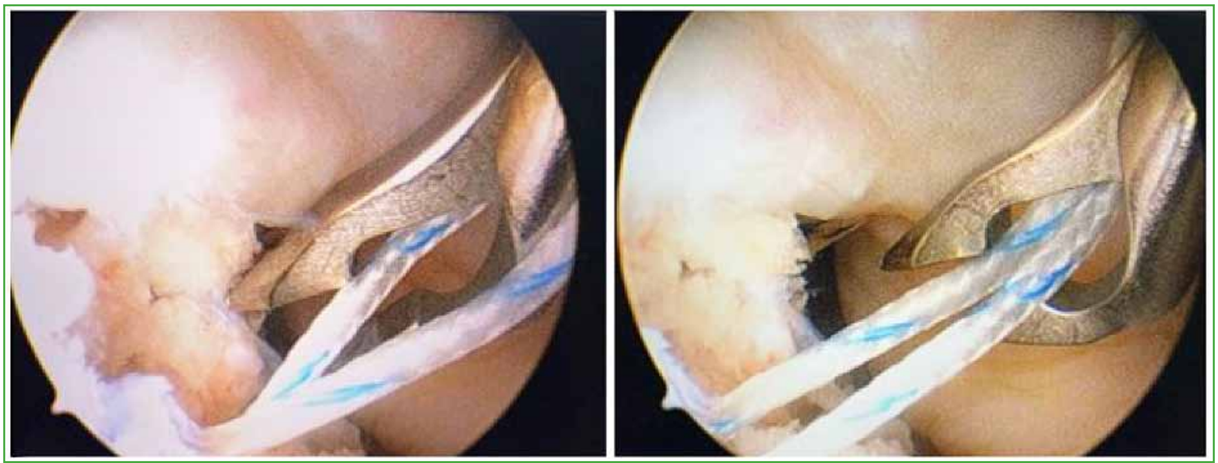

Figure 4. Arthroscopic view. Suture passage through the subscapularis muscle.

Second, posterior labral repair was performed using 3.0-mm PEEK suture anchors, double-loaded, through the same anterosuperior portal (Figure 5).

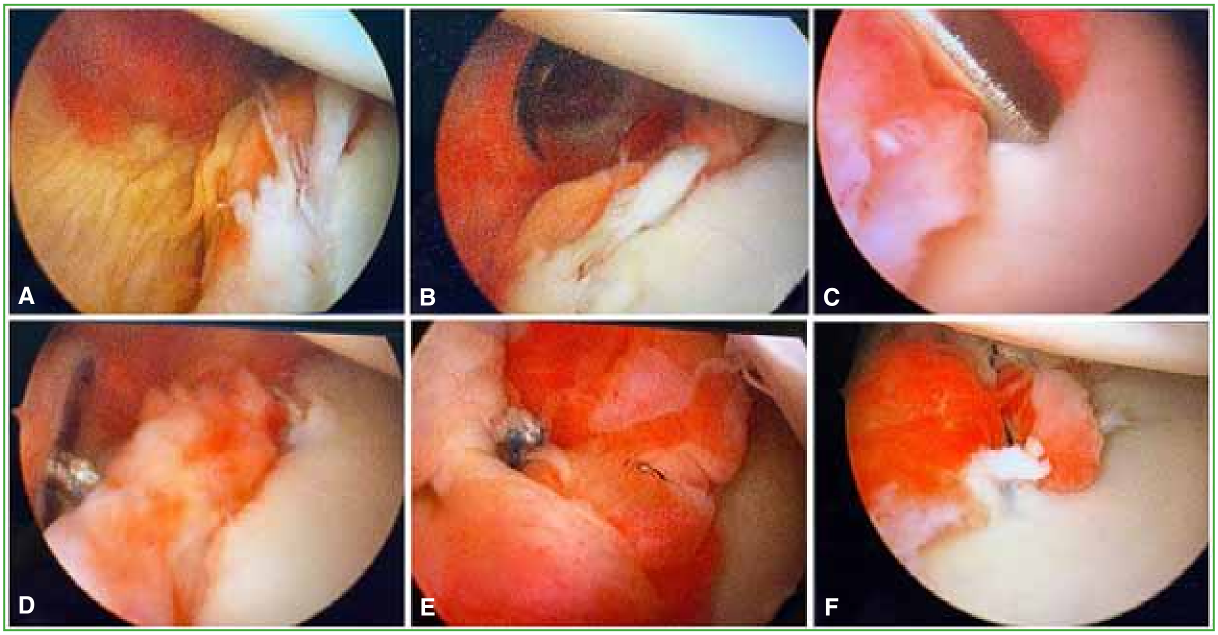

Figure 5. Arthroscopic view. **A.** Reverse Bankart lesion. **B.** Working cannula for anchor placement. **C.** PEEK anchor starter. **D.** Capture of the injured labrum. **E and F.** Labrum repaired with an anchor.

Next, the *remplissage* step was performed to fill the anteromedial humeral head defect using the sutures placed initially together with the subscapularis tendon (we prefer placing these sutures before other steps to avoid damaging the labral repair). The previously placed sutures were then tied. Finally, the alignment of the humeral head relative to the glenoid was reassessed and, after these steps, recentralization was confirmed (Figure 6).

Follow-up Protocol

Over a 9-month period, 3 patients were operated on by the same surgeon. Follow-up visits were scheduled at 2, 4, and 6 weeks, and then monthly.

A sling and arm immobilization were indicated until week 3; thereafter, patients began abduction up to 90° and forward elevation, with unrestricted elbow flexion–extension, while avoiding forced internal rotation or internal rotation >80°.

At week 6, the sling was discontinued and shoulder range of motion was progressively increased.

The first patient completed the WOSI at months 1, 3, and 9, and the other two at months 1 and 6. VAS pain scores were collected monthly through month 6 (patient 1) and through month 3 (patients 2 and 3).

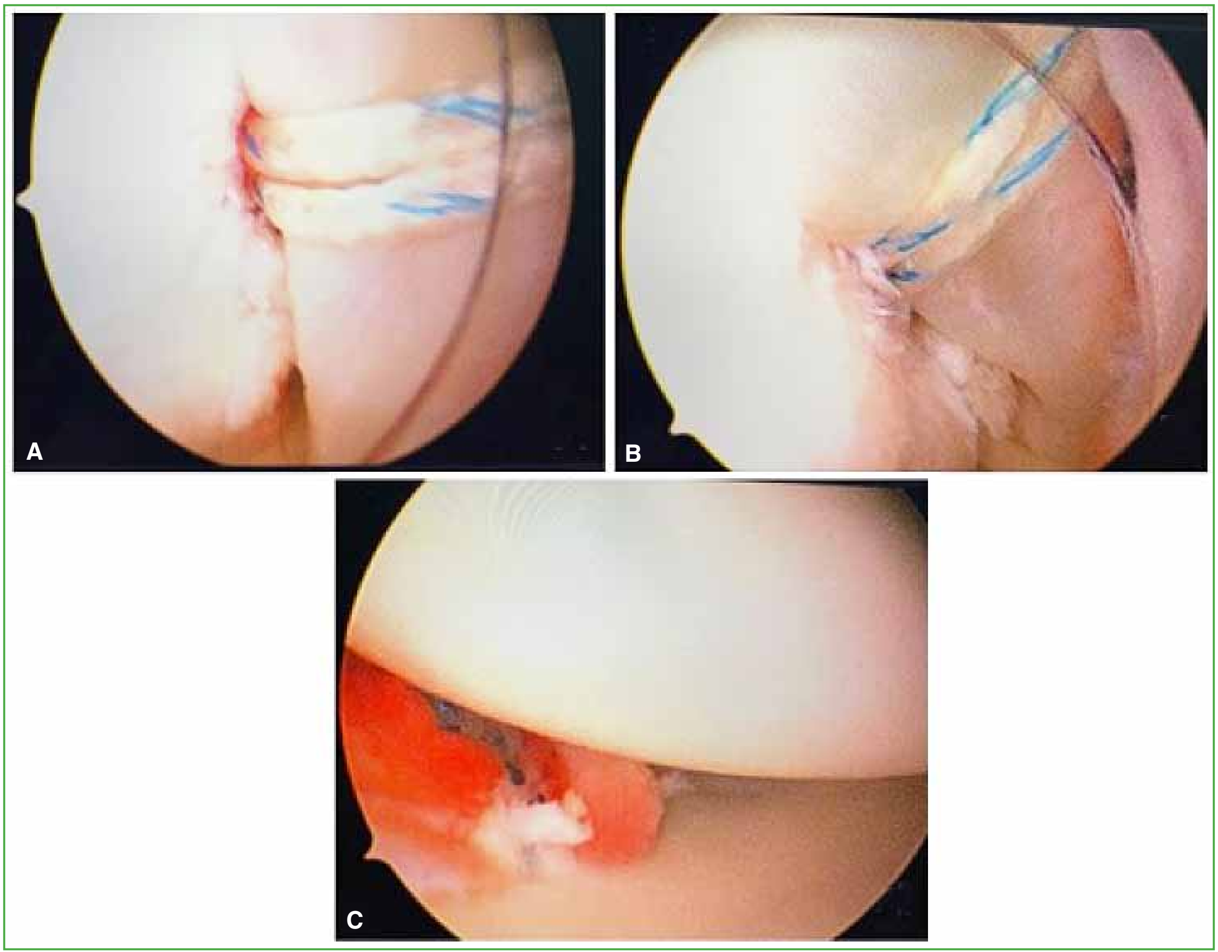

Figure 6. Arthroscopic view. **A and B.** *Remplissage:* filling of the humeral head defect. **C.** Humeral head centered within the glenoid.

RESULTS

Operative time ranged from 80 to 150 minutes (mean, 100). There were no redislocations, infections, or signs of instability in any of the 3 patients (Figure 7).

All patients reported postoperative VAS pain scores between 1 and 3 (mean, 2), managed satisfactorily with oral analgesics.

WOSI scores for the first patient were 82 at month 1, 54 at month 3, and 12 at month 9. Scores for the second patient were 81 at month 1 and 40 at month 6; for the third patient, 81 and 47, respectively.

At 7 months, the first patient was already regularly participating in impact sports.

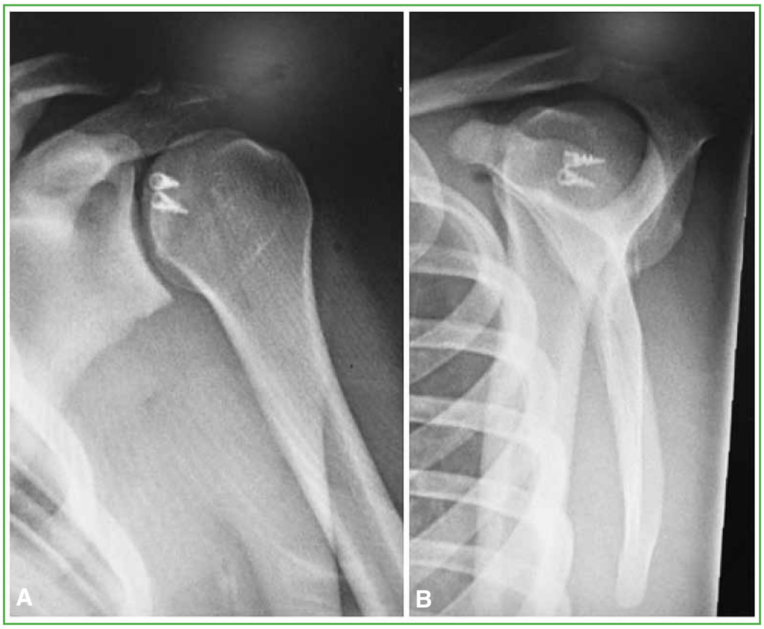

Figure 7. Radiographs, anteroposterior shoulder (**A**) and lateral scapula (**B**), 6 months after surgery, showing joint congruence.

DISCUSSION

Posterior shoulder dislocation is less common than anterior dislocation. The humeral head defect resulting from a traumatic dislocation can progress to instability if left untreated.[10,11]

The literature describes different treatments based on the percentage of the reverse Hill–Sachs defect, as labral and capsular repair alone is insufficient when this lesion is present.[11,12]

Provencher et al. recommend addressing the defect when it involves ≥10% of the articular surface.[13]

Defects up to 25% can be addressed with a *remplissage* technique using the subscapularis tendon. When the defect is 25–50%, a bone graft is recommended; however, McLaughlin described subscapularis transfer for 20–40% defects, and Neer proposed a modification that included transferring the subscapularis with a small osteotomy of the lesser tuberosity.[14,15]

Rotational osteotomies with graft reconstruction have also been described for 25% and 50% defects. Finally, if the defect is >50%, hemiarthroplasty is recommended, and if there is glenoid erosion, total shoulder arthroplasty may be indicated.[14]

In our cases, we opted for an arthroscopic modification of the McLaughlin technique, which protects the humeral head impaction fracture and helps prevent possible redislocation during internal rotation.

By attaching the subscapularis tendon to the impaction site, we achieved a filling effect of the bony deficit. Our technique also allows repair of the posterior labral lesion when required.

Unlike the approaches proposed by Martetschläger et al. and Arauz et al., we first placed the anchors within the defect and captured the subscapularis, taking advantage of the instability to work more comfortably; we then repaired the labrum and, at the end, only needed to tie the previously placed sutures to complete filling of the defect.[15,16]

Compared with our technique, Besnard and Kelly used two 5.0-mm anchors positioned superiorly and inferiorly, performing filling by first tightening the inferior knot and then the superior knot. We believe that placing the anchors centrally within the defect allows adequate filling without generating a loss of internal rotation.[17]

Duey and Burkhart mentioned the option of using the middle glenohumeral ligament as a substitute for the subscapularis tendon; we consider this an alternative for patients with subscapularis lesions in whom the tendon cannot be used, although recovery time with this technique is longer than with the subscapularis transfer.[18]

Regarding functional outcomes, we believe the WOSI is the instrument of choice, as other scoring systems are less useful for assessing stability.[5]

A limitation of this study is the short follow-up: 9 months (one patient) and 3 months (two patients).

CONCLUSIONS

Although some dislocations may evolve favorably with physical therapy, when a bony defect is present, repair using this technique is indicated.

In these patients, stability was achieved with plication and tension results similar to those obtained with the open technique, thereby avoiding the morbidity associated with large approaches. This arthroscopic variant can be used as an option to avoid open repair techniques.

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

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Treatment of Scapular Chondrosarcoma with a 3D-Printed Implant and Reverse Total Shoulder Arthroplasty: Case Report

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ABSTRACT

Chondrosarcomas are malignant, cartilage-producing tumors most commonly arising in the pelvis, femur, and humerus; involvement of the scapula is rare. Surgery is the primary treatment for nonmetastatic disease. Compared with pelvic chondrosarcoma, scapular lesions generally have a better prognosis because the regional anatomy allows wide local resection with negative margins. We report a case of glenoid chondrosarcoma in a 47-year-old man treated with tumor resection and reconstruction using a 3D-printed implant combined with reverse total shoulder arthroplasty. The rationale for presenting this case is its low incidence. The proposed surgical approach—including deltoid detachment—provided adequate exposure while protecting neurovascular structures. Reconstruction of the osseous defect with a 3D-printed implant and reverse shoulder arthroplasty facilitated recovery of shoulder motion and yielded good functional outcomes.

Keywords: Bone tumor; sarcoma; chondrosarcoma; glenoid tumor; scapular tumor; biopsy; surgical approach; reconstruction.

Level of Evidence: IV

Tratamiento del condrosarcoma de escápula con un implante impreso en 3D y una prótesis total invertida. Presentación de un caso

RESUMEN

Los condrosarcomas son tumores malignos que producen cartílago, y son más comunes en la pelvis, el fémur y el húmero. Su aparición en la escápula es rara. La cirugía es la principal modalidad de tratamiento en los casos no metastásicos. El condrosarcoma escapular tiene mejor pronóstico que el condrosarcoma de la pelvis, ya que la anatomía regional es más favorable para una resección local amplia con margen negativo. Se describe un caso de condrosarcoma en la glena en un hombre de 47 años sometido a resección y reconstrucción con implante impreso en 3D y una prótesis invertida. El motivo de la presentación de este caso es su baja incidencia. El abordaje quirúrgico propuesto que incluye desinserción del deltoides se considera efectivo para lograr una buena exposición durante la resección y proteger las estructuras vasculonerviosas. La reconstrucción del defecto óseo con un implante 3D y una prótesis invertida es un método útil para facilitar la recuperación de la movilidad del hombro y consigue buenos resultados funcionales.

Palabras clave: Tumor óseo; sarcoma; condrosarcoma; tumor de glena, tumor de escápula; biopsia; abordaje; reconstrucción.

Nivel de Evidencia: IV

INTRODUCTION

Sarcomas are a rare group of mesenchymal tumors that account for less than 1% of all cancers and arise in bone and soft tissue.[1] Chondrosarcomas are the second most frequent malignant bone neoplasm after osteosarcoma and show diverse behavior depending on the histologic subtype. Most chondrosarcomas are

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conventional central (75%) or conventional peripheral (10%) and are histologically subdivided into grades I, II, and III. Ten-year survival rates by histologic grade range from 79% to 100%, 53%–90%, and 29%–55%, respectively.[2]

The mean age at presentation is 51 years, and more than 70% of patients are older than 40 at diagnosis.[3]

Approximately 30% of tumors arise in proximal locations such as the pelvis, proximal femur, and proximal humerus. Scapular involvement is relatively uncommon. Surgical excision is the cornerstone of treatment, and histologic grade is the key prognostic factor.

The extent of surgical resection determines prognosis; good tumor control can be achieved with complete tumor resection. Chondrosarcomas are relatively radioresistant, and chemotherapy is not very effective, particularly for the conventional subtype.[4]

We report a relatively rare presentation of a scapular chondrosarcoma involving the glenoid in a 47-year-old adult who underwent a previously undescribed approach: tumor resection and reconstruction of the bony defect using a 3D-printed trabecular titanium implant in combination with a reverse total shoulder arthroplasty (RTSA).

CLINICAL CASE

A 47-year-old man presented with right shoulder pain of one year's duration. Physical examination revealed pain and functional limitation with restriction of all ranges of shoulder motion. Shoulder radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) were obtained. Imaging showed a lobulated, expansile lesion with cortical ballooning and internal calcifications (Figure 1). On sagittal CT slices, hypodense areas were visible within the glenoid, and on T2-weighted MRI there was hyperintensity in the supraspinous fossa involving the infraspinatus and subscapularis muscles (Figure 2).

Figure 1. Anteroposterior radiograph of the right shoulder. Lobulated, expansile lesion with cortical ballooning and internal calcifications.

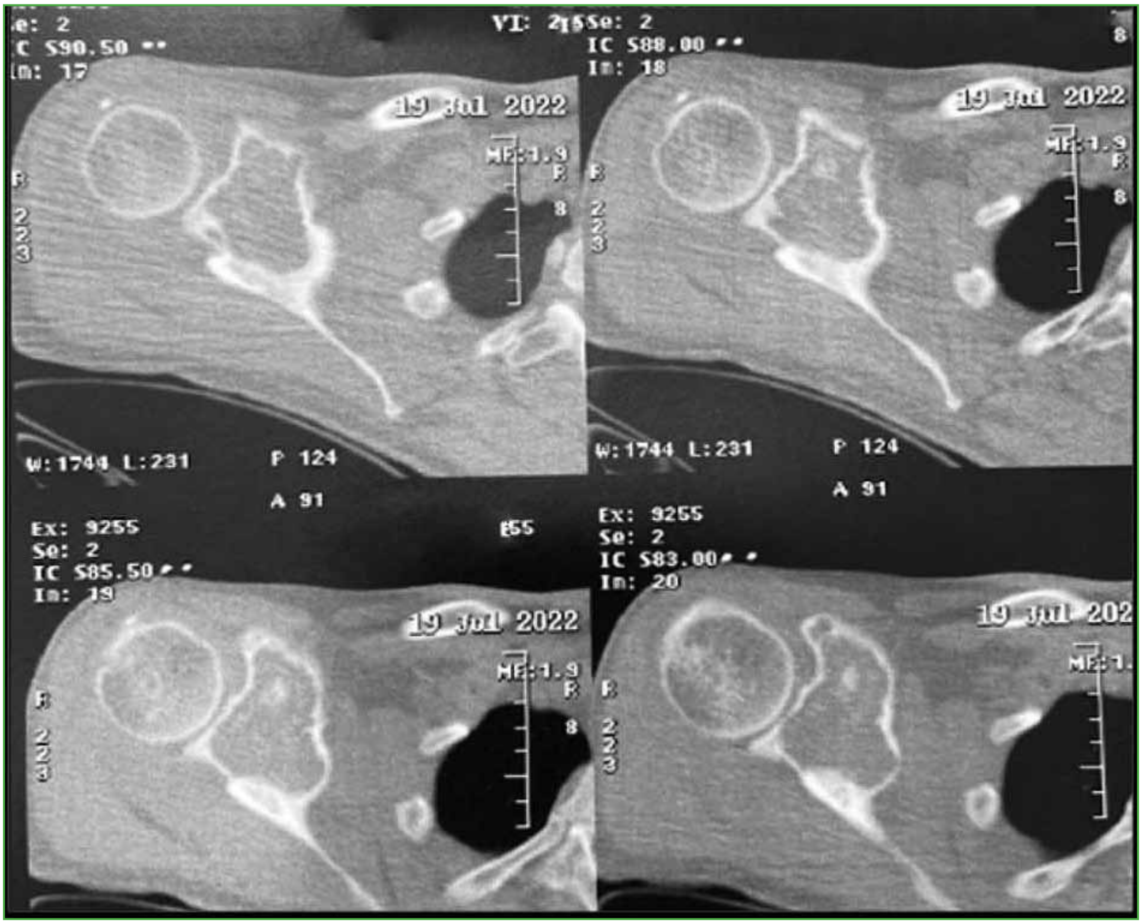

Figure 2. Shoulder CT, axial view. Hypodense areas within the glenoid.

A whole-body bone scan demonstrated increased uptake in the right glenoid region (Figure 3). No distant metastases were identified on the remaining studies.

A CT-guided core needle biopsy was performed to maximize diagnostic yield and obtain a representative sample of the lesion[5] (Figure 4). Pathology reported a grade II chondrosarcoma.

Considering the patient's age, soft-tissue involvement, and functional expectations, a multidisciplinary consensus recommended resection of the tumor with adequate margins, followed by reconstruction of the bone defect using a 3D-printed trabecular titanium implant together with an RTSA.

For prosthesis planning, right-shoulder CT images with 1-mm slices were imported into dedicated software to generate a virtual 3-D model of the scapula, visualize the tumor, and define safe margins for resection. Patient-specific cutting guides were designed and printed to facilitate accurate tumor removal and subsequent implant placement (Figure 5).

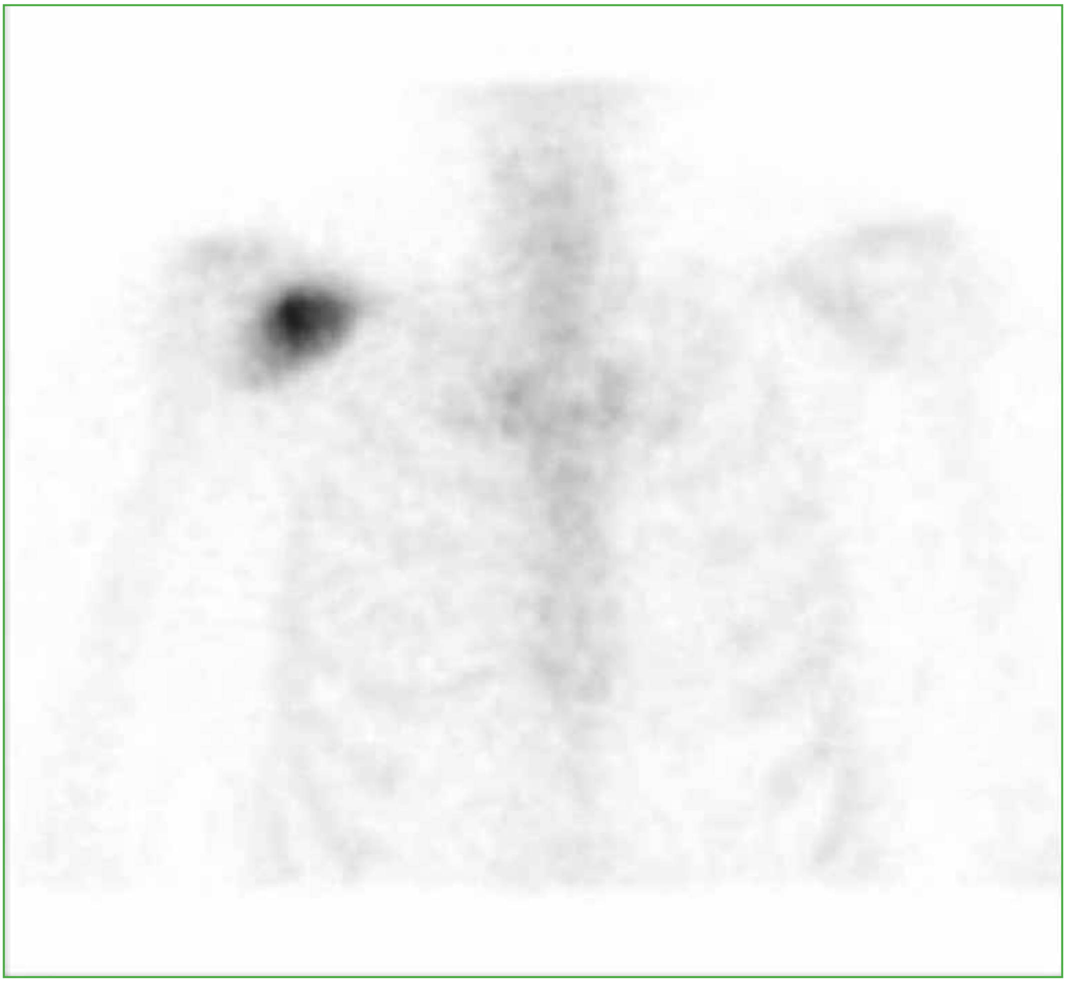

Figure 3. Whole-body bone scan. Increased uptake in the right glenoid region.

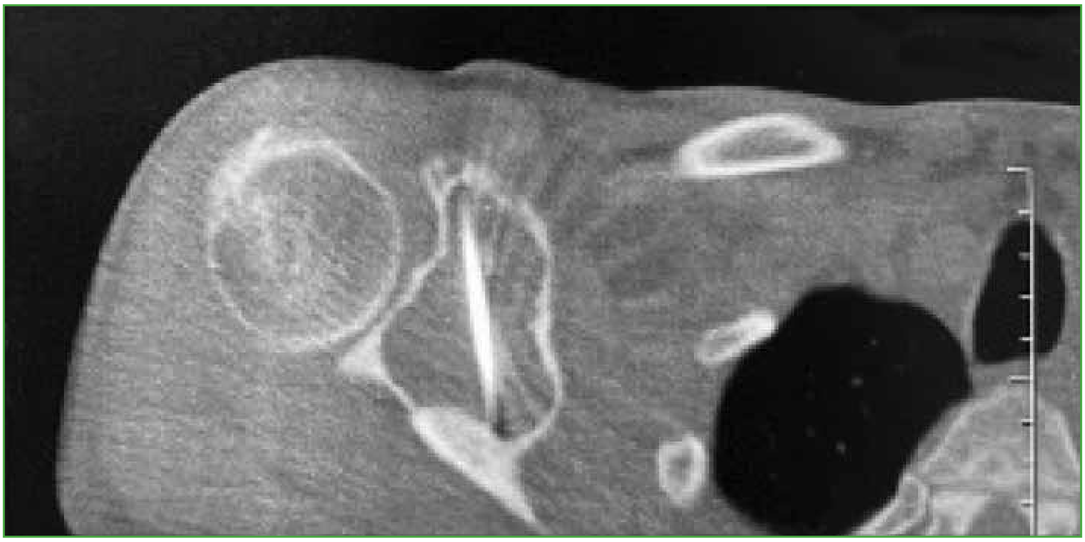

Figure 4. CT-guided core needle biopsy.

Figure 5. Preoperative planning based on CT slices with 3-D reconstruction.

Surgical Technique

The patient was positioned in the beach-chair position. A shoulder approach—anterior and posterior, bayonet-shaped and incorporating a lozenge over the prior biopsy tract—was performed; this provided excellent exposure. The supraspinatus was transected and resected, as were portions of the subscapularis and infraspinatus; the suprascapular bundle had been ligated beforehand.

Using the cutting guides, the tumor was resected, and the 3D-printed implant was placed with acromial support to enhance fixation and component stability, counteract axial loads, and improve the function of the associated reverse prosthesis. The mass was resected with macroscopically negative margins; the deltoid was repaired with reinforced sutures, and implant stability was confirmed (Figure 6). Postoperative control radiographs were obtained (Figure 7).

Figure 6. Intraoperative images of the resection and deltoid repair with reinforced sutures.

Figure 7. Postoperative control radiographs.

Postoperative management included sling immobilization for approximately 4 weeks; pendulum exercises began in week 2, followed by passive/active-assisted stretching and progressive strengthening. At the 30-day follow-up, early range of motion was good; subsequent follow-ups were scheduled at 2, 4, 6, 12, and 48 months (Figure 8).

Figure 8. Follow-up at 2 years after surgery.

DISCUSSION

Chondrosarcoma accounts for 20%–25% of sarcomas and is the second most common malignant bone neoplasm after osteosarcoma. It occurs mainly in the pelvis and long bones (e.g., femur and humerus) and, less frequently, in the scapula.[6] The conventional subtype is the most common (80%–90%). The typical age at presentation is the fourth to fifth decade. Clinical manifestations of scapular chondrosarcoma include pain in the affected area, a palpable mass or swelling, and limitation of shoulder motion. As disease progresses, pain may intensify and additional findings—such as weakness or neurological symptoms from mass effect—can appear. Diagnosis relies primarily on radiographs and CT, which often show expansile osteolytic destruction, soft-tissue mass, and calcifications; CT-guided core needle biopsy is essential for accurate diagnosis.[7]

Chondrosarcoma is typically resistant to radiation and chemotherapy; therefore, wide surgical excision remains the most effective treatment.[8]

Reconstruction after tumor resection in the scapula is challenging, and glenoid involvement—as in the present case—is particularly complex. Before the 1970s, malignant shoulder-girdle tumors were treated with amputation; later, the Tikhoff–Linberg limb-sparing procedure was introduced, with functional outcomes varying according to the structures resected.[9]

With advances in technology, the development of 3D-printed segmental implants combined with reverse prostheses has enabled satisfactory outcomes, including functional recovery of the shoulder in middle-aged patients. Endoprosthetic reconstruction is considered the reference procedure and has provided better functional outcomes than other reconstructive options, such as partial resection with allograft or soft-tissue reconstruction alone.[10]

Despite these advances, the rarity of glenoid tumors limits high-quality comparative evidence, making it difficult to define a standardized surgical strategy. In our case, a custom 3D-printed implant with acromial support combined with an RTSA provided a tailored reconstructive option that permitted rapid recovery of mobility. We consider this approach promising for the reconstruction of complex bony defects after resection of malignant tumors.

CONCLUSIONS

Scapular chondrosarcoma is uncommon, and few case reports describe this tumor in the glenoid or detail surgical management. In a middle-aged patient with grade II chondrosarcoma, reconstruction using a 3D-printed scapular implant combined with a reverse prosthesis yielded satisfactory outcomes with good functional mobility, supporting its consideration in treatment planning. Given the lack of standardized surgical solutions, we believe that a 3D-printed, acromial-supported implant plus RTSA offers a specific, promising reconstructive option for complex bone defects.

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Acute Exostosis Bursata: A Rare Complication of Scapular Osteochondromas—Case Report and Literature Review

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ABSTRACT

Osteochondromas involve the scapula in only about 4% of cases. Although many are asymptomatic, they may produce symptoms and complications such as pain, crepitus, palpable masses, scapular dyskinesia, snapping scapula, scapular winging, and the formation of large bursae. This latter complication—which can occur at any skeletal site—is referred to as *exostosis bursata*, a large bursa that typically develops slowly and progressively and may prompt consideration of malignant transformation or infection in the differential diagnosis.

We report a rare case of the acute, post-traumatic onset of exostosis bursata secondary to an osteochondroma on the ventral surface of the scapula. The treatment is described, and a review of the literature is provided.

Keywords: Exostosis bursata; scapular osteochondroma; bursitis; bone tumor.

Level of Evidence: V

Exostosis bursata aguda: una complicación poco frecuente de los osteocondromas de la escápula. Presentación de un caso y revisión bibliográfica

RESUMEN

Los osteocondromas se localizan en la escápula solo en el 4% de los casos. Si bien un porcentaje importante cursa de forma asintomática, pueden provocar síntomas y complicaciones, como dolor, crepitaciones, tumoraciones, discinesia y resaltos escapulares, escápula alada y la formación de grandes bursas. Esta última complicación que, en realidad, puede sobrevenir en cualquier localización esquelética de los osteocondromas, se ha denominado "exostosis bursata". Se trata de una bursitis de gran tamaño, generalmente de desarrollo lento y progresivo, que puede determinar la necesidad de considerar diagnósticos diferenciales con malignización tumoral e infecciones. Se presenta un raro caso de aparición aguda postraumática de una "exostosis bursata" secundaria a un osteocondroma localizado en la cara ventral de la escápula. Se describe el tratamiento y se presenta una revisión de la bibliografía.

Palabras clave: Exostosis bursata; osteocondroma de escápula; bursitis; tumor óseo.

Nivel de Evidencia: V

INTRODUCTION

Osteochondromas are the most common benign bone tumors. Their location in the scapula accounts for only 4% of cases.[1,2] They have been identified on the dorsal aspect of the scapula,[2] but the most frequent location is on the ventral surface of the bone.[1]

When small and located in areas not subject to excessive friction, patients may remain asymptomatic even with ventral scapular osteochondromas.[1] However, when they enlarge, are situated in mechanically demanding regions

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with greater friction, or occur in very active patients, they can produce significant symptoms and complications.[1] The most frequent complications include scapular dyskinesis, snapping scapula, winged scapula, and the development of large bursae.[1] The latter is a very uncommon complication characterized by the slow and progressive appearance of a large mass that may necessitate consideration of infectious processes or even malignant tumors in the differential diagnosis. In the literature, these bursae—sometimes of considerable size—have been termed "exostosis bursata." The term was first used in 1891 by Orlow,[3] who described it as a slowly developing bursal tumor located between an osteochondroma and the surrounding soft tissue in different regions of the musculoskeletal system.

Given the rarity of this complication and the infrequent occurrence of osteochondromas in the scapula, few cases have been published. We found no previous reports of "exostosis bursata" in our setting.

The purpose of this article is to present a rare case of "exostosis bursata" secondary to a scapular osteochondroma that, unlike the usual presentation, appeared rapidly after trauma. In addition, we conducted a literature review by searching the PubMed, Google Scholar, and PEDro electronic databases from their inception through April 2024. The search terms were: exostosis bursata, scapulothoracic bursitis, snapping scapula and scapular osteochondroma.

CASE REPORT

A 21-year-old woman had been asymptomatic in her left, nondominant shoulder until a traumatic event. She reported a backward fall with a direct contusion to the posterior aspect of the shoulder. Within 48 hours of the trauma, a large medial parascapular mass appeared, extending along the entire medial border of the scapula (Figure 1).

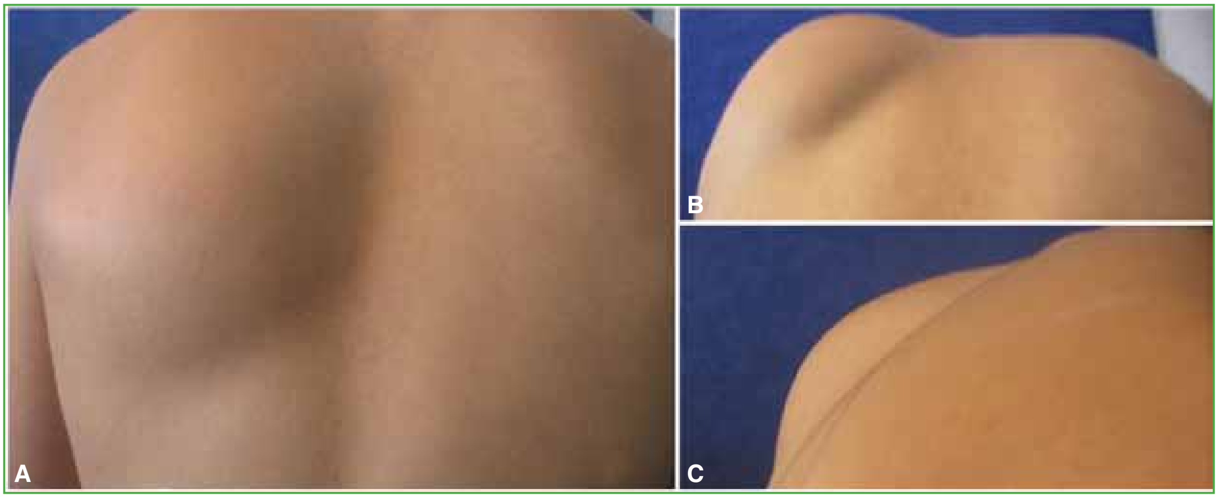

Figure 1. A. Dorsal view in standing position. **B.** Sagittal view, anterior aspect. **C.** Sagittal view, lateral aspect.

The patient reported pain and functional limitation. Active range of motion measured 60° of forward flexion and 40° of external rotation; internal rotation allowed the tip of the thumb on the affected side to reach the level of the spinous process of the fifth lumbar vertebra.

There was no alteration of scapular protraction against resistance, scapular lateralization, the shoulder shrug test, or scapular retraction against resistance.

Complementary studies revealed a ventral osteochondroma near the inferior angle of the scapula (Figure 2). Computed tomography showed the typical mushroom-shaped image at approximately the level of the fifth rib and a homogeneous hypodense fluid collection measuring 16 × 5 cm. Traumatic bone lesions were ruled out. Ultrasound also demonstrated the fluid collection, measuring 150 x 30 x 80 mm (Figure 3).

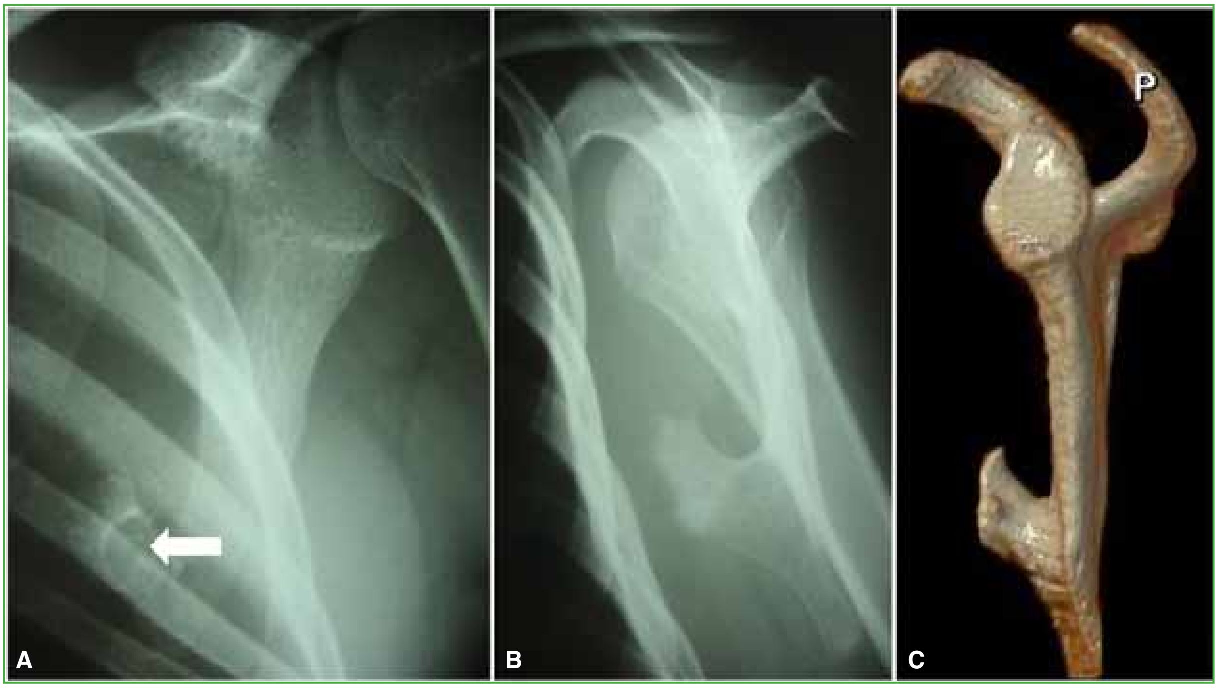

Figure 2. A. Anteroposterior radiograph of the left shoulder. The arrow indicates the area of the osteochondroma. **B.** Lateral radiograph of the left scapula showing the lesion clearly. **C.** Computed tomography of the scapula, lateral view, with 3-D reconstruction showing the characteristics of the osteochondroma.

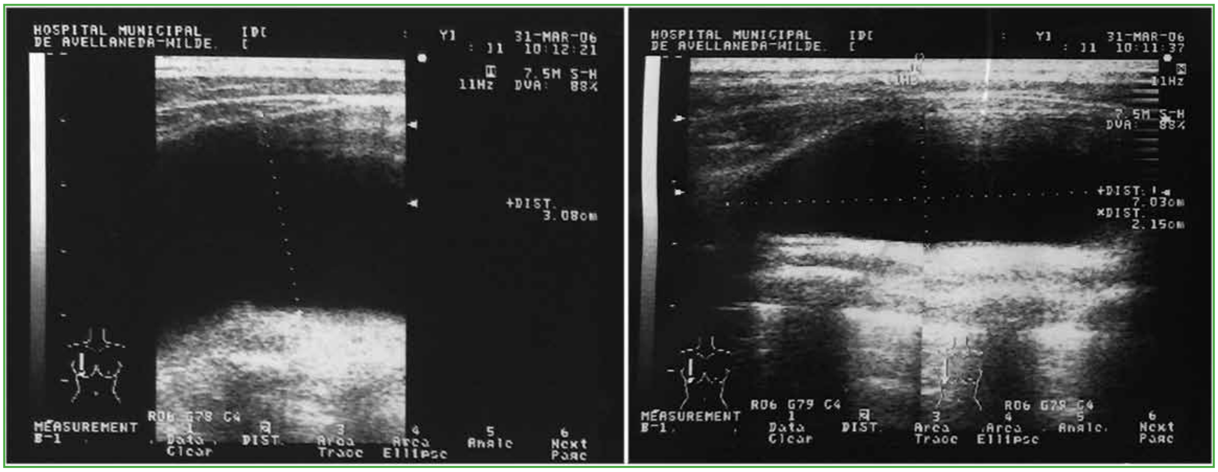

Figure 3. Ultrasound measurement of the bursa.

The mass was interpreted as a post-traumatic exacerbation of chronic bursitis secondary to an osteochondroma that had not produced symptoms prior to the event.

Surgical Treatment

Surgery consisted of resection of the bursa and the osteochondroma. Under general anesthesia, the patient was placed in oblique prone position (ventral decubitus), supported on the right hemithorax.

A longitudinal approach parallel to the inferomedial border of the scapula was used, approximately 10 cm in length and about 3 cm medial to the vertebral border of the scapula. The trapezius fibers were split, and the rhomboid major muscle was detached from the medial border of the scapula (Figure 4A). The scapula was mobilized laterally, revealing a large thick-walled bursa (Figure 4B), which was drained. Careful dissection was performed, and most of the bursa was resected.

Subperiosteal dissection allowed separation of the scapula from the chest wall to expose the osteochondroma (Figure 5A). The pleura was protected throughout the procedure. The osteochondroma was excised at its base with a chisel (Figure 5B), and a clear cleavage plane was observed. The lesion measured 3.5 x 2 cm (Figure 5C).

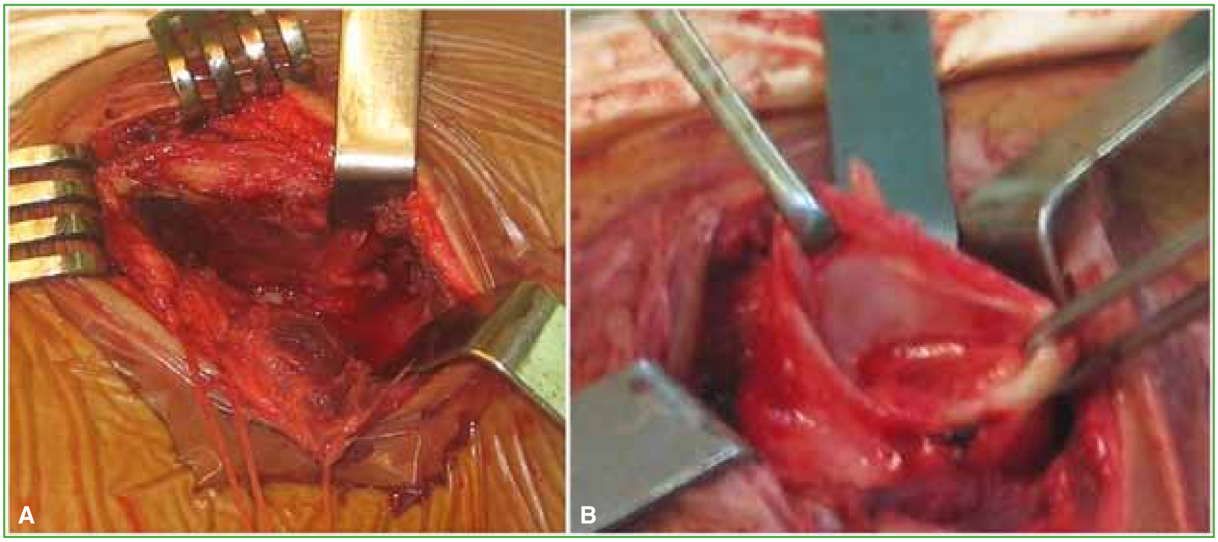

Figure 4. A. F Fibers of the rhomboid major detached and retracted medially. **B.** Bursa after drainage of synovial fluid. Note the thickness of its walls.

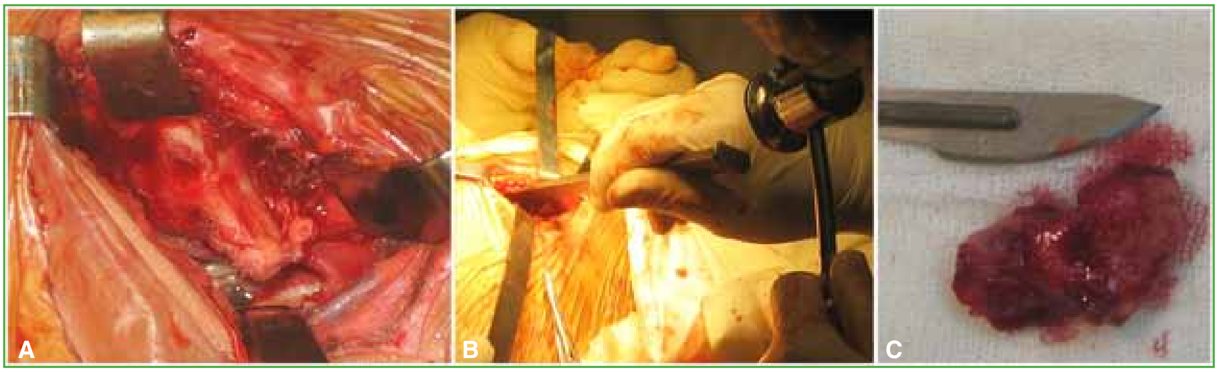

Figure 5. A. Osteochondroma on the deep surface of the scapula. **B.** Separation of the base of the osteochondroma from the scapular body with a chisel. **C.** Resected osteochondroma.

Electrocautery was applied to the insertion area of the osteochondroma pedicle. The rhomboid major was reinserted using transosseous tunnels, and the superficial muscular layer was repaired.

A postoperative chest radiograph ruled out pleural and pulmonary complications. In the immediate postoperative period, a sling was prescribed for 2 weeks, and the patient began protected shoulder mobility starting in the fourth week.

Histologic examination confirmed the typical features of an osteochondroma with no evidence of malignant transformation.

The patient progressed favorably, recovering full, asymptomatic range of motion. At 2-year clinical and radiographic follow-up, the results remained favorable (Figure 6).

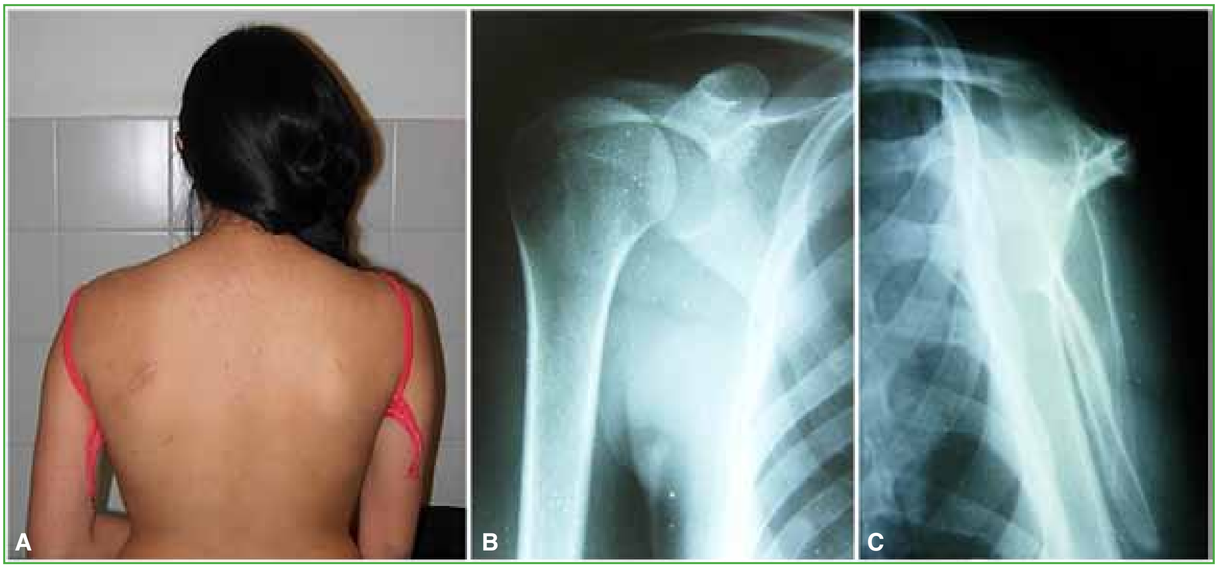

Figure 6. A. Dorsal view of the patient 2 years after surgery. Note the incision in the left scapular region. **B.** Follow-up shoulder radiograph, anteroposterior view. **C.** Follow-up shoulder radiograph, lateral view.

DISCUSSION

The first description of a large bursitis related to an osteochondroma is attributed to Billroth, in Germany, in 1863.[4] This first case, together with a second case, was presented by Fehleisen in Berlin at a surgical congress in 1885 under the title "Zur Casuistic der Exostosis Bursata."[4] This appears to have been the first use of that name.

In 1890, Orlow, in a German-language publication, classified exostoses into three types: solitary, multiple, and bursata.[3] He noted that, in the latter variety, the exostosis is surrounded by a bursa of such size that it is usually the reason for the patient's consultation. He reported cases located in the femur, humerus, and metatarsals.[3] In 1889, Bell[4] published the first English-language article describing a tumor located in the distal third of the femur.

In 1914, McWilliams[5] published the first case of a scapular osteochondroma associated with significant bursitis. That case is very similar to ours in terms of location and treatment, but involved an 18-year-old woman with a one-year history.

Since McWilliams' publication, approximately twenty cases have been reported worldwide (Table),[6-28] and only 10 explicitly mention the term "exostosis bursata."

We analyzed the 24 cases reported in 23 publications that document the presence of significant bursitis associated with a scapular osteochondroma. In 18 of them, the descriptions indicate that the bursae were large (Table, column 3). Only 4 of the 24 cases had a confirmed traumatic antecedent, and all 4 presented large bursae.[11,13,16,24] In our case, the formation of a large bursa occurred just 48 hours after the traumatic event. Among the 4 published cases with a traumatic history, only one had immediate bursa formation;[11] the remaining 3 patients were initially evaluated after an interval ranging from 7 weeks[13] to 6 months.[24]

Our patient also has long-term follow-up, unlike most published cases.[6-28]

When growth is rapid, as in the present case, other diagnoses must be ruled out, including infectious processes, malignant tumors, and fractures of the osteochondroma pedicle.

Table. Publications reporting large bursitis associated with scapular osteochondromas.

Author and year	Onset of symptoms	Trauma	Exostosis bursata
McWilliams[5] (1914)	1 year	No	?
El-Khoury and Bassett[7] (1979)	2 months	No	Yes
Borges et al.[8] (1981)	18 years	No	?
Charelli et al.[9] (1988)	?	?	Yes
Griffiths et al.[10] (1991)	20 years	No	Yes
Cuomo et al.[11] (1993)	Immediate	Yes	Yes
Ben Hamouda et al.[12] (1993)	?	No	Yes
Jacobi et al.[13] (1997)	7 weeks	Yes	Yes
Okada et al.[14] (1999)	1 month	No	Yes
Shackcloth and Page[15] (2000)	6 months	No	Yes
Chávez and Giménez Bascuñana[16] (2001)	4 months	Yes	Yes
Rahul et al.[17] (2014).	2 years	No	?
Mohsen et al.[6] (2006)	6 months	No	Yes
Yoo et al.[18] (2009)	3 months	No	Yes
Aalderink and Wolf[19] (2010)	15 years	No	Yes
Frost et al.[20] (2010)	?	?	?
Orth et al.[21] (2012)	"several months"	No	?
	"several years"	No	?
Ceberut et al.[22] (2013)	3 months	No	Yes
Sivananda et al.[23] (2014)	6 months	Yes	Yes
Flugstad et al.[24] (2015)	4 months	No	Yes
Ali et al.[25] (2016)	1 year	No	Yes
Ogawa and Inokuchi[26] (2018)	11 years	No	Yes
Tuncer et al.[27] (2018)	4 months	No	Yes

In long-standing conditions, it is necessary to differentiate the condition from Sprengel deformity when the bursa is located in the upper region of the scapula, and to consider the possibility of malignant transformation of the osteochondroma.

Although primary tumors of the scapula are rare, the risk of malignancy at this site has been reported to be higher than in other parts of the shoulder girdle.[29] The rate of malignant transformation of solitary osteochondromas of the scapula is approximately 2%.[29]

This study has the limitations inherent to a case report. Such articles are typically considered low level of evidence and tend to have low citation rates.[30] However, case reports also have strengths. In general, they can reveal findings that often go unnoticed in large series of patients.[30] In our particular patient, we describe a very rare presentation with growth that has been reported only once before; it is well documented and includes 2-year follow-up.

CONCLUSIONS

The formation of large bursae secondary to an osteochondroma is an uncommon phenomenon. In most cases, development is slow and progressive; however, abrupt onset may occur and requires a differential diagnosis that includes malignant transformation, infection, and fracture.

The presentation of "exostosis bursata" is not limited to scapular osteochondromas, and clinicians should be alert to this uncommon complication.

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Posterior Sternoclavicular Dislocation: Reinforced Autograft Reconstruction. A Case Report

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ABSTRACT
Post-traumatic posterior sternoclavicular dislocation is a rare injury that typically occurs in young men following high-energy trauma. It can cause potentially life-threatening complications due to compression of mediastinal structures and therefore requires treatment that achieves a stable reduction. Computed tomography (CT) plays a crucial diagnostic role, determining the type and degree of displacement and the anatomical relationship with mediastinal and cervical structures. We present the case of a 25-year-old man with post-traumatic posterior sternoclavicular dislocation who underwent ligament reconstruction using a modification of the classic figure-of-8 technique with a palmaris longus autograft.
Keywords: Posterior sternoclavicular dislocation; sternoclavicular reconstruction; palmaris longus tendon graft.
Level of Evidence: III

Luxación esternoclavicular posterior: reconstrucción con autoinjerto reforzado. Reporte de un caso

RESUMEN
La luxación esternoclavicular posterior postraumática es un cuadro infrecuente que ocurre típicamente en varones jóvenes, por traumatismos de alta energía. Puede acarrear complicaciones potencialmente letales por compresión de estructuras mediastínicas; por lo tanto, requiere un tratamiento que aporte una reducción estable. La tomografía computarizada tiene un rol crucial en el diagnóstico, determinando el tipo y el grado de desplazamiento, así como la relación anatómica con estructuras mediastínicas y cervicales. Presentamos a un hombre de 25 años con luxación esternoclavicular posterior postraumática, que fue sometido a una reconstrucción ligamentaria mediante una modificación de la técnica clásica en "figura de 8" con autoinjerto de palmar menor.
Palabras clave: Luxación esternoclavicular posterior; reconstrucción esternoclavicular; injerto de tendón palmar menor.
Nivel de Evidencia: III

INTRODUCTION

Post-traumatic sternoclavicular dislocation is a rare entity, accounting for 1% of all dislocations and 3% of upper-extremity dislocations. It occurs mainly in young men as a consequence of high-energy trauma. Thirty percent of posterior dislocations are associated with tracheal, esophageal, or neurovascular compression, and the mortality rate is 3–4%.[1-4]

Surgical treatment is indicated after failure of closed reduction or for unstable dislocations. Multiple surgical procedures have been described for sternoclavicular joint reconstruction, and there is no single reference procedure for comprehensive management.[5,6]

The aim of this article is to describe a simple, safe, and reproducible modification of the surgical technique for reconstruction of posterior sternoclavicular dislocation using a figure-of-eight palmaris longus autograft, illustrated with a case and 2-year postoperative follow-up.

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CLINICAL CASE

A 25-year-old man sustained direct trauma to the shoulder and left upper hemithorax during rugby. After discharge from an emergency trauma unit and two prior orthopedic consultations, he was evaluated in our clinic 30 days after the event with sternoclavicular pain and functional limitation of the left shoulder. Physical examination revealed depression of the left sternoclavicular joint (Figure 1A), and limitation of flexion and abduction greater than 90° due to sternoclavicular pain, with marked exacerbation on adduction greater than 10°, without neurovascular or respiratory abnormalities.

Radiographs showed no signs of osseous injury. Given the examination findings and suspicion of a sternoclavicular injury, CT was obtained, which confirmed the diagnosis and demonstrated proximity of the medial clavicle to the great vessels of the neck (Figure 1B). Neck MR angiography (Figure 1C) was subsequently performed to delineate the relationship with mediastinal and cervical structures in detail.

With the diagnosis of posterior sternoclavicular dislocation and considering chronicity as an unfavorable factor for closed reduction, surgery was scheduled.

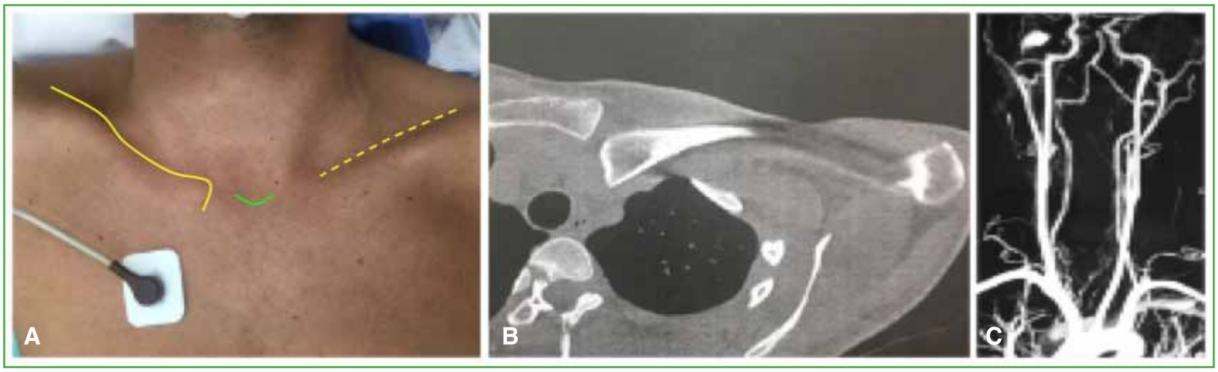

Figure 1. **A.** Normal silhouette of the right clavicle (solid yellow line) with depression of the medial epiphysis of the left clavicle at the sternoclavicular joint (dashed yellow line). The central green line highlights the contour of the sternal manubrium. **B.** CT of the sternoclavicular joint, axial view, showing posterior sternoclavicular dislocation with mediastinal displacement of the medial clavicular epiphysis. **C.** Neck MR angiography, normal.

Surgical Technique

Under general anesthesia and with a vascular surgeon present, standard closed-reduction maneuvers were attempted with the patient supine on a scapular bolster, applying traction and shoulder abduction, without success, so open reduction was performed.

With the patient in the beach-chair position, an ipsilateral palmaris longus tendon graft was harvested using a tendon stripper (Figure 2). An L-shaped skin incision was made over the left sternoclavicular joint to expose the medial clavicle and sternal manubrium. An empty space was first noted where the medial clavicular epiphysis should have been (Figure 3A). With the clavicle dislocated, the free space was used to drill two oblique tunnels in the sternal manubrium, starting on the anterior surface 1 cm from the articular margin and exiting at the posterolateral angle of the sternal joint. The dislocated clavicle acted as a protective barrier, shielding posterior structures from the drill bit (Figure 3B). Adhesions were released, the posterior aspect of the medial clavicular epiphysis was gently debrided with gauze, and reduction was achieved by gentle anterolateral traction on the clavicle. Two parallel oblique bone tunnels were then drilled from anterior to the posteromedial border of the medial clavicular epiphysis (Figure 3C). The articular disc was preserved by drilling small posterior perforations to allow passage of the graft and suture. The graft was paired with a No. 2 ultra-strong flat braided UHMWPE suture tape with a braided polyester jacket, and a thick PDS suture was used as a shuttle (Figure 3D). The construct was passed in a figure-of-eight through the tunnels (Figure 4A), crossing the two free graft ends on the anterior aspect of the joint (Figure 4B). The suture tape was first tensioned and tied to maintain reduction, functioning as a temporary stabilizer until graft ligamentization. The free graft ends were then crossed anteriorly and sutured to themselves (Figure 4B).

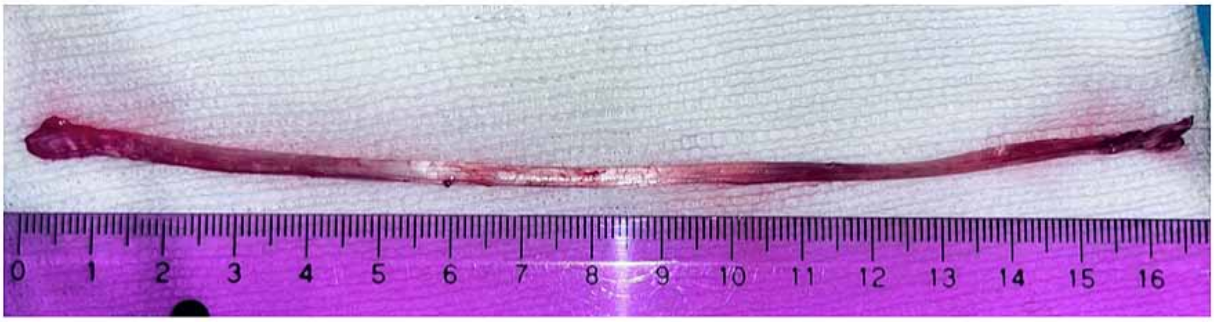

Figure 2. Palmaris longus autograft.

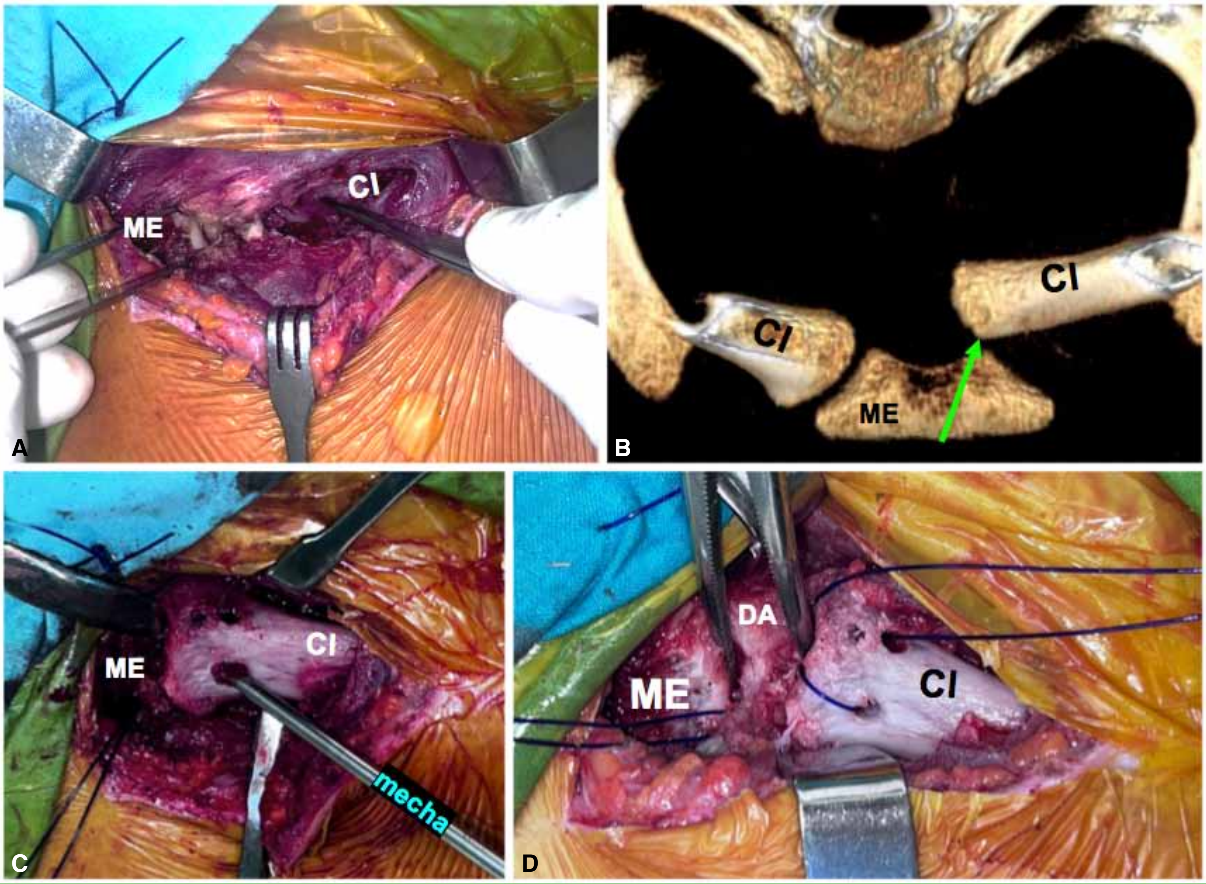

Figure 3. **A.** Surgical exposure after sternoclavicular approach, marking the posteriorly dislocated medial clavicular epiphysis (Cl) with a closed clamp. Before joint reduction, tunnels are drilled in the sternal manubrium (ME), indicated by an open clamp. **B.** CT with 3-D reconstruction, craniocaudal view. The green arrow shows the direction of the manubrial tunnels with the clavicle dislocated posteriorly, which facilitates visualization and protects mediastinal structures from the drill bit. **C**. Clavicle reduced and tunnels drilled. Note the oblique trajectory of the drill. **D.** Thick PDS suture passed through the holes to shuttle the palmaris longus autograft and the high-strength suture tape. The articular disc (AD) is marked with a Crile forceps; it was preserved by creating posterior perforations for passage of the graft and suture.

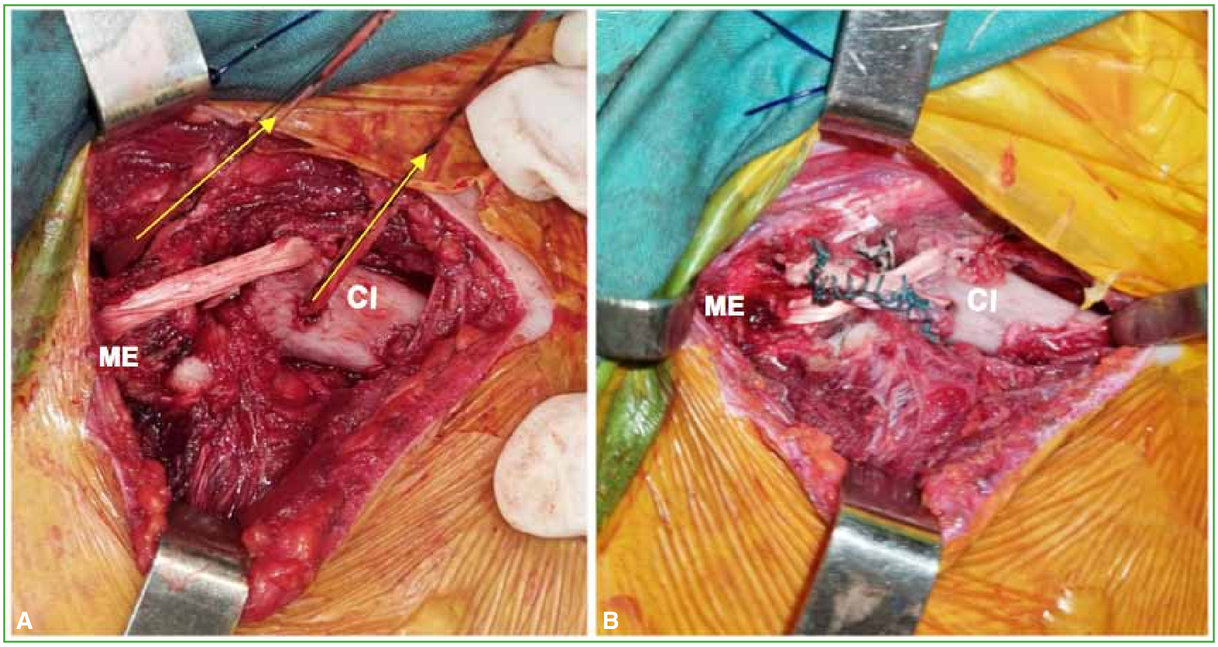

Figure 4. **A.** Passage of the graft and ultra-strong flat braided suture tape through the holes in the sternal manubrium (ME) and the medial clavicular epiphysis (Cl). Yellow arrows indicate the traction direction that maintains reduction. **B.** Completed figure-of-eight with the braided suture tied posteriorly and both graft ends sutured to themselves anteriorly.

Postoperative Protocol

Postoperative management consisted of sling immobilization for 40 days and immediate elbow flexion–extension and pronation–supination exercises. At 2 weeks, the patient began physical therapy and pendulum exercises, with complete restriction of adduction and flexion/abduction less than 90°. After 6 weeks, the sling was removed and range of motion was released; resisted strengthening began at 3 months. At 6 months, CT was normal (Figure 5) and the patient was cleared for contact sports.

Figure 5. CT at 6 months after surgery confirming adequate sternoclavicular alignment.

At the 2-year evaluation, shoulder range of motion was full (Figure 6), pain on the visual analog scale was 0/10, and the QuickDASH score was 6.8. He had returned to his previous sport without limitations.

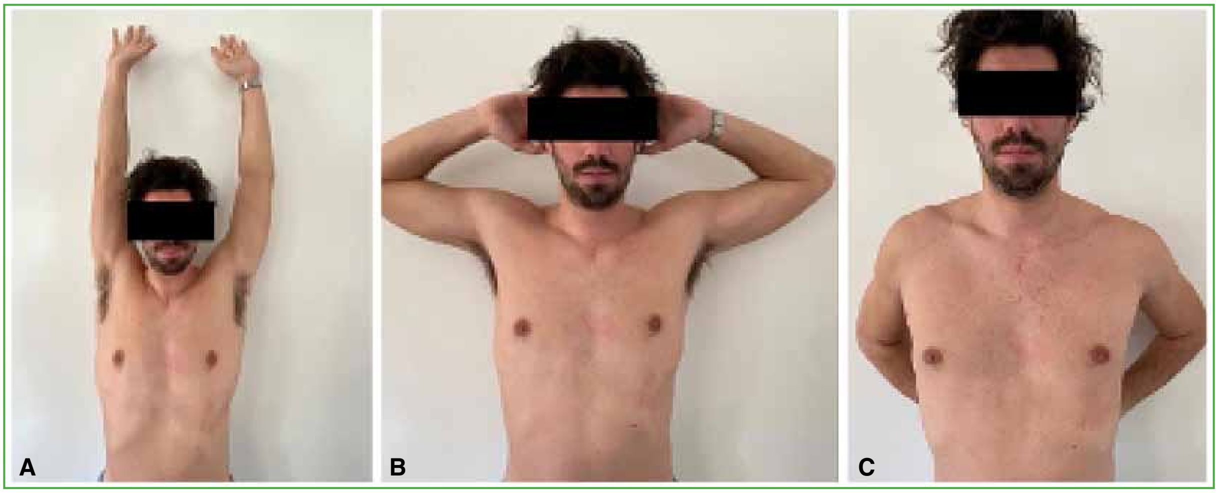

Figure 6. Normal range of motion 2 years after the procedure. **A.** Flexion and abduction. **B.** Abduction and external rotation. **C.** Internal rotation.

DISCUSSION

Posterior sternoclavicular dislocation is rare, but prompt diagnosis is critical because consequences can be severe, including pneumothorax, dysphagia, hoarseness, vascular injury, and brachial plexus injury.[4] The brachiocephalic vein usually lies directly behind the sternoclavicular joint. Other structures commonly in close proximity include the carotid arteries, subclavian veins, superior vena cava, aortic arch, internal mammary arteries, and trachea.[2]

Diagnosis is challenging because of rarity and variable signs and symptoms, so the condition is often overlooked. Diagnostic suspicion based on trauma history, a careful physical examination, and appropriate imaging is essential.[2,3] Radiographs are difficult to interpret due to overlapping structures and are often inconclusive (Figure 7A). CT is the most useful diagnostic tool because it visualizes the joint injury and involvement of cervical and mediastinal structures (Figure 7B). MR angiography helps characterize possible vascular injuries (Figure 1C).

Closed reduction is usually effective in acute cases. If closed maneuvers fail or instability persists after reduction, open reduction with ligament reconstruction using tendon grafts is indicated, since direct repairs do not usually yield effective results.[2,5]

Biomechanically, the sternoclavicular joint allows about 35° of tilt in both the coronal and horizontal planes and about 45° of rotation, contributing to both mobility and stability of the shoulder girdle. Treatment should achieve a stable reduction to restore biomechanics successfully.[7,8] Because this is an infrequent condition, only small case series have been published.[5] The large number of described reconstruction techniques reflects the lack of consensus on optimal treatment. These approaches can be grouped into techniques with joint resection and techniques that preserve the joint. In the former, auto- or allograft hamstring tendons have been used with resection of the medial articular surfaces of the clavicle and sternal manubrium, an option indicated when joint deterioration is evident. Among joint-preserving techniques, the classic figure-of-eight with anteroposterior tunnels in the proximal clavicle and manubrium has shown superior biomechanical stability compared with other graft configurations.[8] Our modification with oblique tunnels (Figure 8) facilitates the procedure, reduces the risk of mediastinal injury, shortens the graft path by approximately 10% so a shorter graft suffices, and simplifies and shortens the surgery by requiring less bone surface preparation with minimal posterior marginal joint damage.

We also recommend drilling the manubrial tunnels before clavicular reduction, which improves visualization and reduces the risk to posterior structures because the dislocated medial clavicle acts as a barrier for the drill. Although these modifications reduce iatrogenic risk, the procedure remains in close proximity to vital vascular structures, so it should be performed in a center with appropriate support and immediate availability of a vascular surgeon.

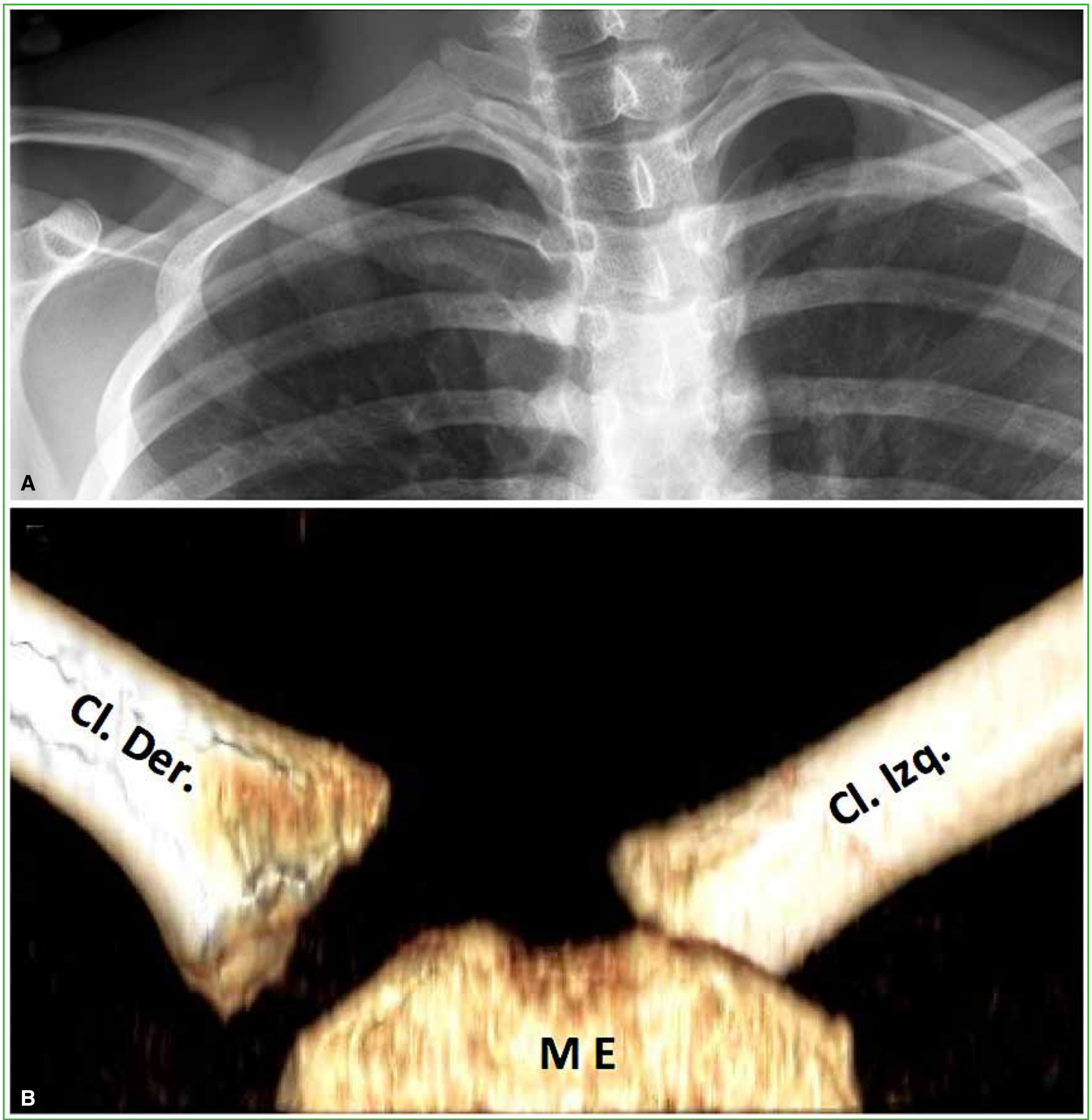

Figure 7. A. Chest radiograph, anteroposterior view. May be suggestive but is not conclusive. **B.** CT of both sternoclavicular joints with 3-D reconstruction, anterior view, showing posterior dislocation of the left sternoclavicular joint. ME = sternal manubrium; Cl Rt = right clavicle; Cl Lt = left clavicle.

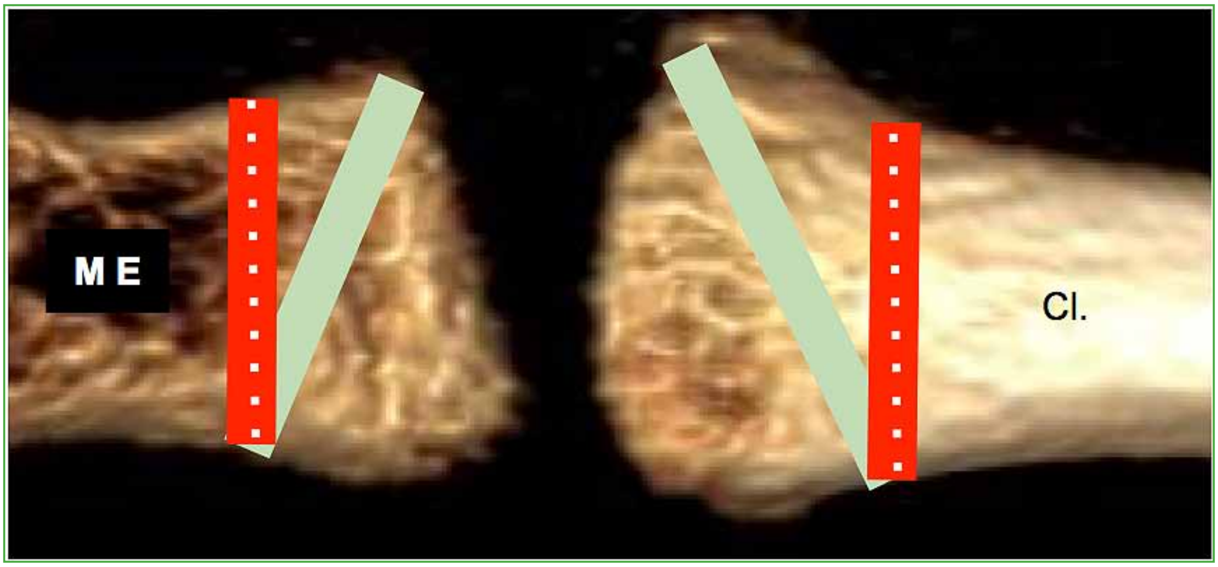

Figure 8. CT of the sternoclavicular joint with 3-D reconstruction, craniocaudal view. The red line with white dots shows the direction of the classic figure-of-eight reconstruction with perpendicular anteroposterior tunnels. The solid green line shows our modification with oblique tunnels, which facilitates and shortens the procedure, decreases the graft path and offers greater length for anterior closure, and reduces risk and tissue damage without significant injury to the articular surface.

We prefer autograft to avoid the rare but catastrophic risk of disease transmission, to maximize tissue incorporation, and to reduce costs. Among autograft options, we favor the ipsilateral palmaris longus tendon if present because harvest is simple, morbidity is negligible, and the graft can be obtained within the same operative field.

Given the risk of hardware failure and migration with severe complications, Steinmann pins, wire cerclage, and Kirschner wires are contraindicated.[9] High-strength flat suture tape can provide additional temporary stability until graft ligamentization.[2,8]

Return to sport at a level similar to preinjury, as in our case, is common after ligament reconstruction.[10]

CONCLUSION

Figure-of-eight sternoclavicular ligament reconstruction using palmaris longus provided a stable reduction with a simplified, effective, and durable technique and low morbidity.

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

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Acute Elbow Dislocation and Instability: Update on Diagnosis and Management

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ABSTRACT

Nonsurgical treatment is the most common approach for simple elbow dislocations. After reduction, careful clinical evaluation to identify injured stabilizers is essential. In selected cases, ligament repair or reconstruction is indicated. Outcomes are generally predictable, with restoration of a functional elbow and a low complication rate. The objective of this article is to provide an update on the diagnostic and therapeutic management of acute elbow dislocations.

Keywords: Elbow dislocation; elbow instability; elbow; medial instability; lateral instability; posterolateral rotatory instability.

Level of Evidence: V

Luxación e inestabilidad aguda de codo

RESUMEN

El tratamiento incruento es el más frecuente para la luxación simple de codo. Luego de la reducción de una luxación de codo, es importante la evaluación clínica y el diagnóstico de los estabilizadores lesionados. En algunos casos, se impone la cirugía de reparación o reconstrucción ligamentaria. Los resultados suelen ser previsibles, se logra un codo funcional y la tasa de complicaciones es baja. El objetivo de este artículo es presentar una puesta al día del manejo diagnóstico y terapéutico de las luxaciones agudas de codo.

Palabras clave: Luxación de codo; inestabilidad de codo; codo; inestabilidad medial; inestabilidad lateral; inestabilidad rotatoria posterolateral.

Nivel de Evidencia: V

INTRODUCTION

Elbow dislocations account for 20% of all joint dislocations and are the second most common in the upper limb after the glenohumeral joint. They are more frequent in males between 10 and 20 years of age.

Acute elbow instability (traumatic dislocations) and chronic instability are easier to understand—and therefore better treated—when the interaction among the joint's stabilizing structures is well known. For elbows that remain stable after reduction, nonoperative care is the accepted treatment. Nevertheless, there is ongoing controversy regarding the mechanisms of injury, duration of immobilization, and surgical techniques.

The aim of this article is to provide an update on the diagnostic and therapeutic management of acute elbow dislocations.

Elbow Range of Motion

The anatomic ("normal") flexion–extension arc ranges from 0° to 140° (±10°), taking 0° as full extension. The functional arc required for most activities of daily living is 30° to 130°.[1] Pronation and supination are normally about 75° and 85°, respectively; a functional arc of 50° in each direction is usually sufficient.

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Elbow Stability

Stability is provided by osseous, capsuloligamentous, and muscular components. Soft tissues and articular surfaces contribute in similar measure. [2]

The lateral collateral ligament complex (LCLC) maintains relatively uniform tension throughout the flexion–extension arc. The anterior bundle of the medial collateral ligament (ulnar collateral ligament, UCL) is commonly described as having anterior and posterior portions: the anterior portion tightens in extension, whereas the posterior portion tightens in flexion, so one or the other contributes to stability across the arc.

It is useful and didactic to compare the elbow's stabilizers to a fortress whose defenses must be breached to create instability, as proposed by O'Driscoll et al.[3]

Stabilizers are divided into primary, secondary, and dynamic. Primary stabilizers are the humeroulnar joint, the UCL, and the LCLC—particularly the lateral ulnar collateral ligament (LUCL). Secondary stabilizers are the radial head, the origins of the common flexor and common extensor muscles (medial and lateral), and the joint capsule. Dynamic stabilizers are the muscles crossing the elbow, which generate compressive forces.

An elbow is stable when all of these structures are intact. Injury to any stabilizer determines the pattern of instability and the compensatory role of remaining intact structures. For example, with a coronoid fracture, a primary stabilizer as part of the humeroulnar articulation, the radial head becomes especially important and should be preserved in the setting of a fracture-dislocation.

CLASSIFICATION OF ELBOW DISLOCATIONS

Several parameters have been proposed to classify them, such as:

1. Direction of displacement: varus, valgus, anterior, or posterolateral.
2. Degree of displacement: complete or incomplete (perched).
3. Chronicity: acute, chronic, or recurrent.
4. Associated fractures: simple or complex.

Two classifications guide treatment: simple vs complex (absence or presence of associated fractures) and complete vs incomplete (perched), the latter based on a true lateral radiograph showing the humerus entirely anterior or perched on the coronoid (Figure 1).

Common acute instability patterns, by region involved, include posterolateral rotatory instability (PLRI), valgus instability, and posteromedial rotatory instability (PMRI).

Figure 1. **A.** Lateral elbow radiograph. Complete dislocation. **B.** Lateral elbow radiograph. Incomplete or perched dislocation. **C.** Sagittal CT of the elbow. Detail of a perched (incomplete) dislocation.

According to several authors, posterolateral rotatory instability is the most common type,[4-6] and may present as dislocation, fracture–dislocation, or fracture–subluxation. Acute subluxations are often missed after trauma; a small flake from the coronoid tip may be the only clue. These fractures result from trochlear loading on the coronoid. If a coronoid fracture measures >2 cm on a lateral radiograph, CT should be obtained because such injuries can evolve to varus posteromedial rotatory instability, which is associated with early elbow osteoarthritis.

Acute valgus instability can follow trauma or chronic valgus overload. When traumatic, it involves the UCL and is often associated with a radial head fracture.

Varus posteromedial rotatory instability has been more recently described and represents the end stage of PLRI during axial loading with the elbow flexed. It is associated with lateral ligament injury and anteromedial facet fracture of the coronoid.

CLINICAL EVALUATION

In elbow dislocation, a thorough assessment of the affected limb (shoulder, elbow, forearm, wrist, and hand) is required to identify associated injuries, along with a neurovascular examination (median, ulnar, and radial nerves). Compare pulses with the contralateral side and examine soft tissues for abrasions and open wounds.

Standard AP and lateral elbow radiographs are generally sufficient initially. CT helps delineate fractures. MRI is seldom obtained in the acute phase; we reserve it for later, once treatment has begun, to characterize soft-tissue injuries (Figure 2).

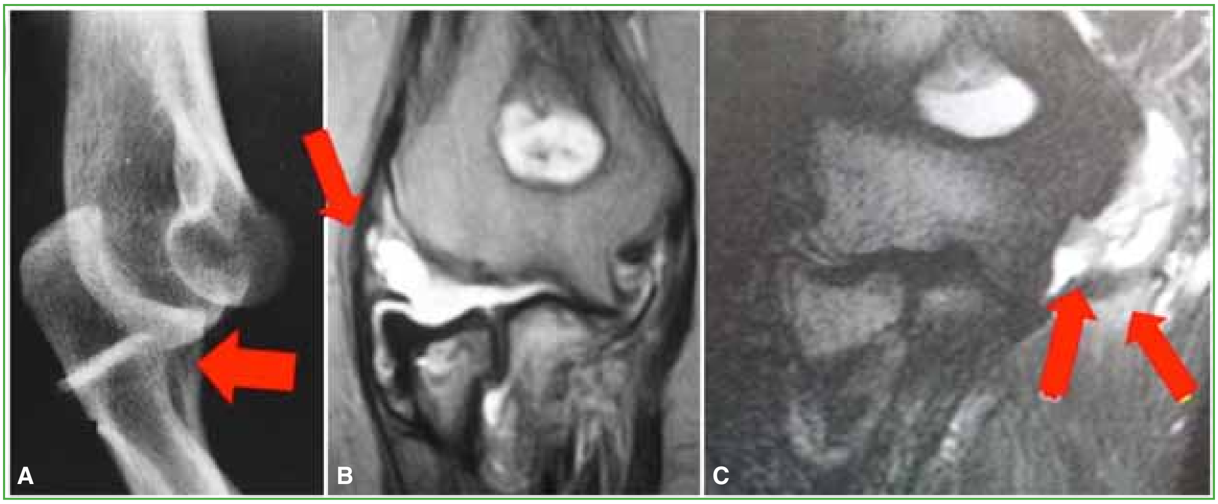

Figure 2. A. Lateral elbow radiograph showing the radial head positioned below the capitellum during a *pivot-shift* maneuver in PLRI. **B.** Coronal elbow MRI. Avulsion of the lateral ligament complex. **C.** Coronal MRI of the left elbow. Avulsion of the medial ligament complex.

MANAGEMENT OF ACUTE DISLOCATIONS

Following clinical and radiologic assessment, closed reduction is the primary goal and should be performed as atraumatically as possible. Reduction under anesthesia avoids certain complications.

The key maneuver is to disengage the coronoid from behind the trochlea, typically by combining forearm supination and elbow extension while applying anterior force to the olecranon. Fluoroscopic control is useful to confirm a concentric reduction and to assess for intra-articular fragments.

Next, assess range of motion and perform stress testing to evaluate post-reduction stability. Document the extension angle at which the elbow tends to subluxate or redislocate; this defines the allowable extension limit during rehabilitation. If ≥90° of flexion is required to maintain reduction, the elbow is unstable and surgical repair is likely indicated.

Radiographs may show avulsions, capitellar impaction (the Osborne–Cotterill lesion),[7] and cubitohumeral subluxations. These injuries may occur after dislocation due to interposed soft tissue or bone, joint hematoma, or muscle atony or tear (e.g., brachialis).

An increased humeroulnar distance on a lateral radiograph (the *drop sign*) immediately post-reduction may indicate greater instability; in one series, 20% with this finding required ligament repair.[8]

Even if the elbow appears stable after reduction, we immobilize it and confirm maintenance of reduction on radiographs. If congruent, we continue immobilization (splint or cast). At 7–10 days, we re-evaluate. If the elbow subluxates in extension, a pronated position with a 30° extension block can be used; however, if >30–45° of extension block is needed to maintain a congruent reduction radiographically, surgical treatment should be considered. If stable, immobilization is continued for 3 weeks, followed by re-evaluation in the same fashion.

When stability is maintained in the acute phase, a shorter immobilization period improves prognosis.

The elbow is also examined for valgus, varus, and posterolateral rotatory instability. Valgus stress is tested with the forearm fully pronated and the elbow extended to avoid mistaking PLRI for valgus instability (medial soft tissues in pronation act as a hinge to prevent lateral dislocation). Varus stress is tested with the shoulder internally rotated and the elbow extended, then at 30° of flexion to unlock the olecranon from the fossa. *Pivot-shift* and posterolateral drawer tests are also useful.

When there are major soft-tissue injuries (ligaments, capsule, muscle masses), the elbow may remain dislocated even beyond 90° of flexion. In these markedly unstable cases in which reduction cannot be maintained, external fixation may be indicated. [9]

RESULTS OF NONOPERATIVE TREATMENT OF ACUTE DISLOCATIONS

For a stable elbow after reduction, nonoperative treatment remains the standard. Three weeks of immobilization followed by exercises generally yields functional results for most activities of daily living, with some moderate extension stiffness and a low instability rate (<2%). Some authors immobilize for one week instead.

Maripuri et al. reported better outcomes (higher MEPS, lower DASH scores, shorter therapy, and quicker return to work) using a sling and early motion compared with two weeks of immobilization. They concluded that prolonged immobilization correlates with greater stiffness and worse function. [12]

It is important to note that, after nonoperative care of simple dislocations (not fractures), the main complication is stiffness or restricted range of motion, not instability. To mitigate this, we favor early mobilization.

Complex Dislocations

A dislocation is complex when fractures are present. The forces causing dislocation also injure bone, most commonly the coronoid and the radial head. Given their key stabilizing roles, careful evaluation and appropriate treatment are essential.

Management depends on fragment size and displacement. For radial head fractures, options include nonoperative care, partial fragment excision in select cases, screw or plate fixation, and prosthetic replacement. Complete radial head excision is contraindicated in the presence of instability because it worsens instability.

For coronoid fractures, options include nonoperative care; anterograde or retrograde fixation for large fragments; bone grafting for irreparable defects; and anterior capsular plication onto a raw coronoid surface when only small fragments are present.

Surgical Treatment of Acute Dislocations

After reduction, the rate of instability is low in simple dislocations (2%).[13,14]

Indications for surgery include: instability after reduction with/without associated fractures; recurrent subluxation or dislocation unless prevented by forced flexion; recurrent instability after immobilization; open dislocations; and vascular injury.

Surgical Technique

Lateral Approach

The patient is supine with regional anesthesia (or combined with general). Prepare and drape sterilely; if reconstruction is anticipated, prepare the graft harvest site. Fluoroscopy is helpful: assess for medial joint opening with valgus stress in forearm supination and lateral opening with varus stress. On dynamic lateral fluoroscopy, progressively extend to the point of dislocation and assess lateral ligament insufficiency. In our experience and that of many authors, most patients require lateral repair; fewer need medial repair. Apply a tourniquet after exsanguination. A lateral skin incision is made beginning 2–3 cm proximal to the lateral epicondyle and extend distally and obliquely toward the subcutaneous border of the proximal ulna. The Kocher interval between the posterior ulnar (*extensor carpi ulnaris)* and the anconeus muscle is then identified. The fascia over the interval is incised with a scalpel. The anconeus is elevated from the lateral collateral ligament at the distal interval to differentiate the muscle from the ligament complex, which in chronic cases may be thinned or attenuated. Next, the anconeus is reflected posteriorly to expose the proximal ulna at the level of the supinator crest. The anterior ulnar muscle is detached and reflected anteriorly from the lateral ligament complex. Once the ligament is exposed, an assessment is made as to whether ligament repair or reconstruction will be performed. In general, when the fascia is opened, avulsion of the lateral ligament complex of the lateral epicondyle is observed to varying degrees. Tears of the epicondylar muscles may also be seen. Tear of the insertion from the ulna is rare (Figure 3).

Ligament repair. In acute injuries with suitable tissue, we reinsert the capsuloligamentous complex and extensor origin to the distal humerus using strong sutures, typically with one or two double-loaded suture anchors. Tie sutures with the forearm in pronation and the elbow in valgus. Multiple high-strength sutures are passed to capture the collateral ligament, capsule, and extensor mass as needed. Transosseous sutures to the distal humerus are an alternative. Place anchors at the isometric point or slightly anterior/proximal; posterior/distal placement may facilitate instability (most evident in extension). After repair, reassess stability through the arc. For simple dislocations that remain unstable, lateral repair alone is usually sufficient. If medial instability persists, repair the medial side via a separate approach with ulnar nerve protection (see Medial repair and reconstruction). Identify and reattach the anterior band of the UCL with the flexor–pronator origin as indicated.

Ligament reconstruction. Some recommend reconstruction even acutely; we reserve it for chronic cases or insufficient tissue. After exposure, debride the epicondylar footprint and elevate a portion of the common extensor and triceps origins to expose the distal humerus for tunnel creation.

Many surgeons leave remaining capsuloligamentous tissue interposed between graft and joint; others resect it.

Graft options include palmaris longus, semitendinosus, or allograft flexor tendons. Prepare the ends with high-strength Krackow sutures.

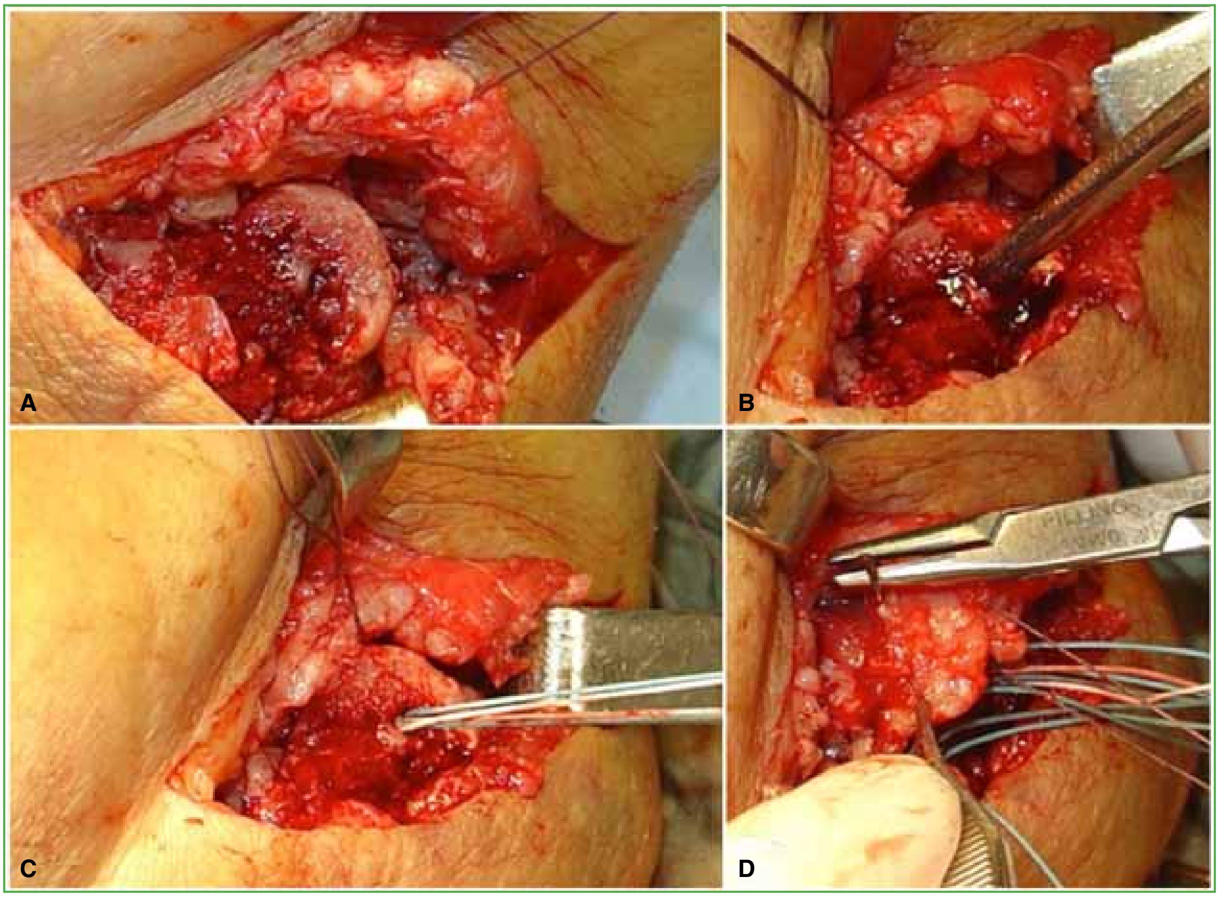

Figure 3. Lateral repair for complete tear/avulsion. **A.** Denuded distal humerus. **B.** Placement of a lateral suture anchor. **C.** Detail of double high-strength sutures. **D.** Reinsertion of the lateral ligament complex.

Drill two ulnar tunnels (3.5 mm burr): one at the proximal supinator crest or radial neck region, and a second 1–2 cm proximal to the first near the base of the annular ligament. Maintain at least a 1 cm bone bridge to avoid fracture.

Connect the tunnels with a curette. In the humerus, drill a 4.5 mm tunnel at the isometric point (near the capitellar center of rotation at the tip of the lateral epicondyle; slightly anterior/proximal placement can help maintain tension).

Create two additional 2 mm tunnels anterior and posterior to the superior epicondyle and connect them to the main anterior tunnel, again preserving a 1 cm bone bridge.

Use a suture passer to shuttle the graft through the ulnar tunnels. Seat both graft limbs into the humeral anterior tunnel and retrieve the traction sutures posteriorly through the two small tunnels; tie the sutures with the elbow at 90° flexion, maximal pronation, and slight valgus. Check graft tension in extension; side-to-side sutures between the graft limbs can increase tension (Figure 4).

Release the tourniquet, achieve hemostasis, and close in layers.

Immobilize in a posterior splint at 90° flexion and full pronation. Alternatives include hinged braces with extension limits or external fixation.

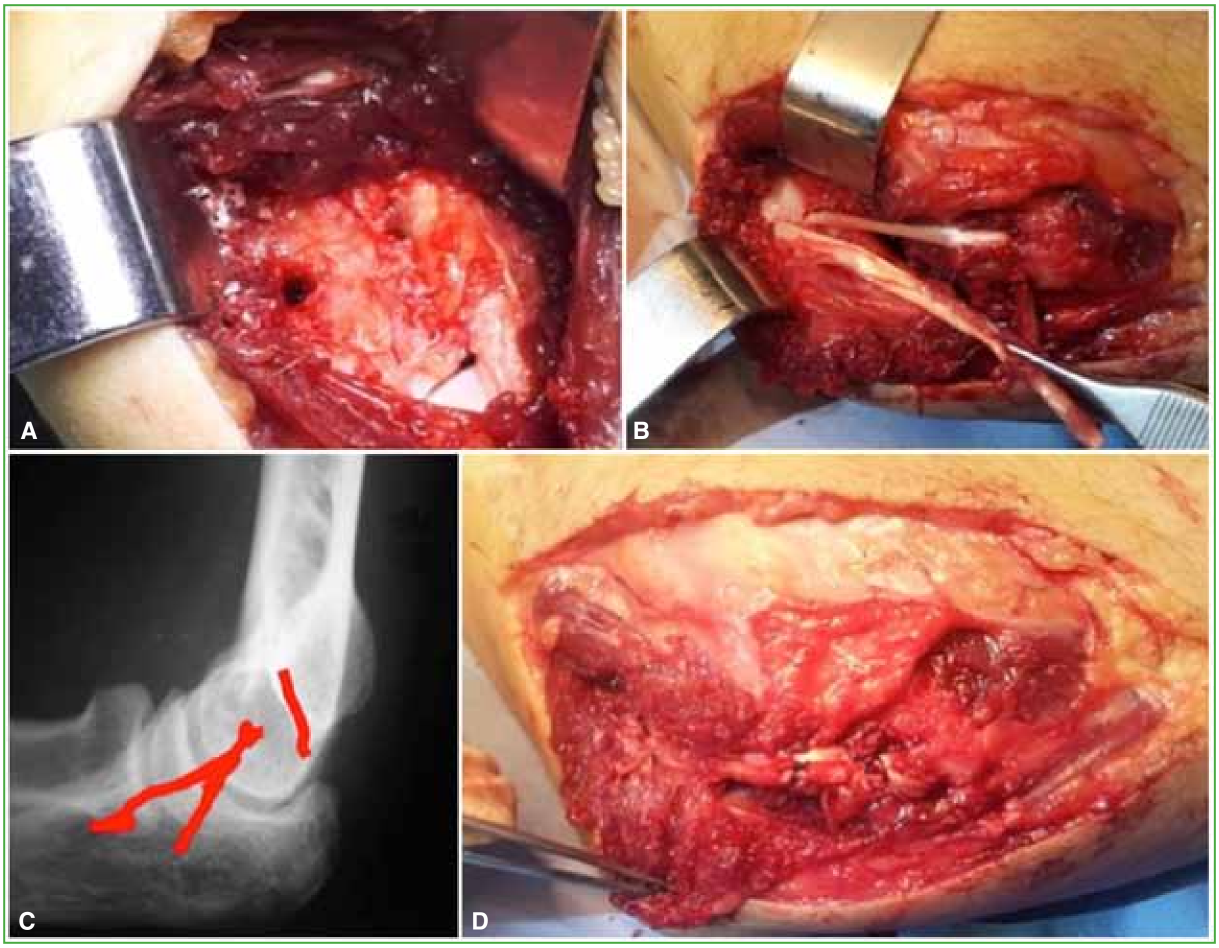

Figure 4. Lateral reconstruction. **A.** Transosseous tunnels. **B.** Passage of the tendon graft through ulnar tunnels. **C.** Passage of the graft through the distal humerus (red lines represent the graft). **D.** Final suture of the lateral reconstruction.

Postoperative Management

Immobilize in a splint or brace at 90° flexion and pronation for 2 weeks. Begin flexion–extension while maintaining pronation; limit extension to 30° initially and progress to full extension by 4 weeks. Flexion is not restricted. At 2 weeks, start forearm rotation with the elbow at 90°; avoid supination in extension until 6 weeks. Discontinue immobilization at 6–8 weeks (often converting the splint at 2 weeks) when full motion is allowed. Resistive/strengthening exercises begin at 12 weeks. Unrestricted activity is permitted at 6–9 months.

Medial Repair and Reconstruction

If reconstruction is planned, confirm the presence of a palmaris longus (have the patient oppose thumb and little finger while flexing the wrist against resistance). If absent, options include the contralateral palmaris or semitendinosus; we have also used flexor tendon allografts. Anesthesia may depend on graft choice. Position supine with the shoulder abducted and externally rotated. Make a curved medial incision centered at the elbow. Identify the medial antebrachial cutaneous nerve and protect it within the skin flap.

Identify the ulnar nerve proximally, releasing the cubital tunnel (epitrochlear–olecranon groove) distally. Distal to the tunnel, incise fascia over the two heads of the flexor carpi ulnaris (FCU); the ulnar nerve lies between them. Harvest autograft first if used.

Expose the distal medial UCL insertion on the proximal ulna by elevating FCU from the medial epicondyle to ~5 cm distal to the sublime tubercle. Assess tissue quality and lesion type. In acute injuries with good tissue, reattach the capsuloligamentous complex to the medial distal humerus with suture anchors; reattach the flexor–pronator origin if avulsed.

For reconstruction, drill two convergent 3.5 mm tunnels just distal to the margins of the sublime tubercle, separated by 1 cm, and connect with a curette. Pass the graft through the ulnar tunnel.

At the humeral origin of the anterior band of the UCL, drill the larger anterior tunnel to receive both graft limbs. Connect it to two posterior tunnels in a Y-configuration. Assess tension with the forearm in supination and trim excess graft. Pass both limbs (Krackow traction sutures) into the anterior tunnel and retrieve each limb through a posterior tunnel (docking technique).[15]

Repair residual capsule/tendon over the graft. Tension by pulling across the posterior bone bridge and tie the sutures together. Release the tourniquet, achieve hemostasis, and close in layers (Figure 5).

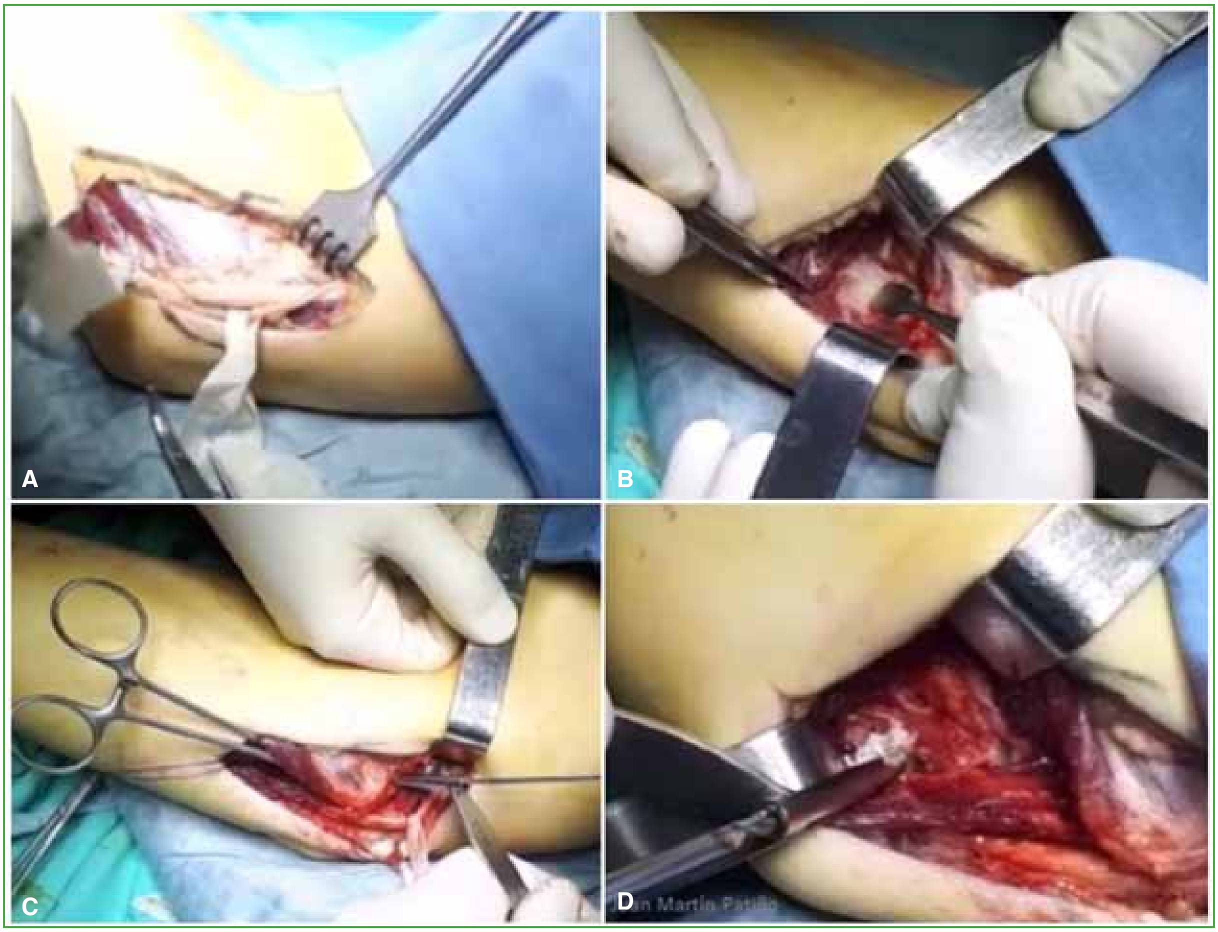

Figure 5. Medial ligament reconstruction. **A.** Identification and protection of the ulnar nerve. **B.** Curettage of the proximal ulna before drilling. **C.** Bone tunnel drilling in the distal humerus. **D.** Bone tunnel drilling in the proximal ulna.

Postoperative Management

Apply a posterior splint with the elbow at 90° flexion and the forearm supinated. At 14 days, begin flexion–extension while limiting varus–valgus stress and maintaining supination. Initiate full range of motion at 6–8 weeks. Begin strengthening at 12 weeks. Graduated return to sport occurs between 4 and 6 months, once a functional arc and adequate strength are achieved.

Results of Surgical Treatment

In one series, 13 patients underwent primary repair for subluxation after reduction with an incongruent joint requiring a 45° extension block to maintain reduction. One had isolated medial repair, two had isolated lateral repair, and ten had combined repairs. Mean MEPS was 93.5 (range 70–100); all elbows were stable with a mean 13° flexion contracture and 15° loss of extension.[16]

In another evaluation of 21 patients treated via a lateral approach (only four also had medial repair if instability persisted), immobilization lasted one week; mean follow-up was 15 months. All elbows were considered stable, with mean flexion 121°, mean extension loss 6.8°, and mean MEPS 91.[17]

In a further series of open lateral repairs (sutures or anchors) after acute PLRI, all elbows were stable with mean flexion 120°, extension loss 13°, and mean MEPS 86.9. Eighteen results were good/excellent and one fair; two patients had signs of instability with moderate pain.[9]

Some authors report that repair alone may be insufficient due to a 42% recurrence rate, and have used hinged external fixation, transarticular pins, or hinged braces limiting extension.[11]

Arthroscopic techniques are an option: in a series of 14 athletes treated arthroscopically after acute/subacute dislocation with suture anchors, all were satisfied with a return to preinjury level, achieving a flexion–extension arc of 3° to 130° and a mean MEPS of 99.6.[18]

Recently, augmentation of repairs—so-called internal bracing—has been proposed to increase construct strength, enable early rehabilitation, and expedite return to activity.[19]

Residual Instability After Medial and Lateral Repair

Persistent instability after both medial and lateral repair is uncommon. In such cases, external fixation with a static or hinged brace may be used. Hinged frames are less available in our setting, but they allow early elbow motion within a safe range. Typically, the brace is removed at 2–4 weeks, transitioning to a splint to protect the range of motion. An alternative is a transarticular pin as a stabilizer/protector in residual instability. In a comparative study, functional outcomes and scores were similar between methods, but transarticular pins had more complications.[20]

Post-dislocation and Postoperative Complications (Lateral and Medial)

Fractures between the tunnels have been reported; therefore, it is important to maintain adequate bone bridges to avoid this complication.

Recurrent instability: about 2% in older patients and associated with difficult reductions. Close follow-up after reduction is essential to detect recurrent instability, redislocation, severe stiffness, soft-tissue injury, or neurologic sequelae. The most challenging issues are chronic instability and chronic dislocations.

Nerve injuries: in the acute stage, they are rare; in simple dislocations, about 1% require surgery. Ulnar nerve irritation/palsy has been reported after surgery; routine release affords visualization and protection. If the nerve's position conflicts with tunnel creation, anterior transposition can be performed. Avoid knot stacks adjacent to the nerve.

Vascular injury: uncommon. In a series of 634 simple dislocations, brachial artery injury occurred in 3 (0.47%).[21] In these cases, arterial repair or *bypass* was required.

Stiffness: common after immobilization and increases with longer immobilization. [11]

Osteoarthritis: chondral injuries may be occult at the time of dislocation. Symptomatic osteoarthritis requiring surgery has been reported at low rates (7 of 5000 in long-term follow-up).[13]

FINAL CONSIDERATIONS

Simple elbow dislocations are common. Associated injuries must be identified, and reduction should be early and atraumatic. After reduction, evaluate stability under fluoroscopy with stress testing through the flexion–extension arc; this guides the indication for surgery.

When the elbow remains stable after reduction, 7–10 days of immobilization followed by motion within the stable arc reduces the risk of residual stiffness. For a stable elbow, nonoperative treatment is standard.

The mechanism of dislocation remains debated; injuries may begin laterally or medially.[22] Medial onset appears to be less common.

Isolated lateral repair is often sufficient, even when there is medial ligament injury. Neurologic and vascular complications are rare. Complications such as instability, stiffness, and osteoarthritis infrequently require surgery.

Most cases do not require operative repair, but when indicated, outcomes are generally good.

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

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Intra-articular Arthroscopic Tenodesis of the Long Head of the Biceps Using a Knotless Threaded Anchor: Surgical Technique

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ABSTRACT
Introduction: Shoulder pain associated with pathologies of the long head of the biceps—such as tenosynovitis, SLAP lesions, instability (pulley lesions and dislocation), and tendon tears (partial or complete)—is common. **Objective:** To describe, step by step, an intra-articular arthroscopic tenodesis of the long head of the biceps using a high-strength suture passed through the tendon with a Penetrator® suture passer and fixation with a 4.75-mm knotless threaded anchor. **Conclusion:** This technique is simple, easy to learn, minimally invasive, and yields good postoperative outcomes.
Keywords: Long head of the biceps; SLAP lesion; tenotomy; tenodesis.
Level of Evidence: V

Tenodesis articular de bíceps proximal mediante artroscopia y fijación con anclaje sin nudo. Técnica quirúrgica

RESUMEN
Introducción: Los distintos cuadros de la porción larga del bíceps proximal, como tenosinovitis, lesión SLAP, inestabilidad (lesión de poleas y luxación), desgarros (parciales o completos) históricamente han generado consultas frecuentes por dolor de hombro. **Objetivo:** Describir paso a paso una técnica de tenodesis articular de la porción larga del bíceps mediante artroscopia y toma del tendón con sutura de alta resistencia con pinza Penetrator® y fijación con un anclaje roscado sin nudo de 4,75 mm. **Conclusión:** Esta técnica es un método simple de aprender, poco invasivo y consigue buenos resultados posoperatorios.
Palabras clave: Porción larga del bíceps proximal; lesión SLAP; tenotomía; tenodesis.
Nivel de Evidencia: V

INTRODUCTION

Disorders of the long head of the biceps (LHB), such as tenosynovitis, superior labrum anterior to posterior tear (SLAP), instability (pulley lesion and dislocation) and tears (partial or complete) have historically generated frequent consultations for shoulder pain.[1-4] The LHB originates at the supraglenoid tubercle and the superior labrum, crosses the glenohumeral joint distally, and then enters the bicipital groove.[5,6]

On physical examination, passive and active range of motion are assessed, together with rotator cuff and biceps strength, and specific provocative maneuvers for LHB pathology (e.g., Speed, Yergason, O'Brien). Ancillary studies typically include ultrasound, radiographs, and magnetic resonance imaging to evaluate the aforementioned conditions.

Surgery is indicated if conservative treatment fails. In many articles, similar outcomes have been reported for LHB tenotomy and tenodesis.[7,8] However, at present, better outcomes are achieved with tenodesis in terms of strength, pain relief, and aesthetics (lower rate of the Popeye deformity).[9]

The aim of this article is to describe a step-by-step intra-articular arthroscopic LHB tenodesis technique.

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SURGICAL TECHNIQUE

General anesthesia is administered with the patient in the lateral decubitus position and the arm under traction (we prefer this position with the arm in extension, because it decreases the probability of complications, such as postoperative Popeye's sign) with the stretcher inclined at 25°. Standard arthroscopic portals are used—posterior viewing and anterior working portals, in this case.

Through the posterior intra-articular portal, a 30° arthroscope is introduced to perform diagnostic arthroscopy, looking for labral, glenohumeral, rotator cuff and LBH lesions. The LHB is examined from its origin along its intra-articular course to the bicipital groove, and the biceps pulley is inspected (Figure 1).

Figure 1. The intra-articular posterior portal is entered for arthroscopic exploration. A SLAP lesion is observed.

Once tenodesis has been indicated, an intramuscular needle is used to mark the skin and determine the position of the anterior working portal at the intended level of fixation (Figure 2). The humeral bone bed is prepared by removing articular cartilage and periosteum until bleeding bone is obtained. For this purpose, a 4.5-mm shaver and a curette are used.

Through the working portal, a high-strength suture is loaded onto a penetrating suture passer (Penetrator®) (Figure 3). A double pass is made through the tendon to create a lasso-loop that securely captures the LHB (Figure 4). On some occasions, for greater safety, the same maneuver is then performed with a second high-strength suture.

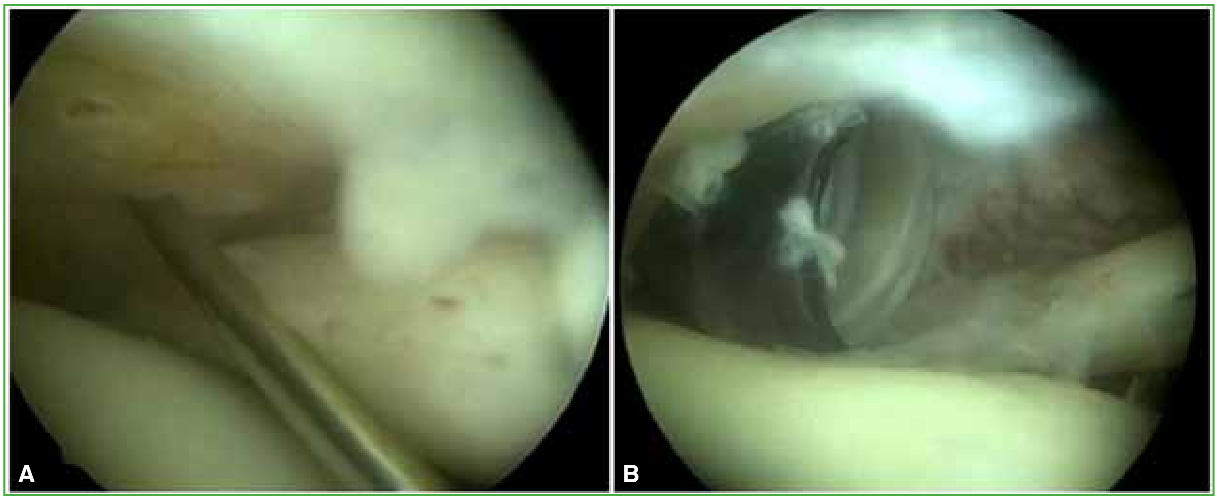

Figure 2. A. Skin marking with an intramuscular needle to locate the anterior working portal at the planned level of tendon fixation. **B.** Placement of a cannula.

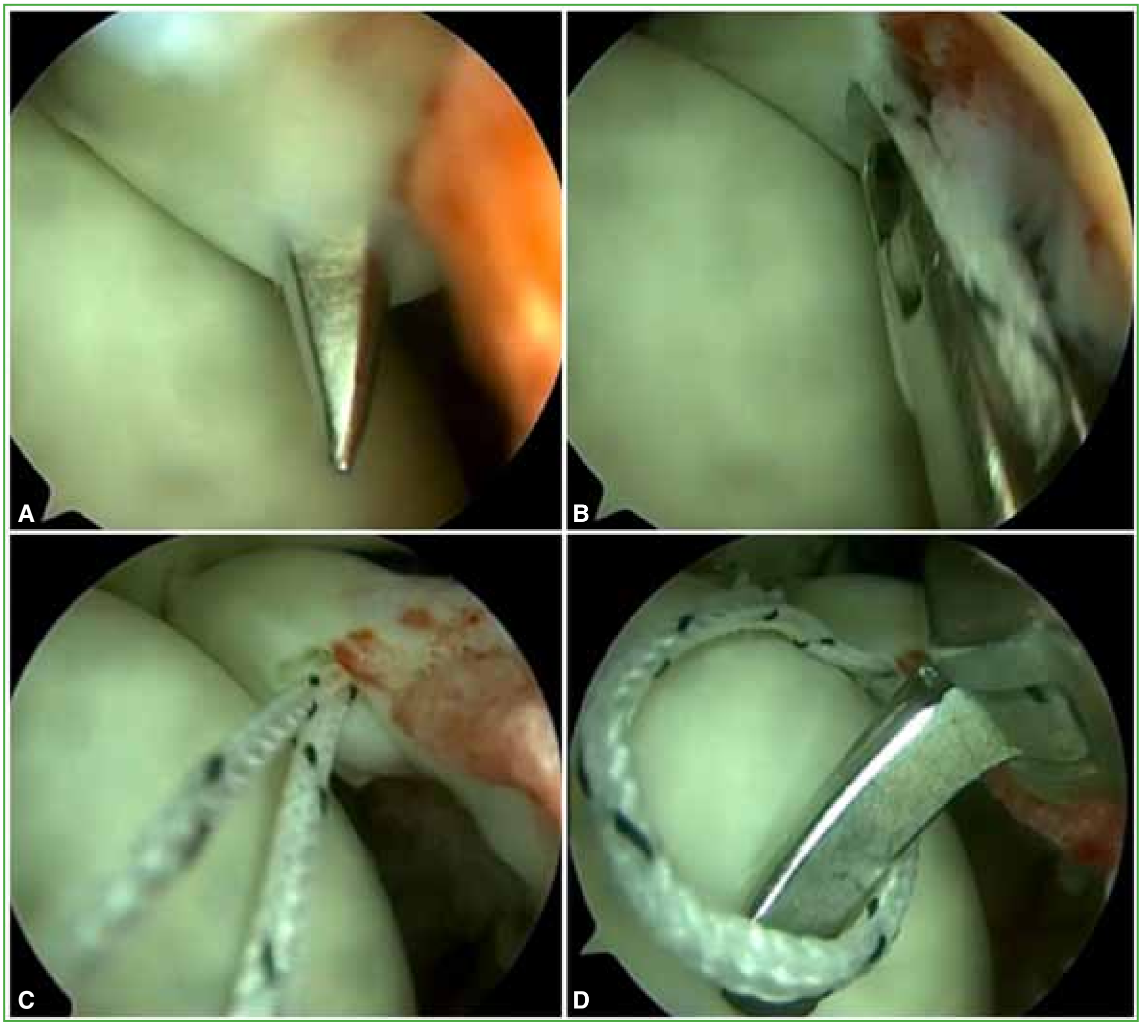

Figure 3. **A.** Preparation of a high-strength suture on a penetrating suture passer (Penetrator®). **B.** The suture is passed twice through the long head of the biceps to then retrieve the loop (**C and D**).

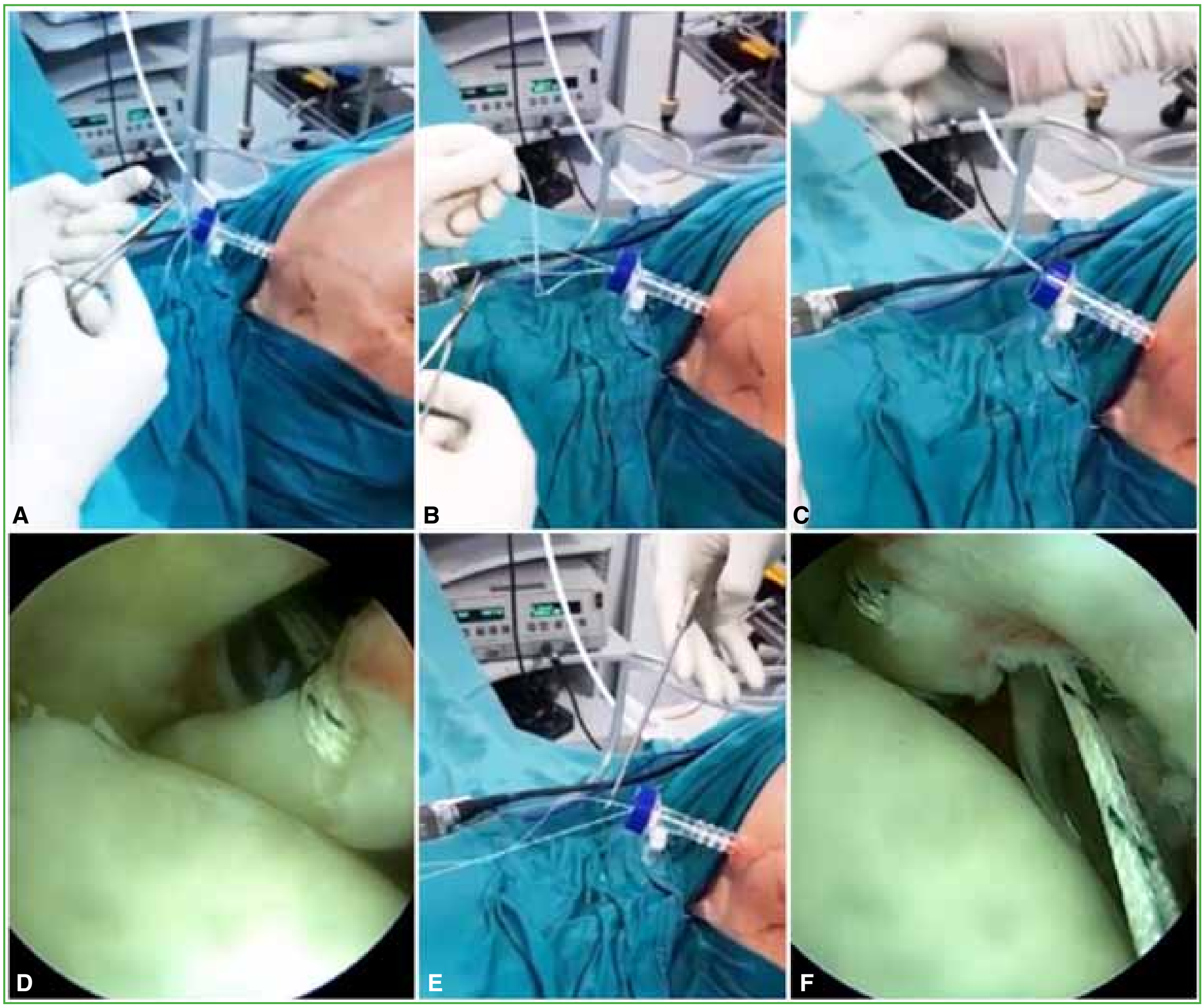

Figure 4. **A and B.** Creation of a simple double knot by passing the sutures inside. **C and D.** Advancing and tightening the know for a secure repair. **E.** Taking one of the sutures with a forceps, from one side of the tendon. **F.** Creation of a simple knot.

After the tendon has been captured, one or two 4.75-mm knotless threaded anchors are inserted for tenodesis of the LHB (Figure 5). Finally, tenotomy is performed and the proximal and distal stumps are coagulated (Figure 6).

Postoperative Management

A sling is indicated for one month. During the first week, pendulum and passive range-of-motion exercises are started. From week 3, passive and active range-of-motion exercises are progressed with the assistance of a kinesiologist. Finally, muscle strengthening exercises are indicated at the sixth week, in a progressive manner, evaluating the range of motion. The average recovery time is between 3 and 6 months, depending on the patient's activity level.

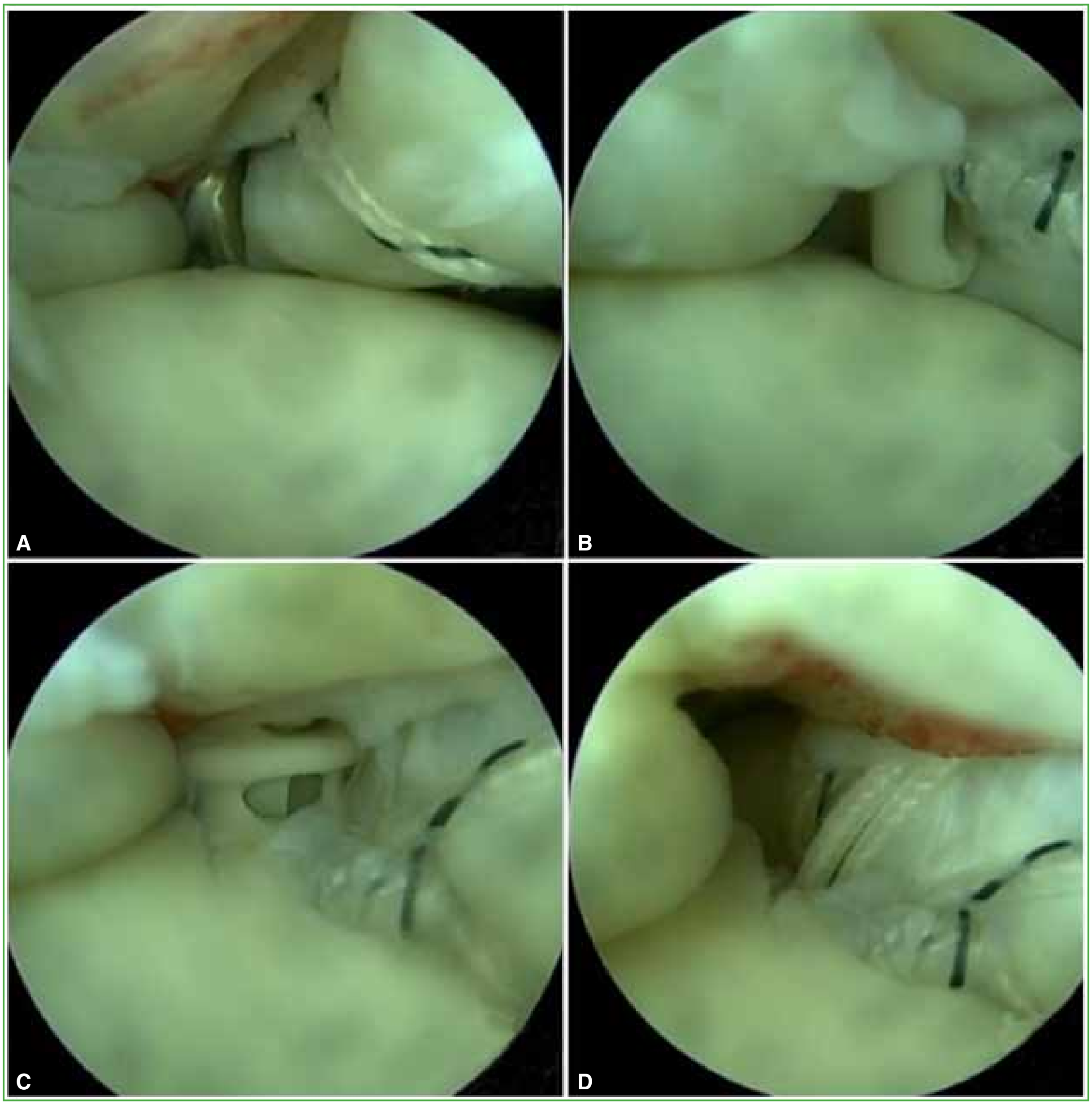

Figure 5. Once the tendon has been captured, one or two 4.75-mm knotless threaded anchors are used. **A.** Creation of the hole with the corresponding starter. **B and C.** Placement of the anchor and tensioning until the anchor reaches the threaded segment. **D.** Threading until it is fixed.

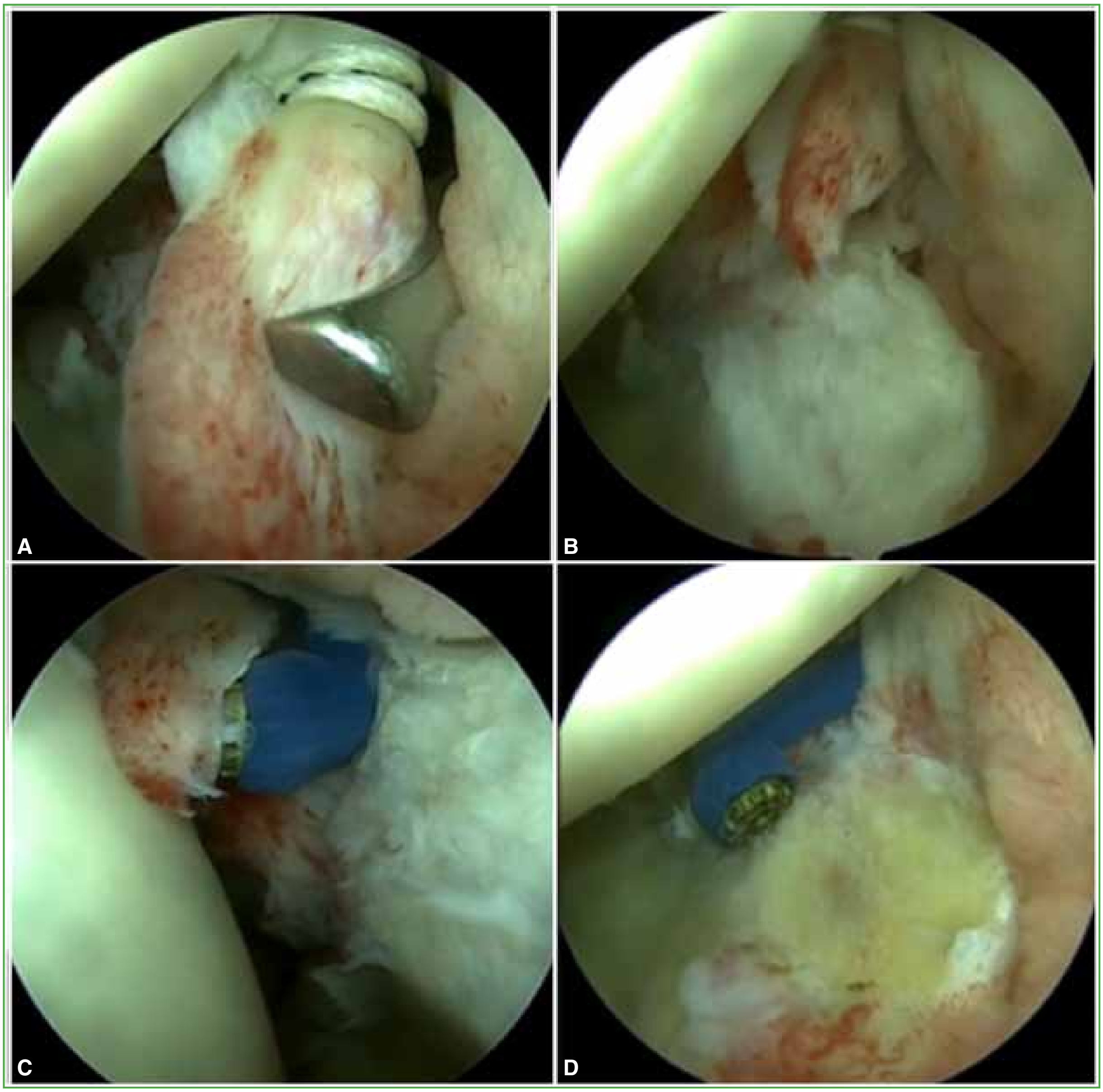

Figure 6. A and B. Tenotomy performed with arthroscopic scissors. **C and D.** Coagulation of the proximal and distal stumps.

DISCUSSION

The ideal surgical treatment for conditions of the LHB (tenosynovitis, SLAP lesions, instability due to pulley injury or dislocation, and tears) remains controversial and depends on the specific entity.

A particularly debated topic is the management of type II SLAP lesions. Different options have been proposed based on the patient's age, work or sports activity, expectations, and the demands to which the shoulder will be exposed. The current central question is the choice between labral repair and biceps tenodesis and their respective outcomes.[10] According to some authors, labral repair is mainly indicated for young patients (with a proposed cut-off around 30–35 years) without degenerative changes or biceps pulley lesions. However, Boileau et al. reported unsatisfactory results and a low rate of return to prior activity with repair compared with tenodesis (repair: 40% satisfaction and 20% return to activity; tenodesis: 93% and 87%, respectively).[11] In addition, revision surgery is more frequent after repairs than after tenodesis (11.5% vs 0%).[12] In our experience, tenodesis is associated with higher patient satisfaction, greater predictability, and a better rate of return to previous activities.

Key considerations for tenodesis, whether performed arthroscopically or through a mini-open approach, include the fixation method (anchors of various types, such as suture-only, PEEK, or knotless systems), or the use of interference screws, and the fixation site (intra-articular, suprapectoral, or subpectoral).[13,14]

The advantage of tenodesis is that it maintains the biceps length–tension relationship and, as a result, offers cosmetic benefits (avoids the Popeye deformity), reduces discomfort, and preserves muscle strength compared with isolated tenotomy.[15]

In 2006, Lafosse et al. described, for LHB tendon harvesting, the initial use of a "harpoon" suture passer to place sutures and then apply their lasso-loop technique to secure the biceps.[16] In our practice, we prefer to first harvest the LHB tendon with one or two high-strength sutures, fix it with a knotless PEEK anchor, and then proceed with the tenotomy.

EXPERIENCE

This technique was performed in 88 patients (65 men and 23 women; age range, 18–71 years). Fifty-nine had pathology involving the bicipital groove (pulley lesions, cysts and lobulations within the groove or decentration, tenosynovitis, and partial tears); 5 had lesions at the subscapularis tendon insertion; and 24 had SLAP lesions. There were no systemic or infectious complications and no tendon detachment. Notably, in 10% of patients a palpable residual bulge was present at the level of the bicipital groove; this improved by month 6, and normal function was recovered after 8 months. All patients returned to their previous work or sports activity. Pre- and postoperative strength measurements were not compared.

CONCLUSION

The technique described is simple to learn, minimally invasive, and achieves good postoperative outcomes.

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

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The Logic of Clinical Reasoning in Medicine

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ABSTRACT
Three modes of inference underpin clinical reasoning: abduction, deduction, and induction. Abduction generates plausible explanations or diagnostic hypotheses at the outset of evaluation. Deduction guides the selection of tests to probe the consequences of those hypotheses and to assess whether the presumptive diagnosis accounts for all clinical findings. Induction then compares the hypotheses' predictions with observable facts to determine whether the expected findings are indeed present.
Keywords: Medical diagnosis; clinical reasoning; critical thinking.
Level of Evidence: V

La lógica del criterio clínico médico

RESUMEN
Los tres tipos de razonamiento que conforman el criterio clínico de los médicos son la abducción, la deducción y la inducción. La abducción se utiliza para generar explicaciones o hipótesis posibles al principio del proceso diagnóstico. El razonamiento deductivo se utiliza para determinar qué pruebas deben realizarse para explorar las consecuencias de las hipótesis y luego preguntarse si realmente el diagnóstico presuntivo explica todos los hallazgos. La fase inductiva compara las afirmaciones de la hipótesis con los hechos observables para finalmente evaluar si están presentes o no los hallazgos esperados.
Palabras clave: Diagnóstico médico; razonamiento clínico; pensamiento crítico.
Nivel de Evidencia: V

INTRODUCTION

Reaching a definitive diagnosis in a patient is a complex phenomenon because it involves dynamic and incomplete information. To address this, physicians use logic, evidence-based medical knowledge, and clinical experience to arrive at a diagnosis through a structured process.[1] This process is analytical and systematic and combines scientific aspects with deductive and inductive reasoning skills. This formula, known as the hypothesis method, consists of choosing one hypothesis among several alternatives.[2] More than a mere part of our medical legacy or an interesting historical and philosophical vestige, the hypothesis method is the cornerstone of diagnostic reasoning. In Phaedo, Plato formulated for the first time the hypothetical method that consists of choosing one hypothesis over other alternatives.[3] Undoubtedly, critical thinking predates clinical judgment.

Critical thinking is the cognitive tool used to analyze knowledge. Its application in medicine is called clinical reasoning. It requires both knowledge of disease and familiarity with the particular patient's clinical context, since critical thinking is used to discern and interpret both the scientific evidence and the patient's presentation.

The diagnostic process, like practicing a surgical approach, is always trainable and improvable. A long career is not a guarantee of good practice or *savoir faire*. It is an error to confuse experience with expertise and expert performance. The latter implies the correct interpretation of the available information and, therefore, proper execution. The logic of expertise cannot stand on its own; it must be articulated between scientific evidence and

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the information we obtain from our patients. The objectivity of scientific evidence is fundamental, since formal logic deals with the rules that govern inferences and focuses on the structure of arguments, but not on the truth of their premises. In the end, logic concerns itself with the structures and laws that govern meanings and relations among propositions, but it cannot go beyond these.

In most cases, well-trained subspecialists can reach the correct diagnosis with little effort using deductive reasoning alone. However, although pattern recognition can be an essential part of the deductive process, relying on it exclusively is likely to lead to diagnostic errors in less common diseases. Stereotyped diagnosis limits us to skill only in what is common, much like grandmothers who could recognize teething-related diarrhea in an infant.

To use deductive reasoning with minimal error, we must be aware of the logical fallacies into which the diagnostic process may fall. Correct diagnoses rest on valid reasoning as well as correct information. The shoulder specialist who disregards logic may naively assume that a diagnosis has been proven when, in reality, it has only been shown to be possible or probable. Knowing the logical basis of proof and refutation should help us not only to be more accurate in individual diagnosis, but also to provide a rational approach to developing diagnostic criteria supported by Evidence-Based Medicine.

The purpose of this article is to review the hypothesis method as it applies to medical diagnosis and to the application of clinical judgment.

FIRST IMPRESSION AND ABDUCTIVE REASONING

The expression abductive reasoning (or abductive judgment) refers to a form of logical reasoning that physicians (and others) use to formulate explanatory hypotheses based on incomplete observations. The concept was introduced and developed by the American philosopher and logician Charles Sanders Peirce and is defined as the process of inferring the best possible explanation from the available data.[4]

When the patient states the chief complaint, we can abduct from this history the possible causes and the etiopathogenesis of the illness. To achieve this, we resort to abductive judgment, because deductive and inductive reasoning by themselves are insufficient to explain and infer what occurs during the initial stage of the diagnostic process, when the physician must generate potential diagnoses and their possible causes, given that the information available cannot yet contribute to the development of explanatory theories. Abduction, as a form of creative inference, is used instead to generate possible explanations or hypotheses through the analysis of incomplete observations at the outset of the diagnostic process.

Abductive judgment rests on conditional probability, namely the probability that something occurs given that something else has already occurred. In practical terms, if a patient reports a fall from a bicycle and presents with a deformity of the clavicle, a fracture of that bone is to be expected. The analysis then proceeds to the recognition of key elements or sets of elements, such as “shoulder pain” or “active loss of mobility.” In this way, the formulation of abductive reasoning builds the foundations that will guide the next step in the process: deduction.

DEDUCTIVE REASONING

After the first impression furnished by abduction, the physician lists possible differential diagnoses; the scientist, hypotheses; and the detective, suspected criminals. Each recognizes that most hypotheses are incorrect and that the work consists in eliminating the incorrect ones and confirming the correct ones, two complementary yet very different processes. For example, the detective uses an alibi for elimination and motive or evidence of presence at the scene, or both, for incrimination. The scientist proposes a hypothesis, defines its implications, and then designs experiments based on these deductions. If the experiment confirms expectations, the hypothesis is supported. If the experimental results contradict the hypothesis, that hypothesis must be abandoned. On this point, José Manuel del Sel[5] wrote: “… Hypotheses in science are always conditioned by being refutable; unfavorable evidence must be sought conscientiously. The scientist does not try, nor does he grow upset if his theory is refuted, because it would be much worse to persist if it is fraudulent …”

Findings that are merely compatible do not affirm a diagnosis; they simply establish that it is possible. Conversely, if our presumptive diagnosis fails to explain the findings that emerge from the physical examination, it is likely because the diagnostic hypothesis has been incorrect, that is, the abductive reasoning has failed. In such a case, either we lack knowledge about the possible diseases the patient may have, or our history taking and initial assessment have been inadequate, or we have too hastily discarded other differential diagnoses.

Deductive reasoning is used to determine which tests should be performed to explore the consequences of the hypotheses. It applies a known general rule to a particular case. Here, we assume a hypothesis is possible, and the examiner must decide which clinical tests and ancillary studies are necessary to confirm or refute it. If predicted and observed results match, the hypothesis is supported but not confirmed, unless the examination findings are specific to that disease. If the findings cannot be explained by our diagnostic hypothesis, the hypothesis is rejected (Figure 1).

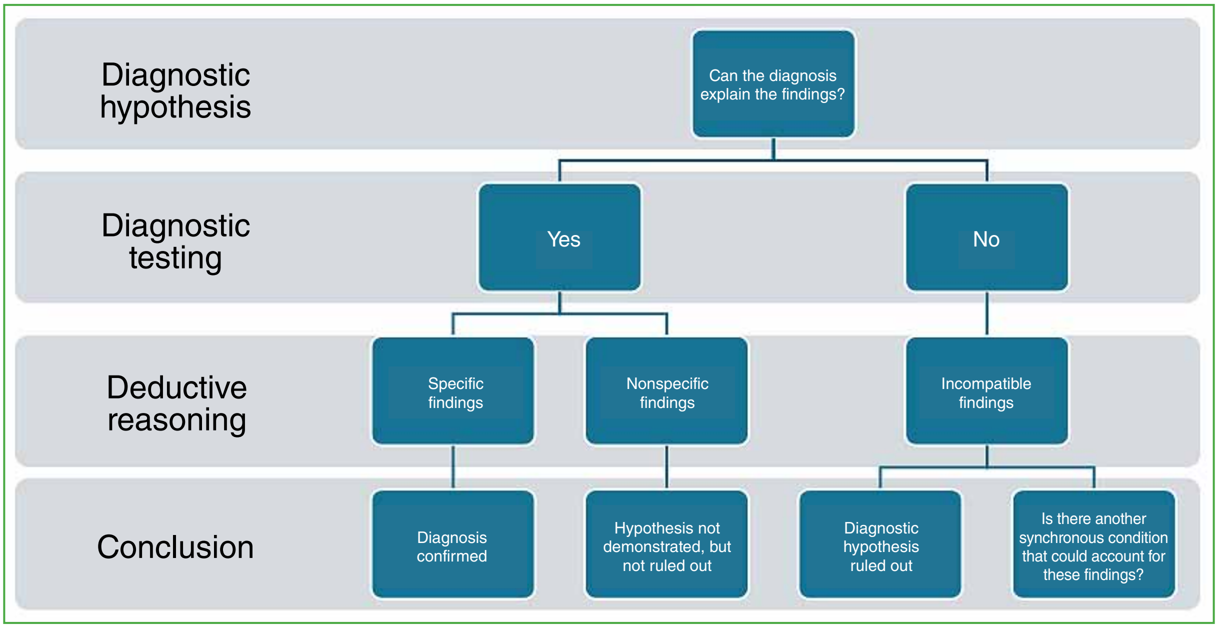

Figure 1. Does the diagnosis explain all the clinical findings?

INDUCTIVE REASONING

The physician tests each hypothetical diagnosis in turn, attempting to refute the incorrect and to prove the correct. To do so, two elementary questions are posed: does the diagnosis explain all the clinical findings, and are the expected findings present? If these findings are specific to the disease, we have reached a definitive diagnosis (Figure 2).

To answer the first question, we examine the particular case (the illness) to see whether it fits into a class (the disease or syndrome proposed as the hypothetical diagnosis). For the second, our perspective is reversed, and we examine the class to see whether the attributes of the class (diagnostic criteria) are congruent with the particular case (the illness).

Inductive reasoning complements this process by allowing the physician, through the systematic performance of diagnostic tests in different patients, to observe how different combinations of signs and symptoms are repeatedly associated with certain diseases. Thus, abstraction and generalization arise not only from clinical observation but also from the inductive interpretation of positive or negative results of specific tests according to the case. It involves abstracting findings, sowing clinical observations, and discerning what is common among what is diverse.

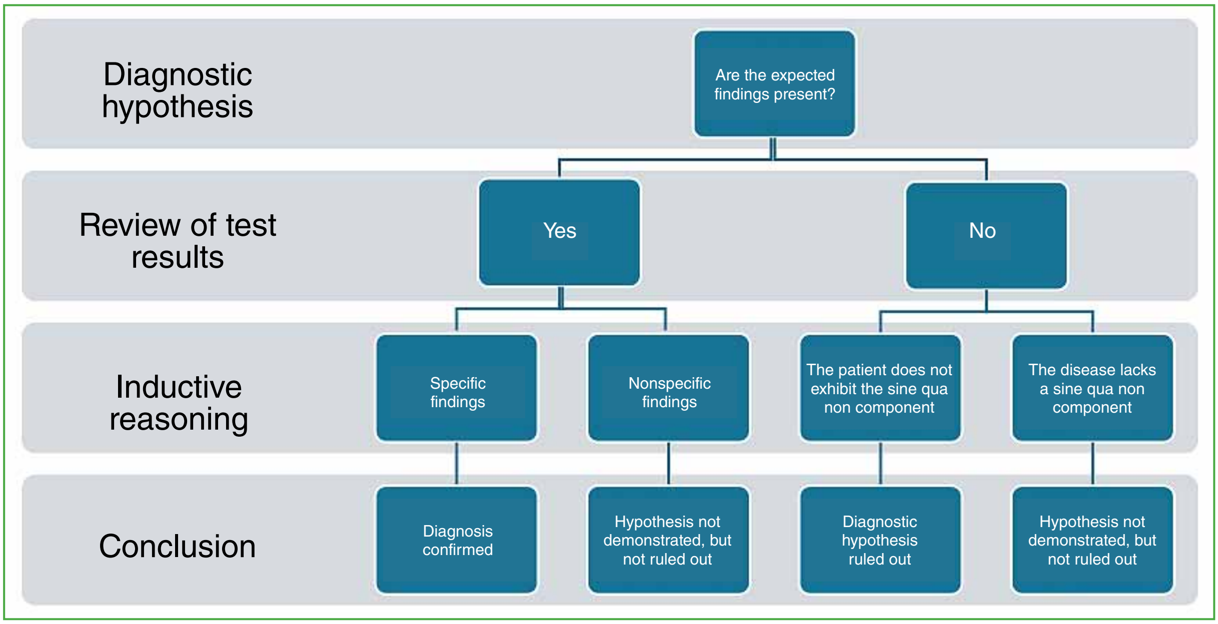

Figure 2. Are the expected findings present?

Jorge Luis Borges, in his short story *Funes the Memorious*, describes a main character who lacks this capacity for reasoning: "*I suspect, nevertheless, that he was not very capable of thought. To think is to forget a difference, to generalize, to abstract. In Funes' crowded world there were only details, almost immediate,*" thereby illustrating the epistemological importance of the ability to relativize and contextualize details in order to think in general terms. This is essential to build clinical judgment, identify patterns, and derive a diagnosis from the integration of multiple data.[6]

Figures 1 and 2 depict the path from test questions to proof or refutation. It is immediately evident that a highly specific test is used primarily to confirm a disease. Specificity measures a test's ability to correctly identify people who do not have the disease, thus avoiding false positives. If a test is highly specific and yields a positive result, it is very likely that the person actually has the disease, so the positive predictive value is high. Conversely, sensitive tests are used to rule out diseases, because they have a high capacity to detect people who do have the disease, thereby avoiding false negatives. It is also evident from Figures 1 and 2 that, on certain occasions, the physician may end up with neither confirmation nor refutation of the presumptive diagnosis in a strict logical sense.

Figure 3 indicates the relationship that may exist between a manifestation and a disease. A manifestation may be associated with a disease all the time (as a sine qua non condition), most of the time, occasionally, or never. Unlike deduction, induction does not provide logical certainties but clinical probabilities, so it must be complemented by statistical evidence and by linked, consecutive testing. Despite its relativity, it is essential for creating diagnostic criteria in daily practice.

REFUTING THE DIAGNOSIS BY INCOMPATIBLE FINDINGS

If the case presents incongruent features that cannot be explained in terms of the hypothetical diagnosis, then that differential diagnosis must be discarded. For example, if a patient presents with shoulder pain but lacks clinical manifestations (M1) considered fundamental (or sine qua non), such as asymmetric loss of shoulder abduction, shoulder-girdle atrophy, or scapular dyskinesia, we could initially rule out facioscapulohumeral muscular dystrophy, even if there is a hereditary history of this disease (Figure 4).

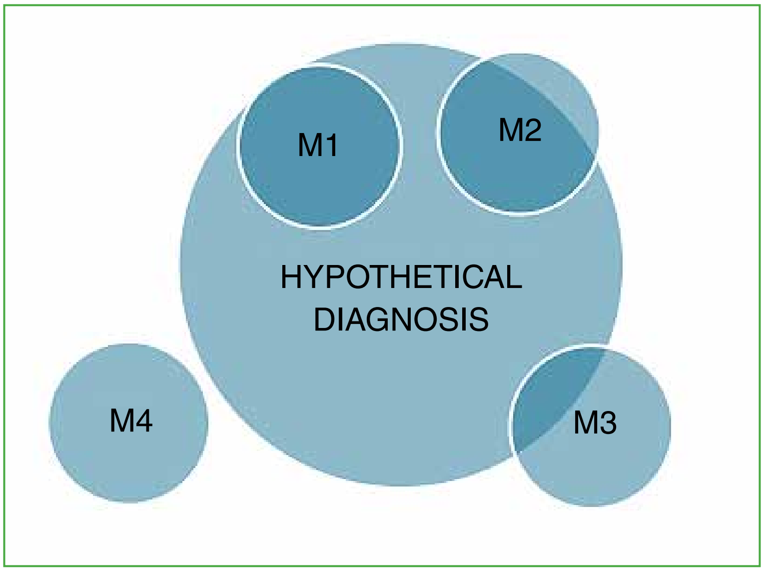

Figure 3. A manifestation of disease may be associated with a disease—and thus with a hypothetical or presumptive diagnosis—always (M1, *sine qua non* manifestation), most of the time (M2), occasionally (M3), or never (M4). In none of these cases is the manifestation uniquely specific or pathognomonic for that disease.

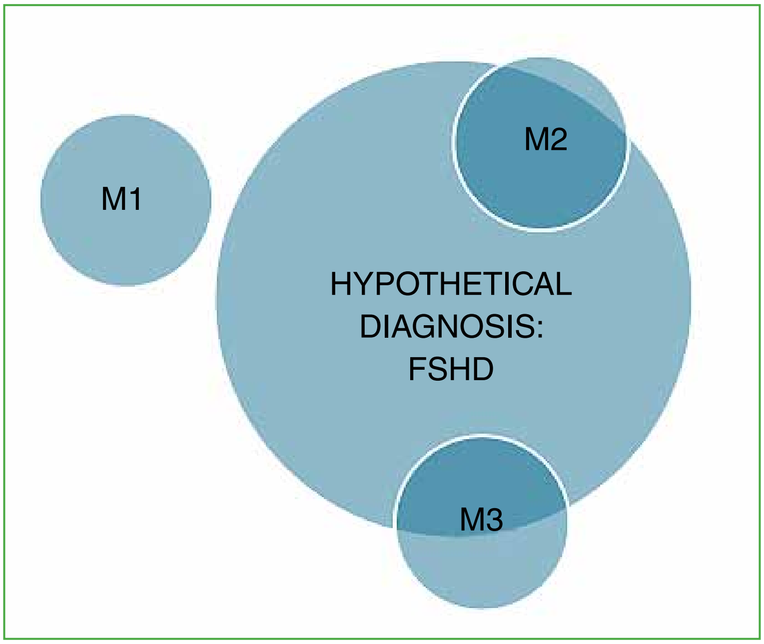

Figure 4. A hypothetical diagnosis can be discarded if a finding (M1) of the disease cannot be identified. M1 = asymmetric loss of shoulder abduction, shoulder-girdle atrophy, and scapular dyskinesia; M2 = facial weakness with asymmetric smile; M3 = sensorineural hearing loss. The absence of M1 is incompatible with the hypothetical diagnosis of facioscapulohumeral muscular dystrophy (FSHD).

However, the physician need not terminally reject the hypothetical diagnosis when encountering an unexpected manifestation. The unforeseen manifestation may be caused by a disease other than that indicated by the hypothetical diagnosis. This additional clinical manifestation may represent another synchronous disease, as can occur in a C5 radiculopathy coexisting with rotator cuff syndrome (Figure 5). If the manifestation can be attributed neither to the hypothetical diagnosis nor to a coexisting synchronous diagnosis, the physician should consider a new hypothetical diagnosis.

Beyond this clinical scenario, ideally multiple independent diagnoses should be avoided whenever possible because they compromise logical simplicity. The more complicated the hypothesis, the more difficult it is to verify its probability. This is known as the logical dictum of Ockham's razor. In the nineteenth century, Sir William Hamilton reformulated this principle as the "law of parsimony," which forbids, without proven necessity, the multiplication of entities, powers, principles, or causes. Its best-known formulation is *Entia non sunt multiplicanda praeter necessitatem*—entities are not to be multiplied without necessity—since simple theories are easier to prove or refute because they involve fewer variables and logical steps.[7] This makes errors, if present, easier to detect. In science, the capacity to refute a hypothesis is crucial. Therefore, although the simplest explanation is not always the correct one, simple models prevail over more complex ones.

Nevertheless, in older patients or those with prior conditions, Ockham's razor may lead to excessive simplification of clinical interpretation, premature diagnostic conclusions, and potentially suboptimal care.[8]

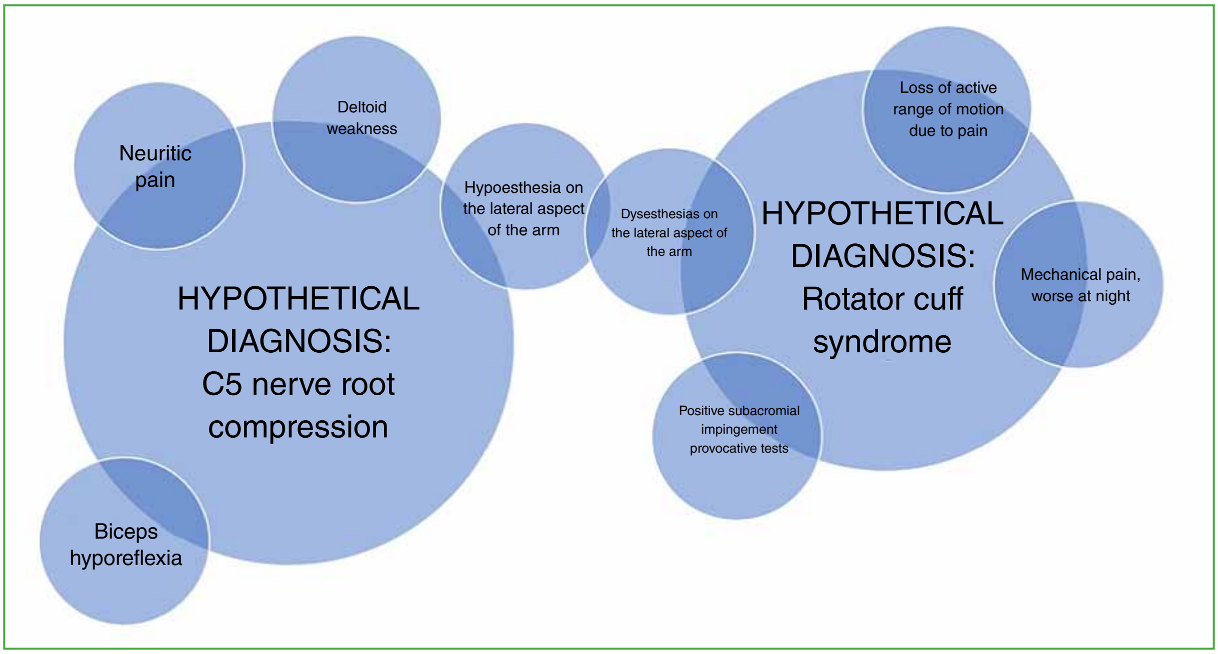

Figure 5. A C4–C5 cervical disc herniation could compress the C5 root and cause weakness of the deltoid and biceps muscles, decreased sensation along the lateral arm, and loss of the bicipital reflex. This lesion could coexist with rotator cuff syndrome, which causes lateral arm pain, loss of active mobility due to pain, mechanical pain with nocturnal worsening, and positive subacromial impingement tests.

PROVING THE DIAGNOSIS BY CONGRUENT FINDINGS

To claim a definitive diagnosis on the grounds that it could explain all the findings is to commit a logical fallacy: affirming the consequent.[9] For example, "If the supraspinatus tendon is completely torn, then the patient will have pain. If the patient has shoulder pain, it is because the supraspinatus tendon is completely torn." There are many other causes of shoulder pain unrelated to the rotator cuff, and the prevalence of supraspinatus tendon lesions in asymptomatic individuals is high, so this reasoning is false.

A diagnosis is proven only when the clinical findings, considered as a whole, are attributable exclusively to the hypothetical diagnosis and to no other disease. Unfortunately, few clinical findings are pathognomonic; otherwise, the diagnostic process would be straightforward. For instance, the combination of mechanical pain with nocturnal worsening and loss of active mobility does not confirm rotator cuff syndrome.

When there is no single pathognomonic finding, such as a Popeye sign attributable to a lesion of the long head of the biceps, a combination of findings considered together may serve the same function. While a single clinical manifestation may not be pathognomonic, the combination may be specific to a condition. This is the rule in most clinical presentations and their corresponding diseases (Figure 6).

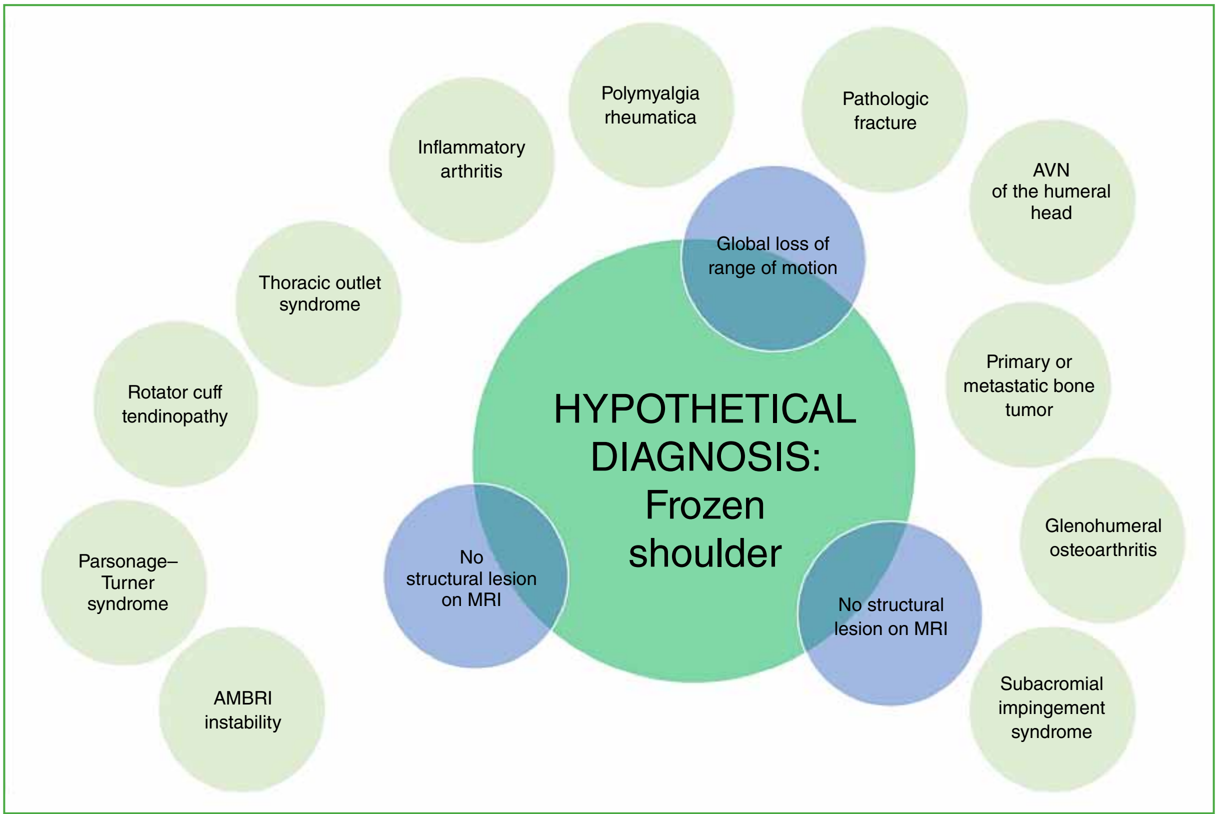

Figure 6. Shoulder pain, loss of active and passive motion greater than 50 percent, absence of a traumatic history, and imaging that rules out a structural lesion are individually nonspecific. However, their combination is specific for frozen shoulder.

ARE THE EXPECTED FINDINGS PRESENT?

Refuting the diagnosis by absence of the expected findings

Can the combination of clinical manifestations that characterizes the hypothetical diagnosis be found in the case at hand? Refutation of a diagnosis by failure to find an expected finding is logically valid only if the expected finding is always present in the disease in question, as in a *sine qua non* condition. For example, a patient with a history of a bicycle fall who has pain at the distal end of the clavicle but no "key-sign" deformity will not have a complete injury of the coracoclavicular and acromioclavicular ligaments, since the presence of that deformity is a sine qua non feature of Rockwood grade 3, 4, and 5 acromioclavicular dislocations.[10]

PROVING THE DIAGNOSIS BY THE PRESENCE OF THE EXPECTED FINDINGS

It is logically false to claim that a diagnosis has been proven simply because the expected manifestations are present. The claim requires that the combination of manifestations be unique; otherwise, the fallacy of affirming the consequent has been committed, as discussed above.

If a disease always causes a given clinical finding, then that manifestation (*sine qua non*) must be present or the diagnosis is refuted. But the presence of a sine qua non manifestation does not prove the diagnosis. Proof requires that the findings be unique (pathognomonic), not merely essential. A manifestation that is only sometimes found in association with a disease may be used to affirm its presence if that manifestation meets the prerequisite of uniqueness. Such a finding could be, for example, calcific tendinopathy of the rotator cuff in a patient with shoulder pain.

Experience (and inductive inference) does not yield judgments with true and strict universality, but rather with assumed and relative generalization. In this sense, evidence-based medicine offers statistical and therefore probabilistic knowledge. The frequency with which particular manifestations associate with a disease does have affirmative value. If we find manifestations with a high statistical association with the hypothesized diagnosis, our argument is stronger than if the manifestations are rarely associated. The more such manifestations we identify, the more confidently we may affirm the diagnosis. For example, in a patient with diabetes and hypothyroidism, the likelihood of frozen shoulder is much higher if sudden, atraumatic pain is associated with a global loss of mobility.[11]

The ideal clinical manifestations to validate our diagnostic hypothesis will be those that, taken together, are highly specific and statistically associated with the disease. If we select a group of manifestations with these attributes, we will have developed diagnostic criteria. As noted, this is achieved through pattern recognition, categorization, and hypothesis testing. If we fail to achieve certainty through this method, we must persist in the search rather than deny contradictory evidence in order to choose an unrealistic hypothesis.

CONCLUSIONS

Medical diagnosis is a complex process. To accomplish it, physicians employ logic, knowledge, and experience through the hypothesis method, which consists of choosing the best explanation among several alternatives. This method is grounded in critical thinking, applied in medicine as clinical reasoning.

The diagnostic process combines three modes of reasoning: abductive, deductive, and inductive. Abductive reasoning allows hypotheses to be formulated from incomplete and dynamic observations, establishing possible explanations based on conditional probability. Deductive reasoning then evaluates which tests would confirm or refute the hypothesis, eliminating incorrect diagnoses. Finally, inductive reasoning analyzes whether the clinical findings match the hypothesized diagnosis.

Diagnostic errors may arise from overreliance on pattern recognition without considering exceptions or from ignoring logical fallacies. The objectivity of scientific evidence is key to avoiding misdiagnosis. Diagnostic error is not inevitable, and accuracy improves with the proper use of logic, scientific evidence, and systematic patient evaluation.

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

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Case Resolution

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Case Presentation on page 307.

Normal Glenoid Ossification Mimicking a Fracture in an Adolescent Patient

ABSTRACT
Differentiating normal ossification variants from fractures in children and adolescents with shoulder trauma is a common diagnostic challenge. We report the case of a 14-year-old male who, after a sports-related injury, was initially diagnosed with a glenoid fracture based on radiographs and computed tomography (CT). Subsequent evaluation, including a detailed physical examination and contralateral shoulder radiographs, showed that the suspected fracture represented normal ossification of the scapular growth centers. This case underscores the importance of a solid understanding of developmental anatomy, a thorough clinical examination, and the use of comparative imaging to avoid misdiagnosis and unnecessary treatment in this population.
Keywords: Ossification; fracture; pediatrics; shoulder; diagnosis.
Level of Evidence: IV

Osificación normal de la glenoides que simula una fractura en un adolescente

RESUMEN
La diferenciación entre las variantes normales de la osificación y las fracturas en pacientes pediátricos y adolescentes con traumatismos de hombro es un desafío diagnóstico común. Presentamos el caso de un varón de 14 años que, tras un traumatismo deportivo, fue inicialmente diagnosticado con una fractura glenoidea sobre la base de estudios radiográficos y tomográficos. Una evaluación posterior, que incluyó un examen físico detallado y radiografías contralaterales, reveló que la supuesta fractura correspondía a la osificación normal de los centros de crecimiento escapulares. Este caso subraya la importancia de un conocimiento profundo de la anatomía del desarrollo, un examen clínico exhaustivo y el uso de estudios comparativos para evitar diagnósticos erróneos y tratamientos innecesarios en esta población.
Palabras clave: Osificación; fractura; pediátrica; hombro; diagnóstico.
Nivel de Evidencia: IV

DIAGNOSIS: Normal glenoid ossification mimicking a fracture in an adolescent patient.

DISCUSSION

Shoulder injuries in children and adolescents are increasing, largely due to earlier and greater participation in contact and competitive sports that demand intensive upper-extremity use.[1,2] Interpreting imaging in this population is particularly challenging: the normal evolution of ossification centers and variations of the physes around the glenohumeral joint can mimic pathology and cause confusion, even for experienced orthopedists.[3] This diagnostic difficulty may lead to unnecessary, costly studies (with attendant radiation exposure), delays in diagnosis, inappropriate treatment, and uncertainty about return-to-sport timelines.

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Accurate knowledge of the timing, location, radiographic appearance, and fusion patterns of the relevant ossification centers, together with a thorough history and physical examination, is crucial for proper diagnosis and management after shoulder trauma in skeletally immature patients.

In this case, comparison radiographs of the contralateral shoulder (Figure 3) and MRI (Figure 4) were obtained to confirm the diagnosis and identify associated injuries. Given favorable clinical progress within the first 48 hours and the absence on MRI of findings suggestive of fracture or injury to the epiphyseal growth plate at the base of the coracoid, conservative treatment was indicated: analgesics for 3 days followed by a progressive return to sports over 21 days. The patient progressed well and returned to sports without restrictions.

Figure 3. Left-shoulder radiographs of the same patient, anteroposterior (**A**) and axial (**B**) views. A radiolucent line extends from the base of the coracoid to the glenoid articular surface (*), similar to the contralateral side.

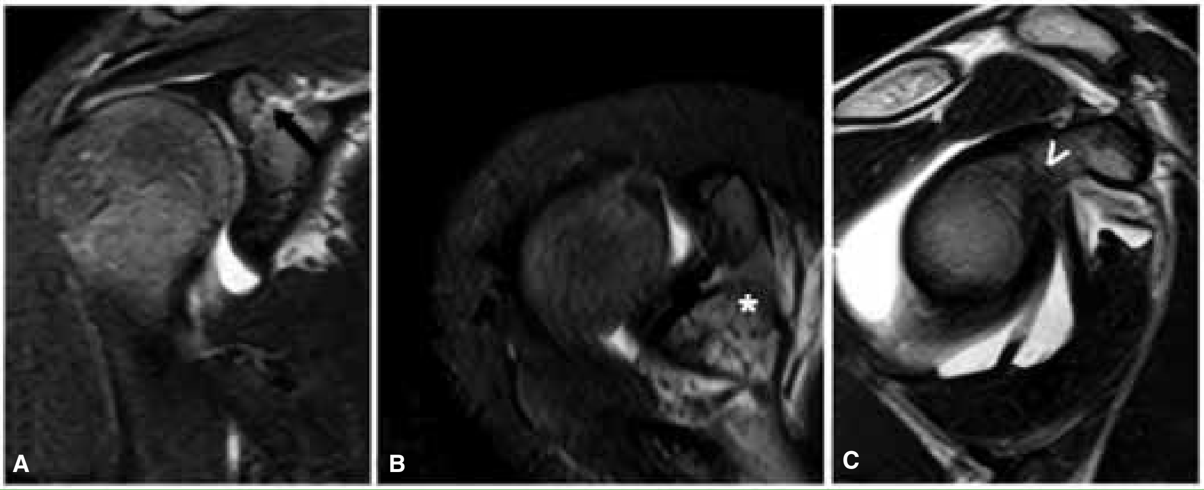

Figure 4. MRI of the right shoulder: coronal STIR (**A**), axial STIR (**B**), and sagittal T2 (**C**). The secondary ossification center of the coracoid (indicated by ↑, * and >, respectively) is seen extending toward the physis between the coracoid base and scapula, with signal intensity similar to the surrounding scapular bone.

Collision sports such as rugby are increasingly popular among children and adolescents, and upper-extremity injuries are common, on par with lower-extremity injuries and head trauma.[3,4] In the setting of high-energy trauma, interpreting advanced imaging can be challenging and may result in misdiagnosis and mistreatment.[3,4]

In this patient, the normal secondary ossification center of the coracoid was initially mistaken for a fracture of the superior glenoid extending into the coracoid. Development of the glenoid and coracoid base in childhood and adolescence is complex, with a bipolar growth plate and multiple secondary ossification centers. The coracoscapular physis begins to close around age 13 and is usually fused by age 17.[5]

The scapular secondary ossification centers include two main components (Figure 5): 1) Coracoid secondary ossification center: the first scapular secondary center to appear; it contributes to the upper third of the glenoid articular surface. It typically appears between 9 and 12 years and fuses with the scapular body between 12 and 16 years; 2) Inferior glenoid secondary ossification centers: multiple centers arranged in a horseshoe configuration that form the lower two-thirds of the glenoid. These usually appear between 11 and 14 years and fuse between 12 and 16 years.[5] Comparison radiographs of the contralateral shoulder are an important tool, allowing reliable distinction between a pathologic fracture line and a normal physis.[6,7] On CT, ossification centers appear on all planes as linear foci of bone and should not be confused with fracture lines, as occurred here. Similar diagnostic confusion has been reported—e.g., Galán-Olleros et al.[8] described a comparable case in a 13-year-old basketball player—highlighting how common and relevant this pitfall is in pediatrics.

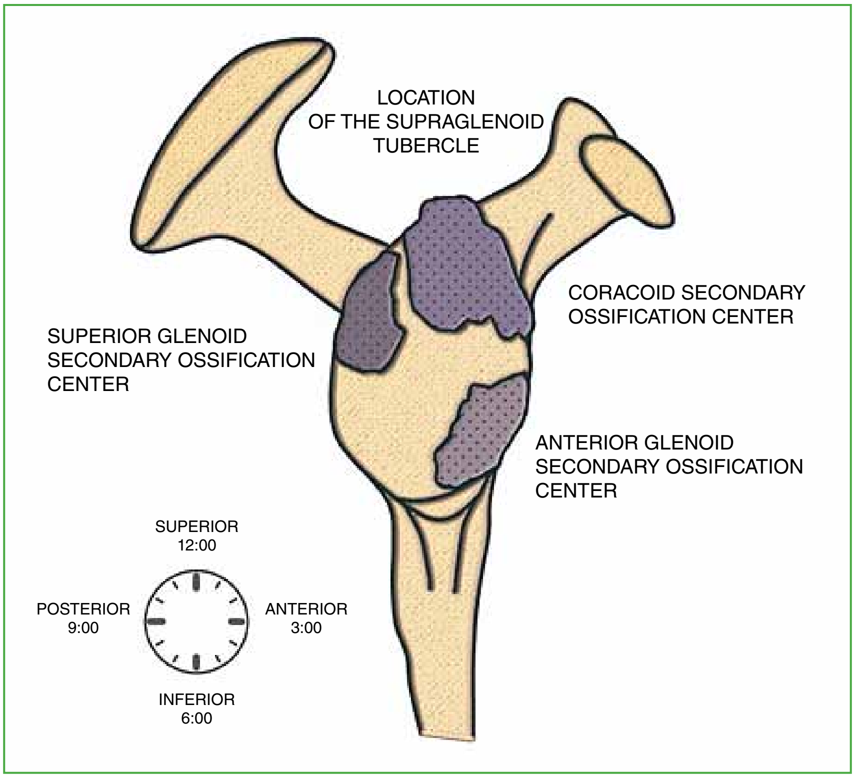

Figure 5. Clockface schematic of the glenoid with the supraglenoid tubercle at 12 o'clock. The anterior ossification center extends from 3 to 6 o'clock; the coracoid secondary ossification center, from 12 to 2 o'clock; and the superior ossification center, from 10 to 12 o'clock.

Finally, the sequence of glenoid ossification and fusion should guide interpretation of pediatric shoulder MRI. Recent studies show that the anteroinferior ossification center may ossify and fuse later than the rest of the glenoid, a variability that can confound assessment of glenohumeral instability and mimic a Bankart lesion on MRI.[1]

CONCLUSIONS

Orthopedic clinicians must be thoroughly familiar with the ossification centers of pediatric joints and their age- and sex-related variability, particularly in light of the rising incidence of high-energy sports trauma in youth. In addition to a comprehensive physical examination, it is essential to complement imaging with comparison views of the contralateral shoulder to ensure accurate diagnosis and avoid unnecessary or erroneous treatment.

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

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