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Original article

Internal impingement of the shoulder in overhead athletes: Retrospective multicentre study in 135 arthroscopically-treated patients

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ABSTRACT

Background: Internal impingement of the shoulder (IIS) is the leading cause of chronic shoulder pain in overhead throwing athletes. No consensus exists about which techniques are optimal when surgery is in order. The available studies are limited by small sample sizes and short follow-ups. The primary objective of this study was to assess return-to-sports (RtS) outcomes after surgical treatment for IIS. A favourable RtS outcome (RtS+) was defined as returning to the previous sport at the same or a higher level.
Hypothesis: The main hypothesis was that surgical treatment resulted in an RtS+ outcome. The secondary hypothesis was that epidemiological factors, pre- and intra-operative anatomical factors, and specific surgical procedures were associated with higher RtS+ rates.
Material and methods: A retrospective multicentre design was used. We included 135 patients with IIS managed arthroscopically using any of the following procedures: anterior capsulorrhaphy, posterior capsulotomy/capsulectomy, postero-superior labral debridement, posterior glenoidplasty, and rotator cuff tear debridement or repair. Follow-up was at least 1 year. The patients were divided into two groups based on whether they had an RtS+ outcome as defined above or an RtS– outcome defined as a return to the previous sport at a lower level, a switch to another sport, or an inability to engage in any sport. The Kerlan-Jobe Orthopaedic Clinic (KJOC) and Constant's score were used to evaluate subjective and objective shoulder function.
Results: Mean follow-up was 7.9 years. Of the 135 patients, 120 (90%) returned to sports after surgery including 70 (52%) to the previous sport at the same level (RtS+ outcome). By univariate analysis, the following factors were associated with an RtS+ outcome: male sex, rotator cuff tear documented intra-operatively, absence of a greater tuberosity cyst on pre-operative imaging studies, and cuff tear debridement. Anterior capsulorrhaphy was associated with worse post-operative pain.

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Discussion: The RtS + rate in this study differed from previously reported values, due to differences in the sports practiced by the patients and to considerable variability in the surgical techniques used. The positive association between presence of a rotator cuff tear and an RtS + outcome is at variance with most of the previously published data. Some of the apparent discrepancies between our results and those from other countries may be ascribable to differences in the most popular sports.
Level of evidence: IV.

1. Introduction

Chronic shoulder pain is the leading pain syndrome in overhead throwing athletes and the main reason for discontinuing play [1–6]. Internal impingement of the shoulder (IIS) was first defined in overhead throwing athletes by Gilles Walch in 1991 [7] as chronic shoulder pain and damage to the cuff undersurface without evidence of shoulder instability [8]. Anterior laxity was suggested at the time by Frank Jobe [9,10] as possibly contributing to the pain, notably in baseball pitchers. Nevertheless, IIS does not appear to involve true shoulder instability but seems related instead to direct impingement of the cuff undersurface on the postero-superior glenoid rim and labrum [8,11]. The impingement may be ascribable to a modification in the centre of rotation of the shoulder, with retraction of the posterior capsule and alteration of the rotation arc during arm cocking [8,12,13].

The first-line management of IIS is non-operative. Whenever possible, preventive measures should be started at a very young age to decrease the risk of progression towards damage to the cuff undersurface, which constitutes a turning point in the course of the condition [14–17]. Rehabilitation therapy should focus not only on the movements of the shoulder itself but also on the entire kinetic chain involved in arm cocking [18–20]. The goal is to allow the return to sports (RtS) at the same level, which is the key criterion for evaluating patient satisfaction and the efficacy of all treatment strategies [21]. When non-operative treatment fails, surgery can be offered. However, no consensus exists regarding the procedures that provide optimal outcomes [10,11,22–39].

Differences in interpretations and treatments hinder the evaluation of the relevant literature. Several factors may explain these differences. First, opinions about the most likely aetiopathogenic mechanisms vary. In the US, anterior laxity is deemed an important factor and anterior capsulorrhaphy is therefore advocated [10,11]. In France and Japan, in contrast, procedures involving the posterior glenoid and labrum have been suggested as helpful [24,33,38]. Second, the sports that enjoy the greatest popularity vary across countries, and the type of lesion may vary across sports [40]. Thus, most studies from the US and Japan focussed on baseball, whereas the most popular throwing sports in France are tennis, handball, and volleyball [8,38,40,41]. Finally, the management of rotator cuff lesions varies considerably, from abstention to simple debridement to repair after tendon resection, and the outcomes of these procedures are highly variable and at times extremely disappointing [22,28–32,34–39].

The primary objective of this study was to assess RtS outcomes after surgical treatment for IIS. A favourable RtS outcome (RtS +) was defined as returning to the previous sport at the same or a higher level. The main hypothesis was that surgical treatment resulted in an RtS + outcome. The secondary hypothesis was that epidemiological factors, pre- and intra-operative anatomical factors, and specific surgical procedures were associated with higher RtS + rates.

2. Material and method

2.1. Study design

A retrospective observational multicentre study of standard care was designed. We included consecutive overhead throwing athletes managed arthroscopically for IIS between January 1992 and June 2017. A follow-up duration of at least 1 year was required, as well as the performance of one or more of the following procedures: simple debridement or repair of a deep rotator cuff tear, postero-superior labral debridement, postero-superior capsulotomy or capsulectomy, anterior capsulorrhaphy, or glenoidplasty. Exclusion criteria were as follows: partial-thickness rotator cuff tear in a patient who did not practice a high-risk sport for this injury, surgery for a reason that was not directly related to IIS (e.g., anterior SLAP tear, established anterior or posterior instability with an anterior and/or inferior and/or postero-inferior Bankart lesion, or acromio-clavicular disjunction), gleno-humeral osteoarthritis, no surgical treatment, or post-operative follow-up shorter than 1 year.

The primary outcome measure was RtS at the same level or a higher level (RtS +). RtS (was defined as returning to the previous sport at a lower level, switching to another sport because of the shoulder, or not returning to sports. The secondary outcome measures were the Kerlan Jobe Orthopaedic Clinic Overhead Athlete Shoulder and Elbow score (KJOC) [42] and Constant's score [43].

2.2. Clinical and radiological assessment

The results of the pre-operative clinical assessment were abstracted from the medical records. At each study centre, the investigators reviewed the initial radiological documents (radiographs, computed tomography scans, and magnetic resonance imaging scans). At last follow-up, the investigators at each centre performed a physical evaluation. Scapulo-thoracic dyskinesis was sought by observing the patient [12] and rotator cuff manoeuvres were performed. Tenderness of the acromio-clavicular joint to palpation and evidence of anterior and posterior shoulder instability were sought routinely. Patients with pain in the arm-cocked position, i.e., with the arm abducted and externally rotated, were examined to determine whether the reverse Jobe relocation test (protraction with the arm abducted) relieved the pain. Beighton's criteria were applied to identify factors conducive to shoulder laxity [44]. Gagey's angle was measured as a marker for distension of the inferior gleno-humeral ligament [45]. Finally, shoulder function was assessed based on Constant's score [43] and the impact on sports activities based on the KJOC score [42].

2.3. Statistical analysis

Continuous variables were described as mean ± SD (range) and categorical variables as *n* (%). Student's test for paired data was applied to compare differences between pre-operative and post-operative values. Patient groups were compared using the Mann-Whitney test or Fisher's exact test. Multivariate logistic

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Table 1
Main baseline features of the 135 study patients.

	n (%)
Sex	
Male	103 (76%)
Female	32 (24%)
Dominant upper limb	
Right	112 (83%)
Left	23 (17%)
Sport	
Handball	54 (40%)
Tennis	35 (26%)
Volleyball	28 (21%)
Swimming	10 (7%)
Other[a]	22 (16%)
Level of play	
Recreational	23 (18%)
Regional competitions	56 (41%)
National competitions	54 (40%)
International competitions	2 (1%)

[a] Goal keeper, pole dancer, and others.

Table 2
Pre-operative physical findings.

	n (%)
Specific tests	
Posterior pain in arm cocked position	125 (92%)
Reverse Jobe relocation test	38 (30%)
Non-specific tests	
Scapulo-thoracic dyskinesia	5 (4%)
Acromio-clavicular pain	3 (2%)
Anterior or posterior instability	0 (0%)
Jobe test	28 (21%)
O'Brien test	15 (12%)
Patte test	14 (11%)
Speed test	12 (9%)
Gerber's lift-off test	1 (0.7%)
Belly press test	0 (0%)
Bear hug test	0 (0%)

regression was performed to identify factors associated with the primary outcome measure (RtS+). For data collection and statistical testing, we used EasyMedStat (www.easymedstat.com; Neuilly-sur-Seine, France) and R (version 3.4.2; The R Foundation). Values of $p < 0.05$ were considered significant for all tests.

3. Results

3.1. Patient population

We included 135 patients, whose main features are listed in Table 1. Mean age at surgery was 29.0 ± 0.7 years (range, 16–50 years) and mean follow-up was 7.9 ± 0.5 years (range, 1–22 years). The dominant arm was involved in 128 (96%) patients. All 135 patients were overhead throwing athletes and 112 (82%) played competitively, including 56 (41%) who played in national or international competitions. Finally, 18 patients played more than one sport.

Mean pain duration at surgery was 2.4 ± 0.2 years. The pain was described as stabbing by 67%, discomfort by 22%, and numbness by 11% of patients. Due to the pain, 64 (47%) patients were unable to practice their sport at the time of surgery, and only 13 (9.6%) patients still played at their usual level.

3.2. Pre-operative physical findings

Table 2 lists the main pre-operative clinical findings. Posterior shoulder pain upon arm cocking was a feature in 125 (92%) patients, including 38 (30%) with pain relief during the reverse Jobe relocation test. Laxity was not a feature: mean Beighton's score was 1.3 ± 2.4 (range, 0–9) and mean Gagey's angle was 94° ± 18° (range, 0°–130°) on the involved side and 92° ± 17° (range, 0°–110°) on the normal side. The Jobe test was positive in 28 (21%) patients. Before surgery, the mean KJOC score was 44 ± 17 (range, 0–97) and the mean Constant's score was 67 ± 18 (range, 36–95).

Table 3
Surgical procedures and depth of cuff lesions.

	(%)
Cuff debridement	*n* = 70
Ellman I	(57%)
Ellman II	(35%)
Ellman III	(8%)
Repair	*n* = 21
Ellman I	(19%)
Ellman II	(24%)
Ellman III	(57%)
No procedure	*n* = 34
No lesion	(97%)
Ellman I	(3%)

3.3. Pre-operative imaging study findings

The imaging studies showed a posterior labral lesion in 90 (67%) patients. A rotator cuff lesion was visualised in 80 (59%) patients, including 57 (43%) with a tear at the junction of the supraspinatus and infraspinatus, 12 (9%) with a tear in the supraspinatus, and 11 (8%) with a tear in the infraspinatus. A glenoid spur was seen in 57 (43%) patients, a greater tuberosity cyst in 24 (18%) patients, and a notch produced by repeated impingement on the posterior humeral head in 35 (26%) patients.

3.4. Non-operative treatment used before surgery

Non-steroidal anti-inflammatory drug therapy provided temporary pain relief to 65 (48%) patients. The 12 (9%) patients who received a subacromial glucocorticoid injection derived no benefit from this procedure. Of the 67 (50%) patients given a glucocorticoid injection into the gleno-humeral joint, 41 (61%) reported temporary pain relief. Rehabilitation was the first-line treatment in 100 (75%) patients, of whom 85 had no clinical improvements. Surgical treatment was offered only after the failure of non-operative treatment.

3.5. Surgical treatment

Lesions of the cuff undersurface were noted intra-operatively in 99 patients, with the following distribution: Ellman I, *n* = 54 (40%); Ellman II, *n* = 28 (21%); and Ellman III, *n* = 17 (13%) [46]. The remaining 36 (26%) patients had no intra-operative evidence of cuff lesions. In 34 (32%) patients, no procedure was performed on the cuff. Of the remaining 101 patients, 78 (78/135, 58%) had cuff debridement and 23 (23/135, 16%) had cuff repair, which was performed either in situ (*n* = 14) or after resection (*n* = 9). Table 3 reports the procedures performed according to the depth of the cuff lesion.

Labral debridement was performed in 94 (71%) patients, glenoidplasty with posterior capsule release in 82 (61%), patients, posterior capsule release without glenoidplasty in 24 (18%) patients, and anterior capsulorrhaphy in 20 (15%) patients.

3.6. Outcomes at last follow-up

Mean follow-up was 7.9 ± 0.5 years (range, 1–22 years). At last follow-up, 70 (54%) patients had persistent pain, including 53 (82%)

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Table 4
Results of the univariate analysis of factors associated with the return to sport at the same or a higher level (RtS +).

	RtS+ $n = 70$	RtS- $n = 50$	p value
Pre-operative clinical features			
Female sex	14%	32%	0.023*
Pre-operative pain duration, years	2.6	2.6	0.984
Type of sport			
Tennis	33%	18%	0.057
Handball	34%	40%	0.499
Initial trauma in arm cocked position	32%	18%	0.124
Pain only while playing	67%	59%	0.354
Type of pain	20% discomfort 69% stabbing pain 11% numbness	31% discomfort 61% stabbing pain 8% numbness	0.619
Location of pain	50% posterior 12% anterior 38% global	61% posterior 6% anterior 33% global	0.522
Pre-operative imaging findings			
Cuff tear	62%	65%	0.738
Tear depth	53% Ellman I 34% Ellman II 13% Ellman III	54% Ellman I 32% Ellman II 14% Ellman III	1
Cuff lesion seen intra-operatively	77%	57%	0.033*
Intra-operative Ellman	49% Ellman I 33% Ellman II 18% Ellman III	42% Ellman I 33% Ellman II 25% Ellman III	0.725
Posterior labral lesion	67%	86%	0.063
Glenoid spur	50%	52%	0.816
Greater trochanter cyst	14%	32%	0.030*
Posterior notch	26%	32%	0.536
Surgical procedures			
Simple cuff debridement	66%	47%	0.042*
Simple labral debridement	75%	72%	0.750
Anterior capsulorrhaphy	16%	10%	0.585
Glenoidplasty	63%	66%	0.732
Cuff repair	17%	15%	0.764
Posterior capsule release	20%	20%	0.954

*: p values < 0,05.

with mild pain described as discomfort. In 46 (65%) patients, the residual pain was located anteriorly or involved the entire shoulder.

Of the 135 patients, 120 (90%) returned to sports after surgery, including 70 (70/135, 52%) who returned to the same sport at the same level, i.e., had an RtS + outcome; of the remaining 50 patients, 30 (22%) returned to the same sport at a lower level and 20 (15%) switched to another sport because of their shoulder. Mean time to return to training was 6 ± 6 months (range, 1–48 months) and mean time to return to competition was 9.5 ± 6.0 months (range, 1–48 months).

The final mean KJOC score was 82 ± 19 (range, 44–100) and the mean KJOC score increase versus baseline was 40 ($p < 0.001$). The final Constant's score was 81 ± 12 (range, 44-96), with a mean increase versus baseline of 16 ($p = 0.024$).

Table 4 reports the results of the univariate analysis. Factors significantly associated with an RtS + outcome were male sex [odds ratio (OR), 3.4; 95% confidence interval (95%CI), 1.4–8.3; $p = 0.01$], absence of a greater trochanter cyst by pre-operative imaging (OR, 2.8; 95%CI, 1.1–7.4; $p = 0.03$), intra-operative documentation of a cuff lesion (OR, 2,6; 95%CI, 1.1–6.4; $p = 0.04$), and simple cuff debridement (OR, 2.2; 95%CI, 1.0–4.6; $p = 0.04$). Anterior capsulorrhaphy was not associated with an RtS + outcome (OR, 1.1; 95%CI, 0.4–2.9; $p = 0.86$) but was associated with worse post-operative pain (OR, 2.9; 95%CI, 1.0–8.7; $p = 0.03$). Glenoidplasty was associated neither with an RtS + outcome (OR, 1.2; 95%CI, 0.6–2.5; $p = 0.61$) nor with worse post-operative pain (OR, 0.6; 95%CI, 0.3–1.3; $p = 0.19$). Similarly, the repair of cuff lesions seen intra-operatively was associated neither with an RtS + outcome (OR = 0.7; 95%CI, 0.2–2.4; $p = 0.746$) nor with post-operative pain (OR, 1.8; 95%CI, 0.7–5.3; $p = 0.30$).

Table 5
Results of the multivariate analysis of factors associated with the return to sport at the same or a higher level (RtS +).

	Odds ratio	95%CI	p value
Female sex	0.31	0.10–0.93	0.04*
Greater trochanter cyst	0.25	0.072–0.77	0.02*
Glenoidplasty	0.82	0.29–2.23	0.70
Posterior capsule release	2.87	0.74–13.56	0.15
Cuff lesion	3.07	1.14–8.66	0.03*

95%CI: 95% confidence interval.
* Significant p values (< 0.05).

Table 5 lists the factors independently associated with an RtS + outcome by multivariate analysis. Negative associations were found for female sex (OR, 0.31; 95%CI, 0.10–0.93; $p = 0.039$) and pre-operative greater trochanter cyst (OR, 0.25; 95%CI, 0.07–0.77; $p = 0.020$). Intra-operative documentation of a cuff lesion, in contrast, was positively associated with an RtS + outcome (OR, 3.1 (95%CI, 1.14–8.66; $p = 0.029$).

4. Discussion

The objective of this study was to assess the return to sports after arthroscopic surgery for IIS in overhead throwing athletes. The 52% rate of return to the previous sport at the same or a higher level (RtS + outcome) is at variance with the results of earlier studies, which vary considerably (from 0% to 100%) [1,10,11,23–25,27–39]. These differences may be ascribable to variability in the nature of the pre-operative lesions and in the types of surgical procedures performed.

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In the studies by Ozaki et al., Yoneda et al., and Levigne et al. [24,33,38], all patients were managed using glenoidplasty with no procedure on the anterior capsule. The rate of return to sports at the same level was 69% in two of these studies [33,38] and 100% in the small study by Ozaki et al. in 7 patients [24]. In our population, in contrast, glenoidplasty was not associated with an RtS+ outcome. Anterior capsulorrhaphy was performed in 15% of our patients and was associated with worse post-operative pain (OR, 2.9). Consequently, we believe this procedure is not recommended in IIS in the absence of convincing evidence of instability. Favourable outcomes were obtained in several studies from the US [10,11,22,25]. These studies are difficult to compare with our work, however, as many patients (up to 68% in one study [25]) had incontrovertible anterior instability with a Bankart lesion and received the treatment appropriate for this situation.

The presence of a cuff lesion was associated with poorer outcomes in all the studies that involved performing a procedure on the cuff, particularly when this procedure consisted in cuff repair. Thus, in the study by Mazoué and Andrews [34] of 16 baseball players with full-thickness rotator cuff tears managed by mini-open repair, only 4 (25%) patients returned to the same level of baseball play. Similarly, in the study by Van Kleunen et al., only 35% of patients returned to play at the same level [39]. Even lower rates were found in some studies. For instance, of the baseball pitchers studied by Namdari et al., none returned to the previous level of play [37]. Neri et al. obtained better outcomes, with a 57% rate of return to the same level of play [36], in keeping with our findings. Simple debridement of cuff lesions seemed associated with better outcomes than cuff repair in some studies. Reynolds et al. reported that 55% of patients returned to play at the same level after cuff debridement [35]. Similarly, in our univariate analysis, simple debridement was associated with a higher RtS+ rate (68% vs. 47%, $p = 0.01$), whereas cuff repair was associated with a lower RtS+ rate (35% vs. 42%, $p = 0.77$). Nonetheless, our findings should be interpreted with discernment given the variability in the procedures performed. For instance, repair was performed in some patients with Ellman I lesions and debridement in others with Ellman III lesions (Table 3). Caution is also in order when interpreting our finding that the presence of cuff lesions was associated with a higher RtS+ rate, in contradiction to the results of other studies. The sample sizes were too small in our study to assess potential differences in outcomes between in situ repair without tissue resection and repair after tissue resection.

We found no evidence in the literature that gender or the presence of a greater trochanter cyst was associated with the return to sports.

The semi-quantitative assessments performed in our study using the KJOC score and Constant's score showed noticeable improvements. Thus, the KJOC score increased significantly, from 44 before surgery to 82, i.e., near the normal value of 90. Residual pain did not prevent most patients from feeling satisfied with the quality of their return to play. Constant's score also improved significantly but may be less relevant for evaluating patients with IIS.

The limitations of our study are those inherent in the retrospective multicentre observational design. Retrospective patient recruitment may have induced selection bias for the patients with the longest follow-ups. Thus, the use in some patients of anterior capsulorrhaphy may cast doubt on the relevance of the diagnosis and appropriateness of the initial surgical indication in this subgroup. Furthermore, practices varied across the participating centres. First, the number of patients per surgeon varied considerably. Two centres contributed large numbers of patients and may have introduced bias due to the specific practice patterns of their surgeons, with a preference for glenoidplasty in Lyon and a high proportion of patients managed using anterior capsulorrhaphy in Nancy. Finally, practice patterns varied across surgeons. Some surgical procedures are controversial and their use may have biased the results. Examples are debridement for major Ellman III cuff lesions, repair for minor Ellman I cuff lesions, and glenoidplasty in the absence of a glenoid spur. The most popular overhead throwing sports are tennis, handball, and volleyball in continental Europe and baseball in the US and Japan. Consequently, comparisons of studies from these two groups of countries have little relevance. The pre- and post-operative motion arcs were not assessed in detail in our patients. More specifically, accurate data were not available on internal rotation with the arm abducted, which is of key diagnostic and prognostic significance. This parameter has been evaluated in greater depth in studies of non-operative treatments, chiefly from the US and Japan. Finally, neither computed tomography nor magnetic resonance imaging was performed post-operatively in our patients. Consequently, we did not have data on tendon healing quality in patients with cuff lesions, outcomes of cuff lesions managed with simple debridement, or the quality of glenoidplasty. All these points may influence the clinical outcomes [38].

Several strong points of our study deserve to be pointed out. To our knowledge, this is the largest retrospective study of the outcomes of surgery in patients with IIS. The long mean follow-up is also of note. The results showed that the presence of a cuff lesion, notably when small and therefore managed by simple debridement, was associated with an RtS+ outcome, in contradiction to previously reported data.

Disclosure of interest

Lisa Peduzzi, Mikaël Chelli, Yves Lefebvre, Simon Bertiaux, Nicolas Holzer, and Matthieu Sanchez declare that they have no competing interest.

Jean Grimberg is a consultant for Smith & Nephew and receives royalties from Zimmer-Biomet.

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Contributions

L.P., J.G., and M.C. drafted the manuscript.

Y.L., C.L., J.K., and P.C. revised the manuscript for important intellectual content.

S.B., J.G., A.H., N.H., and M.S. collected the data.

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