Original Article With Video Illustration

Arthroscopic Subscapularis Augmentation of Bankart Repair in Chronic Anterior Shoulder Instability With Bone Loss Less Than 25% and Capsular Deficiency: Clinical Multicenter Study

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Purpose: To assess the short-term outcomes of the arthroscopic subscapularis augmentation (ASA) technique, consisting of a tenodesis of the upper third of the subscapularis tendon and a Bankart repair, and its effect on shoulder external rotation. **Methods:** Patients selected for this study were involved in contact sports, with a history of traumatic recurrent shoulder dislocations and a minimum of 2-year follow-up. Inclusion criteria were patients with glenoid bone loss (GBL) ranging from 5% to 25%, anterior capsular deficiency, and Hill-Sachs lesion who underwent ASA technique. Exclusion criteria were GBL >25%, multidirectional instability, preexisting osteoarthritis, and overhead sports activities. Visual analog scale (VAS) scale for pain, Rowe score, and American Shoulder and Elbow Surgeons (ASES) scores were used to assess results. Loss of shoulder external rotation was measured with the arm at the side (ER1 position) or 90° in abduction (ER2 position). Analysis of variance and Fisher tests were used for data evaluation. Significance was established at $P \leq .05$. **Results:** One hundred ten patients (84 men and 26 women, mean age 27 years) were evaluated with a mean follow-up of 40.5 months (range: 24 to 65 months). In 98 patients, a Hill-Sachs lesion was observed and in 57 patients a capsular deficiency was present. Three patients (2.7%) had a traumatic redislocation. At final follow-up, the mean scores were as follows: VAS scale decreased from a mean of 3.5 to 0.5 ($P = .015$), Rowe score increased from 57.4 to 95.3 ($P = .035$), and ASES score increased from 66.5 to 96.5 ($P = .021$). The mean deficit of external rotation was 8° ± 2.5° in the ER1 position and 4° ± 1.5° in the ER2 position. **Conclusions:** The ASA procedure has been shown to be effective in restoring joint stability in patients practicing sports, affected by chronic anterior shoulder instability associated with anterior GBL (<25%), capsular deficiency, and Hill-Sachs lesions, with mild restriction of external rotation. **Level of Evidence:** Level IV, therapeutic case series.

The treatment of chronic anterior shoulder instability associated with bone loss is still controversial. In 2000, Burkhart[1] highlighted the role of bone defects in his failed arthroscopic cases. He noted that the high failure rate of 67% was mainly due to significant bone defects in the form of anterior inferior glenoid bone loss (GBL) or large engaging Hill-Sachs. Currently, the GBL percentage,[2-4] which is considered critical for recurrences, is approximately 25%, and in such cases, a glenoid bone augmentation is mandatory.[5] Open Latarjet[6-8] is one of the most popular techniques for managing chronic instability with severe GBL because of its low recurrence rate (from 1% to 8%), but it has to be considered a non-anatomical reconstruction with a significant number of intra- and postoperative complications[9-11] and even an overtreatment if GBL is less than 20%. The current literature provides other different techniques for the treatment of GBL, such as bone graft procedures[12-16]; however, the indications are not well defined, particularly in the presence of anterior capsulolabral insufficiency.[17,18] The Hill-Sachs "remplissage" could be another option, but it is not indicated in the presence of an anterior capsular

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insufficiency.[19] Over the past few decades, arthroscopic Bankart repair was the gold standard for the treatment of anterior instability, especially in patients without significant GBL, but the redislocation rate can exceed 13%.[20-23] Starting from a former idea proposed by Lanny Johnson,[24] who described an arthroscopic technique to address chronic recurrent shoulder dislocations with "virtually nonexistent gleno-humeral ligaments" that involved the articular portion of the subscapularis tendon, the authors used a procedure defined as arthroscopic subscapularis augmentation (ASA)[25] consisting of a tenodesis of the upper third of the subscapularis tendon in addition to Bankart repair in young active individuals, practicing contact sports, to address recurrent anterior shoulder dislocation, capsular deficiency, Hill-Sachs Lesions, and GBL ranging from 5% to 25%.

The purpose of this multicenter study was to assess the short-term outcomes of ASA technique, consisting of a tenodesis of the upper third of the subscapularis tendon and a Bankart repair, and its effect on shoulder external rotation. We hypothesized that the ASA technique would be effective in restoring joint stability without compromising shoulder external rotation.

Methods

Study Population

Between January 2010 and August 2015, patients who were treated for chronic anterior shoulder instability with arthroscopic Bankart repair and ASA by 4 surgeons (M.M., A.Z, R.R., S.S) at 4 different hospitals were identified. A total of 110 patients met the inclusion criteria. The inclusion criteria were as follows: primary and revision surgery with at least a 2-year follow-up; practice in contact sports, that is, sports with physical contact between players, including the ground. All patients had a positive apprehension test at 90° of abduction and a GBL ranging from 5% to 25% as assessed by computed tomography (CT). Patients with a Hill-Sachs lesion (regardless of the size) were also included. The exclusion criteria were as follows: voluntary anterior, posterior, or multidirectional instability; preexisting glenohumeral osteoarthritis; and overhead sports activities, assuming that a loss of external rotation might interfere with the sport-specific activities of throwing athletes. Failure of a prior stabilization procedure was not considered an exclusion criterion.

Functional and Radiologic Assessments

The Rowe score, visual analog scale score for pain, and American Shoulder and Elbow Surgeons score were used for preoperative functional assessments. Two independent observers conducted the postoperative ratings of functional results using consistent methods. The sports activity level was evaluated using the following rating system: grade I, no limitations in sports (100% of premorbidity level); grade II, mild limitations in sports (90%-99% of premorbidity level); grade III, moderate limitations in sports (71%-90% of premorbidity level); and grade IV, severe limitations in sports (<70% of premorbidity level).[22] These assessments could quantify apprehension, subluxation or recurrence of instability, functional level restrictions in activity, range of motion (ROM) assessed by goniometer with the arm at the side (ER1 position), and with the arm in abduction (ER2 position) and strength. Preoperative imaging for all patients was performed using CT and the Pico surface area method[2] to quantify the percentage of GBL compared with the contralateral shoulder. The assessment of GBL was obtained using a 3-dimensional CT system (Optima CT660 64-slice multidetector CT; General Electric, Little Chalfont, UK) with multiplanar reconstructions of the glenoid neck and digital subtraction of the humeral head. Magnetic resonance imaging was effective in revealing labral modifications, and a Hill-Sachs lesion was documented in 98 patients (90%)[26] according to Koo's arthroscopic evaluation: "When the Hill-Sachs lesion engages the glenoid rim in a position of athletic function (abduction and external rotation) it is deemed to be an engaging Hill-Sachs lesion," and the humeral defect is considered moderate to large when ≥3 mm in deep. All patients underwent postoperative magnetic resonance imaging examination to assess the position of the anchors and the absence of early osteochondral damage at 12 months.

Surgical Technique

The arthroscopic procedure was performed with the patient under an interscalene block in a lateral decubitus position; anterior, posterior, and anterosuperior portals were used. The anterior portal is placed just over the superior border of the subscapularis tendon to obtain an easy approach for the suture-passing devices through the tendon tissue. The anterior and posterior glenohumeral joint structures were inspected to assess any anteroinferior labral insufficiency (Fig 1A), SLAP lesions, anterior glenoid defects, and Hill-Sachs lesions (Fig 1B). The damaged anterior labrum, if present, was completely mobilized from the glenoid neck; abrasion of the anterior border of the glenoid neck was always performed from the anterosuperior portal. A lower capsular repair was always performed using knotless PEEK (polyether ether ketone) 2.9-mm anchor (PushLock; Arthrex, Naples, FL) loaded with a Fiberwire suture; after subscapularis tendon penetration with a Fiber-tape (Fig 2) a 3.5-mm knotless PEEK suture anchor (PushLock) was used for the subscapular tenodesis.[27] The articular portion of the subscapularis tendon was perforated approximatively 5 mm from its upper border, just above the

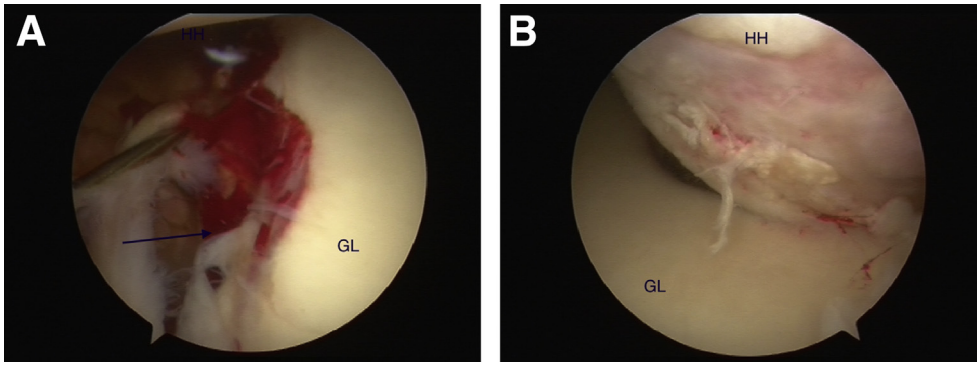

Fig 1. (A) A right shoulder in the lateral decubitus position, viewed from an anterosuperior portal, shows an anterior capsulolabral insufficiency (arrow) and anterior glenoid bone loss. (B) In the same patient viewed from the posterior portal, an Engaging Hill-Sachs is clearly seen. (GL, glenoid; HH, humeral head.)

glenoid surface, with a penetrator punch loaded with multistrand tape (Fibertape, Arthrex), so that the free ends of the tape remain accessible through the same lower cannula. In the next step, one of the free ends is passed through the upper cannula, then the same suture tape end is passed again in the lower cannula, so that the 2 ends are astride the perforated tissues and come out again from the same lower cannula. At this point, both free ends of the tape are passed through the eyelet's anchor (3.5-mm knotless PEEK suture anchor [PushLock]) that is pushed along the tape toward the bone hole (Fig 3). While impacting the anchor, care is taken to keep the patient's arm in neutral rotation to avoid excessive tensioning on the tenodesis (Video 1, available at www.arthroscopyjournal.org). The closure of the anterior pouch and centering of the humeral head in the glenoid cavity is assessed by arthroscopic examination from the posterior and anterosuperior portal (Fig 4). Coexistent SLAP lesions were repaired with 2.9-mm knotless PEEK suture anchors (PushLock).

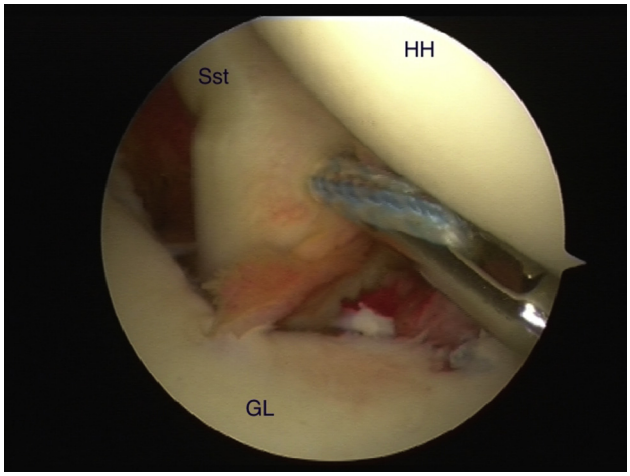

Fig 2. A suture-passing device loaded with multistrand tape penetrates the upper third of the subscapularis tendon, viewed from the posterior portal viewing. (GL, glenoid; HH, humeral head; Sst, subscapularis tendon.)

Postoperative Protocol

After surgical repair, the shoulder was immobilized in a brace with the arm in 0° of abduction and internal rotation for 4 weeks. The rehabilitation program consisted of 4 phases. The first phase was initiated in the fifth week, using both shoulder passive ROM and active ROM exercises to increase joint mobility. In the second phase, at 6 to 8 weeks, the aim was recovery of full ROM. The third phase, at 8 to 9 weeks, was focused on the recovery of strength and proprioceptive abilities. In the fourth phase, at 10 weeks, resumption of certain sport-specific activities was permitted. Return to sports

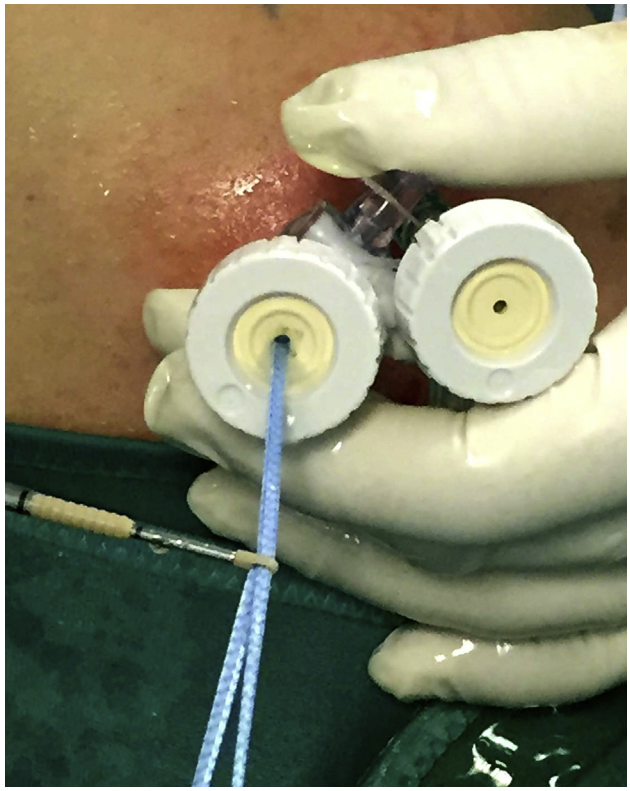

Fig 3. Knotless nonabsorbable suture anchor (3.5-mm PushLock) loaded with multistrand tape, the 2 ends of the tape are seen coming out from the anteroinferior portal.

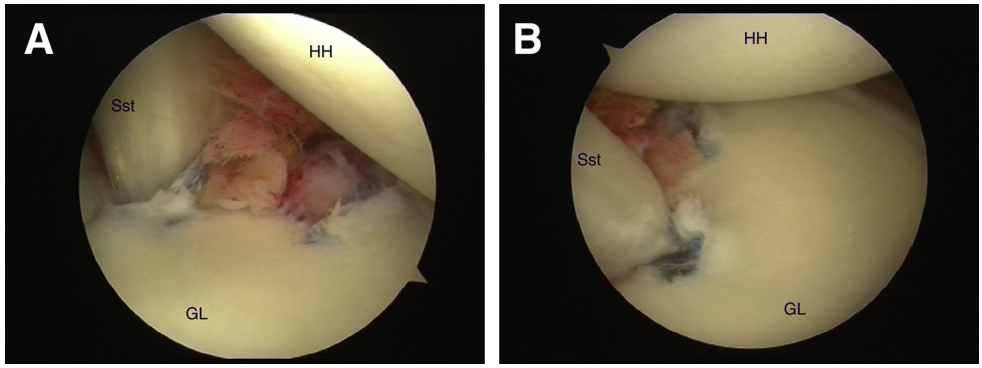

Fig 4. (A) Tenodesis of the upper third of the subscapularis tendon at the 3 o'clock and lower capsular repair at the 5 o'clock position, viewed from the posterior portal. (B) Closure of the anterior pouch and recentering of the humeral head, viewed from the anterosuperior portal. (GL, glenoid; HH, humeral head; Sst, subscapularis tendon.)

was allowed at 4 months. The same protocol was used in all patients.

Statistical Analysis

Baseline data obtained from the 110 participants who completed the study were analyzed using analysis of variance and Fisher test. The mean and 95% confidence interval of differences were evaluated using analysis of variance. Data were presented as the mean standard deviation. The χ^2 test or Fisher test was used to analyze our results. The level of significance was set at $P \leq .05$.

Results

During the study period, 295 patients were treated for chronic anterior shoulder instability with arthroscopic Bankart repair and ASA. Among these patients, 160 were excluded from this study because they could not fulfill the minimum 2-year follow-up and 25 interviewed by phone, who did not return at final follow-up, so they were excluded. One hundred ten patients were available for follow-up ranging from 24 to 65 months (mean 40.5 months). Sixty-one patients (55.5%) were right-hand dominant (55.5%), and there were 84 men and 26 women included in the study. The mean age was 27 years (minimum, 16 years, maximum, 44 years). All patients were affected by recurrent anterior dislocation (mean, 7 dislocations; range, 2-20 dislocations) and practiced contact sports (Table 1).

A prior arthroscopic capsulolabral repair had failed in 24 patients. All of these patients were treated with absorbable anchors; 2 anchors were used in 16 patients, and 3 anchors were used in 8 patients.

Findings at the time of surgery are detailed in Table 2: a total of 38 involved engaging Hill-Sachs lesions (34.5%); in 57 patients (52%), insufficiency of the anterior capsulolabral tissue was present (type IV according to Habermayer's classification[18]); a loose body was found in 9 patients (8%). The mean anterior GBL was 12.8% (range 5%-23%). In 8 patients (7%) with partial-thickness rotator cuff tears, a debridement procedure was required; in 23 (21%) patients with type II SLAP lesions, a concomitant labral repair has been always performed using a third suture anchor.

At the final follow-up, the mean scores were the following: visual analog scale score, 0.5 ± 0.9 (P = .015); Rowe score, 95.3 ± 8.5 (P = .035); and American Shoulder and Elbow Surgeons score, 96.5 ± 3.6 (P = .021) (Table 3). Discomfort when placing the arm in external rotation and touching the back of the head was

Table 1. Demographic Data of 110 Patients Who Underwent Arthroscopic Subscapularis Augmentation Procedure

Characteristic	Data
Age, yr, mean (range)	27 (16-44)
Gender	
Male patients	84 (76.3)
Female patients	26 (23.6)
Bilateral symptoms	2 (1.8)
Sport activity before surgery	100
Judo	38 (34.5)
Rugby	27 (24.5)
Soccer	19 (17.2)
Skiing	17 (15.4)
Snowboard	9 (8.1)
Dislocation number, mean (range)	7 (2-20)
Affected side	
Left	49 (44.5)
Right	61 (55.5)
Dominant hand	84 (76.4)
Patients with prior surgery	24 (22)

NOTE. Data are n (%) unless otherwise noted.

Table 2. Operative Findings and Glenoid Bone Defect Evaluation

Variable	Data
Arthroscopy	112 (100)
SLAP type II	23 (21)
Partial-thickness rotator cuff tear	8 (7)
Loose bodies	9 (8)
Capsulolabral insufficiency	57 (52)
Engaging Hill-Sachs	38 (34.5)
Glenoid bone defect, %, mean (range)	12.8 (5-23)

NOTE. Data are n (%) unless otherwise noted.

Table 3. General Functional Outcome

Score	Preoperative	Postoperative Mean FU	Mean Difference	*P* Value	95% CI
VAS score	3.5 ± 1.7	0.5 ± 0.9	2.7	.0157	−2.85 to −2.35
Rowe score	57.4 ± 7.3	95.3 ± 8.5	37.5	.0351	35.71 to 39.43
ASES score	66.5 ± 7.5	96.5 ± 3.6	29.7	.0217	26.83 to 30.25

NOTE. Data are presented as mean ± standard deviation.
ASES, American Shoulder and Elbow Surgeons; CI, confidence interval; FU, follow-up; VAS, visual analog scale.

noted in 4 patients (4.5%). A post-traumatic shoulder redislocation occurred in 3 patients (2.7%): in 2 of the patients, redislocation was due to a sports injury, whereas in 1 patient, redislocation was due to an accidental fall. One of these patients underwent a repeat ASA procedure. A second pilot hole was drilled, and the tenodesis was performed again using a 2.9-mm Push-Lock loaded with Labraltape (Arthrex). The review surgery was not included in this series.

No early postoperative complications related to the ASA procedure occurred. At the final follow-up, no significant differences were observed in shoulder forward flexion ($P = .348$), extension ($P = .425$), abduction ($P = .195$), lateral elevation ($P = .215$), and internal rotation ($P = .285$) compared with the contralateral side. In contrast, compared with the contralateral side, shoulder external rotation at the side ($P = .035$) and in abduction ($P = .025$) significantly differed; moreover, the mean deficit of external rotation was 8° ± 2.5° with the arm at the side of the trunk, and the mean deficit was 4° ± 1.5° with the arm in 90° of abduction (Table 4). All these functional and subjective results enabled all patients to return to full work activities. At the final follow-up, no limitation in sports activities (grade I) was reported in 84 patients (75.4%), a mild limitation of the premorbidity level (grade II) was reported in 18 patients (16.3%), and a moderate limitation of sports activities (grade III) in 8 patients (7.2%); these restrictions where due to the limitation of external rotation. No grade IV limitation was found. Magnetic resonance imaging evaluations at follow-up at 12 months showed good positioning of the anchors and no signs of early osteochondral damage.

Discussion

The main significant finding of this study was that the association of ASA with Bankart repair yielded good clinical outcomes, good patient satisfaction scores, and functional improvement with a relatively low rate of recurrence and low deficit of external rotation, particularly with the arm in RE_2 position. In our opinion, this result could be explained by the different distances between the attachment of the subscapularis tendon at the humerus, and the tenodesis at the glenoid at 0° abduction versus 90° abduction as reported in a biomechanical study.[28]

The overall redislocation rate in our series was 2.7% (3 of 110 patients). No recurrence occurred in the 24 patients with prior Bankart repair failure. The good outcome of this group of patients was unexpected because it is well known that an arthroscopic capsulolabral revision can lead to a high risk of recurrence.[29,30] No recurrence of ASA for our revision surgery was significantly superior compared with other studies,[31-34] in which the rate of recurrence has ranged from 16% to 30%.

Many studies in the literature within the past 10 years reported that the rate of recurrence after primary arthroscopic stabilization is highly variable[35-40] ranging from 0% up to 40% when a simple Bankart repair was performed and GBL was less than 25%. This resulted in a widespread need for techniques such as both the

Table 4. Comparison of Active Shoulder Range of Motion at Follow-Up Between Operated Shoulder and Contralateral Side

	Operated Shoulder (n = 110)	Contralateral (n = 110)	Mean Difference	*P* Value
Forward flexion, °	176.3 (150-180)	178 (160-190)	−1.7 ± 0.5	.348
Extension, °	60 (30-90)	63 (35-90)	−2.5 ± 1.4	.425
Abduction, °	165 (100-160)	170 (100-165)	−5 ± 0.5	.195
Lateral elevation, °	174 (160-180)	180 (160-185)	−6 ± 1.3	.215
IR*	5.4 (4-10)	5.8 (2-10)	0.4 ± 1.1	.285
ER1	60 (35-80)	68 (40-90)	−8 ± 2.5	.035
ER2	78 (55-90)	82 (55-100)	−4 ± 1.5	.025

NOTE. Data are presented as mean (range).
ER1, external rotation measured with arm at the side; ER2, external rotation measured with the arm in abduction; IR, internal rotation.
*Number of the thoracic vertebra reached by the thumb: the first thoracic vertebra is numbered 1, proceeding to the 12th thoracic vertebra, which is numbered 12.

open[41,42] and arthroscopic[43,44] Bristow-Latarjet procedures, which were shown to systematically yield much lower recurrence rates.[45] Furthermore, because of the high frequency of moderate glenoid defects,[46,47] there are still difficulties in selecting the appropriate procedure, especially in active young people. We can suggest that there is a "gray zone" where the application of the Latarjet can be considered an overtreatment—not severe GBL (<15%)[48]—whereas the simple arthroscopic Bankart repair cannot prevent a high recurrence rate. The literature on this subject seems to be regional: in the United States, many surgeons who treat anterior shoulder instability in the presence of GBL and engaging Hill-Sachs underscored the need for a large number of anchors to fix the soft tissue on the glenoid as well as a remplissage procedure,[49-53] whereas in Europe the Latarjet procedure is considered the gold standard.

In our study, we aimed to probe whether arthroscopic "double soft-tissue" stabilization on the glenoid rim yielded good clinical functional results in an active young population with anterior GBL of less than 25%, capsular deficiency, and with engaging Hill-Sachs lesions, albeit without altering the anatomy of the coracoacromial arch. We did not analyze the amount of bipolar bone loss according to the concept of on-track or off-track lesion[19] because it does not take into account the pathologic function of the soft tissue deficiency.

During the past century, use of the subscapularis tendon as a mechanical barrier to prevent anterior instability was widely reported in the Putti-Platt procedure,[54,55] which was subsequently modified by Symeonides.[56,57] The use of the subscapularis tendon was also reported in the Magnuson-Stack procedure.[58] Long-term clinical reviews of the results of these open techniques have been controversial because whereas these studies reported good results, even in patients practicing contact sports,[59] joint stability was achieved to the detriment of external rotation. It is a well-known concept that postoperative joint stiffness does not equal joint stability as there is a significant danger in soft tissue overconstraint.

Some authors proposed that this limitation of external rotation could cause secondary osteoarthritis.[43,55,60] In our study, the loss of external rotation (8° ± 2.5° with the arm at the side of the trunk and 4° ± 1.5° with the arm in 90° of abduction) was significantly lower compared with the loss resulting from the open Putti-Platt procedure (ranging from 6° to 25°), and such a loss did not exceed the functional limitations of other types of techniques[11-13,61,62] (ie, arthroscopic Bankart repair, Bankart repair plus remplissage, and open or arthroscopic bone-block transfers). Recently, 2 techniques have been described in which the subscapularis tendon was used to treat anterior capsulolabral insufficiency. The first technique, described by Denard et al.,[33] consisted of a subscapularis flap used to augment the Bankart repair, whereas the second technique, described by Chaudhury et al.,[63] consisted of a complete tenodesis of the tendon and its advancement and fixation to the medial border of the glenoid neck using a large number of anchors.

This is a short-term and consecutive multicenter study in which the patients were operated by 4 surgeons (M.M., R.R., A.Z., S.S.) with an arthroscopic procedure consisting of a Bankart repair in association with a tenodesis of the upper third of the subscapularis tendon; moreover, no early postoperative complications were reported after this procedure.

On the basis of the current knowledge regarding the GBL percentage and the Hill-Sachs lesion size necessary to determine an engaging humeral head, these encouraging results prompted the consideration that this technique could have a definitive place in the treatment strategy for young athletes and for individuals with previous failed Bankart repair, thereby avoiding the recourse to more complex procedures. We still recommend a simple Bankart repair in case of good quality of capsulolabral tissue, without severe GBL and individuals not engaged in contact sports.

Limitations

There were a number of limitations in this study. First, it is a short-term follow-up study of a retrospective nature; however, recall and observation biases were reduced by the prospective data collection of our clinical database. Second, not having used a more appropriate subjective questionnaire, such as the Western Ontario Shoulder Instability Index, Walch-Duplay score, or Melbourne Instability Shoulder Score, which are more responsive in a recurrent shoulder instability population, may have introduced a detection bias in the evaluation of postoperative functional changes and patient satisfaction. Third, a control study group operated with other techniques by the same surgeons in lacking. Fourth, the lack in literature of the minimal clinically important difference and patient acceptable symptom state specifically determined for shoulder instability did not allow us to evaluate whether improvements after ASA plus Bankart repairs were clinically significant. We did not analyze shoulder on-track or off-track, an alternative measure of GBL.[19] We assessed the GBL by CT scan with Pico area method and the engaging of the Hill-Sachs was an arthroscopic findings. Lastly, this study did not enable the assessment of the tendon tissue healing to the bone.

Conclusions

The ASA procedure has been shown to be effective in restoring joint stability in patients practicing sports,

affected by chronic anterior shoulder instability associated with anterior GBL (<25%), capsular deficiency, and Hill-Sachs lesions, with mild restriction of external rotation.

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