Knee Surgery, Sports Traumatology, Arthroscopy
https://doi.org/10.1007/s00167-019-05648-3

SHOULDER

Arthroscopic subscapularis augmentation combined with capsulolabral reconstruction is safe and reliable

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Received: 4 December 2018 / Accepted: 26 July 2019

Abstract

Purpose The study aimed to compare modified arthroscopic subscapularis augmentation (MASA) with tenodesis of the upper third of the subscapularis tendon using a tendon combined with capsulolabral reconstruction (Group A) or Bankart repair (Group B) for recurrent anterior shoulder instability (RASI).

Methods A retrospective series of 49 patients underwent primary surgery for RASI with glenoid bone loss (GBL) < 25%. Outcomes included the Oxford Shoulder Instability Score (OSIS), Visual Analogue Scale (VAS) score, Rowe score, and American Shoulder and Elbow Surgeons (ASES) functional outcome scale score. Recurrent instability, sports activity level, and range of motion (ROM) were also analysed.

Results No significant differences were observed at baseline. Forty-six patients were available for more than 2 years of follow-up. At the last follow-up after surgery, the patients in both groups had experienced significant improvements in all outcome scores ($P < 0.05$ for all), and obvious decreases in forward flexion and external rotation were noted in both groups ($P < 0.05$ for all). Group A had superior ASES scores, VAS scores, and OSISs ($P < 0.05$) but did not experience significant differences in either the Rowe score or ROM compared to Group B. Group A had lower rates of recurrent instability and superior outcomes for the return to sports activities. One patient in Group A had subluxation, and 4 patients in Group B had dislocation or subluxation. No patients in either group experienced neurovascular injury, joint stiffness, or surgical wound infection.

Conclusion For RASI with GBL < 25%, MASA with tenodesis of the upper third of the subscapularis tendon using a tendon combined with capsulolabral reconstruction was a safe technique that produced better outcomes in terms of ASES scores, VAS scores, OSISs, the return to sports, and postoperative recurrent instability and did not decrease the ROM compared to that achieved by arthroscopic Bankart repair.

Level of evidence III.

Keywords Recurrent shoulder instability · Anterior instability · Capsulolabral reconstruction · Subscapularis augmentation

Introduction

Anterior shoulder dislocation is common, with an incidence rate of 1.7% in the general population, and causes recurrent instability of the shoulder joint, particularly in young patients [15, 17]. However, optimal surgical management of anterior shoulder instability remains controversial [19]. With contemporary surgical techniques, the rates of both open and arthroscopic failure are 7–19% [7, 23].

Two surgical principles for shoulder stabilization exist, namely, anatomic and nonanatomic. Anatomic techniques include the conventional Bankart repair, capsular shifts, and other soft tissue fixation processes. Repair of bone deficiencies of the humeral head (Hill–Sachs lesions) with bone grafts and the Bristow-Latarjet technique, which involves transfer of the coracoid process [3] and glenoid reconstruction using iliac crest bone grafts [13, 21], are nonanatomic techniques [1]. Further revision surgery with nonanatomic techniques is more difficult due to the loss of anatomical landmarks [1], and the techniques are usually more invasive.

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Conventional anatomic procedures for open capsulolabral reconstruction involving the use of hamstring, iliotibial band, and Achilles tendon grafts [1] to reconstruct the main stabilizing structures of the anterior labrum, the middle glenohumeral ligament (MGHL), and the anterior band of the inferior glenohumeral ligament (IGHL) have been previously published [6]. The following two new techniques are based on Johnson's technique: using part of the subscapularis tendon that is detached from the distal end and fixed at the anterior glenoid rim [16] and stabilizing the shoulder with a tendon graft to enhance the anterior glenoid rim with the same graft [11].

A new anatomical surgical technique has been developed that combines arthroscopic subscapularis augmentation (ASA) with tenodesis of the upper third of the tendon using a graft and arthroscopic capsulolabral reconstruction with tendon allografts or autografts (Fig. 1). The indications for this technique to treat anterior shoulder instability are active patients with primary anterior capsulolabral insufficiency or previously failed surgical procedures, Hill–Sachs lesions, and GBL (<25%).

Materials and methods

This study was performed after ethical approval from the Institutional Review Board at the Peking University Shenzhen Hospital (IRB201768) and was designed as a retrospective case-series study following two parallel groups. Patients were retrospectively collected from 2013 to 2016. The inclusion criteria were as follows: (1) post-traumatic recurrent anterior dislocation with a minimum of two episodes of documented dislocations and a positive apprehension test at 90° of abduction; (2) a Hill–Sachs lesion (bone loss of the humeral head < 20%) and anterior GBL less than 25% as assessed by computed tomography (CT); and (3) age < 45 years and > 18 years. The exclusion criteria were as follows: (1) GBL > 25% and bone loss of the humeral head > 20%; (2) voluntary anterior, posterior, or multidirectional instability; (3) pre-existing glenohumeral osteoarthritis; and (4) other concomitant injuries [cuff tears, superior labral anterior–posterior (SLAP) lesions] or previous surgery.

Forty-nine patients were included. Twenty-five patients were included in Group A (ASA with tenodesis of the upper third of the subscapularis tendon using tendon allografts or autografts and capsulolabral reconstruction), and 24 patients were included in Group B (arthroscopic Bankart repair). All the patients underwent surgery performed by the same surgeon.

One independent sports medicine practitioner conducted the preoperative and postoperative functional assessments using consistent methods at baseline and at 1 and 2 years postoperatively. The sports activity level was evaluated using the following rating system according to Kim et al. [10]. These assessments [Oxford Shoulder Instability Score

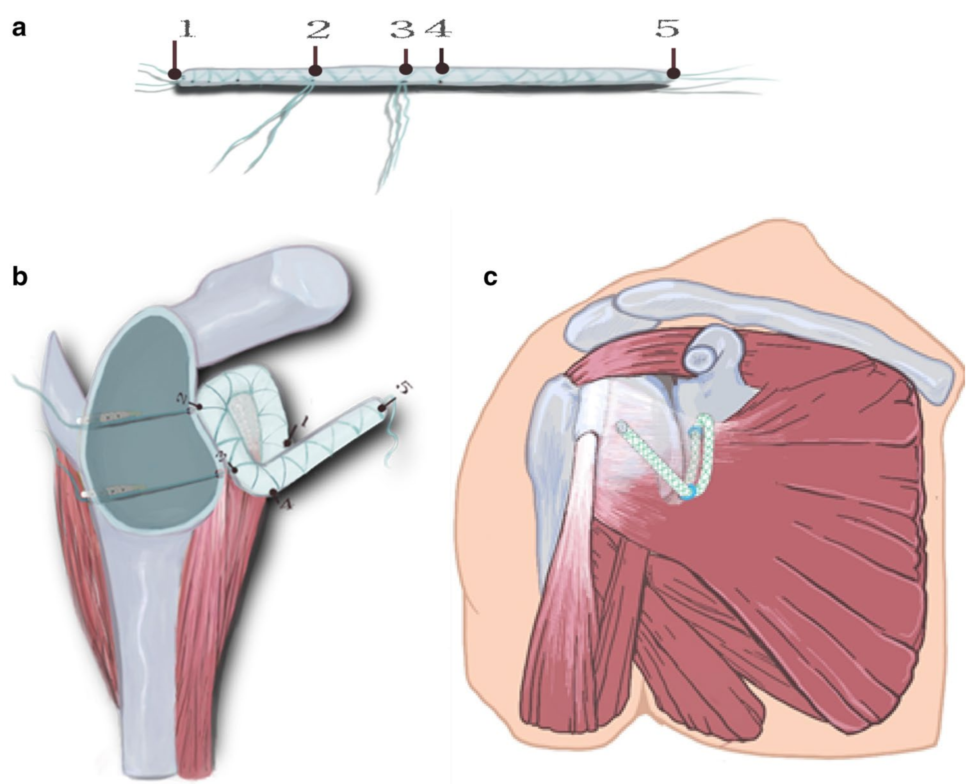

Fig. 1 Illustration of glenohumeral ligament complex reconstruction combined with tenodesis of the upper third of subscapularis (ASA) using tendon. **a** Tendon graft preparation: 1–2 upper limb of tendon was 3 cm,2–3 was 2 cm, 3–4 was 0.8 cm, 4–5 inferior limb was 5 cm. **b** Tenodesis of subscapularis and allografts or autografts. 1 point was fixed to 4 point, and 5 was fixed to the humerus. **c** Diagrammatic representation of images a and b during surgery

(OSIS), Visual Analogue Scale (VAS) score, Rowe score, and American Shoulder and Elbow Surgeons (ASES) score] were used to quantify the range of motion (ROM), subluxation or recurrent instability, and functional restrictions in activity [14].

Surgical technique

Tendon graft preparation

The reinforcing graft was either a 5- or 6-mm tibialis anterior allograft or a semitendinosus autograft. The tendon was trimmed to approximately 10 cm in length. Ethibond (No. 5; Ethicon, Somerville, NJ, USA) was placed with a whipstitch at each free end and in the middle of the graft for later traction, spreading and fixation of the tendon (Figs. 1a, 2a).

The surgical technique for Group A

The patients were positioned in the lateral decubitus (LD) position [18]. A special glenoid guide arm was placed into the shoulder through the posterior portal. A 2-mm K-wire was drilled into the glenoid from posterior to anterior, and the anterior exit points of the K-wires were 5 mm below the anterior rim of the glenoid surface. The anterior exit points of the K-wires were located at the 2:30 and 4:30 clock positions of the glenoid (Figs. 2b, 4a, b), and the posterior entry points were located at clock positions ranging from 8:00 to 10:00 without strict confinement. The K-wire was overdrilled with a 5-mm cannulated drill to create two glenoid tunnels (Fig. 2c). Transglenoid tunnels prevent the risk of neurovascular damage caused by outside-in techniques [12].

The upper free limb of the graft was used as a sling and placed around the upper part of the tendon [11], and the lower free limb was used to reconstruct the anterior band of the IGHL. The transplant was pulled into the shoulder joint and fixed to the anterior glenoid rim (Fig. 3). With an extra suture on the outer upper free end of the transplant, the transplant was pulled into the joint above the subscapularis tendon and out through the upper portal (Figs. 1, 3).

The two ends of each suture in the middle of the graft were passed through the upper and inferior glenoid tunnels separately. Two 5.5-mm Swivelocks (Arthrex) were pushed along the sutures to the posterior orifice of the glenoid tunnels. A 2- to 3-cm-long longitudinal incision (anterior incision) was made on the anterolateral side of the humeral head to expose the bicipital groove, greater tubercle, and lesser tubercle. The outer upper free end of the tendon was secured at the exit point, and the inferior limb of the graft went through the subscapularis (Figs. 1, 4a). As a result, the end loop was placed as an extra tissue wall on the glenoid

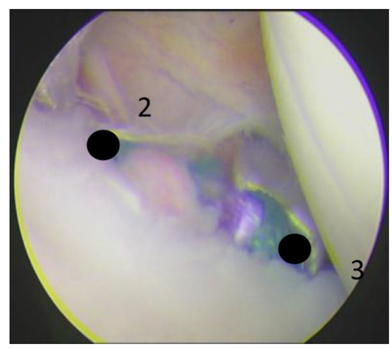

Fig. 3 The graft was fixed to the anterior glenoid rim

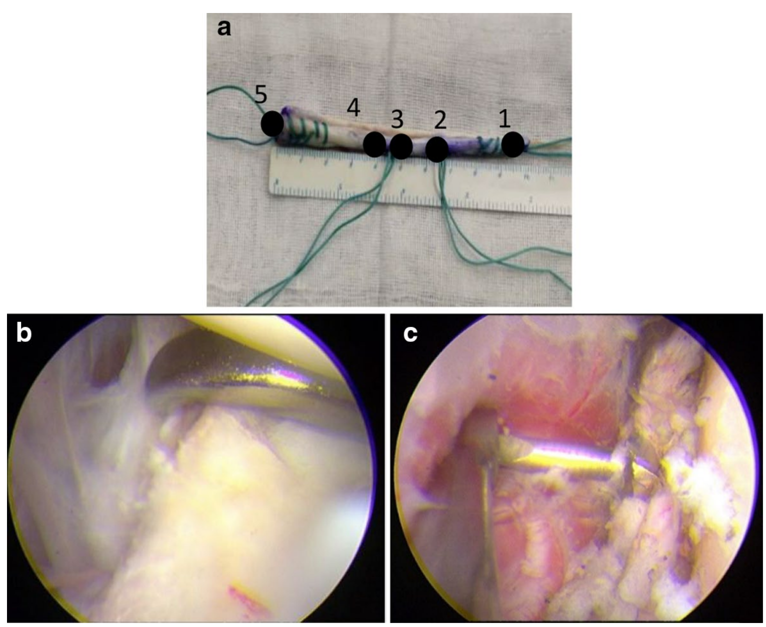

Fig. 2 **a** Ethibond (No. 5; Ethicon, Somerville, NJ) was placed with a whipstitch at each free end and middle of the graft. **b** Drilling into the glenoid from posterior to anterior under arthroscopy. **c** Using spatula protected the neurovascular while the K-wires exit points of glenoid,the tunnels were made by 5-mm cannulated drill

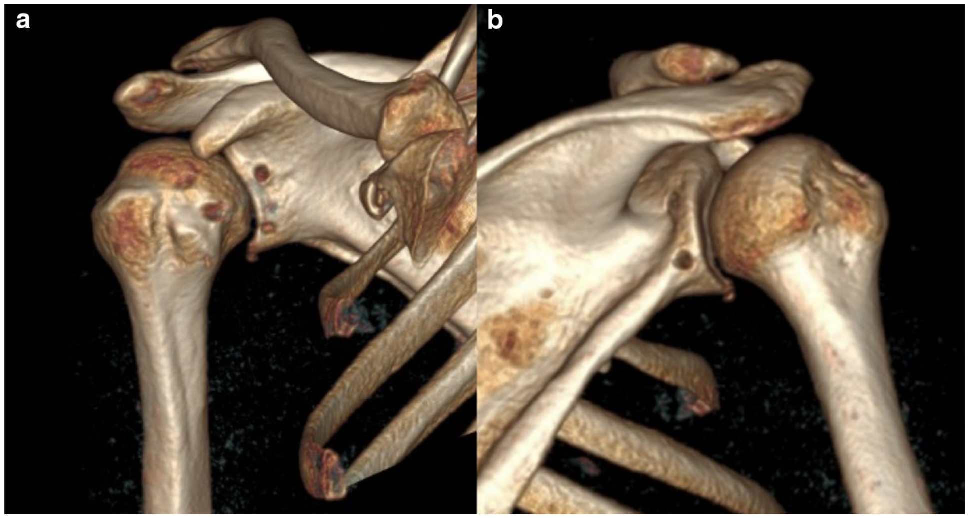

Fig. 4 **a** The location of tunnels on humerus and glenoid was exposed from anterior aspect. **b** The location of tunnels on glenoid for 5.5-mm Swivelocks was exposed from posterior aspect

anteriorly, similar to a thick labrum (Fig. 1).The lower free end of the graft was fixed to the humerus in 1 appropriately sized tunnel (Fig. 4a) that ran from medial to lateral and exited lateral to the bicipital groove. The grafts were fixed with BIOSURE°PK Screws (5- or 6-mm Biotenodesis; Smith & Nephew, USA) at the lateral tunnel aperture away from the articular margin (Figs. 1c and 4).

The surgical technique for Group B

The arthroscopic procedure was performed using the classic 3-portal technique. Any anteroinferior labral insufficiency, SLAP lesions, anterior glenoid defects, and Hill–Sachs lesions were assessed. Bankart repair and retensioning of the anterior capsule were performed according to the technique described by Cole and Romeo [5]. The anterior capsulolabral tissue was successfully restored after the procedure.

Postoperative rehabilitation

Postoperatively, the shoulder was immobilized in a brace with shoulder dynamic immobilization in a special sling with external rotation limited to neutral and 30° of abduction for 6 weeks. Shoulder passive ROM to increase joint mobility, pendulum exercises, and wrist and hand exercises were permitted during this time. Active ROM was initiated 7–8 weeks after surgery, and the aim was recovery of full ROM. Then, recovery of strength and proprioceptive abilities were the primary focus. When full ROM and strength were recovered, return to activity was expected after 6 months.

Statistical analysis

Statistical analysis was performed using SPSS software for Windows (version 19.0, SPSS Inc., Chicago, IL, USA). The data were analysed using ANOVA and Fisher's exact test. The data followed a Gaussian distribution. Data are presented as the mean values ± standard deviation. The OSIS, ASES, Rowe, and VAS scores and ROM were analysed with separate independent *t* tests. The McNemar test was used for continuous and noncontinuous variables. Spearman correlation analysis was used to determine whether the changes in the follow-up results were associated with possible risk factors. $P < 0.05$ was considered significant; $\beta < 0.2$, the effect size and standard deviation was references from Russo's study [18]. The calculation of sample size yielded 20 patients in each group.

Results

A total of 46 patients were available for the follow-up, and the two groups had the same baseline (Tables 1 and 2). The new technique in Group A required substantially more time than arthroscopic Bankart repair in Group B.

At the last follow-up after surgery, patients in both groups had experienced significant improvements in all outcome scores ($P < 0.05$ for all, Table 2). However, Group A had an obvious decrease in ROM ($P < 0.05$ for all, Table 2), and Group B also had an obvious decrease in ROM ($P < 0.05$ for all, Table 2) except for internal rotation at 90° of abduction (n.s.) compared to the preoperative values.

For the follow-up results, Group A had a superior ASES score, VAS score, and OSIS ($P < 0.05$, Table 2) but no significant differences in the Rowe score or ROM compared to Group B (Table 2). Thus, the new technique did not decrease the ROM compared to that associated with arthroscopic Bankart repair.

A subgroup analysis of the different grafts used was performed in Group A. It was found that using allografts could save substantially more time compared to using autografts

Table 1 Demographic characteristics of the patient population

	Group A[a]	Group B[b]	
Patients	25	21	
Age	27.6 ± 6.9	30.1 ± 7.8	n.s.
Sex (male/female)	18/7	15/6	n.s
Side (dominant)	19/6	14/7	n.s
Body mass index, kg/m^2	23.4 ± 2.2	23.2 ± 1.7	n.s
FU (m)	32.2 ± 14.2	30.8 ± 12.8	n.s
Number of shoulder dislocations before surgery	15.4 ± 5.8	14.8 ± 6.0	n.s
Glenoid defect size (%)	13.6 ± 5.2	12.9 + 5.1	n.s
Beighton score	5.5 ± 2.2	5.8 ± 1.9	n.s

n.s. statistically non-significant

[a]Group A, MASA with tenodesis of the upper third of the subscapularis tendon using tendon allografts or autografts and capsulolabral reconstruction with part of the grafts

[b]Group B, arthroscopic Bankart repair

Table 2 Comparison of outcome scores and ROM between Group A and Group B

	Group A[a]	Group B[b]	
n	25	21	
Surgery time (h)	3.3 ± 0.7	2.6 ± 0.5	$P = 0.0003$
ASES			
Pre	56.3 ± 9.4	57.6 ± 6.9	n.s.
Post	90.6 ± 3.7	85.0 ± 4.3	$P < 0.001$
	$P < 0.001$	$P < 0.001$	
VAS			
Pre	3.4 ± 0.6	3.2 ± 0.5	n.s
Post	0.6 ± 0.4	0.9 ± 0.5	$P = 0.039$
	$P < 0.001$	$P < 0.001$	
Rowe			
Pre	49.7 ± 10.8	48.6 ± 11.0	n.s
Post	92.1 ± 4.8	90.1 ± 5.7	n.s
	$P < 0.001$	$P < 0.001$	
OSIS			
Pre	28.6 ± 7.2	29.8 ± 5.2	n.s
Post	43.3 ± 4.0	40.8 ± 4.1	$P = 0.045$
	$P < 0.001$	$P < 0.001$	
ROM			
Forward flexion			
Pre	168.9 ± 4.8	170.0 ± 5.5	n.s
Post	165.3 ± 5.0	163.4 ± 5.3	n.s
	$P = 0.011$	$P < 0.001$	
External rotation			
Pre	69.7 ± 6.2	70.4 ± 6.7	n.s
Post	57.2 ± 5.1	59.6 ± 4.1	n.s
	$P < 0.001$	$P < 0.001$	
External rotation at 90° of abduction			
Pre	77.2 ± 6.3	78.4 ± 4.5	n.s
Post	66.8 ± 4.6	69.0 ± 4.3	n.s
	$P < 0.001$	$P < 0.001$	
Internal rotation at 90° of abduction			
Pre	62.1 ± 6.6	60.5 ± 5.6	n.s
Post	57.6 ± 4.7	58.0 ± 3.8	n.s
	$P = 0.007$	n.s	

n.s. statistically non-significant

[a] Group A, MASA with tenodesis of the upper third of the subscapularis tendon using tendon allografts or autografts and capsulolabral reconstruction with part of the grafts

[b] Group B, arthroscopic Bankart repair

($P < 0.001$, Table 3), but no significant difference in clinical outcomes was found (Table 3) between different grafts at the last follow-up.

There was a significant association between changes in glenoid defect size and the postoperative Rowe score, ASES score, OSIS, and number of shoulder dislocations before surgery (negative correlation, $P < 0.05$, Table 4). No significant association was found between changes in the follow-up results and BMI or age (Table 4).

At the final assessment, most patients (93.4%) had returned to sports activities. An obvious significant difference ($P = 0.043$, Table 5) was observed in the number of patients who returned to preinjury sports activities between the groups at the last follow-up. The overall rate of recurrent instability was 10.9% (5 of 46 shoulders), including 1 patient with subluxation in Group A, and 3 patients with dislocation and 1 patient with subluxation in Group B. No patients in either group experienced neurovascular injury, joint stiffness, or surgical wound infection.

Discussion

The most important finding of the present study was that it provides an alternative option to tendon transfer, arthrodesis, and arthroplasty; demonstrates feasibility and reproducibility; and is the first procedure to combine capsulolabral reconstruction [1, orts activity level between Group A and Group] and subscapularis augmentation [11]. How does the new technique prevent shoulder dislocation?

A "triple effect" accounts for the success of the Latarjet procedure: the coracoid bone graft effectively lengthens the glenoid in the anteroposterior dimension; the lower subscapularis muscle fibres reinforce the IGHL by the conjoint tendon, which acts as a sling (hammock effect); and the lateral aspect of the anterior capsule is strengthened by imbrication of the coracoacromial ligament, which acts as an additional restraint [4]. The ASA technique uses the upper third of the subscapularis, and the Latarjet procedure uses the lower third. These findings are important to understand the mechanism of recurrent shoulder dislocations and to

Table 3 Comparison of outcome scores and ROM between allografts and autografts in Group A at the last follow-up

	Allografts	Autografts	
n	9	16	
Surgery time (h)	2.6 ± 0.6	3.9 ± 0.4	$P < 0.001$
ASES score	89.1 ± 4.1	91.2 ± 3.9	n.s.
VAS score	0.6 ± 0.5	0.6 ± 0.4	n.s
Rowe score	93.1 ± 4.7	91.5 ± 5.2	n.s
OSIS	42.2 ± 3.8	43.9 ± 4.3	n.s
ROM			
Forward flexion	166.0 ± 6.1	164.9 ± 5.2	n.s
External rotation	56.7 ± 4.9	57.5 ± 4.3	n.s
External rotation at 90° of abduction	65.6 ± 5.1	67.5 ± 4.8	n.s
Internal rotation at 90° of abduction	58.9 ± 4.1	56.8 ± 3.5	n.s

n.s. statistically non-significant

Table 5 Comparison of postoperative sports activity level between Group A and Group B (Wilcoxon rank-sum test)

Sports activity level	Group A[a] ($n = 25$)	Group B[b] ($n = 21$)
I	11	3
II	10	12
III	3	4
IV	1	2
P value	0.043	

[a]Group A, MASA with tenodesis of the upper third of the subscapularis tendon using tendon allografts or autografts and capsulolabral reconstruction with part of the grafts

[b]Group B, arthroscopic Bankart repair

emphasize the key role of the subscapularis tendon. In our technique, we create a sling similar to that in the Latarjet method. The sling prevents dislocation of the humeral head through the active and passive functions of the subscapularis tendon in the sling. To achieve this, the sling should be placed around the upper part of the tendon and not the inferior part as in the Latarjet method. By placing the sling in such a way, the inferior movement may be more restricted. Compared with the Latarjet sling with only one leg fixed to the glenoid rim according to Wellmann et al. [24], a sling with two legs was attached to the glenoid in our technique, which can better prevent inferior movement of the humeral head. As the subscapularis muscle plays a very important role in active stability of the joint, two-legged slings can prevent the subscapularis muscle from being pulled inferiorly, which can prevent inferior movement and provide more stability.

The MGHL provides anterior stability only at 45° and 60° of abduction; however, the IGHL complex is the most important stabilizer against anteroinferior shoulder dislocation. Therefore, this component of the capsule is the most frequently injured structure and plays an important role. Recovering the IGHL complex after shoulder dislocation must be considered. In addition, the fibres of the MGHL blend with portions of the subscapularis tendon approximately 2 cm medial to its insertion on the lesser tuberosity [2]. Clinical experiences after the ASA procedure are different with respect to limitations of external rotation [11, 14, 23], and MGHL reconstruction may worsen outcomes. A detached labrum can compromise the IGHL complex and lead to recurrent anterior shoulder instability (RASI). However, additional capsular injury is usually necessary to allow anterior dislocation. The IGHL has its insertions medially on the labrum and the anterior aspect of the scapular neck and laterally on the humeral anatomical neck; therefore, we reconstructed the glenoid labrum simultaneously.

A transglenoid tunnel suture is created in a retrograde manner without risking the axillary nerve. However, blind penetration of the subscapularis using a suture retriever is a dangerous manoeuvre, but with control of the direction and position of penetration, the risk can be reduced [22]. Additionally, by advancing through the tendinous part of the subscapularis tendon, the risk of injuring the musculocutaneous nerve is reduced. When the tendon was pulled, we intended to make a split mainly in the tendinous part and not in the muscular part of the subscapularis

Table 4 Changes in the last follow-up results associated with possible risk factors

	Rowe score	ASES score	OSIS	VAS score
Age	n.s.	n.s	n.s	n.s
Body mass index, kg/m^2	n.s	n.s	n.s	n.s
The number of shoulder dislocations before surgery	n.s	Pearson = – 0.362, $P = 0.014$	Pearson = – 0.290, $P = 0.050$	n.s
Glenoid defect size	Pearson = – 0.395, $P = 0.007$	Pearson = – 0.332, $P = 0.024$	Pearson = -0.465, $P = 0.001$	n.s
Beighton score	n.s	Pearson = 0.445, $P = 0.002$	n.s	Pearson = – 0.412, $P = 0.04$

n.s. statistically non-significant

tendon. The results of the study [11, 20] show that the ASA procedure has a stabilizing effect for external rotation and abduction with trade-offs regarding maximum external rotation; this technique also prevents joint dislocations in patients with Bankart lesions and additional bone defects.

In the present study, one patient in Group A was sustained by subluxation due to a collision while playing basketball, but revision surgery was refused. During revision of our technique, the first problem that we may encounter is rupture of allografts or autografts. Although anchors in the glenoid complicate the addition of new screws, our technique could be used for revision surgery; changing the method to secure the allografts or autografts to the rim of the glenoid was needed and an adjustable-length loop cortical suspensory fixation device was used [9] instead of Swivelocks (Arthrex). Socrates et al. [20] fixed iliac crest bone blocks for reconstruction of the glenoid in such a manner. The second problem may be chronic subscapularis rupture caused by abrasion between grafts and the subscapularis tendon. With subscapularis insufficiency, the Latarjet procedure would be used for revision, and the pectoralis major tendon was transferred for irreparable subscapularis tears.

There were several limitations in this study. The study was not a biomechanical study assessing the stabilizing effect of the procedure and did not assess the quality of the tendon-to-bone tissue healing. In addition, recurrent instability in Bankart repairs occurs after 2 years, and the follow-up period of observation was short and the number of patients low. A larger sample size is needed for further investigations in the future. At last, the capsulolabral complex was altered in patients with > 10 dislocations, and augmentation was needed [8]. Group B (an arthroscopic Bankart repair) might not have been the optimal control group. However, the new technique to treat anterior shoulder dislocation in the study might be a substitute for the Latarjet procedure and for other operations used.

Conclusion

For RASI with GBL < 25%, MASA with tenodesis of the upper third of the subscapularis tendon using a tendon combined with capsulolabral reconstruction was a safe technique and resulted in better outcomes in terms of ASES scores, VAS scores, OSISs, return to sports, and postoperative recurrent instability and did not decrease the ROM compared to that associated with arthroscopic Bankart repair.

Funding This study was supported by Sanming Project of Medicine in Shenzhen (Grant No. SZSM201612078).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval IRB approval was obtained (Peking University Shenzhen Hospital, approval, ID: 201768).

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