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ARTHROSCOPY AND SPORTS MEDICINE

Graft tears after arthroscopic superior capsule reconstruction (ASCR): pattern of failure and its correlation with clinical outcome

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Abstract

Introduction Arthroscopic superior capsule reconstruction (ASCR) using fascia lata autograft is a new surgical technique developed to overcome irreparable rotator cuff tears. There is little information about graft tear after ASCR and its impact on clinical outcome. This study is to investigate the graft tear rate, pattern of failure, and its correlation with clinical outcomes after arthroscopic superior capsule reconstruction (ASCR).

Materials and methods From June 2013 to June 2016, 31 shoulders in 31 consecutive patients (mean 65.3 years) underwent ASCR using fascia lata autograft for irreparable large-to-massive tears. Magnetic resonance imaging (MRI) was performed before surgery and at mean 12.8 months (12–24 months) after surgery to assess fatty infiltration progression and graft integrity. Graft tear was defined as the loss of graft continuity and was categorized as medial and lateral rows according to the failure location. Acromiohumeral distance (AHD) was pre- and postoperatively measured with the standard radiograph. Pain visual analog scale (VAS) score, American Shoulder and Elbow Surgeons (ASES) score, constant score, and physical examination were used to assess clinical outcomes. Average follow-up was 15 months (range 12–24 months) after surgery.

Results Mean active forward elevation increased from 133° to 146° ($P=0.011$). Mean VAS score, ASES score, and constant score significantly improved: from 6 to 2.5, 54.4 to 73.7, and 51.7 to 63.7, respectively ($P<0.001$). There was no remarkable progression of fatty infiltration after surgery. AHD increased from 5.3 mm preoperatively to 6.4 mm postoperatively ($P<0.016$). Nine patients (29%) showed graft tear on follow-up MRI: 7 and 2 at the medial and lateral rows, respectively. Although the intact graft group showed better outcomes than the graft tear group (pain VAS score 2.3 vs. 3.0; ASES score 74.1 vs. 69.8; constant score 63.4 vs. 57.9), the results were not statistically significant.

Conclusions Graft tear rate after ASCR assessed by MRI was 29%, and failures mostly occurred at the medial row. The graft tear group showed clinical improvement despite the recurred superior capsule defect.

Level of evidence IV, case series, treatment study.

Keywords Shoulder · Rotator cuff tear · Arthroscopic surgery · Superior capsule reconstruction · Graft tear · MR imaging

Introduction

Rotator cuff repair is one of the most common shoulder surgeries, and recent advances in surgical techniques have provided favorable results. However, irreparable large-to-massive rotator cuff tears still pose a great challenge for many shoulder surgeons due to the poor outcome and lack of surgical options to restore cuff integrity. Various surgical options for massive rotator cuff tear were reported in the literature such as debridement and biceps tenotomy [4, 37, 44], tuberoplasty [11, 27], partial repair [5, 9, 25], tendon transfer [15, 16, 24, 36], patch graft [1, 3, 20, 22, 45], and reverse shoulder arthroplasty [2, 8, 12, 34, 46]. To date,

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there appears to be no general consensus regarding the best option for treating irreparable cuff tears.

Mihata et al. [31] recently emphasized on the role of superior capsular defect in large-to-massive cuff tears, which could lead to the upward migration of the humeral head during active arm elevation in a cadaveric study. In his series of 23 patients with irreparable cuff tears [29], arthroscopic superior capsule reconstruction (ASCR) using a fascia lata autograft achieved excellent shoulder function with a mean American Shoulder and Elbow Surgeons (ASES) score of 92.9 at a minimum 2-year follow-up. In cases, where the anatomic restoration of the rotator cuff is not feasible, ASCR can be considered as a viable option for relieving pain and restoring shoulder function.

However, little is known about the fascia lata graft tears and their impact on clinical function outcomes after ASCR. It requires both glenoid side and humeral side fixation of autograft, which may put the graft into failure of healing on either location. If the graft tears and superior stability are compromised, the clinical outcome may be unsatisfactory. This study aimed to (1) evaluate the graft tear rate after ASCR using serial magnetic resonance imaging (MRI), (2) categorize graft tear patterns, (3) evaluate the influence of risk factors on graft integrity, and (4) analyze the correlation between graft tears and clinical outcomes.

Materials and methods

Patient selection

After acquiring the approval of the institutional review board, patients who underwent ASCR at a tertiary university hospital from June 2013 to June 2016 were queried retrospectively from the prospectively collected surgical database. Candidates for ASCR were patients who had large-to-massive cuff tear with medial retraction on preoperative MRI and showed no evidence of significant glenohumeral joint arthritis on the standard shoulder anteroposterior (AP) X-ray (Hamada Grade 1,2) [21]. These patients underwent diagnostic arthroscopy and those who had tears that could not be reduced to the footprint or could be reduced only with undue tension subsequently underwent ASCR. Any patients who were lost to follow-up or did not have postoperative MRI study were excluded from the study.

Surgical technique

All procedures were performed by a senior shoulder surgeon. Patients were prepared in the beach chair position under general anesthesia. Diagnostic shoulder arthroscopy using a standard posterior portal was performed to determine the size and configuration of the tear. After releasing the adhesions using an electrocautery device and shaver, trial reduction to the footprint was performed to determine whether the tear could be repaired. If the torn tendon was determined to be irreparable, the following procedures were performed. Acromioplasty was routinely performed to prevent postoperative graft attrition by subacromial spur. The distance from the glenoid medially to the footprint of the greater tuberosity laterally and the anterior-to-posterior defect size of the cuff were measured using a probe for determining the required size of the fascia lata graft. An ipsilateral fascia lata graft was harvested according to the size of the defect and was folded in two layers using multiple No. 2 Ethibond stitches to obtain at least a 6-mm-thick graft. After the graft preparation, the glenoid side was prepared for graft attachment. The long head of biceps tendon was tenotomized if present, and the superior glenoid was debrided and cleared for insertion of 2 or 3 anchors. The lateral portal was extended to approximately 2 cm, and the graft was introduced into the subacromial space via the portal. Sutures from the glenoid anchors were passed through the medial end of the graft and fixed first. The lateral end of the graft was attached to the footprint of the greater tuberosity using a double-row suture bridge construct (Fig. 1). After the surgery, all patients were placed in shoulder abduction brace for 6 weeks and started performing pendulum exercises at 3 weeks. After gaining range of motion, strengthening

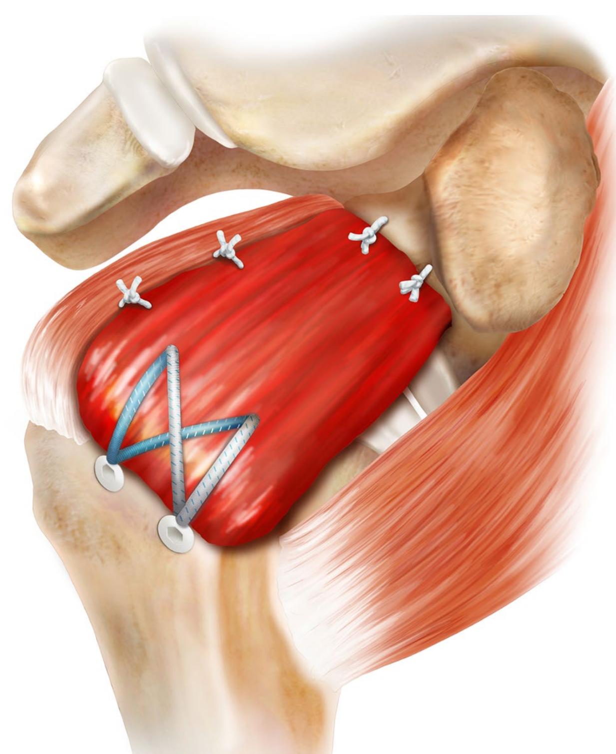

Fig. 1 Schematic overview of double-row suture bridge construct in ASCR

exercises for the periscapular muscle and rotator cuff were prescribed under the guidance of a physiotherapist.

Imaging study

Preoperative MR images were reviewed to assess the involved tendons and fatty infiltration according to Goutallier's classification [13, 17] of subscapularis, supraspinatus, and infraspinatus tendons. The presence of subscapularis tears, defined as lesions that were larger than a full thickness tear of the upper third (Lafosse type II or above), were noted [26]. For evaluating the graft integrity after the index surgery, patients were prescribed to undergo 3.0-Tesla MRI (Achieva, Philips Medical System, Amsterdam, The Netherlands) at 3, 6, and 12 months and annually thereafter. To define the graft tear, we modified Sugaya classification of repair integrity after rotator cuff repair to assess the repair integrity of the fascia lata graft [41]. The graft tear was classified as a minor tear if minor discontinuity (1–2 cuts in the coronal sequence) that was analogous to Sugaya type 4 was observed and as a major tear if a considerable defect (> 3 cuts in the coronal sequence) that was analogous to Sugaya type 5 was observed. To categorize the graft tear pattern, we modified the recurrent tear patterns of the repaired rotator cuff tendons, as proposed by Cho et al. [7]. Type 1 graft tear was defined as failure at the lateral row of the anchor in which no tissue remained on the footprint (Fig. 2a), and type 2 graft tear was defined as failure that occurred immediately medial to the medial row of the anchor in which remnant graft tissue at the insertion site was observed (Fig. 2b). Fatty infiltration of tendons was reviewed to check for progression. The acromiohumeral distance (AHD), namely, the distance between the undersurface of the acromion and superior margin of the humeral head, was measured preoperatively and at the last follow-up using the standard shoulder AP X-rays. All imaging studies were analyzed by a fellowship-trained shoulder specialist who was blinded to the identifying information of the patients and the clinical outcome.

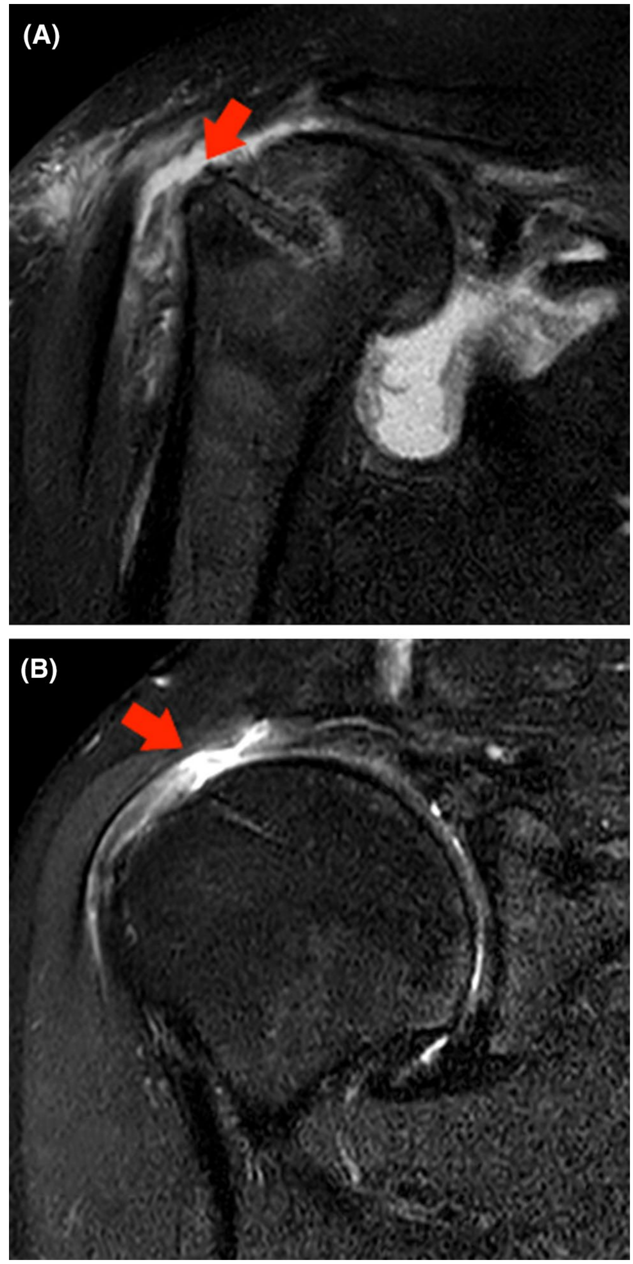

Fig. 2 Graft tear pattern after ASCR on postoperative MRI. Red arrows indicate location of the failure. **a** Type 1 tear; lateral row failure without any remnant tissue. **b** Type 2 tear; medial row failure with remnant tissue at greater tuberosity

Clinical evaluation

All patients were clinically evaluated by an independent nurse practitioner with more than 10 years of experience in shoulder treatment before undergoing the index surgery and at a mean of 15 months postoperatively (range 12–24 months). The range of motion (forward elevation and external rotation) was measured using a handheld goniometer preoperatively and at each follow-up. Supraspinatus and external rotator muscle strength was measured using the Nottingham Mecmesin Myometer (Mecmesin Co., Nottingham, UK). Pain visual analog scale (VAS) score, ASES scores, and constant scores were recorded preoperatively and at regular follow-ups. Clinical factors such as age, sex, hand dominance, and history of diabetes mellitus, which could influence graft healing, were investigated. The medical records were reviewed for any complications regarding the surgery, such as wound problems, deep infection, nerve injury, and cardiopulmonary events.

Statistical analysis

Paired *t* test and Wilcoxon signed-rank test were used to compare pre- and postoperative clinical outcomes and radiologic parameters. To compare the differences between the intact graft group and graft tear group, Fisher's exact test was used to for the categorical data and Mann–Whitney test was used for the numerical data. Logistic regression analysis was used for evaluating the influence of possible risk factors (e.g., age, sex, hand dominance, history of diabetes mellitus, presence of a subscapularis tear, and preoperative fatty infiltration for each tendon) on graft tear. Statistical analyses were performed using the SPSS software (version 21; IBM, Armonk, NY, USA). The significance level was set at a *P* value of 0.05.

Result

All 31 patients (average age 65.3 years; range 44–85 years; 9 males, 22 females) who underwent ASCR during the study period were enrolled without any follow-up loss. The injury involved the dominant shoulder in 25 patients and the non-dominant shoulder in 6. Seven patients had diabetes and were on oral hypoglycemia agents.

Pain VAS score, ASES score, Constant score, and forward elevation range of motion significantly improved following surgery ($P<0.001$, $P<0.001$, $P<0.001$, and $P=0.011$, Table 1). Five patients had pseudoparalysis before the surgery, which resolved after ASCR. Muscle strength and external rotation range of motion did not substantially change. No complications such as wound problems, deep infection, or nerve palsy, which were directly related to the surgery, were noted. One patient (64-year-old female) developed pulmonary embolism that completely resolved after anticoagulation therapy without any sequelae.

On the basis of MRI obtained at a mean of 12.8 (range 12–24) months postoperatively, 9 of 31 patients (29%) had a graft tear [6 minor and 3 major tears; 7 tears at the medial (type 2); and 2 at the lateral (type 1) rows of the greater tuberosity footprint]. No patients had graft failure at the glenoid anchor site. Graft tears were visible at an average of 5.7 (range 3–12) months postoperatively. In the intact graft group, 22 patients had average 13 (range 12–24)-month follow-up MRI study which showed graft healing (Fig. 3). There was no evidence of synovial reaction in any of the patients. Regarding preoperative fatty infiltration, the mean preoperative Goutallier grade for subscapularis, supraspinatus, and infraspinatus tendons was 1.1 ± 0.7, 2.7 ± 0.6, and 2.5 ± 0.7, respectively. After ASCR, the mean fatty infiltration grade changed to 1.2 ± 0.7, 2.9 ± 0.4, and 2.6 ± 0.7, respectively, with little clinically significant differences ($P=0.043$, 0.056, and 0.212, respectively). The mean preoperative AHD was 5.3 ± 2.2 mm, which increased to 6.4 ± 2.3 mm postoperatively ($P=0.016$; Table 1). Logistic regression analysis revealed that no risk factor influenced the graft tear ($P>0.05$).

Table 1 Clinical outcomes after ASCR ($n=31$)

	Preop	Postop	*P* value
VAS	6 ± 1.2	2.5 ± 1.2	< 0.001*
ASES	54.4 ± 17.9	73.7 ± 10.8	< 0.001*
Constant	51.7 ± 13.9	63.7 ± 8.1	< 0.001*
ROM, FE (°)	133 ± 35	146 ± 18	0.011*
ROM, ER (°)	28 ± 16	30 ± 15	0.4
SST power (kg)	1.8 ± 0.7	1.9 ± 0.6	0.526
ER power (kg)	2.1 ± 0.7	2.2 ± 0.7	0.622
Fatty infiltration			
Subscapularis	1.1 ± 0.7	1.2 ± 0.7	0.043*
Supraspinatus	2.7 ± 0.6	2.9 ± 0.4	0.056
Infraspinatus	2.5 ± 0.7	2.6 ± 0.7	0.134
AHD (mm)	5.3 ± 2.2	6.4 ± 2.3	0.016*

The values are reported as mean ± standard deviation

VAS Visual Analog Scale; *ASES* American Shoulder and Elbow Surgeons score; *ROM* range of motion; *FE* forward elevation; *ER* external rotation; *SST* supraspinatus; *ER* external rotator

VAS, ASES, Constant, ROM FE, Subscapularis, AHD all correctly represent significant *p*-value

*Significant level = $P<0.05$

[a]Test used = paired *t* test

Subgroup analysis between the graft tear ($n=9$) and intact graft ($n=22$) groups showed no significant difference with regard to age, sex, hand dominance, and history of diabetes (Table 2). The incidence of a full thickness tear of the subscapularis tendon was higher in the graft tear group (33.3%) than in the intact graft group (18.2%), although this was not statistically significant ($P=0.384$). Preoperatively, no significant difference in the ASES score, constant score, range of motion, and muscle power was observed between the two groups, although a significantly higher pain VAS score was observed in the graft tear group than in the intact graft group (6.8 ± 1.2 vs. 5.7 ± 1.1, $P=0.041$; Table 3). Postoperatively, all clinical outcome parameters and AHD were improved in the intact graft group, although only pain VAS score, ASES score, constant score, forward elevation, and AHD showed a significant difference ($P<0.001$, $P<0.001$, $P<0.001$, $P<0.041$ and $P=0.019$, respectively; Table 3). Despite the loss of graft integrity, pain VAS score, ASES score, constant score, and forward elevation were improved in the graft tear group ($P=0.007$, $P=0.028$, $P=0.172$, and $P=0.18$, respectively; Table 3). Although there was a slight loss in the range of external rotation, supraspinatus muscle strength, and AHD in the graft tear group, it was not statistically significant. The intact graft group showed slightly

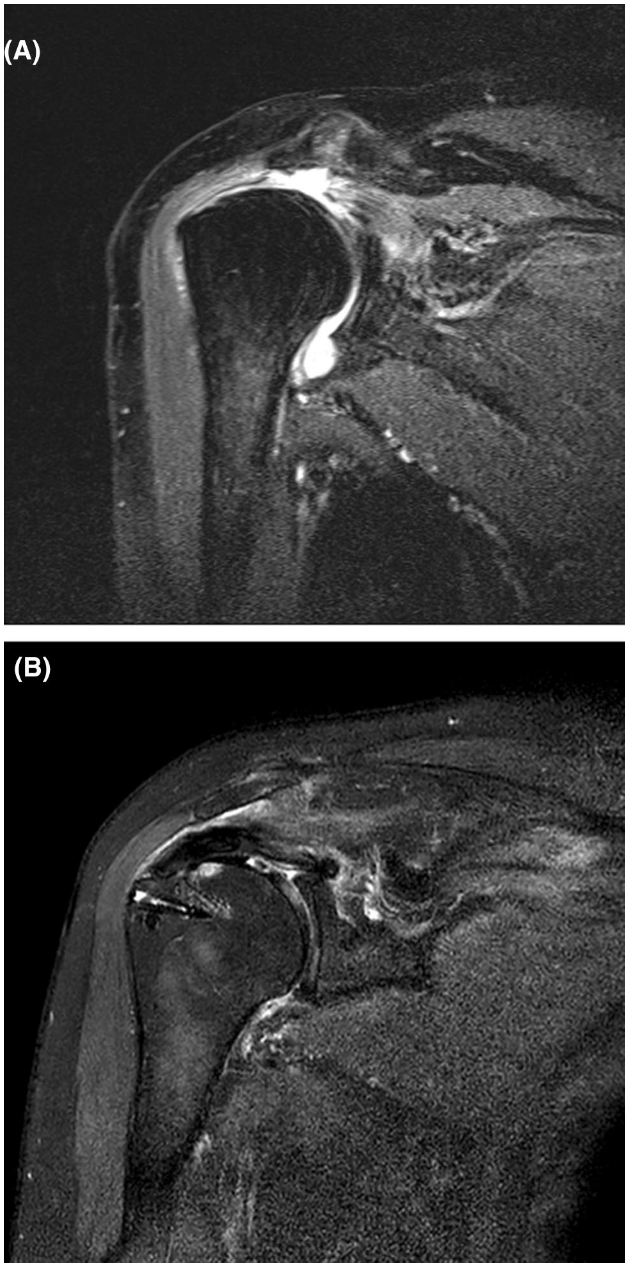

Fig. 3 MRI images of a 73-year-old female with massive cuff tear of right shoulder. **a** Before surgery, **b** graft healing at 12 months after ASCR

better outcomes in pain VAS, ASES score, constant score, and muscle power postoperatively when compared with the graft tear group. However, the differences were not statistically significant. There was no significant difference between the two groups with respect to the preoperative fatty infiltration of the subscapularis, supraspinatus, and infraspinatus tendons ($P>0.05$; Table 4). Furthermore, postoperatively, no significant changes were observed in both the groups with regard to fatty infiltration. However, a significantly higher mean AHD was observed in the intact graft group than in the graft tear group preoperatively (5.8 ± 2.4 vs. 4.1 ± 0.9 mm; $P=0.033$) and postoperatively (7.4 ± 1.9 vs. 4.0 ± 1.5 mm; $P<0.001$).

Table 2 Comparison between graft tear group vs. intact group

	Graft tear ($n=9$)	Intact ($n=22$)	P value[a]
Age	67.4 ± 7.6	64.4 ± 9.5	0.428
Gender (M:F)	4:5	6:16	0.417
Involved side (D:ND)	7:2	18:4	0.999
Diabetes mellitus, *n* (%)	2 (22.2)	3 (13.6)	0.613
Subscapularis tear, *n* (%)	3 (33.3)	4 (18.2)	0.384

The values are reported as mean ± standard deviation

*Significant level = $P<0.05$

D dominant; *ND* nondominant

[a]Test used = Mann–Whitney test for age, Fisher's exact test for the rest

Discussion

To the best of our knowledge, this is the first study to analyze and report the failure patterns of fascia lata graft after ASCR and compare its clinical outcomes to those of a healed graft group. Our results demonstrated an early graft tear rate of 29%, as assessed using MRI at an average of 10 months, and the main pattern of failure was observed at the medial row failure. The patients with graft tear had improvement of pain and function despite the recurrence of superior capsule defect. These findings have not been reported previously, and are similar to the outcome of patients with retear of surgically repaired rotator cuffs.

Besides ASCR, other surgical options are available for irreparable rotator cuff tears. Reverse total shoulder arthroplasty (RTSA), first introduced by Grammont for treating irreparable cuff tears with arthropathy, has been gaining popularity globally [18]. The indication has been recently extended to irreparable cuff tears without significant glenohumeral arthrosis. Mulieri et al. [34] reported regarding the outcomes of 58 patients who were treated with primary RTSA for irreparable massive cuff tears without glenohumeral arthritis. Despite a 20% complication rate, implant survival was 90.7% at a mean follow-up of 52 months with substantial improvement in both postoperative pain and function. Although the results of RTSA without arthrosis showed a favorable outcome, it is the authors' opinion that RTSA should be reserved as last resort because of its high complication rates, concerns for longevity, difficulty in revision surgery, and high medical costs. The result of RTSA for young and active patients is not yet satisfactory with high

Table 3 Functional outcomes after surgery: comparison between graft tear group ($n=9$) and intact graft group ($n=22$)

	Preoperative			Postoperative			P value[b]	
	Tear	Intact	P value[a]	Tear	Intact	P value[a]	Tear	Intact
VAS pain	6.8 ± 1.2	5.7 ± 1.1	0.041*	3.0 ± 1.3	2.3 ± 1.2	0.124	0.007*	< 0.001*
ASES	55.2 ± 19.4	54.1 ± 17.7	0.749	69.8 ± 14.3	74.1 ± 11.2	0.915	0.028*	< 0.001*
Constant	51.5 ± 13.1	51.8 ± 14.5	0.915	57.9 ± 10.3	63.4 ± 6.6	0.16	0.172	0.001*
ROM, FE (°)	132 ± 41	134 ± 33	0.781	145 ± 19	146 ± 18	0.915	0.18	0.041*
ROM, ER (°)	32 ± 12	26 ± 15	0.188	27 ± 17	31 ± 16	0.654	0.439	0.097
SST power (kg)	2.1 ± 0.6	1.7 ± 0.8	0.103	1.7 ± 0.8	2.0 ± 0.5	0.188	0.314	0.107
ER power (kg)	2.1 ± 0.5	2.1 ± 0.8	0.915	2.1 ± 0.7	2.2 ± 0.7	0.453	0.767	0.536

The values are reported as mean ± standard deviation

VAS Visual Analog Scale; *ASES* American Shoulder and Elbow Surgeons; *ROM* range of motion; *FE* forward elevation; *ER* external rotation; *SST* supraspinatus; *ER* external rotator

*Significant level = $P < 0.05$

[a]Test used = Mann–Whitney test

[b]Test used = Wilcoxon signed rank

Table 4 Preoperative and postoperative radiologic parameter graft tear group ($n=9$) and in graft intact group ($n=22$)

	Preoperative			Postoperative			P value[b]	
	Tear	Intact	P value[a]	Tear	Intact	P value[a]	Tear	Intact
Fatty infiltration								
Subscapularis	1.5 ± 1.0	0.9 ± 0.5	0.113	1.6 ± 1.0	1.0 ± 0.6	0.103	0.317	0.083
Supraspinatus	2.6 ± 0.7	2.7 ± 0.5	0.749	3.1 ± 0.3	2.8 ± 0.5	0.254	0.102	0.329
Infraspinatus	2.4 ± 0.8	2.5 ± 0.7	0.814	2.6 ± 0.5	2.6 ± 0.8	0.949	0.317	0.266
AHD(mm)	4.1 ± 0.9	5.8 ± 2.4	0.033*	4.0 ± 1.5	7.4 ± 1.9	< 0.001*	0.314	0.007*

The values are reported as mean ± standard deviation

Fatty infiltration Goutallier grading, *AHD* Acromiohumeral distance

*Significant level = $P < 0.05$

[a]Test used = Mann–Whitney test

[b]Test used = Wilcoxon signed rank

complication and failure rate [6, 10, 33]. ASCR may have a treatment role for these patients.

Reconstruction of the superior capsule raises questions about the success rate of graft healing and the deterioration of function if the graft fails. There is a paucity of data regarding how the graft fails in cases of a patch graft or ASCR. A xenograft patch and dermis allograft had a considerable tear rate [1, 3, 20, 22, 40, 45], and there was severe synovitis related to the foreign material in a porcine intestinal patch [45]. We did not observe any significant synovitis related to the fascia lata graft in the current study, as can be expected from immunogenicity of the autograft. Because ASCR comprises a transosseous-equivalent double-row suture bridge construct to attach autologous tissue as in arthroscopic rotator cuff repair, one can assume that failure of healing may be similar for the graft as in a repaired rotator cuff. Cho et al. [7] reported that type 2 failure, where some cuff tissues remain at the insertion site, was predominant in double-row repair of rotator cuff tears. Similarly, the most common graft tear pattern observed in our series after using a double-row construct also was type 2. In this study, the reasons for not observing any failure around the glenoid side remained unknown. The failures may have occurred because of excessive tension that was concentrated on the distal portion of the graft (graft on the greater tuberosity) during active shoulder abduction and elevation. Of note, most of these failures were early cases in the consecutive series, suggesting that ASCR is a technically demanding procedure that has a steep learning curve.

Mihata et al. [29] previously reported a recurrent tear and graft tear rate of 16.7% (4/24) at a mean follow-up of 34 months. In the current study, the graft tear rate was 30% (9/30), and this higher rate could be explained by the differences in patient characteristics, surgical technique, and definition of healing failure, which were not described in detail in the previous literature. A systematic review of 108 articles that reported on the structural integrity and clinical outcomes after rotator cuff repair revealed that the mean recurrent tear rate was 26.6% at an average of 2 years postoperatively [28]. Retear rates after rotator cuff repair are higher for large-to-massive tears, with rates as high as 36–94% [14, 23, 32, 41–43, 47], which are comparable with those reported in the current study.

There were no significant differences of clinical outcome between the graft tear group and the intact graft group. This may be attributed to the small number of samples and short-term follow-up, as the graft tear group may deteriorate over time. However, the correlation between the anatomic cuff integrity and clinical outcome after rotator cuff repair remains controversial. A recent meta-analysis showed that structural integrity had no correlation with a clinically better outcome [38]. Galatz et al. [14] reported that although the recurrent tear rate was 94% after arthroscopic repair for large and massive cuff tears, patients experienced a significant increase in function and could achieve a satisfactory outcome. In this study, most graft tears were minor, which can result in improved symptoms even with disruption of the capsule reconstruction. The superior stability provided by ASCR, although temporary, and vigorous rehabilitation may help regain functional shoulders for these patients.

Pre- and postoperative AHD was substantially high for patients with a retained graft. AHD has been used as a simple parameter for assessing rotator cuff integrity, and a decrease in AHD of <6 mm indicates a loss of rotator cuff integrity and function [19, 35, 39]. The reason for the intact graft group having a high AHD preoperatively remains unclear. Perhaps, the head depressing function of the remnant rotator cuff was better in patients with an intact graft and consequently affected the survival of the fascia lata graft. Increased AHD after successful ASCR can be attributed to routine acromioplasty and graft thickness. According to the biomechanical cadaveric study by Mihata et al. [30], acromioplasty can help avoid graft friction and eventual progression to graft tear. Thus, we recommend routine acromioplasty for each ASCR.

Limitations

This study has several limitations. First, the clinical result and MRI findings were based on early results. It is possible that the graft tear group may deteriorate over time, and new graft tears occur in the healed group during long-term follow-up. Second, the study sample was relatively small, which was inevitable, because ASCR is a recently developed surgical technique with narrow indications and other options can be used for treating massive cuff tears. This small sample size might explain why there was no significant risk factor related to graft tear in regression analysis. There is also a possibility that the difference in outcome was missed due to the small size of the subgroups. Finally, the retrospective design of the study limited our control of variables. However, despite these limitations, this study has clinical implications, because it can provide data information about the risk of graft tears and result of failed graft healing after ASCR.

Conclusion

The graft tear rate after ASCR was 29%, as assessed using MRI. The most common pattern of graft failures occurred at the medial anchor (equivalent to type 2 recurrent tear in cases of arthroscopic rotator cuff repair). No risk factors for graft failures were identified. Pain VAS score, ASES score, constant score, and forward elevation improved after ASCR. In the graft tear group, pain VAS score and ASES score improved regardless of the tear. The clinical implication of graft failure was uncertain as there was no statistically significant difference between the two groups with respect to the clinical outcomes at a mean follow-up of 15 months. Preoperative AHD was significantly lower in the graft tear group than in the intact graft group. Further studies are warranted for assessing long-term clinical outcomes and correlations with graft integrity.

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Compliance with ethical standards

IRB/ethical committee approval AMC IRB 2017-0487.

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