Which Factors Influence Clinical Outcomes After Superior Capsular Reconstruction Surgery?

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Background: Arthroscopic superior capsular reconstruction (ASCR) has recently been introduced as an alternative treatment for patients with massive irreparable rotator cuff tears. However, the results of ASCR are still limited, and little information about retear after ASCR or subsequent treatment has been reported.

Purpose: To investigate the retear rate of patients who underwent ASCR and to analyze the clinical outcomes of treatments performed for a retear.

Study Design: Case-control study; Level of evidence, 3.

Methods: This was a retrospective analysis of prospectively collected data from 42 patients (46 shoulders) who underwent ASCR between March 2015 and April 2018. All patients were divided into 2 groups: those with no retear (30 shoulders) and those with retear (16 shoulders). Pre- and postoperative clinical and radiological results were compared between the 2 groups. The retear pattern and treatment outcomes of the retear group were analyzed.

Results: The overall incidence of retear was 35% (16/46). No difference was found in preoperative demographic or clinical data between the 2 groups. Preoperative magnetic resonance imaging data showed a significant between-group difference in the preoperative Goutallier grade of the subscapularis (1.5 ± 1.1 in the no-retear group vs 2.5 ± 1.3 in the retear group; $P = .016$). In the retear group, there were 10 cases of lateral side tears, 3 cases of midsubstance tears, 2 cases of medial side tears, and 1 case of medial and lateral tears. Reoperation was performed in 8 patients who had lateral insertion tear.

Conclusion: Overall, clinical scores improved after ASCR in patients with massive irreparable rotator cuff tears. However, 35% (16/46) of the patients showed retear, and lateral side retear occurred in 68% (11/16). The clinical outcome of the patients with preoperative subscapularis atrophy or postoperative lateral side retears was worse, and reoperation was often required. Therefore, it is important that the lateral side be firmly fixed during the ASCR procedure.

Keywords: irreparable rotator cuff tear; arthroscopic superior capsule reconstruction; clinical outcome; revision; retear rate

Surgical treatment of massive rotator cuff tears in patients without advanced cuff arthropathy or arthritis is still one of the most difficult problems in the treatment of shoulder diseases. Recent treatments include arthroscopic debridement, partial or complete repair, tendon transfer, various grafting techniques, balloon spacer, and arthroscopic superior capsular reconstruction (ASCR).[1,12,21,27]

Since Mihata et al[19,20] introduced ASCR, several studies have reported the radiologic and clinical outcomes of the procedure.[7,8,10,15,17,25] Restoring a stable fulcrum of glenohumeral motion with a reconstructed superior capsule has been considered an attractive option of ASCR. In their initial report, Mihata et al[19] found that the graft was intact up to an average of 34 months of follow-up in 20 of 24 shoulders. Burkhart and Hartzler[3] recently reported that patients with pseudoparalysis recovered 90% of function after ASCR. Early results from several studies have suggested that

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ASCR can provide improvements in pain, range of motion (ROM), function, and validated outcome measures.[7,8,10,15,17,25]

However, the effect of failed ASCR surgery is still unclear. It is unknown whether clinical outcomes or satisfaction levels of patients with postoperative retear after ASCR are higher compared with those with the preoperative state. Our study was conceptualized from the question "Which factors could influence the satisfaction of retear patients?" For this study, we hypothesized that such factors could consist of (1) preoperative factors, such as patient characteristics, tear pattern, preoperative cuff atrophy, and acromiohumeral distance (AHD); (2) intraoperative factors, such as allograft versus autograft, subscapularis repair, infraspinatus repair, and surgical technique experience (2015 vs 2018); and (3) postoperative factors, such as retear site and retear pattern. Thus, the aim of this study was to investigate the retear rate of patients who underwent ASCR and to analyze the factors associated with clinical outcomes of retear.

METHODS

This study was a retrospective analysis of prospectively collected data from patients who had undergone ASCR between March 2015 and April 2018. All surgeries were performed by the experienced senior author (S.-J.L.), who has performed >3000 rotator cuff repairs. We received an exemption from approval by an institutional review board given the retrospective nature of the study.

The inclusion criteria were as follows: (1) a large to massive full-thickness rotator cuff tear that was detected using preoperative magnetic resonance imaging and confirmed arthroscopically, (2) failure of nonoperative treatment for at least 3 months, (3) age <70 years, (4) a rotator cuff tear that was considered irreparable despite the use of interval slides, and (5) a need for active performance. The exclusion criteria were as follows: (1) a history of fractures or operations on the affected shoulder (except for arthroscopic rotator cuff repair), (2) severe arthritic changes of the glenohumeral joint on radiographs (Hamada grade 5), (3) age >70 years, (4) inflammatory arthropathies, and (5) no need for active performance.[14]

Allograft and autograft were selected for graft materials based on the patient's economic condition and needs. Autograft (tensor fascia lata) was used in 30 shoulders, and allograft (MegaDerm; L & C BIO) was used in 16 shoulders. The autograft thickness was measured at the center portion of the graft folded 2 or 3 times. Allograft thickness was also measured after the 3 pieces of the grafts were overlapped. No difference was noted in the surgical method between allograft and autograft. Moreover, no difference was reported in the surgical technique between 2015 and 2018. The technique was the same as previously reported.[14]

In this study, patients were divided into a retear group and a no-retear group. Preoperative and postoperative clinical and radiological results were compared between the 2 groups. Then, the retear pattern and treatment outcomes for the retear group were analyzed.

Clinical and Radiographic Assessment

All patients were assessed preoperatively, and postoperative evaluation was regularly performed during outpatient visits at 3, 6, 9, 12, 18, and 24 months and once a year thereafter. Clinical results were evaluated using American Shoulder and Elbow Surgeons (ASES) scores, Constant scores, and visual analog scale (VAS) scores. Active ROM in forward elevation, external rotation, and internal rotation was also assessed.

True anteroposterior radiographs were obtained preoperatively, postoperatively, and during follow-up visits. The AHD was measured using true anteroposterior radiographs. The AHD was defined as the shortest distance between the dense cortical bone at the inferior aspect of the acromion and the subchondral cortex at the superior aspect of the humeral head.[5] Postoperatively, sonography was performed at 3 months, and magnetic resonance imaging was performed at 6 and 12 months to confirm the integrity of the graft tissue.

Statistical Analysis

All statistical analyses were performed using SPSS Version 21.0 (IBM Corp). The independent t test was used to analyze continuous variables between the 2 groups. Categorical variables were analyzed using the chi-square test. All analyses were performed using 95% CIs. The level of statistical significance was defined as $P < .05$.

RESULTS

In this study, we performed ASCR on 48 shoulders (44 patients). In total, 2 patients without clinical and radiologic follow-up were excluded. Finally, 46 shoulders of 42 patients who underwent ASCR were included. The mean ± SD age of all patients was 61.0 ± 6.2 years. The minimum follow-up period was 2 years, and the mean follow-up period was 31.2 ± 6.5 months (range, 25-60 months). The no-retear and retear groups included 30 and 16 shoulders, respectively.

The overall incidence of retear was 35% (16/46). Age, sex, body mass index, underlying disease, smoking, osteoporosis, symptom duration, initial VAS score, previous surgery, and clinical score were analyzed as preoperative factors, and there was no difference between the 2 groups. Retear occurred in 10 (33%) of 30 shoulders that received an autograft and in 6 (38%) of 16 shoulders that received an allograft. No statistical difference was found according to graft material and graft thickness (Table 1).

No statistical difference in preoperative radiologic data was found in terms of AHD, torn tendon involvement, and Hamada grade. However, the preoperative Goutallier grade of the subscapularis differed: 1.5 ± 1.1 in the no-retear group and 2.5 ± 1.3 in retear group ($P = .016$) (Table 2).

Both groups showed significant improvement in VAS, ASES, and Constant scores after ASCR. In the no-retear group, the preoperative mean VAS score of 5.8 ± 1.1

TABLE 1
Preoperative Descriptive Data[a]

	No Retear (n = 30)	Retear (n = 16)	*P* Value
Age, y	60.2 ± 6.6	62.1 ± 4.0	.293
Sex, male:female, n	18:12	12:4	.352
Follow-up, mo	32.0 ± 7.7	30.1 ± 5.2	.296
Body mass index	25.1 ± 1.9	24.5 ± 2.6	.387
Duration of preoperative symptoms, mo	20.1 ± 13.4	15.8 ± 10.3	.263
Initial visual analog scale score	5.8 ± 1.1	5.5 ± 1.1	.411
Previous arthroscopic rotator cuff repair, n	10	2	.170
Range of motion, deg			
Forward elevation	108.3 ± 22.9	105.0 ± 26.5	.659
External rotation	41.3 ± 10.1	39.3 ± 11.0	.550
Internal rotation	10.3 ± 2.9	10.7 ± 3.2	.690
ASES score	51.9 ± 9.8	53.5 ± 8.7	.597
Constant score	56.2 ± 7.7	59.8 ± 10.6	.194
Graft type, autograft:allograft, n	20:10	10:6	≥.999
Graft thickness, mm	5.7 ± 1.5	5.6 ± 1.5	.893

[a]Data are reported as mean ± SD unless otherwise indicated. ASES, American Shoulder and Elbow Surgeons.

TABLE 2
Preoperative Radiologic Data[a]

	No Retear	Retear	*P* Value
Preoperative acromiohumeral distance, mm	5.0 ± 2.2	3.9 ± 1.5	.083
Torn tendon involvement, No. of patients			.781
Supraspinatus tear only	4	2	
Supraspinatus tear and infraspinatus tears	7	4	
Supraspinatus tear and subscapularis tears	1	2	
All 3 tendons	18	8	
Preoperative Goutallier grade			
Supraspinatus	3.2 ± 0.8	3.3 ± 0.8	.847
Infraspinatus	2.0 ± 1.0	2.1 ± 0.8	.861
Subscapularis	1.5 ± 1.1	2.5 ± 1.3	.016
Teres minor	1.7 ± 1.4	2.2 ± 1.3	.236
Hamada classification, No. of patients			.209
Grade 1	10	3	
Grade 2	12	7	
Grade 3	7	4	
Grade 4	1	2	
Grade 5	0	0	

[a]Data are reported as mean ± SD unless otherwise indicated.

TABLE 3
Surgical Results According to Retear[a]

	No Retear	Retear	*P* Value
Last visual analog scale score	1.1 ± 1.4	3.5 ± 2.3	.002
Range of motion, deg			
Forward elevation	153.6 ± 29.7	118.7 ± 39.3	.035
External rotation	52.5 ± 15.8	47.1 ± 17.4	.363
Internal rotation	9.8 ± 4.5	9.5 ± 4.1	.704
ASES score	84.8 ± 4.3	74.0 ± 5.0	.021
Constant score	83.0 ± 3.9	73.1 ± 7.5	.036
Last acromiohumeral distance, mm	8.9 ± 1.9	6.3 ± 2.4	.003

[a]Data are reported as mean ± SD. ASES, American Shoulder and Elbow Surgeons.

improved to 1.1 ± 1.4 ($P < .000$) at the last follow-up, the preoperative ASES score of 51.9 ± 9.8 improved to 84.8 ± 4.3 ($P < .001$), and the preoperative Constant score of 56.2 ± 7.7 improved to 83.0 ± 3.9 ($P < .001$). The no-retear group also had significant improvement in forward flexion postoperatively. In the retear group, the preoperative mean VAS score of 5.5 ± 1.1 improved to 3.5 ± 2.3 ($P = .003$), the preoperative ASES score of 53.5 ± 8.7 improved to 74.0 ± 5.0 ($P < .001$), and the preoperative Constant score of 59.8 ± 10.6 improved to 73.1 ± 7.5 ($P < .001$). However, in the retear group, no statistical difference was found in ROM. Furthermore, at the last follow-up, a statistical difference was noted in forward flexion and clinical scores, with the patients in the no-retear group having better outcomes than those of the retear group (Table 3).

Retear was found at a mean of 7.8 months postoperatively. Location of the retear was at the lateral humeral suture site in 10 patients, at the medial glenoid site in 2 patients, in the midsubstance in 3 patients, and at both sites (medial and lateral sites) in 1 patient (Appendix Figures A1 and A2).

The mean time to retear was 5.8 months at the lateral site, 7.5 months at the medial site, and 15.3 months in the midsubstance. Retear occurred at a mean of 9.9 months in the patients who received autograft and 4.3 months in the patients who received allograft. The time to retear was significantly earlier in the patients who received allograft ($P = .031$). Of the 16 patients with retear, 3 patients had pseudoparalysis, and 9 patients had an ASES score of 70 or less. Of these patients, 1 patient had less pain than before surgery and wanted nonoperative treatment. Finally, reoperation was performed in 8 (50%) of 16 patients with retear. All 8 patients who underwent reoperation had lateral site tears. In 3 patients, complete repair was possible using remnant graft. In 3 patients, partial repair was performed using remnant graft. There were 2 patients who underwent revision ASCR using allograft after removal of the remnant graft tissue. Patient 12 showed rerupture, and rapid destructive arthropathy of the humeral head occurred with pseudoparalysis within 3 months after reoperation. Subsequently, reverse total shoulder arthroplasty was performed (Table 4). No other complications, such as infection or nerve injury, were seen in any patients.

DISCUSSION

Overall, our study showed clinically good results after superior capsular reconstruction. However, retear was found in

TABLE 4
Summary of Failed Superior Capsular Reconstruction[a]

Patient	Sex	Age, y	Torn Tendon	Previous ASCR	Graft Type	Hamada Grade	Months to Retear	Retear Site	Revision
1	Male	58	SS, IS, SSC	Revision	Auto	3	6	Lat	Nonoperative treatment
2	Male	62	SS, SSC	Primary	Auto	2	24	Midsub	Nonoperative treatment
3	Male	61	SS, IS, SSC	Primary	Auto	2	7	Lat	Remnant repair
4	Male	58	SS, IS	Primary	Auto	1	9	Lat	Remnant repair
5	Male	66	SS, IS	Primary	Auto	3	3	Lat	Remnant repair
6	Male	59	SS, IS, SSC	Primary	Auto	2	11	Lat	Remnant repair
7	Female	66	SS, IS, SSC	Revision	Auto	2	12	Midsub	Nonoperative treatment
8	Female	60	SS, SSC	Primary	Allo	1	10	Midsub	Nonoperative treatment
9	Male	59	SS, IS	Primary	Auto	2	12	Med	Nonoperative treatment
10	Male	68	SS, IS, SSC	Primary	Auto	4	12	Lat	Nonoperative treatment
11	Male	66	SS	Primary	Allo	1	6	Med, lat	Remnant repair
12	Female	69	SS	Primary	Allo	2	1	Lat	Remnant repair (second op), reverse TSA (third op)
13	Male	66	SS, IS, SSC	Primary	Auto	3	3	Lat	Allograft conversion
14	Male	56	SS, IS	Primary	Allo	2	3	Lat	Nonoperative treatment
15	Male	61	SS, IS, SSC	Primary	Allo	4	3	Lat	Allograft conversion
16	Female	60	SS, IS, SSC	Primary	Allo	3	3	Med	Nonoperative treatment

[a]Allo, allograft; ASCR, arthroscopic superior capsular reconstruction; Auto, autograft; IS, infraspinatus; Lat, lateral; Med, medial; Midsub, midsubstance; Op, operation; SS, supraspinatus; SSC, subscapularis; TSA, total shoulder arthroplasty.

35% of the patients, 50% of whom had reoperation. Retear occurred mainly on the lateral side, and all reoperations were performed in patients who had lateral side tear. Although the difference in the frequency of retear of allograft and autograft was not statistically significant, allograft retear occurred more frequently after surgery.

Mihata et al[19] first introduced ASCR using a fascia lata autograft for massive, irreparable rotator cuff tears. Those investigators had an 83.3% healing rate and reported an effective improvement in AHD as well as clinical outcome. In a recent paper, Mihata et al[18] reported graft failure in 3 of 30 patients who had been observed for 5 years. The investigators concluded that healed ASCR restored shoulder function and resulted in high rates of return to recreational sports and work in a 5-year follow-up study. Burkhart and Hartzler[3] reported functional recovery in 90% of patients with pseudoparalysis. Those investigators reported that ASCR was a valid joint-preserving option for improving function with a low rate of complications. Similar to a previous study,[14] the present study showed statistically improved postoperative ROM and clinical scores in the no-retear group ($P < .001$). Furthermore, the results of the no-retear group were statistically better than those of the retear group. However, the retear group also showed statistically improved postoperative clinical scores compared with the preoperative scores. We performed acromioplasty and tuberoplasty during ASCR, and we also tried to repair the grafts to the remnant cuff tissue. We posit that the postoperative functional improvement in the retear group resulted from the tuberoplasty and improved fulcrum kinematics. Lim et al[15] reported that 29% of their total sample had graft tears, and there were no clinical differences between an intact group and a retear group that consisted mostly of medial (glenoid side) tears. This stands in contrast to the retear group of our study, which mostly consisted of lateral tears. The poor results with the lateral retear group in our study were similar to results reported by Mirzayan et al,[22] who showed that the tuberoplasty effect could be an important postoperative functional factor. This could explain the worse results and the high need for reoperation in our patients who had retear on the lateral side. Our single-row fixation of the lateral side, different from the techniques used by Mihata et al[19] and other authors described above, could be the reason why retear occurred mainly on the lateral side in our patients. Our results showed that the lateral side tears were more common after single-row fixation of the humeral side and that the clinical results were relatively better in patients with medial side tears than in patients with lateral side retears. Especially, preoperative subscapularis atrophy and postoperative lateral side tear were associated with relatively poor outcomes in the retear group.

To our knowledge, there are few reports about complications of ASCR. A systematic review[9] described 8 studies (186 patients) that reported complications. Overall, 25 patients (13.4%) had complications, with graft rupture being the most common (3.8%); 8 patients (4.3%) required revision surgery. In our study, the overall incidence of retear was 35% (16/46). We noted no complications, such as infection, glenoid fracture, or nerve damage, but there was 1 case of rapid destructive arthropathy. The affected shoulder was in the dominant arm of an elderly woman. Further research should be conducted to determine whether revision ASCR in the dominant shoulder of elderly women could be a potential risk factor for this complication.[13] In our study, similar to other studies,[3,4,18,19] ROM and clinical outcomes were poorer in the retear group than in the no-retear group. Revision surgery was needed in 8 of

16 patients with retear. In particular, all 8 patients who underwent revision surgery had lateral insertion tears. In 6 patients, remnant repair was possible using graft. Partial graft repairs were performed because of graft retraction at 16 months (patient 3) and 8 months (patient 4) after retear. Long-term follow-up may be needed after revision surgery, but reverse total shoulder arthroplasty was not considered a revision option because patients were relatively young at the time of revision. Furthermore, the 2 patients with postoperative retear did not want to undergo revision reverse total shoulder arthroplasty because they were satisfied with their postoperative clinical scores, which were better than their preoperative scores.

Mihata et al[19] mentioned that the mean Goutallier grades of the subscapularis tendon were different between a healed group (grade 1.6) and an unhealed group (grade 4). In our study, no statistical difference in preoperative radiologic data was found in terms of the preoperative AHD, torn tendon involvement, and Hamada classification, regardless of retear. However, a statistically significant difference was observed in the preoperative Goutallier grade of the subscapularis. The subscapularis tendon is important for providing a stable fulcrum for glenohumeral motion and for preserving rotator cuff balance.[6] Park et al[24] showed a trend toward a high failure rate for the repair of massive posterosuperior rotator cuff tears extending over half of the subscapularis tendon. Although more patients will need to be evaluated, our results revealed that subscapularis function may be important in ASCR, and fixation and restoration of the subscapularis function must be considered to maintain rotator cuff balance.

In this study, no difference was found between autograft and allograft in terms of the retear rate. However, retear occurred at a mean of 9.9 months in patients who received autograft and 4.3 months in patients who received allograft ($P = .031$). Early failure occurred in the patients who received allograft. A recent systematic study[26] comparing allograft and autograft noted that both types of graft resulted in clinical improvement at a minimum 12-month follow-up. Autogenous fascia lata has been known to be a stiff and strong graft material; however, the ultimate load to failure of the fascia lata has been reported to vary according to the shape of the fascia lata and direction of the stress applied. Thomas et al[28] found that the strength of a fascia lata graft significantly increased when it was converted from a sheet to a tube. In addition, Pancheri et al[23] noted that because the fascia lata is orthogonally oriented, it is strong with longitudinal stress but weak with transverse stress. The midterm failure of our autogenous fascia lata graft could result from the relative weakness in the pangraft (sheet type), despite the high potential of the early host tissue-graft incorporation.

Conversely, Hirahara et al[11] found signs of vascular regeneration on dermal allograft with a minimum time of 4 months and a maximum of 9 months after surgery. In another study, the density of the microvessels in the acellular dermal matrix after 3 months and the remodeling-associated molecules showed peak expression at 3 to 6 months after implantation.[22] Lubowitz et al[16] mentioned that acellular human dermal allograft is a biological scaffold but biomechanical properties may be weak at 4.5 months after surgery, a factor that should be considered during rehabilitation.[16] Another study reported on mechanical strength of allografts.[2] However, compared with autografts, allografts must survive in the early stages postoperatively when revascularization is relatively slow. We could hypothesize that long-term results could be improved if the early retear stage could be avoided when using allograft; however, long-term follow-up is needed.

This study has some limitations. First, this was a retrospective study; however, this study enrolled all consecutive patients treated by a single surgeon in 1 hospital. Second, we collected data prospectively. A prospective study with additional randomization according to graft material should be conducted in the future. Third, the number of patients was relatively small. This limitation makes it difficult to analyze various factors that affect retear. Fourth, the follow-up period was relatively short. Retear is usually found within 1 year, but some patients experience retear after 2 years; therefore, longer follow-up is needed, especially for patients who undergo reoperation. Fifth, the critical shoulder angle is known to be a risk factor for cuff tear and for cuff retear after repair. Although we did not check the critical shoulder angle in our study, it could be included as a possible predictor in future studies.

CONCLUSION

In this study, we investigated the retear rate for patients who underwent ASCR, and we analyzed the clinical outcomes of treatments. Patients with a healed ASCR had better motion and outcome scores than those with a retear. However, the clinical outcomes of patients with preoperative subscapularis atrophy and postoperative lateral side retear were worse and often were related to reoperation in the retear group. Therefore, it is important that the lateral side is firmly fixed during the ASCR procedure.

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APPENDIX

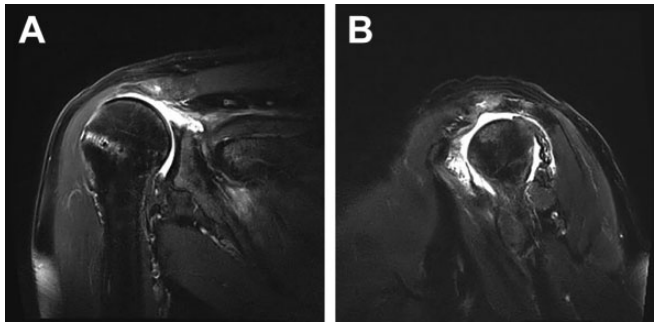

Figure A1. Patient 11: Magnetic resonance images at 6 months after superior capsular reconstruction. (A) Retear on the lateral side after superior capsule reconstruction using allograft. (B) Sagittal magnetic resonance image: posterior migration of allograft after retear.

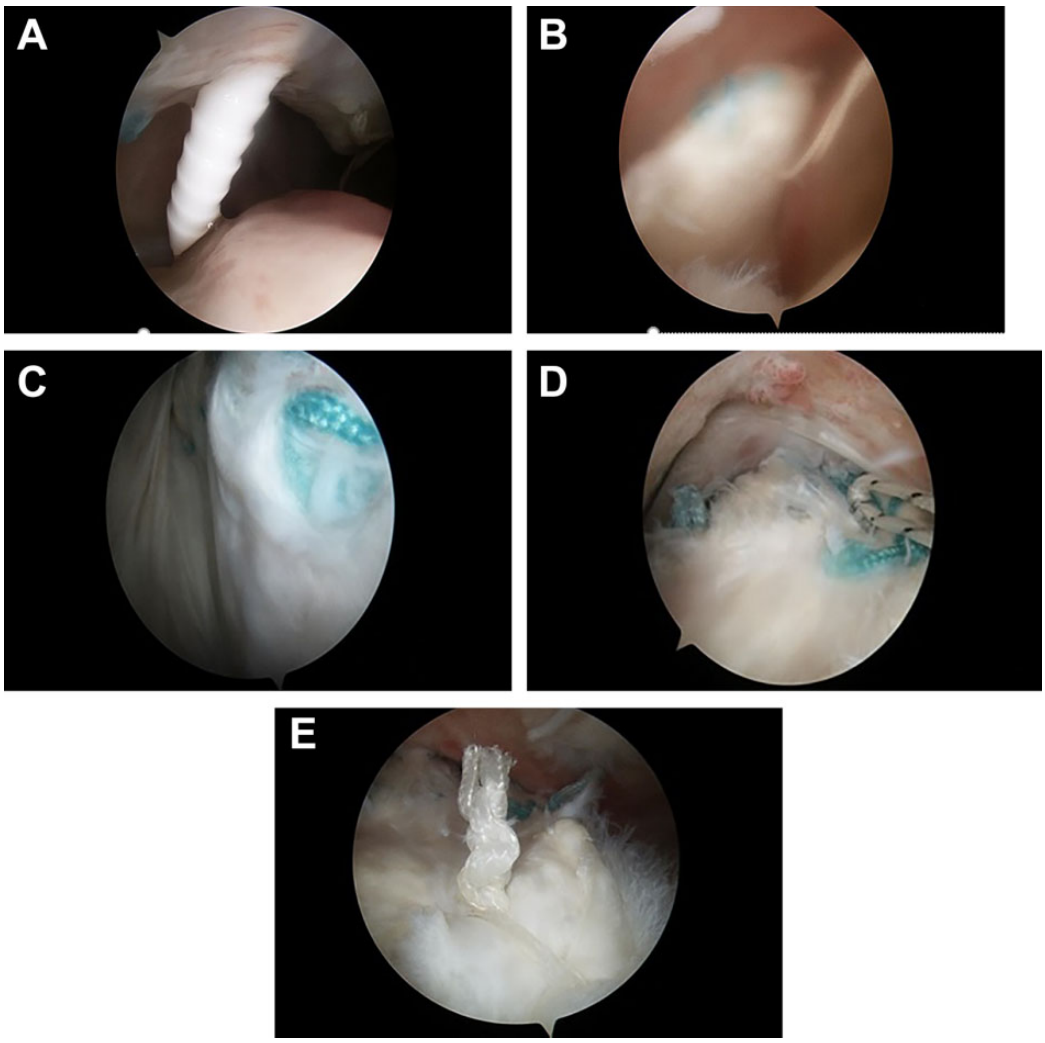

Figure A2. Patient 11: Arthroscopic images at revision operation. (A) Migration of the medial anchor. (B) Anterolateral retear of the superior capsule reconstruction allograft. (C) Healing state between the posterior remnant tissue and superior capsule reconstruction. (D) Repair of the medial side. (E) Repair of the lateral side.