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Clinical outcomes of arthroscopic superior capsule reconstruction in patients aged over 70 with irreparable rotator cuff tears

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Background: Arthroscopic superior capsule reconstruction (SCR) was developed to restore superior shoulder stability, muscle balance, and function after irreparable posterior-superior rotator cuff tears. The purpose of this study was to investigate whether favorable clinical outcomes after SCR for irreparable rotator cuff tears would be obtained in patients aged more than 70 years.
Methods: A total of 173 consecutive shoulders in 162 patients who underwent arthroscopic SCR using autografts of fascia lata for irreparable rotator cuff tears were allocated to 3 groups according to patient age at the time of surgery: Group 1, <55 years old (11 shoulders); Group 2, 55-70 years old (85 shoulders); and Group 3, > 70 years old (77 shoulders). American Shoulder and Elbow Surgeons and Japanese Orthopaedic Association scores, active shoulder range of motion, and visual analog scale were evaluated before surgery and at the final follow-up. Postoperative complications, including graft tears in magnetic resonance imaging and donor-site morbidity, were assessed.
Results: The mean follow-up was 3 years and 9 months. Both American Shoulder and Elbow Surgeons and Japanese Orthopaedic Association scores and active range of motion (elevation, external rotation, and internal rotation) increased significantly after arthroscopic SCR in all 3 groups ($P < .001$), and visual analog scale decreased significantly. All 3 groups had low graft tear (6%-10%) and donor site morbidity (0%-1%) rates, with no significant difference among the groups.
Conclusion: Arthroscopic SCR can lead to functional improvement and pain relief with a low rate of complications regardless of patient age.

Since we developed superior capsule reconstruction (SCR) as a joint-preserving shoulder surgery for patients with irreparable rotator cuff tears in 2007, many clinical studies have shown that SCR provides pain relief and functional improvement.[3,5,7,14-17] Biomechanical studies demonstrated that SCR improves superior glenohumeral stability by fixing the graft on both the glenoid and the greater tuberosity and restores force coupling in the glenohumeral joint by adding side-to-side suturing between the posterior rotator cuff (infraspinatus or teres minor) and the graft.[10-13] These biomechanical effects result in improved shoulder function and decreased shoulder pain in patients with irreparable rotator cuff tears.[14-17] Therefore, graft healing is key to restoring shoulder stability and function after SCR,[8] although shoulder pain decrease even in graft tear patients.

Recently, SCR was recommended for younger and still active patients with irreparable rotator cuff tears, and reverse shoulder arthroplasty is widely used in older patients. However, even in the elderly population, SCR can be expected to improve shoulder function with a low complication rate because it is less invasive than reverse shoulder arthroplasty. The purpose of this study was to investigate whether favorable clinical outcomes after SCR for irreparable rotator cuff tears would be obtained in patients aged more than 70 years.

Materials and methods

We retrospectively reviewed our database of irreparable rotator cuff tears, which was collected prospectively. From 2007 through 2016, arthroscopic SCR (Fig. 1) was performed on 181 consecutive shoulders in 170 patients with irreparable posterior-superior rotator cuff tears refractory to conservative treatment. A rotator cuff tear was defined as irreparable when the torn rotator

This study was approved by the Institutional Review Board of Osaka Medical and Pharmaceutical University (Approval No. 1854).

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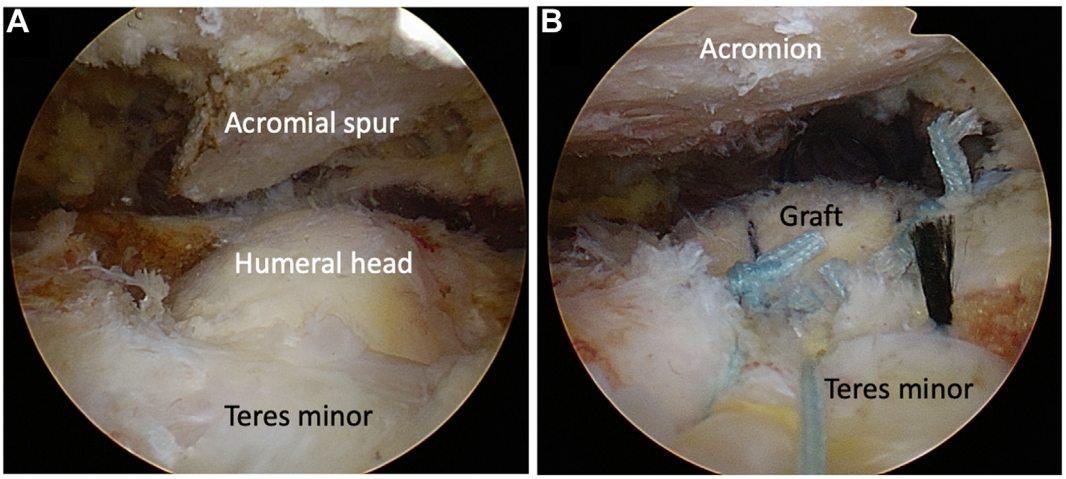

Figure 1 Arthroscopic findings before and after superior capsule reconstruction. (**A**) Posterior view before surgery. (**B**) Posterior view just after surgery.

cuff tendons could not be made to completely cover the original footprint on the greater tuberosity at 30° of shoulder abduction during arthroscopic surgery. The inclusion criterion for this study was an irreparable rotator cuff tear that had been followed for at least 2 years after SCR. Eight patients were lost to follow-up. The remaining 162 patients were allocated to 3 groups according to patient age at the time of surgery: Group 1, <55 years old; Group 2, 55-70 years old; and Group 3, >70 years old. The age cut-offs were defined based on clinical significance. Patients aged more than 70 years with irreparable rotator cuff tears are thought to be a good indication of reverse shoulder arthroplasty. Therefore, I assessed clinical outcomes of SCR in patients aged more than 70 years. The stage of preoperative cuff tear arthropathy was classified by using the Hamada grade.[2] We also evaluated fatty degeneration of the rotator cuff muscles with preoperative magnetic resonance imaging (MRI) by using the grading system of Goutallier et al.[1] Biceps pathology was evaluated arthroscopically. The mean time to final follow-up was 3 years and 9 months (range, 2-12 years). This study was approved by the Institutional Review Board of our university (Osaka Medical and Pharmaceutical University, Approval No. 1854).

Superior capsule reconstruction

The defect size of the superior shoulder capsule and rotator cuff tears was evaluated with a measuring probe at 30° of shoulder abduction. The correct graft size was determined from the defect size. The graft length in the anterior-posterior direction was exactly the same as the length of the defect without partial repair of the torn infraspinatus tendon. The graft length in the medial-lateral direction was 15 mm more than the length from the superior edge of the glenoid to the lateral edge of the greater tuberosity.

The fascia lata and intermuscular septum, which consists of the tissues of 2 tendons of the gluteus maximus and tensor fasciae lata, were harvested from the proximal lateral thigh. The optimal graft thickness was 6-8 mm, as determined by a biomechanical study[8,11]; we achieved this thickness by folding the fascia lata and interposing intermuscular septum between the 2 layers of fascia lata.

Two 4.5-mm suture anchors (Corkscrew Suture Anchor, Arthrex) were inserted into the superior glenoid at the positions of 10-12 o'clock and 12-1 o'clock on the glenoid of the right shoulder (or 11-12 o'clock and 12-2 o'clock on the glenoid of the left shoulder). The graft, which was inserted into the subacromial space

Table I
Preoperative patient characterization.

	Group 1: <55 years old (n = 11)	Group 2: 55-70 years old (n = 85)	Group 3: >70 years old (n = 77)	*P** (Group 1 vs. Group 2 vs. Group 3)
Torn tendons (no. of patients)				.52
2 tendons: SSP and ISP	8	53	55	
3 tendons: SSP, ISP, and SubS	0	27	17	
3 tendons: SSP, ISP, and Tm	3	5	4	
4 tendons: SSP, ISP, SubS, and Tm	0	0	1	
Goutallier classification of supraspinatus (no. of patients)				.98
Grade 1	0	0	0	
Grade 2	1	6	4	
Grade 3	3	22	20	
Grade 4	7	57	53	
Hamada grade (no. of patients)				.41
Grade 1	3	13	17	
Grade 2	7	50	31	
Grade 3	1	20	26	
Grade 4A	0	1	2	
Grade 4B	0	1	1	
Grade 5	0	0	0	

SSP, supraspinatus; *ISP*, infraspinatus; *SubS*, subscapularis; *Tm*, teres minor.
*One-way analysis of variance.

Table II
Graft thickness for superior capsule reconstruction.

	Group 1: <55 years old (n = 11)	Group 2: 55-70 years old (n = 85)	Group 3: >70 years old (n = 77)	*P** (Group 1 vs. Group 2 vs. Group 3)
Glenoid side	5.5 (2.6)	6.0 (2.4)	6.0 (2.0)	.73
Greater tuberosity side	6.2 (2.3)	7.1 (2.5)	7.2 (2.2)	.39

Values are given as means, with standard deviations in parentheses.
*One-way analysis of variance.

through the lateral portal, was fixed medially by using No. 2 nonabsorbable sutures from the 2 suture anchors on the superior glenoid. Laterally, the graft was attached to the rotator cuff footprint on the greater tuberosity at 30° of shoulder abduction by using the compression double-row technique (4 4.5-mm suture anchors: Corkscrew Suture Anchor; Arthrex, Naples, FL, USA),[9,18] which is a combination of the conventional double-row technique and the suture bridge, or the SpeedBridge (Arthrex, Naples, FL, USA) transosseous-equivalent technique (4 4.75-mm knotless suture anchors). Finally, 2 or 3 side-to-side sutures with No. 2 nonabsorbable sutures were added between the graft and the infraspinatus or teres minor tendon to improve force coupling in the shoulder joint.

Reparable subscapularis tears were repaired arthroscopically by using a single-row or double-row technique with 4.5-mm suture anchors. In cases of irreparable subscapularis tear, only SCR was performed, without any surgical treatment of the subscapularis in this series, although patients with irreparable subscapularis tear have higher graft tear rate.[15]

Postoperative protocol

For the first 4 weeks after surgery, the shoulder was immobilized by using an abduction sling (Block Shoulder Abduction Sling; Nagano Prosthetics and Orthotics, Osaka Japan). Five weeks after surgery, passive and active assisted exercises were initiated to promote elevation in the scapular plane. Muscle strengthening was begun 8 weeks postoperatively. Physical therapists assisted all patients. Most patients can walk the day after SCR. Running can be allowed at 3 months after SCR, and most patients can return to sports and physical work without thigh pain at 6-12 months.

Clinical and radiological outcome assessment

Active shoulder range of motion (ROM) measurement, muscle strength measurement, functional assessment, radiography, and MRI were performed before surgery and at the final follow-up after SCR surgery. Shoulder ROM and muscle strength were evaluated by physical therapists. Shoulder function was assessed by using the American Shoulder and Elbow Surgeons score (ASES, a 100-point scoring system) and Japanese Orthopaedic Association score (JOA, a 100-point scoring system). Shoulder pain was evaluated by using the visual analog scale (VAS) score. Postoperative complications, including graft tears in MRI and donor-site morbidity (thigh pain) based on patients' complaint after surgery, were recorded. Graft tear was assessed using T2-weighted MRI (1.5-T or 3.0-T closed-type scanner) in all patients at the final follow-up.

Statistical analysis

One-way analysis of variance followed by Tukey's post-hoc test was performed to compare all data among the 3 groups. Also, all data were compared between before surgery and at the final follow-up by using the paired *t*-test. The Goutallier grade, Hamada grade, and complication rate (graft tear and infection) were compared among the 3 groups by using a chi-squared test. Data are shown as means ± standard deviation of the mean. A significant difference was defined as $P < .05$.

Results

The number of shoulders was 11 in Group 1 (<55 years old), 85 in Group 2 (55-70 years old), and 77 in Group 2 (>70 years old).

Comparison of severity of rotator cuff tear, graft size, and additional treatments

Preoperative findings: There were no significant differences among the 3 groups in the number of torn tendons ($P = .52$); the Goutallier grades of the supraspinatus muscle ($P = .98$), infraspinatus muscle ($P = .08$), subscapularis ($P = .30$), and teres minor muscle ($P = .90$); or in the Hamada grades ($P = .41$) (Table I).

Intraoperative findings: Graft thickness on the glenoid ($P = .73$) and on the greater tuberosity ($P = .39$) also did not differ significantly among the 3 groups (Table II). The rate of biceps pathology was 82% (9/11) in Group 1, 68% (58/85) in Group 2, and 78% (60/77) in Group 3. Biceps tenodesis or tenotomy was performed in 7% of Group 2 and 9% of Group 3. There was no significant difference in the rate of biceps pathology ($P = .65$) or biceps treatment ($P = .88$) among the 3 groups. Acromioplasty was performed in all patients (Table III).

Table III
Intraoperative findings and treatments.

	Group 1: <55 years old (n = 11)	Group 2: 55-70 years old (n = 85)	Group 3: >70 years old (n = 77)	*P** (Group 1 vs. Group 2 vs. Group 3)
Biceps pathology (no. of patients)				.65
Intact (no treatment)	2	27	17	
Partial tear (no treatment)	6	36	33	
Complete tear (no treatment)	3	16	20	
Dislocated biceps	0	6	7	
Treatment of biceps				.88
No treatment	11	79	70	
Tenodesis	0	5	6	
Tenotomy	0	1	1	
Acromioplasty	11	85	77	

*One-way analysis of variance.

Table IV
Visual analog scale and functional scores.

	Group 1: <55 years old (n = 11)	Group 2: 55-70 years old (n = 85)	Group 3: >70 years old (n = 77)	P* (Group 1 vs. Group 2 vs. Group 3)
VAS				
Preoperative	5.6 ± 3.0	6.1 ± 2.2	6.3 ± 2.2	.59
Postoperative	0.1 ± 0.3	0.5 ± 1.2	0.7 ± 1.6	.25
P* (preoperative vs. postoperative)	<.001	<.001	<.001	
ASES score				
Preoperative	36 ± 13	36 ± 19	35 ± 17	.94
Postoperative	96 ± 6	95 ± 8	90 ± 13†	.004
P* (preoperative vs. postoperative)	<.001	<.001	.003	
JOA score				
Preoperative	49 ± 12	51 ± 14	52 ± 12	.77
Postoperative	95 ± 7	94 ± 8	90 ± 12†	.02
P* (preoperative vs. postoperative)	<.001	<.001	.003	

VAS, Visual Analog Scale; *ASES*, American Shoulder and Elbow Surgeons; *JOA*, Japanese Orthopaedic Association. Values are given as means and standard deviations.
*Paired *t*-test.
†Significantly smaller than in Group 2 ($P < .05$), one-way analysis of variance with Tukey's post-hoc test.

VAS and functional scores

VAS decreased significantly after SCR in all 3 groups ($P < .001$) (Table IV). There was no significant difference in preoperative ($P = .59$) and postoperative ($P = .25$) VAS among the 3 groups. There were no significant differences in the preoperative ASES ($P = .94$) and JOA ($P = .77$) scores among the 3 groups. Both the ASES scores and the JOA scores improved significantly after arthroscopic SCR in all 3 groups (all $P < .01$). Postoperatively, the ASES score in Group 3 was 90 ± 13 and the JOA score was 90 ± 12; these values were each significantly lower than the respective values in Group 2 (ASES, 95 ± 8, $P = .004$; JOA, 94 ± 8, $P = .02$) (Table IV).

Active shoulder range of motion

There were no significant differences in the preoperative ranges of active elevation ($P = .14$), active external rotation ($P = .67$), or active internal rotation ($P = .10$) among the 3 groups. SCR significantly improved the ranges of active elevation, active external rotation, and active internal rotation in all 3 groups ($P < .05$) (Table V). Postoperative active elevation and active internal rotation were significantly lower in Group 3 than in Group 2 ($P < .05$) (Table V).

Complications

The graft tear rate in each group was 9% (1/11 patients) in Group 1, 6% (5/85 patients) in Group 2, and 10% (8/77 patients) in Group 3 (Table VI). One patient in Group 3 had discomfort in the gluteus maximus muscle at the harvest site 1 year after surgery and underwent repair of the gluteus maximus. No patients had pain at the graft harvest site at final follow-up. One patient in Group 2 with worker's compensation complained of thigh pain; however, after termination of his follow-up for worker's compensation, he no longer complained of any pain. Seven patients in Groups 2 and 3 had postoperative infection with *Cutibacterium acnes*. All infections were healed by arthroscopic débridement and removal of some sutures or anchors without removal of the graft. There was no significant difference in the complication rate among the 3 groups.

Table V
Active shoulder ranges of motion.

	Group 1: <55 years old (n = 11)	Group 2: 55-70 year old (n = 85)	Group 3: >70 years old (n = 77)	P* (Group 1 vs. Group 2 vs. Group 3)
Active elevation				
Preoperative	61° ± 53°	92° ± 56°	96° ± 52°	.14
Postoperative	161° ± 21°	160° ± 22°	149° ± 31†	.02
P* (preoperative vs. postoperative)	<.0001	<.0001	<.0001	
Active external rotation				
Preoperative	20° ± 22°	26° ± 21°	24° ± 21°	.67
Postoperative	48° ± 18°	44° ± 19°	39° ± 15°	.10
P* (preoperative vs. postoperative)	.002	<.0001	<.0001	
Active internal rotation				
Preoperative	L3	L4	L5	.10
Postoperative	L1	L1	L2†	.003
P* (preoperative vs. postoperative)	.04	<.0001	<.0001	

Values are given as means and standard deviations.
*Paired *t*-test.
†Significantly smaller than Group 2 ($P < .05$), one-way analysis of variance with Tukey's post-hoc test.

Table VI
Complications.

	Group 1: <55 years old (n = 11)	Group 2: 55-70 years old (n = 85)	Group 3: >70 years old (n = 77)	*P** (Group 1 vs. Group 2 vs. Group 3)
Graft tear	1 (9%)	5 (6%)	8 (10%)	.57
Donor-site morbidity	0	1 (1%)	1 (1%)	.93
Infection	0	1 (1%)	6 (8%)	.34

Values are given as no. of patients, with rate in parentheses.
*One-way analysis of variance.

Discussion

The VAS, ASES, and JOA scores and active shoulder ROM were all significantly improved after SCR in all 3 groups. Furthermore, there was no significant difference in complication rate among the 3 groups. These results suggest that, even in patients aged more than 70 years, SCR can improve shoulder function and provide pain relief with a low rate of complications.

Although the postoperative ASES and JOA scores and active shoulder elevation and internal rotation in Group 3 were significantly lower than those in Group 2, the average postoperative ASES and JOA scores were 90 points each in Group 3, and postoperative elevation was 149°. Therefore, even in patients aged more than 70 years with irreparable rotator cuff tears, we can expect to obtain acceptable shoulder function after SCR.

The graft tear rate was relatively low in all 3 groups and was not significantly different among the 3 groups. This result suggests that the healing response is similar in young patients and patients aged more than 70 years when a fascia lata autograft is used for SCR. Previous clinical reports showed that healed patients had better shoulder function after SCR.[3,8,16] Therefore, functional improvement in patients aged more than 70 years probably resulted from a high graft healing rate in this study.

Donor-site morbidity is a possible complication of SCR using a fascia lata autograft. The present study showed that donor-site morbidity was only 1% in Groups 2 and 3, probably because the gluteal muscles were securely repaired after the fascia lata and intermuscular septum were harvested. Repairing gluteal muscles can eliminate dead space under the skin and prevent postoperative hematoma. Most patients can walk the day after SCR, and most thigh pain is gone within 1 month after SCR. Running can be allowed at 3 months after SCR, and most patients can return to sports and physical work without thigh pain at 6-12 months. Thus, by the time shoulder function is recovered, there should be no pain from harvesting the fascia lata. Therefore, shoulder surgeons should not worry too much about donor-site morbidity after harvesting the fascia lata.

The surgical indication for most graft materials for SCR, including dermal allograft[5,6] and biceps long head tendon,[7] is Hamada grade 1 or 2. In the present study, excellent shoulder function was obtained after SCR using a fascia lata autograft even in Hamada grade 3 or 4, which is a specific advantage of autografting fascia lata. Furthermore, fascia lata autograft has a higher rate of graft healing than dermal allograft.[5,6] Therefore, SCR using a fascia lata autograft is strongly recommended for the treatment of irreparable rotator cuff tears regardless of the patient's age, especially when the patient requires functional improvement with pain relief.

In all age groups, patients with irreparable rotator cuff tears had a high rate of biceps pathology (82% in Group 1, 68% in Group 2, and 78% in Group 3). However, shoulder pain was relieved in most patients after SCR without any treatment of the biceps pathology. This result suggests that biceps does not generate shoulder pain after rotator cuff tears are treated with SCR. Recently, SCR using the biceps tendon, also known as biceps rerouting, has been performed for irreparable rotator cuff tears.[4,7] Although this surgery dislocates the biceps to make for the SCR, shoulder pain is reported to be decreased. A clinical study of biceps rerouting also suggests that the biceps itself might not cause shoulder pain.[4,7]

Our study has limitations. First, the sample size in Group 1 was small. Second, the graft thickness in some patients was lower than the biomechanically recommended size of 6-8 mm. If a thicker graft was used for SCR, better clinical outcomes might be able to be obtained. Third, clinical outcomes were not compared with patients who underwent reverse shoulder arthroplasty. A strength of this study was the lack of significant differences in the number of torn tendons, the Goutallier grades of the rotator cuff muscles, the Hamada grades, and the biceps pathology and treatment among the 3 groups. Fourth, although definition of irreparable rotator cuff tear is various, our criteria of irreparable rotator cuff tear were "the torn rotator cuff tendons could not be made to completely cover the original footprint on the greater tuberosity at 30° of shoulder abduction during arthroscopic surgery" as previously published.[14,15,17]

Conclusion

Arthroscopic SCR using fascia lata autografts among patients aged more than 70 years significantly increased functional scores, active elevation, and muscle strength with significant pain relief and a low rate of complications. Therefore, arthroscopic SCR can lead to functional improvement and pain relief with a low rate of complications regardless of patient age.

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