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Arthroscopic superior capsule reconstruction with Teflon felt synthetic graft for irreparable massive rotator cuff tears: clinical and radiographic results at minimum 2-year follow-up

Kenji Okamura, MD[a], Masayuki Abe, MD[a], Yuichiro Yamada, MD[a], Takeshi Makihara, MD[a], Takaki Yoshimizu, MD[a], Yoshinari Sakaki, PT[a], Yuki Suzumori, PT[a], Teruhisa Mihata, MD, PhD[b,*]

[a]*Department of Orthopedic Surgery, Hitsujigaoka Hospital, Sapporo, Hokkaido, Japan*
[b]*Department of Orthopedic Surgery, Osaka Medical College, Takatsuki, Osaka, Japan*

Background: Superior capsule reconstruction (SCR) was developed to improve shoulder function and relieve pain in patients with irreparable rotator cuff tears. Here, we investigated the clinical and radiographic outcomes and postoperative complications of SCR using a Teflon graft for reconstruction.

Methods: Thirty-five consecutive patients with irreparable rotator cuff tears underwent SCR with Teflon grafts. The American Shoulder and Elbow Surgeons score, active shoulder elevation, shoulder muscle strength, visual analog scale pain scores, acromiohumeral distance, and postoperative complications were investigated. Data obtained before and after surgery were compared by using a paired *t*-test, χ^2 test, and 1-way analysis of variance, and data from 1-layer-graft SCR (15 patients; mean age, 75.1 years) and 3-layer-graft SCR (20 patients; mean age, 76.6 years) were compared by using an unpaired *t*-test. The average time to final follow-up was 42 months (range, 24-69 months).

Results: SCR using Teflon grafts of either 1 or 3 layers significantly improved the American Shoulder and Elbow Surgeons score (by 20.8, $P = .001$ for a 1-layer graft; and by 31.1, $P < .0001$ for a 3-layer graft), visual analog scale score for motion pain (by 3.2, $P = .001$; and by 3.0, $P < .0001$), and muscle strength in shoulder abduction (by 11.9 N, $P = .02$; and by 10.9 N, $P = .008$). Active elevation at final follow-up was significantly greater in the 3-layer-graft group ($142° \pm 27°$) than in the 1-layer-graft group ($107° \pm 42°$) ($P = .006$). One year after SCR, acromiohumeral distance in the 3-layer-graft group was significantly greater than preoperatively ($P = .04$), whereas in the 1-layer-graft group, it was not. On postoperative magnetic resonance imaging, none of the patients in the 3-layer-graft group had graft tears, whereas 2 patients had graft tears and 1 patient had severe synovitis after 1-layer-graft SCR.

Conclusion: SCR using a Teflon graft—especially a 3-layer graft—significantly improved shoulder function and shoulder abduction strength, with pain relief and a low rate of postoperative complications. SCR using a Teflon graft can be a viable option for irreparable rotator cuff tears, especially when an autograft or allograft is not available.

This study was approved by the institutional review board of Hitsujigaoka Hospital (IRB no. 21).

*Reprint requests: Teruhisa Mihata, MD, PhD, Department of Orthopedic Surgery, Osaka Medical College, 2-7 Daigaku-machi, Takatsuki, Osaka 569-8686, Japan.

E-mail address: tmihata@osaka-med.ac.jp (T. Mihata).

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Superior capsule reconstruction (SCR) was developed to improve shoulder function and provide pain relief in patients with irreparable rotator cuff tears.[9-20] In this technique, a fascia lata autograft[12-20] or a dermal allograft[1,2,6,11] is attached medially to the glenoid superior tubercle and laterally to the greater tuberosity to restore superior shoulder stability without the need to repair tears of the supraspinatus and infraspinatus tendons.[11,17-20] Clinical studies have shown that active elevation, shoulder muscle strength, American Shoulder and Elbow Surgeons (ASES) score, and acromiohumeral distance (AHD) all increase significantly after SCR using a fascia lata autograft or a dermal allograft, although a fascia lata autograft makes higher healing rate than a dermal allograft.[12-15] Recent studies have also shown high rates of return to sports and physical work after SCR using a fascia lata autograft,[12,13] and SCR is a surgical option for young and active patients with irreparable rotator cuff tears.

In some countries, for economic reasons, it is difficult to use reverse shoulder arthroplasty or a dermal allograft for SCR of irreparable rotator cuff tears.[3,8] Moreover, fascia lata harvest for SCR has not been well accepted by surgeons or patients in all countries, although SCR using fascia lata autografts has shown excellent clinical outcomes, with low rates of postoperative complications. Teflon felt has been used for conventional patch graft surgery[23,25,26] (tendon reconstruction for rotator cuff tears), as well as in thoracic and cardiovascular surgery.[5,7,27] Typically, it costs only US$100 per rotator cuff surgery. Although conventional patch graft surgery using a Teflon graft was reported to improve short-term clinical outcomes,[23,25,26] some previous studies showed that conventional patch graft surgery showed a high rate of graft tears,[21,24] which deteriorate shoulder function because of lack of superior stability even after surgery.[20] Therefore, to avoid the need to harvest fascia lata, to minimize costs, and to improve shoulder function, we have developed SCR using a Teflon graft for the treatment of irreparable rotator cuff tears. Here, we investigated the clinical and radiographic outcomes and postoperative complications of SCR using a Teflon graft. Our hypothesis was that this procedure would provide functional improvement with a low rate of postoperative complications in patients with irreparable rotator cuff tears.

Materials and methods

We retrospectively reviewed our database of rotator cuff tears. All patients signed an informed consent form. From 2014 through 2017, a single surgeon (KO) performed 2173 consecutive arthroscopic or open surgeries on shoulders with rotator cuff tears for which conservative treatment had failed. Rotator cuff tear patients with concomitant cervical spine disease were not included in this study. Arthroscopic rotator cuff repair was performed on 2001 of the shoulders. The remaining 172 shoulders with irreparable rotator cuff tears—in which the torn tendon failed to reach the original footprint during shoulder arthroscopy—were managed with arthroscopic SCR (41 shoulders, 1.8%), arthroscopic partial rotator cuff repair (128 shoulders, 5.9%), or reverse shoulder arthroplasty (3 shoulders, 0.1%). The indication for arthroscopic SCR was severe shoulder dysfunction that was not improved by subacromial lidocaine injection, meaning that shoulder pain was not the cause of shoulder dysfunction. When subacromial lidocaine injection improved shoulder function, arthroscopic partial rotator cuff repair or reverse shoulder arthroplasty was selected. Patient age, Hamada grade, presence of fatty infiltration of rotator cuff musculature, pseudoparalysis, and the degree of external rotation weakness were not included to select a surgical option in this series. Of the 41 patients who underwent arthroscopic SCR, 5 were excluded from this study because of concomitant cervical spine problems, cerebrovascular disease 6 months after surgery, or the use of a different grafting technique. One patient was lost to follow-up for reasons unrelated to the surgery. Consequently, 35 patients were enrolled in the study. The follow-up rate was 97% (35 of 36 patients). The number of torn tendons was 2 (supraspinatus and infraspinatus) in 8 of these patients and 3 (supraspinatus, infraspinatus, subscapularis) in 27 patients. The torn infraspinatus and subscapularis tendons were repaired with SCR in 13 and 3 patients, respectively. The 35 patients who underwent SCR using Teflon grafts were allocated to 2 groups according to graft thickness (Table I): (1) 1-layer graft (15 patients who underwent SCR between 2014 and 2016; mean age, 75.1 years; range, 63-88 years) and (2) 3-layer graft (20 patients who underwent SCR in 2017; mean age, 76.6 years; range, 61-90 years) (Fig. 1). Age, tear size, and number of tendons did not differ significantly between the 2 groups (Table I). The average time to final follow-up was 42 months (range, 24-69 months).

Patient assessment

Shoulder function was assessed by using the ASES shoulder index, which is a 100-point scoring system with higher numbers indicating better function. Motion pain, rest pain, and night pain were evaluated by using a visual analog scale (VAS) consisting of a 10-cm horizontal line, where 0 represented no pain and 10 maximum pain. Shoulder range of motion in elevation was measured actively. Shoulder muscle strength in flexion, abduction, and external rotation was measured with a handheld dynamometer (Commander PowerTrack II; JTech Medical Industries Co., West Jordan, UT, USA). Postoperative complications were recorded. ASES and VAS scores, active shoulder elevation, and shoulder muscle strength were evaluated before surgery and at final

Table I Patient age and severity of rotator cuff tear

	One-layer graft (n = 15)	Three-layer graft (n = 20)	*P* value (1 layer vs. 3 layers)
Age (yr)	75.1 (63-88)	76.6 (61-90)	.59
Tear size in the anterior-posterior direction (cm)	4.9 (4-5)	4.8 (4-5)	.41
Torn tendons (patients)			
2 tendons: supraspinatus and infraspinatus	3	5	.73
3 tendons: supraspinatus and infraspinatus, subscapularis	12	15	

Age and tear size are expressed as means (ranges).

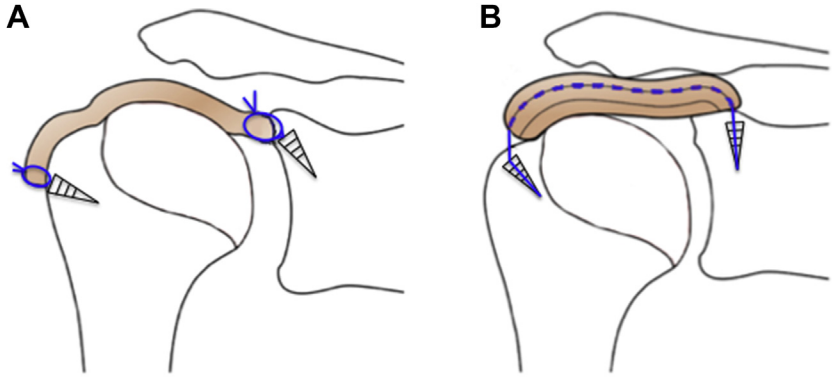

Figure 1 Superior capsule reconstruction using a Teflon felt synthetic graft. (**A**) One-layer graft. The graft was attached to the glenoid medially and to the greater tuberosity laterally by using a single-row technique. (**B**) Three-layer graft. Tapes, which were located between the first and second layers of the graft, were fixed to the glenoid medially and to the greater tuberosity laterally, without knot-tying. The graft can move in a medial-lateral direction.

follow-up. Shoulder muscle strength could not be evaluated preoperatively in 19 patients because of severe pain. Eleven patients did not provide complete answers to any of the pain scales before or after surgery.

Magnetic resonance imaging (MRI) was performed by using a 0.4-T open scanner (Aperto Eterna; Hitachi Medical, Tokyo, Japan) before surgery and at final follow-up after surgery. Oblique coronal, oblique sagittal, and axial T2-weighted MRI scans were acquired for structural and qualitative assessment of the rotator cuff and of repair integrity after surgery. Rotator cuff muscle quality was evaluated by using Goutallier grading[4] before surgery and at final follow-up. Plain X-rays were used to evaluate AHD before surgery, just after surgery, and at 1 year after surgery.

SCR technique

Preparation

For all procedures, patients were placed under general anesthesia and in the lateral decubitus position with 4 kg of arm traction. Five portals were used: posterior and anterior portals for the intra-articular arthroscope, posterolateral and anterolateral portals for subacromial decompression, and a Neviaser portal for anchor insertion. Tenotomy was performed on the dislocated or partially torn biceps tendon. Subacromial decompression was performed in all cases. If the subscapularis tendon tear was reparable, it was completely repaired by using a single-row or double-row technique.

Choosing the graft size and making the Teflon felt synthetic graft

The appropriate graft size was determined by using Mihata's protocol.[12,13,15] The size of the superior capsular defect was evaluated with a measuring probe in both the anteroposterior (from the anterior edge to the posterior edge of the torn tendon) and mediolateral (from the superior edge of the glenoid to the lateral edge of the greater tuberosity) directions at 30° of shoulder abduction. The optimal graft length in the anteroposterior direction was exactly the same as the length of the defect. The graft length in the mediolateral direction was 15 mm longer than the distance from the superior edge of the glenoid to the lateral edge of the greater tuberosity in order to give a 15-mm footprint on the superior glenoid.

The Teflon felt (Bard PTFE [polytetrafluoroethylene] Felt, C.R. Bard, Inc., Murray Hill, NJ, USA) was trimmed to match the measured defect size. In the first 15 cases (group 1), the synthetic graft was made from 1 layer (2.9 mm thick) of Teflon felt (Fig. 1, *A*). The remaining 20 cases (group 2) were treated by SCR using 3 layers (8.7 mm thick) of Teflon felt (Fig. 1, *B*).

Graft attachment

In group 1, 2 SwiveLocks (diameter, 5.5 mm; Arthrex, Naples, FL, USA) with No. 2 FiberWire (Arthrex) were inserted into the superior glenoid at the 10-11 o'clock and 12-1 o'clock positions in the right shoulder (or the 1-2 o'clock and 11-12 o'clock positions in the left shoulder). All No. 2 FiberWires from the superior

Table II VAS score

	One-layer graft (n = 9)	Three-layer graft (n = 15)	*P* value (1 layer vs. 3 layers)
VAS score at rest			
Preoperative	0.3 (0-2)	0.9 (0-4)	.25
Postoperative	0.4 (0-2)	0.0	.05
P value (preoperative vs. postoperative)	.81	.03	
VAS score during shoulder motion			
Preoperative	3.9 (2-6)	5.2 (1-8)	.16
Postoperative	0.7 (0-3)	2.2 (0-6)	.08
P value (preoperative vs. postoperative)	.001	<.0001	
VAS score at night			
Preoperative	1.1 (0-2)	1.6 (0-7)	.55
Postoperative	0.3 (0-2)	0.2 (0-4)	.76
P value (preoperative vs. postoperative)	.81	.03	

VAS, visual analog scale.
The values are expressed as means (ranges).

Table III ASES score and active elevation

	One-layer graft (n = 15)	Three-layer graft (n = 20)	*P* value (1 layer vs. 3 layers)
ASES score			
Preoperative	42.4 (13.3-80)	40.3 (1.7-76.7)	.74
Postoperative	63.2 (28.3-88.3)	71.4 (31-100)	.23
P value (preoperative vs. postoperative)	.001	<.0001	
Active elevation			
Preoperative	76 (20-160)	79 (20-160)	.88
Postoperative	107 (50-140)	142 (60-180)	.006
P value (preoperative vs. postoperative)	.06	<.0001	

ASES, American Shoulder and Elbow Surgeons.
The values are expressed as means (ranges).

glenoid were placed through the Teflon felt synthetic graft in a mattress fashion outside the body. The graft was then inserted through a 15-mm cannula (Thoracoport; Medtronic, Minneapolis, MN, USA) in the anterolateral portal into the subacromial space. When the medial edge of the Teflon felt synthetic graft had reached the superior glenoid, all FiberWires were tied. To attach the lateral side of the Teflon felt synthetic graft to the rotator cuff footprint on the greater tuberosity, 2 SwiveLocks (Arthrex) with No. 2 FiberWire were inserted 5-10 mm inferior to the lateral edge of the greater tuberosity. The Teflon felt synthetic graft was attached to the footprint on the greater tuberosity by tying all No. 2 FiberWires from the lateral SwiveLocks, which were placed through the Teflon felt synthetic graft (single-row repair) (Fig. 1, *A*).

In group 2, 2 SwiveLocks with ULTRATAPE (Smith & Nephew, Andover, MA, USA) were inserted into the superior glenoid at the same locations as in group 1. All ULTRATAPES and No. 2 FiberWires from the superior glenoid were placed between the first and second layers of the 3-layer Teflon felt graft in a medial-lateral direction outside the body. Then the graft was inserted through a 15-mm cannula (Thoracoport; Medtronic) in the anterolateral portal into the subacromial space. When the medial edge of the Teflon felt synthetic graft had reached the superior glenoid, all ULTRATAPES and No. 2 FiberWires from the glenoid were fixed 5-10 mm inferior to the lateral edge of the greater tuberosity by using 2 SwiveLocks. No knots were tied in group 2 (cable-graft technique) (Fig. 1, *B*).

Postoperative protocol

The postoperative protocols for groups 1 and 2 were the same. An abduction sling (Global Sling; Cosmos, Sapporo, Japan) was used for 1 month after surgery. Just after surgery, passive elevation exercises were initiated on the bed. Seven days after surgery, passive external rotation exercises were started. Three weeks after surgery, patients began to perform active elevation exercises. Physical therapists helped all patients.

Data analysis

Active shoulder elevation angle and muscle strength were measured 3 times, and the average value was used for data analyses. ASES score, VAS score, active shoulder elevation angle, muscle strength, Goutallier grade, and AHD before surgery and at final follow-up were compared by using a paired *t*-test. To compare age, tear size, ASES score, VAS score, active shoulder elevation angle, muscle strength, and Goutallier grade between 1-layer-graft SCR and 3-layer-graft SCR, unpaired *t*-tests were used. AHD before surgery, just after surgery, and 1 year after SCR were compared by using 1-way analysis of variance followed by Fisher's post hoc test. Number of tendons torn and rate of positive drop arm signs before surgery and at final follow-up were compared by using the χ^2 test. All data analyses were performed by using STATISTICA version 6.0 software (StatSoft, Tulsa, OK, USA).

Table IV Muscle strength

	One-layer graft (n = 7)		Three-layer graft (n = 9)		*P* value (1 layer vs. 3 layers)
	Muscle strength (N)	% Muscle strength (%)	Muscle strength (N)	% Muscle strength (%)	
Abduction					
Preoperative	11.5 (4.4-25.7)	41.8 (13.1-106.2)	15.7 (7.3-30.8)	37.4 (23.2-55.9)	.35
Postoperative	23.4 (8.1-35.2)	82.8 (20.3-145.5)	26.6 (9.5-59.4)	66.5 (37.0-100.0)	.62
Contralateral side	30.2 (24.2-43.3)		43.3 (22.2-108.7)		
P value (preoperative vs. postoperative)	.02		.008		
External rotation					
Preoperative	19.4 (8.1-40.0)	68.5 (11.8-224.7)	28.0 (8.8-84.3)	70.6 (20.8-171.7)	.46
Postoperative	28.4 (13.3-55.7)	72.1 (29.9-158.2)	30.9 (13.3-75.5)	74.3 (29.8-132.0)	.80
Contralateral side	49.0 (17.8-93.4)		43.1 (17.8-76.3)		
P value (preoperative vs. postoperative)	.28		.80		
Internal rotation					
Preoperative	46.4 (28.1-79.2)	79.1 (49.4-131.8)	52.9 (19.7-98.7)	73.1 (35.0-125.8)	.62
Postoperative	60.1 (26.7-86.5)	100.3 (77.8-126.8)	66.5 (32.6-91.7)	97.0 (57.9-156.2)	.53
Contralateral side	65.2 (26.7-86.5)		69.2 (56.3-91.7)		
P value (preoperative vs. postoperative)	.15		.25		

The % muscle strength was calculated by dividing muscle strength in the affected side by contralateral muscle strength. The values are expressed as means (ranges).

Table V Acromiohumeral distance

	One-layer graft (n = 15)	Three-layer graft (n = 20)	*P* value (1 layer vs. 3 layers)
Preoperative	6.0 ± 3.0	6.6 ± 2.9	.60
Immediate postoperative	10.6 ± 2.8	12.0 ± 3.4	.25
One-year postoperative	5.6 ± 2.3	8.6 ± 2.9	.005
P value (preoperative vs. immediate postoperative)	.0003	<.0001	
P value (preoperative vs. 1-yr postoperative)	.69	.04	

The acromiohumeral distance is given as the mean and the standard deviation.

To determine the appropriate sample size, a power analysis was performed by using the G*Power3 statistical analysis software package. Power ($1 - \beta$) was calculated by defining the sample size (see the Results section) with the threshold for significance (α) set to 0.05. The effect sizes for 1-layer-graft and 3-layer-graft SCR were, respectively, 1.09 and 1.61 for ASES score, 0.66 and 1.19 for active elevation angle, 1.21 and 0.88 for abduction strength, and 2.44 and 1.32 for VAS score of motion pain.

The power analysis indicated that a total sample size of 35 patients provided 80% power ($1 - \beta = 0.8$; $\alpha = 0.05$) to detect significant differences in ASES score and active elevation angle between before surgery and at final follow-up, assuming a power of 0.96 to discriminate ASES scores before surgery and at final follow-up for both 1- and 3-layer-graft SCRs, a power of 0.96 to discriminate active elevation angle before surgery and at final follow-up for 1-layer-graft SCR, and a power of 0.97 to discriminate active elevation angle before surgery and at final follow-up for 3-layer-graft SCR. At a total sample size of 16, the power to detect a significant difference in shoulder abduction strength between before surgery and at final follow-up was 0.95 in 1-layer-graft SCR and 0.96 in 3-layer-graft SCR. The power to detect significant differences in VAS score of motion pain between before surgery and at final follow-up was 0.97 in 1-layer-graft SCR and 0.95 in 3-layer-graft SCR.

Results

Shoulder pain

The VAS score during shoulder motion was significantly lower at final follow-up than before surgery in both the 1-layer-graft group (3.9 preoperatively and 0.7 at final follow-up, $P = .001$) and the 3-layer-graft group (5.2 preoperatively and 2.2 at final follow-up, $P < .0001$) (Table II). After SCR using the 3-layer graft, VAS scores at rest (0.9 preoperatively and 0 at final follow-up, $P = .03$) and at night (1.6 preoperatively and 0.2 at final follow-up, $P = .03$) were also significantly lower than those before surgery.

Table VI Goutallier classification (grade)

	One-layer graft (n = 15)	Three-layer graft (n = 20)	*P* value (1 layer vs. 3 layers)
Supraspinatus			
Preoperative	3.6 (2-4)	2.8 (1-4)	.01
Postoperative	3.7 (2-4)	3.0 (2-4)	.01
P value (preoperative vs. postoperative)	.67	.27	
Inraspinatus			
Preoperative	3.4 (1-4)	2.7 (1-4)	.03
Postoperative	3.7 (2-4)	2.8 (1-4)	.01
P value (preoperative vs. postoperative)	.16	.67	
Teres minor			
Preoperative	1.7 (1-3)	1.4 (1-3)	.21
Postoperative	1.9 (1-3)	1.6 (1-2)	.11
P value (preoperative vs. postoperative)	.08	.19	
Subscapularis			
Preoperative	1.8 (1-3)	1.9 (1-4)	.83
Postoperative	1.9 (1-3)	1.9 (1-3)	.93
P value (preoperative vs. postoperative)	.33	1.0	

The values are expressed as means (ranges).

Functional results

The ASES score increased significantly after SCR using a 1-layer graft (42.4 preoperatively to 63.2 postoperatively, $P = .001$) or a 3-layer graft (40.3 preoperatively to 71.4 at final follow-up, $P < .0001$) (Table III). There was no significant difference in preoperative ($P = .74$) and final follow-up ($P = .23$) ASES scores between the 1-layer graft and 3-layer graft. Active elevation significantly increased after SCR using the 3-layer graft ($P < .0001$), whereas it did not increase significantly after SCR using the 1-layer graft ($P = .06$). Postoperative active elevation was significantly greater after SCR using the 3-layer graft (142° ± 27°) than after the 1-layer graft (107° ± 42°) ($P = .006$) (Table III). Shoulder abduction strength was significantly greater at final follow-up than before surgery with SCR using either a 1-layer graft ($P = .02$) or a 3-layer graft ($P = .008$) (Table IV). Shoulder external rotation and internal rotation strengths did not increase significantly after either type of SCR. Percent drop arm sign decreased significantly after SCR using either a 1-layer graft (73%, 11 of 15 patients preoperatively, compared with 27%, 4 of 15 patients at final follow-up; $P = .01$) or a 3-layer graft (55%, 11 of 20 patients preoperatively, compared with 0% at final follow-up, $P = .0001$).

Radiographic results (Figs. 2 and 3)

AHD increased significantly just after SCR in both the 1-layer-graft group (6.0 ± 3.0 mm preoperatively to 10.6 ± 2.8 mm postoperatively, $P = .0003$) and the 3-layer-graft group (6.6 ± 2.9 mm preoperatively to 12.0 ± 3.4 mm postoperatively, $P < .0001$) (Table V). Average AHD before ($P = .60$) and just after ($P = .25$) SCR did not differ between the 1-layer-graft and 3-layer-graft groups. One year after SCR, AHD in the 3-layer-graft group was significantly higher than the preoperative AHD ($P = .04$) and significantly higher than the 1-year value in the 1-layer group ($P < .005$); AHD in the 1-layer-graft group had returned to about the preoperative level. The Goutallier grade of all 4 rotator cuff muscles did not change significantly in either group (Table VI). Two patients in the 1-layer graft group had graft tears after SCR. None of the patients in the 3-layer-graft group had graft tears on postoperative MRI.

Complications

The rate of complications other than graft tears was 2.9% (1 of 35 patients). The affected patient had severe synovitis after SCR using a 1-layer graft (Fig. 4, *A* and *B*); it required arthroscopic débridement without graft removal (Fig. 4, *C* and *D*). There was no infection and no shoulder stiffness after surgery in this series.

Discussion

To our knowledge, this is the first report of the clinical and radiographic outcomes of SCR using synthetic grafts for irreparable large to massive rotator cuff tears. SCR using a Teflon graft of either 1 or 3 layers significantly improved the ASES and VAS scores and muscle strength in shoulder abduction, with low rates of graft tears or complications after surgery. Furthermore, the rate of the drop arm sign was significantly decreased after Teflon graft SCRs.

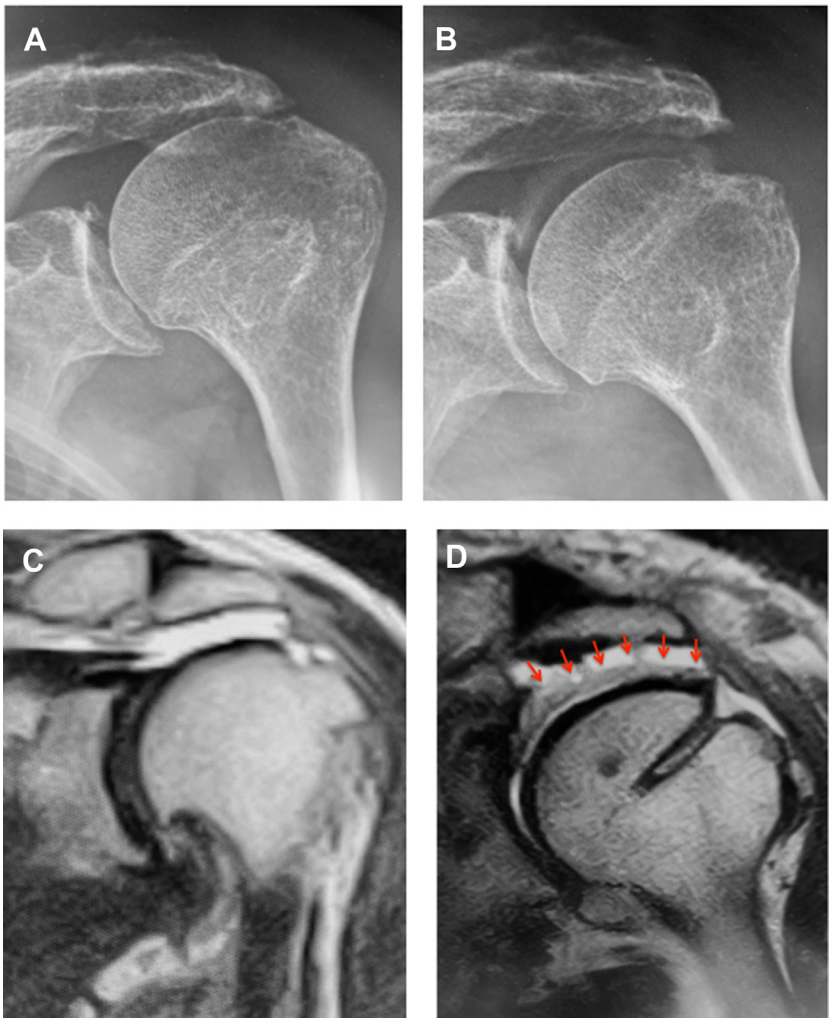

Figure 2 X-ray and T2-weighted magnetic resonance imaging (MRI) findings before and after arthroscopic superior capsule reconstruction (SCR) using a 1-layer Teflon felt graft. (**A**) X-ray before surgery. (**B**) X-ray 1 year after SCR. (**C**) Coronal MRI image before surgery. The torn supraspinatus tendon is severely retracted, and the supraspinatus muscle is severely atrophied. (**D**) Coronal MRI image 1 year after SCR. → show the single-layer Teflon felt graft.

Therefore, SCR using a Teflon graft can be a viable option for irreparable rotator cuff tears, especially when autografts or allografts are not available for economic, health, cultural, or religious reasons.

The comparison of functional outcomes after SCR between 1-layer grafts and 3-layer grafts demonstrated significantly higher postoperative active elevation in the 3-layer-graft group than in the 1-layer-graft group, although postoperative ASES score and muscle strength did not differ significantly between the 1- and 3-layer-graft groups. Plain X-rays showed that the AHD at 1 year after surgery was significantly larger in the 3-layer-graft group than in the 1-layer-graft group. These results suggest that SCR using 3-layer Teflon grafts may improve the superior stability of the shoulder joint, resulting in an increase in active shoulder elevation. A previous cadaveric biomechanical study showed that the use of an 8-mm-thick graft could completely restore superior stability after SCR using a fascia lata graft, whereas using a 4-mm-thick graft only partially restored it.[18] The results of that biomechanical study support our current results, because our 3-layer graft was approximately 8-9 mm thick.

We found a change in AHD with time. Just after SCR, both grafts had a significant increase in AHD compared with before surgery, and the increase in AHD was larger than the graft thickness, indicating that the increased AHD resulted from tension of the graft after SCR. However, the AHD 1 year after SCR was significantly smaller than that just after SCR. This result suggests that the graft loosened with time, even though the ASES scores and muscle strength in shoulder abduction at final follow-up were still significantly better than the preoperative values. Therefore, we now intend to follow up our patients who received SCR with Teflon grafts for longer to look for long-term functional or radiographic changes.

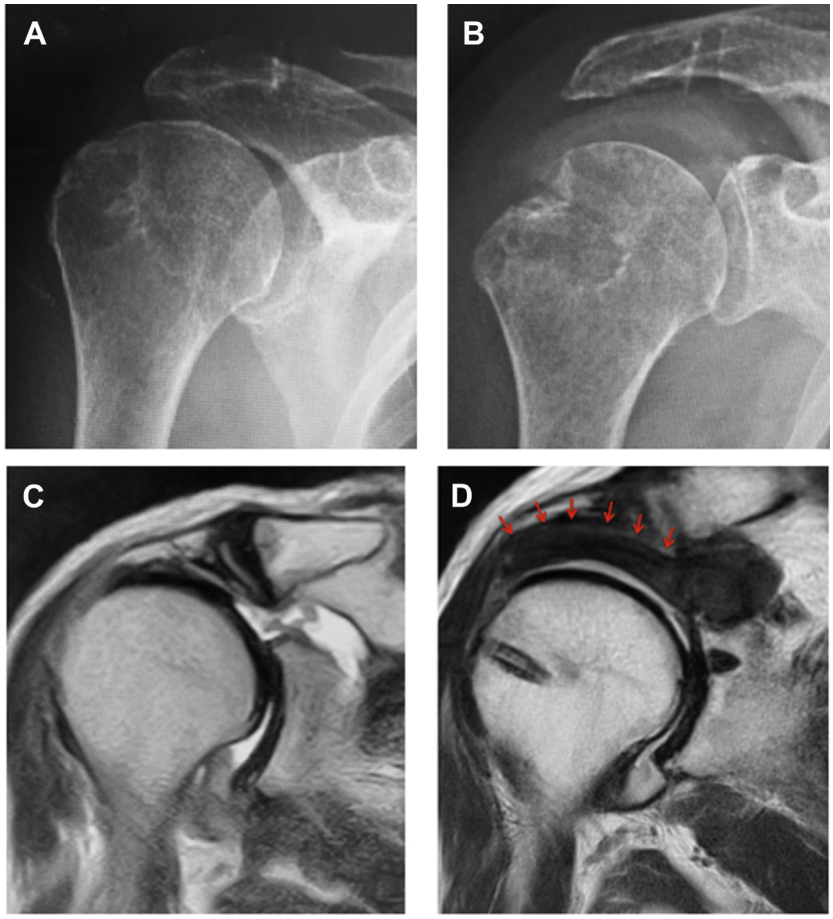

Figure 3 X-ray and T2-weighted magnetic resonance imaging (MRI) findings before and after arthroscopic superior capsule reconstruction (SCR) using a 3-layer Teflon felt graft. (**A**) X-ray before surgery. (**B**) X-ray 1 year after SCR. (**C**) Coronal MRI image before surgery. The torn supraspinatus tendon is severely retracted, and the supraspinatus muscle is severely atrophied. (**D**) Coronal MRI image 1 year after SCR. → show the 3-layer Teflon felt graft.

In previous short-term clinical studies, shoulder range of motion (ROM), muscle strength, and functional outcome were reported to improve, with low rates of graft tears, after conventional patch graft surgery using Teflon grafts in patients with irreparable rotator cuff tears.[23,25,26] However, a cadaveric biomechanical study showed that superior stability was only partially restored when the graft was attached to the torn tendon, whereas SCR, in which the graft is attached to the glenoid, completely restored superior stability.[20] Lack of superior stability after surgery may result in abrasion of the graft under the acromion and may cause shoulder function to deteriorate. Therefore, we attached the graft to the glenoid medially to complete the SCR. At a minimum follow-up of 2 years in our patient series, shoulder function and pain scores after SCR, especially a 3-layer graft, were still better than those before surgery.

The use of autografts of fascia lata for SCR was first reported in 2013.[16] In that report, the mean ASES score improved from 23.5 to 92.9 points after SCR, and active shoulder ROM increased significantly in external rotation and internal rotation as well as in abduction. In a recent report of SCR using dermal allografts, the ASES score improved from 52 to 89 points and active external rotation increased significantly after SCR.[2] There was less functional improvement in our current series of SCR using Teflon grafts. Furthermore, a recent 5-year follow-up study after SCR using autografts of fascia lata showed that the AHD increased significantly from 3.4 mm preoperatively to 8.1 mm 5 years after SCR.[13] In contrast, we showed here that AHD was significantly smaller 1 year after SCR than just after SCR. A decrease in AHD is thought to lead to deterioration of shoulder function in patients with rotator cuff tears.[22] Therefore, in active and young patients, autografts or allografts, if available, should be used in preference to Teflon grafts.

Because the tension effect makes more consistent superior stability than the spacer effect as a balloon spacer, we recommend suturing the Teflon graft to the glenoid medially and to the greater tuberosity laterally. Even though a Teflon graft cannot be expected healing to the bone and sutures become brittle with time, 97.1% (34 of 35 patients) of graft stayed on the glenoid and greater tuberosity in MRI at 2 years after SCR in our current study.

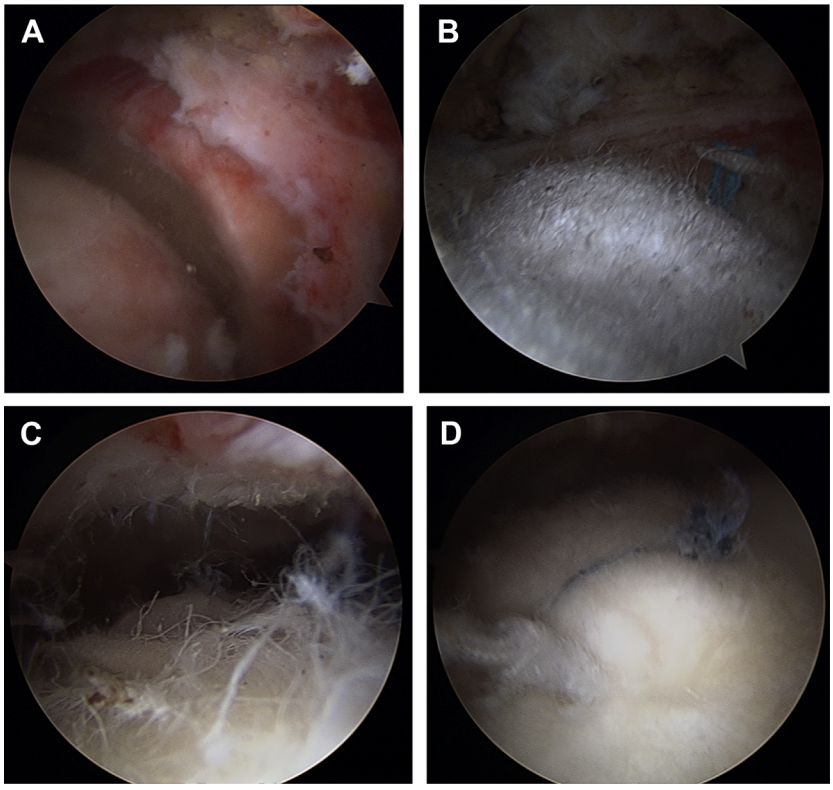

Figure 4 Arthroscopic findings in patient with severe synovitis after superior capsule reconstruction (SCR) using a 1-layer Teflon graft. (**A**) Irreparable rotator cuff tear before SCR. (**B**) Just after SCR. (**C**) Fraying of the Teflon graft at 3 weeks after SCR. (**D**) Just after arthroscopic débridement without graft removal for severe synovitis after SCR. The Teflon graft was not torn.

Possible explanation for the low rate of graft tears was that scar tissue formation may fix the Teflon graft to the glenoid and greater tuberosity instead of sutures. Furthermore, for 3-layer SCR, All ULTRATAPES and No. 2 FiberWires, which were fixed to the glenoid medially and to the greater tuberosity laterally, were placed between the first and second layers of the 3-layer Teflon felt graft in a medial-lateral direction. Therefore, the Teflon graft can move during shoulder motion, which may prevent over tension near the maximum ROM, resulting in low risk of graft tears. Although the Teflon graft, which is roentgenopaque, could be seen in postoperative X-ray, it is hard to assess the partial tear of the graft, postoperative synovitis, or other tendon tears only using X-ray. Therefore, we used MRI to assess shoulder pathology including graft tears in this study.

The current study showed only 1 patient (3%) with postoperative synovitis, which healed after débridement without removal of the Teflon graft, and no patient with postoperative infection. The clinical study of rotator cuff repair with polytetrafluoroethylene patch showed 5% of postoperative infection and no evidence of inflammatory reaction, tissue rejection, or major adverse outcome in 58 shoulders.[25] Therefore, we believe that SCR using the Teflon graft is a safe and promising surgical option for irreparable rotator cuff tears.

Our study had several limitations. First, the data on the 2 groups were collected from different time periods to eliminate patient selection bias, but doing so might have influenced the clinical results. Nevertheless, all surgeries were performed by the same experienced shoulder surgeon (KO), and postoperative physical therapy was performed by using the same postoperative protocol and the same physical therapy team. Therefore, we believe that the different time periods of data collection had no noteworthy effect on our results. Second, AHD was evaluated before surgery, just after surgery, and at 1 year after surgery, and we found that AHD decreased with time after SCR. Therefore, in the near future, we intend to perform another study to assess AHD with a longer follow-up. Third, we were unable to evaluate VAS scores and muscle strength in all patients, although there was still sufficient power for statistical analysis. Fourth, SCR using the 1-layer Teflon graft was performed earlier than SCR using the 3-layer Teflon graft. The learning curve and longer follow-up may affect higher rate of graft tears in SCR using the 1-layer Teflon graft.

Conclusion

SCR using a Teflon graft—especially a 3-layer graft—significantly improved shoulder function and shoulder abduction strength, with pain relief and low rates of postoperative complications. This technique is

therefore a viable surgical option for irreparable rotator cuff tears, especially when autografts or allografts are not available.

Disclaimer

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