Original Research

A Comparative Study on Arthroscopic Superior Capsular Reconstruction Using Fascia Lata Autograft With and Without Long Head of the Biceps Tendon Augmentation

Two-Year Patient-Reported Outcomes and Radiographic Analysis

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Background: Given the growing concerns regarding objective measures of clinical outcomes, attention has recently been devoted to the establishment of clinically significant outcome (CSO) thresholds for patient-reported functional scores after rotator cuff surgery.

Purpose: To retrospectively compare patient-reported outcome (PRO) measures (PROMs) and radiographic data between patients who underwent arthroscopic superior capsular reconstruction (SCR) with and without long head of the biceps tendon (LHBT) augmentation.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 43 patients receiving arthroscopic SCR between 2016 and 2020 were enrolled, including a biceps augmentation group (n = 27) and a nonaugmentation group (n = 16). Patients were asked an anchor question regarding their satisfaction and perception of improvements. PROMs of American Shoulder and Elbow Surgeons (ASES), Constant score, Single Assessment Numeric Evaluation (SANE), and visual analog scale (VAS) for pain scores and radiographic data including magnetic resonance imaging and plain radiographs were collected and compared between the 2 groups. Anchor questions in CSO analysis for deriving the minimal clinically importance difference (MCID), substantial clinical benefit (SCB), Patient Acceptable Symptom State (PASS), and maximal outcome improvement (MOI) values were applied $\geq$2 years postoperatively.

Results: Based on satisfaction responses, 17 patients were classified as satisfied, 16 as unsatisfied, and 10 as fair. Additionally, 13 patients felt they were improved, 14 changed, and 16 unchanged. Intergroup comparison based on patients' satisfaction and perception of change or improvement exhibited significant differences in all 4 functional scores in favor of the satisfied and improved patients. However, there was no significant difference in the ΔVAS scores between the groups. CSO analyses showed no significant difference in percentage of patients achieving MCID, SCB, and PASS thresholds for the ΔASES, ΔConstant, and ΔSANE scores between patients undergoing arthroscopic SCR with or without LHBT augmentation. A significant difference was found in the percentage of patients achieving the MOI for ΔASES score with 70.4% in the augmented group and 37.5% in the nonaugmented group, respectively. The mean acromiohumeral distance (AHD) differed significantly between augmentation (8.1 $\pm$ 2.2 mm) and nonaugmentation (7 $\pm$ 1.9 mm) groups. The graft tear rate did not differ significantly.

The Orthopaedic Journal of Sports Medicine, 12(10), 23259671241270243
DOI: 10.1177/23259671241270243

Conclusion: There was no significant difference in PROs and percentage of patients achieving MCID, SCB, and PASS between isolated and augmented SCR groups. A higher percentage of patients achieving MOI and slightly greater AHD were found in the augmented group. Further evaluation is required to determine if there is any long-term benefit to LHBT augmentation of SCR.

Keywords: shoulder; biceps tendon; rotator cuff; clinically significant outcome; patient-reported outcome measures; superior capsular reconstruction

The technique of arthroscopic superior capsular reconstruction (SCR) was first described by Mihata et al[28] in a biomechanical cadaveric model and has been adopted using autologous fascia lata (FL) to successfully treat patients with irreparable rotator cuff tears (RCTs).[26] Subsequent reports of arthroscopic SCR utilizing dermal allografts and autologous long head of the biceps tendon (LHBT) have also demonstrated clinical improvement, yielding lower retear rates compared with arthroscopic rotator cuff repair.[3,11] All of these grafts are suitable options, and the treatment outcomes are largely dependent on proper surgical techniques[25] and sustained graft survival to restore stable shoulder fulcrum[31] and acromiohumeral distance (AHD).[27] LHBT has inherent advantages of regional availability and tissue viability, and it exhibits versatile technical application[20]; however, SCR techniques using adventive autogenous or allogenic grafts often sacrifice LHBT even with grossly intact integrity. Instead of sacrificing the tendon, we followed the recently published technique of incorporating LHBT into FL grafts as an augmentation of SCR[8,18] and compared the clinical outcomes of the index surgery with those of the original SCR without LHBT augmentation. Quantitatively scored patient-reported outcome (PRO) measures (PROMs) are commonly used tools for hypothesis testing. Since there is increasing emphasis on the risk that differences in the reported PROM scores are too small to be clinically relevant, the concept of clinically significant outcomes (CSOs) was introduced to correspond to patient-perceived functional improvement.[34] Owing to the lack of objective measures of patient satisfaction to optimize clinical outcomes, attention has recently been devoted to the establishment of CSO thresholds by calculating the minimal clinically importance difference (MCID), substantial clinical benefit (SCB), Patient Acceptable Symptom State (PASS), and maximal outcome improvement (MOI) thresholds after surgery.[33] The aim of our study was to compare PROMs based on the establishment of CSO thresholds and the results of radiographic analysis after FL SCR with and without LHBT incorporation. Our hypothesis was that graft augmentation using LHBT in FL SCR for patients with irreparable RCTs would yield at least similar outcomes compared with FL SCR without LHBT augmentation. All abbreviations that are used throughout our manuscript are listed in Table 1.

TABLE 1
Abbreviations used throughout text

Abbreviation	Meaning
AHD	Acromiohumeral distance
ASES	American Shoulder and Elbow Surgeons
AUC	Area under the curve
CSO	Clinically significant outcome
FL	Fascia lata
LHBT	Long head of the biceps tendon
MCID	Minimal clinically important difference
MOI	Maximal outcome improvement
MRI	Magnetic resonance imaging
PASS	Patient Acceptable Symptom State
PRO	Patient-reported outcome
PROM	Patient-reported outcome measure
RCT	Randomized controlled trial
ROC	Receiver operating characteristic
SANE	Single Assessment Numeric Evaluation
SCB	Substantial clinical benefit
SCR	Superior capsular reconstruction
VAS	Visual analog scale

METHODS

Study Design and Participants

This study was a retrospective analysis of prospectively collected data from patients undergoing SCR for irreparable RCTs between 2016 and 2020. The inclusion criteria were as follows: primary SCR using FL autograft in patients with irreparable RCTs and $\geq$2 years of

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Final revision submitted February 7, 2024; accepted February 26, 2024.

The authors declared that they have no conflicts of interest in the authorship and publication of this contribution. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from Chang Gung Medical Foundation (ref No. 202000604B0).

postoperative follow-up. The exclusion criteria were as follows: incomplete baseline and follow-up data and revision SCR surgery. Old age was not considered a contraindication for SCR surgery, while patients with Hamada classification grades 4 and 5 were not included. The institutional review board of Chang Gung Medical Foundation approved this study. Each patient was evaluated preoperatively by the surgeon, and all baseline and follow-up data were collected by orthopaedic fellows in the outpatient clinics. A total of 47 patients underwent surgery during the period of interest; 1 patient who passed away due to unrelated underlying diseases at 6 months after surgery and 3 patients who only completed a 1-year postoperative survey were excluded from the study. Ultimately, 43 patients were enrolled and divided into 2 compared groups. The first group consisted of 27 patients who received LHBT augmentation in addition to SCR using FL autografts (LHBT augmentation group); the second group consisted of 16 patients without LHBT augmentation (no–LHBT augmentation group). Augmentation procedures were performed only when the LHBT was grossly intact or partially torn in <50% of the tendon diameter. All surgeries were performed by a fellowship-trained orthopaedic surgeon (A.C.C.).

Surgical Technique

All surgeries were carried out with patients under general anesthesia. Patients were initially positioned on their side to harvest an autologous FL graft measuring 5 × 15 cm^2 from their ipsilateral thigh. After this, patients were repositioned in the beach-chair position, and arthroscopic portals were established in the posterior, posterolateral, lateral, anterior, and Neviaser portals, with the pump pressure set at 30 to 50 mm Hg. The surgical procedure began with a thorough intra-articular inspection to confirm the condition of the articular cartilage, the presence of an irreparable RCT, and the availability of the LHBT. Upper one-third tears of the subscapular tendon were repaired using 2.3-mm Iconix all-suture anchors (Stryker Endoscopy). We performed subacromial decompression to remove pathological tissue and spur and facilitate the smooth passage of the graft, and we debrided the supraglenoid fossa and greater tuberosity to expose the cortical bone and facilitate graft-to-bone healing. The harvested FL graft was folded and securely sutured to create a patch measuring 3 × 5 cm^2 with a thickness of 6 to 8 mm. For patients with normal LHBT integrity or minor tears within 50% of the diameter, the rectangular graft patch was introduced through the anterolateral portal, passed beneath the LHBT until the short side reached the supraglenoid fossa, and then securely fixed using two 1.4-mm Iconix all-suture anchors (Figure 1). The proximal LHBT was sutured and incorporated into the anterosuperior portion of the FL graft patch with single No. 2 Ethibond suture (Ethicon). With the shoulder kept at 30° of flexion and abduction, the lateral one-fourth of the graft patch was affixed to the greater tuberosity in the compression suture-bridging technique using two 2.3-mm Iconix all-suture anchors and two 4.5-mm Reelx anchors (Stryker Endoscopy). The

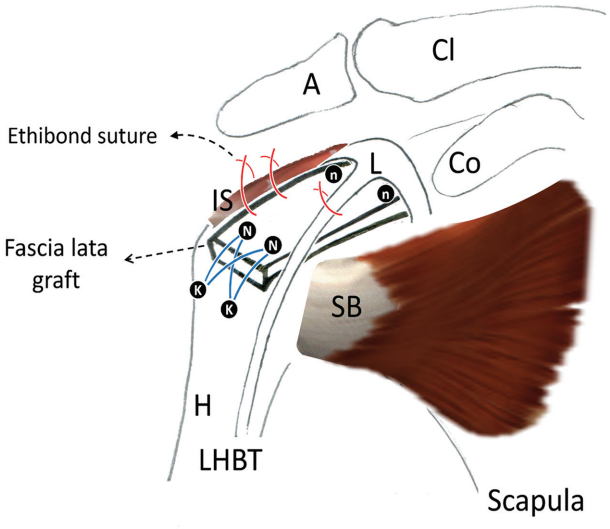

Figure 1. Diagram of superior capsular reconstruction using fascia lata graft and biceps tendon augmentation in the right shoulder with an irreparable rotator cuff tear. A, acromion; Cl, clavicle; Co, coracoid process; L, superior glenoid labrum; IS, infraspinatus; SB, subscapularis; LHBT, long head of the biceps tendon; H, humerus; n, 1.4-mm Iconix suture anchor; N, 2.3-mm Iconix suture anchor; K, Reelx knotless anchor (with permission of the journal and authors[8]).

posterior border of the graft patch and residual infraspinatus were closed with side-to-side Ethibond sutures for full coverage of the posterosuperior rotator cuff defect.[8] If the LHBT was severely damaged, suprapectoral tenodesis at the biceps groove was performed with one 2.3-mm Iconix suture anchor before graft passage. In the patients with an absent LHBT who received tenodesis, the graft was introduced and fixed in the same way except in the procedure of suture incorporation with the LHBT. After wound closure with 3-0 nylon, an abduction pillow brace was applied to keep the shoulder at 45° of abduction for 1 month. Postoperative rehabilitation was started at 4 weeks postoperatively with Codman exercises and assisted forward flexion for 3 months. Active motion was not allowed until full assisted elevation was achieved and began ≥4 months after SCR surgery. For patients with insufficient assisted motion of internal rotation, passive stretch began ≥6 months after surgery. Resistant exercise was permitted at 9 months after surgery.

Data Collection and Analysis

A fellowship-trained orthopaedic surgeon (Y.-H.C.) reviewed preoperative and postoperative 2-year functional data and radiographs while remaining blinded to patient demographics. Active range of motion for forward elevation, abduction, and external rotation was measured using a handheld goniometer. Internal rotation was assessed by determining the highest level of the vertebral body that the patient's thumb tip could reach without experiencing

pain and then converted to a 5-point scale.[10] Functional assessments were conducted using the American Shoulder and Elbow Surgeons (ASES) score with a maximum of 100 points,[34] the Constant score with a maximum of 100 points,[9] and the Single Assessment Numeric Evaluation (SANE) method with scores ranging from 0% to 100%.[16] Pain scores were measured using a 10-point visual analog scale (VAS) for pain. Questionnaires were administered to determine patients' responses to treatments, and anchoring methods were used. One anchor question was about patients' surgical satisfaction, consisting of a yes or no response, and patients were thus divided into satisfied (with the answer of yes), fair (with the answer of partial satisfaction), and unsatisfied (with the answer of no) groups. To clarify the outcome difference based on patient satisfaction, only the functional scores of the satisfied and unsatisfied groups were adopted for prevalidation in the analysis of difference. Patients were classified into the partially satisfied group if they expressed satisfaction only with certain aspects of the PROMs and fair response to the surgical intervention. Consequently, they were excluded from the prevalidation outcome analysis. The other question assessed patients' functional status after surgery, with response options including A (none), B (poor), C (fair), and D (excellent). Patients answering A or B were classified as the unchanged group; patients answering C were classified as the changed group; and patients answering D were classified as the improved group. Cutoff values for the MCID, SCB, PASS, and MOI were established to compare outcomes between patients with and without LHBT preservation based on the patient-level metrics for the ΔASES, ΔConstant, ΔSANE, and ΔVAS scores.[4,14,16] Additionally, the proportion of patients achieving the CSO thresholds for functional scores was calculated.

Radiographic Assessment

Radiographs were obtained in 2 projections from a picture archiving and communication system (GE Centricity) with a thickness of 2 mm in each slice, including the anteroposterior view with the arm in neutral rotation and the lateral view in the scapular plane. The distance between the acromion and humeral head was measured in the anteroposterior view. The Hamada classification[17] was used to categorize patients based on the status of the acromiohumeral space and glenohumeral joint. Before surgery, magnetic resonance imaging (MRI) was conducted to assess the severity of the RCT and muscular fatty infiltration using the Collin classification system[21] and Goutallier classification,[15] respectively. Patients underwent MRI examination in the neutral position on a 1.5-T scanner (Optima MR450 W; GE Healthcare) with a dedicated receive-only shoulder coil. The parameters were set as follows: the field of view was 18 cm, and the matrix was 256 × 256 with a slice thickness and gap of 4 mm and 1 mm, respectively. The global fatty degeneration index represented a mean grading of the supraspinatus, infraspinatus, and subscapularis muscles based on the Goutallier classification.[32] Two-year follow-up MRI also included evaluation of graft integrity and tear pattern. Image interpretation mainly relied on oblique coronal proton density and T2-weighted images with fat suppression. Any tear across both the bursa and the articular sides of the graft patch was considered a complete tear. Any tear confined to only either the bursal or the articular site was recorded as a partial tear. Based on tear location, graft tears were divided into 3 types: glenoid site, midsubstance site, and tuberosity site. One orthopaedist and 1 radiologist (Y.-H.C. and C.-T.W.), both of whom were blinded to the patients' demographic data, confirmed all image analyses. The 2 observers reached a consensus, and the surgeon confirmed the image analyses.

Statistical Analysis

Descriptive statistics were calculated for bivariate analyses. With a null hypothesis, the estimated sample size to achieve 80% power and an effect size of 0.5 in detecting at a significance level of .05 was approximately 32. To compare demographic data between isolated and augmented SCR groups, Mann-Whitney (for nonnormally distributed data) and Fisher exact tests (for categorical data) were performed. The Wilcoxon signed-rank test was used to identify differences between preoperative and postoperative 2-year scores. Before defining CSO thresholds, a standard 2-sample t test was used to determine whether the difference in functional scores differed between the satisfied and unsatisfied groups, between the changed and unchanged groups, and between the improved and nonimproved groups at the 2-year assessment. $P < .05$ indicated statistical significance. All statistical analysis was performed using SPSS, version 20 (IBM, armonk, NY, USA).

The CSO thresholds of the MCID, SCB, PASS, and MOI for the ΔASES, ΔConstant, ΔSANE, and ΔVAS scores were derived through anchor-based methods. Receiver operating characteristic (ROC) curves were drawn for each score, and the area under the curve (AUC) was calculated. An AUC $\geq$0.7 was considered acceptable, and an AUC $\geq$0.8 was considered excellent.[7] For the ROC curve analysis, the optimum cutoff value between the unchanged and changed groups was determined to be the MCID value; the optimal cutoff value between the unchanged and improved groups was the SCB value; and the optimal cutoff value between the unsatisfied and satisfied groups was the PASS value (sensitivity- and specificity-based approach). The Youden index was used to identify the optimal cutoff that maximized the sensitivity and specificity for each outcome.[30] The percentage of MOI for each score was determined by the ratio of changes in the recent score over the improvement threshold.[23]

RESULTS

Analysis of Baseline Data

A total of 43 patients were included in the study and divided into 2 groups: the LHBT augmentation group

TABLE 2
Comparison of Baseline Data[a]

	LHBT Augmentation Group (n = 27)	No–LHBT Augmentation Group (n = 16)	*P*
Age, y	67.0 ± 6.7	66.6 ± 7.5	.418
Sex, n			.366
Male	12	8	
Female	15	8	
BMI, kg/m^2	25.6 ± 3.7	26.5 ± 3.9	.431
Dominant side	21 (78)	12 (75)	.421
Pseudoparalysis	9 (33)	5 (31)	.395
AHD, mm	4.1 ± 2.8	3.9 ± 2.6	.415
Range of motion			
Forward flexion, deg	130.7 ± 42.9	126.9 ± 56.9	.408
External rotation, deg	40.0 ± 18.9	38.8 ± 21.9	.429
Internal rotation[b]	2.3 ± 0.7	2.5 ± 1.0	.209
Hamada classification			.463
Stage 1	7 (26)	4 (25)	
Stage 2	14 (52)	8 (50)	
Stage 3	4 (15)	3 (19)	
Stage 4	2 (7)	1 (6)	
GFDI	1.9 ± 0.6	1.9 ± 0.5	.484
Subscapularis repair	9 (33)	5 (31)	.360
Surgical time, min	223.1 ± 30.5	218.7 ± 21.1	.417

[a]Data are presented as the mean ± SD or n (%) unless otherwise indicated. AHD, acromiohumeral distance; BMI, body mass index; GFDI, global fatty degeneration index; LHBT, long head of the biceps tendon.
[b]Internal rotation is presented as the mean ± SD based on a 5-point scale.[10]

had 27 patients, and the no–LHBT augmentation group had 16 patients. The baseline data of the 2 groups are shown in Table 2. There were no significant differences in these baseline data between groups. Regarding the preoperative imaging, the mean AHD was 4.1 ± 2.8 mm (LHBT augmentation group) versus 3.9 ± 2.6 mm (no–LHBT augmentation group); the mean global fatty degeneration index was 1.9 ± 0.6 (LHBT augmentation group) versus 1.9 ± 0.5 (no–LHBT augmentation group); and the mean Hamada grade was 1.9 ± 0.7 (LHBT augmentation group) versus 2.1 ± 0.6 (no–LHBT augmentation group). None of these differences were statistically significant. 9 patients in the LHBT augmentation group and 5 patients in the no–LHBT augmentation group underwent simultaneous subscapularis repair. The mean total surgical time was 223.1 ± 30.5 minutes in the LHBT augmentation group and 218.7 ± 21.1 minutes in the no–LHBT augmentation group; this difference was nonsignificant.

Prevalidation of Functional Scores

Based on patient responses to the questions about satisfaction, 16 patients were classified as the unsatisfied group, 17 patients were classified as the satisfied group, and the remaining 10 patients were classified as the fair group. Figure 2 shows that the mean scores of functional assessments were significantly different between the unsatisfied versus satisfied groups, including the ΔASES (42.8 ± 12.8 versus 53.5 ± 10.6, respectively; $P = .004$), the ΔConstant score (30.7 ± 9.8 versus 43.9 ± 8.1, respectively; $P < .001$), the ΔSANE (53.4 ± 10 versus 62.4 ± 10,

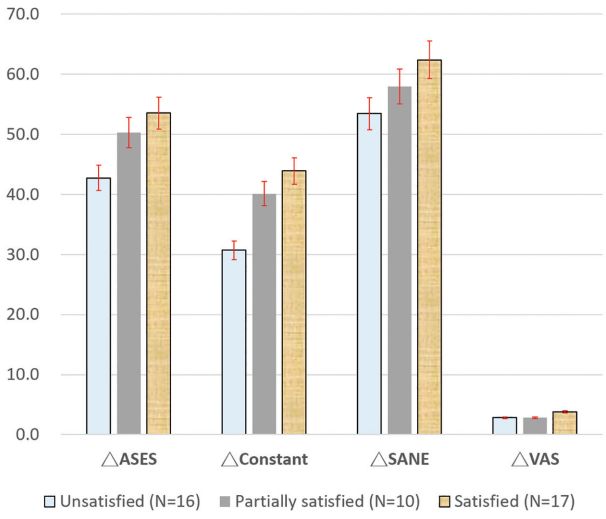

Figure 2. Score changes at 2-year follow-up in unsatisfied (n = 16), partially satisfied (n = 10), and satisfied (n = 17) patients. ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

respectively; $P = .004$) and the ΔVAS (2.8 ± 1.2 versus 3.7 ± 1.2; $P = .009$). The other anchor questionnaire classified all patients into 3 groups: 16 patients were in the unchanged group, 14 patients were in the changed group, and 13 patients were in the improved group (Figure 3). For the unchanged, changed, and improved groups, the

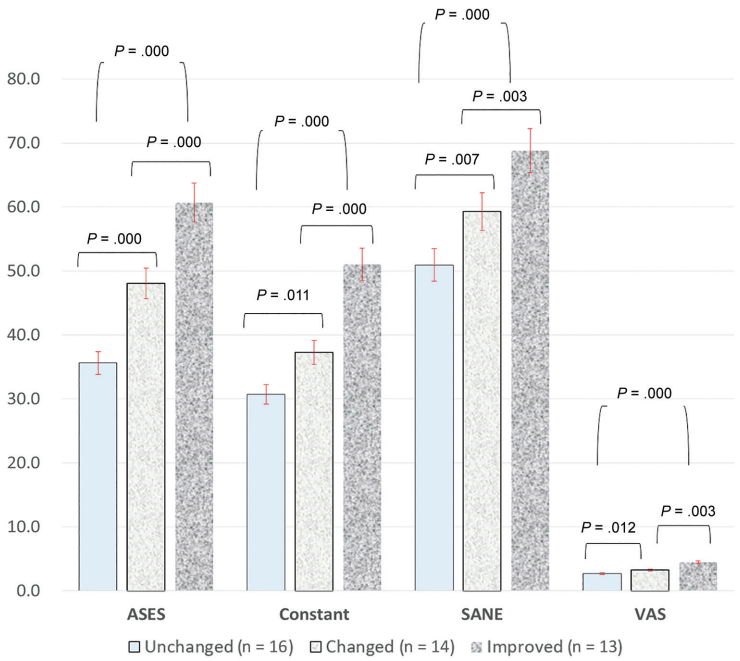

Figure 3. Comparison of score changes at the 2-year follow-up among the unchanged, changed, and improved patients. ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

mean ΔASES scores were 35.6 ± 7.4, 48.1 ± 7.6, and 60.7 ± 7.5, respectively; the mean ΔConstant scores were 30.7 ± 7.7, 37.3 ± 7.2, and 51 ± 5.2, respectively; the mean ΔSANE scores were 50.9 ± 7.8, 59.3 ± 9.4, and 68.8 ± 6.6, respectively; and the mean ΔVAS scores were 2.7 ± 1.1, 3.2 ± 1.3, and 4.5 ± 0.7, respectively. The between-group differences in the mean ΔASES, ΔConstant, and ΔSANE scores were significant. There were significant differences in ΔVAS scores between the changed and improved groups and between the unchanged and improved groups; however, the difference between the unchanged and changed groups was nonsignificant, with a *P* value of .122.

CSO Thresholds and Intergroup Comparison

ROC curve analysis was performed to determine the optimal cutoff values for the MCID, SCB, PASS, and MOI functional scores. Since there was no significant difference regarding ΔVAS scores between the unchanged and changed groups (2.7 ± 1.1 and 3.2 ± 1.3 respectively; *P* = .122), CSO thresholds for ΔVAS were not established for subsequent intergroup comparison. For the ΔASES, ΔConstant, and ΔSANE scores, the MCID values were 33 (AUC of 0.881; 95% CI, 0.857-0.903), 21 (AUC of 0.802; 95% CI, 0.781-0.813), and 45 (AUC of 0.921; 95% CI, 0.886-0.929), respectively; the SCB values were 47 (AUC of 0.802; 95% CI, 0.773-0.823), 44 (AUC of 0.901; 95% CI, 0.877-0.914), and 60 (AUC of 0.761; 95% CI, 0.742-0.775), respectively; the PASS values were 63 (AUC of 0.881; 95% CI, 0.862-0.901), 31 (AUC of 0.801; 95% CI, 0.767-0.821), and 75 (AUC of 0.921; 95% CI, 0.890-0.933), respectively; and the MOI percentages were 49 (AUC of 0.812; 95% CI, 0.772-0.851), 43 (AUC of 0.781; 95% CI, 0.748-0.825), and 60 (AUC of 0.837; 95% CI, 0.773-0.871), respectively. The proportions of patients whose functional scores achieved the CSO thresholds are listed in Table 3. There was no significant difference between the LHBT augmentation and no–LHBT augmentation groups in the MCID, SCB and PASS values of the ΔASES, ΔConstant, and ΔSANE scores. The proportions of patients who achieved the CSO threshold for the MOI were 70.4% (LHBT augmentation group) versus 37.5% (no–LHBT augmentation group) for the ΔASES score; this difference was significant (*P* = .011). There was no significant difference regarding the proportions of patients whose Constant scores and ΔSANE scores achieved the CSO threshold for the MOI between the LHBT augmentation and no–LHBT augmentation groups.

Radiographic Outcomes

Plain radiographs in the anteroposterior projection showed a mean AHD of 8.1 ± 2.2 mm and 7 ± 1.9 mm for the LHBT augmentation group and the no–LHBT augmentation group, respectively, at the 2-year follow-up; this difference was significant (*P* = .037) (Table 4). Graft integrity was evaluated using MRI at the 2-year follow-up; 16 patients in the LHBT augmentation group and 8 in the no–LHBT augmentation group exhibited intact graft contours. Partial-thickness bursal or articular-site graft tears were observed in 9 patients in the LHBT augmentation group and 6 patients

TABLE 3
CSO Thresholds and Intergroup Comparison of 2-Year Outcomes[a]

	2-Year Results from CSO analysis	AUC	LHBT Augmentation Group (n = 27) % Achieved	No–LHBT Augmentation Group (n = 16) % Achieved	*P*
ΔASES					
MCID	33	0.881	92.6	87.5	.308
SCB	47	0.802	70.4	50	.068
PASS	63	0.881	74.1	62.5	.242
MOI	49	0.812	70.4	37.5	.011[b]
ΔConstant					
MCID	21	0.802	92.6	100	.133
SCB	44	0.901	40.7	37.5	.382
PASS	31	0.801	70.4	81.3	.201
MOI	43	0.781	51.9	43.8	.268
ΔSANE					
MCID	45	0.921	92.6	93.8	.432
SCB	60	0.761	51.9	62.5	.399
PASS	75	0.921	77.8	81.3	.374
MOI	60	0.837	51.9	62.5	.296

[a]ASES, American Shoulder and Elbow Surgeons; AUC, area under the curve; CSO, clinically significant outcome; LHBT, long head of the biceps tendon; MCID, minimal clinically importance difference; MOI, maximal outcome improvement; PASS, Patient Acceptable Symptom State; SANE, Single Assessment Numeric Evaluation; SCB, substantial clinical benefit.
[b]A p-value less than 0.05 indicates statistical significance.

TABLE 4
Radiographic Analysis and Comparison[a]

	LHBT Augmentation Group (n = 27)	No–LHBT Augmentation Group (n = 16)	*P*
AHD, mm	8.1 ± 2.2	7 ± 1.9	.037[b]
Graft tear	11 (41)	8 (50)	.320
Partial thickness	9	6	
Full thickness	2	2	
Graft tear pattern			
Glenoid site	1	4	
Midsubstance	5	2	
Tuberosity site	5	2	

[a]Values are presented as mean ± SD, n (%), or n. AHD, acromiohumeral distance; LHBT, long head of the biceps tendon.
[b]A p-value less than 0.05 indicates statistical significance.

in the no–LHBT augmentation group; complete tears were observed in 2 patients in the LHBT augmentation group and 2 patients in the no–LHBT augmentation group. The graft tear rates were 41% (11 patients) in the LHBT augmentation group and 50% (8 patients) in the no–LHBT augmentation group; this difference was not significant (P = .320). Regarding the graft tear pattern, there were 1 and 4 glenoid tears, 5 and 2 midsubstance tears, and 5 and 2 tuberosity tears in the LHBT augmentation group and no–LHBT augmentation group, respectively.

DISCUSSION

The major finding of this study is that patients undergoing autologous FL SCR with in situ LHBT augmentation achieved similar PROs and better restoration of AHD compared with those without LHBT augmentation. CSO thresholds were established by performing ROC curve analysis based on anchoring methods after the prevalidation of preoperative and postoperative differences in functional scores. Optimal cutoff values for the MCID, SCB, PASS, and MOI were determined for the ΔASES, ΔConstant, and ΔSANE scores, with acceptable or excellent AUC values (>0.7). Because of the nonsignificant difference in ΔVAS scores between the unchanged and changed groups, the ΔVAS threshold was not used for CSO comparison. We also noticed that a high percentage of patients achieved the level of MCID in all 3 functional scores, although approximately one-third of patients subjectively felt unchanged at the time of the survey. Given the similar MCID thresholds reported in other SCR

studies,[6,33] further investigation in a larger cohort is crucial to better clarify the roles of CSO analyses in PROMs regarding minimal difference and maximal satisfaction while avoiding potential ceiling effects. Nevertheless, this study is the first to compare outcomes between SCR with and without LHBT augmentation. Furthermore, this is the first study of CSO that includes an MOI survey for SCR in the usage of FL autografts.

The role of the superior capsule is increasingly recognized as essential for maintaining a stable pivot point in the glenohumeral joint when the rotator cuff is not functioning properly.[1] Recent biomechanical research conducted on 7 cadavers has suggested that the superior capsule not only acts as a spacer under the acromion but also plays a stabilizing role in all directions of the glenohumeral joint.[19] SCR, initially proposed by Mihata et al[26] using a folded FL autograft, has gained significant attention due to its positive outcomes, raising general concerns about graft usage and technique refinement.[2]

In a previous study of SCR using FL grafts, CSO thresholds were determined in relation to VAS, ASES, Constant, and SANE scores based on patient responses and satisfaction at a 1-year follow-up.[13] However, issues may arise regarding the ceiling effect of MCID and SCB; furthermore, individual-level data outside the range in which these values are relevant may lead to a misinterpretation of the results.[9] The concept of MOI was previously adopted in shoulder surgery to establish the threshold for maximal predictability of excellent satisfaction based on ROC analysis.[4,5,12] In our study, the MOI threshold was established and calculated; the percentage of patients who surpassed the threshold percentages for achieving ΔASES MOI was significantly greater in the LHBT augmentation group compared with the no–LHBT augmentation group for 2-year outcomes, while other patient-level metrics showed no significant difference. The assessment of MOI emerges as a complement to the "tiered evaluation system" of MCID, PASS, and SCB.[4] The threshold of achieving MOI is normalized by the maximal possible improvement in each patient. Consequently, MOI allows for setting a higher standard for a better outcome compared with MCID, which denotes the minimal functional change postsurgery deemed meaningful by patients. As there is still a limited number of mid- to long-term reports in FL SCR, our finding in CSO analyses may suggest the determination of the MOI threshold as one of the essential patient-level metrics in CSO research with longer observations.

The SCR technique using FL autografts was originally developed by Mihata et al,[26] and the biomechanical study showed that sufficient thickness of the FL graft was mandatory to restore superior stability[28] and to regain a stable fulcrum in the presence of rotator cuff dysfunction.[1] Lee and Min[22] performed a clinical study and found a correlation between the thickness of the graft and the enhancement of the AHD after arthroscopic SCR. Furthermore, their findings indicated that inadequate improvement in AHD served as a predictive factor for graft tear after the surgical procedure. A sandwich graft technique was proposed in combination with a synthetic scaffold patch and yielded feasible 2-year outcomes with a high rate of graft healing and improved AHD owing to a spacer effect.[6] We followed the technical principles in using LHBT as an augment, which was previously published in 2 articles.[8,18] In our study, better restoration of AHD was observed in the augmentation group, which could be attributed to the combined thickness of the FL graft patch and LHBT. There are theoretical reasons to use the biceps for FL SCR augmentation. First, the LHBT contains a high concentration of tenocytes, which closely resembles the physiological requirements of the rotator cuff tendon. This similarity makes the LHBT a suitable graft for augmentation in rotator cuff tendon repairs and capsular reconstructions.[29] Second, the LHBT plays a crucial role as a stabilizer for the glenohumeral joint and is readily accessible in most patients. Combining LHBT with an FL graft patch can provide an additional stabilizing effect, particularly against anterior translation, while also improving force coupling.[13] Last, during the index surgery, the FL graft patch is further stabilized by suturing it to the proximal LHBT rather than to the subscapularis tendon in addition to anchor fixation in the glenoid side. This approach alleviates concerns about shoulder stiffness resulting from the closure of the rotator interval.[24]

Limitations

This study has several limitations that should be considered. These limitations include a small sample size, exclusion of partially satisfied patents during prevalidation analysis, and only a short-term follow-up duration. Furthermore, due to the retrospective design of the study, there was no randomization in the recruitment of patients. Importantly, the surgical decision and availability of LHBT were determined based on arthroscopic inspection prior to the reconstruction procedures. Therefore, the technique described in this study is presented as an augmentation to the original FL SCR surgery rather than a substitution. In addition, given the lack of preclinical cadaveric research, we could not determine the mechanical superiority of biceps augmentation, if any. Last, all surgeries included in this report were performed by a single surgeon, which could have led to bias in the outcome analysis.

CONCLUSION

There was no significant difference in PROs and percentage of patients achieving MCID, SCB, and PASS between isolated and augmented SCR groups. A higher percentage of patients achieving MOI and slightly greater AHD were found in the augmented group. Further evaluation is required to determine if there is any long-term benefit to LHBT augmentation of SCR.

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