Superior capsular reconstruction using the long head of the biceps does not negatively affect outcomes in terms of pain or stiffness in the repair of large rotator cuff tears at 6 months post-operatively: matched-pair design for equivalence study

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Purpose: The long head of the biceps tendon (LHBT) is considered a pain generator, and some concerns could be raised if used for superior capsule reconstruction (SCR). The goal is to analyze, in a study of equivalence, the complications and the clinical outcomes in patients who underwent a repair associated with SCR using the LHBT for an irreparable supraspinatus tear (with reparable infraspinatus and subscapularis tendons) and those with an isolated repair in case of reparable rotator cuff tear.

Methods: Twenty-six patients (27 shoulders) in the "SCR" group were matched to twenty-seven patients (27 shoulders) in the "Isolated Repair" group, all Collin type C or D. Follow-up evaluation included complications, pain, subjective shoulder value (SSV), corticosteroid infiltrations and range of motion (ROM). An ultrasound at 6 months was performed to assess tendon healing.

Results: Both techniques were equivalent for all ROM at 6 months, average pain, and pain improvement post-operatively. The average SSV and the SSV improvement were significantly greater for the SCR group. There were no differences in tendon healing or frequency of postoperative injections.

Conclusions: The main finding of this study is that using the LHBT does not add morbidity such as pain or stiffness, despite the proximal portion being considered as a pain generator. SCR using the LHBT does not cause any additional complications and clinical outcomes are equivalent at 6 months to those of an isolated repair of rotator cuff tears.

Keywords: Arthroscopic; Equivalence study; Long head of the biceps; Rotator cuff tears; Superior capsular reconstruction

Study design: Retrospective comparative study

Level of evidence: Level III

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Introduction

An irreparable rotator cuff tear (RCT) is a peri-operative definition [1] corresponding to the of the inability to achieve direct repair of native tendon to the humeral greater tuberosity despite an intra and extra-articular release of the remaining tissue. This finding results from muscle fatty infiltration and excessive chronic tendon retraction and degeneration, which cause high failure rates of direct repairs [2][3]. Nowadays, when repair is impossible, various superior capsular reconstruction (SCR) techniques are described to avoid progression to cuff tear arthropathy. The procedures can use biological tissues such as autograft (fascia lata, long head of biceps tendon) [4][5][6][7], dermal allograft [8][9][10][11][12][13], and non-biological synthetic patch [14]. The arthroscopic surgical technique using the long head of the biceps tendon (LHBT) named « the Chinese Way » has been described by Boutsiadis et al. [4]. The LHBT mechanical properties and the resistant force for superior humeral migration have been validated by cadaveric biomechanical studies [15][16]. Using the LHBT as a superior static stabilizer is achieved without applying any materials to the glenoid and without any additional incisions for tendon harvesting [4]. However, the LHBT has been thought to be a pain generator, and some questions persist in using a pathological tissue to achieve a superior capsular reconstruction [17][18][19][20]. There is concern that there could be increasing pain or stiffness with such a procedure despite promising short-term clinical outcomes [21][22]. Still, no long-term study has yet been done to evaluate if this technique could stop the natural history of massive posterosuperior rotator cuff tears. Even though infraspinatus integrity seems to be preserved in the short term [23]. The purpose of our article is to compare, in an equivalence study, the complications and the clinical outcomes in patients who underwent a repair associated with SCR using the LHBT for an irreparable supraspinatus tear (with reparable infraspinatus and subscapularis tendons) and those with an isolated repair in the case of reparable posterosuperior rotator cuff tear. We hypothesize that SCR using the LHBT for an irreparable supraspinatus tear is equivalent in terms of complications and clinical outcomes at 6 months after surgery to a rotator cuff tear isolated repair (RCTIR).

Materials and Methods

Cohort

With approval of the institutional review board of the Centre Ostéo-Articulaire des Cèdres (COAC IRB #2018-06), a retrospective comparative study was conducted for all patients who underwent a large or massive posterosuperior RCT surgery in patients with Collin type C or D [24] by the same experienced surgeon (J.B.) between January 2017 and June 2018. For this period, the inclusion criteria were age ≥18 years, rotator cuff tear with radiographic changes Hamada [25] 2 or less, no neurological lesions, and surgery performed arthroscopically. The exclusion criteria were patients with one tendon tear or with prior surgery on the ipsilateral shoulder, repair with the use of a dermal patch.

Pre-operative assessments

The expert physiotherapist (P.D.) used a goniometer to measure pre-operative ranges of motions (ROM): active forward elevation (AFE), external rotation 1 (ER1), and internal rotation 1 (IR1) relative to spinal segments [26] while standing. With the patient lying down, the physiotherapist measured passive forward elevation (PFE). The pre-operative subjective shoulder value (SSV) and pre-operative visual analog scale (VAS) pain rating (0-10) were also recorded (**Table 1**). Patients were operated on only if they did not have shoulder stiffness.

Surgical technique

The surgical technique for SCR using the LHBT has been described in detail previously [4].

The quality of the LHBT was analyzed and mentioned if it presented tenosynovitis or frayed abnormalities. In brief, with the aid of the radiofrequency cautery device, the biceps tendon was dissected and tenotomized approximately at the middle of the bicipital groove. No tenodesis was performed on the distal part of the LHBT. The LHBT was transferred and securely fixed onto the footprint of the supraspinatus tendon on the greater tuberosity acting as a superior static stabilizer of the shoulder joint. Therefore, the biceps tendon, natively fixed on the glenoid, acted as the autograft for SCR. Moreover, side-to-side fixation of the infraspinatus (and eventually remnants of the supraspinatus) with the LHBT was achieved to prevent any later posterior retraction of the tendon.

In cases of lesions without significant retraction of the infraspinatus, depending on the tear size, a classic independent double row or a suture bridge technique was performed. In some cases, a concomitant acromioplasty and/or a resection of the distal clavicle were performed (according to Critical Shoulder Angle and symptomatic acromioclavicular joint).

Postoperative Rehabilitation

Post-operatively for the « SCR group », the arm was placed in an abduction pillow at 60°, which was generally maintained for 6 weeks. However, active hand, wrist, and elbow exercises were allowed from the first day, and progressive passive shoulder mobilization was started 30 days postoperatively.

For the « RCTIR group», the arm was placed in an abduction pillow at 20°, which was generally maintained for 6 weeks. Unlike the « SCR group », progressive passive shoulder mobilization was started immediately after surgery.

For both groups, no strengthening or resistance exercises were allowed before 6 months.

Clinical assessment

Operative notes were retrieved to report various lesions of the LHBT (**Table 1**), repair arthroscopic techniques, and any peri-operative complications. Follow-up assessments at 1.5 months, 3 months, 4.5 months, and 6 months were performed by the same expert physiotherapist (P.D.) without having pre-operative assessments available. The physiotherapist evaluated (i) any postoperative complications (hematoma, sepsis, neurological lesions, complex regional pain syndrome, etc.), (ii) shoulder pain on VAS, (iii) corticosteroid injections in the sub-acromial bursae in cases of pain, (iv) post-operative time, ROM comprising AFE, ER1, and IR1 in the standing position and PFE while lying down, and (v) SSV. Both techniques were considered equivalent for a difference in motion of +/- 11 ° for AFE, PFE, and ER1; and for +/- 2 vertebral segments for IR1.

An ultrasound performed by an expert physician was performed for all patients at 6 months to evaluate tendon healing.

Statistical Analysis

Power calculations of data collection determined that a minimum sample size of 16 subjects by group was required to have an 80% chance ($\alpha = 0.05$, $\beta = 0.2$) of detecting a difference in each ROM of 11 degrees between the two groups for AFE, PFE, ER1 and 2 vertebral segments for IR1. The comparisons between pre-operative data used Fisher f test, Student t test or Khi2. Mann-Whitney U test was performed to compare clinical outcomes between both groups. Paired two one-sided test (TOST) [27] procedures were used to test equivalence of means. Confidence intervals (CI) were set at 95%. Differences were considered significant for p-value < .05.

Table 1. Study Patient Characteristics

	SCR group (n = 27)	RCTIR group (n = 27)	P Value
Male sex, n (%)	21 (77.8)	20 (74)	1
Mean age at surgery, y (range)	59.7 (47-80)	56.7 (43-73)	.447
Surgery on dominant shoulder, n (%)	17 (63)	15 (56)	.79
Mean pre-operative pain, VAS (range)	4.3 ± 2.9 (0-10)	4.9 ± 2.7 (0-9)	.331
Mean pre-operative SSV, n (range)	38.3 ± 17.9 (10-80)	47.4 ± 22.6 (10-100)	.117
Pre-operative AFE motions, ° (range)	149.1 ± 24.5 (50-180)	150 ± 30.6 (30-180)	.457
Pre-operative PFE motions, ° (range)	153 ± 11.2 (140-180)	157.4 ± 13.5 (135-180)	.208
Pre-operative ER1 motions, ° (range)	56.5 ± 14.8 (20-80)	60.7 ± 17.6 (10-80)	.115
Pre-operative IR1 motions, ° (range)	9.5 ± 2.3 (6-14)	10.2 ± 2.1 (4-13)	.164
Rotator cuff tear - Collin et al. classification[6], n (%)	type C: 14 (52)	type C: 17 (63)	.580
	type D: 13 (48)	type D: 10 (37)	
Supraspinatus tear - Patte classification[14], n (%)	type 1: 0	type 1: 16 (59.3)	< .0001
	type 2: 5 (18.5)	type 2: 9 (33.3)	
	type 3: 22 (81.5)	type 3: 2 (7.4)	
Goutallier classification[29], n (%)			
Supraspinatus fatty infiltration	grade 0: 6 (22.2)	grade 0: 20 (74.1)	< .0001
	grade 1: 4 (14.9)	grade 1: 5 (18.5)	
	grade 2: 7 (25.9)	grade 2: 2 (7.4)	
	grade 3: 9 (33.3)	grade 3: 0	
	grade 4: 1 (3.7)	grade 4: 0	
Infraspinatus fatty infiltration	grade 0: 7 (26)	grade 0: 24 (88.9)	< .0001
	grade 1: 8 (29.6)	grade 1: 3 (11.1)	
	grade 3: 8 (29.6)	grade 3: 0	
	grade 4: 4 (14.8)	grade 4: 0	
Subscapularis fatty infiltration	grade 0: 24 (88.9)	grade 0: 25 (92.6)	.114
	grade 1: 0	grade 1: 2 (7.4)	
	grade 3: 3 (11.1)	grade 3: 0	
Distal clavicle excision, n (%)	1 (3.7)	3 (11.1)	.611
Acromioplasty, n (%)	19 (70.4)	27 (100)	.005
LHBT tear, n (%)	tenosynovitis: 14 (51.9)	tenosynovitis: 13 (48.1)	.613
	frayed: 12 (44.4)	frayed: 13 (48.1)	
	healthy: 1 (3.7)	healthy: 0	
	ruptured: 0	ruptured: 1 (3.8)	

Abbreviations: VAS, Visual Analog Scale; SSV, Subjective Shoulder Value; AFE, Active Forward Elevation; PFE, Passive Forward Elevation; ER1, External Rotation 1; IR1, Internal Rotation 1; LHBT, Long Head Biceps Tendon.

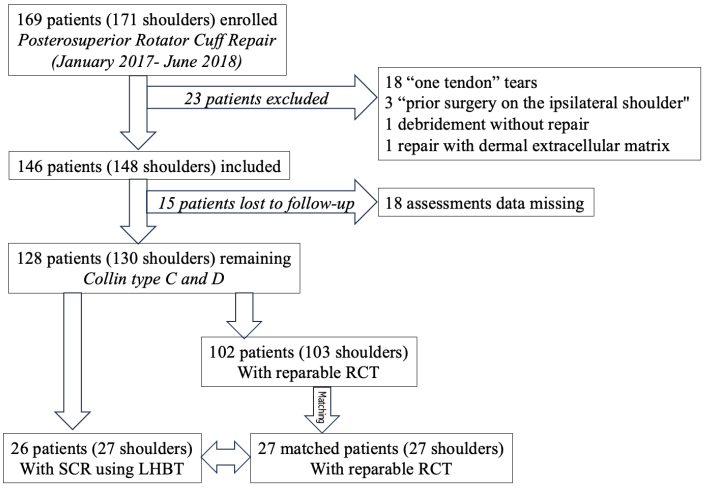

Figure 1. Flowchart detailing inclusion and exclusion of patients from the original cohort.

Results

A total of 169 patients (171 shoulders) Collin type C and D were enrolled, of which 23 patients (23 shoulders) were excluded and 15 with missing data, who were considered lost to follow-up. Among 128 remaining patients (130 shoulders), all patients were included in the « SCR group » if the LHBT was used for SCR in cases of RCT with irreparable retracted, degenerated supraspinatus tendon, and with reparable infraspinatus and subscapularis tendons if they were torn. Patients within the control group were matched to "SCR group" patients by nearest neighbor matching among the 102 patients (103 shoulders) who had not undergone SCR. Finally, a paired patient was selected with the same number of cases i.e. 27 shoulders (**Figure 1**), totaling 53 patients (54 shoulders) available for the study, all had post-operative ultrasound records at 6 months (**Table 1**).

Both populations were comparable (**Table 1**), with no significant differences in pre-operative clinical scores between the 2 groups regarding, age, sex, dominant side operated, pre-operative range of motion, pain (VAS), SSV and distal clavicle excision. Concerning tendon tears, there was no significant difference in the Collin et al. classification and Goutallier classification for subscapularis. Supra and infraspinatus tears were more severe in the SCR group, as expected: Goutallier classification and Patte classification for supra-spinatus (P < .0001) and Goutallier classification for infra-spinatus (P < .0001).

Both techniques were equivalent for all ranges of motion at 6 months: equivalent for a difference in AFE of +/- 11 ° (P < .05), PFE (P = .01), ER1 (P < .03) and in IR1 of +/- 2 vertebral segments (P < .05) (**Table 2**). At 6 months post-operatively, there is no significant difference in average pain (P = .23) or for pain improvement (P = .9). The average SSV and the improvement of the SSV were significantly greater for the SCR (respectively, P = .03 and P = .04). There was no difference in tendon healing on ultrasound (P = 1) or frequency of infiltrations (P = .4) (**Table 3**). No acute complications were reported in either group.

Figure 2 represents the boxplots of the range of motion at each follow-up assessment. There was no statistical difference between groups except for the M3 timepoint for ER1 in the SCR group (P = .007).

At 6 months post-operatively no significant difference between the 2 groups was observed in average pain (P = .5), average SSV (P = .6), improvement of the pain (P = .8), improvement of the SSV (P = .07), improvement of the AFE (P = .5), of the PFE (P = 1), of the ER1 (P = .8) and of the IR1 (P = .9).

Table 2. Post-operative range of motion at 6 months - equivalence analysis

	SCR group (n = 27)	RCTIR group (n = 27)	P Value
Equivalence ROM ± 11°			
AFE, ° : mean ± sem [range]	150.4 ± 3.9 [110-180]	152.4 ± 3.6 [100-180]	
difference of means 90% CI	] -10.82 ; 6.75 [		< .05
PFE, ° : mean ± sem	155.7 ± 3.1 [120-180]	154.8 ± 2.9 [125-180]	
difference of means 90% CI	] -6.14 ; 8.00 [		.01
ER1, ° : mean ± sem [range]	46.7 ± 3.8 [5-80]	45.6 ± 3.5 [10-75]	
difference of means 90% CI	] -7.43 ; 9.65 [		.03
Equivalence ROM ± 2 vertebral segments			
IR1,° : mean ± sem [range]	7.6 ± 0.6 [3-14]	8.2 ± 0.6 [3-13]	
difference of means 90% CI	] -1.98 ; 0.72 [		< .05

Abbreviations: CI, Confidence interval; ROM, Range Of Motion; AFE, Active Forward Elevation; PFE, Passive Forward Elevation; ER1, External Rotation 1; IR1, Internal Rotation 1.

Discussion

SCR using the LHBT for an irreparable RCT is equivalent in terms of complications and clinical outcomes at 6 months after surgery to a RCT isolated repair. The main finding of this study, is that using the LHBT does not add morbidity e.g. pain or stiffness although this portion of the tendon was considered to be a pain generator in RCTs [17][18][19][20].

However, this procedure is limited by the quality of the tendon, and in particular its possible rupture. We have always been able to use the LHBT for SCR, even with a frayed tendon, which was the case in 12/27 cases. Pre-operative imaging can be used to check the continuity of the tendon. There is a common belief that using a damaged tendon can be a source of ongoing pain for the shoulder [17][18][19][20] but our results show no difference in clinical outcomes even when the LHBT used is tendonopathic or frayed.

Chillemi et al. [7] also observed that this technique is not associated with an increase in post-operative pain for the first 6 months.

Regarding improvements in function and pain using SCR techniques, other studies [6][7][8][28] confirm that the range of motion improves significantly, and that VAS score improves by an average of 5 points.

Recently several SCR techniques have been described (fascia lata, dermal allograft, long head of the biceps or synthetic patch) [4][5][6][7][8][9][10][11][12][13][14] and less complications have been reported with the LHBT [29]. The use of fascia lata or patch are more technically demanding procedures. Mihata et al. [30] reported complications, such as anchor pull-out, severe shoulder stiffness, and infection. SCR using the LHBT is not a technically demanding surgical procedure; is simple, reproducible, and inexpensive. The tendon acts as a vascularized graft, bridging rotator cuff muscle remnants to the anatomical supraspinatus footprint on the humeral greater tuberosity, and as a material for superior capsular reconstruction. Other authors also agree on the unique advantages of using the LHBT for SCR [4][7][31], which include lack of donor site morbidity, using a tendon for SCR, which is biomechanically superior to dermal allograft, maintenance of graft vascularization, and its local availability and no cost. Additionally, side-to-side suturing anteriorly and posteriorly integrates the graft into the native residual rotator cuff tissue, resulting in the restoration of anterior and posterior force couples [4][7]. We propose that SCR using the LHBT is a reasonable treatment option for younger patients with posterosuperior large RCTs to avoid tendon transfer or reverse total shoulder arthroplasty [8][28][30][31].

We emphasize that although the results of both groups were equivalent in terms of clinical outcomes, the SCR group was immobilized with a more cumbersome abduction pillow and started rehabilitation later, at 30 days postoperatively. This conservative rehabilitation protocol could have contributed to stiffness and pain. In the future, it may be advisable to begin rehabilitation earlier, which may allow quicker recuperation of ROM [32][33][34].

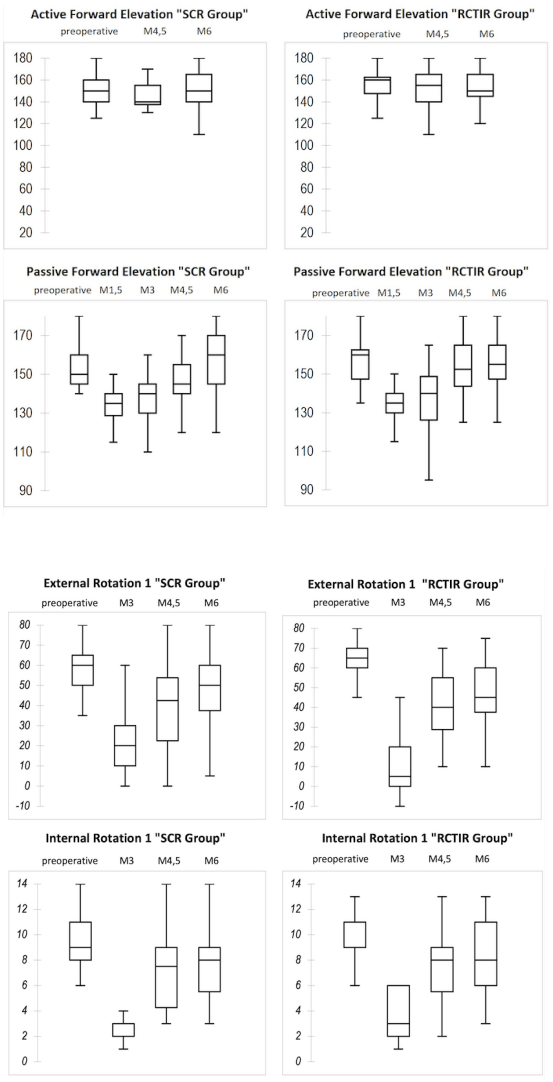

Figure 2. Range of motions at each follow-up assessment. No statistical difference between the both groups except for M3 for ER1 in the SCR group (P=.007).

Table 3. Postoperative clinical outcomes at 6 months

	SCR group (n = 27)	RCTIR group (n = 27)	P Value
Mean SSV, n (range)	70.0 ± 16.2 (30-100)	60.2 ± 25.3 (10-100)	.03
SSV Improvement, n (range)	31.7 ± 25.5 (-20-80)	12.8 ± 34.5 (-55-70)	.04
Mean pain, VAS (range)	0.93 ± 1.2 (0-3)	0.4 ± 0.9 (0-3)	.23
Pain Improvement, VAS (range)	3.3 ± 2.6 (0-10)	4.6 ± 2.6 (-2-9)	.9
Cuff integrity (ultrasound), n (%)	25 (92.6)	25 (92.6)	1
Corticosteroid infiltrations, n (%)	9 (33.3)	13 (48)	.4

Abbreviations: SSV, Subjective Shoulder Value; VAS, Visual Analog Scale; LHBT, Long Head Biceps Tendon.

Our study is limited by the retrospective study design and the loss of follow-up of 10% of our patients, as well as the lack of power analysis, and the absence of a randomized controlled trial to select both groups. Another limitation of this equivalence study is the difference between groups in the severity of supraspinatus and infraspinatus tears. Indeed, in the SCR group, lesions were more severe. However, it is precisely this difference that justifies a reconstruction for these irreparable rotator cuff tears. Furthermore, regarding the measurement of ROM, patients were evaluated with a goniometer by the same independent senior physiotherapist pre-and post-operatively, thus limiting measurement error. To the authors' knowledge, this study, which comprises a cohort of consecutive patients operated on by a single surgeon, is the first equivalence study of complications and clinical outcomes of SCR using the LHBT.

Conclusion

SCR using the LHBT is a simple and reliable technique. We did not demonstrate worse complications, and we showed that the clinical outcomes of ROM, function and pain are equivalent at 6 months to those of an isolated repair of rotator cuff tears.

Conflicts of interest: None

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