Capsular Repair Matters for Residual Micromotion After Latarjet. An Externally Controlled Trial from the LaTour Group

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Background: Even though surgery is commonly used to treat glenohumeral instability, there is no evidence that such treatment effectively corrects glenohumeral translation.

Purpose: This study aimed to analyze the effect of a new capsular reconstruction on residual micromotion after Latarjet procedure.

Methods: Bilateral glenohumeral translation was assessed in nine patients preoperatively and one year postoperatively following Latarjet with a new capsular reconstruction (treatment group). Translation was measured using optical motion capture, computer tomography (CT) reconstructions, and 3--dimensional (3D) simulation. The results were compared with a previous cohort of eleven patients operated with traditional capsular reconstruction (control group).

Results: A total of 20 patients were included in this study. The median follow-up duration was 12 months (range, 12 to 16 months). A statistically significant improvement in shoulder pain and function was reported postoperatively in treatment and control groups. No patients reported recurrent dislocation during the study period or had a positive apprehension sign at the final follow-up. The preoperative to postoperative range of motion (ROM) improvement was more pronounced in the treatment group than the control group with respect to shoulder flexion (P = .001), abduction (P = .041), and internal rotation with elbow at side (P = .035) for thoracohumeral motion, and shoulder abduction (P = .037), and internal rotation at 90/90 position (P = .006) for glenohumeral motion. The treatment group also exhibited more significant preoperative to postoperative reduction in anteroposterior translation during shoulder internal and external rotation with the elbow at the side (P = .018 and .016, respectively).

Conclusion: This study demonstrated that a new type of capsulolabral reconstruction during the Latarjet procedure could reduce residual anteroposterior micromotion compared with a previously used technique, without compromising postoperative ROM. Although no differences in clinical apprehension were observed between groups, these biomechanical findings support the hypothesis that careful capsular management may influence postoperative shoulder stability. Whether this effect translates into long-term clinical benefit remains to be established in larger studies with extended follow-up.

What this study adds:

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Potential impacts on research, practice or policy:

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Study Design: Prospective Externally Controlled Trial

Level of Evidence: Level II (prospective comparative study)

Keywords: Glenohumeral stabilization; Subtle or minor instability; Unstable painful shoulder; Apprehension; Dislocation; Kinematics modeling; Biomechanics; Motion capture; 3D simulation; Computer tomography (CT).

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Introduction

The prevalence of long-term persistent postoperative glenohumeral apprehension after the Latarjet procedure has been documented to range from 3.4% [1] to 28% [2]. Its underlying mechanisms remain insufficiently characterized. Shoulder stabilization may only prevent new episodes of dislocation rather than indeed stabilizing the shoulder [3]. Theoretically, such apprehension after glenohumeral stabilization could be related to central nervous system sequelae secondary to a traumatic dislocation event [4][5], peripheral neurological lesion consecutively to dislocation affecting proprioception [6], or residual mechanical instability of the glenohumeral joint [7][8].

Time and muscle reconditioning seem to allow progressive brain healing by promoting central nervous system plasticity, a phenomenon through which structural and functional reorganization of neural pathways occurs, restoring proprioceptive integration and motor control after traumatic dislocation [9][10]. Residual mechanical instability can be mitigated with augmented surgical techniques such as Bankart remplissage, which reduce the sense of apprehension [11]. Improved capsular reconstructions have been proposed in combination with the Latarjet procedure, but their impact on residual micromotion remains uncertain [12][13].

The purpose of this study was to evaluate the effect of different types of capsular reconstruction after the Latarjet procedure on glenohumeral translation in patients suffering from anterior instability. We hypothesized that capsulolabral reconstruction would play a role in anteroposterior translation.

Methods

Patient Selection

The present prospective clinical trial was externally controlled using data from a previously published comparative prospective trial of eleven patients operated on by the same surgeon with an identical evaluation protocol. No formal matching procedure was applied between the two cohorts. Instead, baseline characteristics of the treatment and control groups were compared, and no statistically significant differences were found regarding age, gender, body mass index (BMI), involved side, dominant side, history of trauma, or profession. This ensured the comparability of the two groups without requiring explicit matching [3]. Institutional review board approvals were obtained prior to studies beginning (CCER 2019–02469). Written informed consent was obtained from all participants. From May 2020 to August 2020, twelve patients who underwent a Latarjet procedure performed by the senior author (A.L.) Hôpital de La Tour who fulfilled one or more of the following criteria were included in the study: anterior shoulder instability with (A) glenoid bone defect >20%, contact athlete, or failed either open or arthroscopic Bankart repair, (B) informed consent as documented by signature, (C) age between 18 and 65 years. Participants were excluded if any of the following criteria were present: (A) preoperative subscapularis tear, (B) polytrauma inducing significant limitation of a rehabilitation program, (C) significant other trauma of the involved upper arm (e.g., associated scapular or clavicular fractures, acromioclavicular dislocation), (D) preoperative stiffness (defined by active and passive loss of motion in at least two directions, abduction and anterior elevation <100 degrees, external rotation <20 degrees, internal rotation <L3), (E) dislocation arthropathy [1], (F) patients suffering from symptomatic anemia or patients with severe cardiorespiratory insufficiency, (G) known or suspected non-compliance, drug or alcohol abuse, (H) patients incapable of judgment or under tutelage, (I) inability to follow the procedures of the study, e.g., due to language problems, psychological disorders, dementia, and contraindication for CT scan (i.e., pregnancy) of the participant, (J) enrolment of the investigator, their family members, employees, and other dependent persons, and (K) patients with hyperlaxity [14] defined as more than 85 degrees of glenohumeral external rotation with the elbow at the side [15].

Operative Technique

All operations were performed in a semi-beach chair position under general anesthesia with a single-shot interscalene block or continuous catheter. Open Latarjet was performed as classically described [16] with a subscapularis split [17] and a triple locking mechanism approach [18]. The graft remained intra-articular in every case.

Control Group

In the control group, the labrum was removed, and the capsule was reinserted into the glenoid (**Figures 1 and 2**) [19]. Two sutures were run in a U form through the flap for “south-north” retention. The capsular sutures were knotted, and the inferior capsule flap stretched upward, with the arm held in 50 degrees external rotation [19].

Treatment Group

In the actual series, the labrum was kept and reattached with two sutures on the glenoid thanks to one or two suture anchor(s), creating a bump effect (**Figure 3**). The anterior capsule was then reattached to the coracoacromial ligament remnant using two sutures (**Figure 4**). To limit residual anterior instability [3], a maneuver including a reduction of the humeral head during capsulolabral reconstruction as described by Nabergoj et al. [13] was performed. While the operated arm was held in glenohumeral external rotation to avoid the postoperative rotational deficit, the humeral head was reduced posteriorly in the center of the glenoid during adduction, slight anterior forward flexion, and a posterior lever push. Only then was adequate capsular tension expected.

Postoperative Rehabilitation

Postoperative rehabilitation was identical in both groups. The arm was protected in a sling for three to four weeks [20][3]. Postoperatively, an immediate passive, active assisted movement was allowed. Return to low-risk sports was permitted after six weeks, while high-risk activities such as throwing and collision sports were allowed between three and 4.5 months.

Clinical Evaluation

The following baseline characteristics were assessed: age, gender, shoulder side, and arm dominance. Preoperatively and at one year follow-up, patients completed a visual analog scale (VAS) pain score graded from 0 points (no pain) to 10 points (maximal pain) [21], the subjective part of the Rowe score [22][4], and the single assessment numeric evaluation (SANE) instability [23] using tablets equipped with the Follow Health software (Follow Health, Rennes, France) while waiting in the reception area, ensuring unbiased results. Range of motion (ROM) and strength measurements were conducted in person by independent evaluators who were not part of the current study, under the supervision of the senior author (A.L.), ensuring the reproducibility of the results. Apprehension was defined as the presence of anxiety or fear of imminent dislocation when the arm was placed in an at-risk position during the physical examination, as assessed by the surgeon.

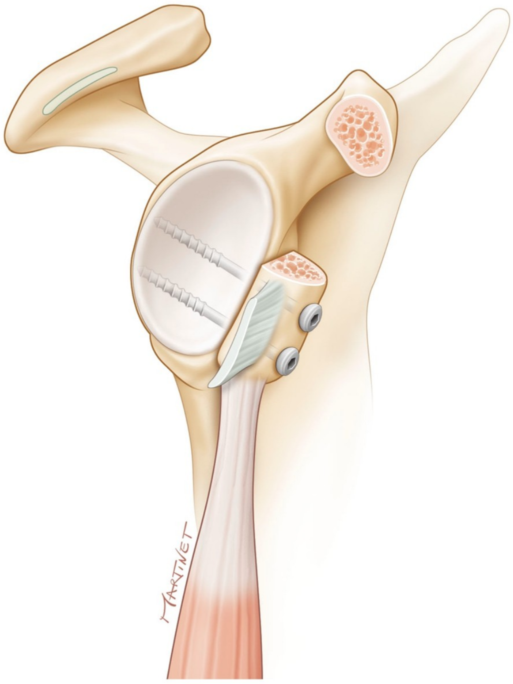

Figure 1: Illustration of a Latarjet procedure on a right shoulder. The labrum has been excised, and the bone graft is secured to the anterior glenoid using two screws.

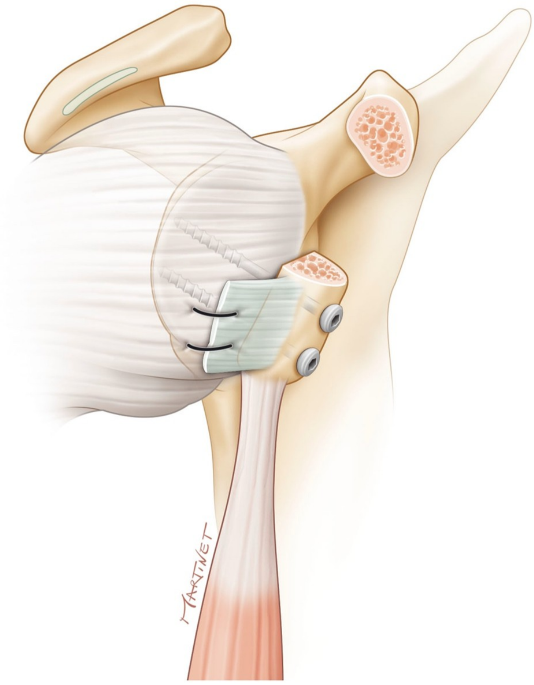

Figure 2: Illustration of a capsular reinsertion on a right shoulder. Two sutures are placed in a U-shaped pattern through the capsular flap for "south-to-north" stabilization. The sutures are tied with the arm in external rotation to allow controlled anterior subluxation of the humeral head.

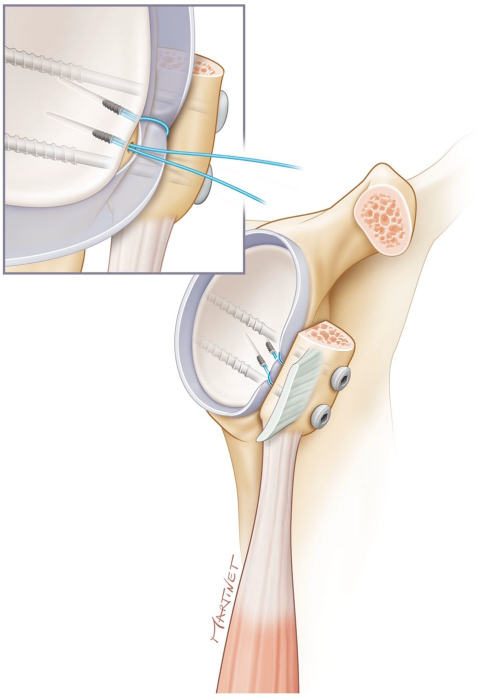

Figure 3: Illustration of a right-sided labral reinsertion between the glenoid and the bone graft, achieved using two suture anchors, which creates a "bump effect" at the graft-labrum junction.

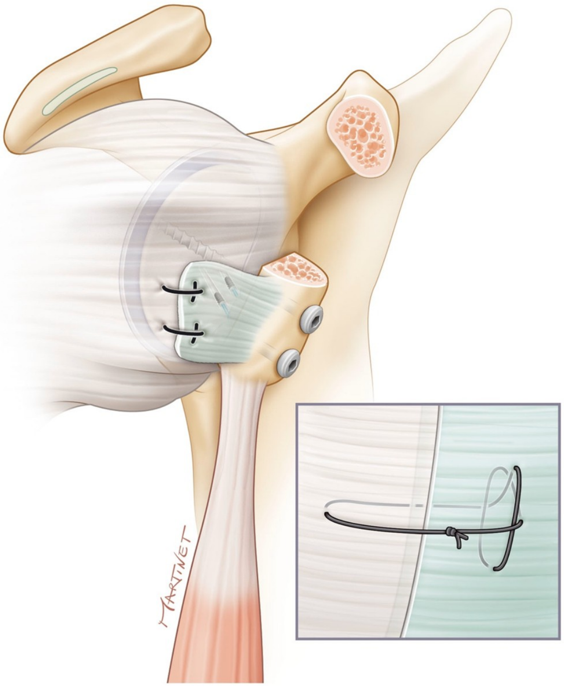

Figure 4: Illustration of a capsular reinsertion on the coracoacromial ligament using two Mason-Allen sutures. During this procedure, posterior reduction of the humeral head is performed to reduce anterior capsular redundancy.

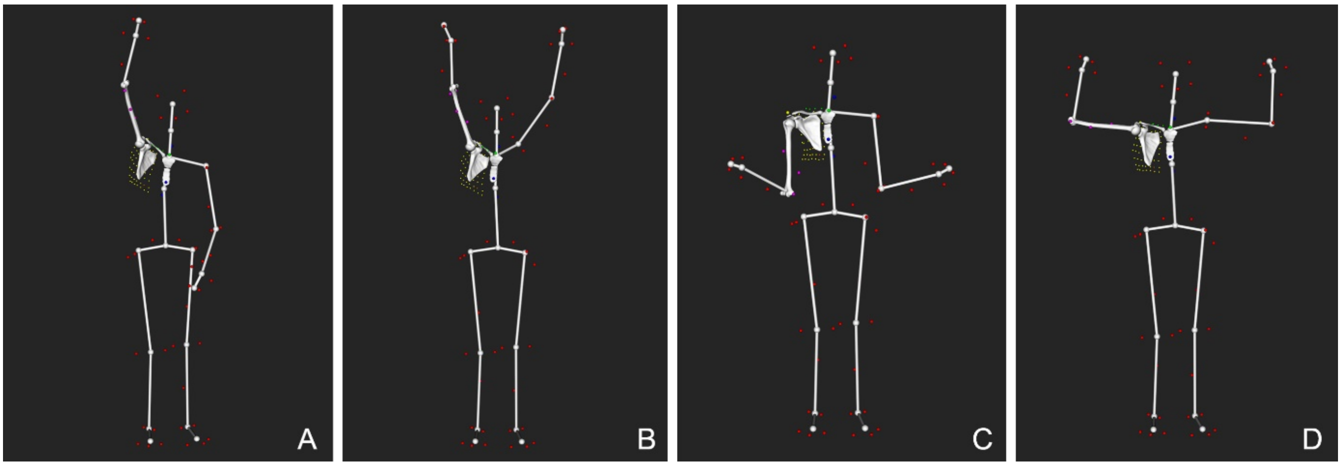

Figure 5: Examples of computed postures on a right shoulder showing the markers setup (small colored spheres) and a virtual skeleton used to better visualize the motion as a whole: (A) maximum flexion, (B) maximum abduction in the scapular plane, (C) maximum external rotation with elbow at side, and (D) maximum external rotation with 90 degrees of abduction and the elbow flexed 90 degrees.

Radiographic Evaluation

All patients underwent a preoperative computed tomography (CT) of bilateral shoulders and arms. The CT examinations were conducted with a LightSpeed VCT 64 rows system (General Electric Healthcare, Milwaukee, WI, USA). Images were acquired with a minimum 1 mm slice thickness. Based on the CT images, patient-specific three-dimensional (3D) models of the shoulder bones (humerus, scapula, clavicle, and sternum) were reconstructed for each patient using Mimics software (Materialize NV, Leuven, Belgium).

Motion Capture and Kinematic Analysis

All patients participated in motion capture sessions preoperatively, and one year postoperatively. Kinematic data were recorded using a Vicon MX T-Series motion capture system (Vicon, Oxford Metrics, UK) consisting of twenty-four T40S cameras sampling at 120 Hz. The patients were equipped with a previously described shoulder setup [24], which included sixty-nine spherical retroreflective markers. The setup included four markers (Ø 14 mm) on the thorax (sternal notch, xyphoid process, C7, and T8 vertebra), four markers (Ø 6.5 mm) on the clavicle, four markers (Ø 14 mm) on the upper arm – two placed on the lateral and medial epicondyles and two as far as possible from the deltoid – and fifty-seven markers on the scapula (1x Ø 14 mm on the acromion and a 7x8 grid of Ø 6.5 mm). Finally, additional markers (contralateral arm and legs) were distributed over the body to provide a global motion visualization.

During each session, the patients were asked to perform the following motor tasks (three trials each): (1) internal-external rotation with 90 degrees of abduction and the elbow flexed 90 degrees, (2) internal-external rotation with the arm at the side, (3) forward flexion of the arm from neutral to maximum flexion, and (4) empty-can abduction from neutral to maximum abduction in the scapular plane. Both shoulders (normal and unstable) were measured during the first session, whereas only the surgically stabilized shoulder was assessed postoperatively. Investigators from both control and treatment groups (CC, SC, VJ) attached all markers and performed all measurements.

Shoulder kinematics was computed from the recorded markers' trajectories using a validated biomechanical model which accounted for skin motion artifact [25][24]. The model was based on a patient-specific kinematic chain using the shoulder 3D models reconstructed from the CT data and a global optimization algorithm with loose constraints on joint translations (accuracy: translational error <3 mm, rotational error <4 degrees). **Figure 5** shows some examples of computed postures.

Maximal glenohumeral ROM was quantified for flexion, abduction, internal and external rotation, and expressed in clinical terms [26]. This was achieved by calculating the relative orientation between two local coordinate systems, one for the scapula and one for the humerus, based on the definitions suggested by the International Society of Biomechanics [27]. The local systems were created using anatomical landmarks identified on the patient's bony 3D models. The glenohumeral joint center was calculated based on a sphere fitting method [28]. To facilitate clinical comprehension and comparison, the motion of the humerus with respect to the thorax was also calculated. This was obtained with the same method by using thorax and humerus coordinate systems.

Glenohumeral translation, defined as anterior-posterior and superior-inferior motion of the humeral head center relative to the glenoid coordinate system [29], was assessed at maximal ROM during all tested movements. The coordinate system was determined by an anterior-posterior X-axis and a superior-inferior Y-axis, with an origin placed at the intersection of the anteroposterior and superoinferior aspects of the glenoid rim (**Figure 6A**). Subluxation was defined as the ratio between the translation of the humeral head center and the radius of width (anteroposterior subluxation) or height (superoinferior subluxation) of the glenoid surface (**Figure 6B**). Instability was defined as subluxation bigger than 50% [30].

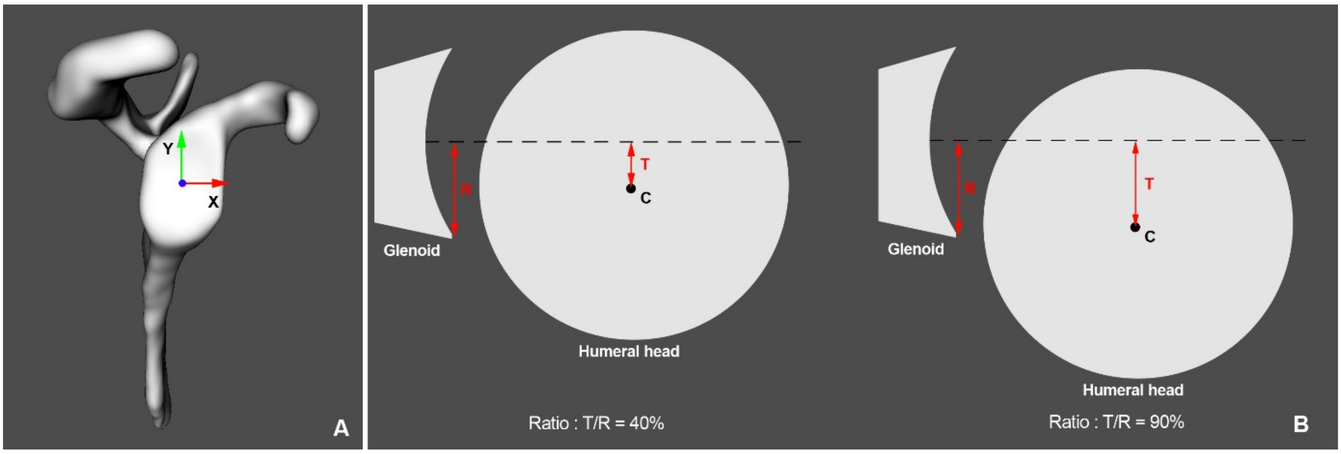

Figure 6: (A) Definition of the glenoid coordinate system used in this study. (B) Schematic representation of glenohumeral subluxation (C = center of the humeral head, R = radius of the width or height of the glenoid surface, T = translation of the humeral head center). Left: the ratio is 40%, there is no instability. Right: the ratio is >50%, instability is noted. Image reproduced from Lädermann et al.,(29) with permission.

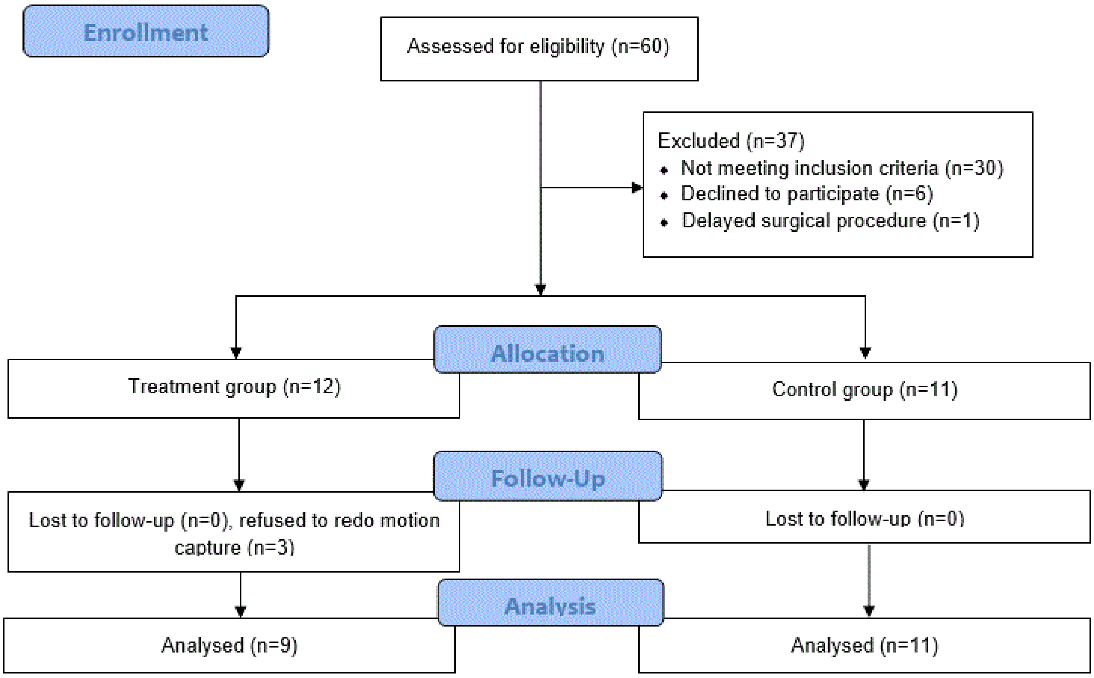

Figure 7: STARD flow diagram.

Study Outcomes

The primary outcome of interest was ipsilateral glenohumeral translation, assessed pre- and postoperatively, as well as contralateral glenohumeral translation. In addition, outcomes related to the primary endpoint were evaluated to provide a comprehensive assessment of shoulder function. These included pain using the VAS, subjective instability scores (Rowe and SANE), ROM of both the normal and unstable shoulders, and the presence or absence of apprehension. All outcomes were obtained with motion capture and complemented by clinical scoring systems.

Statistical Analysis

No formal power calculation was performed due to the complexity of the kinematic and CT-based analyses. Instead, the sample size was determined based on feasibility and on previous shoulder instability studies [29][31][32] using similar methodologies, as well as on the size of the previously published control cohort [3], which our treatment group was designed to match for methodological consistency. Statistical analysis was performed using SPSS Version 25.0 (IBM Corp, Armonk, NY). The normality of data distribution was evaluated using the Shapiro-Wilk Test. Quantitative variables were reported using median and interquartile range, while frequencies and percentages were used for the description of qualitative variables. Categorical variables were compared using the Chi-square test, while numerical variables were compared using the Mann-Whitney U test. Preoperative and postoperative results within each group were compared using Wilcoxon test. P value < .05 was considered to declare statistical significance.

Results

Three patients of the treatment group refused to redo the postoperative motion capture. A total of 20 patients were thus included for the final analysis (9 in the treatment group, 11 in the control group, **Figure 7**). The follow-up duration was 12 months (range, 12 to 16 months). Baseline characteristics of enrolled patients are compared in **Table 1**. No statistically significant difference was observed between treatment and control groups as regards to age, gender, body mass index (BMI), involved side, dominant side, history of trauma, and profession. In addition, both groups had similar anteroposterior glenoid measurements of normal and unstable shoulders.

Clinical Outcomes

A statistically significant pain reduction was reported postoperatively in treatment and control groups (*P* = .036 and .007, respectively). Both groups demonstrated a statistically significant improvement in SANE score postoperatively (*P* = .007 and .003, respectively, **Table 2**). At one year follow-up, eight patients (89%) in the treatment group and 11 (100%) in the control group returned to sports at the same level. No statistically significant difference between treatment and control groups regarding shoulder pain, SANE score, satisfaction rate, or return to sports was observed. No patients reported recurrent dislocation during the study period or had a positive apprehension sign at the final follow-up.

Shoulder ROM

Unstable shoulders demonstrated limited preoperative ROM compared to normal shoulders, especially in terms of flexion, abduction, and internal and external rotation at 90/90 positions (**Table 3**).

In the treatment group, a statistically significant improvement was observed postoperatively in shoulder flexion for thoracohumeral motion, and shoulder abduction and internal rotation at 90/90 position for thoracohumeral and glenohumeral motions. Furthermore, the treatment group demonstrated significantly better shoulder abduction and internal rotation at 90/90 position compared to the normal side for thoracohumeral and glenohumeral motions, respectively.

In the control group, a statistically significant improvement was only observed postoperatively in shoulder internal rotation at 90/90 position for thoracohumeral motion. On the other hand, shoulder flexion and external rotation, with the elbow at the side, demonstrated a statistically significant reduction postoperatively for thoracohumeral motion. Compared to the normal side, the control group shown significantly worse ranges of flexion and external rotation for thoracohumeral and glenohumeral motions, and worse ranges of abduction and internal rotation for glenohumeral motion.

The preoperative to postoperative ROM improvement was more pronounced in the treatment group than the control group with respect to shoulder flexion (*P* = .001), abduction (*P* = .041), and internal rotation with elbow at side (*P* = .035) for thoracohumeral motion, and shoulder abduction (*P* = .037), and internal rotation at 90/90 position (*P* = .006) for glenohumeral motion.

Table 1. Baseline Characteristics (N = 20 patients)

Variable	Treatment (n = 9)	Control (n = 11)	P value
Age, years[a]	30 (24, 51)	33 (28, 40)	.824*
Male gender[b]	9 (100)	10 (91)	.353**
BMI, kg/m^2 [a]	24 (21, 27)	22 (21, 26)	.824*
Right side[b]	5 (56)	10 (91)	.069**
Dominant side[b]	9 (100)	8 (73)	.089**
Trauma[b]	9 (100)	11 (100)	–
Professional[b]	5 (56)	4 (36)	.391**
AP Glenoid Diameter, mm[a]			
Normal	28 (26, 30)	26 (24, 28)	.131*
Unstable	25 (25, 27)	25 (23, 26)	.261*
AP Humerus Position relative to Glenoid Centre, mm[a]			
Normal	7 (5, 7)	7 (5, 9)	.331*
Unstable	8 (5, 8)	8 (6, 11)	.295*

BMI, body mass index, AP, anteroposterior; * Mann-Whitney U test, ** Chi-square test; a Data are presented as median (Q1, Q3); b Data are presented as No. (%)

Table 2. Clinical Outcomes (N = 20 patients)

Variables	Treatment (n = 9)	Control (n = 11)	P value
Pain a			
Preoperative	2 (0.5, 4.5)	2 (1, 4)	.941*
Postoperative	0 (0, 1)	0 (0, 0)	.175*
P value**	.036	.007	
SANE a			
Preoperative	45 (25, 65)	60 (30, 70)	.552*
Postoperative	95 (90, 98)	100 (90, 100)	.261*
P value**	.007	.003	
Satisfaction b	9 (100)	11 (100)	-
Return to Sports b	8 (89)	11 (100)	.257†

SANE, Single Assessment Numeric Evaluation; * Mann-Whitney U test, ** Wilcoxon test, † Chi-square test; a Data are presented as median (Q1, Q3); b Data are presented as No. (%)

Shoulder Stability

As shown in **Table 4**, the treatment group showed a statistically significant reduction in median anteroposterior translation and subluxation from preoperatively to postoperatively during shoulder flexion (2.6 mm to 0.3 mm, and 17% to 2.5%), internal rotation (8.5 to 8 mm, and 64% to 62%) and external rotation (7.6 mm to 7 mm, and 59% to 54%) with elbow at side and anteroposterior subluxation during shoulder abduction (18% to 2.5%). Furthermore, the treatment group exhibited significantly smaller shoulder anteroposterior translation and subluxation compared to the normal side during flexion (0.3 mm *vs*. 2.6 mm and 2.5% *vs*. 22%) and abduction (0.8 mm *vs*. 4.4 mm and 2.5% *vs*. 36%). Although no statistically significant change was observed in anteroposterior stability from preoperatively to postoperatively, median postoperative anteroposterior translation and subluxation were significantly larger than the normal side during internal rotation (7.2 mm *vs*. 6.9 mm and 54% *vs*. 45%) and external rotation (71% *vs*. 51%) at 90/90 position.

In the control group, a statistically significant reduction in anteroposterior translation was only observed during external rotation (7.1 mm to 6.9 mm) at 90/90 position. Compared to the normal side, the control group was associated with significantly larger anteroposterior translation and subluxation during flexion (5 mm *vs*. 1 mm and 39% *vs*. 6%) and abduction (6 mm *vs*. 1.6 mm and 49% *vs*. 12.5%), and larger subluxation during internal rotation (63% *vs*. 49%) with elbow at side.

The preoperative to postoperative reduction in anteroposterior translation was more pronounced in the treatment group compared to the control group during shoulder internal rotation (-0.7 mm *vs*. -0.2 mm) and external rotation (-0.8 mm *vs*. -0.3 mm) with elbow at side (*P* = .018, and .016, respectively). On the contrary, the control group showed more significant reduction in anteroposterior translation and subluxation during external rotation (-0.8 mm *vs*. +0.9 mm and -5% *vs*. +4%) at 90/90 position (*P* = .005 and .024, respectively).

Discussion

There is no consensus concerning capsule management and the position of the bone block (intra- *vs*. extra-articular) [33]. The present study demonstrated that, compared to a previous cohort, a new type of capsulolabral reconstruction, including labral reattachment and cautious capsular reconstruction with the humeral head reduced, decreases residual anteroposterior translation micromotion at one year postoperatively without limiting postoperative ROM, confirming our hypothesis.

The treatment group showed a statistically significant reduction in median anteroposterior translation and subluxation from preoperatively to postoperatively during shoulder flexion (2.6 mm to 0.3 mm, and 17% to 2.5%), internal rotation (8.5 to 8 mm, and 64% to 62%) and external rotation (7.6 mm to 7 mm, and 59% to 54%) with elbow at side and anteroposterior subluxation during shoulder abduction (18% to 2.5%), indicating greater stability. In our treatment group, preoperative ROM of the normal shoulder was statistically significantly higher than in the unstable shoulder, likely due to pain or apprehension during movement. Postoperatively, motion capture analysis revealed an improvement of ROM in the treatment group more pronounced than the control group with respect to shoulder flexion (*P* = .001), abduction (*P* = .041), and internal rotation with elbow at side (*P* = .035) for thoracohumeral motion, and shoulder abduction (P = .037), and internal rotation at 90/90 position (*P* = .006) for glenohumeral motion. The control group showed more significant reduction in anteroposterior translation and subluxation during external rotation, which was explained by the residual stiffness compared to the treatment group.

Table 3. Shoulder range of motion for the normal and unstable pre- and postoperative shoulders during the four recorded movements (n = 60 observations; 20 subjects, 3 trials)

	Treatment Group				Control Group				P value*
	Normal	Unstable pre-operative	Unstable posto-perative	Pre-Post Difference	Normal	Unstable pre-operative	Unstable posto-perative	Pre-Post Difference	
Thoraco-humeral Motion, deg									
Flexion	155 (148, 160)	154 (137, 159) **	161 (152, 164) ‡	6 (2, 11)	163 (158, 168)	157 (153, 161) **	155 (150, 157) †‡	-3 (-10, 2)	.001
Abduction	134 (130, 159)	131 (99, 155) **	145 (140, 168) †‡	18 (8, 36)	150 (138, 167)	150 (143, 159)	158 (136, 163)	9 (-10, 22)	.041
IR, elbow at side	52 (42, 64)	52 (49, 61)	58 (51, 62)	3 (-2, 10)	56 (38, 71)	59 (51, 66)	53 (51, 69)	-7 (-11, 6)	.035
ER, elbow at side	14 (9, 21)	7 (3, 22)	11 (2, 19) †	-1 (-12, 13)	21 (17, 38)	20 (15, 32)	14 (12, 20) †‡	-9 (-17, -0.5)	.081
IR, 90°/90°	45 (40, 54)	44 (35, 50) **	48 (46, 49) ‡	2 (-3, 35)	59 (55, 65)	47 (37, 56) **	53 (49, 63) ‡	5 (-3, 27)	.835
ER, 90°/90°	41 (35, 52)	30 (21, 36) **	35 (34, 37) †	2 (-7, 8)	47 (44, 62)	52 (30, 56)	39 (37, 47) †	-4 (-15, 7)	.231
Gleno-humeral Motion, deg									
Flexion	109 (104, 120)	95 (91, 113) **	105 (95, 112) †	5 (-9, 13)	120 (112, 125)	105 (96, 110) **	104 (96, 111) †	-2 (-6, 3)	.155
Abduction	100 (92, 116)	74 (66, 116) **	95 (89, 100) ‡	15 (2, 26)	106 (100, 121)	100 (91, 106) **	103 (89, 109) †	4 (-12, 13)	.037
IR, elbow at side	36 (27, 49)	38 (29, 47)	39 (36, 41)	6 (-10, 12)	40 (21, 56)	29 (22, 47)	31 (19, 41) †	-5 (-10, 3)	.087
ER, elbow at side	19 (15, 28)	10 (2, 33)	19 (13, 20)	0 (-12, 12)	29 (21, 52)	28 (22, 43)	31 (28, 34)	0 (-13, 11)	.941
IR, 90°/90°	35 (21, 42)	24 (9, 37) **	36 (28, 44) †‡	13 (0, 28)	32 (29, 42)	30 (17, 39) **	26 (18, 36) †	-2 (-11, 10)	.006
ER, 90°/90°	47 (38, 49)	35 (30, 44) **	35 (32, 38) †	-4 (-17, 9)	54 (46, 62)	47 (32, 58)	48 (40, 53) †	-1 (-12, 9)	.513

Data are presented as median (Q1, Q3); * Mann-Whitney U test comparing pre-post difference between treatment and control groups, ** Significant difference between normal and unstable preoperative shoulders data (Wilcoxon test, P < 0.05); †Significant difference between normal and unstable postoperative shoulders data (Wilcoxon test, P < 0.05); ‡ Significant difference between unstable preoperative and postoperative shoulders data (Wilcoxon test, P < 0.05)

Table 4. Anteroposterior Shoulder stability for the normal and unstable pre- and postoperative shoulders during the four recorded movements (n = 60 observations; 20 subjects, 3 trials)

	Treatment Group				Control Group				P value*
	Normal	Unstable pre-operative	Unstable posto-perative	Pre-Post Difference	Normal	Unstable pre-operative	Unstable posto-perative	Pre-Post Difference	
Translation, mm									
Flexion	2.6 (0.3, 4.8)	2.6 (0.3, 3.7)	0.3 (-0.1, 2) †‡	-0.4 (-2.7, 0)	1 (-0.5, 2.2)	5.2 (4.7, 6) **	5 (2.9, 6.7) †	-0.4 (-1.6, 0.7)	.443
Abduction	4.4 (0.1, 5.9)	2.3 (1.6, 3.9)	0.8 (-0.1, 2.5) †	-1.5 (-3, 0.4)	1.6 (0.3, 4.8)	5.9 (4.3, 7.6) **	6 (1.3, 8) †	-0.5 (-4.2, 1.7)	.970
IR, elbow at side	8.2 (6.6, 9.6)	8.5 (6.3, 9.7)	8 (6.6, 8.1) ‡	-0.7 (-1.2, -0.4)	7 (3.7, 7.8)	6.8 (5, 10)	7.3 (5.1, 8.4)	-0.2 (-0.6, 0.5)	.018
ER, elbow at side	6.7 (5.7, 8.8)	7.6 (5.3, 9.6)	7 (6.4, 7.2) ‡	-0.8 (-1.5, -0.3)	6.8 (4.8, 7.9)	7.1 (5.2, 9.6)	6.8 (5.2, 9.2)	-0.3 (-0.7, 0.5)	.016
IR, 90°/90°	6.9 (4.9, 7.8)	7.1 (5.1, 9)	7.2 (5.6, 9) †	0.2 (-0.2, 1.4)	7 (6.1, 11.4)	8.4 (7.1, 11.4)	8.6 (7.6, 9.6)	0.2 (-2, 1.6)	.369
ER, 90°/90°	6.2 (5.7, 6.8)	5.4 (3.3, 7.9)	6.5 (5.7, 7)	0.9 (-0.8, 1.3)	7.1 (6.1, 8.8)	7.1 (6.3, 10.1)	6.9 (6, 9.8) ‡	-0.8 (-1.4, 0.1)	.005
Subluxation, %									
Flexion	22 (3, 35)	17 (2, 27)	2.5 (-1, 16) †‡	-3.5 (-19.5, 0)	6 (-3, 18.5)	41.5 (37.5, 50) **	39 (22, 56) †	-3 (-13, 6)	.430
Abduction	36 (1, 42)	18 (12, 30)	2.5 (-1, 6) †‡	-13.5 (-27.5, 0)	12.5 (2.5, 36.5)	47 (37.5, 65) **	49 (9.5, 68.5) †	-4 (-35.5, 13.5)	.357
IR, elbow at side	57.5 (46, 69)	64 (50, 75)	62 (52, 69) ‡	-5 (-9, 0)	49 (27.5, 66)	65 (37.5, 80) **	63 (39, 68) †	-2 (-4.5, 2)	.088
ER, elbow at side	55 (40, 58)	59 (42, 72)	54 (51, 61) ‡	-8 (-19, -1)	49.5 (39, 58.5)	60 (39.5, 80.5) **	59 (39, 75)	-1 (-8, 5.5)	.054
IR, 90°/90°	45 (35, 53)	53 (40, 62) **	54 (45, 70) †	1 (-1, 11)	45 (35, 49)	43 (26, 57)	50 (44, 54)	7 (-5, 12)	.587
ER, 90°/90°	51 (45.5, 89.5)	68 (54.5, 97)	70.5 (62, 82.5) †	4 (-15.5, 13.5)	50 (46, 65)	62 (50.5, 84.5) **	63 (46, 79)	-5 (-11, 7.5)	.024

Data are presented as median (Q1, Q3)* Mann-Whitney U test comparing pre-post difference between treatment and control groups** Significant difference between normal and unstable preoperative shoulders data (Wilcoxon test, $P < 0.05$)†Significant difference between normal and unstable postoperative shoulders data (Wilcoxon test, $P < 0.05$)‡ Significant difference between unstable preoperative and postoperative shoulders data (Wilcoxon test, $P < 0.05$)

Regarding capsular reconstruction, Allain performed edge-to-edge capsular sutures without retention, thus obtaining an intra-articular bone block [34]. For Coudane et al. [15], the coracoacromial ligament remnant on the bone block was sutured to the capsule in 75% of cases, partially isolating the bone block and allowing persistent contact with the humeral head, which may contribute to the development of long-term osteoarthritis [35]. Bouju et al. performed south-north retention of the capsule in a U-form using three drill holes in the bone block [19]. They demonstrated that an extra-capsular position of the graft decreases the rate of dislocation arthropathy [19]. The capsular reconstruction [13] used in the treatment group of the present study allows a decrease in postoperative anteroposterior translation micromotion. This finding is not without importance. First, residual microinstability might be responsible for persistent apprehension or simply cortical sequelae [9][10]. It is worth noting that no patients in our series reported recurrent dislocation during the study period or had a positive apprehension sign at the final follow-up. Moreover, residual microinstability may also explain the relatively high rate of long-term dislocation arthropathy found in unstable patients [1]. Limiting residual anteroposterior translation to a normal level, even if subclinical, should thus be a goal.

Regarding capsular repair, some authors assumed, mainly based on personal experiences and small retrospective series, that capsular repair is not necessary. They first argue that the capsule would heal by itself and that its repair may limit external rotation postoperatively [36][37][38]. Previous studies showed that cautious capsular repair and the labral reattachment [13][19] helps to render the graft extracapsular, thus preventing potential dislocation arthropathy [19], without limiting postoperative ROM, as shown in the present study. Our findings are consistent with Hovelius et al., who reported that the rate of recurrences decreased, and subjective results improved when a horizontal capsular shift was added to the coracoid transfer [39].

Limitations

First, the number of patients was limited. However, contralateral side, control group, due to the complexity of analyses, was adequate compared to previous shoulder instability studies [29][31][32]. Moreover, patient selection was strict with exclusion of all conditions (hyperlaxity, non-traumatic onset, etc.) that might affect the results. Second, this study was not randomized. The systematic use of randomized controlled trials has been criticized notably for ethical reasons. An appropriate alternative is to conduct externally controlled trials that consist of gathering data from previous clinical trials in the new study design to reduce biases while avoiding unnecessary patients' enrollment (e.g., controlled groups) [40]. Third, the accuracy of the kinematics computation from motion capture data is prone to errors. Glenohumeral orientation and translation errors were respectively within 4 degrees and 3 mm for each anatomical plane, which is acceptable for clinical use in the study of shoulder pathology. Although the translation error could be of significant importance for our model, we previously demonstrated that the computed translation patterns and amplitudes were in good agreement with published data [24][25][29]. For comparison, Karduna et al. reported orientation errors of 10 degrees for a scapula tracker and 11.4 degrees for an acromial method against bone pins [41]. Although glenohumeral translation quantification has been studied for more than two decades [42], we found no other study able to report translation values at the glenohumeral joint using an external measurement system, such as motion capture. Fourth, the limited number of patients did not allow for a comparison between the different surgical techniques. Nevertheless, the results representing the activity of a shoulder surgeon showed that all translations followed similar patterns. Lastly, not the same postoperative protocol of immobilization (4 *vs.* 0 weeks) was performed, but it should disfavor the control group because of postoperative immobilization and, thus, even reinforce the results of the new capsulolabral repair.

Conclusion

This study demonstrated that a new type of capsulolabral reconstruction during the Latarjet procedure could reduce residual anteroposterior micromotion compared with a previously used technique, without compromising postoperative ROM. Although no differences in clinical apprehension were observed between groups, these biomechanical findings support the hypothesis that careful capsular management may influence postoperative shoulder stability. Whether this effect translates into long-term clinical benefit remains to be established in larger studies with extended follow-up.

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Contributor Roles

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Writing – Original Draft. Alexandre Lädermann : Conceptualization ; Funding Acquisition; Investigation; Methodology; Project Administration; Resources; Supervision; Validation; Visualization: Writing – Original Draft; Writing – Review & Editing.

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