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### ► To cite this version:

Alexandre Caubère, Damien Lami, Pascal Boileau, Sébastien Parratte, Matthieu Ollivier, et al.. Is the subscapularis normal after the open Latarjet procedure? An isokinetic and magnetic resonance imaging evaluation. *Journal of Shoulder and Elbow Surgery*, 2017, 26 (10), pp.1775–1781. 10.1016/j.jse.2017.03.034 . hal-03551889

**HAL Id: hal-03551889**

**<https://hal.science/hal-03551889v1>**

Submitted on 1 May 2024

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# Is the subscapularis normal after the open Latarjet procedure? An isokinetic and magnetic resonance imaging evaluation

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**Background:** The Latarjet procedure is considered to be a violation of the subscapularis muscle. This study evaluated the postoperative status of the subscapularis through isokinetic and magnetic resonance imaging analysis after splitting. We hypothesized that compared with a healthy contralateral shoulder, there would be satisfactory recovery of subscapularis strength at the cost of some fatigability and some mild fatty infiltration.

**Materials and methods:** This was a case-control retrospective study of patients who underwent a Latarjet procedure between January 2013 and January 2015. A total of 20 patients were reviewed at 1 year postoperatively. With the patient seated, strength testing of both shoulders was done (concentric, eccentric, and fatigability) with a dynamometer. Trophicity and fatty infiltration were analyzed by magnetic resonance imaging.

**Results:** Strength of the internal rotators (IRs) and external rotators (ERs) of the injured shoulder was significantly lower compared with the healthy shoulder in concentric testing at 180°/s and 60°/s (13% for IR and 20% for E,  $P < .05$ ) and in eccentric testing at 60°/s (19% for IR and 16% for ER,  $P < .05$ ). A peak torque ratio (ER/IR) of the operated-on shoulder was maintained. The difference in muscular endurance was significant ( $P < .001$ ). There was no muscle atrophy and minimal or no fatty infiltration of the subscapularis in any patient.

**Conclusion:** At 1 year after the open Latarjet procedure, isokinetic testing showed a combined strength deficit in both internal and external rotation with a conserved muscle balance. Although no significant sub-scapularis fatty infiltration or atrophy was noted, there was a significant deficit in endurance compared with the healthy shoulder.

**Level of evidence:** Basic Science Study; Kinesiology and Imaging

**Keywords:** Latarjet procedure; subscapularis muscle; splitting; strength; isokinetic; MRI

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Institutional Review Board approval was not required because this was a retrospective study of patients whose surgery followed validated techniques and no unnecessary invasive examinations were performed.

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The Latarjet procedure consists of transferring a coracoid bone block to the antero-inferior neck of the glenoid after its passage through the subscapularis muscle. The procedure is indicated in young patients with anterior recurrent shoulder instability and who play contact and overhead

sports.<sup>1,8</sup> The transfer through the subscapularis muscle represents a violation of the most important active stabilizer of the glenohumeral joint. This surgical aggression can lead to muscle atrophy and imbalanced shoulder musculature.<sup>1,6,8,14,22</sup> However, whether the subscapularis muscle returns to normal after a Latarjet procedure is still unknown.

Our purpose was to evaluate the postoperative status of the subscapularis muscle through isokinetic and magnetic resonance imaging (MRI) analysis and assess the effect on shoulder function. We hypothesized that compared with a healthy contralateral shoulder, recovery of subscapularis strength after the Latarjet procedure would be satisfactory, at the cost of some mild fatty infiltration.

## Materials and methods

### Patients

This was a retrospective case-control study that included all patients who underwent an open Latarjet procedure by a single surgeon between January 2013 and January 2015.

The exclusion criteria were (1) patients with pathology of the contralateral shoulder or who had a bilateral procedure, or both; (2) patients with previous failed instability surgery, and (3) patients with insufficient follow-up of less than 12 months. Patients were informed by mail of the objectives of the analysis and were contacted by the examiner to obtain their consent.

During this period, 35 open Latarjet procedures were performed. Of these patients, 15 were excluded from the series: 7 had bilateral instability of the shoulder (19%), 3 were lost to follow-up, 3 refused to participate in the study, and 2 were in jail and unable to participate. At a follow-up of 12 months, 20 patients (all men) were reviewed with clinical, isokinetic, and MRI evaluation. The demographics of the series are presented in Table I. The patients were a mean age of 25.3 years (range, 17-41 years). The dominant side was involved in 12 patients (60%). Most patients practiced a high-risk sport (type 4 according to the Walch and Duplay score<sup>26</sup>) at a competition level (boxing, swimming, and tennis). Three or more dislocations had occurred in 81% of the patients before surgery, and they had waited an average of 11 months (range, 2-48 months) between the last dislocation and the intervention. It took an average of 4 months of therapy, 50 sessions at a rate of 3 sessions per week, for the patients to resume their professional and sports activities.

### Surgical technique and postoperative management

The patient was selected according to the Instability Severity Index Score described by Balg and Boileau.<sup>2</sup> The operation was performed with the patient under general anesthesia in the beach chair position. A deltopectoral approach was used. After splitting of the subscapularis muscle (at the lower third), the coracoid bone block was prepared and fixed with 2 compressive screws. At the end of the procedure, we systematically sutured the coracoacromial ligament to establish the "triple" blocking effect described by Patte et al.<sup>23</sup>

The patient was immobilized with a sling in internal rotation for 15 days and only permitted to perform pendulum exercises during

**Table I** Population characteristics

Variable	Patients (n = 20)
Age (years)	
Average	25.3
Minimum	17
Maximum	41
Gender, No. (%)	
Male	20 (100)
Female	0 (0)
Body mass index, kg/m <sup>2</sup>	
Average	24.3
Minimum	18.5
Maximum	30.4
Profession at shoulder risk, No. (%)	10 (50)
Dominant side, No. (%)	12 (60)
Sport, No. (%)	
0 (no sport)	0 (0)
1 (no risk)	3 (15)
2 (light risk)	4 (20)
3 (medium risk)	6 (30)
4 (high risk)	7 (35)
Dislocation, No.	
Average	3

this period. The functional rehabilitation protocol was the same for all patients:

- Postoperative day 8 to 21: physiotherapy, soft relaxing massages. Mobilization of elbow and hand. Working in passive, with external rotation limitation up to 20° and anterior elevation up to 100°. No muscle-building work.
- Postoperative day 21 to 45: began progressively active motion.
- From postoperative day 45: recovery of all amplitudes without limitation in anterior elevation, external rotation, and internal rotation. No musculation of the anterior chamber of the arm
- After postoperative day 90: muscular strengthening.
- No-risk sporting activities were permitted at 3 months, depending on the follow-up radiographs, and higher-risk activities were allowed at 4.5 months.

### Clinical evaluation

A questionnaire was used to record the type of sport, level of competition, and patient satisfaction (very satisfied, satisfied, dissatisfied, or disappointed). Objective function of the shoulder was assessed by the scores of Rowe,<sup>24</sup> of Walch and Duplay<sup>26</sup> and the Western Ontario Shoulder Instability Index (WOSI).<sup>18</sup>

### Isokinetic evaluation

Isokinetic evaluation was performed with the Con-Trex MJ dynamometer (CMV AG, Dübendorf, Switzerland). This assessment involved both shoulders, beginning with the nonoperated-on, healthy shoulder. After a warm-up period of 10 minutes, the patient was seated with the shoulder in 45° of abduction in the plane of the scapula



**Figure 1** Isokinetic testing of the shoulder in the modified Davies position.

(modified Davies position; Fig. 1). This position is the most recommended for evaluating the IR and ER muscles in shoulder instability.<sup>11,13</sup> Indeed, in this position, the patient is much more confident and at less risk of dislocation compared with the 90° position.<sup>13</sup> This position also has the advantage of being more reproducible. The arc of range of motion was fixed at 60° (30° of internal rotation and 30° of external rotation) from a position of the forearm defining “anatomical 0°.” The elbow was placed at 90° of flexion with neutral pronation and supination.

We assessed the patients with a series of 5 tests with 1-minute recovery between each set. The following tests were performed for each shoulder: in concentric mode, 5 repetitions at 240°/s and 180°/s and 3 repetitions at 60°/s; in eccentric mode, 5 repetitions at 60°/s; and finally, a fatigue test, 20 repetitions at 180°/s in a concentric mode.

At each angular velocity, dynamic strength of the IRs and ERs was evaluated using the measurement of the average of peak torque normalized to the patient’s body weight (Nm/kg), the ratio RLcon/RMcon and RLexc/RMexc (in %) and total work. The index of fatigability (IF) was calculated by the average of the last third repetitions (M3D) to the total work maximum (Wmax) of the patient during exercise (IF = M3D/Wmax). These parameters were compared with the contralateral shoulders that were not operated on.

## MRI evaluation

Each patient had an MRI of the operated-on shoulder. The sequences were performed on a 1.5-T unit (Intera; Philips Healthcare, Amsterdam, Netherlands). The imaging was interpreted by a single radiologist and systematically reviewed by the examiner. The position of the patient in the MRI was standardized: supine, arms along the body, elbow extended. A 2-dimensional acquisition was performed for all sequences. The sequences were applied in transaxial sectional

**Table II** Magnetic resonance imaging weighted spin echo sequence

Weighted SE sequence	TR (ms)	TE (ms)	Flip angle (°)	Field of view (mm)	Slice thickness (mm)
Coronal T1	514	8.5	90	150	3.5
Sagittal T1	579	9	90	150	4.3
Coronal T2	2353	50	90	150	3.8
Sagittal T2	2500	50	90	150	4.4
Axial T2	2696	50	90	150	4.1

SE, spin echo; TE, time to echo; TR, repetition time.

parasagittal (perpendicular to the scapula) and pericoronal (parallel to the scapula) views (Table II).

The subscapularis was analyzed and compared with other muscles of the rotator cuff on the parasagittal T1 (Y view). Fatty infiltration on MRI imaging was evaluated by the Fuchs and Gerber<sup>15</sup> criteria with an adaptation of the Bernageau classification. Trophicity was considered normal or atrophic compared with the other muscles of the rotator by the examiner according to subjective criteria.

## Statistical analysis

The demographic characteristics of patients, functional scores, isokinetic, and radiologic findings are reported as mean ± standard deviations for continuous variables or numbers (percentages) for categorical variables. An audit of the normal distribution of quantitative variables was assessed by the Kolmogorov-Smirnov test. Normally distributed quantitative variables were compared using the Student *t* test, and the Wilcoxon test was used for non-normally distributed

variables. The analysis of the correlation between clinical, isokinetic, and radiologic outcomes was simple regression with estimation of correlation coefficients. All statistical tests were bilateral. *P* values of  $< .05$  were considered statistically significant. The analysis was performed using SPSS 18 software (SPSS Inc., Chicago, IL, USA).

## Results

### Clinical and radiologic outcomes

Of the 20 patients in the study, 17 (85%) were satisfied or very satisfied, and 3 (15%) were not satisfied with longer follow-up. The average of the Rowe and the Walch-Duplay scores was 83.8 and 87 points, respectively. The average WOSI score was 73.4% (range, 44.6%-90.2%).

The bone block in all patients was in a subequatorial position, flush with the anterior inferior glenoid (Fig. 2).

### Isokinetic outcomes

There was a significant deficit of strength of 13% in the IRs and 19% in the ERs for the injured shoulder compared with the healthy shoulder with the isokinetic tests performed in concentric mode at 180°/s and at 60°/s ( $P < .05$ ). A significant deficit ( $P < .001$ ) of 19% for the IRs and 16% for ERs was also observed in eccentric testing at 60°/s at the last follow-up. This deficit was not found in the concentric mode at 240°/s ( $P = .057$ ).

Tables III and IV report the results of maximum force couples in different tests compared with the operated-on side. The ER/IR ratio of maximum torque force was 57% and comparable between the 2 shoulders during concentric and eccentric tests ( $P = .1$ ). The agonist-antagonist balance was maintained despite the surgical procedure.

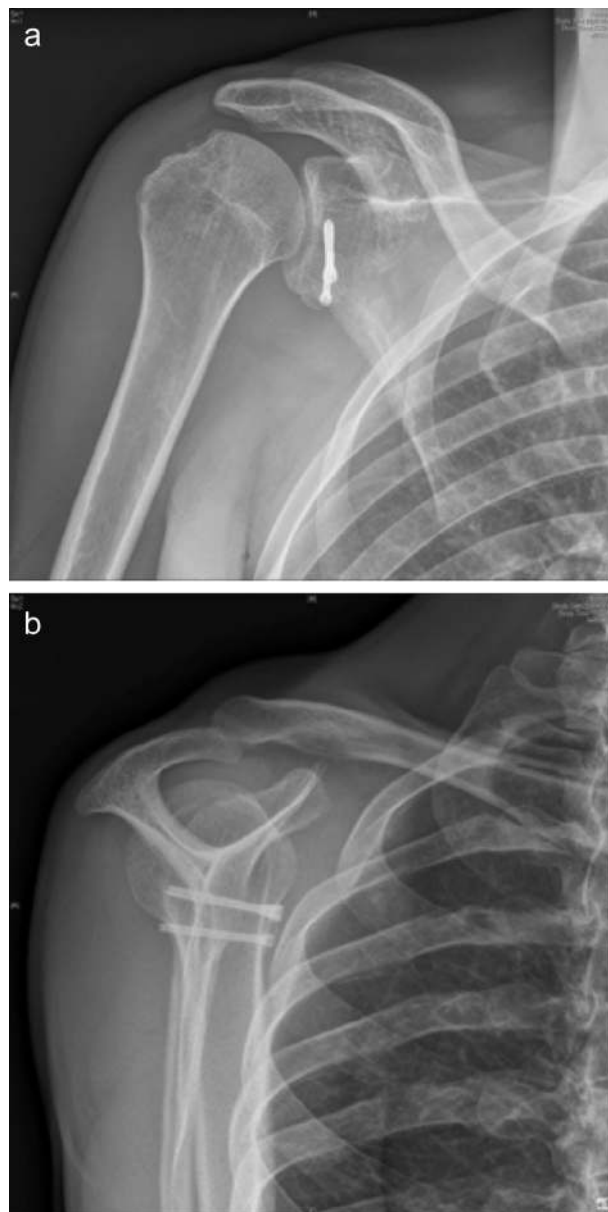
A concentric endurance test at 180°/s with 20 repetitions allowed us to calculate a fatigue index. We evaluated the relationship between the M3D and the Wmax. There was a very significant difference ( $P < .001$ ) in IR muscle fatigability compared with the healthy shoulder (Tables II and III). This difference was also significant in the ERs ( $P = .039$ ).

No significant correlation was found between the isokinetic deficit and the overall characteristics of the population, including age, number of dislocations, type of sport, level of competition, and whether the dominant limb was operated on. Patients who presented with worse clinical and functional scores showed no larger deficit of shoulder rotators compared with the healthy shoulder.

### MRI outcomes

No injury to the subscapularis tendon was found on axial imaging.

Fatty degeneration, classified by Goutallier modified for MRI,<sup>15</sup> was 0 in 55% of patients and stage 1 in 45%. No



**Figure 2** Postoperative x-ray image at 6 months in (A) antero-posterior and (B) lateral (Y view) views of the scapula.

correlation was found between the presence of fatty degeneration and the size of the deficit.

Trophicity of the subscapularis muscle was considered normal in all patients compared with the other muscles of the rotator cuff (Fig. 3). The mean transverse diameter of the subscapularis muscle was 120 mm, and the horizontal diameter of the upper and lower end 30 mm and 36 mm, respectively.

## Discussion

Maynou et al,<sup>19</sup> with a computed tomography scan evaluation of 102 patients, showed that compared with splitting in the direction of the fibers, tenotomy of the subscapularis was significantly correlated with poor clinical outcomes as a result

**Table III** Isokinetic results of internal rotators

Variable	Uninjured shoulder side (Mean ± SD)	Injured shoulder side (Mean ± SD)	Deficit (%)	P values
Concentric test				
240°/s	0.83 ± 0.17	0.75 ± 0.16	10	.037
180°/s	0.90 ± 0.19	0.78 ± 0.16	13	.007
60°/s	0.90 ± 0.17	0.78 ± 0.16	13	.004
Eccentric test				
60°/s	0.79 ± 0.18	0.64 ± 0.18	19	<.001
Fatigability index	0.07 ± 0.02	0.08 ± 0.02		.038

SD, standard deviation.

**Table IV** Isokinetic results of external rotators

Variable	Uninjured shoulder side (Mean ± SD)	Injured shoulder side (Mean ± SD)	Deficit (%)	P values
Concentric test				
240°/s	0.53 ± 0.13	0.48 ± 0.14	10	.007
180°/s	0.55 ± 0.11	0.44 ± 0.12	20	<.001
60°/s	0.53 ± 0.13	0.43 ± 0.12	19	.002
Eccentric test				
60°/s	0.43 ± 0.13	0.36 ± 0.12	16	<.001
Fatigability index	0.07 ± 0.02	0.08 ± 0.02		.039

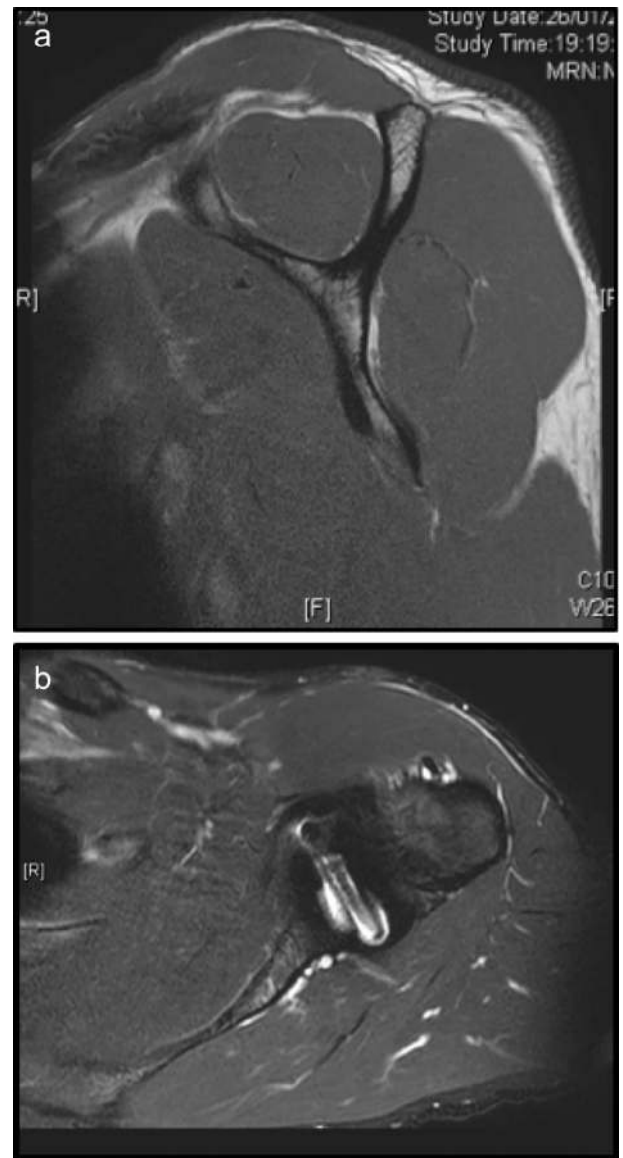
SD, standard deviation.

of fatty degeneration and muscle atrophy. This notion of muscle preservation, well described by Molé and Walch,<sup>20</sup> is one of the key elements for the success of the bone block stabilization procedure.

The results in our series confirmed our hypothesis: the subscapularis muscle retains satisfactory function, normal trophicity, and minimal fatty infiltration despite surgical splitting at a mean follow-up of 1 year.

Prospective isokinetic studies are scarce in the literature. Dauty et al<sup>6</sup> found an almost complete recovery of shoulder rotator strength 3 months postoperatively in the concentric mode but a significant deficit of 9% to 15% when testing in the eccentric mode. Edouard et al<sup>8</sup> in 2012 compared preoperative values with those at 3, 6, and 21 months after surgery and reported an on-deficit of 28% of the strength of the IRs and 16% of the strength of ERs after Latarjet surgery. This additional deficit was transient up to 6 months, and recovery was stable over time, with the last follow-up at 21 months.

We found a significant strength deficit in the concentric and eccentric mode of 13% and 19%, respectively, of the IRs, and of 20% and 16%, respectively, of the ERs. The ratio of rotator strength (ER/IR) remained unchanged because the deficit concerns both the agonist and antagonist of the shoulder. This reflects that the balance of the shoulder muscle is maintained.



**Figure 3** Magnetic resonance imaging evaluation of the subscapularis muscle in the (A) Y view and (B) horizontal view.

In 2011, Edouard et al<sup>12</sup> reported a significant deficiency of both IR and ER strength with chronic anterior shoulder instability. Their analysis of the literature<sup>10</sup> confirmed the existence of preoperative deficit, but determining whether there is cause or consequence of the disease is difficult. Our study did not permit us to confirm these results because we did not have preoperative isokinetic testing. We only show that surgical stabilization does not allow the complete recovery of muscle strength compared with the contralateral healthy shoulder.

We also found significantly ( $P < .001$ ) greater fatigability in the IRs with respect to the healthy shoulder. The fatigability index calculated by the M3D on the Wmax seems to be the most reproducible parameter.<sup>4,5</sup> Edouard et al<sup>7</sup> confirmed this by finding significant ( $P < .001$ ) fatigability in the IRs at 3 months postoperatively with a recovery at 6 months after surgery, which remains stable at 21 months.

However, isokinetic analysis alone is not enough to analyze precisely the recovery of the subscapularis muscle. MRI is noninvasive and appears to be the most accurate and most elaborate method to assess tendon injuries, trophicity, and fatty degeneration of the subscapularis muscle.<sup>3,17</sup> Our results show that the subscapularis muscle recovers satisfactory characteristics after splitting in the direction of the fibers. There was no muscle atrophy, and fatty degeneration was zero or minimal (stage 1) in all patients.

Few studies have used MRI to evaluate the fate of the subscapularis. The only MRI studies we found that analyzed the subscapularis muscle after a tenotomy confirmed the results already published using analysis of computed tomography scans.<sup>21,25</sup> A tenotomy of the subscapularis muscle after the Latarjet procedure is accompanied by a fatty infiltration and muscle atrophy that are significantly correlated with poor functional outcomes. Forthomme et al,<sup>14</sup> with a scannographic analysis, show that the deficit is significant for the patient when the fatty degeneration is  $\geq 2$  according to the classification of Goutallier et al<sup>16</sup> (ie, a fatty degeneration  $< 50\%$  compared with muscle) and is also accompanied by muscular atrophy. Subscapularis muscle recovery is necessary for good outcomes after surgical stabilization.

Edouard et al<sup>9</sup> reported no correlation between the strength of IRs and ERs evaluated by measuring muscle strength in concentric mode and functional outcome assessed by the Rowe and the Walch-Duplay scores. Meanwhile, Amako et al<sup>1</sup> showed minimal correlation between the Rowe score and the recovery of shoulder rotator strength in their analysis of a population of elite Japanese soldiers who depend on their shoulder and can therefore be considered as top athletes.

We found a weakly significant correlation between the deficit and the WOSI score. Nonetheless, considering these results is difficult given the small size of our series. The follow-up of 1 year is short, and patients sometimes do not recover complete shoulder mobility by this time. Thus, whether the loss of mobility in external or internal rotation, or both, is correlated with the deficit of rotators strength will be interesting to analyze.

Our analysis has several limitations. This was a retrospective study with a small population. The follow-up of 1 year to the clinical, isokinetic, and MRI evaluations was short. Thus, finding a correlation between the deficit of rotators strength, the deficit of the shoulder mobilities, and the functional scores is difficult. Moreover, we had no preoperative isokinetic and MRI evaluations to assess the strength and the initial characteristic of the subscapularis muscle after repeated episodes of anterior glenohumeral dislocation. However, we are not aware of any studies in the literature evaluating the recovery of the subscapularis muscle by combining an isokinetic and MRI evaluation.

## Conclusion

Isokinetic testing at 1 year after open Latarjet procedure shows a combined strength deficit in internal and external

rotation while conserving muscle balance for concentric and eccentric evaluation. Although no significant subscapularis fatty infiltration or atrophy was seen on MRI, there was a significant deficit in endurance compared with the healthy shoulder.

Further studies must be performed comparing preoperative strength and function with a longer follow-up period. A larger series is necessary to measure whether this strength deficit is correlated with a loss of external or internal rotation, or both, after the coracoid bone block. Moreover, it might also be interesting to compare the open Latarjet with the arthroscopic procedure in respect to the subscapularis muscle.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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