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Risk factors associated with glenohumeral arthritis before and after the Latarjet procedure: minimum follow-up of 5 years, using computed tomography imaging

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Background: Latarjet surgery has emerged as a prevalent option for managing anterior glenohumeral instability. Despite its efficacy, concerns persist regarding the development of postoperative osteoarthritis (OA), a significant complication. Understanding arthritis pathogenesis in patients undergoing this procedure proves challenging, as OA can manifest even in cases without surgical repair. Additionally, studies suggest correlation between inadequate surgical technique and the occurrence of postoperative arthritis. Traditional radiographic imaging may also underestimate the identification of early OA. Therefore, the objective of this study aimed to analyze the risk factors associated with glenohumeral arthritis before and after the Latarjet procedure, with a minimum follow-up of 5 years, using computed tomography imaging (CT).

Methods: This retrospective study involved patients who underwent the Latarjet procedure between 2012 and 2017. Inclusion criteria were availability of preoperative and at least 5 years postoperative CT and physical examinations. The primary outcome studied was the presence of glenohumeral OA, classified preoperatively and postoperatively using CT scans. Risk factors for progression to pre and postoperative OA were assessed, including etiology, age at the initial injury, number of dislocation episodes before surgery, time interval from the initial injury to surgical stabilization, size of glenoid defect, position and presence of graft resorption, and screw position.

Results: Fifty joints of 45 patients were included in the final analysis. The presence of preoperative OA was found in 21 of 50 cases (42%). The risk of osteoarthritis (OA) was significantly associated with both shoulder dislocation following a seizure disorder and a larger glenoid size defect ($P < .05$). Of the 29 shoulders without preoperative arthritis, 8 developed arthritis postoperatively (27.5%). Of those 21 cases with preoperative osteoarthritis, progression occurred in 11 cases (52.3%) ($P = .25$). When considering all cases with OA progression, significant risk factors were the presence of intraarticular screws and when both screws had angulation equal or above 16° ($P < .06$). When considering those patients with progression of OA above 1 grade, significant risk factors were lateral graft position, screw angulation, and the presence of intra-articular screws.

Conclusion: Our study reveals a higher incidence of osteoarthritis than reported in the literature, likely attributed to the imaging method employed. Preoperatively, risk factors for the presence of OA included cases resulting from seizure disorders and larger glenoid bone defects. Postoperatively, the only factors related to the progression of osteoarthritis were those associated with potential surgical technique issues.

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Latarjet surgery has become an increasingly common option for treating anterior glenohumeral instability.[26] Numerous investigations into the Latarjet procedure have demonstrated excellent short-term patient-reported outcomes and low recurrent instability rates, ranging from 0 to 12%.[2-4,7] However, this technique is associated with a unique set of complications, with overall complication rates reaching up to 30%.[20,32] A recent systematic review identified that the overall complication rate after the Latarjet procedure was 6-7% in the short term, with graft-related issues being the most common.[19] Alfraidy et al reported an overall complication rate of 18.6% in their open Latarjet series, noting that revision cases had a higher rate of complications than primary cases, and that the learning curve significantly impacted the rate of adverse events.[1] In a prior publication by the author, the complication rate following the Latarjet procedure was 21.2%, with 9% of patients requiring revision surgery.[9]

One of the most serious complications is the development of postoperative osteoarthritis (OA). Understanding arthritis pathogenesis in patients undergoing the Latarjet procedure is challenging since OA can occur after a single shoulder dislocation, even in patients without surgical repair. Additionally, inadequate surgical technique, such as a lateral overhang of the coracoid bone graft, has been shown to be associated with postoperative arthritis.[6,9,16-18,23]

To establish the rate of progression to degenerative changes in the glenohumeral joint after the Latarjet procedure, it is crucial to consider the presence of OA before surgery. Most studies classify shoulder OA secondary to instability based on radiographs.[8,31] However, the limitation of this approach is the potential underestimation of degenerative disease occurrence compared to computed tomography (CT) imaging.[30] CT allows for a more detailed evaluation and can detect early osteophyte formation, suggesting that most postoperative OA recognized radiographically may have occurred before surgery.

Therefore, the objective of this study was to analyze the prevalence and risk factors associated with glenohumeral arthritis before and after the Latarjet procedure, with a minimum follow-up of 5 years, using CT imaging. The hypothesis of the study was that using this diagnostic method would result in a higher observed incidence of osteoarthritis compared to previous publications. Additionally, it was hypothesized that the risk factors for postoperative OA would be related to technical factors.

Materials and methods

Approval of this retrospective cohort comparison study was obtained from the institutional ethics committee of the National Institute of Traumatology and Orthopedics, Rio de Janeiro, Brazil. This study involved patients who underwent the Latarjet procedure between 2012 and 2017. Inclusion criteria were availability of preoperative and at least 5 years postoperative CT scans and physical examinations. Patients unable to attend a follow-up visit after 5 years or those with concomitant rotator cuff tears, multidirectional instability, or deviations from the classic Latarjet technique were excluded.

The main outcome studied was the presence of glenohumeral OA, classified preoperatively and postoperatively into 4 types according to Samilson and Prieto,[36] modified by Buscaryet et al.[8] Grading evaluation was based on findings described by Ogawa et al.[31,30] (Fig. 1).

Risk factors for progression from pre to postoperative glenohumeral arthritis were analyzed, including etiology, age at the initial injury, number of dislocation episodes before surgery, time interval from the initial injury to surgical stabilization, size of glenoid defect, position and presence of graft resorption, and screw position.

Etiology was defined based on the first episode cause, categorized as traumatic, atraumatic, or occurring after a seizure disorder. Since most patients in our cohort could not recall the exact number of dislocations before surgery, we classified them into 4 categories based on the total number of instability events before surgery: up to 10 events, 10 to 20 events, 20-30 events, and 30 or more events (Table I).

Radiologic evaluation

Preoperatively and at final follow-up, all patients underwent radiologic evaluation with CT scan of the involved shoulder. OA classification using CT was performed according to the method published by Ogawa et al., employing the modified Samilson and Prieto grading system (Fig. 1). CT scans were assessed for marginal spur formation or sharpened margin of the humeral head, irregularity, or sclerosis of the subchondral bone, and narrowing of the joint space. A humeral head with an acute-angled margin or sclerotic bone, even without an obvious spur, was classified as grade 1, indicating the earliest stage of osteoarthritis. Findings confined to the glenoid were excluded from the assessment because it is impossible to differentiate these glenoid changes from those resulting from repeated instability episodes or previous surgery. Preoperative glenoid bone loss was measured using 3D reconstruction employing the concept of the ''best fit circle.'' Postoperatively, graft healing, position, and resorption were assessed. Healing was confirmed by bone bridging between the bone block and the glenoid, with cases

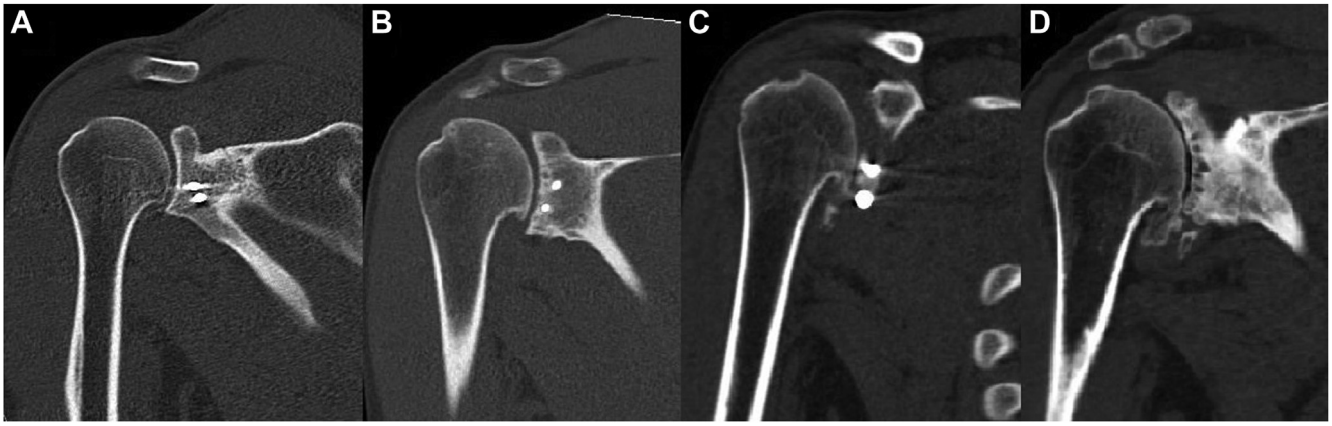

Figure 1 Postoperative osteoarthritis classified using the modified Samilson-Prieto classification system, with assessment performed through CT scans. (**A**) Grade 1: indicated by an inferior humeral spur, measuring less than 3 mm in height. Humeral heads with the margin making an acute angle or being associated with the addition of sclerotic bone are classified into this grade, even if no obvious spur formation is present. (**B**) Grade 2: indicated by a spur measuring between 3 and 7 mm. (**C**) Grade 3: indicated by a spur exceeding 7 mm. (**D**) Grade 4: complete obliteration of the glenohumeral joint space with or without osteophytes. *CT*, computed tomography.

Table I Detailed patient data

	Study population
N	50
Sex	
Male	47
Female	3
Diagnosis	
Epilepsy	8
Atraumatic	5
Traumatic	37
Age at the time of first dislocation or subluxation (yr)	25.2 ± 6.7
Time living with instability (mo)	
Mean ± SD	105.9 ± 83
Median [min-max]	88 [8-408]
Number of dislocations and/or subluxations before surgery	
0-10	11
10-20	5
20-0	8
>30	26

SD, standard deviation.

demonstrating partial bone integration considered as healed.[25,27] Evaluation of bone graft position on axial planes involved defining the coracoid position as medial or lateral overhanging if the lateral cortex of the coracoid was more than 4 mm medial or 1 mm lateral to the articular surface of the glenoid, respectively. Coracoid graft resorption was assessed using Zhu et al's classification system.[10,38] The assessment of screw positioning was conducted according to criteria published by the authors of this study.[22] For analysis, screw angles were grouped into 2 ranges: 0 to 15 degrees and equal to or greater than 16 degrees, based on studies by Hovelius et al., which concluded that screw angulation should be less than 15 degrees for adequate coracoid position and stable fixation.[16,17]

Clinical assessment

Patients underwent preoperative and postoperative physical examinations performed by a single experienced shoulder surgeon, with a minimum follow-up of 5 years. Range of motion, apprehension, pain (measured with Visual Analog Scale scores), and shoulder function (assessed with Rowe and Walch-Duplay scores) were recorded.

Statistical analyses

For descriptive statistics, data were presented as mean and standard deviation or as frequency. The quantitative variables were tested for normality through the Kolmogorov–Smirnov. Continuous variables were compared by T-test or Mann–Whitney-test and categorical variables were compared by $\chi 2$ test. A significance level of 0.05 was set for all tests. All analyses were performed using GraphPad Prism software version 8.0 for Windows (I GraphPad software, Boston, MA, USA). For odds ratio analyzes of glenoid lesion size with preoperative OA, a receiver operating characteristic curve was calculated to determine the optimal cutoff point, which was then used to calculate the odds ratio.

Results

Demographic data

Out of 106 patients who underwent the Latarjet procedure during the study interval, 61 patients were excluded because they did not complete the follow-up. Fifty joints of 45 patients were included in the final analysis. All the cases included had preoperative and postoperative CT scans with a minimum follow-up of five years. The mean age of the patients was 38.7 years (range, 20-56), with a mean follow-up of 5.8 years (range, 5-12). Most patients were male (42

Table II Association between potential risk factors and presence of preoperative osteoarthritis

	Without preoperative OA	With preoperative OA	*P* value
N	29	21	
Sex			>.99*
Male	27	20	
Female	2	1	
Diagnosis			.06*
Epilepsy	2	6	
Atraumatic	2	3	
Traumatic	25	12	
Age at the time of first dislocation or subluxation (yr)	24.5 ± 6.8	26.4 ± 7.2	.13†
Time living with instability (mo)			.46†
Mean ± SD	96.4 ± 76.4	116 ± 90.9	
Median [min-max]	60 [8-312]	108 [24-408]	
Number of dislocations and/or subluxations before surgery			.41*
0-10	8	3	
10-20	4	1	
20-30	4	4	
>30	13	13	
Glenoid defect size	18.03 ± 8.8	25.7 ± 6.50	.0017‡

OA, osteoarthritis; *SD*, standard deviation.
* Fisher test.
† Mann Whitney test.
‡ T test.

men and 3 women). Of the 50 cases with anterior shoulder instability, 37 had a traumatic etiology, 8 developed instability after a seizure disorder, and 5 had an atraumatic cause. The mean age at first-time dislocation was 25.2 years (range, 12-39). A primary Latarjet procedure was performed in 41 (82%) while 9 cases (18%) were revision surgeries for failed arthroscopic instability repairs (Table I).

Postoperative CT evaluation was performed at a mean follow-up of 72 months after surgery (60 to 132 months).

Radiologic results

Graft position, healing, and resorption

Postoperatively, bone osteointegration occurred in 48 cases (96%). The position of the graft was considered optimal in 44 cases. Three were considered medial, and 3 were considered lateral. According to Yi-Ming Zhu et al's[32] classification system, graft resorption occurred in 35 cases (70%), with 18 type I, 13 type II, and 4 type III. In 2 cases, screw removal was necessary due to hardware impingement, making classification impossible. In all cases, more severe resorption occurred in the superior part of the graft around the superior screw.

Risk factors for preoperative OA

The presence of OA was found in 21 of 50 cases (42%). Of those, 18 were graded as Samilson 1, 2 Samilson 2, and 1 Samilson 3. The risk of OA was significantly associated with both shoulder dislocation following a seizure disorder and a larger glenoid size defect ($P < .05$). Factors found to have no statistical influence on the development of preoperative OA included age at the initial injury, number of preoperative dislocations and time interval from the initial injury to surgical stabilization (Table II).

Regarding glenoid defect size, we found that patients presenting with lesions greater than 22% were 4.7 times more likely to have preoperative OA (OR:4.7, CI95 [1.405-16.05], $P = .01$).

Risk factors for progression of OA

All patients with postoperative OA were divided into 4 groups: (1) patients without preoperative OA that developed postoperatively; (2) patients with preoperative OA that worsened in grade; (3) combination of groups 1 and 2 (all cases with grade progression); and (4) a group of patients with progression of OA more than one stage above (Fig. 2).

Of the 29 shoulders without preoperative arthritis, 8 developed arthritis postoperatively (27.5%), including 7 in stage 1 and 1 case in stage 2 (group 1). Of those 21 cases with preoperative osteoarthritis (group 2), progression occurred in 11 cases (52.3%) ($P = .25$). When considering all cases with OA progression (group 3), significant risk factors were the presence of intra-articular screws and when

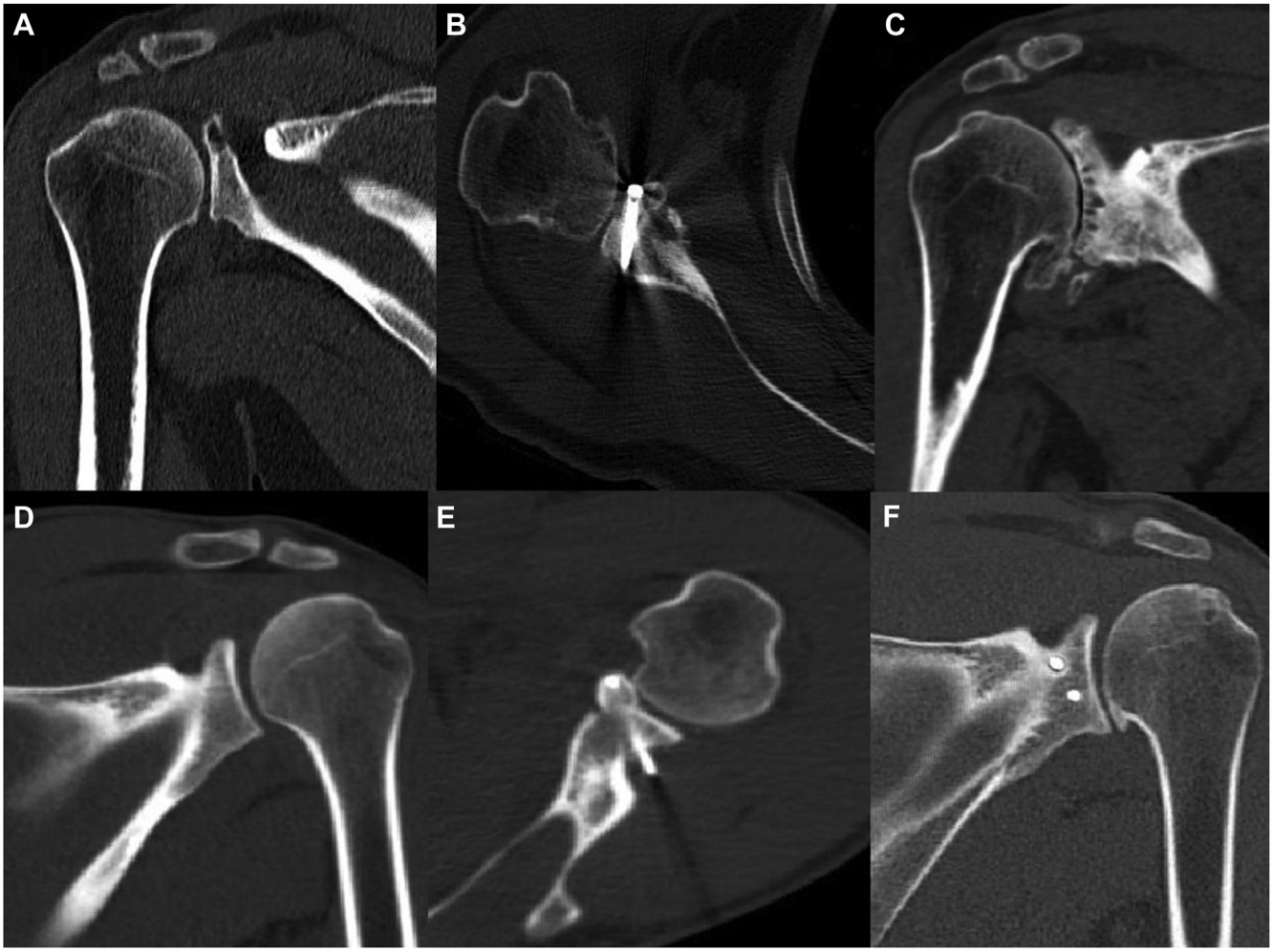

Figure 2 CT scan revealing progression of osteoarthritis related to technical errors. (**A**) Preoperative CT scan showing osteoarthritis grade 1; (**B**) Presence of intra-articular screw after Latarjet procedure; (**C**) Evolution to grade 4 osteoarthritis and screw removal; (**D**) Preoperative CT scan showing no presence of osteoarthritis; (**E**) Presence of lateral overhang position of the coracoid graft; and (**F**) Evolution to grade 2 osteoarthritis. *CT*, computed tomography.

both screws had angulation equal or above 16° ($P < .06$) (Table III). When considering those patients with progression of OA above 1 grade, significant risk factors were lateral graft position, screw angulation, and the presence of intra-articular screws (Table IV).

Clinical evaluation

Range of motion was measured before surgery and at the final follow-up. Forward flexion was 158.2° ± 26° preoperatively and 165° ± 14° postoperatively. The average of active external rotation was 62.9° ± 15° preoperatively and 60° ± 16° postoperatively. The average of active internal rotation was preoperatively T6 (T3-L3) and T8 (T5-L5) postoperatively. The mean Rowe score was 90 (range, 45-100), with ratings of excellent for 39 joints, good for 6 joints, fair for 4 joints, and poor for 1 joint. The mean Walch-Duplay score was 87.8 (range, 55-100) postoperatively. No cases of recurrence of instability occurred as obvious dislocations. Eight patients presented a positive anterior apprehension test, but none required further surgery for instability. When including only the group of patients with a positive anterior apprehension test, functional scores were lower, with the mean Rowe score being 70 (range, 45-95) and the mean Walch-Duplay score being 73.5 (range, 55-90).

Discussion

The current literature recommends the Latarjet procedure for patients with bony deficiency as little as 13.5% to 15% of the glenoid.[32,37] Additionally, some surgeons advocate for this procedure in patients at risk of failure of an arthroscopic soft tissue repair, even in the absence of bone loss.[12,29,34,35,37] Riff et al published an insightful paper on

Table III Association between potential risk factors and presence of postoperative osteoarthritis

	Without OA progression	With OA progression	*P* value
N	31	19	
Sex			.84*
Male	29	18	
Female	2	1	
Diagnosis			.99*
Epilepsy	5	3	
Atraumatic	3	2	
Traumatic	23	14	
Age at the time of first dislocation or subluxation (yr)	24.6 ± 6.5	26.6 ± 7.8	.32†
Time living with instability (mo)			.78‡
Mean ± SD	98.1 ± 67.2	119.1 ± 103.4	
Median [min-max]	90 [8-268]	88 [24-384]	
Number of dislocations and/or subluxations before surgery			.44*
0-10	8	3	
10-20	3	2	
20-30	3	5	
>30	17	9	
Glenoid defect size	20.7 ± 8.6	22.1 ± 9.0	.59
Preoperative OA			.08*
No	21	8	
Yes	10	11	
Mean follow up time (mo)	65.8 ± 23.2	78.0 ± 32.7	.21†
Apprehension			>.99
No	26	16	
Yes	5	3	
Revision			.27
No	27	14	
Yes	4	5	
Bone healing			.15
No	0	2	
Yes	31	17	
Bone graft position			.58
Flush	28	16	
Lateral	1	2	
Medial	2	1	
Coracoid graft resorption			.53
No	10	3	
Yes	21	14	
Intraarticular screws			.05
No	31	16	
Yes	0	3	
Screw positioning			.13
0-15°	16	5	
≥16° (at least 1)	15	14	
Screw positioning			.06
0-15° (at least 1)	23	9	
Both ≥16°	8	10	

OA, osteoarthritis; *SD*, standard deviation.

* Fisher test.

† T-test.

‡ Mann Whitney test.

Table IV Association between potential risk factors and presence of postoperative osteoarthritis with progression above 2 grades

	OA progression = 1	OA progression >1	*P* value
N	14	5	
Sex			>.99
Male	13	5	
Female	1	0	
Diagnosis			.29
Epilepsy	3	0	
Atraumatic	2	0	
Traumatic	9	5	
Number of dislocations and/or subluxations before surgery			.57
0-10	3	0	
10-20	1	1	
20-30	4	1	
>30	6	3	
Preoperative OA			>.999
No	6	2	
Yes	8	3	
Mean follow up time (mo)	81.7 ± 33.9	67.6 ± 30.1	.42
Revision			.1
No	9	5	
Yes	5	0	
Bone graft position			.04
Flush	13	3	
Lateral	0	2	
Medial	1	0	
Coracoid graft resorption			.32
No	3	0	
Yes	11	2	
Intra-articular screws			.0016
No	14	2	
Yes	0	3	
Screw positioning			.11
0-15°	5	0	
≥16° (at least 1)	9	5	
Screw positioning			.01
0-15° (at least 1)	9	0	
Both ≥16°	5	5	

OA, osteoarthritis.

trends in shoulder stabilization techniques between 2007 and 2015. Despite the limitation of using a private database from a single insurance provider in the United States, they clearly demonstrated that arthroscopic stabilization remained the most utilized stabilization technique. The study showed that the use of the Latarjet procedure was steadily increasing and, at the time of publication, rivaled open Bankart repair among the most commonly used open stabilization techniques. They also noted that 33% (63 of 190) of the Latarjet procedures were performed in the last 2 years of the study, highlighting the growing adoption of this technique.[33] Given the increasing number of Latarjet procedures in young patients, understanding the risk factors for preoperative and postoperative OA in mid-term follow-up is crucial, as well as understanding the factors related to the rate of OA progression.[14,18,19,28] Another important consideration is whether there is a superior method for diagnosing OA.[21,30] Hovelius et al conducted a prospective 15-year follow-up study on patients who underwent the Bristow-Latarjet procedure to analyze dislocation arthropathy using radiographs.[17] In their study, they observed variations in results when employing different X-ray projections for grading according to the Samilson-Prieto classification.[36] Notably, they reported 5 cases that had been initially classified as having arthritis, but exhibited a reversal to a normal joint status after the 15-year follow-up period. These findings imply potential inaccuracies in assessing OA through plain radiographs.[16,17] Ogawa et al

investigated preoperative OA development in young patients with unilateral traumatic anterior instability using radiography and CT evaluation.[30] The radiographic incidence of OA was 11.3%, while CTs revealed a humeral head spur incidence of 31.2% of the shoulders. These findings suggest that the occurrence rate of OA may be underestimated based on radiography alone, highlighting the utility of CT in visualizing incipient OA not revealed by radiography. Buscayret et al reported an incidence of 8.4% of preoperative OA in patients with anterior shoulder instability, identifying risk factors such as older age at the initial instability episode, age at the time of surgery, longer time interval between the first episode and surgery, and lesions at the anterior glenoid rim.[8] Mizuno et al demonstrated the presence of preoperative OA in 11.8% of cases undergoing the Latarjet procedure.[29] Both authors used radiographic exams for grading OA, likely underestimating this rate, and explaining the higher incidence (42%) in our study group, even though most cases (86%) were considered mild arthritis. Preoperatively, in our series, risk factors for the presence of OA included cases involving instability resulting from seizure disorders and larger glenoid bone defects.

Several well-established risk factors significantly contribute to the progression or development of osteoarthritis after Latarjet surgery. In a systematic review conducted by Menon et al, it was concluded that the Latarjet procedure is a safe surgical treatment for recurrent anterior shoulder instability, with a low risk of developing moderate or severe OA even during long-term follow-up.[28] The study also concluded that the principal risk factor for joint degeneration was identified as the overhanging position of the bone graft, while hyperlaxity appeared to have a protective effect.[28] In our series, we could note that the cases with worsening arthritis by more than one grade were those associated with the presence of an intra-articular screw or when both screws exhibited an inclination greater than 15 degrees suggesting that hardware impingement is a factor that surgeons should be cautious about. This is crucial, given the increasing frequency of arthroscopic Latarjet procedures, and one of the most challenging steps in this technique is the screw fixation.[5,11] A systematic review by Suarez et al compared screw-related complications after open and arthroscopic Latarjet procedures, reporting that the rate of screw removal may be higher after the arthroscopic Latarjet procedure (up to 18%) compared to open procedures (up to 7.3%).[24] Also, coracoid graft resorption and glenoid remodeling can occur after the Latarjet procedure, and a well-placed metallic screw at the time of surgery may become proud and cause humeral head impingement. A previously published series by us, demonstrated a significant relationship between screw angle and the presence of radiographic complications.[22] The average angle between the 2 screws was significantly greater in cases with observed complications. These findings align with prior studies that recommend a maximum screw inclination of 15 degrees relative to the glenoid articular surface.[15-17] Therefore, placing the screws as parallel as possible to the joint line should be recommended.

Due to the complications associated with the Latarjet procedure and concerns related to the development of glenohumeral OA, some surgeons prefer using a free bone block for glenoid reconstruction in cases of anterior shoulder instability. When comparing the progression to OA between the Latarjet procedure and free bone block, most studies have not shown significant differences between the 2 techniques.[13] In a systematic review conducted by Gilat et al, despite significant heterogeneity among the studies, no statistically significant differences were found between the procedures in terms of OA progression rates.[13]

This study has several strong points. Firstly, the consistent use of CT scans both before and after surgery ensures a comprehensive and detailed assessment of anatomical changes of the humeral head allowing more predictability. The substantial minimum follow-up period of 5 years is a significant strength, allowing for a thorough understanding of outcomes and potential complications over a medium-term timeframe. Moreover, the fact that all patients were examined at the final follow-up by the first author ensures a standardized and reliable assessment process, minimizing variability in evaluations. The present study also has some limitations and includes the retrospective design. Tracking limitations inherent in the social system in our country may be one of the significant barriers to conducting follow-up studies resulting in a substantial loss of patients. Additionally, while associations can be identified in a retrospective cohort design, causality cannot be established, which would require a prospective cohort study.

Conclusion

Our study reveals a higher incidence of osteoarthritis than reported in the literature, likely attributed to the imaging method employed. Preoperatively, risk factors for the presence of OA include cases resulting from seizure disorders and larger glenoid bone defects. Postoperatively, the only factors related to the progression of osteoarthritis were those associated with potential surgical technique issues, specifically the placement of joint screws or their excessive inclination.

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