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ORIGINAL ARTICLE

ARTHROSCOPIC LATARJET STABILISATION PROCEDURE – CLINICAL AND RADIOLOGICAL SHORT TERM OUTCOMES IN THE FIRST 101 CASES

ARTROSKOPOWA STABILIZACJA LATARJET – KLINICZNE I RADIOLOGICZNE KRÓTKOTERMINOWE WYNIKI LECZENIA 101 PRZYPADKÓW

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ABSTRACT

Introduction and aim

Latarjet remains one of the most efficient stabilisation procedures in anterior shoulder instability. The goal of this study was to evaluate the clinical outcomes and radiological parameters after arthroscopic Latarjet.

Material and methods

Between 2011–2016 an arthroscopic Latarjet stabilisation was performed in 104 patients, who were controlled with clinical examination, X-ray and CT-scans at a minimum follow up of 13 months.

Results

101 shoulders (97.1%) were available for clinical evaluation. The mean follow-up was 23.8 months (13 to 50). 96 shoulders (95%) had CT scan evaluation. Patients satisfaction was evaluated as 92%, SSV 88%, Walch-Duplay and Rowe scores respecitvely 77 and 80 points. The mean external rotation loss was 17˚ with no further motion deficits. Recurrence was reported in 4 (4%) patients. 2 out of 4 cases of recurrence had intraoperative complications (correlation in M-L *Chi²* test p = 0.0107). Revision surgery was performed in 10 patients (9.8%). CT evaluation showed 95.8% of graft fusion rate, 1 case (1%) of total graft osteolysis, 2 cases (2.1%) of graft pseudoarthrosis and 2 cases (2.1%) of graft fracture.

Conclusions

The arthroscopic Latarjet demonstrates satisfactory results in short term follow-up. Some factors influencing the outcome are: intraoperative graft related complications (correlated strongly with recurrence), subjective return to sport anxiety and loss of external rotation (correlated with worsened clinical outcome).

Keywords: Latarjet, arthroscopic, anterior shoulder instability, coracoid transfer, shoulder stabilisation, short term outcome

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STRESZCZENIE

Wstęp i cel

Latarjet pozostaje jedną z najbardziej skutecznych procedur stabilizacji w przypadku niestabilności przednia barku. Celem tego badania była ocena wyników klinicznych i parametrów radiologicznych po stabilizacji techniką artroskopowego Latarjet.

Materiał i metody

W latach 2011–2016 stabilizację artroskopową Latarjet wykonano u 104 pacjentów, u których wykonano badanie kliniczne, RTG i TK po minimum 13 miesiącach obserwacji.

Wyniki

Oceną kliniczną objęto 101 barków (97,1%). Średni okres obserwacji wyniósł 23,8 miesiąca (13 do 50). Ocenę TK wykonano u 96 barków (95%). Zadowolenie pacjentów oceniono na 92%, SSV 88%, a skale Walch-Duplay i Rowe wykazały 77 i 80 punktów. Średnia utrata rotacji zewnętrznej wynosiła 17° bez dalszych deficytów ruchu. Nawrót wystąpił u 4 (4%) pacjentów. W 2 z 4 przypadków nawrotu wystąpiły powikłania śródoperacyjne (korelacja w teście M-L *Chi²* p = 0,0107). Operację rewizyjną wykonano u 10 chorych (9,8%). Ocena TK wykazała 95,8% wgojenia przeszczepu, 1 przypadek (1%) całkowitej osteolizy przeszczepu, 2 przypadki (2,1%) stawu rzekomego przeszczepu i 2 przypadki (2,1%) złamania przeszczepu.

Wnioski

Stabilizacja metodą artroskopowego Latarjet daje zadowalające wyniki w krótkoterminowej obserwacji. Niektóre czynniki wpływające na wynik to śródoperacyjne powikłania związane z przeszczepem (silnie skorelowane z nawrotami), subiektywny lęk powrotu do sportu i utrata rotacji zewnętrznej (skorelowana z pogorszeniem wyników klinicznych).

Słowa kluczowe: Latarjet, artroskopia, niestabilność przednia barku, transfer, stabilizacja barku, wyniki krótkoterminowe

Introduction and aim

Latarjet coracoid bone block stabilisation is one of the most efficient surgical procedures for treating anterior shoulder instability providing low recurrence rate and high patient satisfaction (Latarjet, 1954; Allain *et al.*, 1998; Hovelius *et al.*, 2004; Butt and Charalambous, 2012; Edwards and Walch, 2012; Bhatia *et al.*, 2014). While the open technique remains the 'gold standard', the number of arthroscopic stabilisations has been increasing (Lafosse *et al.*, 2007; Lafosse and Boyle, 2010; Dumont *et al.*, 2014; Rosso *et al.*, 2016; Castricini *et al.*, 2013; Boileau *et al.*, 2016; Kany *et al.*, 2016; Marion *et al.*, 2017; Zhu *et al.*, 2017). The goal of this study was to evaluate clinical and the radiological – via use of computed tomography (CT) – outcomes, in patients after the arthroscopic Latarjetstabilisation. We hypothesised that surgical and radiological factors influencing the outcomes and increasing the risk of complications and recurrence may be identified, as some tendencies were already described in the previous studies (Lafosse and Boyle, 2010; Kany *et al.*, 2016; Kordasiewicz *et al.*, 2017, 2018). Identification of the weak spots is a way to improve the technique.

Material and methods

Between 2011 and 2016 at our institution 104 arthroscopic Latarjetstabilisations were performed for anterior shoulder instability, including 11 revision cases after primary soft tissue repair. The surgeries were performed by the senior author (BK). Preoperatively X-ray (AP and Y view) was performed, combined with CT or MRI. Based on radiological and clinical data the indication for soft-tissue or bone-block procedure has been made. Patients qualified for Laterjetstabilisation were supposed to have several risk factors, usually combined: professional sport or high risk activity, Hill-Sachs lesion of more than 15% of humeral head diameter, glenoid bone loss > 10%, laxity (thumb – forearm distance less than 2 cm, external rotation with arm at the side > 85°), recurrence after prior soft tissue procedure. The final operative decision was undertaken after arthroscopic glenohumeral joint inspection encompassing anterior soft tissue quality (poor tissue in favour of Latarjet procedure) and assessment of Hill-Sachs lesion engagement (anterior glenoid rim and Hill-Sachs lesion contact and dislocation in abduction and external rotation, according to 'on track/off track' hypothesis) (Yamamoto *et al.*, 2007; Di Giacomo, Itoi and Burkhart, 2014). During the abovementioned period of time the senior author performed 112 arthroscopic soft tissue stabilisations – resulting in Latarjet procedure being performed for 48.1% of anterior instability cases. Patients with multidirectional instability or hyperlax patients with anterior shoulder subluxations without any single traumatic episode were routinely treated non-operatively.

Surgical technique

Arthroscopic stabilisation was performed according to Lafosse's technique, using specific arthroscopic instruments (DePuy, Mitek, Raynham, MA, USA) in the beach chair position under general anaesthesia and interscalene block (Figure 1). Postoperatively, a simple sling was used for 2 to 10 days depending on the patient's control of pain. In this period, active exercise of fingers, wrist and elbow were introduced along with passive, pendulum exercises of the shoulder. After pain and swelling decreased, the sling was discontinued and active mobility started within pain free limits and with respect to natural scapulo-thoracic rhythm. Water exercises were recommended after wound healing. After 2 to 4 weeks stretching exercises were introduced and after achieving full forward flexion, muscle strengthening was started, no sooner than 8 weeks after the surgery. Contact sports were allowed after restoration of a full range of motion and strengthening, but no sooner than 3 months after surgery.

Patient evaluation

From 2014 all patients were invited for a control review: clinical examination, radiographic and CT scan with a minimum follow-up of 13 months. Informed consent was obtained from all individuals included in the study – patients were informed about the potential risk of CT. This control study achieved approval of the institution's ethical committee (Ethical Board of the Centre of Postgraduate Medical Education, No 38/PB/2014). Clinical control was performed by 2 senior residents, not involved in surgery and radiological evaluation was supervised by a senior specialist in a musculoskeletal radiology. Clinical results were assessed with Walch-Duplay, Rowe and simple shoulder value (SSV) scores and pain in VAS score (Rowe, Patel and Southmayd, 1978; Walch, 1987; Wewers and Lowe, 1990; Gilbart and Gerber, 2007). Patients also evaluated satisfaction answering the question (rating from 0 to 100%): 'How satisfied are you with the surgery outcome?' CT scans were performed on a GE Bright Speed 16-row scanner, using the standard shoulder protocol and slice thickness 0.63 mm. All measurements were made using Carestream software version 11.4 (Carestream Health; Rochester, NY, USA). Three dimension (3D) and multiplanar reformations were used for the optimal visualization of anatomy and the screws (Figure 2–5). Graft fusion was determined by the presence of a bone bridge between the coracoid and the glenoid. Non-unions were identified as stable – with no lysis around the screws and unstable – with hardware loosening and graft dissociation. Bone block osteolysis was evaluated in both axial and

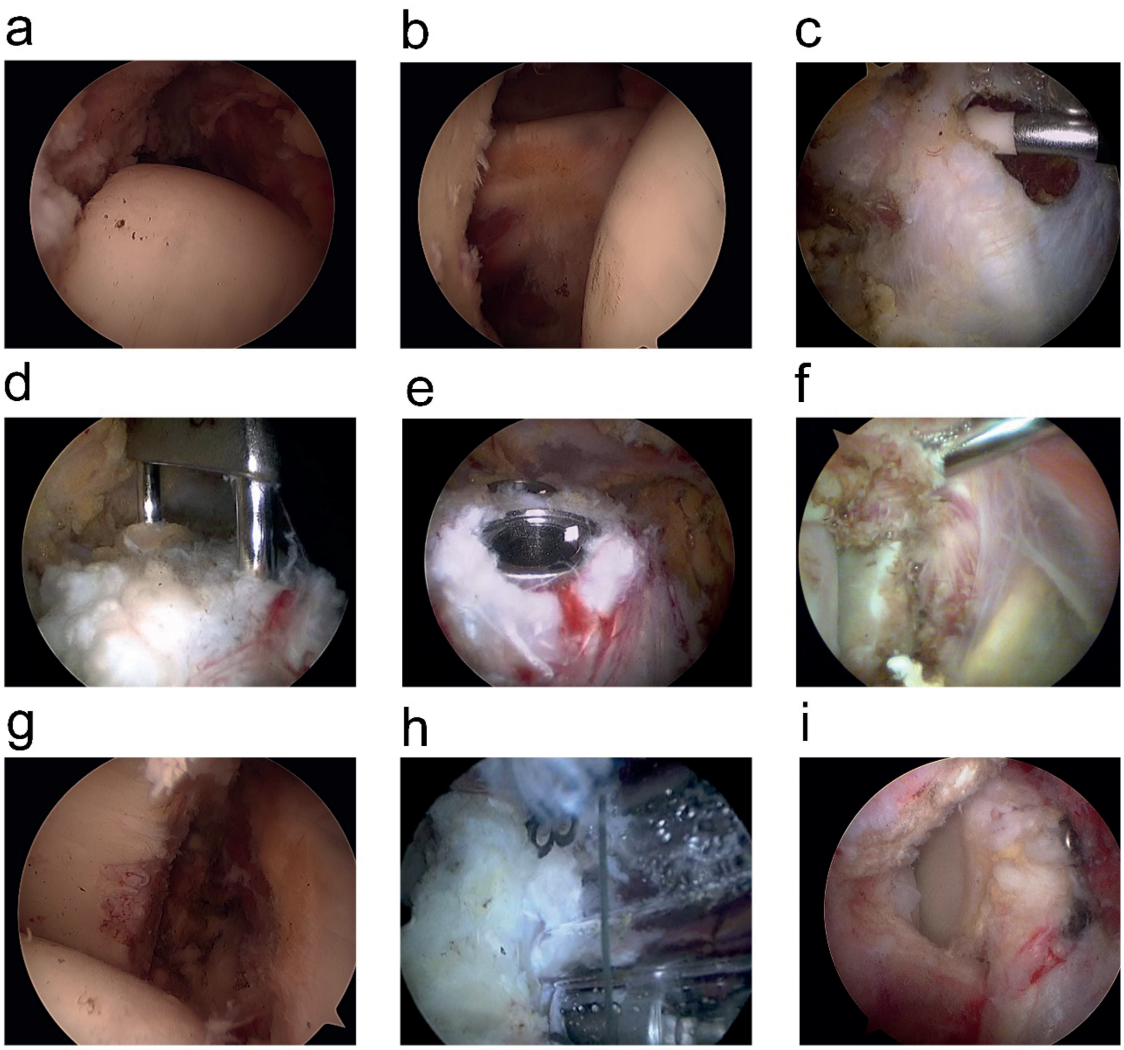

Figure 1. Arthroscopic Latarjet – surgical steps, right shoulder, patient in a beach chair position. a) Hill-Sachs lesion appreciation and its 'engaging' – this test is performed in 'apprehention position' of 90 degrees of abduction and external rotation, according to 'on track/offtrack' hypothesis (posterior portal view); b) Capsule removal – glenoid bone loss and subscapularis tendinous chords are visible (posterior portal view); c) Coracoid preparation – rotator interval opening (posterior portal view); d) Coracoid preparation – K wires to mark the positioning of the bone tunnels (anterolateral portal view); e) Coracoid with top hats after drilling – ready for harvesting (anterolateral portal view); f) Subscapularis view from outside the joint, switching stick penetrating the muscle and axillary nerve visible (anterolateral portal view) Final glenoid neck preparation – after subscapularis split a bur is used to create a flat bed of bleeding bone (anterolateral inferior portal view); h) Coracoid fixation onto scapular neck – the harvested coracoid is introduced through the subscapularis split onto glenoid neck between 3 and 5 o'clock position, 1 to 2 mm medial to the glenoid rim to avoid graft lateralization – temporary fixation was achieved using long K-wires – when the graft placement was optimal, 3.2 mm cannulated drill was used and a final fixation was completed with 3.5 mm cannulated screws. Drilling and fixation were performed through the double-barrel cannula from medial portal (anterolateral inferior portal view); i) final view of the coracoid bone block.

sagittal plane and described as total – concerning the entire graft, or partial – around the superior or the inferior screw. The bone block position was evaluated according to Kraus *et al.* technique (Kraus *et al.*, 2013). In the axial view, the line between anterior and posterior glenoid rims was the reference line. The graft could be positioned flush, medial or lateral to this glenoid line (Figure 2). The bone block position in the vertical axis – graft height – was evaluated in the sagittal plane and the 'clock system' was used following Kraus *et al.* technique (Figure 3) (Kraus *et al.*, 2013). The axis connecting the most superior and the most inferior aspect of glenoid formed the vertical line between 12 and 6 o'clock points. The anterior glenoid was always considered between the 12 and

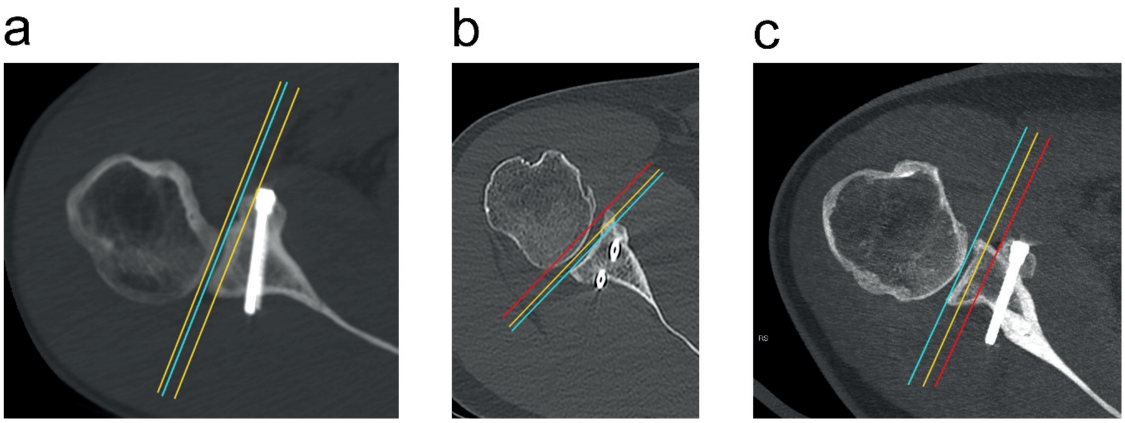

Figure 2. Axial view; a) a bone block healed in a flush position with the line of reference (blue line between anterior and posterior glenoid rims), the yellow lines are medial (4 mm) and lateral (2 mm) tolerance line regarding the bone block position in the axial view – the zone of 'tolerance' is between these yellow lines; b) a bone block healed in overhanging position (red line) – it is more lateral than a tolerance line (yellow line) related to the cartilage presence – 2 mm lateral to the reference line (blue line); c) a bone block healed in too medial position (red line) – more medial then a tolerance line (yellow line) that is 4 mm medial to the reference line (blue line).

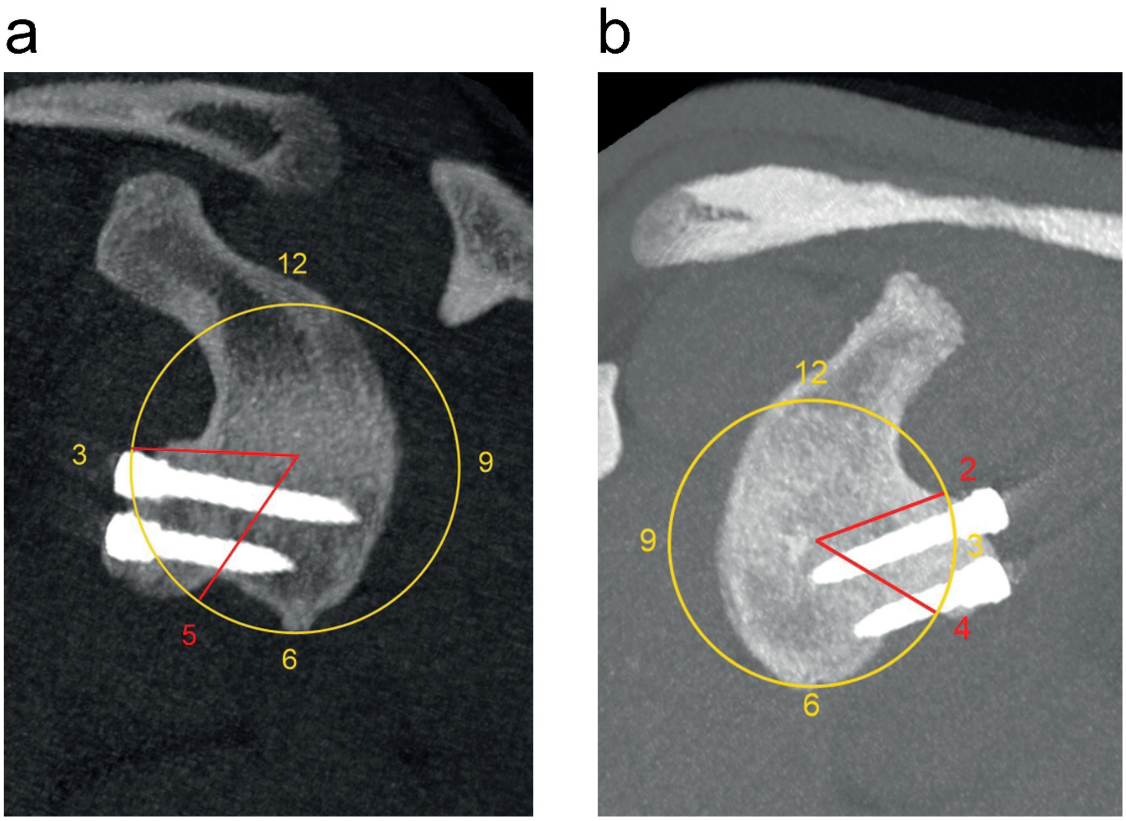

Figure 3. Saggital view; a) a bone block healed in a proper position (height between about 3 and 5 o'clock); b) a bone block healed slightly too high (between 2 and 4 o'clock).

6 o'clock and was divided into 4 sectors (1–3, 2–4, 3–5 and 4–6 o'clock position). Screw orientation in relation to the glenoid was measured in the axial plane as proposed by Ladermann *et al.*: screw angle was determined as the angle between the line linking the posterior and anterior glenoid rim and the screw axis (Figure 4) (Ladermann, Denard and Burkhart, 2012). In the same plane, screw protrusion in relation to the posterior glenoid neck cortex was measured to evaluate its penetration into infraspinatus fossa. The screw-equator angle was measured between the line perpendicular to the glenoid

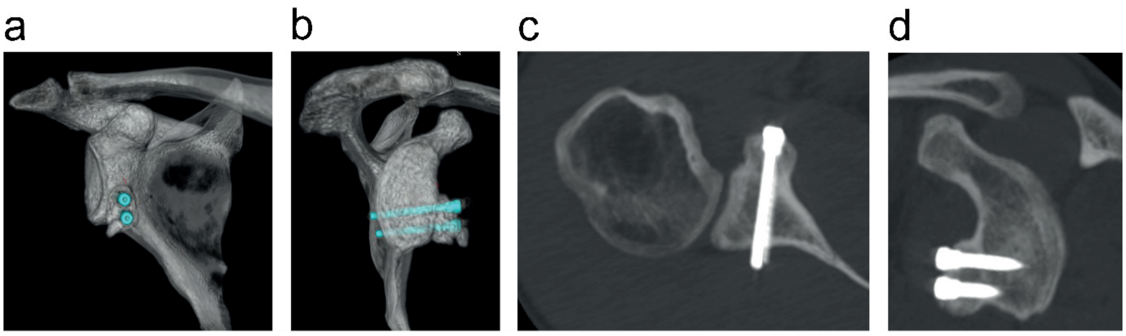

Figure 4. Properly healed bone block: a) view from anterior of a 3D reconstruction; b) view from lateral (saggital view) of a 3D reconstruction – graft healed in a proper position between 3 and 5 o'clock; c) axial view of the same graft; d) saggital view of the same graft.

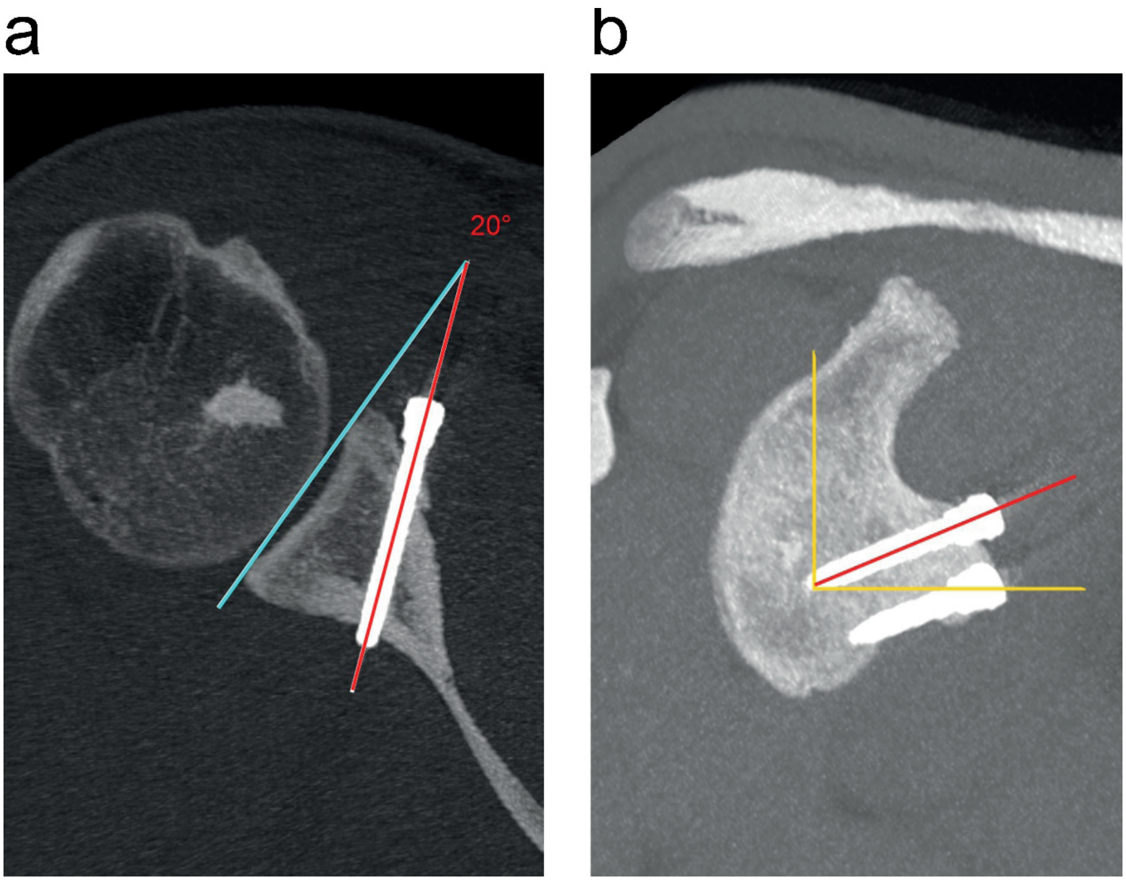

Figure 5. The screws position: a) axial view – the screw angle is created between the line of reference (blue line) and the axis of the screw (yellow line); b) saggital view – a screw-equator angle measured between the equatorial line (yellow horizontal line perpendicular to the yellow vertical line between superior and inferior glenoid pole – 12 and 6 o'clock) and the axis of the screw (red line).

meridian and the screw axis in the sagittal plane (Figure 5). The subscapularis muscle fatty infiltration was evaluated according to Goutallier *et al.* classification (Goutallier *et al.*, 1995).

Statistics

The correlations between preoperative, intraoperative and postoperative data and clinical results were analysed. All statistical analysis was performed using STATISTICA 7.0 software (StatSoft, Inc., STATISTICA for Windows, Tulsa, OK). The analysed groups were compared using descriptive statistics and non-parametric statistics analysis. Cross tabulation tables were used for the descriptive statistics. All measures of the relations between cross tabulated variables were performed using the following tests: Pearson *Chi²*, *Chi²* with Yates' correction and M-L *Chi²*. For the non-parametric statistics the following tests were used: Mann-Whitney U test, Kolmogorov-Smirnov, Friedman ANOVA, Wald-Wolfowitz and Kruskal-Wallis. Spearman rank R correlation test was used to assess the relationship (correlation) between the variables. A p-value of < 0.05 was considered statistically significant.

Results

One hundred and four arthroscopic Latarjetstabilisation procedures were performed between 2011 and 2016: 93 primary and 11 revision cases. Three cases were lost to follow-up and 101 shoulders (97.1%) were available for clinical evaluation: all revision cases and 90 out of 93 shoulders (96.8%) operated on primarily. Ninety-six (95%) out of 101 controlled shoulders were available for complete radiological evaluation: all revision cases and 85 shoulders after primary stabilisation – 5 patients did not accept the radiological part of the study. The mean follow-up was 23.8 months (from 13 to 50), 88 patients (87.1%) were males, the average age at surgery was 26.2 years (from 16 to 50), the dominant shoulder was operated on in 61 patients (60.4%), the average number of dislocations and subluxations before surgery was 4 and 14 respectively. The detailed patient characteristics is reported in Table 1. There were no significant differences between – primary and revision groups – with exception regarding preoperative Rowe score in favour of primary stabilisation (27 versus 25 points). For this reason we decided to analyse both groups in this study. All the results are presented in tables divided into 3 groups: primary and revision cases as well as results combined for both groups. Below the overall results are presented and discussed with significant differences between primary and revision cases pointed out.

Intraoperative data

The average time of surgery was 113 minutes (from 70 to 210) – Table 2. Concomitant injuries were identified in 12 patients (11.9%): 2 partial supraspinatus tear, 4 SLAP lesions, 1 SLAP lesion with loose bodies, 2 loose body, 1 posterior labrum tear, 1 isolated LHB tendon tear, 1 glenoid chondromalacia grade III – and were addressed accordingly. There were 9 intraoperative complications (8.9%): 1 medial cutaneous antebrachial nerve injury; 1 graft breakage at the proximal hole level, fixed with 1 screw; 3 cases of graft ventral side infraction without any influence on final fixation; 1 superior screw fixed too deep in the graft due to poor bone quality; 2 distal cortices destroyed whilst drilling a distal hole in the graft – no top hats – washers for fixation; 1 distal screw poor fixation. In the last 4 cases no compression was achieved with only an anti-rotational effect of the second screw. Eight out of 9 intraoperative complications concerned graft harvesting, drilling or fixation. Correlation was found (M-L *Chi²* test p = 0.0107), between the intraoperative complications and recurrence: 2 cases of intraoperative problems (graft breakage with 1 screw fixation and destruction of the peripheral cortex whilst drilling with no compression of the distal screw) had recurrence. The remaining 7 complications had no impact on the results.

Clinical results

Patient satisfaction was evaluated as 92%, SSV 88%, Walch-Duplay and Rowe scores 77 and 80 points respectively (Table 3). The mean forward flexion and abduction was 176˚. External rotation with arm at the side was 57˚ with 17˚ of loss of rotation compared to the contralateral shoulder. Noticeable is a significant difference in range of motion between patients after primary and revision stabilisation – flexion and abduction: 177˚ versus 165˚, as well as loss of external rotation with arm at the side: 15˚ and 31˚ respectively. We found statistically significant correlations between these 3 parameters and

Table 1. Patient data; in brackets values describing each group; SD – standard deviation; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

	Primary surgery	Revision surgery	p-value	Total
Number of cases	90	11	–	101
Sex F/M	10 (11.1%)/ 80 (88.9%)	3(27.3%)/ 8 (72.7%)	0.171	13 (12.9%)/ 88 (87.1%)
Age at first episode (years)	21.2 (13–40) SD 5.2	22.5 (12–49) SD 10.8	0.469	21.3 (12–49) SD 6
Age at surgery (years)	26.2 (16–44) SD 5.6	26.5 (16–50) SD 9.9	0.863	26.2 (16–50) SD 7
Follow-up (months)	23.7 (13–50) SD 7.1	24.3 (13–38) SD 6.9	0.203	23.8 (13–50) SD 7.1
Time to surgery (months)	59.0 (4–228) SD 47.6	47 (10–108) SD 29.5	0.437	58 (4–228) SD 46
Dominant	55 (61.1%)	6 (54.5%)	0.799	61 (60.4%) 2 (2%) bilateral
Number of dislocations	4 (0–40) SD 7	6 (0–15) SD 6	0.401	4 (0–40) SD 7
Number of subluxations	13 (0–100) SD 20	17 (0–75) SD 22	0.401	14 (0–100) SD 20
Pain in live activity	22 (24.4%)	3 (27.3%)	0.273	25 (24.7%)
Laxity	55 (61.1%)	7 (63.6%)	0.870	62 (61.4%)
Walch – Duplay score	21 (–10–40) SD 9	19 (5–25) SD 9	0.836	21 (-10–40) SD 9
Rowe score	27 (0–40) SD 6	25 (15–30) SD 7	0.003	27 (0–40) SD 9

Table 2. Intraoperative data; in brackets values describing each group; HS – Hill-Sach's lesion, type I – in proximity of infraspinatus tendon insertion, type II – located more medially and separated from isfraspinatus tendon insertion by the cartilage insula; SD – standard deviation; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

	Primarysurgery	Revisionsurgery	p-value	Total
Time of surgery (minutes)	113 (70–210) SD 27	116 (70–180) SD 29	0.752	113 (70–210) SD 27
Intraoperativecomplications	8 (8.9%)	1 (9.1%)	0.982	9 (8.9%)
HS type I	73 (81.1%)	11 (100%)	0.248	84 (83.1%)
HS type II	17 (18.9%)	0	0.248	17 (16.8%)
Concomitantinjuries	9 (10%)	3 (27.3%)	0.135	12 (11.9%)

Walch-Duplay, Rowe and SSV scores, with the strongest influence of loss of external rotation with arm at the side (Table 4).

Recurrence

There were 4 cases (4%) of recurrence – 1 dislocation and 3 subluxations:

- 1 patient with an intraoperative graft fracture fixed with 1 screw – dislocation with graft and screw fractures 7 months after surgery;
- 1 patient after fixation with 2 screws, but one with only an anti-rotation effect due to graft distal cortex destruction when drilling – subluxation with graft and screw fracture 2 weeks after surgery;
- 1 patient – severe trauma 18 months after surgery with subluxation and a screw head fracture and perfectly healed graft left intact;
- 1 patient – revision Latarjetstabilisation after Bankart repair – 4 months after revision stabilisation this patient was revised due to lateral placement of the graft and conflict with the screws – revision surgery of hardware removal and graft trimming was performed and 8 months later this patient reported subluxations. In all these cases 3 screw fractures and 2 postoperative

Table 3. Postoperative results; in brackets values describing each group; SD – standard deviation; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

	Primary surgery	Revision surgery	p-value	Total
Walch-Duplay score	79 (0–100) SD 19	65 (35–100) SD 21	0.210	77 (0–100) SD 20
Rowe score	81 (15–100) SD 19	67 (10–100) SD 26	0.752	80 (10–100) SD 20
Satisfaction %	92 (40–100) SD 14	93 (60–100) SD 13	0.074	92 (40–100) SD 14
SSV %	90 (30–100) SD 12	80 (50–100) SD 18	0.447	88 (30–100) SD 13
Flexion (°)	177 (70–180) SD 12	165 (100–180) SD 30	0.000	176 (70–180) SD 15
Abduction (°)	177 (70–180) SD 13	165 (90–180) SD 32	0.000	176 (70–180) SD 16
ER1 (°)	59 (10–90) SD 20	41 (10–75) SD 25	0.065	57 (10–90) SD 21
Delta ER1 (°)	15 (0–70) SD 17	31 (0–65) SD 25	0.003	17 (0–70) SD 19
ER2 (°)	82 (30–95) SD 10	74 (40–90) SD 16	0.789	81 (30–95) SD 11
Delta ER2 (°)	6 (0–60) SD 9	14 (0–50) SD 16	0.428	7 (0–60) SD 10
VAS	1 (0–8) SD 2	3 (0–9) SD 3	0.197	2 (0–9) SD 2
Subjective apprehension	41 (45.6%)	6 (54.5%)	0.573	47 (46.5%)
Recurrence	3 (3.3%)	1 (9.1%)	0.415	4 (4%)
Revision	9 (9.9%)	1 (9.1%)	0.932	10 (9.8%)

Table 4. Correlations between flexion, abduction, loss of external rotation with arm at the side and clinical scores (Walch-Duplay, Rowe and SSV); evaluated by Spearman Rank Order Correlations test, R = strength of correlation; statistically significant when p < 0.05.

	Walch-Duplay	Rowe	SSV
Flexion	R = 0.391 p = 0.00005	R = 0.371 p = 0.00013	R = 0.265 p = 0.00906
Abduction	R = 0.353 p = 0.00030	R = 0.366 p = 0.00017	R = 0.286 p = 0.00480
Delta ER1	R = −0.571 p = 0.00000	R = −0.464 p = 0.00000	R = −0.452 p = 0.00000

graft fractures were reported (correlation in Yates corrected *Chi²* test, p = 0.00 for both screw and graft fracture). As mentioned above 2 out of 4 cases of recurrence had intraoperative complications (correlation in M-L *Chi²* test p = 0.0107). Three out of 4 patients were revised: 2 had an iliac crest bone graft and one with a healed bone block had a remplissage procedure. One patient presenting subluxations after revision surgery refused any further surgical attempt to re-stabilize the shoulder as it was still possible to maintain his manual professional activity. Forty-seven patients (46.5%) reported the feeling of 'subjective return to sport anxiety' (SRSA – the term denoting a patient's incertitude to return to overhead activity), which was neither confirmed in clinical examination nor in the patients' satisfaction. However, this factor had a strong influence on the results: patients with SRSA received 65 points in Walch-Duplay and 66 points in Rowe scores, as patients without it – 88 and 92 points respectively (Wald-Wolfowitz test, p = 0.002 for Walch-Duplay score and p = 0.0 for Rowe score).

Revision

Nine revisions (8.9%) were performed. One patient after revision stabilisation was re-operated on 4 months later due to both screws and bone block lateral position conflicting with the humeral head – the screws were removed and the graft was trimmed. Three patients (3.3%) were revised due to recurrence as mentioned above; 2 patients had graft osteolysis at the superior pole and screw loosening – the screw was removed; 1 had a frozen shoulder suffering from lack of external rotation – undergoing arthroscopic arthrolysis 26 months after the initial surgery; 1 patient due to reasons not related with primary surgery – a car accident with a posterior shoulder subluxation and a posterior labrum injury – underwent posterior labrum repair 24 months after initial stabilisation. One patient was operated on for discomfort related to dorsal screw protrusion irritating the infraspinatus muscle – leading to screw's removal – and for the same reason another patient is still hesitating in regards to undergoing revision. If this 1 potential patient were added we would come up with 10 revisions (9.8% reported in Table 3).

Computed tomography evaluation

CT showed 95.8% of graft fusion rate, 1 case (1%) of total graft osteolysis, 2 cases (2.1%) of graft pseudoarthrosis and 2 cases (2.1%) of graft fracture (Table 5). Graft osteolysis around the superior screw was found in 65 patients (67.1%), as graft osteolysis around the inferior screw in 2 (2.1%). The graft was positioned flush to the anterior glenoid rim in the axial view in 40 patients (42.1%), medial in 37 (38.9%) and lateral in 18 (18.9%). If the 'acceptable zone' of bone block placement was considered between 2 mm lateral and 4 mm medial to the glenoid rim, too lateral position of the graft were found in 9 patients (9.5%) and too medial position in 10 patients (10.5%) – Table 6. The graft height evaluated in the sagittal plane (Table 7) was between 3 and 5 o'clock in 49 patients (51.6%), 2 and 4 o'clock in 29 (30.5%), 4 and 6 o'clock in 6 (6.3%) and 1 and 3 o'clock in 11 (11.6%). The mean angle between the line connecting the anterior and posterior glenoid rim and screw axis in the axial view (screw angle – Table 8) was 14.1° for the superior and inferior screws. The average screw-equator angle was 17.5° for both superior and inferior screws. Screw protrusion into infraspinatus fossa was on average 6.3 mm for the superior and 4.8 mm for the inferior one. Hardware problems were reported in 14 cases (14.4%): 3 screw fractures (3.1%), 1 conflict with the humeral head (1%), 7 superior screw loosening (7.3%), 2 inferior screw loosening (2.1%) and 1 both screws loosening – Table 9. The subscapularis muscle grade I infiltration was found in 14 (16.5%) patients after primary stabilisation and in 6 patients (54.5%) after revision stabilisation – this difference was statistically significant (Yates corrected Chi^2 test, $p = 0.01136$). The remaining 76 (79.2%) patients had no fatty infiltration. As mentioned above 2 postoperative graft fractures and 3 screw fractures were related with recurrence (correlation in Yates corrected Chi^2 test, $p = 0.00$ for both screw and graft fracture). All other parameters reported above on CT evaluation had no correlation with clinical results.

Table 5. Graft healing; in brackets values describing each group; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

	Primary surgery	Revision surgery	p-value	Total
Graft healing	81 (95.3%)	11 (100%)	0.318	92 (95.8%)
Total graft lysis	1 (1.2%)	0	0.271	1 (1%)
Superior screw – graft lysis	55 (64.7%	10 (90.9%)	0.159	65 (67.7%)
Inferior screw – graft lysis	2 (2.3%)	0	0,543	2 (2.1%)
Graft pseudoarthrosis	2 (2.3%)	0	0.485	2 (2.1%)
Graft fracture	2 (2.3%)	0	0.485	2 (2.1%)

Table 6. Graft position – medial to lateral position in the axial view; in brackets values describing each group; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

Graft position	Primary surgery	Revision surgery	p-value	Total
Flush	34 (40.5%)	6 (54.5%)	0.551	40 (42.1%)
Medial	34 (40.5%)	3 (27.3%)	0.626	37 (38.9%)
Lateral	16 (19%)	2 (18.2%)	0.705	18 (18.9%)
Medial > 4 mm	10 (11.9%)	0	0.106	10 (10.5%)
Lateral > 2 mm	7 (8.3%)	2 (18.2%)	0.338	9 (9.5%)

Table 7. Graft position – height of graft in the sagittal view; in brackets values describing each group; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

Glenoid zones	Primary surgery	Revision surgery	p-value	Total
1–3	11 (13.1%)	0	0.438	11 (11.6%)
2–4	25 (29.8%)	4 (36.4%)	0.921	29 (30.5%)
3–5	45 (53.6%)	4 (36.4%)	0.451	49 (51.6%)
4–6	3 (3.6%)	3 (27.3%)	0.017	6 (6.3%)

Table 8. Screw fixation; in brackets values describing each group; SD – standard deviation; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

	Primary surgery	Revision surgery	p-value	Total
Superior screw angle (°)	14.1 (0–42.4) SD 8.98	14.2 (7–29.7) SD 6.46	0.966	14.1 (0–42.4) SD 8.7
Inferior screw angle (°)	14.2 (0–40) SD 9.13	13.1 (5–26) SD 5.35	0.677	14.1 (0–40) SD 8.77
Superior screw-equator angle (°)	17.6 (0–41) SD 7.83	16.8 (0–27) SD 10.46	0.780	17.5 (0–41) SD 8.11
Inferior screw-equator angle (°)	17.5 (0–41) SD 7.96	17.6 (0–30) SD 11.03	0.965	17.5 (0–41) SD 8.3
Superior screw protrusion (mm)	6.2 (0–17.5) SD 4.57	6.9 (1–11) SD 4.1	0.667	6.3 (0–17.5) SD 4.5
Inferior screw protrusion (mm)	4,7 (0–14) SD 3.69	5.6 (0–12) SD 3.58	0.442	4.8 (0–14) SD 3.67

Table 9. Hardware problems; in brackets values describing each group; statistically significant difference between primary and revision Latarjetstabilisation group when p < 0.05.

	Primary surgery	Revision surgery	p-value	Total
Screw fractures	3 (3.6%)	0	0.482	3 (3.1%)
Screw conflict with humeral head	0	1 (9.1%)	-	1 (1%)
Superior screw loosening	7 (8.2%)	0	0.709	7 (7.3%)
Inferior screw loosening	2 (2.3%)	0	0.543	2 (2.1%)
Both screws loosening	1 (1.2%)	0	0.223	1 (1%)

Discussion

Open Latarjet stabilisation remains the gold standard in high risk patients with anterior shoulder instability with reported recurrence rate between 0% and 13%, complications from 1.7% up to 25% and revision between 1% and 14.6% (Allain *et al.*, 1998; Hovelius *et al.*, 2004; Shah *et al.*, 2012). Arthroscopic Latarjet stabilisation is a relatively new technique with a short term follow-up and little information as yet (Lafosse and Boyle, 2010; Cunningham *et al.*, 2016; Zhu *et al.*, 2017; Zhu *et al.*, 2017; Marion *et al.*, 2017; Athwal *et al.*, 2016; Metais *et al.*, 2016; Boileau *et al.*, 2016; Dumont *et al.*, 2014; Castricini *et al.*, 2013; Casabianca *et al.*, 2016; Kany *et al.*, 2016). Some papers comparing the open and arthroscopic technique were already published showing relatively comparable results (Kordasiewicz *et al.*, 2017; Kordasiewicz *et al.*, 2018; Zhu *et al.*, 2017; Metais *et al.*, 2016; Marion *et al.*, 2017; Nourissat *et al.*, 2016; Cunningham *et al.*, 2016). Additionally up to date there are few studies assessing the graft position and fusion after the arthroscopic technique (Boileau *et al.*, 2016; Casabianca *et al.*, 2016; Zhu *et al.*, 2017; Zhu *et al.*, 2017).

The strength of this study is based on a homogenous, single-surgeon, relatively large cohort of patients with a follow-up rate exceeding 95%. Clinical and radiological follow-up allowed us to identify some factors influencing the results. Identification of the week points, discussed more meticulously below, is the first step to correct the arthroscopic technique.

Surgical technique, complications and revisions
The average time of surgery in this study was 113 minutes, ranging from 70 to 210, which is comparable to other published studies. This confirms that the arthroscopic technique usually consumes more time than the open variant – 81 minutes reported by Cunningham *et al.* (Cunningham *et al.*, 2016).

The 'graft related' complications whilst harvesting, drilling and screw fixation were the most frequent problems encountered in our study: 8 out of 9 cases. As mentioned before, we found correlation (M-L Chi^2 test p = 0.0107), between the intraoperative complications and recurrence. The number of complications and revisions in our study (8.9% and 9.8% respectively) remains in proximity of already published outcomes of the arthroscopic technique. Only Zhu *et al.* reported no single complication neither revision in patients operated on arthroscopically in their 2 studies (Zhu *et al.*, 2017; Zhu *et al.*, 2017). Our study shows that serious intraoperative technical difficulties in arthroscopic stabilisation (a graft fracture or a doubtful graft compression whilst fixation) are the predictor of unfavourable clinical outcome. This could lead to the statement that if the surgeon encounters different surgical difficulties, with common denominator of inability to achieve solid graft compression, conversion to open technique or changing the system of fixation might be considered (Valenti *et al.*, 2018). If this technical modification is able to improve results in this difficult group requires further research.

Recurrence – clinical evaluation
The recurrence rate of 4% in this study remains comparable to the other results already published. It is important to note that we also included the episodes of subluxation into the recurrence rate, as we consider it to be a failure of our stabilisation. We also decided to emphasize the fact that many patients were afraid to return to pre-injury sporting activity – we called this situation 'subjective return to sport anxiety' (SRSA) – it means patients were perfectly stable during clinical examination and daily activity, however reported incertitude before getting back into overhead sports. SRSA was found in 47 patients (46.5%) and strongly influenced the clinical score results (as it was qualified by the evaluating physician as presence of 'apprehension', however without any objective findings). In our previous studies we used the term 'subjective apprehension', however the term 'apprehension' could be misleading, suggesting a poor outcome, which is not the case (Kordasiewicz *et al.,* 2017, 2018, 2019). That is why we believe this interesting finding should be labelled as SRSA to emphasize the feeling of the patient without any clinical signs. We have some hypotheses to explain the presence of SRSA. This could be a biomechanical problem representing some multi-directional or micro-instability related to a patient laxity presented in 61.4% of patients in this study. Collin *et al.* reported 34% rate of persisting apprehension after open Latarjet procedure, as the recurrence rate was only 5% (Collin, Rochcongar and Thomazeau,

2007). They recommended performing an additional capsuloplasty in patients with preoperative hyperlaxity. Another possibility was that SRSA was related to the arthroscopic technique: excision of the capsule and MGHL could create some proprioceptive deficit related to the lack of some mechanoreceptors (Backenkohler, Strasmann and Halata, 1997; Gohlke *et al.*, 1998). We also think it might be a psychological effect, as none of these patients had any signs of instability on examination – however we found no significant correlation between the number of instability episodes before surgery, duration of instability or follow-up after stabilisation (Ardern *et al.,* 2013; Gerometta *et al.*, 2017).

Patients in this study restored their range of motion similar to the ranges already reported in other arthroscopic technique studies. It is important to notice that patients after primary stabilisation had significantly better flexion, abduction and smaller loss of external rotation with the arm at the side when compared to patients after revision surgery. It should not be surprising that patients undergoing revision surgery presented a poorer range of motion after the initial surgery; this was confirmed by significantly worse results in Rowe score – the only significant difference between primary and revision cases in preoperative data. Flexion, abduction and loss of external rotation influenced the final scores, however the last factor seemed to have the strongest impact (correlation) on clinical results. The mean loss of external rotation in this study was 17˚, that remained comparable to data reported by other authors (Lafosse and Boyle, 2010; Castricini *et al.*, 2013). We hypothesized this could be related to the inside-out technique of the switching stick insertion from the posterior portal to determine the level of subscapularis split that was proven by Ladermann *et al.* (Ladermann *et al.*, 2017). Using this technique the split is performed higher than the recommended junction of middle and inferior third of the muscle that could lead to positioning the graft too high – its consequence may be the increased tension of the conjoint tendon and loss of external rotation. Another reason might be related to a more aggressive subscapularis muscle split (as in the arthroscopic technique the split is done using a radiofrequency probe, not a gentle blunt splitting technique using scissors as in the open technique) and capsule excision, creating greater scar formation in the postoperative period. We believe scar formation is a more probable reason for loss of external rotation than muscle fatty infiltration, as we found no correlation between the subscapularis muscle fatty infiltration and loss of external rotation.

Bone block healing

It has already been proven that a CT scan is necessary to properly evaluate screw placement and bone block position and healing (Clavert *et al.,* 2016). Our study showed a very high (95.8%) graft fusion rate. Despite this fact, graft osteolysis around the superior screw was found in 67.1%, while osteolysis around the inferior screw only in 2.1%. Zhu *et al.* found the resorption of the superior part of the graft in 78.8% of patients (Zhu *et al.*, 2017). Heani *et al.* reported the superior half of the graft volume decreased significantly from 0.89 cm³ at 6 weeks post-operatively to 0.53 cm³ at 6 months post-operatively (Haeni *et al.,* 2017). As previously mentioned, two cases of postoperative graft fracture in our study were reported in patients with recurrence as the other cases of graft 'healing problems' had no influence on the clinical results.

Bone block position

Optimal bone block position is still debatable in the literature. In the axial view a graft should be flush with the anterior glenoid rim, however some authors believe a graft could be translated 4 to 5 mm medially (Boileau *et al.*, 2010; Casabianca *et al.*, 2016; Kraus *et al.*, 2016). One should remember that the point of reference during surgery is the glenoid cartilage with thickness evaluated to about 2.3 mm by Zumstain *et al.* (Zumstein *et al.*, 2014). These are the reasons why we decided to establish an appropriate graft placement between 4 mm medially and 2 mm laterally. In our study the graft was positioned flush to the anterior glenoid rim in the axial view in 42.1%, medial in 38.9% and lateral in 18.9%, so the tendency to put the graft too medially was visible. If the 'acceptable zone' of the bone block placement was considered between 2mm lateral and 4mm medial to the glenoid rim – 80% of our cases would be in the proper position, 9.5% too lateral and 10.5% too medial, that is comparable to other results using arthroscopic technique. Only Zhu *et al.* reported perfect flush position of the graft in all cases (Zhu *et al.*, 2017; Zhu *et al.*, 2017). Bone block position in the sagittal plane also remains controversial: some authors recommend positioning the graft below the equator, which is below 3 o'clock, as others believe the optimal position is between 2 : 30 to 4 : 20 or like Kany *et al.* between 2 and 5 o'clock according to the methodology of our study (Boileau *et al.*, 2016; Casabianca *et al.*, 2016; Kany *et al.*, 2016). In our study the graft height was below the equator in about 58% of cases: between 3 and 5 o'clock in 51.6% and between 4 and 6 o'clock in 6.3%. The graft was above the equator in about 42% of the cases: between 2 and 4 o'clock in 30.5% and between 1 and 3 o'clock in 11.6%. When the proper graft position was judged between 2 and 5 o'clock 82% of the grafts would be in an appropriate height. However, there was still a visible tendency to put the graft too high (11.6%). We believe this is explained by slightly higher level of the subscapularis split reported by Ladermann *et al.* that may result in different exposition of the glenoid in the arthroscopic technique (Ladermann *et al.*, 2017). It is also of notice that we found no correlation between the graft position and clinical results.

Hardware

The screw angle was slightly more parallel (14.1°) than reported by other authors, nevertheless still remained slightly distanced from Ladermann's *et al.* recommendations of less than a 10° (Ladermann, Denard and Burkhart, 2012). Despite this fact, suprascapular nerve lesion was not reported in this study, as other studies reported only 2 cases in a multicentric study conducted by SFA and one case reported by Sastre *et al.* (Metais *et al.*, 2016; Sastre *et al.*, 2016). The screw-equator angle was described in our study, however its influence on graft healing or clinical results is unknown. We found no correlation between these angles and clinical results. Screw protrusion into infraspinatus fossa was on average 6.3 mm for superior and 4.8 mm for the inferior one. This was the reason why we had to revise one case due to infraspinatus muscle irritation and consider this surgery in another case. Screw protrusion could be avoided by attentive preoperative planning and meticulous surgical technique, as recommended by Hardy *et al.* as its measurement whilst arthroscopic surgery is not viable (Hardy *et al.*, 2016). Hardware problems were reported in 14.4% in our study, however not all of them required revision. It is important to notice that screw problems were found in 8 out of 10 cases of revision after an arthroscopic Latarjetstabilisation. These findings are comparable to other reports (Lafosse and Boyle, 2010; Dumont *et al.*, 2014; Athwal *et al.*, 2016; Metais *et al.*, 2016). Shah *et al.* reported using cannulated screws as a risk factor (Shah *et al.*, 2012). We may hypothesize that use of a cannulated screw (mechanically weaker than a full screw) combined with any technical error (single screw fixation or inadequate fixation due to some bone weakness) could lead to complications like screw fracture or recurrence.

Clinical implications

Having received the above results our hypothesis to uncover some weak points of the arthroscopic Latarjet technique could be confirmed, leading to several clinically important conclusions:

1. Serious intra-operative complications (graft fracture and inability to achieve solid two-screw graft fixation) are important risk

factors for recurrence and may be a hint to change the fixation technique or convert to an open procedure.
2. Combination of cannulated screw and any technical error could lead to an increased risk of recurrence and screw fracture. To our knowledge the company has changed the screws for more solid ones.
3. Another hardware problem – too long screws – could be responsible for infraspinatus muscle irritation increasing the risk of revision surgery.
4. The inside-out technique of determining the level of the subscapularis muscle split may result in a tendency to put the graft too high leading to loss of external rotation with the arm at the side. Another reason could be the more aggressive split using radiofrequency probe creating more scar tissue formation.
5. Incidence of SRSA was strongly influential on the results, however its explanation remains unclear
6. Osteolysis of the upper part of the graft is a visible problem, also lacking a clear reason.

Following the above results we have changed the following steps in our technique; the influence of this change remains yet to be assessed:

1. Sparing the capsule, as already proposed by some authors (Boileau *et al*., 2016; Zhu *et al*., 2017; Zhu *et al*., 2017) – could have some advantages:
   a. less scar tissue around the subscapularis muscle (potentially smaller limitation of external rotation);
   b. repair of the capsule could diminish the joint volume and maintain the proprioceptive 'activity', thus limiting SRSA, particularly in lax patients;
   c. anchor placement at 3 o'clock, to restore the capsule later, could be also a landmark for graft position, to avoid 'graft height' disturbances.
2. Subscapularis split level is determined using outside-in technique at the same level as recommended in open technique – between middle and inferior third of the muscle. Less aggressive subscapularis split is attempted to avoid any muscle 'burning', as it may be another cause of scar formation potentially leading to external rotation deficit.
3. Using the superior 'top-hat' was abandoned, trying to place the screw slightly deeper, as graft remodelling affects mainly the superior part, so it is possible that this might prevent the superior screw from loosening.
4. Meticulous preoperative planning with calculation of the screw length to avoid any protrusion into the infraspinatus fossa.

Analysing the above results, it is to remember that methodology of our study is not free of certain weaknesses, which shall be taken into consideration:

1. Short term follow-up is an important factor before any definitive conclusions are made; however Griesser *et al*. reported that 73% of recurrence occurred within the first 12 months after surgery (Griesser *et al*., 2013).
2. Preoperative radiographic parameters were not collected in a systematic manner so we decided not to include it in the study – this is why preoperative bone loss was not assessed in patient data.
3. The clinical results of patients did not include postoperative pain, recovery and rehabilitation time to restore full activity, which are important for technique evaluation.
4. Experience and technical skills of the surgeon could strongly influence results. This study concerns the first patients operated on in 2011 as well as patients operated on almost 5 years later. This could be an important factor diminishing the value of this study; however it is the 'natural history' of the implementation of a new technique.

Conclusions

The arthroscopic Latarjet stabilisation procedure demonstrates satisfactory results in short term follow-up, however some factors influencing the outcomes were found.

Intraoperative graft related complications are a risk factor for recurrence. Subjective return to sport anxiety and loss of external rotation with the arm at the side are important factors worsening the results. A tendency to position the graft too high and a superior part of the graft resorption are visible in radiographic evaluation, however without influence on the clinical results.

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