Mid-term to long-term results of open posterior bone block grafting in recurrent posterior shoulder instability: a clinical and CT-based analysis

Villefort, Christina ; Stern, Christoph ; Gerber, Christian ; Wyss, Sabine ; Ernstbrunner, Lukas ; Wieser, Karl

Abstract: BACKGROUND: There is little consensus on the best treatment after failed conservative management of recurrent posterior shoulder instability. The purpose of this study was to analyze our clinical and radiological mid-term to long-term results of an open, posterior bone block procedure for the treatment of recurrent posterior shoulder instability. METHODS: From 1999 to 2015, 14 patients were included in the study and available for clinical and radiographic follow-up (FU). FU included a standardized physical examination, assessment of the Constant-Murley-Score, subjective shoulder value, American Shoulder and Elbow Surgeons score, and Western Ontario Shoulder Instability Index. Conventional radiographs and a computed tomography (CT)-scan were performed preoperatively and at latest FU. Glenohumeral arthropathy was classified as per Samilson and Prieto. The CT scans were used to evaluate the structure of the graft (resorption, union), graft positioning, glenoid version, centering of the humeral head, and glenoid erosion and morphology. RESULTS: The median age at the time of surgery was 26 years (range 16-41 years) and the median FU period was 9 years (range 4-20 years). The rate of reported dynamic postoperative subluxation and instability was 46% (n = 6) and the rate of dynamic posterior instability during clinical testing at FU was 31% (n = 4). The tested instability rate in the traumatic group was 14% (n = 1) compared to the atraumatic group with 50% (n = 3) during clinical FU. The mean Constant-Murley-Score increased from preoperatively (77 ± 11 points) to postoperatively (83 ± 14 points, P = .158). The last FU showed an American Shoulder and Elbow Surgeons score of 85 ± 12; the Western Ontario Shoulder Instability Index score was 715 ± 475 points. The mean subjective shoulder value increased from 58% ± 19 preoperatively to 73% ± 17 at final FU (P = .005). Degenerative changes increased by at least one grade in 67% of the patients. Mean preoperative glenoid retroversion (CT) was 7.5° ± 6°. The position of the graft was optimal in 86% (n = 12). In 62% of the cases, a major resorption of the graft (Zhu grade II) was observed. CONCLUSION: The rate of tested recurrent instability at last FU was as high as 31% (n = 4, atraumatic [n = 3] vs. traumatic [n = 1]) after a median FU of 9 years. Given the moderate improvement of clinical outcome scores, shoulder stability and the increase of degenerative joint changes by at least one grade (Samilson/Prieto) in 67% of patients, a posterior bone block procedure is not a uniformly satisfying treatment option for recurrent posterior shoulder subluxation, especially in cases of atraumatic posterior instability.

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Mid-term to long-term results of open posterior bone block grafting in recurrent posterior shoulder instability: a clinical and CT-based analysis

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Background: There is little consensus on the best treatment after failed conservative management of recurrent posterior shoulder instability. The purpose of this study was to analyze our clinical and radiological mid-term to long-term results of an open, posterior bone block procedure for the treatment of recurrent posterior shoulder instability.

Methods: From 1999 to 2015, 14 patients were included in the study and available for clinical and radiographic follow-up (FU). FU included a standardized physical examination, assessment of the Constant-Murley-Score, subjective shoulder value, American Shoulder and Elbow Surgeons score, and Western Ontario Shoulder Instability Index. Conventional radiographs and a computed tomography (CT)–scan were performed preoperatively and at latest FU. Glenohumeral arthropathy was classified as per Samilson and Prieto. The CT scans were used to evaluate the structure of the graft (resorption, union), graft positioning, glenoid version, centering of the humeral head, and glenoid erosion and morphology.

Results: The median age at the time of surgery was 26 years (range 16-41 years) and the median FU period was 9 years (range 4-20 years). The rate of reported dynamic postoperative subluxation and instability was 46% (n = 6) and the rate of dynamic posterior instability during clinical testing at FU was 31% (n = 4). The tested instability rate in the traumatic group was 14% (n = 1) compared to the atraumatic group with 50% (n = 3) during clinical FU. The mean Constant-Murley-Score increased from preoperatively (77 ± 11 points) to postoperatively (83 ± 14 points, $P = .158$). The last FU showed an American Shoulder and Elbow Surgeons score of 85 ± 12; the Western Ontario Shoulder Instability Index score was 715 ± 475 points. The mean subjective shoulder value increased from 58% ± 19 preoperatively to 73% ± 17 at final FU ($P = .005$). Degenerative changes increased by at least one grade in 67% of the patients. Mean preoperative glenoid retroversion (CT) was 7.5° ± 6°. The position of the graft was optimal in 86% (n = 12). In 62% of the cases, a major resorption of the graft (Zhu grade II) was observed.

Conclusion: The rate of tested recurrent instability at last FU was as high as 31% (n = 4, atraumatic [n = 3] vs. traumatic [n = 1]) after a median FU of 9 years. Given the moderate improvement of clinical outcome scores, shoulder stability and the increase of degenerative joint changes by at least one grade (Samilson/Prieto) in 67% of patients, a posterior bone block procedure is not a uniformly satisfying treatment option for recurrent posterior shoulder subluxation, especially in cases of atraumatic posterior instability.

Posterior shoulder instability is a rare condition accounting for only 4% of cases of recurrent shoulder instability. Causes can either be traumatic or congenital due to hyperlaxity. Clinical and anatomical findings range from bony abnormalities such as an abnormal joint surface orientation or osteochondral fracture of the glenohumeral head or cavity to posteroinferior capsuloligamentous deficiencies.[1,4,13,19]

The importance of detailed analyses of the clinical and radiological presentation to choose the correct individual treatment

The study was approved by the institutional review board (W 743) at Balgrist University Hospital, University of Zurich, prior to initiation of the study.
A waiver of the Cantonal Ethics Committee was obtained (Req-2018-01929) prior to publication.

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should not be underestimated. However, optimal treatment of recurrent posterior shoulder instability remains controversial.

A shoulder physiotherapy rehabilitation program is still the standard initial treatment. There is a paucity of information on the best treatment option after failed conservative management for recurrent posterior shoulder instability. Operative techniques involve soft-tissue repairs (capsular plication, labral repair, and tendon transfers), glenoid and humeral osteotomy, filling of bony defects, and posterior bone block procedures. However, there is no consensus for posterior shoulder instability management.[1,4,12,14]

To our knowledge, there is just one long-term study analyzing the clinical and radiographic outcome of posterior shoulder instability treated by an open posterior bone block procedure, showing significant deterioration of the outcome parameters after a follow-up (FU) period of 18 years.[4,10] Only one recent study analyzed an arthroscopically assisted technique of posterior glenoid bone augmentation clinically and radiologically based on computed tomography (CT) scans. The authors reported on 18 patients (FU rate 61%) with a minimum FU of 5 years and a mean FU of 7.3 years. The indication for surgery was recurrent posterior shoulder instability due to glenoid dysplasia, posterior glenoid bone loss or irreparable soft-tissue defect, and in case of revision for persistent instability following soft-tissue stabilization. Despite a high number of reoperations for symptomatic screw irritation, acceptable clinical outcomes with a significant improvement of the Constant-Murley ($P = .05$) and American Shoulder and Elbow Surgeons (ASES) scores ($P = .03$) were described. Clinical tests for instability showed a posterior apprehension rate of 22% (n = 4).[3]

The purpose of this study was to analyze clinical and radiological (radiographs and CT) mid-term to long-term outcome of an open bone block procedure in recurrent posterior shoulder instability. Our hypothesis was that patients who underwent a posterior bone block procedure after recurrent posterior shoulder instability had a greatly improved stability but might develop osteoarthritis at mid-term to long-term FU.

Patients and methods

This is a retrospective case-control study of patients with recurrent posterior shoulder instability who underwent a posterior bone block augmentation.

Ethical approval was obtained from the cantonal ethics committee; a declaration of consent was signed by all participating patients.

From 1999 to 2015, 21 consecutive patients (21 shoulders) were treated with posterior bone block augmentation due to recurrent posterior shoulder instability. Inclusion criteria were met when the patient had a complete medical record regarding routine diagnostics (preoperative standard radiographs, magnetic resonance imaging or CT of the shoulder) and clinical examination.

To reduce performance bias, we excluded the following patients from our analysis: 2 patients who had a later shoulder arthroplasty, 2 patients with multidirectional shoulder instability, and 1 patient with poor medically controlled convulsive disorder leaving 16 eligible patients.

At the time of final FU, one of these patients had died unrelated to the surgery and another one was lost to FU.

The resulting study group consisted of 14 patients (14/16, 87%; 10 male, 4 female), who agreed to partake in a questionnaire survey (ASES and Western Ontario Shoulder Instability Index [WOSI] scores). Thirteen patients could also be clinically and radiologically re-examined.

The median age at the time of surgery was 26 (range 16-41 years) years. Prior surgery was performed in 6 of the patients.

Based on an initial trauma triggering the instability either documented in the medical records or the survey, we divided the patients into a traumatic and atraumatic group. In 8 (57%) patients the first episode of instability was the result of a clear traumatic event. Of this group, 4 patients received the bone block procedure as the primary stabilization procedure and the other 4 as a revision after failed soft-tissue stabilization procedures.

A bone block procedure as a revision after failed soft-tissue stabilization procedures was done in 50% (n = 7) of all cases (traumatic and atraumatic).

In our cohort, mild to moderate dysplasia of the glenoid with rounding of the postero-inferior glenoid rim and convexity of the inferior bony glenoid was seen in the majority of cases (n = 10, Table I, indication = 1). In 4 of the patients of the traumatic group, a bone deficiency was radiologically interpreted as post-traumatic bone deficiency (Table I, indication = 2).

Further details regarding the study cohort are provided under Table I.

All patients with an atraumatic posterior shoulder instability (n = 6) reported multiple subluxation events preoperatively. None of the patients in the reported study group required closed reduction.

The physical examination included the measurement of active and passive ranges of motion, stability testing (posterior apprehension sign, jerk test), and assessment of the Constant-Murley-Score (CMS), ASES score, and WOSI. Clinical outcome parameters included etiology of dislocation, complications, revision surgery, sports participation, and work capacity. Recurrent instability and subjective shoulder value (SSV) were additionally evaluated. A positive jerk test and/or posterior apprehension test were defined as objective dynamic posterior shoulder instability. Tests for dynamic posterior instability were considered positive either with subluxation with pain or an uncomfortable sensation reproducing the symptoms of the patient. Subluxation was defined as the subjective sensation of posterior translation of the humeral head over the glenoid rim followed by spontaneous reduction. An event requiring reduction by either the patient or a third person was defined as dislocation.

Radiographically, conventional radiography and CT scans were performed preoperatively and at the time of the last FU. The radiographic measurements and classifications were performed by a fellowship-trained musculoskeletal radiologist (C.S.) who was blinded from the clinical results. Glenohumeral arthropathy was classified as per the modified classification of Samilson and Prieto.[15] Due to lacking data on interobserver agreement for this classification, the radiographs were graded by two observers (C.V. and C.S.).

Posterior acromial height (PAH) and the anterior (AAC) and posterior acromial coverage (PAC) and acromial tilt were measured on the lateral radiographs as per Meyer et al[11] to assess acromial morphology and position to check a possible relationship of acromial anatomy to glenohumeral stability.

The CT scans were used to evaluate graft resorption, union, and graft positioning. The resorption of the graft was graded as per Zhu et al,[22] grade I if only the screw head, grade II if part of the screw shaft was exposed, and grade III if there was total bone block resorption with a fully exposed screw.[22]

The glenoid version as per Friedman et al,[7] the centering of the humeral head as per Walch et al,[8,20,21] and preoperative glenoid shape and bone loss at the posterior edge of the glenoid were additionally assessed. Glenoid erosion and morphology were determined based on the modified Walch criteria.[6,20]

Surgical technique and postoperative regimen

The patient was placed in a standard lateral decubitus position under general anesthesia. As a preoperative antibiotic prophylaxis, a single shot of 1.5 g Cefuroxim was administered. A posterior

Table I
Etiology of instability, indication for surgery, surgeon, and graft type.

Patient	Atraumatic (=0), traumatic (=1) shoulder instability	Hyperlaxity (0 = no, 1 = yes)	Indication 1-Dysplasia 2-Bone loss R-revision after previous soft-tissue stabilization	Surgeon	Graft type 1 = posterior acromion 2 = scapular spine 3 = iliac crest
1	1	0	2	A	1
2	1	1	1R	B	2
3	0	1	1R	C	2
4	0	1	1	A	3
5	0	1	1	A	2
6	1	0	2	C	3
7	0	0	1	A	2
8	0	1	1R	A	3
9	0	0	1	D	3
10	1	0	1R	D	3
11	1	0	2	A	3
12	1	1	1R	D	3
13	1	0	2R	A	3
14	1	0	1R	A	3

transdeltoid approach to the shoulder joint was done through the interval between the infraspinatus and teres minor muscle. The infraspinatus tendon was not detached from the greater tuberosity. Through a vertical incision of the posterior capsule, the posterior labrum was detached with preparation of the posterior glenoid rim. A tricortical bone graft was either harvested from the posterior acromion (1 case), scapular spine (4 cases), or the iliac crest (9 cases).

The harvested bone block was shaped and fixed with two 3.5-mm screws in flush position to the posterior glenoid. The graft was positioned flush with the glenoid trying to avoid an overhang of the graft with respect to the glenoid surface. The graft was intraarticular and not recovered with capsule, thus corresponding to a graft as using in the Latarjet procedure for anterior instability.

The postoperative regimen consisted of immobilization of the shoulder joint in a neutral-wedge shoulder brace for 6 weeks. Active-assisted elevation and abduction was allowed to a maximum of 60° in neutral rotation, without internal rotation or transverse adduction in front of the scapula plane. After 6 weeks, active-assisted elevation and abduction was allowed until full range of motion was achieved. With reaching full active range of motion, gradual build-up of strength was started under physical therapy guidance.

Statistical analysis

Normal distribution of data was assessed with the Shapiro-Wilk test. Descriptive data were calculated using mean and standard deviation. Preoperative and postoperative functional scores were compared with the paired *t*-test (normal distribution) and the Wilcoxon signed-rank test (non-normal data). Subgroup analysis was conducted using the Mann-Whitney U test. For categorical variables, the Chi-squared and the Fisher's exact tests (if $n < 5$) were used. Survival without signs of posterior instability in the entire series (including the 2 patients who died or were lost to FU) was assessed using Kaplan-Meier curve analysis.

Significance was set as $P < .05$ and all P values were two-tailed.

Interobserver reliability was measured for dislocation arthropathy by means of the Intraclass Correlation Coefficient for absolute agreement, with 1 indicating perfect reliability.

Results

The median age at the time of surgery was 26 years (range 16-41 years) and the median FU period was 9 years (range 4-20 years).

Table II
Clinical findings preoperatively and at final follow-up.

Variable*	Preoperative	Postoperative	Gain	*P* value
Shoulders, No.	13	13		
CS				
Absolute, pts	77 ± 11	83 ± 14	+6	.158
Relative, %	80 ± 17	86 ± 13	+6	.136
Pain, pts	11 ± 4	13 ± 3	+2	.125
SSV, %	58 ± 19	73 ± 17	+15	.005
ROM, °/pts				
AAE, °	157 ± 31	171 ± 13	+14	.317
Abduction, °	158 ± 29	172 ± 14	+14	.257
External rotation, °	65 ± 21	58 ± 21	−7	.317
Internal rotation, pts	9 ± 2	7 ± 3	−2	.011
Satisfaction, n (%)				
Excellent		6		
Good		3		
Fair		3		
Unsatisfactory		1		

CS, Constant Score; *SSV*, Subjective Shoulder Value; *ROM*, range of active motion; *AAE*, active, anterior elevation.
*Data are presented as mean ± standard deviation.

Subluxation events before the index surgery were documented in 85% of cases; the median age at the event of first subluxation was 18 years (range 13-39 years). Two patients only reported subluxation after a trauma and the other patients had repetitive subluxation events without a preceding trauma or dislocation.

Clinical outcome

At final FU, 6 patients had recurrence of posterior instability (46%). Four patients had physical findings of dynamic posterior instability (positive posterior apprehension/Jerk test) (31%).

The mean SSV significantly improved over the preoperative state (58 ± 19 vs. 73 ± 17; $P = .005$). The improvement of absolute and relative CMS, pain score, active anterior elevation, abduction, and abduction strength was not statistically significant ($P > .05$). Active internal rotation was reduced by a mean of 2 CMS points at final FU ($P = .011$). At final FU, the ASES score averaged 85 ± 12 points and the WOSI score 715 ± 475 points. Further details about clinical outcome are provided under Table II.

At the time of final FU, 10 patients (77%) reported no change in working capacity, 2 had undergone retraining, and 1 patient remained on sick leave 9 years after the index procedure.

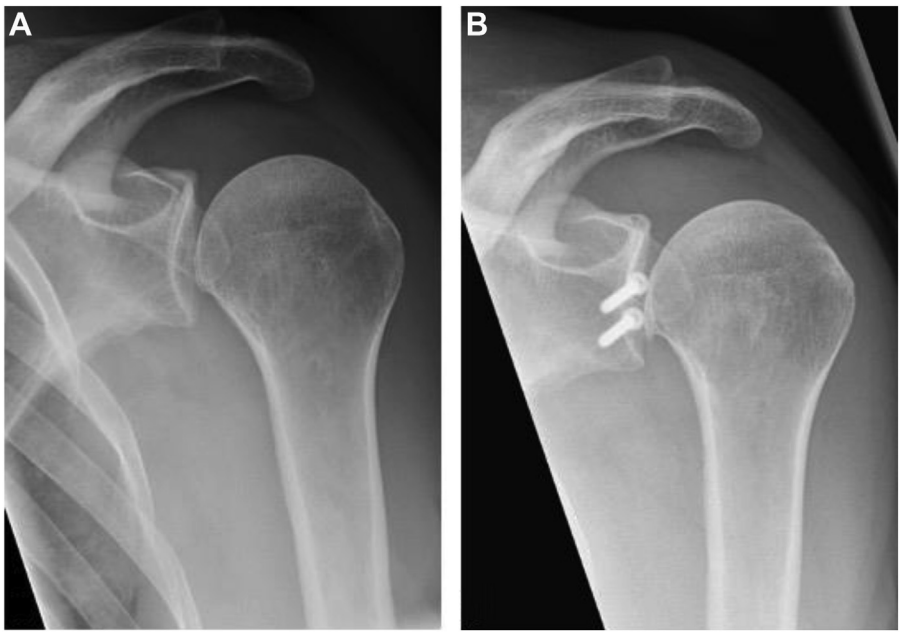

Figure 1 Preoperative (**A**) and postoperative (**B**) anteroposterior (ap)-shoulder radiographs of a 41-year-old male patient, left nondominant shoulder, that underwent posterior bone block augmentation of the glenoid due to recurrent posterior shoulder instability. Nine years postoperatively a progression of the glenohumeral osteoarthritis can be observed (Samilson-Prieto from grade 1 to 2).

Table III
Radiographic results preoperatively and at final follow-up.

Patient	Glenohumeral arthropathy classification of Samilson and Prieto[16]	
	Preoperative	At last FU
1	n.a.	2
2	n.a.	2
3	1	2
4	0	0
5	0	0
6	1	2
7	0	1
8	0	1
9	0	1
10	0	1
11	1	2
12	0	0
13	0	1
14	0	2

n.a., not available; FU, follow up.

Patients with an initial traumatic posterior shoulder dislocation (n = 7) showed a significantly higher abduction strength and SSV compared with patients with initial atraumatic posterior shoulder instability symptoms (n = 6; 12 vs. 23 CMS points, $P = .013$; 84% vs. 62%, $P = .014$). Surgery before posterior glenoid bone grafting had no significant influence on any clinical outcome measure ($P > .05$). Recurrent dynamic postoperative instability (n = 6) was significantly associated with inferior ASES (79 vs. 93 points; $P = .035$) and WOSI scores (377 vs. 975 points; $P = .008$) compared with patients with an ultimately stable shoulder (n = 7). Patients with postoperative subluxations had a significantly lower relative CMS preoperatively than those with a stable postoperative shoulder (70% vs. 85%; $P = .042$).

Radiographic outcome

Preoperative dislocation arthropathy on standardized conventional radiographs was mild (Class 1 Samilson and Prieto) in 3 cases. There was a significant increase in degenerative changes by at least one grade from preoperative to postoperative in 9 patients ($P = .005$) (Fig. 1, Table III). The acromial tilt, AAC, PAC, and PAH measured on the preoperative conventional radiographs averaged 58° ± 23°, 6° ± 10°, 54° ± 11°, and 24 mm ± 7 mm, respectively. Interobserver reliability was reported to be either excellent or good for acromial tilt, PAH, AAC, and PAC.[11]

PAH was significantly higher in the traumatic, compared to the atraumatic group (27 mm ± 6 mm vs. 20 mm ± 5 mm, $P = .038$). Otherwise, no significant differences in those with initial traumatic posterior shoulder dislocation (n = 7) compared with patients with initial atraumatic posterior shoulder instability symptoms (n = 6; $P > .05$) could be shown.

None of the factors were significantly associated with self-reported postoperative subluxation events ($P > .05$).

Glenoid version measured on the CT scans was preoperatively −7.5° ± 6° and postoperatively −3.9° ± 4° ($P = .005$) at the final FU.

In 4 cases, a bone defect at the posterior glenoid margin was found. The mean preoperative posterior glenoid defect was 5% ± 9% (range 6%-27%), measured as described by Sugaya H.[18] The rest showed no preoperative posterior bone defect.

In 75% (n = 9/12), the preoperative CT scan showed a centered humeral head without signs of degeneration or static posterior subluxation and a mean subluxation index of 56%. Preoperatively, only one patient showed a static preoperative posterior subluxation without degeneration (Walch B0, subluxation index >65%), one patient showed a preoperative narrowing of the posterior joint space with posterior subluxation of the humeral head (Walch B1, subluxation index >65%), and another patient showed a borderline centering of the humeral head with narrowing of the posterior joint space.

At FU, the glenoid was classified as B0 in 4 cases; none of them showed a posterior subluxation preoperatively. The 2 patients with a static posterior subluxation preoperatively, both showed a centered humeral head with a normal subluxation index at FU.

We evaluated the position of the graft as optimal in 86% (n = 12) of the cases; in the remaining 2 patients the graft was positioned

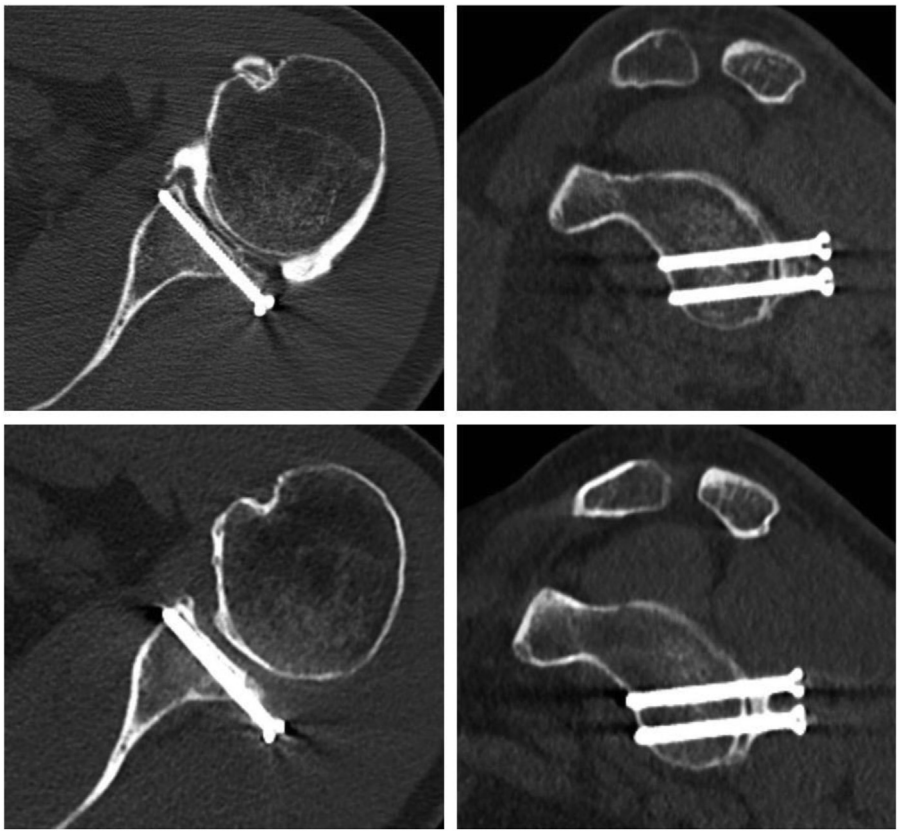

Figure 2 Postoperative CT scan of a left adominant shoulder 7 months **(Top)** and 9 years **(Bottom)** after posterior bone block augmentation of the glenoid **(Bottom)** due to recurrent posterior shoulder instability. A progression of the graft resorption can be seen. A major bone block resorption (Zhu Grade II) can be observed at the final follow-up. *CT*, computed tomography.

with a lateral step of 2 mm. The humeral head was centered in 71% (n = 10/14) of cases; the remaining 4 patients showed a posterior subluxation. At FU, major graft resorption (grade II) was detected in 8 (62%) cases (Fig. 2). Osseous consolidation was seen in all cases.

The SSV remained postoperatively significantly lower in those with major graft resorption (68% vs. 86%; $P = .048$). Major graft resorption was not significantly associated with postoperative instability symptoms or humeral head subluxation. Humeral head subluxation was not significantly associated with any clinical outcome parameter ($P > .05$). The interobserver reliability for dislocation arthropathy was excellent (r = 0.94; 95% confidence interval 0.83-0.98).

Complications and reoperations

Of note, that 2 operated patients had been excluded because they had undergone TSA in the postoperative period. In our cohort, a total of 3 (21%) patients underwent a reoperation following the index surgery.

In one patient the reoperation was done due to persistent pain and soft tissue snapping in the region of the screw with screw removal due to disturbing screws 2.8 years after the bone block procedure.

The second patient underwent a diagnostic arthroscopy and screw removal with an additional posterior soft-tissue stabilization due to persistent pain 2.3 years after the index procedure.

One patient had 4 documented reoperations after the posterior bone block procedure. He underwent soft-tissue stabilization 7 months before the index surgery. Due to persistent pain of unclear origin, a diagnostic arthroscopy was done 1.1 years after the bone block procedure with additional posterior soft-tissue stabilization. Furthermore, anteroinferior soft-tissue stabilization was done due to multidirectional instability over time. Two years after the index surgery another diagnostic arthroscopy including a microbiological sampling was done which showed a low grade Cutibacterium acnes infection so that an antibiotic treatment was initiated over a time period of three months. Persistent pain 5 months after the last arthroscopic surgery led to another shoulder arthroscopy with once more microbiological sampling, at this time with negative results. In the FU 19.4 years after the index procedure, this patient presented with persistent shoulder pain (SSV 70%, compared to 60% preoperative) with moderate to severe osteoarthritis.

Survival analysis

The overall rate of survival without a positive posterior apprehension or Jerk test at final FU was 83% at 5 years and 46% at 10 and 20 years (Fig. 3, *A*). The survival rate without postoperative subluxation or redislocation as the end point was 83% at 5 years and 32% at 10 and 20 years (Fig. 3, *B*).

Discussion

The most important findings of this study were that almost half of the patients reported a recurrent or persistent dynamic posterior instability after a mean FU period of 9 years. Nevertheless, the SSV had improved in most patients representing 75% of a normal shoulder.

Although there are favorable short-term to mid-term clinical and radiographic results in the literature, there is controversy

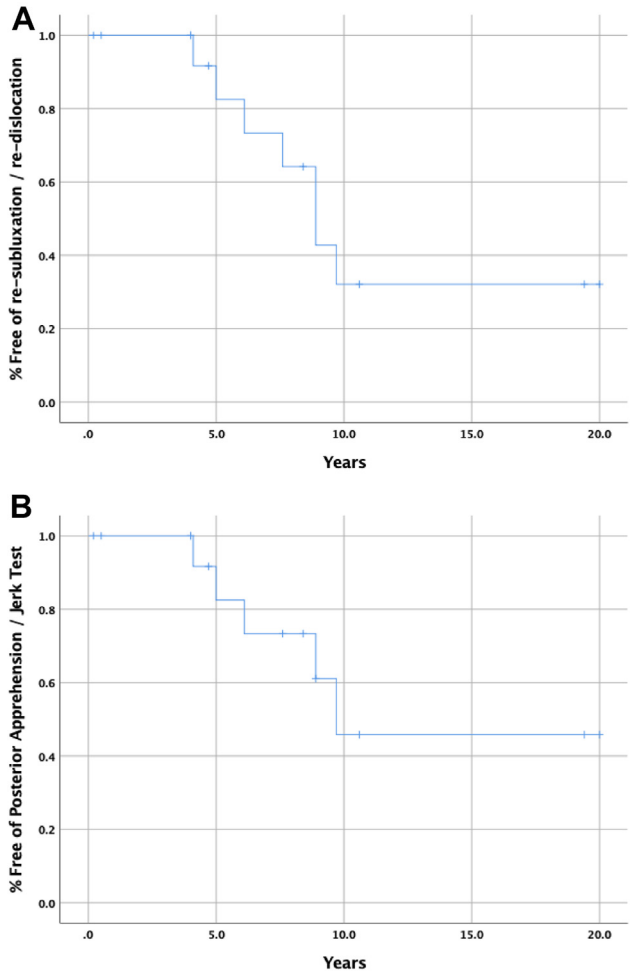

Figure 3 Kaplan-Meier survivorship analysis. (**A**) The rate of survival without a positive posterior apprehension or Jerk test at final follow-up was 83% at 5 years and 46% at 10 and 20 years. (**B**) The rate of survival without postoperative subluxation or redislocation was 83% at 5 years and 32% at 10 and 20 years.

regarding long-term results of posterior bone block procedures.[1,12,17] Servien et al[16] showed good clinical and radiological results after a mid-term FU of 6 years. One of 21 patients complained of persistent apprehension and another had recurrent dislocations of the shoulder. [16]

Meuffels et al[10] published the only long-term study with a median FU of 18 years following a mid-term report with a 6-year FU. The clinical results deteriorated significantly over time. Poor long-term results were also shown with a high rate of recurrent posterior instability and glenohumeral arthritis. After a mean FU of 18 years, only 3 of 11 patients had a stable shoulder, all showed signs of osteoarthritis. Interestingly and in agreement with our data, the clinical outcome was significantly better in patients with a traumatic onset of posterior shoulder instability. In our cohort, patients with a traumatic onset (n = 7) showed postoperatively a significantly higher SSV (84% vs. 62%, $P = .014$) but also abduction strength (23 vs. 12 Constant points, $P = .013$) compared with patients with initial atraumatic posterior shoulder instability symptoms (n = 6). The tested instability rate in the traumatic group was 14% (n = 1) compared to the atraumatic group with 50% (n = 3) during clinical FU.

In contrast to our results and those of Meuffels et al,[10] Godeneche et al[9] reported no difference in functional outcome scores for traumatic and atraumatic posterior shoulder instability. However, in this study, surgical treatment included Bankart repair, capsular retention, and bone block procedures without doing a subgroup analysis regarding the operative treatment method. Camenzind et al[2] could also not find a significant difference between traumatic posterior bone loss and dysplastic glenoids regarding final clinical outcomes.

Resorption rate in our study was determined based on the CT images with 62% of the patients showing major resorption of the graft (grade II). Compared to our findings, Meuffels et al[10] described a resorption rate of 18% in conventional radiographs but without grading of the resorption. Clavert et al[5] described a major resorption rate in nearly one-third of the study population and another one-third which showed partial lysis of the bone blocks. Camenzind et al[2] described partial lysis of all grafts at a mean FU of 7.3 years after arthroscopic bone grafting. Interestingly, our patients with major resorption of the bone block were preoperatively and postoperatively significantly worse in SSV and Constant Scores. Conversely, resorption of the bone block was not related to persistent or recurrent instability symptoms or static posterior subluxation.

The incidence of glenohumeral osteoarthritis in our study group increased by one grade as per Samilson and Prieto from preoperatively to postoperatively in 67% of the patients. Meuffels et al[10] also demonstrated a significant increase of radiological osteoarthritis over a long-term FU with glenohumeral osteoarthritis in all 11 cases.

Regarding acromial morphology, Meyer et al[11] described a significantly greater mean PAH and posterior acromial tilt in patients with posterior instability compared to a control group. A higher and more horizontally oriented acromion was shown to be strongly associated with recurrent posterior shoulder instability. This may be explained by a possible mechanical predisposition in posterior instability with a lack of osseous restraints created by the posterior aspect of the acromion predisposing to posterior instability.[11] In our study population, the mean PAH was 24 mm ± 6 mm. Meyer et al compared the PAH of patients with posterior instability (mean = 31 mm) with a control group (mean = 20 mm).[11] As stated by the authors, a cutoff value of 23 mm for PAH was highly significant associated with developing a posterior instability (Odds ratio 32).

We did not observe a significant association between postoperative subluxation and acromial anatomy. The acromial tilt, AAC, PAC, and PAH were not significantly associated with postoperative instability symptoms ($P > .05$).

There are limitations to this study with its retrospective study design. A control group is missing and with 14 cases the sample size is rather small. In addition, the drop out of 2 patients is an additional limitation but in view of the length of FU this is to be expected. Furthermore, for clinical analysis, 1 additional patient was missing and could not be included in the clinical results.

Heterogeneity concerning the study cohort itself, the surgical indications, and the surgeries performed by 4 different surgeons as shown in Table I are additonal limitations. All indications, however, were approved by the senior author (A) and the surgeries were performed under his supervision so that the variability is limited. As the necessity for such intervention is rare, marked differences in FU may represent another limitation.

Posterior instability is a rare and complex problem with no gold standard treatment. This case-control study can give an insight into a mid-term to long-term FU of one treatment option including clinical and detailed radiological outcome measures.

Conclusion

The rate of tested recurrent instability at last FU was as high as 31% (n = 4, atraumatic [n = 3] vs. traumatic [n = 1]) after a median

FU of 9 years. Major graft resorption (Zhu grade II) was observed in 62% of cases.

Given the moderate improvement of clinical outcome scores, shoulder stability and the increase of degenerative joint changes (at least one grade [Samilson/Prieto] in 67%) a posterior bone block procedure is not a uniformly satisfying treatment option for recurrent posterior shoulder subluxation, especially for younger patients and cases of atraumatic posterior instability.

The hypothesis that shoulder stability is reliably restored must be rejected, whereas the hypothesis that osteoarthritis progresses can be confirmed.

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