Recurrence after arthroscopic Bankart repair: Is quantitative radiological analysis of bone loss of any predictive value?

C. Sommaire\textsuperscript{a,\,*}, C. Penz\textsuperscript{a}, P. Clavert\textsuperscript{a}, S. Klouche\textsuperscript{b}, P. Hardy\textsuperscript{b,c}, J.F. Kempf\textsuperscript{a}

\textsuperscript{a} CCOM UF 9406, 10, avenue Achille Baumann, 67400 Illkirch-Graffenstaden, France
\textsuperscript{b} Hôpitaux Universitaires Paris Ile-de-France Ouest, AP-HP, 92100 Boulogne-Billancourt, France
\textsuperscript{c} Université de Versailles Saint-Quentin, 78035 Versailles, France

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Summary

Introduction: Bone defects in the humeral head or antero-inferior edge of the glenoid cavity increase recurrence risk following arthroscopic Bankart repair. The present study sought to quantify such preoperative defects using a simple radiological technique and to determine a threshold for elevated risk of recurrence.

Materials and methods: A retrospective study conducted in two centers enrolled patients undergoing primary arthroscopic Bankart repair for isolated anterior shoulder instability in 2005. The principle assessment criterion was revision for recurrent instability. Quantitative radiology comprised: the ratio of notch depth to humeral head radius (D/R) on AP view in internal rotation; Gerber’s X ratio between antero-inferior glenoid cavity edge defect length and maximum anteroposterior glenoid cavity diameter on arthro-CT scan; and the D1/D2 ratio between the glenoid joint surface diameters of the pathologic (D1) and healthy (D2) shoulders on Bernageau glenoid profile views. Seventy-seven patients were included, with a mean follow-up of 44 months (range, 36–54).

Results: Overall recurrence rate was 15.6%. Recurrence risk was significantly greater when the humeral notch length was more or equal to 20\% of the humeral head diameter and the Gerber ratio more or equal to 40\%. On Bernageau views, mean D1/D2 ratio was 4.2\% (range, 0–23\%) in patients without recurrence, versus 5.1\% (range, 0–19\%) in those with recurrence (\(P = 0.003\)).
Introduction

Arthroscopic Bankart capsulorrhaphy has become widespread over the last decade thanks to the advent of absorbable anchors and ancillaries, improvements in arthroscopic knotting techniques and better anatomopathological understanding of the lesions. Recurrence rates now seem comparable to those reported for open Bankart procedures [1] although higher than for bone-block procedures [2], especially in case of bone defect of the humeral head (humeral notch or Hill-Sachs lesion) or antero-inferior glenoid cavity edge [3,4]. In 2007, a prospective study [5] determined predictive factors for recurrence: age less than 20 years, competitive sports, contact or forced overhead sport, shoulder hyperlaxity, and bone defect visible on plain AP radiograph. On the basis of these factors, a preoperative Instability Severity Index Score (ISIS) was drawn up to help surgeons to decide between stabilization either by bone-block (in case of ISIS > 6) or by isolated Bankart repair (ISIS < 3). A recent study [6] however reported that only the glenoid and not the humeral ISIS criterion proved reproducible in daily practice. Moreover, the ISIS analysis is purely qualitative; not being quantitative, it makes no contribution, for example, to preoperative planning of complementary filling procedures [7].

There are now many reports of bone lesion screening methods, but few of these measurement techniques provide threshold values, to get round the problems of image enlargement. In the case of humeral notching, one study [8,9] demonstrated that a ratio of notch depth to humeral head radius (D/R) exceeding 15% on AP view in medial rotation correlated with moderate to poor postoperative results in terms of Duplay-Walch score [10]. On the glenoid side, Bernageau et al. [11] recommended comparative glenoid profile views to assess glenoid defect with respect to the healthy contralateral shoulder: recurrence was on average associated with larger defects; however, no clinically relevant threshold was identified. In 2002, Gerber and Nyffeler [12] described an arthro-CT scan measurement of joint surface defect relative to theoretic total glenoid cavity area; in an anatomical study, they showed that resistance to dislocation was proportional to the ratio (X index) between antero-inferior glenoid defect length and maximum anteroposterior glenoid cavity diameter, diminishing by 30% when X = 0.5 and by 50% when X = 0.75.

The main objective of the present study was quantify preoperative glenohumeral bone defect using a simple radiological method, and to determine a threshold value for elevated risk of recurrence. The secondary objective was to analyze other recurrence risk factors in the series according to ISIS score.

Discussion: Beyond the above thresholds, bone defect as such contraindicates isolated arthroscopic stabilization. The D/R and Gerber ratios are simple and reproducible quantitative measurements can be taken in routine practice, enabling preoperative planning of complementary bone surgery as needed.

Level of evidence: Level IV; retrospective cohort study.
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Patients and methods

A retrospective study in two centers was conducted for a 1-year period from January 1st to December 31st, 2005. Patients meeting the inclusion and exclusion criteria were contacted.

Inclusion and exclusion criteria

The inclusion criteria were:

- isolated anterior shoulder instability;
- in patients not previously operated on for the affected shoulder;
- managed by arthroscopic Bankart repair and;
- with a complete radiology file.

The exclusion criteria were:

- multidirectional or posterior instability;
- recurrence of dislocation or subluxation caused by voluntary action;
- in a shoulder already previously operated on for instability and;
- associated rotator-cuff tear.

Preoperative radiological assessment

Preoperative radiology comprised:

- standard X-ray assessment: AP views in neutral and external rotation. The D/R ratio [8,9] was calculated from the AP view in internal rotation (Fig. 1), using templates of progressive diameters to solve the problems of radiographic enlargement;
- arthro-CT scan: sagittal slice through the glenoid cavity before the appearance of the humeral head, for calculation of Gerber’s X index [11] (ratio of antero-inferior glenoid defect length to maximum anteroposterior glenoid diameter: Fig. 1);
- Bernageau’s glenoid profile view [10], with the patient in upright posture, arm in abduction (Fig. 2). An exact glenoid profile requires that the line projecting the anterior edge of the superior part of the cavity should be continuous with the anterior line of the scapula; once this was checked visually, the radiograph was printed out. Only one view respects these criteria in this position, from which the D1/D2 ratio between glenoid joint
surface diameters of the pathologic (D1) and healthy (D2) shoulder was calculated.

Surgical procedure

Patients were positioned either semi-seated, or in lateral decubitus under double traction. The Bankart procedure was performed using two approaches: posterior for the arthroscope and anterior for the instruments. Anchors were either Panalock Mitek™ or Biofastak Arthrex™. Suture used either slow-absorption monofilaments (PDS®, or braided absorbable sutures Panacryl®). Sutures were introduced into the capsulo-labral complex so as to obtain the most inferior hold possible with capsule retention from south to north. The first suture was introduced into the inferior glenohumeral ligament (IGHL) and pulled to an anchor at the 5 o’clock position; the second was then introduced into the upper IGHL and fixed to an anchor at 4 o’clock; then the third was introduced into the capsulo-labral complex and fixed to an anchor at about 3 o’clock. If needed, complementary procedures such as rotator interval closure or capsule plicature were performed.

Postoperative course

The upper limb was immobilized in internal rotation in a splint for 4 to 6 weeks, allowing pendular motion. Active and passive rehabilitation was then initiated to recover range of motion in anterior elevation and in abduction. External rotations were deliberately kept limited. Contact or overhead sport was allowed only at 6 months postoperatively.

Assessment criteria

The main criterion was recurrence of instability in the form of subluxation or dislocation requiring revision surgery. Quantitative radiology comprised: the D/R ratio, Gerber’s X index and the D1/D2 ratio. Secondary criteria were the retrospectively calculated preoperative ISIS score, the Duplay-Walch score at last follow-up and global satisfaction.

Figure 1  a: quantitative measurement of humeral notch depth in internal rotation: D/R ratio (1) D: notch depth; (2) R: humeral head radius; b: quantitative measurement of glenoid bone loss: Gerber’s X index.

Figure 2  Patient positioning for Bernageau profile view.
Recurrence after arthroscopic Bankart repair

on the Subjective Shoulder Value (SSV) score [13] (What is the overall percent value of your shoulder if a completely normal shoulder represents 100%).

Patients

One hundred and fourteen patients in the two centers underwent primary surgery for isolated anterior shoulder instability: 90 by arthroscopic Bankart repair and 24 by coracoid bone block. Eighty-four patients had analyzable radiology files; analysis concerned the 77 (92%) who could be followed up, at a mean 44.4 months (range, 36–54; median, 45). Mean age at surgery was 27.48 (16–58) years. There were 17 under 20 years old (22.1%). Fifty-four patients were male and 23 female (sex-ratio, 2.35). Forty-eight patients practiced overhead sports (62.3%), including forced overhead sport for 31 (40.2%); 43 practiced contact sports (55.8%). Nineteen patients (24.7%) showed shoulder hyperlaxity (six positive on Gagey test, nine ER1 more than 85 and four with both signs). Initial episodes comprised: 38 (49.3%) dislocations, 27 (35.1%) subluxations and 12 (15.6%) unstable painful shoulders (UPS). The mechanism was trauma in 53 cases (68.8%). Mean trauma-to-surgery interval was 62.9 months (range, 12–420; median, 36). Panalock MitekTM anchors were used in 63 patients (81.8%) and Biofastak ArthrexTM in 14 (18.2%); the mean number of anchors was 3 (range, 2–5). The rotator interval was closed in two patients and capsule plicature was performed in 3.

At follow-up, two cases of frozen shoulder (2.6%) were diagnosed clinically and confirmed on bone scan in the 4th and 6th months; resolution was achieved after 24 months’ sub-threshold rehabilitation, with recovery of range of motion and pain relief.

Statistical analysis

Statistical analysis used XLSTAT 2007 software (AddinsoftTM). First-order risk (probability of false rejection of H0) was set at 0.05. Quantitative variables were compared by Student t test and qualitative variables by chi². Survival curves were drawn up according to Kaplan-Meier and compared by log-rank test. The event of interest was the occurrence of an instability-related accident. Optimal thresholds for D/R and Gerber’s X index were determined on receiver operating characteristic (ROC) curves with sensitivity (Se) as x-axis and specificity (Sp) as y-axis, so as to maximize Se and Sp and thus negative predictive value (NPV). AUC (area under the ROC curve) indicated predictive quality: 1 for ideal and 0 for random prediction.

Results

Twelve of the 77 patients (15.6%) underwent revision for recurrence: subluxation in eight cases (10.4%) and dislocation in four (5.2%). Recurrence occurred at a mean 15.3 months (range, 2–34; median, 12). The mechanism was trauma in two cases (2.5%) and non-traumatic in ten (13%). Revision consisted in coracoid bone block in ten cases (83.3%) and a second arthroscopic Bankart procedure in two (16.7%). Overall survival at 54 months was 84% (Fig. 3).

On AP X-ray, seven of the 77 patients (9.1%) showed isolated glenoid cavity bone lesion, 26 (33.8%) isolated humeral notch, and 18 (23.4%) both. Nine of the 12 cases of recurrence (75%) showed a visible notch and one (8.3%) an associated glenoid cavity lesion.

Mean D/R ratio was 10.3% (range, 0–33; median, 10.7%). The ROC curve (Fig. 4) showed the most discriminatory
D/R threshold to be 20% (Se = 50%, Sp = 86%, NPV = 90%). Humeral notch depth less than 20% of head radius was associated with significantly better survival (recurrence = 9.6% vs. 40% for > 20%; P = 0.016). Mean Gerber X index was 30% (range, 0–70%; median, 40%). The ROC curve (Fig. 4) showed the most discriminatory threshold for X to be 40% (Se = 69%, Sp = 71%, NPV = 92%). Survival differed significantly (P = 0.004) according to X > 40% (recurrence = 12.7%) or more or equal to 40% (recurrence = 20%). On Bernageau profile views, mean D1/D2 ratio was 4.2% (range, 0–23) in patients without recurrence, versus 5.1% (0–19) in those with (P = 0.003).

Mean ISIS was 2.97 (range, 0–8; median, 3). In 52 cases (67.5%), ISIS was less or equal to 3, in 22 (28.6%) 3–6, and in three (3.9%) more than 6. Eight of the patients with recurrence (66.7%) had ISIS less or equal to 3 and 4 (33.3%) more than 6. Intergroup differences according to ISIS less or equal to 3 vs. more than 3 and to ISIS less or equal to 6 vs. more than 6 were not significant.

Analysis of other known risk-factors found elevated recurrence risk with age less than 20 years at first episode (P = 0.038). No other risk factors could be identified (Table 1).

Mean Duplay-Walch score for the series as a whole was 76.68/100 (range, –10 to 100), and 87.46/100 (range, 40–100; median, 90/100) in patients free of recurrence. Mean SSV for the series as a whole was 72.6% (0–100) and 84% (20–100) in patients free of recurrence.

### Discussion

The recurrence rate in the present series was 15.6%. Results showed elevated recurrence risk following arthroscopic Bankart repair associated with a humeral notch more or equal to 20% of humeral head radius and/or with Gerber X index more or equal to 40%.

Recurrence rates according to the literature are higher in case of bone defect. In Burkhart’s series [3], the overall recurrence rate following arthroscopic Bankart repair was 10.8%; 67% of recurrences were associated with significant glenohumeral bone lesion.

Humeral notch dimensions have seldom been reported on. They can be assessed preoperatively, as suggested by Burkhart [3], in terms of mechanical lesion impact on abduction associated to lateral rotation of the limb, but this method fails to guide preoperative decision-making as regards, for example, notch filling. Ito et al. [14] recommended taking views at 135° flexion and 15° internal rotation to estimate humeral lesion depth and extension; the lesion is considered to be a risk factor for recurrence when depth is 3.9 mm or more. This measurement, however, requires a strict protocol in taking the X-rays, as it requires image enlargement; measuring the D/R ratio from the AP view in internal rotation avoids this problem of enlargement.

Recent publications sought to determine a method of measuring antero-inferior glenoid cavity edge lesions and determining threshold values [15]. Sugaya et al. [16] demonstrated that the inferior edge of the cavity describes a perfect circle through the posterior, inferior and anterior edges; this has been the basis for several measurement proposals. Burkhart et al. [17] recommended a peroperative assessment based on the “bare spot” said to be in the center of the circle; this estimation however, lacks precision, as soft tissue on the posterior edge of the cavity can hinder visualization. Kralinger et al. [18], moreover, in a study of 20 anatomic specimens, found that the bare spot was not in the center. Gerber’s X index, calculated on arthrosco, is a simple and reproducible measurement: it requires no special imaging software and is based on a routine examination that is almost systematic, especially when screening for associated lesions. In 1976, Bernageau et al. [11] recommended comparative “glenoid profile” views to assess bone defects; Sugaya et al. [16] recommended measuring differential glenoid area on comparative scans. Both of

### Table 1  Analysis of recurrence risk factors.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Recurrence-free n (%)</th>
<th>Recurrence n (%)</th>
<th>P</th>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
<td>52 (85.3)</td>
<td>9 (14.7)</td>
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<tr>
<td>Female</td>
<td>13 (81.3)</td>
<td>3 (18.7)</td>
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<tr>
<td>Side</td>
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<tr>
<td>Dominant</td>
<td>42 (82.3)</td>
<td>9 (17.7)</td>
<td>0.75</td>
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<td>Non-dominant</td>
<td>23 (88.5)</td>
<td>3 (11.5)</td>
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<tr>
<td>Mechanism of 1st episode</td>
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<tr>
<td>Traumatic</td>
<td>43 (81.1)</td>
<td>10 (18.9)</td>
<td>0.58</td>
</tr>
<tr>
<td>Non-traumatic</td>
<td>22 (91.6)</td>
<td>2 (8.4)</td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
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<tr>
<td>Subluxation</td>
<td>34 (87.2)</td>
<td>5 (12.8)</td>
<td>0.23</td>
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<tr>
<td>Dislocation</td>
<td>31 (81.5)</td>
<td>7 (18.5)</td>
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<tr>
<td>Athletic level</td>
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<tr>
<td>No sport</td>
<td>12 (85.7)</td>
<td>2 (14.3)</td>
<td>0.48</td>
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<tr>
<td>Recreational</td>
<td>22 (84.5)</td>
<td>4 (15.5)</td>
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<tr>
<td>Competition</td>
<td>31 (83.8)</td>
<td>6 (16.2)</td>
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<tr>
<td>Overhead sport</td>
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<td></td>
<td></td>
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<tr>
<td>No sport</td>
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<td>2 (14.3)</td>
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<tr>
<td>Non-overhead</td>
<td>11 (73.3)</td>
<td>4 (26.7)</td>
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<tr>
<td>Overhead</td>
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<td>6 (12.5)</td>
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<tr>
<td>Contact</td>
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<td></td>
</tr>
<tr>
<td>No sport</td>
<td>12 (85.7)</td>
<td>2 (14.3)</td>
<td>0.85</td>
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<tr>
<td>Non contact</td>
<td>17 (85.0)</td>
<td>3 (15.0)</td>
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<tr>
<td>Contact</td>
<td>36 (83.7)</td>
<td>7 (16.3)</td>
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<td>Shoulder laxity</td>
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<td>Hyperlaxity</td>
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<td>5 (26.3)</td>
<td>0.29</td>
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<td>Non-hyperlaxity</td>
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<td>7 (12.1)</td>
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<td>Humeral notch</td>
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<tr>
<td>Visible</td>
<td>36 (81.2)</td>
<td>8 (18.8)</td>
<td>0.06</td>
</tr>
<tr>
<td>Non-visible</td>
<td>30 (91.0)</td>
<td>3 (9.0)</td>
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<tr>
<td>Glenoid cavity lesion</td>
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<tr>
<td>Visible</td>
<td>23 (92)</td>
<td>2 (8)</td>
<td>0.13</td>
</tr>
<tr>
<td>Non-visible</td>
<td>42 (80.8)</td>
<td>10 (19.2)</td>
<td></td>
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<tr>
<td>Occupation</td>
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<tr>
<td>Non-manual</td>
<td>36 (81.8)</td>
<td>8 (18.2)</td>
<td>0.48</td>
</tr>
<tr>
<td>Light manual</td>
<td>13 (86.6)</td>
<td>2 (13.4)</td>
<td></td>
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<tr>
<td>Heavy manual</td>
<td>16 (88.9)</td>
<td>2 (11.1)</td>
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these methods presuppose a healthy contralateral shoulder. Bernageau, comparing pathologic and healthy sides on his profile views found recurrence to be associated with larger mean defect; the difference in mean value between the two sides, however was 0.9% - too small for a clinically relevant threshold value to be discerned. Mean retrospectively calculated ISIS score in the present series was 2.97 (range, 0—8), with 67.5% of the cohort scoring less or equal to 3 and only 4% more than 6: although the original surgeons had not calculated any prognostic score as such, they had selected patients with few risk factors, proposing bone-block stabilization to the others.

The main limitation of the present study lies in its retrospective design and 8% loss to follow-up. The only risk factors able to be identified were bone defect and age less than 20 years.

Conclusion

Quantitative measurement of bone loss determined a D/R ratio threshold of 20% and Gerber X index threshold of 40%, as of which bone defect as such contraindicates isolated arthroscopic repair. Both of these quantitative measurements are simple, reproducible and feasible in everyday practice.

Disclosure of interest

Pr Hardy is consultant for Arthrex.
Pr Clavert is consultant for Mitek
The other authors declare that they have no conflicts of interest concerning this article.

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