



Does glenoid remodeling occur with an erosion-type bone loss after arthroscopic Bankart repair?



Leonardo Hideto Nagaya, MD, Nobuyuki Yamamoto, MD, PhD, Kiyotsugu Shinagawa, MD, Taku Hatta, MD, PhD, Eiji Itoi, MD, PhD*

Department of Orthopaedic Surgery, Tohoku University School of Medicine, Sendai, Japan

ARTICLE INFO

Keywords:

Shoulder instability
glenoid bone loss
erosion
Bankart repair
stabilization procedure
remodeling

Level of evidence: Level IV; Case Series;
Treatment Study

Introduction: Fragment-type glenoid bone loss is known to remodel after arthroscopic Bankart repair. To our knowledge, no studies have been reported about the morphologic changes of the erosion-type bone loss.

Aim: To determine the morphologic changes of erosion-type glenoid bone loss after arthroscopic Bankart repair.

Methods: Twenty-eight patients (mean age: 31 years) with traumatic anterior glenohumeral instability with an erosion-type glenoid bone loss <25% underwent arthroscopic Bankart repair. The minimum follow-up was 2 years. Pre- and postoperative bilateral computed tomography scans were performed in all patients. The width and surface area of the glenoid were measured by a software program and compared pre- and postoperatively.

Results: The recurrence rate was 7.1% (2 of 28 shoulders). The size of the bone loss was $7.2 \pm 5.3\%$ (mean \pm standard deviation). The preoperative glenoid width and area were 24.9 ± 2.2 mm and 7.0 ± 0.8 cm², respectively, and the postoperative ones (2 years after surgery) were 24.7 ± 2.2 mm and 6.8 ± 0.8 cm², respectively. There were no significant differences between the pre- and postoperative glenoid width and area.

Discussion and conclusion: Unlike the fragment-type bone loss, the erosion-type bone loss <25% did not show any morphologic changes of the glenoid at least 2 years after arthroscopic Bankart repair.

© 2020 The Authors. Published by Elsevier Inc. on behalf of American Shoulder and Elbow Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Anterior shoulder instability is a frequent condition in the young athletic population and frequently caused by a traumatic event. There are several options of treatment such as the Latarjet procedure, Neer capsular shift surgery, and arthroscopic Bankart repair.^{1,5,8} The main objective of arthroscopic Bankart repair is to restore the integrity of the capsulolabral complex attached to the glenoid. This surgery is recommended for patients with a small glenoid bone loss (<25% of the glenoid width).²

There are 2 types of glenoid bone loss: fragment type and erosion type.¹⁰ Kitayama et al⁶ described bone remodeling of the glenoid after arthroscopic osseous Bankart repair. They concluded that the glenoid morphology could be normalized with time after successful repairs. Moroder et al⁹ showed similar findings with a bone graft from the iliac crest. In patients without a significant bone

loss, the grafted iliac crest that exceeded the original size of the glenoid was absorbed and remodeled.

These reports described the remodeling of a fragment or grafted bone. To our knowledge, there have been no reports about the morphologic changes of the glenoid with erosion-type bone loss after arthroscopic Bankart repair. We hypothesized that an erosion-type bone loss of the glenoid would undergo remodeling like a fragment type after surgical repair. The purpose of this study was to determine the morphologic changes of the glenoid with an erosion-type bone loss after arthroscopic Bankart repair.

Methods

A consecutive series of 75 patients with traumatic anterior dislocation of the shoulder underwent arthroscopic Bankart repair from 2006 through 2015. The minimum follow-up was 2 years. Of these, 28 patients (mean age: 31 years) who met the following inclusion criteria were retrospectively reviewed: (1) patients with an erosion-type glenoid bone loss, (2) patients with a glenoid bone loss less than 25%, and (3) a minimum follow-up of 2 years.

Institutional review board of Tohoku University approved this study (2016-1-521).

* Corresponding author: Eiji Itoi, MD, PhD, Department of Orthopaedic Surgery, Tohoku University School of Medicine, 1-1 Seiryō-machi, Aoba-ku, Sendai 980-8574, Japan.

E-mail address: itoi-eiji@med.tohoku.ac.jp (E. Itoi).

<https://doi.org/10.1016/j.jseint.2020.06.002>

2666-6383/© 2020 The Authors. Published by Elsevier Inc. on behalf of American Shoulder and Elbow Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Exclusion criteria were as follows: (1) patients with a fragment-type glenoid bone loss, (2) patients with a glenoid defect of greater than 25% of the glenoid width due to contraindication for Bankart repair,¹² (3) revision Bankart repairs, (4) patients with a full-thickness rotator cuff tear, and (5) patients with a capsular tear at the humeral insertion (humeral avulsion of the glenohumeral ligament lesion). The mean follow-up was 28 months. At 2-year follow-up, patients underwent physical examination of the shoulder to complete the Rowe score.

Computed tomography images

All patients underwent computed tomography (CT) on bilateral shoulders in a single scan before and after surgery (1 year and 2 years) to make the unaffected side a control. The scan was done only once for both shoulders, not 1 scan for each shoulder. The Digital Imaging and Communications in Medicine data of the CT images of 28 patients were used. CT images were obtained by a CT scanner (SOMATOM Definition; Siemens AG, Munich, Germany) or BrightSpeed (GE Healthcare UK, Chalfont St Giles, UK). CT images were taken with a continuous axial 1-mm slice thickness, pitch of 1 for the former scanner and with a continuous axial 0.625-mm slice thickness, pitch of 1.375 for the latter scanner.

Using zioTerm Software (Ziosoft, Inc., Tokyo, Japan), the en face view of the glenoid was reconstructed, and the width and the area were measured using ImageJ (1.51; NIH, MD, USA) (Fig. 1). First, the uninvolved glenoid was measured. The superior-inferior axis of the glenoid was drawn on the glenoid surface connecting the supraglenoid and infraglenoid tubercles. Another anterior-posterior axis was drawn at the widest portion of the glenoid perpendicular to the superior-inferior axis. The length of the anterior-posterior axis is the width of the intact glenoid (D). Then, the width of the involved glenoid (d) was measured at the same level as the intact glenoid. The difference between “D” and “d” was defined as the width of

bone loss. The amount of bone loss was expressed as the percentage of the bone loss width to the intact glenoid width: $\text{bone loss} = (D - d)/D \times 100 (\%)$. The surface area was also measured using ImageJ by detecting the shape of the entire glenoid. The difference between the intact glenoid area and the involved glenoid area was defined as the area of bone loss.

Regarding the reliability of our measurement technique, 2 senior surgeons measured them independently, and 1 surgeon measured them twice on different days. Using the intraclass correlation coefficients (ICC), the inter-examiner reliability was 0.84 (0.79–0.89) with ICC (2,1) (95% confidence interval) and the intra-examiner reliability was 0.79 (0.73–0.85) with ICC (1,1) (95% confidence interval).

Surgical procedure

Arthroscopic Bankart repair was performed by 2 senior surgeons in beach chair position, using the posterior and anterosuperior portals as viewing portals and the anterior portal as a working portal. Bioabsorbable suture anchors (GRYPHON Anchor, DePuy Mitek, Norwood, MA, USA; and Osteoraptor HA curved, Smith & Nephew, Andover, MA, USA) were used. The curved drill guide system (OSTEORAPTOR CURVED Suture Anchors and Guide System; Smith & Nephew) was used for the most inferior anchor at 5:30 o'clock position. Three to five (mean: 4.2) suture anchors were inserted at the edge of the glenoid depending on the extent of the Bankart lesion. In all cases, the articular cartilage along the anterior glenoid rim was not removed at all, and all anchors were placed at the glenoid edge. We slightly abraded the anterior surface of the scapular neck to prepare bony bed for soft tissue healing.

Statistical analysis

The paired *t*-test was used to compare the differences of the Rowe scores, the glenoid area and width between the preoperative

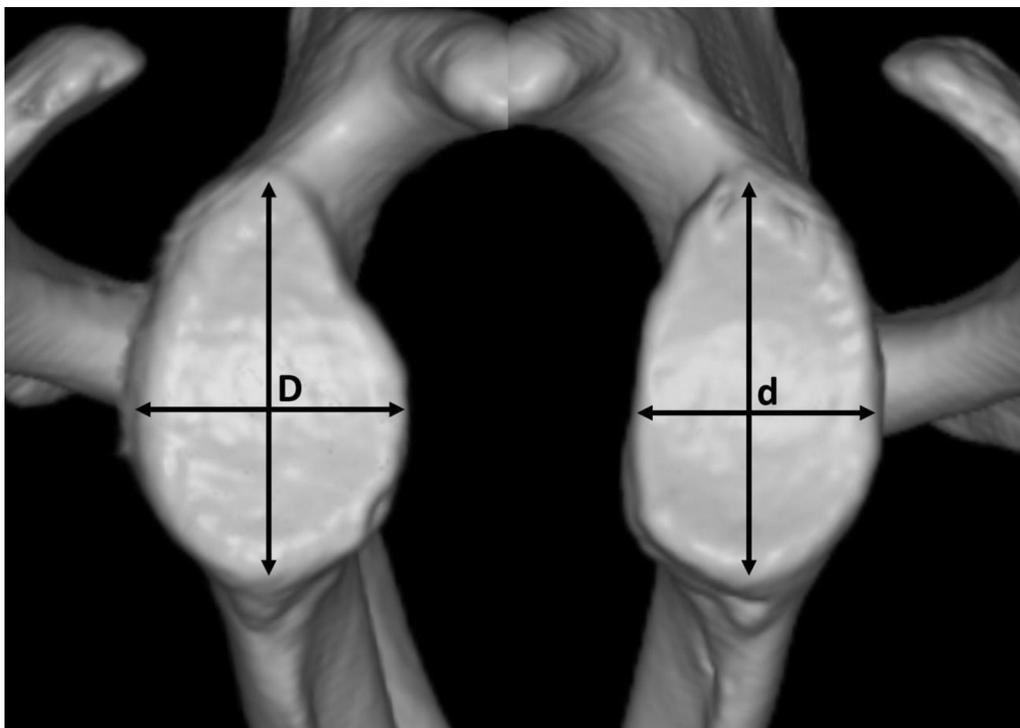


Figure 1 Measurement of the glenoid width. The width of the intact glenoid (left image) was measured (D). Then, the width of the involved glenoid (right image) was measured at the same level as the intact glenoid (d). The difference between “D” and “d” was defined as the width of bone loss. The amount of bone loss was expressed as the percentage of the bone loss width to the intact glenoid width: $\text{bone loss} = (D - d)/D \times 100 (\%)$.

and final follow-up. The *P* value less than 5% indicated a statistically significant difference. All statistical analyses were performed with the use of SPSS Statistics (version 20.0; IBM, Armonk, NY, USA).

Results

The mean age at the time of surgery was 31 years (range, 17–66 years). There were 17 males and 11 females. Sixteen had dominant side involved and 12 nondominant side. The mean number of dislocations was 4.7 (range, 3–30). The size of the bone loss before surgery was $7.2\% \pm 5.3\%$ (mean \pm standard deviation; range, 1.6%–19.3%). Seventeen patients (61%) participated in sports, but there was no significant difference of bone loss between those who participated in sports and those who did not.

The recurrence rate after surgery was 7.1% (2 of 28 shoulders). The 2 patients with re-dislocation had 8.0% and 18.7% of bone loss, respectively. There was no correlation between the recurrence rate and the percentage of bone loss. The Rowe score significantly improved from 44.5 ± 5.7 preoperatively to 92.1 ± 7.5 at the final follow-up ($P < .05$). There was also no significant correlation between the Rowe score and the size of the glenoid bone loss.

The surface area and width of the glenoid are shown in Table 1. The preoperative glenoid width (25.0 ± 2.2 mm) remained unchanged after surgery (1 and 2 years) ($P > .999$, $P > .999$, respectively). The preoperative glenoid surface area (7.0 ± 0.8 cm²) also remained unchanged after surgery (1 and 2 years) ($P > .999$, $P > .999$, respectively). Thus, there were no significant changes of the glenoid width and the glenoid surface area before and after surgery. In addition, there were no correlations between the number of dislocations and the size of bone loss before and after surgery.

The 2 patients with recurrent instability after the surgery showed the following changes of glenoid surface area and width during the follow-up period. One patient with 8% bone loss had 6.57 cm² area and 23.7 mm width before surgery, 6.33 cm² area and 22.7 mm width at 1-year follow-up, and 6.62 cm² area and 25 mm width at 2-year follow-up. Another patient with 18.7% bone loss had 7.4 cm² area and 24.1 mm width preoperatively, 9.85 cm² area and 30 mm width at 1-year follow-up, and 9.23 cm² area and 30.4 mm width at 2-year follow-up.

We further performed subgroup analysis of those with more than 10% of bone loss because there might be a relationship between the size of bone loss and the amount of bone remodeling. There were 8 patients with more than 10% of bone loss. The glenoid width of these 8 patients changed from 22.9 ± 2.2 mm preoperatively to 24.7 ± 3 mm at 1-year follow-up and 24.9 ± 3.1 mm at 2-year follow-up. There were no significant differences among them. The glenoid surface area changed from 6.5 ± 1.1 cm² preoperatively to 7.1 ± 1.4 cm² at 1-year follow-up and 7 ± 1.3 cm² at 2-year follow-up. There were no significant differences among them.

Discussion

Our study clearly showed that the glenoid width and surface area did not change in shoulders with an erosion-type glenoid bone loss regardless of the defect size at least 1 and 2 years after arthroscopic Bankart repair. Our findings are quite different from

the previous studies demonstrating the bone remodeling of the glenoid with a fragment-type bone loss after repair.^{6,11} There are several possibilities that may explain this difference.

First, our data may indicate that bone remodeling is more difficult to occur in erosion-type bone loss cases. A bony fragment is expected to unite with the glenoid when it is fixed in the correct position during bony Bankart repair.¹¹ Once the fragment heals, the area of bone loss becomes much smaller and probably easier to be filled by new bone formation.⁶ In an erosion-type bone loss, the defect remains the same size after the Bankart repair because there is no fragment to fill the defect.

Second, bone remodeling follows Wolff's law.⁹ The glenoid surface bears a compressive force created by the contact with the humeral head. In a fragment-type case, the fixed fragment may bear the compressive force, which may also be helpful to promote bone remodeling. On the other hand, there is no compressive load transmitted to the area of erosion-type bone loss; it seems less likely to observe bone remodeling. Recently, some surgeons^{3,6} removed a small amount of articular cartilage from the glenoid rim to expose the underlying bone for better healing between the soft tissue and the bone. However, after removing the cartilage rim, there is no more force transmission from the humeral head to the glenoid at the rim site. In these cases, it was recently reported that the rim bone of the glenoid had been absorbed and the glenoid width had decreased.¹¹ This lack of force transmission may explain why bone remodeling was difficult to occur in erosion-type bone loss.

Third, the erosion-type glenoid bone defect may be the result of (1) gradual bone erosion caused by repeated instability events, (2) a compression fracture created by the humeral head, or (3) complete resorption of a bony fragment. In case of a compression fracture of the glenoid rim, there is no fresh bony bed at the glenoid rim, which may make a new bone formation more difficult to occur.^{4,7}

Lastly, the average bone loss in the present study was 7.2% of the glenoid width. This amount of bone loss might not be large enough to stimulate bone remodeling of the glenoid. If the bone loss had been much greater, we might have been able to observe bone remodeling. Similarly, the follow-up period was 2 years in the present study. Kitayama et al⁶ demonstrated the remodeling process in patients with a fragment type bone loss with the average follow-up period of 6.2 years. If we had observed the mid-term and long-term outcomes, the result might have been different. Future studies are required to clarify these issues.

There are a couple of limitations in the present study. First, the number of the subjects was small, and the follow-up period was short. A larger sample size would allow us to analyze the data based on the size of bone loss or activity level of the patients. Second, the size of the bone loss ranged from 1.6% to 19.3% of the glenoid width with an average of 7.2% in this series. Much larger bone loss ranging from 20% to 25% might show a different response.

Conclusion

Unlike the fragment-type glenoid bone loss, the erosion-type did not show any morphologic changes at least 2 years after arthroscopic Bankart repair.

Table 1
Surface area and width of the glenoid

	Preoperative	1-yr postoperative	2-yr postoperative	<i>P</i> values
Glenoid width (mm)	25.0 ± 2.2	24.9 ± 2.2	24.7 ± 2.2	>.999
Glenoid area (cm ²)	7.0 ± 0.8	7.0 ± 0.8	6.8 ± 0.8	>.999

All values are the mean \pm standard deviation.

Disclaimer

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

References

- Ahmed I, Ashton F, Robinson CM. Arthroscopic Bankart repair and capsular shift for recurrent anterior shoulder instability: functional outcomes and identification of risk factors for recurrence. *J Bone Joint Surg Am* 2012;94:1308–15. <https://doi.org/10.2106/JBJS.J.01983>.
- Bigliani LU, Newton PM, Steinmann SP, Connor PM, McIlveen SJ. Glenoid rim lesions associated with recurrent anterior dislocation of the shoulder. *Am J Sports Med* 1998;26:41–5.
- Denard PJ, Narbona P, Lädermann A, Burkhart SS. Bankart augmentation for capsulolabral deficiency using a split subscapularis tendon flap. *Arthroscopy* 2011;27:1135–41. <https://doi.org/10.1016/j.arthro.2011.02.032>.
- Griffith JF, Antonio GE, Yung PS, Wong EM, Yu AB, Ahuja AT, et al. Prevalence, pattern, and spectrum of glenoid bone loss in anterior shoulder dislocation: CT analysis of 218 patients. *Am J Roentgenol* 2008;190:1247–54. <https://doi.org/10.2214/AJR.07.3009>.
- Kim KC, Shin HD, Cha SM, Kim JH. Arthroscopic double-loaded single-row repair in chronic traumatic anterior shoulder dislocation. *Arch Orthop Trauma Surg* 2012;132:1515–20. <https://doi.org/10.1007/s00402-012-1571-y>.
- Kitayama S, Sugaya H, Takahashi N, Matsuki K, Kawai N, Tokai M, et al. Clinical outcome and glenoid morphology after arthroscopic repair of chronic osseous Bankart lesions: a five to eight-year follow-up study. *J Bone Joint Surg Am* 2015;97:1833–43. <https://doi.org/10.2106/JBJS.N.01033>.
- Milano G, Grasso A, Russo A, Magarelli N, Santagada DA, Deriu L, et al. Analysis of risk factors for glenoid bone defect in anterior shoulder instability. *Am J Sports Med* 2011;39:1870–6. <https://doi.org/10.1177/0363546511411699>.
- Mishra A, Sharma P, Chaudhary D. Analysis of the functional results of arthroscopic Bankart repair in posttraumatic recurrent anterior dislocations of shoulder. *Indian J Orthop* 2012;46:668–74. <https://doi.org/10.4103/0019-5413.104205>.
- Moroder P, Blocher M, Auffarth A, Hoffelner T, Hitzl W, Tauber M, et al. Clinical and computed tomography-radiologic outcome after bony glenoid augmentation in recurrent anterior shoulder instability without significant glenoid bone loss. *J Shoulder Elbow Surg* 2014;23:420–6. <https://doi.org/10.1016/j.jse.2013.07.048>.
- Sugaya H, Moriishi J, Dohi M, Kon Y, Tsuchiya A. Glenoid rim morphology in recurrent anterior glenohumeral instability. *J Bone Joint Surg Am* 2003;85-A:878–84. <https://doi.org/10.1053/jars.2000.17715>.
- Sugaya H, Moriishi J, Kanisawa I, Tsuchiya A. Arthroscopic osseous Bankart repair for chronic recurrent traumatic anterior glenohumeral instability. *J Bone Joint Surg Am* 2005;87:1752–60. <https://doi.org/10.2106/JBJS.D.02204>.
- Yamamoto N, Muraki T, Sperling JW, Steinmann SP, Cofield RH, Itoi E, et al. Stabilizing mechanism in bone-grafting of a large glenoid defect. *J Bone Joint Surg Am* 2010;92:2059–66. <https://doi.org/10.2106/JBJS.I.00261>.