Biomechanical Comparison of Arthroscopic Single- and Double-Row Repair Techniques for Acute Bony Bankart Lesions

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Background: Single- and double-row arthroscopic reconstruction techniques for acute bony Bankart lesions have been described in the literature.

Hypothesis: The double-row fixation technique would provide superior reduction and stability of a simulated bony Bankart lesion at time zero in a cadaveric model compared with the single-row technique.

Study Design: Controlled laboratory study.

Methods: Testing was performed on 14 matched pairs of glenoids with simulated bony Bankart fractures with a defect width of 25% of the glenoid diameter. Half of the fractures were repaired with a double-row technique, while the contralateral glenoids were repaired with a single-row technique. The quality of fracture reduction was measured with a coordinate measuring machine. To determine the biomechanical stability of the repairs, specimens were preconditioned with 10 sinusoidal cycles between 5 and 25 N at 0.1 Hz and then pulled to failure in the anteromedial direction at a rate of 5 mm/min. Loads at 1 mm and 2 mm of fracture displacement were determined.

Results: The double-row technique required significantly higher forces to achieve fracture displacements of 1 mm (mean, 60.6 N; range, 39.0-93.3 N; $P = .001$) and 2 mm (mean, 94.4 N; range, 43.4-151.2 N; $P = .004$) than the single-row technique (1 mm: mean, 30.2 N; range, 14.0-54.1 N and 2 mm: mean, 63.7 N; range, 26.6-118.8 N). Significantly reduced fracture displacement was seen after double-row repair for both the unloaded condition (mean, 1.1 mm; range, 0.3-2.4 mm; $P = .005$) and in response to a 10-N anterior force applied to the defect (mean, 1.6 mm; range, 0.5-2.7 mm; $P = .001$) compared with single-row repair (unloaded: mean, 2.1 mm; range, 1.3-3.4 mm and loaded: mean, 3.4 mm; range, 1.9-4.7 mm).

Conclusion: The double-row fixation technique resulted in improved fracture reduction and superior stability at time zero in this cadaveric model.

Clinical Relevance: This information may influence the surgical technique used to treat large osseous Bankart fractures and the postoperative rehabilitation protocols implemented when such repair techniques are used.

Keywords: bony Bankart lesion; glenoid rim fracture; arthroscopic repair; single-row repair; double-row repair

Bony Bankart lesions are commonly associated with anterior or anterior-inferior glenohumeral dislocations, often caused by a traumatic event.[1,18,23,27-29] The prevalence of osseous Bankart lesions reportedly ranges from 7.9% to 50.0% in shoulders that exhibit traumatic glenohumeral instability.[1,18,23,25,28,29] Acute osseous Bankart lesions must be differentiated from chronic cases and are defined by acute glenohumeral dislocations with a glenoid rim fracture within 3 to 6 months of the initial injury.[18,23,29] In contrast, chronic lesions, particularly in cases of recurrent anterior instability, often present as bony erosion of the anterior glenoid rim caused by osseous lysis.[1,18,20]

Although it has been shown that acute Bankart lesions can be successfully treated nonoperatively if the fracture is concentrically reduced,[14,26] Nakagawa et al[20] reported a high percentage of fragment absorption within 1 year after an acute injury. Recent advancements in arthroscopic technologies have made arthroscopic bony reconstruction possible.[17,18,22,23,29] Additionally, recent case series have shown favorable outcomes after arthroscopic bony repair with suture anchors for patients with bone defects ranging in size from 11.4% to 49.0% of the inferior glenoid width.[18,23,29]

Two techniques for arthroscopic bony repair of acute bony Bankart lesions have been described in the literature.[17,22] The method described by Porcellini et al[22] involved implementation of 1 anchor in the fracture,

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corresponding to a single-row repair. In contrast, the "bony Bankart bridge" technique described by Millett and Braun[17] used a double-row technique that deployed anchors at the medial and lateral borders of the fracture site. Favorable clinical outcomes have been reported for both techniques.[18,22,23]

Giles et al[4] compared both of the described fixation techniques in a cadaveric biomechanical model with a simulated osseous defect size of 15% without creating a labral avulsion. The authors reported significant differences in fragment displacement at various loading conditions; however, they reported that these small, but statistically significant, differences were likely clinically insignificant. In conjunction with the reported nonsignificant differences in failure strength and load transfer between the 2 techniques, the authors concluded that the 2 techniques were biomechanically equivalent. However, several studies have shown that significantly increased anterior glenohumeral instability associated with glenoid rim lesions only occurs for defects exceeding 20% of the glenoid surface area.[3,5,6,8,31] Thus, controversy exists regarding the need for surgical repair in glenoid rim defects of less than 20%. There exists no biomechanical data to date comparing arthroscopic bony repair techniques for osseous Bankart lesions with defect sizes exceeding 20% of the glenoid surface area.

Therefore, the purpose of this study was to compare the time zero reduction of distance across the fracture and biomechanical stability associated with the single-row technique described by Porcellini et al[22] and the double-row technique described by Millett and Braun[17] of bony Bankart lesions with a 25% defect. The double-row technique was hypothesized to provide improved fracture reduction and superior stability compared with the single-row technique.

MATERIALS AND METHODS

Specimen Preparation

Fourteen matched pairs (14 left, 14 right) of fresh-frozen human cadaveric shoulders (9 male, 5 female; mean age, 54.3 years; range, 44-64 years) were used for this study. Dual-energy x-ray absorptiometry (DEXA) bone density testing was performed on all specimens to assess potential bone mineral density (BMD) biases (mean BMD, 0.491 g/cm^2; range, 0.345-0.608 g/cm^2). Matched-pair specimens were randomized between groups by drawing pieces of paper with specimens from a hat. Specimens were thawed at room temperature 24 hours before testing. All soft tissues were dissected, with the exception of the labrum and medial portion of the capsule. The glenoid and labrum of each specimen were visually inspected, and no pre-existing injuries were identified. The inferior region of the scapulae was removed by cutting in parallel with the inferior border of the scapula spine to a point 1 cm inferior to the caudal glenoid origin, and the superior medial angle was removed. Before potting, 3 screws were drilled circumferentially into the spine of the scapulae to ensure rigid fixation in polymethyl methacrylate (PMMA; Fricke Dental International Inc, Streamwood, Illinois, USA). Specimens were then potted in PMMA in a custom-made cylindrical mold with the glenoid fossa in parallel with the base of the mold. Finally, PMMA was poured 1 cm medial to the root of the acromion.

Surgical Techniques

Biomechanical testing was performed on cadaveric glenoids to reproduce time zero bony repair of a simulated acute bony Bankart lesion. Bony defects of the anterior rim were created so that the width of the defect was 25% of the largest anterior-posterior articular glenoid width, which represented the diameter of the outer fitting circle of the inferior glenoid.[2,13,29] Glenoid and defect widths were measured with a digital caliper (Swiss Precision Instrument Inc, Garden Grove, California, USA) with a manufacturer-reported accuracy of 0.254 mm. Superior-inferior osteotomy was performed using an oscillating saw after marking the osteotomy line by inserting two 1.25-mm K-wires (Arthrex Inc, Naples, Florida, USA). These were inserted perpendicular to a line passing from the origin of the inferior glenoid through the 3-o'clock position, as described by Saito et al[25] (Figure 1). This produced fractures that were reproducible, resembled those associated with anterior instability clinically, and were repairable. The labrum was detached from the glenoid rim up to the 12-o'clock and 6-o'clock positions to be consistent with labral avulsions typically observed clinically with bony Bankart lesions.[1,17,18,29] The superior-inferior length of the fragment was measured, and 2 holes were drilled medial to lateral using a 1.25-mm K-wire through the upper and lower thirds of the fragment in the anterior-posterior center of the fragment. One No. 2 long chain ultrahigh molecular weight polyethylene (UHMWPE) suture core with a braided jacket of polyester (FiberWire,

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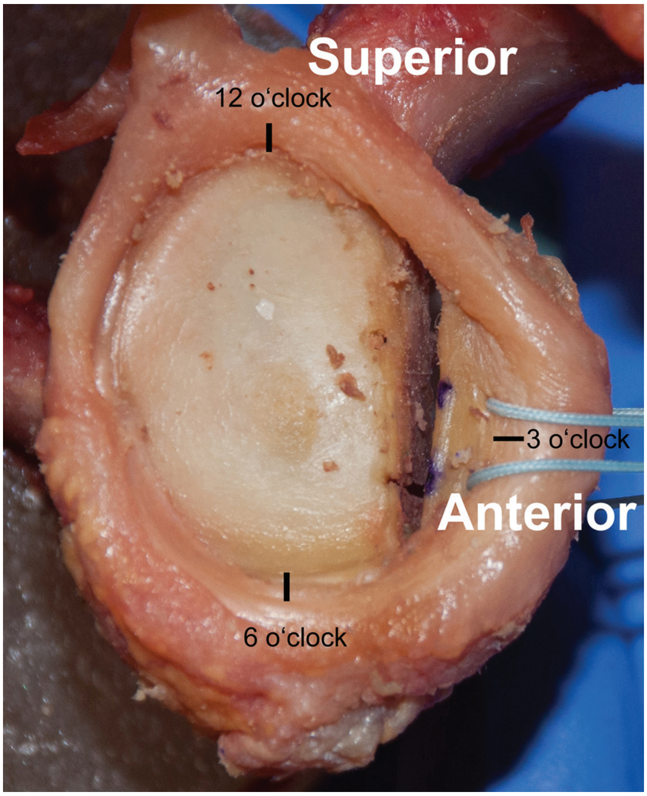

Figure 1. Superior-inferior osteotomy was performed at the 3-o'clock position. The fracture width measured 25% of the inferior glenoid diameter. All glenoid rim defect lengths extended more than half of the inferior glenoid diameter.

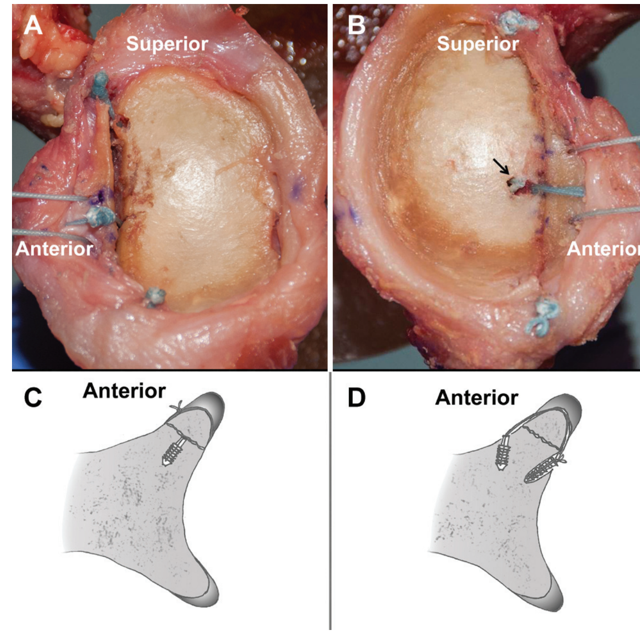

Figure 2. (A) Specimen treated by single-row repair: One anchor is inserted in the glenoid along the rim fracture in the midportion (axial and sagittal planes) of the fracture. (B) Specimen treated by double-row repair: The lateral anchor was placed close to the cartilage-fracture margin at the midportion of the fracture (arrow). (C) Illustration of the single-row repair: The medial limb of the suture was passed through the labrum, trapping the bony fragment at the midportion of the fracture. (D) Illustration of the double-row repair: One anchor is placed medial (axial plane) to the donor site on the glenoid neck and in the midportion (sagittal plane) of the fracture, and an additional anchor is placed lateral to the fracture line. Both limbs are passed around the fragment and fixated using knotless suture anchors.

Arthrex Inc) was inserted through each hole and tied around a 70 mm–diameter rod using 10 alternating half-hitch knots each, creating standardized length loops later used to load the repair construct during biomechanical testing. The nonabsorbable suture loops were determined to have sufficient stiffness and strength to produce failures at the repair site during pull-to-failure testing of the repair constructs. The labral avulsion was repaired using two 3.0-mm bioabsorbable suture anchors loaded with sutures (BioComposite SutureTak [Arthrex Inc] loaded with No. 2 FiberWire). The anchors were placed adjacent to the superior and inferior margins of the fracture in right shoulders at the 1:30 and 4:30 clock positions of the glenoid rim in a standard fashion using typical insertion devices. For suture passage, the capsule tissue was punctured in a standard manner 10 mm from the capsulolabral junction with a 45° curved shuttling device (SutureLasso, Arthrex Inc). The suture from the anchor was shuttled through the capsulolabral tissue with nitinol wire. The sutures were successively shuttled and inserted into the eyelet of the suture anchor. Sliding-locking Weston knots backed up with 2 alternating half-hitches were used for the suture pairs. The simulated bony Bankart lesion was then repaired with 1 of the following 2 techniques.

Single-Row Technique. One 3.0-mm bioabsorbable suture anchor loaded with a suture (BioComposite SutureTak loaded with No. 2 FiberWire) was inserted in the glenoid along the rim fracture in the midportion (sagittal and axial planes) of the fracture. The medial limb of the suture was passed through the labrum with the shuttling device, piercing the bony fragment at the midportion of the fracture as illustrated in Figure 2. A sliding-locking Weston knot was used for reduction and fixation, which was backed up with 2 alternating half-hitches for all suture repairs.

Double-Row Technique. One 3.0-mm bioabsorbable suture anchor loaded with a suture (BioComposite SutureTak loaded with No. 2 FiberWire) was placed medial (axial plane) to the glenoid fracture site on the glenoid neck and in the midportion (sagittal plane) of the fracture. Both limbs of the suture were passed with the shuttling device through the soft tissues, medial to the bony fragment. A hole was drilled for the lateral anchor on the glenoid face at the cartilage-fracture margin in the middle of the fracture. The 2 free limbs of the medial suture anchor were fed into a 2.9-mm bioabsorbable knotless suture anchor (BioComposite PushLock, Arthrex Inc), which was then pressed into the drill hole on the glenoid face. The suture limbs were

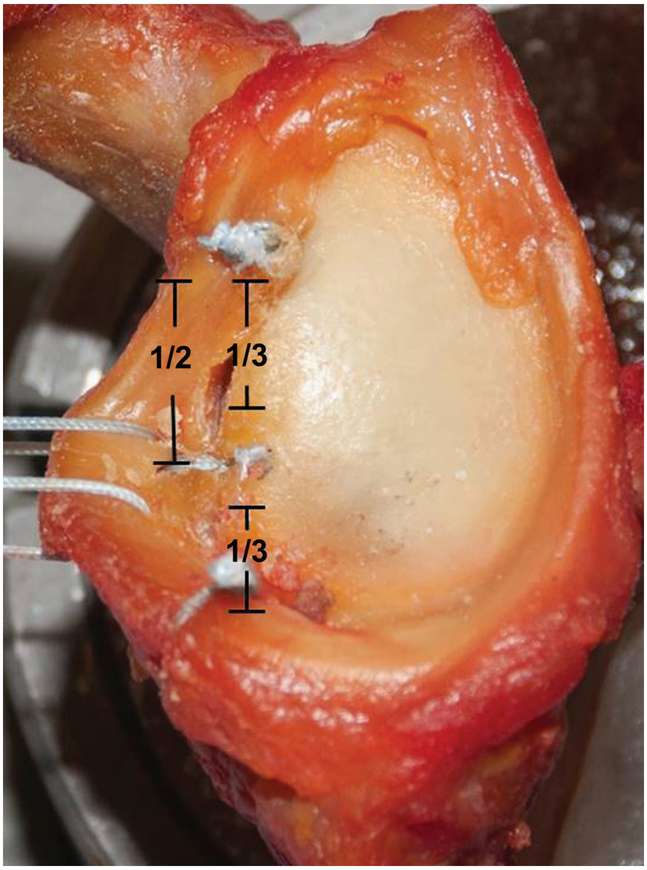

Figure 3. Evaluation of fracture reduction by measuring distance across the fracture: A coordinate measuring machine was used to assess fracture displacement of each repair at the upper third, lower third, and midpoint of the fracture.

tensioned before final fixation of the anchor, compressing the bony fragment back into its donor bed (Figure 2).

Evaluation of Fracture Reduction

The ability of the repair techniques to reduce the distance across the fracture was evaluated using a calibrated coordinate measuring machine (MicroScribe-MX, GoMeasure3D, Amherst, Virginia, USA) with a measurement repeatability of 0.113 mm in our laboratory testing environment.[9] After surgical reconstruction of the glenoid, the distance between the intra-articular fracture edge of the bony fragment and the intra-articular fracture edge of the glenoid was measured at the superior third, inferior third, and middle of the fracture (Figure 3). Measurements were obtained for both an unloaded condition and while a constant force of 10 N directed anteriorly and in parallel with the glenoid face was applied to the bony fragment. All reported measurements were taken by a single investigator to prevent interobserver variability. The 3-dimensional position data were collected with Revware software (Revware Inc, Raleigh, North Carolina, USA) and exported to

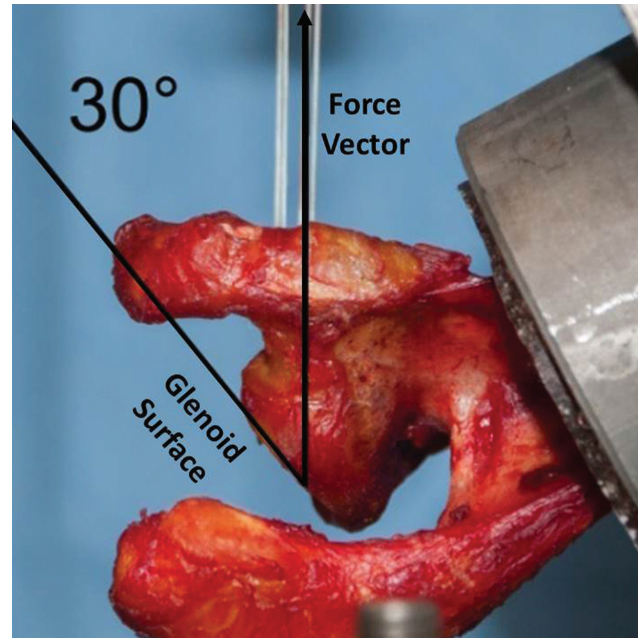

Figure 4. Testing setup: The specimen was fixed in a custom jig with the glenoid face oriented to create a loading vector 30° medial to the anterior-posterior plane.

data processing software (Microsoft Excel, Microsoft Inc, Redmond, Washington, USA) in which spatial deviations across the fracture at the 3 locations were calculated and averaged across the fracture.

Biomechanical Testing

Testing was performed with a dynamic tensile testing machine (ElectoPuls E10000, Instron, Norwood, Massachusetts, USA) after evaluating fracture reduction. The accuracy for this system has been calibrated and verified to be equal to or better than ±0.25% of the indicated force. An advanced video extensometer (AVE; Instron) with a manufacturer-reported accuracy of ±0.5% of the indicated displacement was used to measure displacement of the fracture throughout testing. Specimens were fixed in the dynamic tensile testing machine with a custom steel apparatus and aligned with a goniometer so that the load vector was 30° medial to the anterior-posterior plane (Figure 4). This loading direction was chosen to incorporate both the anteriorly directed forces of the capsule and labrum acting on the fragment as well as the medial force component of the humeral head compressing the glenoid. The 2 suture loops inserted into the bony fragment were passed around a 4.5 mm–diameter stainless steel rod, which was rigidly fixed to the actuator. This testing setup allowed for loads to be concentrated at the repair site. The measurement of displacement at the fracture site with the AVE prevented suture elongation from influencing displacement.

The loading protocol followed similar methodologies described for soft tissue Bankart repair of the labrum.[10,16,21,24] The specimens were preconditioned with sinusoidal cyclic

TABLE 1
Results After Single- and Double-Row Repairs of All 28 Specimens[a]

Specimen	BMD g/cm^2	Single-Row Repair: Side	Load to 1 mm, N	Load to 2 mm, N	Displ at 0 N, mm	Displ at 10 N, mm	Double-Row Repair: Side	Load to 1 mm, N	Load to 2 mm, N	Displ at 0 N, mm	Displ at 10 N, mm
Pair 1	0.345	Right	28.6	78.4	2.1	3.2	Left	93.3	142.1	1.0	1.1
Pair 2	0.388	Right	23.1	42.2	2.1	4.2	Left	50.8	83.5	1.5	2.2
Pair 3	0.431	Left	35.9	74.7	1.4	2.8	Right	64.6	114.1	0.7	1.1
Pair 4	0.434	Right	29.5	48.1	3.0	2.8	Left	39.2	76.4	0.7	1.5
Pair 5	0.450	Right	28.3	46.5	1.5	2.7	Left	40.2	73.5	0.8	1.0
Pair 6	0.452	Right	44.2	78.6	1.9	4.0	Left	61.0	127.1	1.8	2.3
Pair 7	0.468	Left	54.1	118.8	1.8	1.9	Right	80.0	151.2	2.4	2.7
Pair 8	0.502	Left	30.1	69.3	2.3	2.9	Right	39.0	43.4	1.0	1.3
Pair 9	0.515	Left	24.9	56.7	1.6	2.9	Right	44.7	76.8	1.2	1.3
Pair 10	0.525	Left	29.9	75.4	2.3	3.8	Right	64.6	88.7	1.4	1.3
Pair 11	0.557	Left	14.0	26.6	3.4	4.6	Right	62.3	69.6	0.3	0.5
Pair 12	0.590	Right	23.9	41.3	3.0	4.7	Left	72.0	110.7	0.9	1.8
Pair 13	0.605	Left	21.9	46.9	1.3	3.8	Right	90.1	100.1	1.8	2.0
Pair 14	0.608	Right	35.0	88.1	2.1	3.7	Left	47.0	64.9	0.6	2.7
Mean ± SD	0.491 ± 0.078	—	30.2 ± 9.9	63.7 ± 24.1	2.1 ± 0.6	3.4 ± 0.8	—	60.6 ± 18.3	94.4 ± 31.1	1.1 ± 0.6	1.6 ± 0.7

[a]BMD, bone mineral density; Displ, fracture displacement.

loading between 5 and 25 N for 10 cycles at 0.1 Hz and then loaded to failure at a displacement controlled rate of 5 mm/min. Loads (N) at 1 and 2 mm of fracture displacement were recorded. Previous biomechanical studies of soft tissue Bankart repairs have reported 2 mm as a clinically significant threshold for displacement.[10,16,21,24] Provencher et al[24] reported that displacements of 1 to 2 mm may compromise overall repair integrity. Additionally, studies have demonstrated that persistent articular displacement of 1 to 2 mm may lead to posttraumatic osteoarthritis and intra-articular fractures.[11,30]

Statistical Analysis

A power analysis was conducted after testing of the first 7 pairs, which determined that 14 matched pairs would be required to detect a 20% difference in force observed at 2 mm of fracture displacement with 80% power. Two-sample Wilcoxon signed-rank tests were used to compare the central tendency of relevant measurements between the 2 methods, and Kendall τ was used to assess correlation. A significance level of .05 was used, and all statistical analyses were performed using statistical analysis software (SPSS v 20, IBM Inc, Armonk, New York, USA).

RESULTS

Forces at 1 and 2 mm of fracture displacement as well as the distance between intra-articular surfaces of the fragment and glenoid are reported in Table 1. In accordance with the criteria of instability defined by Gerber and Nyffeler,[3] the superior-inferior length of the bony glenoid rim defect measured more than half of the maximum anterior-posterior diameter of the glenoid fossa for all specimens.

Loads at 1 mm and 2 mm of Fracture Displacement

The double-row technique required significantly higher forces to achieve fracture displacements of 1 mm (mean, 60.6 N; range, 39.0-93.3 N; P = .001) and 2 mm (mean, 94.4 N; range, 43.4-151.2 N; P = .004) than the single-row technique (1-mm displacement: mean, 30.2 N; range, 14.0-54.1 N and 2-mm displacement: mean, 63.7 N; range, 26.6-118.8 N) (Figure 5).

Fracture Reduction

Distance across the fracture was significantly lower after double-row repair for both the unloaded condition (mean, 1.1 mm; range, 0.3-2.4 mm; P = .005) and after application of a 10-N anterior force (mean, 1.6 mm; range, 0.5-2.7 mm; P = .001) relative to the single-row repair (unloaded: mean, 2.1 mm; range, 1.3-3.4 mm and 10-N load: mean, 3.4 mm; range, 1.9-4.7 mm) (Figure 6). There was a significant correlation between unloaded fracture reduction and load at 1-mm displacement (τ = –.33, P = .014) and between loaded fracture reduction and load at 1- and 2-mm displacement (τ = –.53, P < .001 and τ = –.30, P = .024, respectively).

DISCUSSION

This study showed improved fracture reduction and stability after double-row bony Bankart repair compared with single-row repair. Distance between the intra-articular fracture edges of the bony fragment and glenoid was significantly less after double-row repair compared with single-row repair. Additionally, the forces required to displace the repaired fracture 1 mm and 2 mm were significanly higher for the double-row technique compared with the

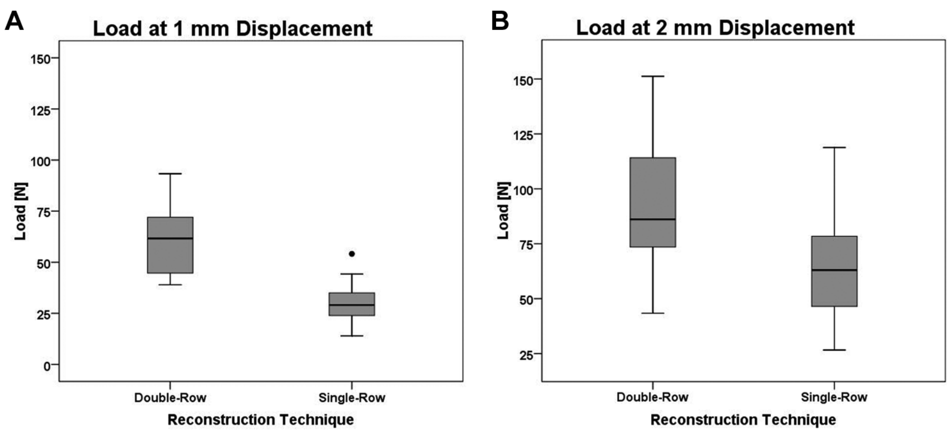

Figure 5. Box plots displaying loads to displace the fracture defect by (A) 1 mm and (B) 2 mm. The double-row repair required significantly higher loads to achieve 1 mm ($P = .001$) and 2 mm of displacement ($P = .004$) compared with the single-row repair.

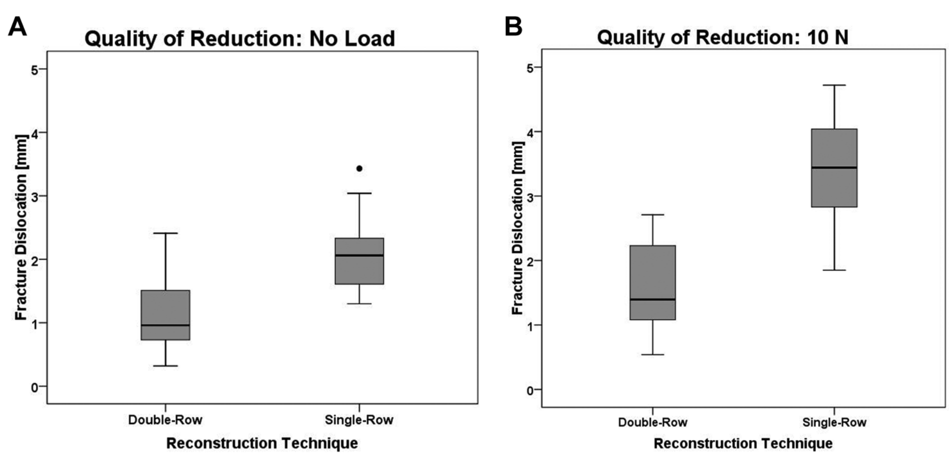

Figure 6. Box plots displaying fracture reduction by measuring displacement across the fracture for (A) unloaded and (B) 10-N anterior load conditions. Distance across the fracture was significantly less for the double-row repair for both unloaded ($P = .005$) and loaded ($P = .001$) conditions compared with the single-row repair.

single-row technique. The better quality of fracture reduction and improved stability observed in the present study after double-row repair compared with single-row repair at time zero may have clinical implications with regard to the postoperative treatment protocol, fracture healing, and potential for restoring a congruent articular surface.

Similar to the present study, Giles et al[4] found greater initial fragment stability after double-row versus single-row fixation. However, the authors found equivalent failure strengths for both techniques in a biomechanical model applying concentric and eccentric loads to the glenoid, imitating the glenohumeral joint with anterior displacement of the humeral head. The discrepancy between the present study's results and those found by Giles et al[4] may be explained by a difference in fracture size and the absence of induced labral avulsion. However, several studies have found significantly reduced dislocation resistance only when the superior-inferior length of the glenoid defect exceeded half of the maximum anterior-posterior diameter of the glenoid fossa or a defect area of more than 20% of the glenoid surface.[3,5,7,31] Yamamoto et al[31] reported no significant differences in stability after creating a 4-mm defect width in comparison to the intact glenoid, whereas a defect width of 6 mm, which was equal to 20% of the glenoid diameter, showed significantly reduced stability. Therefore, the results of the present study are applicable to clinically relevant–sized bony Bankart defects, which are large enough to produce significant instability. Additionally, in the study by Giles et al,[4] there was decreased mean anterior bony glenoid stability after single-row fixation, which was not statistically significant but may have been an underpowered test.

Clinical studies have evaluated arthroscopic single- and double-row repair techniques for acute bony Bankart lesions individually but not in a comparative fashion. Porcellini et al[22] reported that 92% of patients with acute lesions experienced restored shoulder stability and function after single-row repair and were able to return to their prior level of sport at a minimum of 2 years' follow-up. For chronic lesions treated with the same single-row technique, however, Porcellini et al[23] reported less favorable outcomes. In contrast, Sugaya et al[29] reported significantly improved clinical outcomes for patients with chronic lesions treated with single-row repair. Both acute and chronic lesions treated with the double-row repair technique experienced improved subjective scores and high patient satisfaction at a minimum of 2 years' follow-up as reported by Millett et al.[18] Recently, Jiang et al[8] reported primarily good and excellent clinical outcomes after single-row repair of 50 patients with chronic bony Bankart lesions. The authors reported a failure rate of 8%, which rose to a failure rate of 75% if the reconstructed size of the glenoid was below 80%. In 2 of those 3 patients, intraoperative fracture reduction was poor. Postoperative fracture displacement, measured with computed tomography (CT), was evaluated as fair or poor in 24% and 14% of patients, respectively. Therefore, particularly in large osseous Bankart lesions (>20%), optimal and stable fracture reduction seems to be an important factor for avoiding recurrent instability.

A recent study by Nakagawa et al[20] demonstrated that most shoulders with bony Bankart lesions undergo severe absorption of the bony fragment within 1 year after the initial injury. Bony fragment absorption could result in a loss of congruency with the fracture site and complicate operative fragment reduction. This observation may help explain the unfavorable results reported by Porcellini et al[23] for single-row repair of chronic lesions. In contrast, the favorable results reported by Millett et al[18] for double-row repair of chronic lesions may suggest that improved stability from double-row repair observed in the present study of simulated acute lesions may be transferrable to chronic situations. Clinical comparison studies of the 2 described techniques on long-term patient outcomes are still needed.

The authors acknowledge the limitations of the present study. Inherent to a time zero cadaveric study, no conclusions could be made about the effects of in vivo tissue remodeling on the strength and long-term outcome of the repairs. Second, the surrounding and supporting soft tissue of the glenohumeral joint is integral to native stability, and that tissue was removed in this study. Similarly, the effect of muscle function could not be tested in our cadaveric model. This study also used a single tensile force applied to the bony fragment along a vector 30° medial to the anterior-posterior plane, which is a simplified approximation of the complex physiological loading acting on the repair. Next, blinding of the investigator who conducted the displacement measurements was not possible, as the repair techniques differed visually. Therefore, a potential risk of bias cannot be excluded. Double-row repair involves placement of the lateral anchor through the glenoid articular cartilage, resulting in parts of the sutures resting on the glenoid face that presumably articulates with the humeral head. So far, no negative effects have been reported. However, midterm and long-term outcomes of patients utilizing this technique have yet to be reported. Additionally, because of the large osseous fragment size, 1 single- or 1 double-row repair may not provide sufficient stability. Additional double-row fixation at the upper and lower thirds of the fracture with crossed sutures could increase the construct stability and might be considered clinically. The senior author (P.J.M.) has indeed used these linked, bridging techniques on a number of more complex anterior glenoid fractures. Alternatively, in cases of large fracture sizes, screw osteosynthesis is a valid treatment option. Screw osteosynthesis can potentially be performed arthroscopically, but it is technically very difficult. Moreover, many bony Bankart fragments are too small or too comminuted, and these preclude screw fixation. However, based on this study, no conclusion can be made regarding biomechanical advantages and disadvantages between screw osteosynthesis versus arthroscopic suture anchor techniques. Similarly, no conclusion regarding the biomechanical properties of single- or double-row repairs in cases of comminuted fractures as well as of narrow sliver-type fractures can be made based on this study. Last, evaluation of fracture reduction by measuring fracture displacement was performed in the present study with a method not consistent with the CT measurements performed clinically; however, our method allowed for accurate and reproducible measurements of distance across the fracture in both an unloaded state and with tension applied to the fracture site. Our limitations highlight the potential for future research beyond the scope of this study within the growing area of osseous Bankart repairs.

Two millimeters of tissue displacement has been used as the "gold standard" for clinical failure for biomechanical studies relating to Bankart lesions.[10,15,16,19,21] Although it is likely that there exists some degree of displacement beyond which healing is not possible, there is currently little scientific evidence to support 2 mm as a failure. Provencher et al[24] reported that displacement of 1 mm to 2 mm may compromise overall repair integrity. Additionally, fracture displacement of less than 1 mm to 2 mm has been reported as necessary for successful healing of intra-articular fractures.[12] Therefore, based on the limited scientific evidence and for consistency with the prior literature, we recorded loads to achieve both 1 mm and 2 mm of displacement for surgeon interpretation. The precise failure mechanism was recorded, but because of varied and combined mechanisms, categorical failure mechanism definitions were not practical. In many cases, failure occurred via the repair sutures cutting through the labrum and bone, particularly at the fracture edges. Additionally, knot loosening occurred in several of the single-row repairs. These and other varying mechanisms led to impractical differentiation between the modes of failure. Therefore, the mode of failure was not recorded. Similarly, ultimate failure loads were not reported because of the excessive displacements that occurred before catastrophic failure, which would not be acceptable clinically. This study was strengthened by the use of matched-pair specimens with a lower age than is common in cadaveric studies (mean, 54.3 years; range, 44-64 years), representing the common patient population with acute bony Bankart lesions fairly well. Additionally, all specimens were scanned by DEXA to assess bone quality, and osteoporotic specimens were excluded.

CONCLUSION

The double-row fixation technique resulted in improved fracture reduction and superior stability at time zero in comparison to the single-row technique for repair of clinically relevant–sized, acute osseous Bankart lesions in a cadaveric model. This information may influence the surgical technique used to treat large osseous Bankart fractures and the postoperative rehabilitation protocols implemented when such repair techniques are used.

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