

Anatomic and Biomechanical Comparison of Traditional Bankart Repair With Bone Tunnels and Bankart Repair Utilizing Suture Anchors

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Background: Traditional Bankart repair using bone tunnels has a reported failure rate between 0% and 5% in long-term studies. Arthroscopic Bankart repair using suture anchors has become more popular; however, reported failure rates have been cited between 4% and 18%. There have been no satisfactory explanations for the differences in these outcomes.

Hypothesis: Bone tunnels will provide increased coverage of the native labral footprint and demonstrate greater load to failure and stiffness and decreased cyclic displacement in biomechanical testing.

Study Design: Controlled laboratory study.

Methods: Twenty-two fresh-frozen cadaveric shoulders were used. For footprint analysis, the labral footprint area was marked and measured using a Microscribe technique in 6 specimens. A 3-suture anchor repair was performed, and the area of the uncovered footprint was measured. This was repeated with traditional bone tunnel repair. For the biomechanical analysis, 8 paired specimens were randomly assigned to bone tunnel or suture anchor repair with the contralateral specimen assigned to the other technique. Each specimen underwent cyclic loading (5-25 N, 1 Hz, 100 cycles) and load to failure (15 mm/min). Displacement was measured using a digitized video recording system.

Results: Bankart repair with bone tunnels provided significantly more coverage of the native labral footprint than repair with suture anchors (100% vs 27%, $P < .001$). Repair with bone tunnels (21.9 ± 8.7 N/mm) showed significantly greater stiffness than suture anchor repair (17.1 ± 3.5 N/mm, $P = .032$). Mean load to failure and gap formation after cyclic loading were not statistically different between bone tunnel (259 ± 76.8 N, 0.209 ± 0.064 mm) and suture anchor repairs (221.5 ± 59.0 N [$P = .071$], 0.161 ± 0.51 mm [$P = .100$]).

Conclusion: Bankart repair with bone tunnels completely covered the footprint anatomy while suture anchor repair covered less than 30% of the native footprint. Repair using bone tunnels resulted in significantly greater stiffness than repair with suture anchors. Load to failure and gap formation were not significantly different.

Keywords: shoulder instability; Bankart repair; bone tunnels; suture anchors; footprint

Recurrent anterior shoulder instability is a common condition usually associated with an avulsion of the anterior-inferior labrum, also known as a Bankart lesion. Rowe et al¹⁸ popularized Bankart's open surgical technique using

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suture and bone tunnels in the anterior glenoid to repair the labrum to bone. Hovelius et al^{7,8} reported redislocation rates of 0% and 4% in 2 studies with long-term follow-up of longer than 10 years using this technique. Additional studies have demonstrated similarly low failure rates of 2% to 5%.^{13,18,21}

The use of suture anchors to repair the labrum to the glenoid was introduced in the early 1990s to reduce the time and difficulty associated with creating osseous tunnels. Arthroscopic stabilization has been greatly facilitated by suture anchor techniques and has become the preferred method of treatment for most orthopaedic surgeons. However, the mid- to long-term failure rates for modern arthroscopic Bankart repair with suture anchors have been reported to be from 4% to 18% in studies published in the past decade.^{4,5,11,22,23} When comparing open Bankart repair techniques, Tamai et al²¹ found that repair

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with bone tunnels has resulted in significantly lower dislocation rates compared with a repair with suture anchors. At 17-year follow-up, Hovelius et al⁷ showed a difference in revision for instability of 0% for open bone tunnel Bankart repair versus 7% for open suture anchor repair. Additional studies have shown failure rates of 4% to 9% with open Bankart repair performed with suture anchors.^{2,14} Some of these failures are secondary to unrecognized bone loss or residual capsular laxity.²⁰ However, several studies on revision Bankart repair document a retear of the prior labral repair after a traumatic event as the cause of recurrent instability.^{6,19} To date, no satisfactory explanation has been given for these differences in outcomes.

Understanding the footprint coverage of different repair techniques has led to improved restoration of normal anatomy in rotator cuff repair surgery. Cadaveric studies of the rotator cuff show that a transosseous-equivalent rotator cuff repair resulted in increased footprint coverage and provided a stronger repair compared with a single-row technique using suture anchors.^{15,16} Several studies have investigated the anterior inferior labral footprint.^{1,9} Ahmad et al¹ showed that a double-row repair with suture anchors better restores the native insertional footprint compared with a single-row repair. Kim et al⁹ showed that a Cassiopeia double-row repair increases the pressurized contact area over the footprint versus a single-row repair. It has been hypothesized that increased coverage of the native footprint in the rotator cuff would allow for greater healing potential, which could be hypothesized for labral repairs as well.¹⁵ To date, no study has directly investigated the anatomic and biomechanical differences between Bankart repair with bone tunnels and Bankart repair with suture anchors.

This study had 2 objectives. First, we wanted to characterize the native labral footprint and then compare the footprint coverage of Bankart repairs using classic suture-through-bone tunnel fixation and suture anchor fixation. Second, we sought to compare the biomechanical behavior of the 2 repairs in a cadaveric model. We hypothesized that the bone tunnel technique provides more coverage of the native labral footprint compared with suture anchors. Additionally, we hypothesized that bone tunnel repair would result in greater load to failure and stiffness and decreased gap formation between the labrum and glenoid as compared with suture anchor repair in mechanical testing.

METHODS

Specimen Preparation

This cadaveric study was exempt from institutional review board approval at our institution. A total of 22 fresh-frozen human cadaveric shoulders were used: 6 shoulders were used for footprint analysis, and 8 matched pairs were used for biomechanical analysis.

In preparation for the studies, each specimen was thawed for 24 hours in a refrigerator prior to dissection. All soft tissues were carefully dissected from the specimen leaving the scapula, labrum, and glenohumeral capsule intact. Any specimen with obvious bone defects, significant



Figure 1. The area of the labral footprint has been colored with a permanent marker. The footprint can be noted to be wider at the 4 to 6 o'clock positions when compared with the 1 to 3 o'clock positions.

degenerative changes, or labral tears was discarded. The anterior labrum and capsule were sharply dissected off the glenoid, taking careful note of the labral attachment from the 1 o'clock to the 6 o'clock positions. The entire footprint was immediately colored with a fine-tip permanent marker by the same investigator for later analysis (Figure 1). The specimen was then kept moist with normal saline throughout the entire process. The scapular body was potted in epoxy for later mechanical analysis.

Bone mineral density was obtained for all specimens using a Lunar DPI XQ dexascan (GE Healthcare). The region of interest for bone mineral density scanning was the anterior-inferior aspect of the glenoid.

Footprint Analysis

The area of the exposed footprint was then measured using the Microscribe 3D digitizer (Immersion Corp). Each

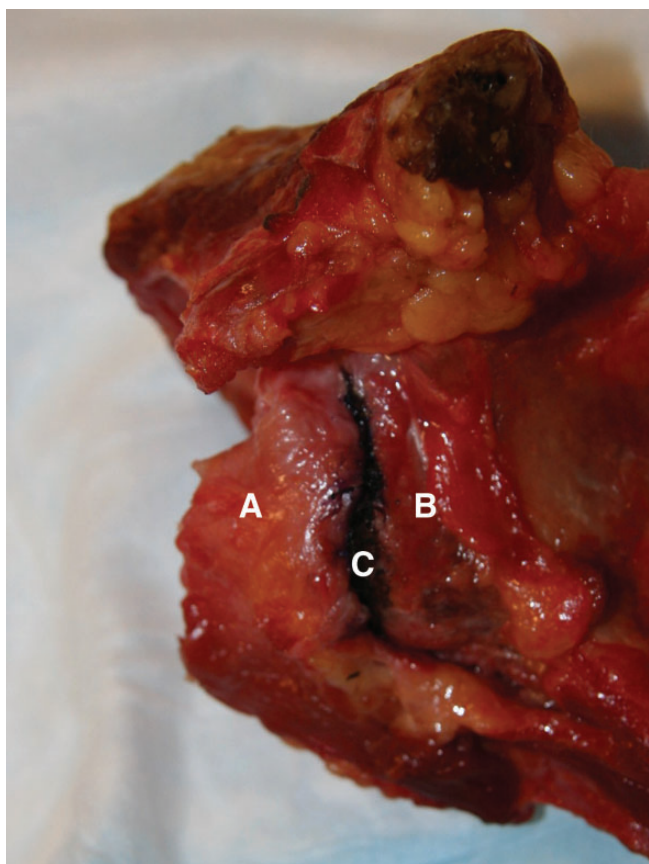


Figure 2. Labral repair with 3 suture anchors at the 2:30, 4, and 5 o'clock positions. The darkly colored portion of the glenoid (C) represents the area of the labral footprint that is not covered by the 3-anchor repair. (A) Reflected capsule and (B) medial glenoid are annotated.

measurement was performed a total of 4 times for each specimen and the surface area was calculated.

Suture anchor repair was performed using 3.0-mm suture anchors (Biosuturetak; Arthrex) single-loaded with No. 2 FiberWire (Arthrex). Suture anchors were placed at the 2:30, 4, and 5 o'clock positions according to the manufacturer's directions at the articular margin of the glenoid. One limb of each suture was passed through the capsule, 1 cm lateral to the labrum. A simple-stitch configuration was used to secure the repair with reverse half-hitches on alternating posts. A simple stitch suture configuration was chosen to be consistent with the stitch configuration necessary for bone tunnel repair.

After performing the repairs, the uncovered area of the footprint medial to the labrum on the glenoid was measured for each specimen using the Microscribe 3D digitizer. Measurements were repeated 4 times for each specimen and the area of the exposed labral footprint averaged (Figure 2).

The suture loops were then cut and the labrum carefully removed. Bone tunnels were created at the medial and lateral margins of the footprint using a drill through the glenoid, similar to the tunnels described by Rowe et al,¹⁸ at the 2:30, 4, and 5 o'clock positions. A 1.5-mm drill was used

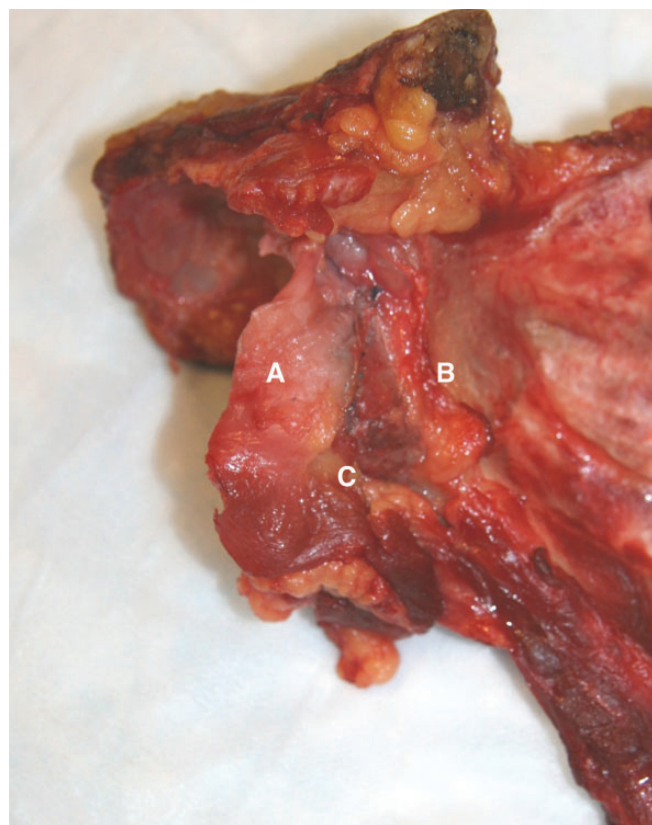


Figure 3. Labral repair with 3 bone tunnels at the 2:30, 4, and 5 o'clock positions. No colored native labral footprint can still be visualized after repair (C), indicating that the entire footprint was covered by the bone tunnel technique. This was consistent in each specimen. (A) Reflected capsule and (B) medial glenoid are annotated.

to create 2 converging tunnels instead of the traditional Bankart instruments to avoid bone fracture. A No. 2 FiberWire suture was passed through each hole and passed through the capsule and labrum in the same configuration as used with the suture anchor repair. The uncovered area of the footprint was again measured for each specimen using the Microscribe 3D digitizer as described (Figure 3).

The percentage of footprint coverage was calculated for each specimen and repair using the following formula: $[native\ footprint\ (mm^2) - exposed\ footprint\ (mm^2) / native\ footprint\ (mm^2)] \times 100$. The percentage of coverage was averaged for each repair.

Biomechanical Analysis

One shoulder of each of the 8 matched pairs was randomly allocated to either a suture anchor repair or a bone tunnel repair. The contralateral specimen received the other repair. The anchors or tunnels used for each repair were placed at the 3:30 and 5 o'clock positions as has been previously published by Nho et al¹² to study labral repair. The scapula was secured at the base of a servo-hydraulic testing machine (MTS Systems Corp) and the capsule was attached



Figure 4. The specimen loaded onto the materials testing apparatus. Tracking markers are placed on the glenoid and capsule for displacement measurements during mechanical testing.

to the load cell using a specially designed soft tissue cryo-clamp 1 cm from the labral repair.

The specimen was oriented such that the vector of force was directed in an anteroinferior direction, 0° from the glenoid surface, as described by Nho et al¹² as a “worst-case scenario” (Figure 4). A 5-N preload was applied. Tracking markers were placed on the glenoid and capsule to monitor displacement at the repair site. A caliper was used to ensure accurate placement of the capsular marker centrally and 5 mm away from the site of repair (Figure 4). A digital video system was used to track displacement of the markers throughout testing with MaxTRAQ 2D (Innovision Systems Inc) and cyclic displacement evaluated as described by Kim et al,¹⁰ with an accuracy of 0.5% to 1% of the field of view.

The following testing conditions were used, as described by Nho et al¹²: (1) preload at 5 N for 2 minutes, (2) cyclical loading at 100 cycles from 5 to 25 N at 1 Hz, and (3) load to failure at 15 mm/min. Gap formation between the labrum and glenoid was calculated at the 100th cycle. Load to failure and mode of failure were recorded. Construct stiffness was calculated from the load-displacement data.

Statistical Analysis

An a priori power analysis was performed. A total of 12 shoulders, 6 in each group, would be required to detect a 20% difference in stiffness between the 2 groups using means and standard deviations as determined by Nho et al.¹² Alpha was set at 0.05 and beta at 0.2 for a power of 80%. An unpaired *t* test was used to analyze our 2 groups, with statistical significance set at $P < .05$.

RESULTS

The mean area of the native footprint was $376 \pm 83 \text{ mm}^2$. The uncovered labral footprint with suture anchors was $275 \pm 54 \text{ mm}^2$ as compared with $0 \pm 0 \text{ mm}^2$ for the bone tunnel repairs ($P < .001$) (Table 1). This corresponded to 27% footprint

TABLE 1
Area of Native Footprint and Uncovered Footprints After Bone Tunnel and Suture Anchor Repairs^a

	Bone Tunnel Repair	Suture Anchor Repair
Native footprint, mm^2	375.7 ± 82.7	375.7 ± 82.7
Uncovered footprint after repair, mm^2	0 ± 0	275.4 ± 53.6
% covered	100	27

^aResults are reported as mean \pm SD unless otherwise indicated.

TABLE 2
Comparison of Ultimate Load to Failure, Stiffness, and Gap Formation (Cyclic Displacement) Between Bone Tunnel and Suture Anchor Repair^a

	Bone Tunnel Repair	Suture Anchor Repair	<i>P</i> Value
Ultimate load to failure, N	259.3 ± 76.8	221.5 ± 59.0	.071
Stiffness, N/mm	21.9 ± 8.7	17.1 ± 3.5	.032 ^b
Cyclic displacement, mm	0.21 ± 0.06	0.16 ± 0.05	.100

^aResults are reported as mean \pm SD.

^bBone tunnel repair was shown to have significantly greater stiffness than suture anchor repair.

coverage for the suture anchor group and 100% coverage with the bone tunnel group. There were no bone tunnel repairs that displayed any uncovered footprint (Figure 3B).

For biomechanical testing, the mean age of the specimens was 61.0 years. The 8 matched pairs were from 2 males and 6 females. The mean bone mineral densities for the suture anchor group ($0.43 \pm 0.24 \text{ g/cm}^2$) and the bone tunnel group ($0.42 \pm 0.21 \text{ g/cm}^2$) were not significantly different ($P = .43$).

Repair with bone tunnels ($21.9 \pm 8.7 \text{ N/mm}$) showed significantly greater stiffness than suture anchor repair ($17.1 \pm 3.5 \text{ N/mm}$, $P = .032$). Mean load to failure was not significantly different between bone tunnel ($259.3 \pm 76.8 \text{ N}$) and suture anchor repairs ($221.5 \pm 59.0 \text{ N}$, $P = .071$). Gap formation at the repair site was not statistically different, with bone tunnels having $0.209 \pm 0.064 \text{ mm}$ of displacement after cyclic loading as compared with $0.16 \pm 0.05 \text{ mm}$ for suture anchors ($P = .100$) (Table 2).

Modes of failure for the 8 bone tunnel repairs included bone failure or suture pull through the bone in 6 specimens and suture pull through the capsule in 2 specimens. In the suture anchor group, 4 specimens failed by anchor pull-out from the bone, soft tissue failure occurred in 2 specimens, and suture breakage in 2 specimens (Table 3).

DISCUSSION

To the best of our knowledge, this study presents the first comparison of the footprint and biomechanical properties of classic Bankart repair using bone tunnels and repair using suture anchors. In this study, we demonstrated that tunnel repair resulted in 100% footprint coverage compared

TABLE 3
Modes of Failure for Bone Tunnel and Suture Anchor Repair in Load-to-Failure Testing

Mode of Failure	
Bone Tunnel Repair (n = 8)	Suture Anchor Repair (n = 8)
6 bone	4 bone
2 capsular soft tissue	2 capsular soft tissue
	1 midsuture break
	1 suture break off anchor

with an average of 27% footprint coverage with repair with suture anchors. The design of the bone tunnels, with the entrance and exit point for each tunnel just beyond the dimensions of the native footprint, resulted in no visible uncovered footprint between the 2 and 6 o'clock positions. Our findings are in agreement with those of Ahmad et al,¹ who investigated the footprint coverage of a single row versus a double row of suture anchors for Bankart repair. They found that a single-row repair resulted in 42% coverage while double-row repair resulted in 86% coverage of the native footprint. The slightly lower number found in this study may be due to fewer suture anchors being used over a smaller interval. Ahmad et al¹ utilized 4 suture anchors from the 2:30 to 5:30 positions, while the present study used 3 anchors from the 2:30 to 5 o'clock positions. Another possible explanation for this finding is that suture anchors in this study were placed as close to the border of the articular margin as possible rather than in the center of the native footprint, which could in turn result in greater footprint coverage. Nonetheless, in both studies, less than half of the native footprint was covered.

Bone tunnel repair was found to result in significantly greater stiffness as compared with suture anchor repair. There was a slight trend toward greater load to failure for bone tunnel repair, and conversely, a trend toward decreased displacement after cyclic loading for suture anchor repair; however, neither of these results was significant. Given that this is a biomechanical study that isolates the repair between the capsulolabral complex and the glenoid and ignores other soft tissues, we cannot directly apply these values to a clinical model. Nonetheless, these data suggest that at time zero, the stiffness provided by a bone tunnel repair may be greater than that of suture anchors. However, biomechanical markers that may be more applicable to failure in a clinical model, such as ultimate load to failure and displacement with repetitive loading, showed no significant differences.

This study showed a significant portion of failures for both repair methods occurring due to bone failure. In the biomechanical analysis by Nho et al¹² of suture anchors for Bankart repair, 47% of failures occurred by anchor pull-out, which is comparable to the 50% noted in the present study's suture anchor group. There were slightly more failures through the bone in our bone tunnel group, resulting in an overall bone failure rate of 62.5%. This could be due to the advanced age of the specimens used for this study, which is older than the typical patient for

which Bankart repairs are performed. In a clinical scenario, the high number of failures through bone tunnels could be significant, as this may result in greater bone loss than suture anchor pull-out. This could complicate a later revision procedure depending on the amount of bone loss sustained.

Fixation of the labrum occurred at 3 sites in the footprint analysis portion of the study as opposed to 2 sites for the biomechanical portion. Clinically, fewer than 3 sites of repair have been associated with recurrence of instability.¹⁷ Therefore, it was considered to be most accurate to assess the footprint coverage as it would be seen clinically with a 3-point repair. Two points of repair fixation were chosen instead of 3 for the biomechanical testing because the testing apparatus applies force along a single vector line. This allows equal stresses to be applied to each point of the repair when 2 points are used; however, due to the rounded anatomy of the glenoid rim, 3 repair points would not allow for a single vector of force to equally stress each point of the repair. This would place unequally high forces on certain points of the repair, possibly causing earlier failure at these sites despite most of the repair remaining intact. Additionally, the anterior band of the inferior glenohumeral ligament is reported to be the strongest portion of the inferior glenohumeral ligament complex in preventing anterior and inferior translation of the humerus.³ Its anatomic area on the clock face is between the 3 and 5 o'clock positions.³ Therefore, the 2 points of fixation were predominantly centered over the most biomechanically important part of the anteroinferior capsulolabral complex for testing. This model of using 2 repair sites for biomechanical testing of Bankart lesions has been utilized in previous literature.¹²

This study had multiple strengths. Matched pairs were used for biomechanical comparison of the different repairs. This resulted in no differences in age or bone mineral density and likely controlled for differences in the capsular strength and laxity between different cadavers. For footprint analysis, the same specimens were used for each repair to eliminate any confounding of different footprint sizes between specimens. Additionally, the same fellowship-trained orthopaedic surgeon performed all repairs with anchors and tunnels in the same positions. Finally, the biomechanical protocol has been described previously and included multiple measures to assess strength of repair, including stiffness, displacement with cyclic loading, and ultimate load to failure.

This study does have certain limitations. First of all, as a cadaveric study, these results do not take into account soft tissue healing and scar generation that may help to stabilize a Bankart repair in vivo in the mid to long term, when many recurrent instability events occur. However, this study sought only to determine the initial strength provided by the repair alone, which likely applies more to failures in the immediate postoperative period. In addition, there are likely a number of suture anchor configurations that can be used for Bankart repair, and this study only addresses 1 configuration. Second, the uncovered footprint area after each repair was measured and used to infer overall footprint coverage. The study did not measure contact at

points under the repair; therefore, it is possible that a portion of the footprint was covered by the labrum but without sufficient contact to induce healing in a clinical setting. Nonetheless, using a Microscribe measuring device to infer footprint coverage has been accepted.¹ The footprint was marked with a fine-tip marker by the same observer, which can be a subjective measurement. However, the footprint was well distinguished as the border of the thick labrum compared with the articular cartilage and the thin periosteum overlying the glenoid neck. Additionally, the differences in coverage percentage were so dramatic that a small variation in labral measurement should not have affected our results. Third, this study looked only at the strength of the repairs against 1 vector of force. We utilized an anteroinferior force vector perpendicular to the lesion and its repair sites, which has been described as a “worst-case scenario” force by Nho et al.¹² Fourth, the cadavers used for this study had a mean age of 61 years, which is significantly older than the typical patient treated for instability. As these specimens likely had a lower bone density than would be expected in a younger specimen, one might expect that failures through the bone might be less likely to occur in a younger, more typical patient population for Bankart repair. However, as the samples were all matched pairs with no differences in bone density, it would be unlikely that this would make the comparisons between the groups less valid.

Making clinical inferences from the cadaveric studies can be difficult, and this study certainly does not advocate abandoning suture anchor Bankart repair as it boasts a number of benefits over bone tunnel repair. In addition, it is unknown whether increased footprint coverage may improve healing or which portion of the footprint is most important to restore. However, this study does raise the question of whether increased coverage of the labral footprint could contribute to the lower failure rate reported in the literature for open repair with bone tunnels. Additional differences could include improved capsular shift and greater scar formation with an open procedure. Further studies investigating how increased footprint coverage can influence recurrence rate in Bankart repair will be important to clarify this relationship.

This study presents the first footprint and biomechanical comparison between bone tunnels and suture anchors for repair of Bankart lesions. Bankart repair with bone tunnels completely restored the footprint anatomy while suture anchor repair covered less than 30% of the native footprint. Repair using bone tunnels resulted in significantly greater stiffness than repair with suture anchors, but load to failure and gap formation were not significantly different.

REFERENCES

- Ahmad CS, Galano GJ, Vorys GC, Covey AS, Gardner TR, Levine WN. Evaluation of glenoid capsulolabral complex insertional anatomy and restoration with single- and double-row capsulolabral repairs. *J Shoulder Elbow Surg.* 2009;18:948-954.
- Berendes TD, Wolterbeek R, Pilot P, Verburg H, te Slaa RL. The open modified Bankart procedure: outcome at follow-up of 10 to 15 years. *J Bone Joint Surg Br.* 2007;89:1064-1068.
- Burkart AC, Debski RE. Anatomy and function of the glenohumeral ligaments in anterior shoulder instability. *Clin Orthop Relat Res.* 2002;400:32-39.
- Carreira DS, Mazzocca AD, Oryhon J, Brown FM, Hayden JK, Romeo AA. A prospective outcome evaluation of arthroscopic Bankart repairs: a minimum of 2-year follow-up. *Am J Sports Med.* 2006;34:771-777.
- Castagna A, Markopoulos N, Conti M, Delle Rose G, Papadaku E, Garofalo R. Arthroscopic Bankart suture-anchor repair: radiologic and clinical outcome at minimum 10 years of follow-up. *Am J Sports Med.* 2010;38:2012-2016.
- Cho NS, Yi JW, Lee BG, Rhee YG. Revision open Bankart surgery after arthroscopic repair for traumatic anterior shoulder instability. *Am J Sports Med.* 2009;37:2158-2164.
- Hovellius L, Vikersfors O, Olofsson A, Svensson O, Rahme H. Bristow-Latarjet and Bankart: a comparative study of shoulder stabilization in 185 shoulders during a seventeen-year follow-up. *J Shoulder Elbow Surg.* 2011;20:1095-1101.
- Hovellius LK, Sanstrom BC, Rosmark DL, Saebo M, Sundgren KH, Malmqvist BG. Long-term results with the Bankart and Bristow-Latarjet procedures: recurrent shoulder instability and arthropathy. *J Shoulder Elbow Surg.* 2001;10:445-452.
- Kim D, Yoon Y, Chung H. Single-row versus double-row capsulolabral repair: a comparative evaluation of contact pressure and surface area in the capsulolabral complex-glenoid bone interface. *Am J Sports Med.* 2011;39:1500-1506.
- Kim DH, ElAttrache NS, Tibone JE, et al. Biomechanical comparison of a single-row versus double-row suture anchor technique for rotator cuff repair. *Am J Sports Med.* 2006;34:407-414.
- Marquardt B, Witt KA, Liem D, Steinbeck J, Potzi W. Arthroscopic Bankart repair in traumatic anterior shoulder instability using a suture anchor technique. *Arthroscopy.* 2006;22:931-936.
- Nho SJ, Frank RM, Van Thiel GS, et al. A biomechanical analysis of anterior Bankart repair using suture anchors. *Am J Sports Med.* 2010;38:1405-1412.
- Ogawa K, Yoshida A, Matsumoto H, Takeda T. Outcome of the open Bankart procedure for shoulder instability and development of osteoarthritis: a 5- to 20-year follow-up study. *Am J Sports Med.* 2010;38:1549-1557.
- Pagnani MD, Dome DC. Surgical treatment of shoulder instability in American football players. *J Bone Joint Surg.* 2002;84:711-715.
- Park MC, ElAttrache NS, Tibone JE, Ahmad CS, Jun B, Lee TQ. Part I: footprint contact characteristics for transosseous-equivalent rotator cuff repair technique compared with double-row repair technique. *J Shoulder Elbow Surg.* 2007;16:461-468.
- Park MC, Tibone JE, ElAttrache NS, Ahmad CS, Jun B, Lee TQ. Part II: biomechanical assessment for a footprint-restoring transosseous-equivalent rotator cuff repair technique compared with a double-row repair technique. *J Shoulder Elbow Surg.* 2007;16:469-476.
- Randelli P, Ragone V, Carminati S, Cabitza P. Risk factors for recurrence of Bankart repair: a systematic review. *Knee Surg Sport Traumatol Arthrosc.* 2012;20:2129-2138.
- Rowe C, Patel D, Southmayd WW. The Bankart procedure. A long term end-result study. *J Bone Joint Surg Am.* 1978;60:1-16.
- Rowe CR, Zarins B, Ciuillo JV. Recurrent anterior dislocation of the shoulder after surgical repair: apparent causes of failure and treatment. *J Bone Joint Surg Am.* 1984;66:159-168.
- Shaha JS, Cook JB, Song DJ, et al. Redefining critical bone loss in shoulder instability: functional outcomes worsen with subcritical bone loss. *Am J Sports Med.* 2015;43:1719-1725.
- Tamai K, Higashi A, Tanube T, Hamada J. Recurrences after the open Bankart repair: a potential risk with use of suture anchors. *J Shoulder Elbow Surg.* 1999;8:37-41.
- Tan CK, Guisasola I, Machani B, et al. Arthroscopic stabilization of the shoulder: a prospective randomized study of absorbable versus non-absorbable suture anchors. *Arthroscopy.* 2006;22:716-720.
- Voos JE, Livermore RW, Feeley BT, et al; HSS Sports Medicine Service. Prospective evaluation of arthroscopic Bankart repairs for anterior instability. *Am J Sports Med.* 2010;38:302-307.