Short-term outcomes after knotless all-suture anchor Bankart repair

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Obere Extremität
Schulter · Ellenbogen

ISSN 1862-6599

Obere Extremität
DOI 10.1007/s11678-020-00616-7

Springer

Original Contribution

Obere Extremität
https://doi.org/10.1007/s11678-020-00616-7
Received: 19 September 2020
Accepted: 6 November 2020

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Bankart lesions can be addressed with numerous surgical techniques. To date, a variety of suture anchor designs such as bioabsorbable anchors made of polyglycolic acid, combinations of bioabsorbable polymers with osteoinductive bioceramic (biocomposite anchors), and polyetheretherketone (PEEK) material have replaced metallic tacks and anchors [7, 15]. To overcome some of the disadvantages of solid suture anchors, such as anchor migration and glenohumeral cartilage damage [11, 20], nonabsorbable all-suture or "soft" anchors with small diameters were developed [9].

Background

Arthroscopic treatment has become the gold standard therapy for symptomatic anterior shoulder instability, offering good clinical results and high return-to-sport rates [14, 25]. One remaining area of concern is the high recurrence rate of up to 25% that was found to be associated with younger age and the number of anchors used for the fixation of the capsulolabral structures [1, 3, 17, 19, 22]. However, placing multiple glenoid anchors to provide better stability can result in "postage stamp" fractures of the anterior glenoid rim [24].

Recently, nonabsorbable all-suture or "soft" anchors have entered the market. Multiple points of soft tissue fixation are possible thanks to the small diameter of the anchors [8, 9, 12]. All-suture anchors are also considered to preserve glenoid bone stock [9, 12]. Other potential advantages are application through curved guides [12], facilitated revision surgery due to little bone loss [2, 8], and low radiographic artifacts in the postoperative setting [2, 23]. Rigidity-related complications such as anchor migration and glenohumeral cartilage damage, which are associated with solid anchors [11, 20], are minimized [2, 9, 12]. Biomechanical studies demonstrated high failure loads [4] and similar ultimate load-to-failure rates compared with classic solid anchors [8, 13]. However, to date, few studies have reported on the clinical outcome after the use of all-suture anchors for glenohumeral instability [2, 9, 23].

Therefore, the purpose of this study was to report on clinical short-term outcomes after arthroscopic knotless all-suture Bankart repair in patients with anterior shoulder instability. It is hypothesized that this technique provides good functional outcomes with low re-dislocation and revision rates.

Study design and investigation methods

Study design

Institutional review board approval was obtained prior to data collection (VHH 2020-20). The study was conducted in accordance with the ethical principles that are reflected in the Declaration of Helsinki. A retrospective analysis of prospectively collected data was performed of patients with symptomatic unidirectional anterior shoulder instability who underwent knotless, all-suture anchor Bankart repair between September 2017 and June 2019 and were at least 1 year out from surgery. Patients were excluded if they had:

1. A Bankart repair with solid anchors
2. Bony Bankart lesions
3. Neurological disorders
4. Concomitant anterior labroligamentous periosteal sleeve avulsions (ALPSA)
5. Humeral avulsions of the glenohumeral ligaments (HAGL)
6. Rotator cuff lesions that necessitated surgical repair

If surgery was performed within 2 weeks (≤14 days) of initial shoulder dislocation, treatment was defined as acute and if surgery was performed after 2 weeks (>14 days), treatment was defined as chronic. All surgeries were performed by one highly experienced shoulder specialist. Prior to surgery, all patients underwent standard radiographic imaging and magnetic resonance imaging (MRI) to verify the Bankart lesion and to exclude concomitant injuries.

Published online: 27 November 2020

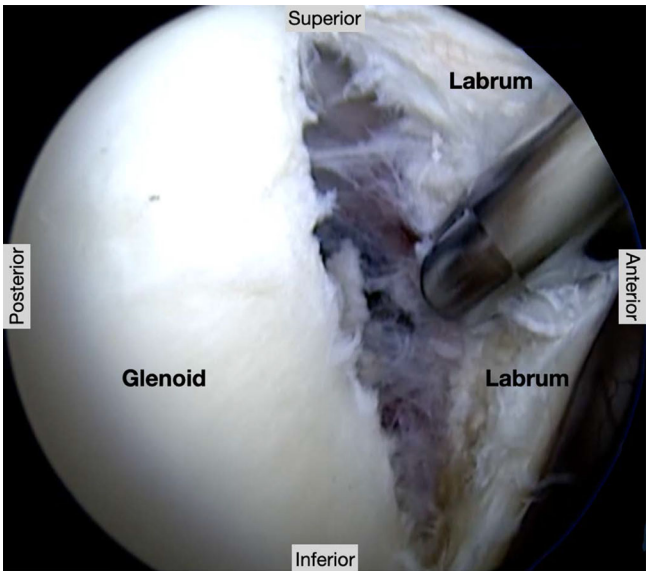

Fig. 1 ▲ Arthroscopic image of a right shoulder demonstrating thorough mobilization of the capsulolabral complex

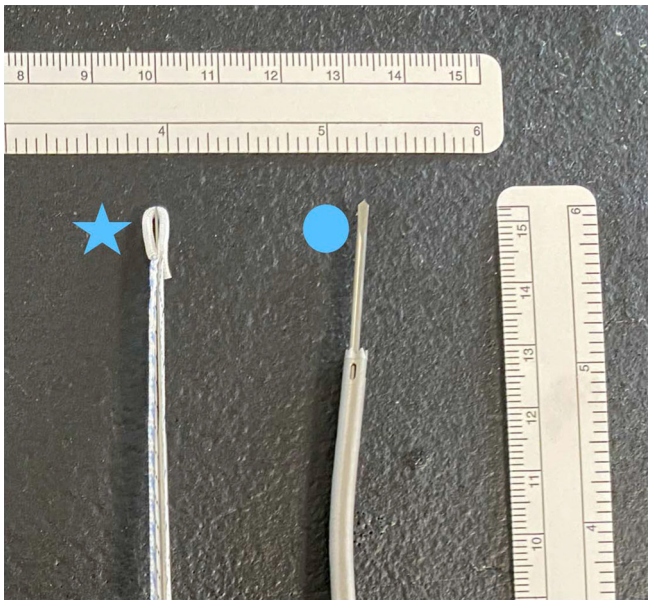

Fig. 2 ▲ Image of the anchor and drill guide/drill combination used in this study. *Star*: 1.8-mm knotless all-suture anchor; *circle*: curved drill guide with drill

Operative procedure

The patient was placed into the beach chair position. A standard posterior viewing portal was created, and a diagnostic arthroscopy was performed. Two working portals were established: The anterosuperior portal was placed high into the rotator interval just underneath the long biceps tendon and the anteroinferior portal was placed just above the border of the subscapularis tendon. To avoid soft tissue bridges, both portals were secured with cannulas: An 8.25-mm cannula was used for the anteroinferior portal in order to accommodate a 25°or 45° curved suture-passing instrument (SutureLasso, Arthrex, Naples, CA, USA). A meticulous mobilization of the capsulolabral complex was considered essential for the later repair and was performed with a combination of a 6-mm curved blade periosteal elevator (Arthrex), an arthroscopic shaver (Arthrex), and an electrocautery device (Arthrex; ◘ **Fig. 1**). The glenoid neck was debrided with the arthroscopic shaver to create a bleeding bone bed and facilitate healing. A 70° scope was used to improve visualization. The repair was performed with at least three, preferably four to five, knotless 1.8-mm all-suture anchors (1.8 mm Knotless FiberTak, Arthrex) from inferior to superior direction depending on the extent of the tear and required stability (◘ **Fig. 2**). For right shoulders, the anchors were typically placed at the 5:30, 4:00, 3:30, and 2:00 o'clock position with an average anchor distance of 7 mm. In preparation for the first anchor at the 5:30 o'clock position, a curved drill guide was inserted through the anteroinferior portal and a drill hole was created on the anteroinferior glenoid rim. The first all-suture anchor was placed through the drill guide into the previously drilled hole and was then impacted into the bone. To activate the anchor expansion process, the connected three suture limbs of the anchor were pulled gently according to the manufacturer's instructions. The repair suture (white-blue) was then separated from the two shuttling suture limbs (white-black) and retrieved through the anterosuperior portal using an atraumatic arthroscopic grasping instrument. A 25° angulated shuttle device was passed through the anteroinferior 8.25-mm cannula to load the capsulolabral tissue and shift it from lateral to medial and from inferior to superior, exiting just inferior of the anchor position. The nitinol wire inside the shuttling device was retrieved through the anterosuperior portal. The repair suture was placed into the loop of the nitinol wire and retrieved back through the anteroinferior portal. One shuttling suture has a looped end in which the repair suture was threaded. The non-looped shuttling suture was then pulled gently until the repair suture passed back through the anteroinferior portal and into the self-locking mechanism of the anchor. The suture was cut flush with a cutting device, resulting in a knotless all-suture construct (◘ **Fig. 3**).

Postoperative rehabilitation

An abduction sling was applied for 4 weeks and external rotation was limited to 30°. After 4 weeks the sling was removed, and patients were cleared for full, unrestricted passive motion and active range of motion. Muscular strengthening with isometrics was initiated and was progressed to closed-chain exercises. After 5 weeks, open-chain strengthening exercises were escalated. Return to full mobility was typically achieved 4 months postoperatively.

Outcome parameters

Demographic data were obtained from the patients' medical records and included age, sex, number of prior dis-

Abstract · Zusammenfassung

Obere Extremität https://doi.org/10.1007/s11678-020-00616-7

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Abstract

Background. Arthroscopic Bankart repair techniques have evolved from solid anchors, with potential disadvantages such as glenoid rim fractures, anchor migration, and glenohumeral cartilage damage, to bone stock-preserving "soft" all-suture anchors.
Objectives. The aim of this study was to report on clinical short-term outcomes after arthroscopic knotless all-suture Bankart repair in patients with anterior shoulder instability. It is hypothesized that this technique provides good functional outcomes with low rates of re-dislocation and revision.
Patients and methods. A total of 39 patients with an average age of 28.8 (SD ± 10.5) years were included. The clinical outcome was evaluated at a minimum follow-up of 12 months in 28 of 39 (72%) patients. The American Shoulder and Elbow Surgeons Score (ASES), Single Assessment Numeric Evaluation Score (SANE), Quick Disabilities of the Arm, Shoulder and Hand Score (QuickDASH), the Short Form 12 physical component summary (SF-12 PCS) as well as general patient satisfaction were assessed. Re-dislocation and revision rates were recorded.
Results. Postoperatively, one patient (3.6%) re-dislocated his shoulder during a baseball game and required revision surgery with a Latarjet procedure. One patient (3.6%) reported a sensation of instability and 37 of 39 (95%) patients remained stable. At the final follow-up, the mean ASES ($p < 0.001$), SANE ($p < 0.001$), QuickDASH ($p < 0.001$), and SF-12 PCS ($p = 0.001$) improved significantly over preoperative levels. Median postoperative satisfaction was 10/10 (range 1–10).
Conclusion. The arthroscopic treatment of Bankart lesions with a knotless all-suture technique leads to promising clinical short-term results with good function and low rates of re-dislocation and revision. Prospective, randomized, long-term follow-up studies with large patient cohorts are needed in the future.

Keywords

Shoulder · Joint instability · Bankart lesions · Suture techniques · Labrum

Kurzzeitergebnisse nach Bankart-Repair mit knotenlosen Ankern aus Fadenmaterial

Zusammenfassung

Hintergrund. Die beim arthroskopischen Bankart-Repair-Ansatz verwendeten festen soliden Anker wurden aufgrund von Komplikationen, wie Glenoidrandfrakturen, Ankermigration sowie glenohumeralen Knorpelschäden, zu nur aus Fadenmaterial bestehenden Ankern weiterentwickelt.
Ziel der Arbeit. Ziel der Studie war die Vorstellung der klinischen Kurzzeitergebnisse nach arthroskopischem Bankart-Repair-Ansatz mit knotenlosen Ankern aus Fadenmaterial bei Patienten mit vorderer Schulterinstabilität. Die Hypothese der Autoren war, dass diese Technik zu guter Schulterfunktion mit geringen Redislokations- und Revisionsraten führe.
Material und Methoden. Es wurden 39 Patienten mit einem Durchschnittsalter von 28,8 (Standardabweichung, SD: ± 10,5) Jahren einbezogen. Das klinische Ergebnis wurde nach mindestens 12 Monaten anhand etablierter Fragebögen bewertet (American Shoulder and Elbow Surgeons Score, ASES; Single Assessment Numeric Evaluation Score, SANE; Quick Disabilities of the Arm, Shoulder and Hand Score, QuickDASH;, Short Form 12 Physical Component Summary, SF-12 PCS). Die allgemeine Patientenzufriedenheit sowie postoperative Reluxations und Revisionsraten wurden dokumentiert.
Ergebnisse. Die Scores in den Fragebögen verbesserten sich von prä- zu postoperativ signifikant (Durchschnitt im ASES: $p < 0{,}001$; SANE: $p < 0{,}001$; QuickDASH: $p < 0{,}001$; SF-12 PCS: $p = 0{,}001$), die mediane Zufriedenheit mit dem postoperativen Ergebnis betrug 10/10 (Spannbreite: 1–10). Postoperativ erlitt ein Patient (3,6 %) eine traumatische Reluxation während eines Baseballspiels, die eine Revisionsoperation mittels Latarjet-Verfahren erforderlich machte. Ein Patient (3,6 %) gab postoperativ ein subjektives Instabilitätsgefühl an, während die Schultern bei 37 von 39 (95 %) Patienten stabil blieben.
Schlussfolgerung. Der arthroskopische Bankart-Repair-Ansatz mittels knotenloser Anker aus Fadenmaterial führt zu vielversprechenden klinischen Kurzzeitergebnissen und geringen Redislokations- und Revisionsraten. Weitere prospektive randomisierte Vergleichsstudien mit großen Patientenkohorten sind noch erforderlich.

Schlüsselwörter

Schulter · Gelenkinstabilität · Bankart-Läsionen · Nahttechniken · Labrum

locations, prior surgeries, and the specific physical activity during the injury. Minimum 1-year patient-reported outcome scores (PROs) were assessed and included the American Shoulder and Elbow Surgeons Score (ASES), Single Assessment Numeric Evaluation Score (SANE), Quick Disabilities of the Arm, and Shoulder and Hand Score (QuickDASH), the Short Form 12 physical component summary (SF-12 PCS), and patient satisfaction. Additionally, return to sport was assessed. Postoperative complications as well as patient-reported postoperative dislocations and revision rates were recorded.

Statistical analysis

All statistical analyses were performed with SPSS version 11.0 (SPSS, Chicago, IL, USA). Continuous numerical data are presented as mean ± standard deviation and categorical values are presented as percentages. The chi-square test was used to assess relationships between two categorical variables. Data were tested for normal distribution using the Kolmogorov–Smirnov test. An independent t-test was used for univariate analysis of normally distributed variables. For nonparametric data, the Mann–Whitney or Kruskal–Wallis tests were performed. Wilcoxon signed-rank test for paired samples was used to compare baseline and postoperative scores.

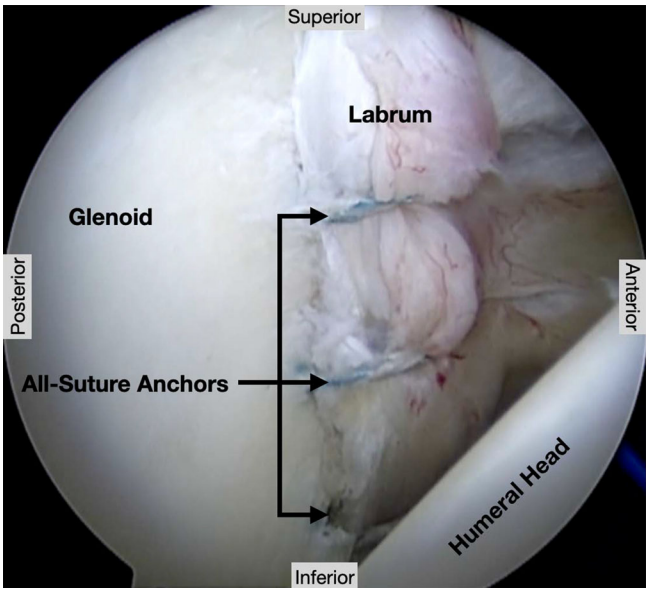

Fig. 3 ◀ Arthroscopic image of a right shoulder demonstrating the knotless all-suture anchor repair construct following Bankart repair

Results

A total of 45 patients were eligible for inclusion in the study. Following application of the exclusion criteria, 40 patients were included for further analysis and PROs were assessed in 72% of patients at a mean follow-up of 19.8 months (range, 12–32; **Fig. 4**). The study population comprised 32 men (80%) and eight women (20%) with a mean age of 28.5 years (range, 16–55). Average time from injury to surgery was 348 days (range, 10–4318), with seven patients (18%) being categorized as having acute injury.

Physical activities that led to the shoulder dislocation are summarized in **Table 1**. The most common physical activities that led to anterior instability in this study group were mountain biking, longboarding, skiing, and snowboarding (40%). The median number of shoulder dislocations prior to surgery was 1 (range, 0–3). The majority of patients ($n = 12$, 30%) experienced one dislocation, ten patients (25%) had three or more dislocations, eight patients (20%) had two dislocations, and eight patients (20%) were diagnosed with symptomatic shoulder instability without having experienced a shoulder dislocation prior to repair. One patient underwent a previous superior labrum anterior to posterior (SLAP) repair on the index shoulder.

Concomitant injuries are summarized in **Table 2**. Overall, SLAP (grade II–IV) lesions were found in 22 patients (55%) and six of them were treated with additional subpectoral biceps tenodesis. The average number of knotless all-suture anchors used in the repair was 5 (range, 2–7).

During the study period, one patient (3.6%) re-dislocated his shoulder while diving for third base during a baseball game and required revision surgery with a Latarjet procedure 2 years after the initial Bankart repair. This patient was excluded from further outcome analyses. One patient (3.6%) reported a sensation of instability not necessitating revision surgery and 37 of 39 (95%) patients remained stable.

At a minimum of 1 year of follow-up, PROs were available for 28 of 39 patients (72%). At final follow-up, all PROs improved significantly from pre- to postoperatively and median postoperative satisfaction was 10/10 (range 1–10; **Table 3**). Return to sport was possible in 24 of 27 (89%) cases.

Discussion

The most important finding of this study was that arthroscopic knotless all-suture Bankart repair for patients with anterior shoulder instability seems safe and effective at a mean follow-up of almost 20 months and resulted in excellent stability, significant improvements in all PROs assessed, and excellent postoperative patient satisfaction.

Arthroscopic labrum repair with knotless all-suture anchors is a relatively new technique with few clinical trials in the literature. To our knowledge, this study is among the first to report on Bankart repair using 1.8-mm all-suture anchors (FiberTak, Arthrex, Naples, USA). Our findings can be compared to three previously published studies on all-suture anchors. In 2015, Agrawal et al. [2] were the first to assess the clinical outcome after the repair of triple labrum lesions (defined as lesions in three different zones: anterior labrum from the 2 o'clock to the 6 o'clock position, posterior labrum from the 6 o'clock to the 10 o'clock position and superior labrum from the 10 o'clock to the 2 o'clock position) in 18 patients with 1.4-mm all-suture anchors (JuggerKnot Soft Anchor, Biomet, Warsaw, IN, USA). The PROs (Constant Score; CS, Flexilevel scale of shoulder function) had improved significantly after a mean follow-up of 2 years and all patients returned to their preinjury level of sports activity.

The same all-suture anchor (JuggerKnot Soft Anchor, Biomet) was used for 20 patients in a study by Willemot et al. [23]. After a minimum of 1 year following arthroscopic Bankart repair, SLAP repair, or a combination of both, the PROs were determined as satisfactory (DASH mean: 18.9; CS mean: 89.3; Western Ontario Shoulder instability Index mean: 70.6) and no postoperative dislocations occurred.

In a recent study, Gül et al. [9] investigated the clinical outcome after arthroscopic shoulder stabilization with two types of 2.8-mm all-suture anchors (Q-Fix, Smith & Nephew, Andover, MA, USA and JuggerKnot Soft Anchor, Biomet) in 62 patients with traumatic anterior shoulder instability. Compared with our study, the follow-up was longer (minimum 24 months), the mean time from the first dislocation to surgical treatment of 12.3 months was comparable, while the mean number of dislocations prior to repair was higher (4.5 vs. 2.4). At final follow-up, PRO scores (Rowe, CS) had also improved

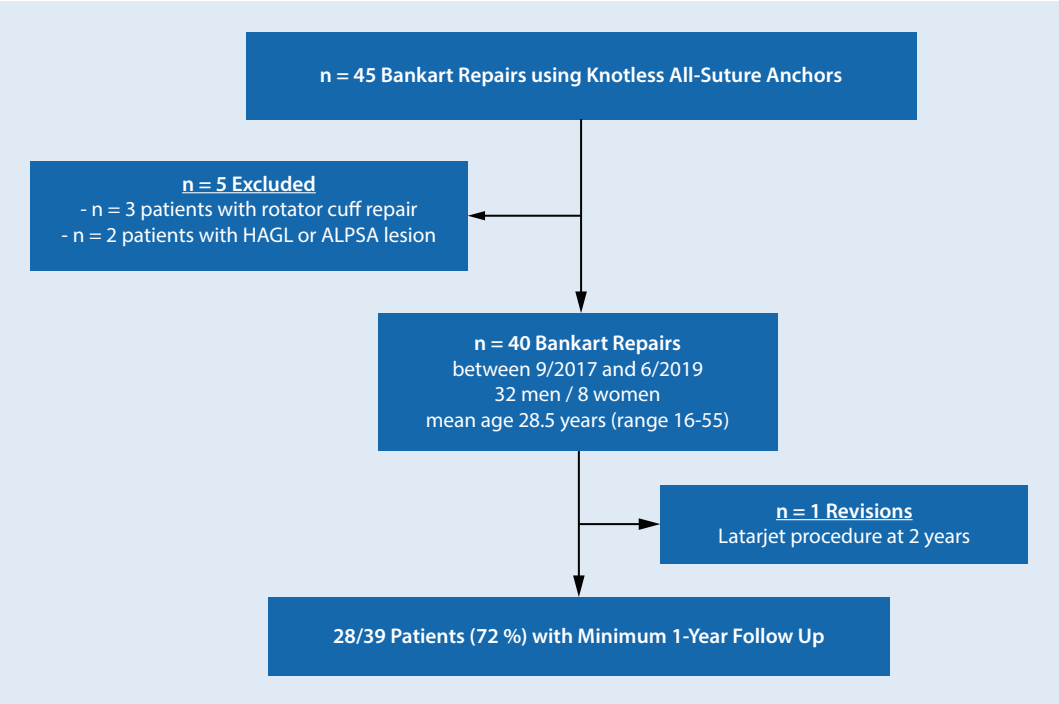

Fig. 4 ◀ Flow chart of exclusion and inclusion criteria of the study cohort. *ALPSA* anterior labroligamentous sleeve avulsion, *HAGL* humeral avulsion of the glenohumeral ligaments

significantly but the rate of postoperative dislocations was higher (8.1%).

The second most important finding in our study was a low re-dislocation rate after a minimum of 1-year follow-up, with a postoperative shoulder dislocation reported by only one patient (3.6%). This patient had a traumatic reinjury with a collision while playing baseball and required revision surgery with a Latarjet procedure. One patient reported a sensation of instability, which did not necessitate revision surgery, and 37 of 39 (95%) patients remained stable. In clinical studies, postoperative re-dislocations were found to be correlated with the number of anchors, contact sports, younger age, sex, time between the first dislocation and surgery, and number of preoperative dislocations [1, 9, 22]. Compared with the study by Gül et al. [9], the number of anchors used in our study was rather high with an average of 5 (range, 2–7) anchors per case. Advantages of the anchors used in this study are the small diameter and the flexible structure that allows more anchors per unit area to be used and therefore more points of soft tissue fixation. Furthermore, the curved drill-guides offers better access to the more inferior aspects of the glenoid rim [6, 8, 9, 12]. The knotless design also decreases the risk of chondral abrasion on the humeral head. Finally, the anchors are permanent and once incorporated into the bone and capsulolabral tissues they help to reinforce the tissues when subsequent trauma occurs.

Higher rates of postoperative re-dislocations in the 2-year follow-up study by Gül et al. [9] led to the question of anchor stability and the biomechanical properties of all-suture anchors. Since there is a paucity of mid- to long-term clinical studies reporting on postoperative re-dislocation rates, studies such as this one and biomechanical studies provide the best information on anchor stability.

Mazzocca [13] and Erickson et al. [8] demonstrated similar ultimate load-to-failure rates comparing all-suture anchors with classic solid anchors in a biomechanical cadaveric study. However, both authors observed less load to 2-mm displacement of all-suture anchors when compared with classic solid anchors. These results were interpreted as the minimal anchor displacement (micromotion) of all-suture anchors that could possibly result in failure of soft tissue healing [8, 13, 18]. Whether micromotion causes cystic changes around all-suture anchors was discussed by Pfeiffer et al. [18], who found larger bone socket width around all-suture anchors (JuggerKnot, Biomet) compared with solid biocomposite anchors (BioComposite Stuture Tak, Arthrex) in a canine model. Bone reactions around all-suture anchors, bone edema, and tunnel widening are phenomena that have been demonstrated in MRI scans but compared with reports on bone reactions around solid anchors with a larger diameter the rate was interpreted as low [23]. Furthermore, MRI studies also demonstrated that all-suture anchor tunnels can heal naturally with fibrous tissue, complete bony healing or combined fibro-osseous healing of the bone tunnels [2].

In this study a knotless technique was used for the fixation of all-suture anchors, but in general knotless or knotted all-suture fixation options exist. While knotted all-suture anchors are associated with longer operation time and technical challenges [21], knotless constructs have raised concerns about anchor stability in the past [5].

Nolte et al. [16] addressed these controversies and evaluated 20 paired cadaveric shoulders with type II SLAP lesions in a biomechanical study. Load to repair failure, load to ultimate failure, and stiffness were similar for knotless and knot-

Table 1 Physical activities that led to shoulder dislocations and consecutive Bankart lesions

Injury event	Number ($n = 40$)
Mountain biking, longboarding, skiing, snowboarding	16
High school to professional football, hockey, rugby	7
High school to college baseball or volleyball	6
No event, ATV accident, fall from horse, fall	5
Rock or ice climbing	3
Kayaking, rafting	3

ATV all-terrain vehicle

Table 3 Pre- and postoperative patient-reported outcome scores

	Preoperative	Postoperative	*p*
ASES score	66.8 (28.3–94.9)	96.0 (81.6–100)	<0.001
SANE score	59.9 (19–99)	88.1 (20–99)	<0.001
QuickDASH score	29.6 (70.4–0.0)	5.8 (50–0)	<0.001
SF-12 PCS	46.6 (30.3–57.8)	53.7 (29.8–61.9)	= 0.001
Median satisfaction	*N*/A	10 (range 1–10)	*N*/A

ASES American Shoulder and Elbow Surgeons Score, *SANE* Single Assessment Numeric Evaluation Score, *QuickDASH* Quick Disabilities of the Arm, and Shoulder and Hand Score, *SF-12 PCS* Short Form 12 physical component summary

ted all-suture anchors. Ultimate failure occurred in 16 of 20 specimen at the proximal long head of the biceps tendon. Lacheta et al. [12] evaluated 30 cadaveric shoulders with Bankart lesions. First failure load, ultimate failure load, and stiffness were similar for knotted and knotless all-suture anchors.

Limitations

This study has limitations that are inherent to its retrospective design. Furthermore, we only reported outcomes of a single cohort in the absence of a control group. Additionally, the number of included patients was relatively small and the minimum follow-up period was short.

Practical recommendations

Arthroscopic Bankart repair with all-suture anchors is an alternative to solid suture anchors. The knotless all-suture anchor (FiberTak, 1.8 mm, with No. 2 FiberWire CL; Arthrex) used in this study comprises a polyester sheath and is loaded with a repair suture (No. 2 FiberWire) and a shuttling suture [16]. The practical advantages of a knotless all-suture repair include the possibility of tensioning the construct even after anchor placement [16], placement of the flexible anchors through curved drill guides, allowing for access to the inferior glenoid and facilitating rotator-cuff-sparing approaches to treat concomitant SLAP lesions [6], a smaller anchor that allows for more points of fixation per unit area, avoidance of inconsistent and time-consuming knot tying [10], postoperative imaging with fewer artifacts [2], and less risk of humeral head abrasion.

Practical conclusion

Arthroscopic treatment of Bankart lesions with knotless all-suture anchors results in excellent stability, high patient-reported outcomes, and excellent patient satisfaction at short-term follow-up with low rates of re-dislocation and revision.

Corresponding address

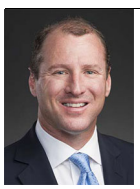

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Table 2 Concomitant pathologies in addition to Bankart lesion

Concomitant pathologies	Number
Type II–IV SLAP	22
Open tenodesis	6
GLAD lesions	2
Hill–Sachs lesion	15
Microfracture of a chondral defect	5
Loose bodies	4

SLAP superior labrum anterior to posterior, *GLAD* glenolabral articular disruption

Compliance with ethical guidelines

Conflict of interest. The authors A.K. Tross, M.P. Horan, J. Ruzbarsky, T. Woolson and B.P. Elrick declare that they have no competing interests. The position of P.C. Nolte at the Steadman Philippon Research Institute was supported by Arthrex. P.J. Millett is a consultant for and receives royalties from Arthrex, Medbridge, and Springer; owns stock in VuMedi; receives support from the Steadman Philippon Research Institute and Vail Valley Medical Center; and has corporate sponsorship from the Steadman Philippon Research Institute, Smith & Nephew, Arthrex, Siemens, and Össur.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975 (in its most recently amended version). Informed consent was obtained from all patients included in the study.

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