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SHOULDER

Biomechanical evaluation of knotless anterior and posterior Bankart repairs

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Abstract

Purpose The value of modern tape-like suture materials and the influence of the number of anchors inserted for arthroscopic Bankart repairs compared to the intact state have yet to be investigated. It was hypothesised: (1) suture-tape repairs will show higher biomechanical strength than common suture repairs, (2) four anchors will be stronger than three, and (3) the strength of the native capsulolabral complex will be greater than repairs.

Methods Six matched-paired cadaveric shoulders received Bankart lesions/reconstructions and three underwent intact state testing. Anteroinferior repairs compared suture and suture-tape repairs using three anchors, while posteroinferior repairs compared three and four suture anchors using common sutures. An established testing protocol was run for biomechanical testing.

Results There was no significant difference in the maximum loads, loads at 2 mm displacement, stiffness or energy between repair groups or between repairs and the intact state (n.s.). However, failure modes were different: 16/24 (66.7 %) of the repair groups showed glenoid labrum detachment compared to 2/12 (16.7 %) within the intact state group ($P = 0.012$).

Conclusions While biomechanical parameters of repairs and intact states showed equivalence, failure-mode analysis reaffirms previous findings that capsulolabrum complex refixation is weaker than the native attachment. Therefore, in daily clinical practice, type of suture is secondary and insertion of a fourth anchor will be unlikely to add strength but may confer additional risk and cost.

Keywords Bankart repair · Glenohumeral joint · Stabilisation · Knotless suture anchor · Shoulder instability

This study was performed at the Department of BioMedical Engineering of the Steadman Philippon Research Institute.

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Introduction

Arthroscopic anterior shoulder stabilisation using suture anchors has become a well established and highly accepted procedure, showing good and reliable clinical results [12–15, 20, 21, 23, 26, 40, 41]. Several stabilisation techniques have been reported with the capsulolabral glenoid bone anchor repair being the most popular. For this technique numerous different anchors, loaded with different kinds of sutures are available. In 2001, Thal [43–45] reported a new knotless suture anchor for arthroscopic repair of the glenoid labrum (Bankart repair). Since then, this technique is widely used and has shown comparable biomechanical and clinical outcomes to normal suture anchor repairs [12, 20, 37, 39]. Typically, two to four anchors are placed into the glenoid rim for anteroinferior or posteroinferior stabilisations [12, 36]. However, there is limited evidence in the literature regarding the amount of anchors required for anteroinferior or posteroinferior repairs. A recent study reported two double-loaded suture anchors to be superior to three single-loaded suture anchors but did not compare double-loaded suture anchor strength versus the number of double-loaded anchors [16]. A long-term follow-up study by van der Linde et al. [48] suggests that using three or more anchors might result in lower recurrence rates when compared to two anchors.

In addition to anchor pullout failure, tearing of the suture through the soft tissue is a well-recognised mode of failure [28, 30, 35]. Increasing attention is being paid to modern suture materials such as new tape-like suture materials which are already in use for rotator cuff repair [7, 47]. A biomechanical study on bovine cadavers documented similar biomechanical properties for tape repairs compared to normal suture repairs in a setting of rotator cuff testing [4]. The use of a suture-tape material has not been evaluated for Bankart repairs yet. Further, the biomechanical properties of the native capsulolabral complex must be defined in order to better understand how well current repair techniques are restoring stability at time zero.

The study aims were to clarify whether the use of suture-tape is advantageous for Bankart repairs compared to normal suture repairs, and whether the amount of anchors placed within the anteroinferior or posteroinferior quadrant is an important factor for stability of the repair. Additionally, the strength of the native capsulolabral complex was investigated, and the failure modes of the intact group were compared to the repair groups.

The following hypotheses were tested for glenoid labrum repairs: (1) anchors loaded with the new suture-tape material will provide higher biomechanical stability compared to anchors loaded with normal sutures, (2) four anchors will provide higher stability compared to three anchors, and (3) the stability of the native capsulolabral complex will be higher when compared to the reconstructions.

Materials and methods

For this study, a total of 18 fresh-frozen human cadaveric shoulders (9 matched pairs) were used; six for each of the repair techniques performed, with two tests run per shoulder, and six for the intact state testing. There were five female and four male donor shoulders with a median age of 55 years (range 43–60 years). Bone mineral density of the included specimens was consistent showing minimal variability (mean 0.69 ± 0.02 g/cm^3). There was no significant difference in age between the groups of shoulder specimens, as indicated in Table 1.

Preparation

Soft tissue was dissected carefully, and the proximal humerus was disarticulated by dissecting the capsular tissue at the most lateral insertion on the humeral head allowing preservation of as much capsular tissue as possible [30]. After thorough inspection, glenoids with significant degenerative changes, lack of labral tissue or any other labral lesions were excluded from the study. Furthermore, any lesion to the capsular tissue was considered an exclusion criterion. All included specimens underwent a bone density testing (dual-energy X-ray absorptiometry) at the glenoid neck, in order to limit bone mineral density selection biases across groups.

For the native state testing, the anteroinferior and posteroinferior capsulolabral complexes were left intact in six specimens. Using a No. 15 scalpel and tweezers, standardised Bankart tears were created by careful elevation and detachment of the chondrolabral junction until the labrum was completely detached from the bony glenoid. Then, the capsule was medially dissected all the way down to the glenoid neck. Moreover, this method of creating a Bankart tear in vitro has already been described by previous biomechanical studies [30, 31]. The capsular tissue was cut with a scalpel at the two, six and ten o'clock position in all specimens, and spare capsule tissue was removed in order to separate the anteroinferior and posteroinferior capsule tissue. The anteroinferior lesion was defined as spanning from the two to six o'clock position and the posteroinferior from the six to ten o'clock position in right shoulders. Figure 1 shows specimen preparation and creation of the Bankart lesion.

Repair

The specimens were randomised into one of the groups where left and right shoulders of the same individual were alternately used for each repair technique in order to serve as internal controls to reduce biases resulting from

Table 1 Specimen properties

	Average age (min–max)	Average bone mineral density (min–max)	*P* value (BMD)	Males	Females	*N* (matched pairs)
Repairs	52.17 (43–60)	0.678 (0.56–0.76)	n.s.	1	5	6
Intact	55.33 (55–56)	0.718 (0.64–0.76)		3	0	3

BMD bone mineral density

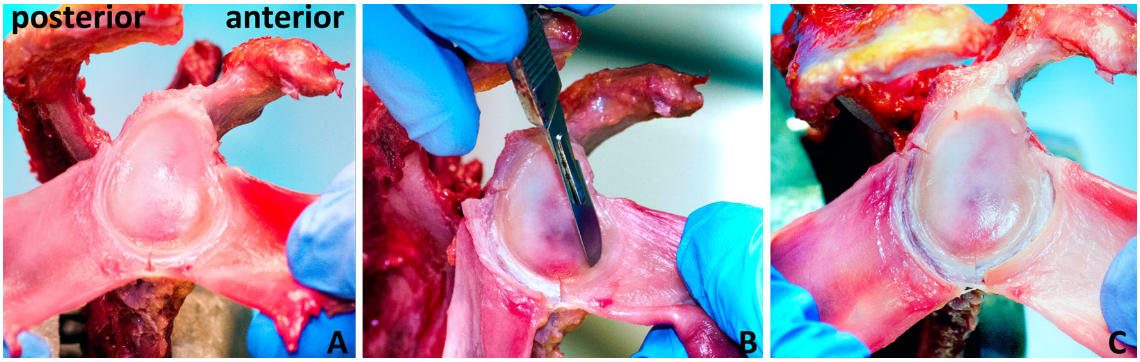

Fig. 1 Specimen preparation: **a** All soft tissue was removed. The anteroinferior (2–6 o'clock) and posteroinferior (6–10 o'clock) capsule was separated (*right shoulder*). **b** Bankart lesions were created down to the glenoid neck using a scalpel. **c** Created Bankart lesions for the anteroinferior and posteroinferior location

different anatomic variations. For the repair techniques, a total of twelve fresh-frozen human cadaver shoulders from six individuals were used. In six shoulders, the anteroinferior Bankart lesion was reconstructed using three knotless suture anchors loaded with common high-strength polyester sutures (2.9 mm BioComposite Push-Lock, loaded with No. 2 FiberWire, Arthrex, Naples, FL, USA). The respective anteroinferior Bankart lesion of the contralateral shoulder was repaired using the same anchors loaded with a suture-tape material (LabralTape, Arthrex, Naples, FL, USA) (Fig. 2). Using the same specimens, the posteroinferior quadrant of one shoulder was reconstructed using three suture anchors, and the contralateral posteroinferior quadrant was reconstructed using four suture anchors (2.9 mm BioComposite Push-Lock, loaded with No. 2 FiberWire, Arthrex, Naples, FL, USA).

The suture anchors were positioned at the three, four and five o'clock position for the anterior three anchor repairs.

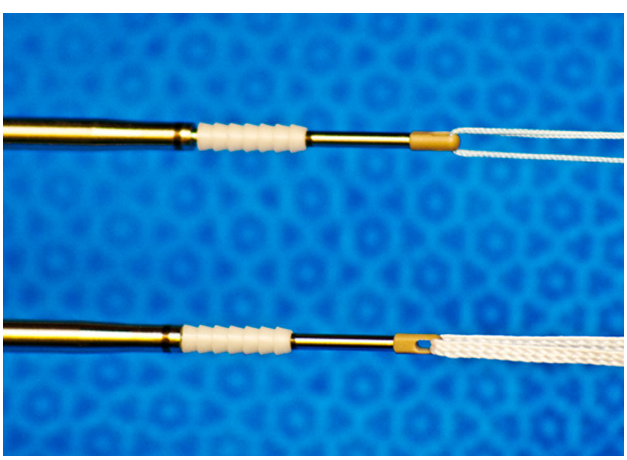

Fig. 2 Knotless suture anchor devices loaded with a common high-strength suture material (*top*) and with a modern suture-tape material (*bottom*)

Posterior suture anchors were positioned at seven, eight and nine o'clock position for three anchor repairs and at the six-thirty, seven-thirty, eight-thirty and nine-thirty position for the four anchor repairs (right shoulder assumed in the aforementioned positions). All anchors were inserted at the apex of the glenoid rim in standard fashion, using the original insertion devices. For suture passage, the capsule tissue was punctured in standard manner at 10 mm from the capsulolabral junction with a 45°-shuttling device (Suture lasso, Arthrex, Naples, FL, USA). The suture from the anchor was shuttled through the capsulolabral tissue by use of the nitinol wire. The sutures were successively shuttled and inserted into the eyelet of the suture anchor. The anchors were inserted from inferior to superior until the repair was completed. Figure 3 illustrates the repair process.

Set-up and biomechanical testing

For biomechanical testing of the intact group or after repair, each specimen was potted using polymethylmethacrylate with the glenoid fossa oriented parallel to the surface of the potting container (Fricke Dental International, Inc., Streamwood, IL, USA). For biomechanical testing, the specimens were then placed into a dynamic tensile testing machine (Instron Electroplus E10000, Instron Corp., Norwood, MA, USA). The potted glenoid was rigidly fixed to the base of the testing machine using a custom made, adjustable jig. The capsular tissue was then gripped by a mechanical soft tissue clamp 15 mm from the glenoid labrum junction. The distance was measured with digital calipers (Mitutoyo Corporation, Kanagawa, Japan) to achieve consistent clamp fixation among specimens. The specimens were aligned with the vector of labral translation force being directed away from the glenoid in anteroinferior or posteroinferior direction, depending on the labrum being tested (vector 0°) as performed in previous biomechanical studies (Fig. 4) [30].

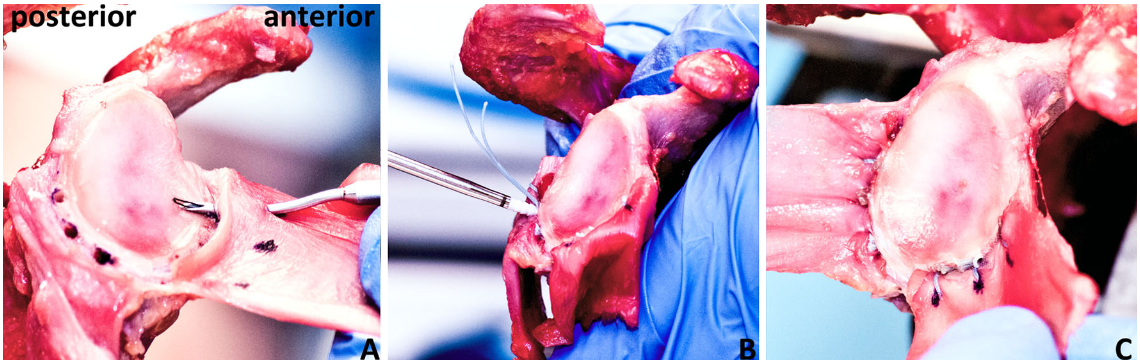

Fig. 3 Specimen repair: **a** Holes were drilled and a shuttling device was used to pass the suture material through the capsule tissue. **b** The knotless suture anchors were inserted in a standard fashion. **c** Final result after anteroinferior and posteroinferior repair with 3 knotless suture anchors using common high-strength sutures

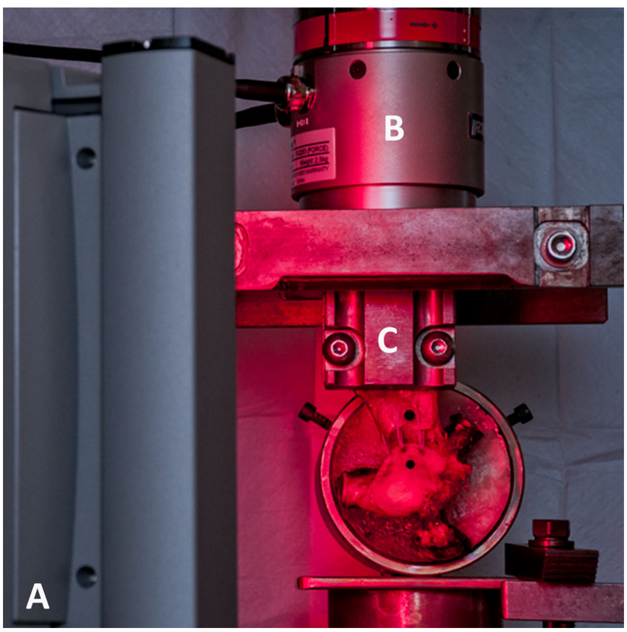

Fig. 4 Testing set-up: The specimen was mounted onto the testing machine using a custom made jig. Load was applied in anteroinferior (posteroinferior) direction. *a* advanced video extensometer (AVE) optical system to test load displacement; *b* dynamic tensile testing machine (Instron); *c* clamp for soft tissue fixation

Load and displacement

Since the load–displacement relation is a relevant parameter for stability of Bankart repair techniques, an advanced video extensometer (Instron Corp., Norwood, MA, USA) was used in a novel way in order to measure the load at 2 mm displacement. When reporting biomechanical properties of Bankart repair techniques, one would like to describe a "clinical failure" which can then be compared to the values found for the repair group. New technologies enable researchers today to detect the exact load at a specific displacement and the "2 mm displacement" which has been introduced in biomechanical testing of Bankart repairs as a new parameter [24, 30, 31, 34]. This parameter seems to be more relevant to describe repair stability than the simply reporting maximum load that the construct can endure which does not account for tissue healing due to the large displacements at maximum load. Although there are no data on the amount of displacement that correlates with clinical failure, we followed the previously mentioned 2 mm displacement as a clinically likely degree of displacement that would correlate with failure. To do this, the AVE was able to follow the displacement of a point on the labrum relative to the glenoid surface placed 5 mm above the glenoid until it had travelled 2 mm from the initial position of the test. The data were analysed with Bluehill 2 software (Instron Corp., Norwood, MA, USA) and synchronised to the load and actuator displacement data by the Instron software. For the measurements in this study, the accuracy was ±50 µm, which equals 0.5 % of the gauge length of the specimen being analysed. For this measurement, two specific markers were placed, one on the surface of the glenoid cartilage and the other one 1 cm away on the surface of the repaired capsulolabral complex. The mark on the glenoid cartilage was created with a contrasting colour paint pen. The marker on the capsulolabral tissue was marked with a circular tack pushed through the tissue which remained flush against the tissue to remain a contrasting circle that did not elongate during tissue deflection for the AVE to locate and accurately track. The small hole in the tissue was always analysed and found to not lead to localised tissue failures during testing. Again, digital calipers were used to achieve consistent location placement among specimens.

Ultimate failure load

In addition, we also performed testing to determine ultimate failure loads [24, 30, 31, 38]. Based on previous studies [29–31, 33], a cyclic loading protocol was run before load to failure testing. An initial a preload of 5 N was applied for 2 min to guarantee a consistent starting point, followed by 10 sinusoidal cycles from 5 to 25 N at 1 Hz by using Instron's Wavematrix software (Instron Corp., Norwood, MA, USA). Finally, the applied force was continuously increased with a rate of 5 mm/min until failure using Bluehill 2 software (Instron Corp., Norwood, MA, USA). Maximum load, load at 2 mm tissue displacement, energy, stiffness and failure mode were evaluated. The accuracy of the calibrated load cell utilised to acquire load data was ±0.5 %. Testing was stopped and completed when a drop in force to 50 % of the applied maximum load occurred. The ultimate load and load when the tissue marker 5 mm above the glenoid had displaced 2 mm were calculated and exported by Bluehill 2 software for each specimen. Stiffness and energy were calculated from the slope of the linear portion of the load–displacement curve and the area under the curve, respectively, from the AVE measurement of the displacement from 0 to 2 mm. Finally, failure mode was visually analysed and documented at the time of removal from the testing set-up.

Statistical analysis

An unpaired t test was used to analyse the different groups using SPSS statistical software (SPSS Science Inc, Chicago, Illinois, USA), with statistical significance at $P < 0.05$. Chi-square test was used to analyse modes of failure between the testing groups, with statistical significance at $P < 0.05$.

Fisher's exact test (FET) was used to test for association between intact/repair state and failure mode. Relative risk (RR) was reported along with 95 % confidence intervals, and P values < 0.05 were deemed significant. Statistical analysis was performed using IBM SPSS Statistics, Version 20 (Armonk, NY, USA).

Results

Biomechanical testing results

There was no significant difference found between the mechanical properties measured across any of the testing groups. As seen in Table 2, there were no significant differences seen in maximum load, load at 2 mm displacement, stiffness or energy among: suture and suture-tape, three anchors and four anchors, and intact and repaired state (n.s. for all comparisons).

Failure modes

We did find differences in the failure modes across groups. Failure modes were divided into three groups: (1) anchor pullout, (2) glenoid labrum detachment (Bankart lesion) and (3) capsule rupture. Failure in the knotless suture repair group occurred by capsule rupture in 1 (16.67 %), by anchor pullout in 3 (50 %) and by glenoid labrum detachment in 2 specimens (33.3 %). In the knotless suture-tape group, 1 specimen failed by capsule rupture (16.7 %), 2 by anchor pullout (33.3 %) and 3 by glenoid labrum detachment (50 %). The three anchor group showed 3 (50 %) capsule ruptures, 1 (16.7 %) anchor pullout and 2 (33.3 %) glenoid labrum detachment, while the four anchor group showed 3 (50 %) capsule ruptures, 2 (33.3 %) anchor pullouts and 1 (16.7 %) glenoid labrum detachment.

However, there was a significant difference between the failure modes of the repair groups and the intact state group. When summarising glenoid labrum detachments and anchor pullouts within the repair groups as failure of the capsulolabral complex to bone refixation, meaning a recurrent Bankart lesion, there were 16/24 failures by glenoid labrum detachment and anchor pullout and only 8/24 by capsule rupture. In contrast, 10 out of 12 (83.3 %) specimens within the intact group failed by capsule rupture and only 2 out of 12 (16.7 %) by a Bankart lesion. Therefore, in our biomechanical model, the risk of a Bankart lesion was four times lower in the intact shoulder than in the repaired shoulder (RR = 0.25; two-sided FET $P = 0.012$; 95 % CI 0.068, 0.914). Figure 5 illustrates the different failure modes.

Discussion

The present study found that the tested repair techniques for glenoid labrum repair had equivalent biomechanical properties and restored the ultimate failure loads back to levels similar to the intact state. In this biomechanical model, there was no significant difference found in knotless repairs performed with suture versus suture-tape or with three versus four anchors. Furthermore, the repaired specimens did not show significant differences in biomechanical properties compared to the intact state group. To our knowledge, this is the first study to biomechanically compare different suture materials for knotless suture anchors and different amounts of anchors used for repair which are then compared to intact control groups. The comparisons of the different groups were made using an established biomechanical model for labrum repair testing [24, 30, 33].

Arthroscopic suture anchor repair is a common and well-established treatment for shoulder instability and has already been extensively examined both biomechanically [2, 5, 19, 24, 25, 28–31, 38, 49] and clinically [1, 8–13, 17, 18, 22, 27, 32, 42, 48]. In recent years, knotless suture

Table 2 Results

	Load at 2 mm [N] (SD)	Maximum load [N] (SD)	Maximum stiffness [N/mm] (SD)	Energy [J] (SD)	Failure mode	*N*
Repairs						
Anterior suture repair	123 (53.6)	400 (267)	86.9 (112)	0.12 (0.05)	2/6 GLD 3/6 APO 1/6 CR	6
Anterior tape repair	99.0 (33.3)	356 (328)	72.4 (78)	0.10 (0.03)	3/6 GLD 2/6 APO 1/6 CR	6
Posterior 3 anchor repair	126 (95.8)	274 (234)	132 (345)	0.17 (0.16)	2/6 GLD 1/6 APO 3/6 CR	6
Posterior 4 anchor repair	74.7 (30.6)	307 (260)	58.8 (75.2)	0.09 (0.04)	1/6 GLD 2/6 APO 3/6 CR	6
Intact						
Anterior intact	138 (43.4)	535 (465)	113 (133)	0.13 (0.04)	1/6 GLD 5/6 CR	6
Posterior intact	90.1 (48.7)	400 (367)	71.2 (158)	0.093 (0.04)	1/6 GLD 5/6 CR	6
P value	n.s.	n.s.	n.s.	n.s.	–	–

SD standard deviation, *GLD* glenoid labrum detachment, *APO* anchor pullout, *CR* capsule rupture

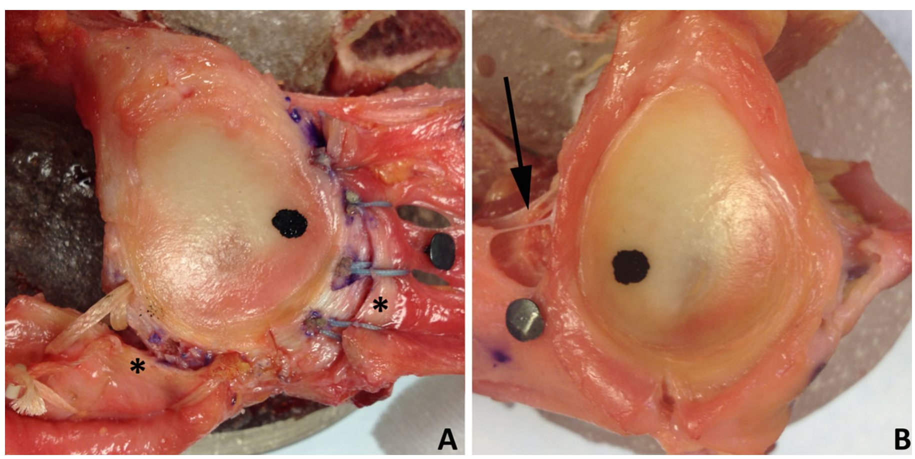

Fig. 5 Failure modes: **a** Typical failure mode of the repaired specimens showing displacement of the labrum (*asterisk*) from the glenoid both anteriorly (*left*, *tape*) and posteriorly (*right*, *suture*). **b** Typical failure mode of the intact specimens showing disruption of the capsule (CR) with the labrum still in place. The *black dots* for the displacement tracking with AVE can also be seen

anchors have been successfully implemented for arthroscopic shoulder stabilisation [12, 13, 20, 46]. The potential advantage of these anchors is that they avoid issues associated with arthroscopic knot tying such as difficulty with tensioning and tying the knot. In addition, the hazard of injury to the articular surface by the knot itself is averted [44].

In 2010, Nho et al. [30] compared the biomechanical properties of knotless suture anchors to conventional suture anchors with different stitch configurations, using a set-up similar to that used in the present study. They found that knotless and simple anchor configurations demonstrated similar maximum loads, although the knotless device required significantly less load to reach 2 mm displacement. Furthermore, all stitch configurations performed similarly. Regarding the difference in the load at 2 mm displacement, they concluded that differences in fixation might be evident during a macrotraumatic event in the early postoperative period.

Ranawat et al. [34] also recently compared a knotless and a knotted suture anchor with a similar set-up. They reported no significant difference in maximum load or stiffness between the groups, while load at 2 mm displacement was not reported in this study.

In contrast to the present study, only 2 suture anchors were used for repair in the studies by Nho et al. [30] and Ranawat et al. [34] Since properties from repair groups were to be compared to the intact state in this study, lesions were repaired using 3 or 4 anchors, which is more likely to be performed in the clinical setting of a large anteroinferior or posteroinferior Bankart lesion and has been shown to result in better outcomes clinically [6]. By doing so, the present study was able to show that all repair groups did not significantly differ from the intact state group regarding maximum load, load at 2 mm displacement, stiffness or energy. This is an important finding, showing these modern repair techniques can restore biomechanical strength of a native capsulolabral complex, at least when analysed in this biomechanical model.

When comparing these results to the results from the above-mentioned studies with similar testing set-up [30, 34], a considerable difference appears. For knotless and knotted anchor repairs, Ranawat et al. [34] reported a maximum load of 96.9 ± 95.1 and 125.3 ± 67.4 N and a stiffness of 19.8 ± 8.6 and 20.9 ± 6.4 N/mm, respectively. The low values may be influenced by a short cycling protocol run before load to failure testing. Without cycling, Nho et al. [30] found a maximum load of 173.1 ± 45.3 N, a load at 2 mm displacement of 66.5 ± 21.7 N and a stiffness of 23.3 ± 4.7 for the knotted anchor repair. The respective values for the knotless anchor repairs were 167.9 ± 42.3, 35.0 ± 12.5 and 28.2 ± 10.3 N/mm. Because these values are considerably lower than our repair groups and the intact state group, the data from the present study suggest that at least three suture anchors should be used for Bankart repairs in the setting of large or complete anteroinferior or posteroinferior lesions in order to approach biomechanical properties of the native shoulder.

Regarding the failure modes observed in the tested repair groups, we did not find considerable differences between the suture and suture-tape repairs or between the three anchor and four anchor repairs. The increased amount of capsule ruptures within the posterior repair groups might be owed to the different capsular properties of the posterior capsule compared to the anterior [3]. Nho et al. [30] reported 1/5 anchor pullouts and 4/5 capsule ruptures for the knotless group and did not find a significant difference compared to the knotted group. The authors only subdivided into anchor pullout or capsule rupture. A glenoid labrum detachment representing a recurrent Bankart lesion with the anchor still in place was not described as potential failure mode in their study. Since pull to failure rates higher than 7 mm/min have been shown to create suture saw-through [33], the rate of 15 mm/min as used in this study might account for the differences in our findings. Ranawat et al. [34] subdivided failure modes into those occurring at the suture-tissue interface or the anchor-bone interface. They found 13/16 failures at the suture-tissue interface and 3/16 failures at the anchor-bone interface, which was also not significantly different to the knotted anchor group. A rupture of the capsule alone was not described as failure mode in this study [34]. Nevertheless, the results from the current study are somewhat comparable to the findings of these studies. The majority (16/24) of failures within the repair groups did not occur by anchor pullout but by capsule rupture or glenoid labrum detachment, whereas the latter resulted from sutures tearing through the capsule.

However, when comparing the failure modes of our repairs to the failure modes of the intact states, we found that the risk for failure at the glenoid labrum junction was significantly higher among the repaired specimens compared to the intact state, in which more specimens failed by capsule rupture. This is also an important finding as it suggests the intact state group to have a stronger capsulolabral complex fixation strength; therefore, mainly failing by capsule rupture, whereas the capsule-labrum complex to glenoid refixation seems to be the weak point among the repair groups.

While “2 mm of displacement” was defined as “clinical failure” based on expert opinion, to our knowledge, there is no scientific rationale for this degree of displacement as being a failure. It seems likely in clinical situations that there is indeed a degree of displacement, beyond which healing is not possible. Because of this limitation in our definition of failure, in the present study, the repairs were compared to intact states in order to better understand the current parameters of Bankart repairs with knotless suture anchors and how they relate to the intact state. Since it is hard to define a clinical failure in a biomechanical analysis of Bankart repairs such as this, the authors believe that defining load displacement using newer technology such as the optical measuring system is an important contribution to biomechanical evaluations of Bankart repair testing. Furthermore, a sole interpretation of the biomechanical parameters might provide misleading conclusions and failure-mode analysis should be included. The failure-mode analysis in this study showed that the current repairs provide less capsule-labrum to bone attachment strength when compared to the intact state.

The study has several weaknesses including the inherent limitation associated with applying a biomechanical model to a clinical problem, using a simplified testing set-up, and therefore not mimicking the true mechanism for instability of the shoulder joint. A dynamic loading model and dynamic muscle forces were not included, which are known to be important stabilisers of the joint. However, this set-up has been shown to be reproducible, reliable and capable of answering the stated hypotheses [24, 30, 31, 34]. Furthermore, this biomechanical study investigates repairs at time zero and allows the investigators to control many variables that cannot be evaluated in vivo, although it excludes any influences of biological healing. While the specimens were randomised using right and left internal controls prior to the start of testing, all three of the intact state specimens were performed on males. While the role of gender on quality and strength of capsule tissue is not known, this might be seen as a potential bias.

On the other hand, the study has several strengths; such as its homogeneity in terms of age, bone mineral density and the use of matched pair specimens for comparison in order to further reduce any bias. Repairs only differed by the repair technique, and all were performed using the original instruments by a single orthopaedic surgeon. Additionally, an optical measurement system (advanced video extensometer) was used in order to enable determine the load required to create a 2 mm displacement of tissue at the capsulolabral junction from the glenoid. Finally, intact state specimens were tested with an identical set-up to allow for comparison and further conclusions regarding the current repair properties.

This study demonstrates that if considering addition of an extra suture anchor or using a braided tape-like suture will be unlikely to add strength to the repair. Further, the addition of an extra procedural step may confer additional risk and cost to the patient with limited benefit.

Conclusion

In the present study, the biomechanical parameters did not show any significant differences for the tested knotless Bankart repairs using suture versus suture-tape or three versus four anchors. Furthermore, these techniques have shown equivalence to the intact state, regarding the assessed biomechanical parameters. The significant differences in mode of failure between the repair groups and the intact state group reaffirm that the weak point in current repair techniques is still the capsule-labrum complex to bone repair strength. Hence, this study demonstrates the value of the current repair techniques and clarifies the region for future research in order to better postoperative stability.

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