ORIGINAL ARTICLE · SHOULDER - BIOMECHANICS

Suture anchor fixation strength in the Latarjet procedure: a biomechanical study in cadavers

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Abstract

Background The use of metallic screws for graft fixation during the Latarjet procedure is not devoid of complications. The purpose of the present cadaver study was to determine the initial strength of coracoid graft fixation using suture anchors and compare it to that of the traditional screw fixation of the graft using a fresh frozen human shoulder cadaver model.

Materials and methods Twelve unpaired fresh frozen cadaver shoulders were utilized. In the first group, suture anchor fixation of the graft was used, while 3.75-mm cannulated screws were used in the second group. The specimens were then cyclically loaded from 5 to 150 N at a speed of 0.05 mm/s for 100 cycles. After cyclic loading, each specimen was then loaded at a constant rate of 0.5 mm/s until 7 mm of displacement. Cyclic elongation, peak-to-peak displacement, stiffness and maximum load were measured.

Results There were no significant differences between the traditional screw fixation and fixation using suture anchors in elongation, peak-to-peak displacement, stiffness and maximum load.

Conclusions In this study, traditional screw fixation and fixation using suture anchors did not significantly affect biomechanical performance in a classic Latarjet procedure.

Keywords Shoulder instability · Latarjet procedure · Screw fixation · Suture anchor fixation

Introduction

Latarjet first described the coracoid bone transfer in 1954 to address glenoid bone loss in patients with recurrent anterior instability of the shoulder [1]. Although the Latarjet

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procedure is safe when used in shoulder stabilization surgery, post-operative complications at rates of approximately 15–25% have been recorded. These complications include recurrences, infection, haematoma formation, intraoperative graft failure, graft malposition or malunion, pseudarthrosis, implant-related complications such as screw bending, migration or failure, adhesive capsulitis, arthropathies and neurovascular complications [2–4].

Generally, the most common intraoperative complications are graft-related or implant 'screw'-related [5, 6]. Griesser et al. [2] reported their results of a systematic review of 1904 patients with an average follow-up of 6.8 years following open and arthroscopic surgeries that had reoperation rates of 7% and 35%, respectively. Most of these surgeries were reported to be related to the removal of symptom-causing implants [2]. Previous studies have reported the successful use of anchors for the fixation of bone fractures, including tibia eminence fractures, bone Bankart lesions, olecranon fractures and displaced medial epicondyle fractures [7–10].

Based on these previous reports, the present study aimed to determine the initial strength of the coracoid graft fixation using suture anchors and compare it to that of the traditional

screw fixation of the graft using a fresh frozen human shoulder cadaver model. The hypothesis was that suture anchor fixation would be at least as strong as screw fixation of the coracoid graft with Latarjet surgery.

Materials and methods

This research was approved by the ethical committee of Dokuz Eylul University (2017/18–37). The study involved 12 fresh frozen human cadavers of unspecified genders (aged 45–90), of which three were right and nine were left shoulder joints. The exclusion criteria included cadavers with glenoid or coracoid fractures and those with damaged conjoint tendons. The groups were randomly divided in two groups with six cadavers in each group.

The cadavers were removed from the deep freezers and allowed to thaw at room temperature overnight before being dissected the next day. Following the surgical set-up and procedures on the cadavers, the biomechanical set-up testing was performed on each cadaver.

Surgical technique

After a deltopectoral incision, the coracoid process was dissected extending to the origin of the coracoclavicular ligament (CC). The pectoralis minor tendon was then freed from the medial edge. The osteotomy line was centred approximately between the horizontal and vertical aspects of the coracoid process, which translates to a graft of approximately 2.2–2.5 cm in length [11–14]. Care was taken to explore the glenoid. A sharp dissection parallel to the muscle fibres was performed between the upper 2/3 and the lower 1/3 of the subscapularis muscle. Subsequently, the anteroinferior portion of the labrum was cleared of periosteum and soft tissues of the glenoid to

create a bone defect of approximately 25% [11–15]. The coracoid graft was aligned, fixed and embedded at zero or less than 1 mm away from the cartilage of the glenoid.

For the fixation, two different methods were used for the two groups.

In the first group, two Lupine 2.4-mm anchors (DePuy Mitek, Raynham, MA) were double loaded, and one knotless 4.75-mm Healix advance anchor and one Orthocord No. 2 suture (DePuy Mitek, Raynham, MA) were used (the anchor was loaded with the same suture) (Fig. 1).

In the anchor group, an adequate bone stock was maintained from the superior to the inferior of the coracoid at a distance of 1 cm using a 2.0-mm drill, and two parallel holes were made at the coracoid graft. Single orthocord sutures were then passed through the holes. A knot was tightly fixed at the posterior edge using a special knot technique [16]. Next, Lupine anchors were implanted at the cartilage edge of the glenoid at both the superior and inferior edges of the defect. Each strand of the pair (two strands total) from the superior anchor was tied to that of the inferior anchor, crossed over to the graft and then cut, leaving two free sutures from the superior anchor and two from the inferior anchor. Then, two free limbs corresponding to the two knotted limbs were tensioned, pushing the knot and the graft onto the glenoid, utilizing the eyelets of the anchors as pulleys. Next, the other two free limbs were tied across the graft using a static knot. The same procedure was performed for the two free sutures from each anchor. Two strands were cut, and two strands were kept for use later as a knotless anchor. The two strands of suture from the lupine anchor system and the two strands from the initially created 'special knot at the posterior edge of the graft' were then loaded to the knotless anchor, which was then implanted again at the cartilage edge of the glenoid in the middle of the superior and inferior lupine anchors (Fig. 1).
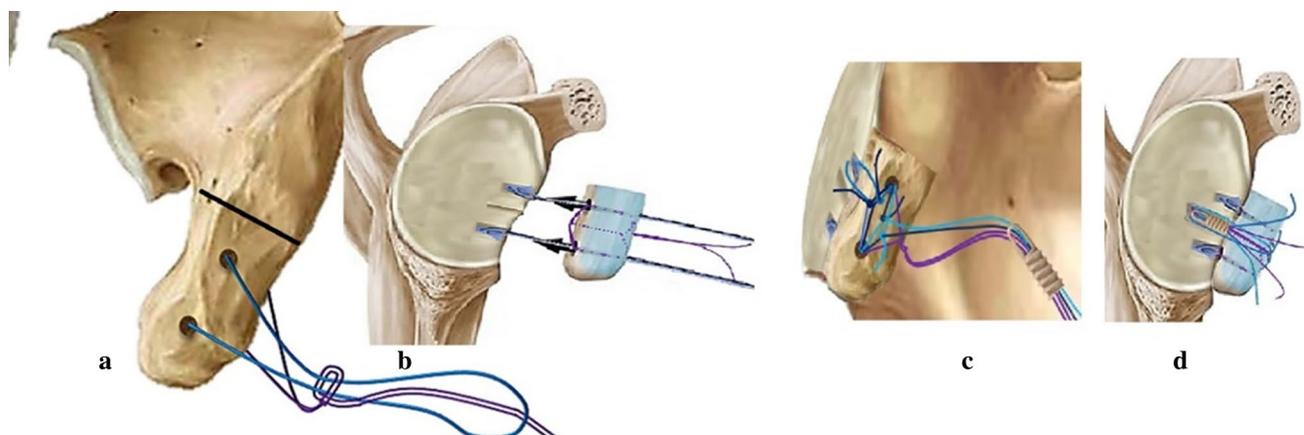

Fig. 1 Schematic drawing of anchor fixation

In the second group, a traditional Latarjet procedure was performed. Two cannulated titanium 3.75-mm screws with washers (Bristow–Latarjet Instability Shoulder System, DePuy Mitek, Raynham, MA) were used. During the insertion of the implant on the defective area of the glenoid, care was taken to ensure that the implants were placed vertically, anterior to the scapular neck, 15 degrees to the surface of the glenoid and centred between the superior and inferior of the glenohumeral surface. After drilling, two appropriately sized screws were placed with bicortical purchase [13, 14].

Biomechanical testing

The scapulae were mounted to a materials testing system (AG-I 10 kN, Shimadzu, Kyoto, Japan) with the aid of a special jaw/gripping device at 30° inclination from the horizontal, and the load was applied directly to the graft, replicating the anterior–inferior loading used clinically and representing the worst-case scenario. The pressing head of the device was designed to mimic the humerus head with a radius of 24 mm (normal humerus head diameter 24 ± 1.5 mm) and a width of 8.5 mm (Fig. 2) [13].

A 1-N preload was applied for 10 s, and each specimen was then cyclically loaded from 5 to 150 N at a speed of 0.05 mm/s for 100 cycles. After the cyclic loading, each specimen was then loaded at a constant rate of 0.5 mm/s until 7 mm of displacement, which was considered the failure point [13].

Fig. 2 Test set-up

The load (N) versus displacement (mm) was recorded until failure. The peak-to-peak displacement and elongation were determined during the cyclic testing. Elongation is the difference in y-displacement between the peak of the first cycle and peak of the hundredth cycle. The average of the peak-to-peak displacement values of the 98th, 99th and 100th cycles was used. The ultimate tensile load was considered the peak force. Stiffness was calculated by determining the slope of the load–displacement curve with the use of a best-fit line on the load versus displacement curve. Peak-to-peak displacement (mm), cyclic elongation (mm), ultimate load (N) and stiffness (N/mm) were measured.

Statistical analysis

Data analysis was performed using SPSS for Windows, version 20.0 (SPSS, Chicago, IL). For data analysis, the distribution of the data was first tested using the Shapiro–Wilk test, and then the Mann–Whitney U test was used to analyse the difference between the mean values of elongation among the groups. The rest of the parameters were analysed using the t test. A P value of less than 0.05 was considered statistically significant.

Results

The data are presented in Table 1. There were no significant differences in elongation among the two groups ($p = 0.15$). The average of the peak-to-peak displacement values of the 98th, 99th and 100th cycles was used. The peak-to-peak displacement values did not show any significant differences between the two groups ($p = 0.92$). When we compared stiffness among the two groups, no statistical differences were noted ($p = 0.48$). In addition, screw fixation group did not have a higher maximum load than the anchor fixation group ($p = 0.69$).

Discussion

The main finding of this study was that suture anchor fixation of the coracoid graft, when compared to the traditional Latarjet procedure using screws, yielded no difference regarding the initial strength. Screw-related difficulties constituted the major complications, such as screw bending, fracture or migration, graft fracture during drilling, tapping and insertion of the screw or neurovascular complications due to the penetration of the posterior cortex via the long screws or during drilling [2–5, 17, 18]. Most of these complications can be prevented by the usage of suture anchors, which have wide applications in orthopaedic surgery, including various fracture fixations such as tibia eminence

Table 1 Data; elongation (mm), peak-to-peak (P–P) displacement (mm), maximum load (N) and stiffness (N/mm)

Group	Elongation (mm)			P–P displacement (mm)			Stiffness (N/mm)			Max. load (N)		
	Mean±SD	Median	95% confidence interval for mean	Mean±SD	Median	95% confidence interval for mean	Mean±SD	Median	95% confidence interval for mean	Mean±SD	Median	95% confidence interval for mean
Anchor (Group 1)	2.3±2.8	1.3	0.7–5.2	0.86±0.23	0.85	0.6–1.1	57±8.9	58.1	48–67	360±118	322	235–484
Screw (Group 2)	0.9±1	6	0.1–2	0.85±0.33	0.7	0.5–1.1	63±16	59	46–80	381±53	382	325–437
P	0.15			0.98			0.48			0.69		

fractures[7], bone Bankart lesions[8], olecranon fractures[9] and displaced medial epicondylar fractures [7–10].

There are few biomechanical studies in the literature on the initial strength of the Latarjet procedure and most of them report the fixation strength of metallic screws [13–19]. Alvi et al. compared 3.5-mm cortical screws with 4-mm cancellous screws and found no difference between the fixation strengths of the two groups: both failed by screw cut-out. However, their testing protocol was different from that of the present study, as they applied an incremental load of 25 N every 20 cycles until failure of the specimens [19]. Weppe et al. compared a bioabsorbable interference screw with two 3- to 5-mm cancellous screws and reported the latter to be stronger (202 N vs. 110 N) and most failing with the graft fracture. Again, the testing protocol was different from that of the present study [20]. Another study compared the classical Latarjet method versus the congruent-arc Latarjet technique utilizing two 3.75-mm cannulated screws and found the classical method to be stronger (ultimate load: 557 N vs. 392 N) [21].

The most recent study utilizing the same testing protocol as that of the present study (comparing 4.0-mm cancellous screws with bicortical fixation, partially threaded solid 4.0-mm cancellous screws with unicortical fixation, fully threaded solid 3.5-mm cortical screws with bicortical fixation, partially threaded cannulated 4.0-mm cancellous screws with bicortical fixation and partially threaded cannulated 4.0-mm captured screws with bicortical fixation) found no difference between the groups and concluded that surgeons may continue to select the type of screw or fixation based on preference [13]. A maximum cyclic displacement of approximately 1–2.2 mm was reported, similar to that of the present study [13].

Limitations exist in the present study. First, this is a biomechanical study testing the strength of a construct at time zero and not the healing response over time. Although there was no macroscopic evidence of damage to any component of the joint, there is a possibility that bone quality differences exist between the specimens tested. Additional bone mineral testing would probably add useful information regarding the interpretation of the results. The supply of fresh frozen human cadavers is limited, and so the number of specimens in each group was kept low ($n = 6$) to prevent a type 2 error or conclude with certainty that the two techniques were not different. However, other biomechanical studies have also utilized only six specimens per group [22–24]. Lastly, there is no clinical study utilizing suture anchor fixation of the coracoid graft. The authors of the present study noted only one clinical case of recurrent instability with glenoid defect, which was treated with iliac bone graft fixation using the same suture anchor technique described here. In the short-term follow-up (6 months postoperatively), although there was a moderate degree of graft
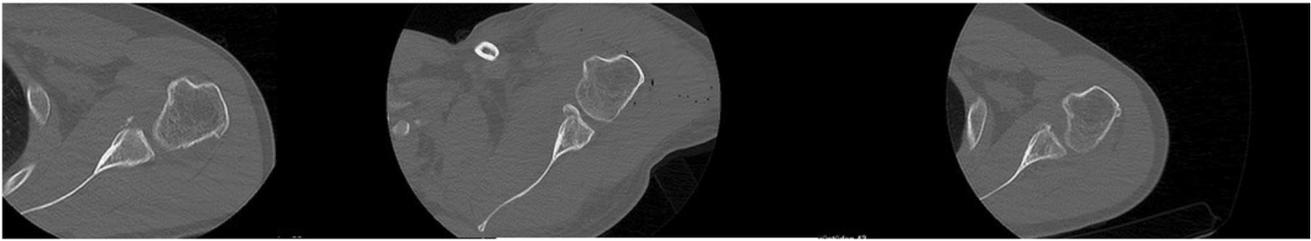
Fig. 3 Patient axial tomographs (pre-operative–post-operative and six-month post-op)

resorption, the patient was asymptomatic without any signs of instability (Fig. 3). Whether this graft resorption was due to the increased cyclic elongation in the anchor group (2.2 mm vs. 1 mm; screw group), although not statistically significant, it warrants further biomechanical and/or clinical studies that incorporate suture anchor fixation in the Latarjet procedure.

Conclusion

Suture anchor fixation of the coracoid graft, when compared to the traditional Latarjet procedure using screws, yielded no difference regarding the initial strength. Suture anchor usage may prevent complications associated with screw usage.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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