Interest of complementary inferior glenohumeral ligament fixation in capsulo-labral repair for shoulder instability: A biomechanical study

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Summary
Arthroscopic repair of Bankart lesions is part of the arsenal available to the shoulder surgeon to manage chronic anterior instability of the shoulder. Despite improvements in technique, rates of recurrence remain high. Some factors relate to the patients and their lesions, others to technique. The hypothesis that insufficient repair may be the cause of failure in Bankart arthroscopy was investigated in an anatomic and biomechanical study. Bankart lesions were made on 12 cadaver shoulders and repaired using two suture techniques. The aim was to investigate whether there was any biomechanical interest in reinforcing the labrum and capsule suture by a complementary inferior gleno-humeral ligament (IGHL) suture to double the labral repair. No significant difference in overall resistance was found between the two techniques. Failure generally started from the superior suture, and the present findings suggest that special attention should be paid to superior reinsertion. In the present model, complementary IGHL fixation did not alter the biomechanics of repair. Failure of repair can be traced to the superior suture.

Level of evidence: IV, biomechanical study.
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Introduction
40% of traumatic lesions of the shoulder involve dislocation and 80% of dislocations are anterior [1]. From the first episode, dislocation causes detachment of the antero-inferior capsulolabral complex, inducing the classic Bankart

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lesion [2,3]. This lesion in turn predisposes to recurrent dislocation, at higher rates in younger patients. Other dislocation risk factors include sport, level of sports activity, hyperlaxity and anatomic bone factors such as glenoid or humeral head fracture [4]. Despite increasingly precise patient selection, recurrence rates remain high [5–7]. One reason for this may lie in reconstruction techniques. Arthroscopic Bankart repair consists in labrum reinsertion, usually associated to capsule plication [8,9].

The present study investigated the possible biomechanical interest of reinforcing labrum and capsule suture by a complementary inferior gleno-humeral ligament (IGHL) suture to double the labral repair.

**Material and methods**

**Preparation of anatomic specimens**

Twelve fresh frozen shoulders were harvested from the Rennes University anatomy laboratory. The mean age of the six subjects was 79 years (range, 65–92 yrs). After 24 hours’ thawing at room temperature, the shoulders were prepared by withdrawing the deltoid and rotator cuff muscles. The scapula and proximal extremity of the humerus remained attached by the anterior capsule, labrum and posterior IGHL expansion. The posterior capsule was withdrawn. For purposes of manipulation, the acromio-clavicular joint and coracoid process were dissected in each specimen.

**Creation of Bankart lesion**

Bankart lesions were induced in each “humerus-capsule-glenoid” complex. The joint cavity was approached posteriorly and the GHLs were located by transillumination in the thickness of the capsule (Fig. 1). A Bankart lesion was then created at the anterior edge of the glenoid cavity by releasing the labrum and capsule in continuity with the anterior side of the glenoid. During release, the planned repair points were traced by dermographic pen on the labral and glenoid sides.

**Performance of two Bankart repair procedures**

Transglenoid fixation was preferred to anchoring so as to avoid bias due to sample bone quality. Using goniometry, three 1-mm bone tunnels were drilled at 3, 4 and 5 hours in each shoulder. Entry angles were identical in all tunnels, at 30° to the glenoid joint surface in both the anterior and approaches, and the tunnels terminated in the infraspinous fossa. Two loops of high resistance suture (FiberWire®, Arthrex, Naples, FL) were fed into each tunnel to repair the lesion. To prevent rupture by slippage and friction during tightening, the sutures were laid on a 1/3-cylinder plate in the infraspinous fossa (Fig. 2). To avoid variation due to tissue quality, the two types of reinsertion were compared in the two shoulders of a given subject. In the first of each pair of shoulders, two simple sutures in each glenoid reinsertion tunnel (at 3, 4 and 5 hours) were used to perform standard 6-point capsulolabral repair (Fig. 3). The same knot was used in all repairs: an “easy knot” (four slip loops) then four inverse loops to tighten. In each tunnel in the contralateral shoulder, suture associated simple capsulolabral suture and U-suture of the IGHL, 2 mm from the labrum, with mixed capsulolabral reinsertion using three simple sutures and three U-sutures of the IGHL (Fig. 4).

**Specimen fixation and biomechanical protocol**

The proximal extremity of the humerus was securely fixed in a steel cylinder with transfixing screws enabling rotation to be controlled. The base of the cylinder was designed so as to be able to place the humeral head in the dislocation posture of maximal external rotation and 60° abduction, ahead of traction tests. A traction support was designed for the study

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Figure 3 Repair model with 2 points for each one of three nivel of fixation.

Figure 4 Repair model with one single point and a U point on the capsule.

to ensure reproducible and comparable testing (Fig. 5). A plane articulated on an axis allowed scapula fixation. The plane could be set at the desired angle to the horizontal; on the plane, a half disk on a rotation axis gave a further degree of freedom for setting, so that the model enabled the successive anatomic preparations to be positioned freely in all three dimensions. For each test, the scapula was fixed, leaning on the suprascapular notch, using a bar to hold it against the disk. To prevent slippage, the scapular tip and spine were blocked by counterbraces on the disk. The adaptability of this traction support allowed bilateral testing, passing easily from the left to the right shoulder on a platform that was entirely symmetrical and reversible, and thus fully adaptable.

Thus, on each test, the glenoid cavity was vertical, with the humerus in 60° abduction and maximum external rotation. The traction axis systematically projected onto the center of the glenoid cavity.

Traction tests

Each preparation was assessed by an automatic traction device (Lloyd Instruments, LR 30K), with results computerized in real time. The data curve and corresponding table showed: the maximum traction (Newtons), the corresponding maximum extension (mm), and the force required to produce the first rupture in each preparation (Newtons). Each tested was filmed to enable analysis of: type of rupture, type of failure, and the chronological sequence of ruptures.

Statistical analysis

Student tests were used to compare mean resistance, maximum force and maximum stretch between the standard and mixed repair techniques. Chi² tests were used to compare rupture locations and types of rupture.

Results

Results are reported in Tables 1 and 2. There was no significant difference in resistance between the standard and mixed repair techniques. In most cases, simple knots stretched without the suture rupturing, and failure arose from loosening of the knot. U-knots, in contrast, stretched the capsule, inducing tear. In most tests, failure started from the superior stitch (see Table 2).

Discussion

Statistical power was limited by the small sample size. The maximum resistance values were notably lower than those reported by Clavert et al. (264 N) [6], although they used fewer suture points for capsulolabral repair. As in any anatomic biomechanical study, findings are to be assessed bearing in mind the age of the subjects and consequent tissue degeneration (loss of capsule elasticity). The design got round the issue of osseous failure (osteoporosis) by replacing suture anchors by transosseous sutures on a metal plate, enabling capsulolabral suture resistance to be tested with-
out risk of tearing out the bone fixation. Moreover, standard and mixed repair were compared in paired shoulders of a given subject, to limit tissue variation issues. Finally, measurement reproducibility was ensured thanks to a dedicated traction support which enabled scapula orientation and traction vector-force direction to be reproduced from assembly to assembly.

Associating U-suture of the capsule did not seem to increase overall resistance in Bankart repair. Standard deviations, however, were wide, precluding any definite conclusion. Despite this limitation, however, the present study does not bear out previous reports [9] of greater mechanical resistance with mixed reinserion in arthroscopic Bankart repair in thinner and more elastic capsules. The present model did not determine horizontal capsule tension, which is a key point in Bankart arthroscopy. The "easy knot" was used, because it is popular among the surgeons of this Symposium, despite there being few biomechanical studies of it.

The present study enabled analysis of the modality of failure of repair. In contrast to what is commonly reported [8,9], failure was not necessarily due to capsule tear, but could also be a matter of suture failure. In fact, in most cases, simple sutures stretched without the suture rupturing, and failure was due to loosening of the knot. The biomechanical resistance of the labrum is also very great: during traction, it was the knot that came undone, not the tissue that tore. U-sutures, in contrast, stretched then tore the capsule. The age of the capsules in the present series partially accounts for these findings. In most tests, failure started from the superior suture—a point which, to the best of our knowledge, has not previously been reported. There may be several explanations for this. IGHL structure varies from place to place, and is thinner in the superior than in the inferior part. Special attention should therefore be paid to this phase of arthroscopic repair, which is the last to be performed, raising a risk of negligence. The superior glenoid repair suture may be a key-point, from which rupture zips down, inducing successive strain on the lower stitches (Fig. 6).

Conclusion

There are many causes of failure in arthroscopic management of Bankart lesion. In the present biomechanical study, the model demonstrated the crucial role of the superior suture in arthroscopic labral repair. This suture locks the reconstruction, and seems to limit the risk of recurrence in abduction - external rotation. At least three fixation points should therefore be used for complete reconstruction of the labral and IGHL.

Conflict of interest statement

None.

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