Frog Glue Enhances Rotator Cuff Repair Ex Vivo

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Introduction: Current rotator cuff repair techniques include using transosseous sutures or suture anchors. The primary in vivo and ex vivo method of failure is at the tendon suture interface while the reported healing rate of rotator cuff repairs is variable, ranging from 10-80%. Surgical adhesives have the theoretical potential to enhance rotator cuff repair by minimising gap formation and increasing the tendon bone contact area.

In an attempt to increase the tendon-bone interface strength we investigated the addition of a novel adhesive secreted from a species of Australian frog (Notaden bennetti) to different methods of rotator cuff repair.

Materials and Methods: Rotator cuff repair model

The ultimate load to failure and energy maximum for different rotator cuff repair techniques was evaluated in a sheep infraspinatus tendon using a technique previously described in the literature. The sheep infraspinatus tendon was chosen for its biomechanical, anatomical and histological properties which are similar to human supraspinatus tendon. Each shoulder specimen was prepared by removing all tissue with the exception of the humerus and infraspinatus tendon. The infraspinatus tendon was sharply detached from its insertion site mimicking complete full thickness rotator cuff tear.

The tendons were detached perpendicular to the course of their collagen fibres to maximise tendon thickness at their distal aspect and optimise the homogeneity between the shoulder specimens. Any remaining soft tissue was removed from the tendons’ insertion site and the width and length of the infraspinatus tendon insertion site using a digital vernier calliper (Mitutoyo American, Aurora, IL).

The tendon repair involved reattaching the infraspinatus tendon using 3 different methods of fixation. Each tendon was reattached to its original footprint of the infraspinatus insertion site. All repair groups used a No 2 braided, non-absorbable polyester suture. One repair group used bone tunnels in which 2 sutures were passed transosseous through 4 bone tunnels. The suture knots were tied laterally over a bone bridge and bone troughs were noted used. The remaining 2 repair groups used 2 titanium alloy suture anchors, spaced between 8-10mm apart to secure the tendon to bone. One group used the Mitek RC® Quikanchor, (Mitek Surgical Products, Norwood, Mass) while the other used the metallic knotless suture anchor (Arthrocare Opus Magnum, Australia).

The following 6 repair techniques were tested to failure

1. Four bone tunnels, 2 sutures, mattress stitch configuration, n=7
2. Four bone tunnels, 2 sutures, mattress stitch configuration + Frog glue, n=7
3. Two Mitek RC® Quikanchors, 2 sutures (anchor single loaded), mattress configuration, n=7
4. Two Mitek RC® Quikanchors, 2 sutures (anchor single loaded), mattress configuration + Frog glue, n=7
5. Two Opus Magnum Anchors, 2 sutures (anchor single loaded), mattress configuration, n=7
6. Two Opus Magnum Anchors, 2 sutures (anchor single loaded), mattress configuration + Frog glue, n=7

Application of frog glue

To produce the frog glue from the dermal glands, the frogs were given an electrical stimulus to the dorsal skin from a Palmer square wave stimulator via bipolar electrodes.

The subsequent glue was then applied to the infraspinatus footprint with a metallic spatula and to the cut edge of the infraspinatus tendon.

Mechanical testing

Before testing, the specimens were thawed at room temperature and kept moist in gauze soaked in normal saline. The mechanical testing was performed using a mechanical tensile testing machine. The humerus was secured to the base plate with a screw (8mm diameter) and washer (25mm diameter). The infraspinatus tendon was secured with tendon grasping clamps that pulled perpendicular to the sagittal plane and parallel to the transverse plane of the tendon.

The tendon repair was tested in tension with the direction of pull 90º to the shaft of the humerus, simulating the position of the patients arm at their side. This is the arm position for which the maximum amount of tension crosses the rotator cuff repair.

The specimens were loaded at an extension rate of 25 mm/min and tested to failure with the data captured on a standard PC computer. The mode of failure was recorded for each shoulder.

Results: The infraspinatus tendon insertion site had a mean width of 16.4 ± 0.2mm and length of 13.2 ± 0.1mm. No statistically significant differences were identified between the 6 repair groups with respect to either the insertion sites width or length. All failures occurred as a result of the tendon pulling through the fixation devices. No failures resulted from the tendon slipping through the clamp or at the site between the humerus and the base plate.

The total energy required to break the constructs was 3 times greater in both suture anchor groups compared to transosseous suture repairs (p=0.001). There were no significant differences between the suture anchor repair groups with regard to load failure or total energy consumed. All repair groups failed as a result of the tendon pulling through the sutures. No tendon repairs failed by suture breakage or pulling out of bone.

The addition of frog glue resulted in a significant increase in load to failure in all the repair groups. There was a 2 fold increase in load to failure of tendons repaired with Opus Magnum (from 69 ± 6 N to 143 ± 8 N) and Mitek RC Fastin (from 50 ± 6 N to 165 ± 20 N) anchors while the transosseous repair had a 1.7 fold increase in its load to failure (from 50 ± 6 N to 86 ± 8 N).

Discussion: This data suggests that: (1) suture anchor fixation is a stronger construct requiring a larger amount of total force to fail than transosseous repair using a one suture repair technique, that (2) the addition of an adhesive to the tendon-bone interface significantly enhances both ultimate load and total energy required to failure in all repair types.

The unique properties of this frog glue (strong, flexible, sets in water and biocompatibility) may ultimately lead to the production of a useful adjunct for rotator cuff repair in humans.