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Double row equivalent for rotator cuff repair: A biomechanical analysis of a new technique

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ABSTRACT

Introduction: There are numerous configurations of double row fixation for rotator cuff tears however, there remains to be a consensus on the best method. In this study, we evaluated three different double-row configurations, including a new method. Our primary question is whether the new anchor and technique compares in biomechanical strength to standard double row techniques.

Methods: Eighteen prepared fresh frozen bovine infraspinatus tendons were randomized to one of three groups including the New Double Row Equivalent, Arthrex Speedbridge and a transosseous equivalent using standard Stabilynx anchors. Biomechanical testing was performed on humeri sawbones and ultimate load, strain, yield strength, contact area, contact pressure, and a survival plots were evaluated.

Results: The new double row equivalent method demonstrated increased survival as well as ultimate strength at 415N compared to the remainder testing groups as well as equivalent contact area and pressure to standard double row techniques.

Conclusions: This new anchor system and technique demonstrated higher survival rates and loads to failure than standard double row techniques. This data provides us with a new method of rotator cuff fixation which should be further evaluated in the clinical setting.

Level of Evidence: Basic science biomechanical study.

1. Introduction

The rotator cuff is essential to the shoulder's biomechanical functionality, making its anatomic reconstruction a necessary step to maximize shoulder mobility.[1,2] The goal of rotator cuff repair is to recreate the anatomic footprint of the shoulder thereby maximizing healing potential and ultimately preserving its function. Various double-row, transosseous-equivalent, and footprint-type repairs have been evaluated in an attempt to maximize the contact area and pressure at the tendon-bone interface. Prior biomechanical studies have shown the superior strength of the double row and transosseous techniques in vitro compared to single row techniques.[3–7] Additionally, studies have demonstrated improved clinical function and improved histologic healing in patients who underwent the double-row technique.[8–11] Although double row and transosseous-equivalent fixation have greater biomechanical strength, they also come at a higher cost due to increased anchor use.

A number of different suture configurations including simple, mattress, and Mason Allen have been evaluated to determine the strongest technique.[11] Burkart et al.[12,13] showed that a diamondback (transosseous) repair had the most strength. Additionally, numerous studies have demonstrated the importance of the medial row linkage for overall construct strength.[14,15] This new system creates an efficient method of forming the medial linkage while eliminating medial knots, thus allowing for a smooth interface at the tendon-suture junction. Despite constant innovation in rotator cuff repair technique, the question remains: which method provides the best footprint restoration, contact pressure, contact area, and strength?

While double row and transosseous systems require two medial and two lateral anchors with a minimum of four suture passes, the new double row equivalent system creates the same number of suture passes using only two anchors total. This is accomplished by creating two interconnected suture anchors via loops in the suture where neighboring suture can be shuttled. The new double row equivalent system

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Table 1
Testing groups. Significance set at $P < 0.05$. mm = millimeters.

Group	Fixation method	Number of Specimens	Average Tendon Thickness (mm)	p-value for tendon thickness (compared to Group C)
A	Trans-Osseous Equivalent #1	6	3.5	0.35
B	Trans-Osseous Equivalent #2	6	3.8	0.33
C	Double Row Equivalent	6	4.5	N/A

delivers an efficient method of providing a medial and lateral row with even tensioning throughout, lending the ability to maximize compression at the tendon-bone footprint.

The aim of the current study was to compare the biomechanical performance of a new double row equivalent system to that of two other linked and unlinked transosseous configurations. Our null hypothesis was that there would be no difference between the various fixation methods.

2. Materials and methods

Sixteen frozen bovine infraspinatus tendons were obtained and thawed. Bovine infraspinatus tendons have been used in a number of other rotator cuff biomechanical studies.[15–18] The tendons were prepared by removing all soft tissues, including muscle. The tendons were then bisected to create 32 specimens. The specimens were evaluated for homogeneity of structure and size and 18 of the most uniform tendon specimens were chosen for testing. At the anticipated suture site, thickness was measured and recorded for each tendon. Tendons were randomly assigned to Group A, Group B or Group C and these were subsequently divided into testing groups. Tendons from the same specimen were assigned to different test groups in an endeavor to control for differences in the size of the tendons. In addition, the surgeon was blinded to the selection of tendons for each group. No statistically significant difference in tendon thickness was observed between groups (Table 1).

Sawbones were used as surrogate humeri. The most distal 75% of the surrogate humerui were encased in epoxy resin in order to achieve greater purchase with test fixturing. Each specimen was fixed in the testing apparatus at a 30° angle from the horizontal.

A TekScan 4205 pressure sensor (TekScan, South Boston, MA) was used to measure contact pressure, which has been shown to be highly accurate in determining pressure and force under an object.[19] A 10 mm × 42 mm sensor was placed under the repairs. The sensor was pinned at one end of the humerus and taped on the other to prevent motion during testing.

The tendons were divided into one of three groups: the Trans-osseous Equivalent #1 (Arthrex SpeedBridge) in Group A, the Trans-osseous Equivalent #2 in Group B, or the new double row equivalent (Stabilynx) in Group C (Table 1, Fig. 1). Group A and Group B were knotless, whereas Group C used knots to secure fixation in the lateral row. Stabilynx medial row anchors were used in Group B in a knotless, linked configuration.

Eight points were marked along the repair site to measure gap formation, footprint strain, and musculotendinous strain during testing.

Video was taken for each group throughout cycling and testing.

3. Surgical technique

The new double row equivalent anchor system (Fig. 2) utilizes two anchors which are first placed at the same level in the anatomic rotator cuff footprint. Each anchor is double loaded with non-absorbable No. 2 braided polyester suture. A pass is made with one suture from either anchor approximately 5 mm medially into the rotator cuff. One of these sutures has a loop where the suture from the other anchor can be shuttled through. The suture with the loop is pulled, and the contralateral suture is shuttled through the path of that suture pass, then through the suture anchor thereby creating a knotless medial bridge. Next, the suture ends that remain are now each passed approximately 5 mm lateral to the anchors. The lateral suture ends are tied thereby creating a lateral knotted bridge in a double row configuration. The end result is a knotless medial bridge with a lateral knotted bridge over the rotator cuff tendon.

The lateral knot acts as the final tensioner. In this system, both the medial and lateral bridges are created using a single suture via the shuttling mentioned above in the technique. Given this, the two rows can be tensioned evenly whereas in the current systems, the medial and lateral rows are NOT interconnected and tensioned independently from another. This potentially leads to different contact forces over the footprint rather than a uniform, even tension.

The trans-osseous equivalent #1 was used with standard technique in Group A which includes two double armed medial anchors that are crossed and pulled down laterally with a knotless anchor. For trans-osseous equivalent #2 in Group B, the technique mirrored Group A with the exception of different medial anchors and an inclusion of a medial bridge. Two double armed medial anchors were placed, a knotless medial bridge was formed, then one arm from each anchor was crossed and all sutures were brought down to the greater tuberosity via knotless suture anchors. No medial bridge was created in Group A. There was a knotless medial bridge created in Group B. The new double row equivalent was performed in Group C to provide fixation and imitate

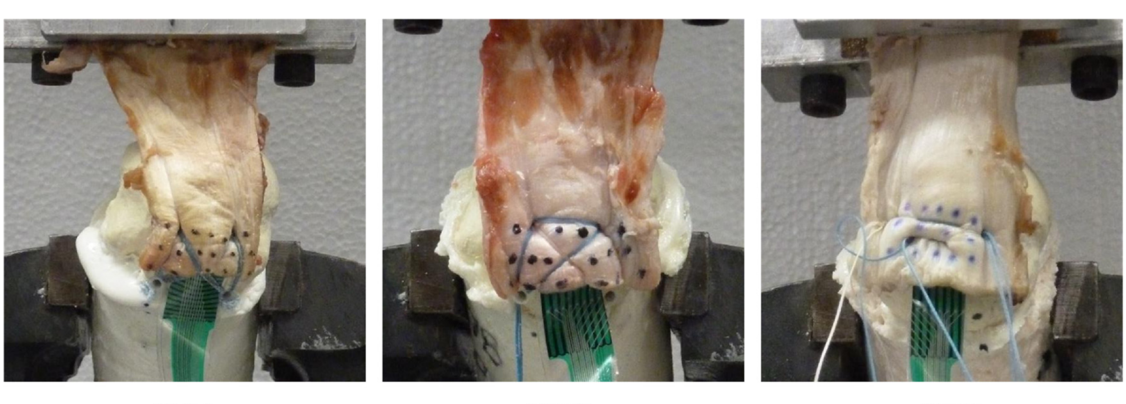

Fig. 1. Lab images of Group A–C Repair Contructs. Images are complete in-lab constructs prior to biomechanical testing. A –Trans-osseous Equivalent #1. B –Trans-osseous Equivalent #2. C –Double Row Equivalent.