Triple-Loaded Suture Anchors Versus a Knotless Rip Stop Construct in a Single-Row Rotator Cuff Repair Model

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Purpose: To compare the biomechanical properties of single-row repair with triple-loaded (TL) anchor repair versus a knotless rip stop (KRS) repair in a rotator cuff repair model. **Methods:** Rotator cuff tears were created in 8 cadaveric matched-pair specimens and repaired with a TL anchor or KRS construct. In the TL construct, anchors were placed in the greater tuberosity and then all suture limbs were passed through the rotator cuff as simple sutures and tied. In the KRS construct, a 2-mm suture tape was passed through the tendon in an inverted mattress fashion, and a free suture was passed medial to the suture tape to create a rip-stop. Then, the suture tape and free suture were secured with knotless anchors. Displacement was observed with video tracking after cyclic loading, and specimens were loaded to failure. **Results:** The mean load to failure was 438 ± 59 N in TL anchor repairs compared with 457 ± 110 N in KRS repairs ($P = .582$). The mean displacement with cyclic loading was 3.8 ± 1.6 mm in TL anchor repairs versus 4.3 ± 1.8 mm in the KRS group ($P = .297$). Mode of failure was consistent in both groups, with 6 of 8 failures in the TL anchor group and 7 of 8 failures in KRS group occurring from anchor pullout. **Conclusions:** There is no statistical difference in load to failure and cyclic loading between TL anchor and KRS single-row repair techniques. **Clinical Relevance:** KRS repair technique may be an alternative method of repairing full-thickness supraspinatus tendon tears with a single-row construct.

Double-row repair has optimized the biomechanical performance of rotator cuff repair with decreased gap formation, improved footprint coverage, and higher load to failure than single-row repair.[1,2] Unfortunately, poor tendon quality is discovered in approximately one-third of arthroscopic rotator cuff repairs.[3] In these scenarios, lateral tendon loss, poor tendon mobility, or medially based tears often preclude the ability to obtain double-row fixation.[4] Single-row repair is frequently performed in these settings but retear rates are up to 94% in large and massive tears.[5]

A variety of techniques have been proposed to improve fixation strength of rotator cuff tears.[6] One of the simplest methods is to increase the points of fixation via triple-loaded (TL) anchors as opposed to double-loaded anchors. Barber et al.[7] actually revealed that single-row repair with TL anchors was more resistant to stretching to a 5-mm and 10-mm gap than a double-row repair.

Another technique that can be used to improve fixation is to alter stitch configuration. The Mason-Allen stitch has been reported to have better holding power than simple sutures but is difficult to perform arthroscopically.[8] A "massive cuff" or "modified Mason Allen" suture configuration, in which a horizontal mattress

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suture is passed and then a simple suture from the same anchor is passed medial to the horizontal mattress has been reported by Baleani et al.[9] to have strength comparable to a traditional Mason-Allen stitch and stronger than simple or mattress suture configurations. This technique essentially creates a "rip-stop" whereby the medial suture limits cut-through of the simple suture. A follow-up biomechanical study by Barber et al.[10] showed greater ultimate mean failure load and footprint coverage with less rotational displacement in rip-stop double-row suture tape construct compared with a triple-loaded single-row repair.

Denard and Burkhart[11] and Burkhart et al.[12] developed the load-sharing rip-stop construct, in which 2 independent single-row constructs are linked together into a single composite overlapping double-row repair to achieve a stronger construct. However, this procedure is technically challenging, increases operative time, and involves complex suture management. A variation of this technique is to perform a knotless rip-stop (KRS) repair with only 2 suture anchors. This technique eliminates knot tying, decreases the anchor burden, but still uses a 2-mm suture tape, which may decrease the risk of tissue cut-through.[13]

The purpose of this study was to compare the biomechanical properties of single-row repair with TL anchor repair versus a KRS repair in a rotator cuff repair model. Our hypothesis was that KRS constructs would reveal equivalent load to failure and cyclic displacement to TL anchor repairs.

Methods

Sixteen fresh-frozen cadaveric shoulders (8 matched pairs) were used for this study. Institutional review board approval is not required for cadaveric studies at our institution. The overlying skin and deltoid were removed. The rotator cuff muscle was sharply elevated from the scapula. The humerus was sectioned in the mid-diaphysis and potted. Beginning anteriorly at the bicipital groove, the supraspinatus tendon insertion was sharply elevated off the greater tuberosity to create a complete full-thickness supraspinatus tendon tear. The cadavers were randomized to repair with either a KRS or TL anchor repair. The senior author (P.J.D.) performed the assessment of the cadaveric specimens.

TL Anchor Repair

In the TL anchor repair, two 5.5-mm suture anchors (BioComposite Corkscrew FT, Arthrex, Naples, FL) triple-loaded with high-strength No. 2 suture (FiberWire) were placed adjacent to the articular margin of the humerus. The first anchor was placed 5 mm posterior to the bicipital groove, and the second anchor was placed 15 mm posterior to the first anchor. Suture limbs from the 2 anchors were passed through the rotator cuff 1 cm medial to the lateral cuff margin as simple sutures using an antegrade suture passer. A total of 6 suture limbs were passed (3 from each anchor). The simple stitches were then hand tied with a 6-throw surgeon's knot using 3 half-hitches in the same direction followed by 3 alternating half-hitches (Fig 1).

Knotless Rip-Stop Repair

The second repair was the KRS construct. In this repair, the sutures were placed prior to anchor placement. A 2-mm suture tape (FiberTape; Arthrex) was placed as an inverted mattress stitch in the rotator cuff, 1 cm medial to the lateral tendon edge. The suture was passed with 1 cm of spacing between the suture limbs. Next, a cinch suture (FiberLink; Arthrex) was passed just medial to the inverted mattress suture tape. A second construct (suture tape and cinch suture) was then placed. Next, the suture tape and cinch suture limbs were then secured to the greater tuberosity with 2 knotless anchors (5.5-mm BioComposite SwiveLock C; Arthrex). Each suture tape/cinch loop construct was secured independently with a 5.5-mm knotless anchor, with anchors placed in a position identical to that used in the TL anchor technique (Fig 2).

Biomechanical Testing

Mechanical testing was performed using an Instron 8871 (Instron, Norwood, MA) with a 5-kN load cell secured to the crosshead (Fig 3). To mimic the physiologic pull of the superior rotator cuff, the humerus was secured to the testing surface by use of a fixed angle clamp that was oriented such that the direction of the pull would be 45°. The supraspinatus muscle belly was secured to the crosshead by use of a custom interdigitating freeze clamp. Displacement was measured from the first cycle to the last cycle by use of a digital video camera and optimal tracking software. A digital video camera (GR-DV3000; JVC, Wayne, NJ) and MaxTraq software (Innovision Systems, Columbiaville, MI) were used to optically measure displacement. Videotaping occurred during the first 20 and the last 20 cycles of the loading period.

Specimens were loaded to a 10-N preload, followed by cyclic loading between 10 and 100 N at 1 Hz for 200 cycles. Load and displacement data were recorded at 500 Hz. Based on previous studies, failure during cyclic loading was defined as 5 mm of displacement.[14] Initial onset of failure was defined as 0.5 mm of displacement without increase in load. After cyclic loading, ultimate load to failure testing was conducted at 33 mm/s.

Statistical Analysis

Continuous data were described by mean and standard deviation. A paired t test was used to analyze the difference between TL anchor repair and KRS groups. Significance was set at $P < .05$ for statistical analysis.