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# A Laboratory Comparison of a New Arthroscopic Transosseous Rotator Cuff Repair to a Double Row Transosseous Equivalent Rotator Cuff Repair Using Suture Anchors

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## Abstract

**Background:** *Because current instrumentation makes it possible to perform an arthroscopic transosseous rotator cuff repair, we performed a biomechanical comparison of a double-row transosseous equivalent rotator cuff repair using suture anchors to an arthroscopic, transosseous rotator cuff repair to determine if they provided similar fixation stability.*

**Methods:** *Six pairs of shoulders were used. One of each pair had a standard double row, transosseous equivalent arthroscopic rotator cuff repair using a suture-bridge technique with suture anchors, and the other had an arthroscopic transosseous repair using an Xbox technique. The repairs were cycled at 150 N for 10,000 cycles with movement of the lateral cuff edge recorded and then tested to failure.*

**Results:** *The total cuff edge displacement at 10,000 cycles in the anchor group (transosseous equivalent repair) was 7.9 mm and 6.3 mm for the bone tunnel group (transosseous repair); these were not significantly different ( $p = 0.19$ ). The anchor group failed at an average of 309 N and the bone tunnel group at an average of 339 N ( $p = 0.22$ ).*

**Discussion:** *Biomechanical testing suggests that arthroscopic, transosseous rotator cuff repair using a Xbox suture configuration is similar in strength and stability to an arthroscopic transosseous equivalent suture-bridge repair. Both techniques demonstrated difficulty in maintaining the lateral position of the tendon.*

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With the advent of newer techniques and technologies, arthroscopic rotator cuff repairs have become the treatment of choice for surgical intervention as opposed to more traditional open or semi-open techniques. With an increasing interest in healthcare costs, recent studies have shown that increases in the costs of rotator cuff repair surgery are attributable, in part, to implantable devices, specifically suture anchors.<sup>1,2</sup> This has led to renewed interest in anchorless repair constructs, such as the traditional transosseous repair, as newly available instrumentation have made it possible to accomplish this arthroscopically at a potentially lower cost.

A number of biomechanical studies have previously used the traditional, open or semi-open, transosseous repair as a “gold standard.”<sup>3-8</sup> Recently, Bisson and coworkers have shown it to be similar in fixation strength and stability to a suture-bridge technique using anchors.<sup>3</sup> The purpose of this study is to mechanically compare a current, double row, arthroscopic transosseous equivalent rotator cuff repair (suture-bridge) to a new, arthroscopic, transosseous rotator cuff repair (Xbox). We hypothesized that the transosseous equivalent repair would have similar fixation stability as the transosseous repair.

## Materials and Methods

Six matched pairs of fresh, frozen cadaveric shoulder specimens were obtained. The specimens were four female and two male with an average age of 54 years (range: 21 to 73 years). The specimens were thawed to room temperature. Inspection revealed no evidence of gross rotator cuff injury or greater tuberosity abnormalities. The supraspinatus muscle and tendon were sharply dissected free from the scapula and the tendon sharply detached from the greater tuberosity. A fine rasp was used to abrade soft tissue off the greater tuberosity while leaving cortical bone intact. The humerus was cut at least 10 cm from the surgical neck to

allow eventual potting for biomechanical testing. The specimen was kept moist with saline gauze during all phases of dissection, preparation, and testing.

### Repair Technique

The order of repair techniques for each pair was randomized. One shoulder had a standard double row transosseous equivalent arthroscopic rotator cuff repair using a suture-bridge technique and the other had an arthroscopic, transosseous repair using a Xbox technique. All knots were tied with a sliding double half-hitch, followed by alternating simple half-hitches for a total of five throws.

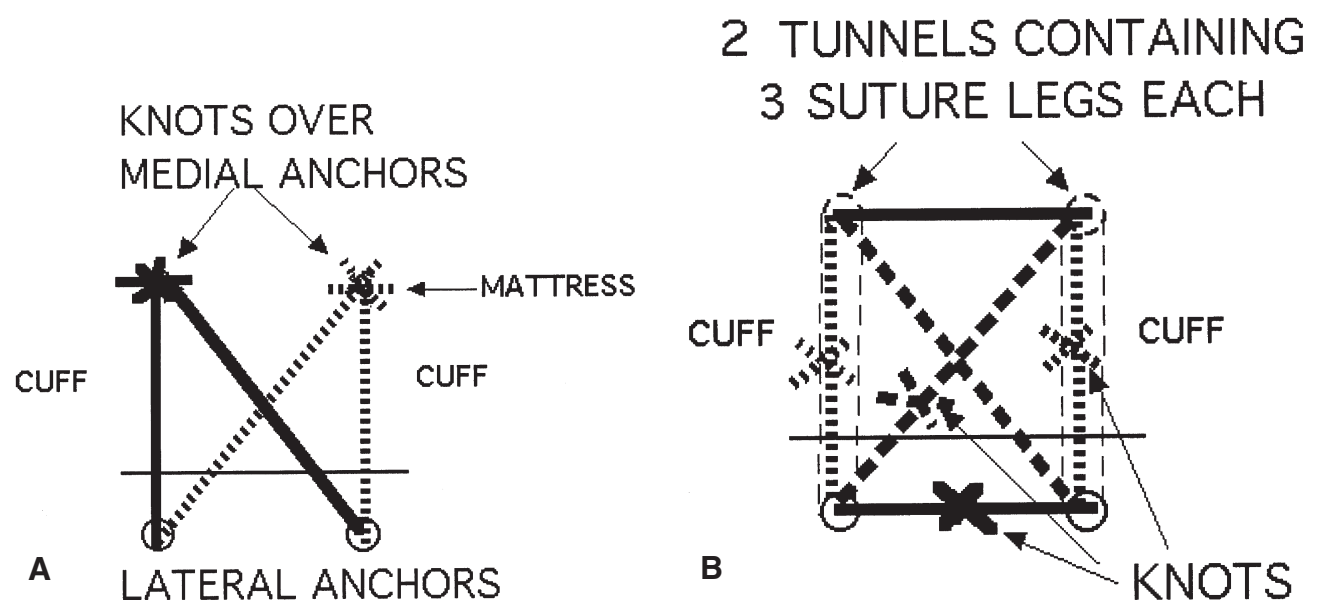
### Suture-bridge Repair

Two medial holes were punched at the medial edge of the greater tuberosity footprint. The most anterior anchor was placed 5 mm posterior to the sulcus of the bicipital groove. The second anchor was placed 12.5 mm posterior to the first anchor. The 4.5 mm BioComposite fully threaded suture anchors loaded with No. 2 FiberWire® (Arthrex, Naples, FL) with the corresponding punch were used. All holes were placed at a 45° angle relative to the footprint surface. A DePuy Mitek ExpresSew® (Raynham, MA) was used to uniformly pass the sutures medially to create two horizontal mattress stitches. This created suture passes through the tendons that were 13 mm medial to the lateral edge to allow complete coverage of the footprint. The suture passes were approximately 7 mm apart, centered over each corresponding anchor. The two medial mattress stitches were tied. Two holes were punched 1 cm distal to the lateral edge of the footprint, each in-line with the medial suture anchors. The punch for the 4.75 mm Bio-Swivelock® (Arthrex, Naples, FL)

was used. A suture limb from each medial mattress stitch was treaded into each of the two 4.75 mm Arthrex Bio-Swivelocks® knotless anchors that were placed laterally. Maximal suture tension was manually applied to the free suture ends, and the lateral anchors were then driven into their respective holes. The cost of these four anchors at our institution was approximately \$1,200.

### Arthroscopic Transosseous Repair

Two medial holes were punched at the medial edge of the greater tuberosity footprint using the 2.9 mm punch from the Tornier® Arthrotunnel® set. This is a single use set costing approximately \$550 that assists in arthroscopic osseous tunnel preparation and in suture passing. The most anterior hole was placed 5 mm posterior to the sulcus of the bicipital groove. The second hole was placed 12.5 mm posterior to the first hole. The holes were placed at a 90° angle relative to the footprint surface. The Tornier® Arthrotunnel® (Edina, MN) guide was placed in the medial holes sequentially to allow drilling using a Tornier® Arthrotunnel® 2.5 mm drill bit. This drill bit created a lateral hole that connected orthogonally with the medially drilled hole in order to create two separate transosseous tunnels. The Tornier® Arthrotunnel® suture stick was inserted into the guide to facilitate shuttling a passing suture in each tunnel. A DePuy Mitek ExpresSew was then used to shuttle these passing sutures through the tunnels and the cuff (13 mm from its lateral edge). Three No. 2 FiberWires® were then pulled with the passing suture through the anterior tunnel and through the cuff. The second passing suture pulled two of the suture limbs from the initial tunnel and an additional suture through the cuff and the posterior tunnel. The ap-



**Figure 1** A, Transosseous equivalent, suture-bridge repair. B, Transosseous, Xbox repair.

appropriate suture ends were carefully selected then tied. This created a suture “Xbox” configuration as described by Gartsman.<sup>9</sup> This consists of four simple stitches, one over each transosseous tunnel, and two between their ends making a “box” and a “X” stitch (Fig. 1B).

### Biomechanical Testing

Specimens were potted in 5 cm diameter metal pipes using a two-part polyester resin; the pipes then secured to the MTS machine using a vise. The lateral tendon edge and medial tendon were marked by inserting two parallel 25 gauge needles approximately 1 cm apart: one into the bone just lateral to the tendon and the other into the body of the tendon just above the suture crossing (to prevent restriction of movement) and the initial pin. The position of these needles was used to calculate medial displacement of the tendon (some studies refer to this as gapping). Digital photographs were taken at specific test stages and measurements between the needle insertion points at the tendon and bone were made using a digital caliper (the needle plastic bases served as a reference dimension). These reference points were not affected if the needle tilted within the tendon. The tendon was then secured to the testing apparatus using a specially fabricated soft tissue clamp. Specimens were mounted to recreate a standard 45° abduction angle with in-line pull and initial pin positions determined. The repairs were then cyclically loaded to 150 N at 2.5 Hz. Pin displacement measurements were taken at 1, 10, 100, 1 K, and 10 K cycles. Load to failure (inability to sustain the applied load) was then performed at a rate of 1 mm/sec. Student's t-test was used to calculate statistical significance. A p

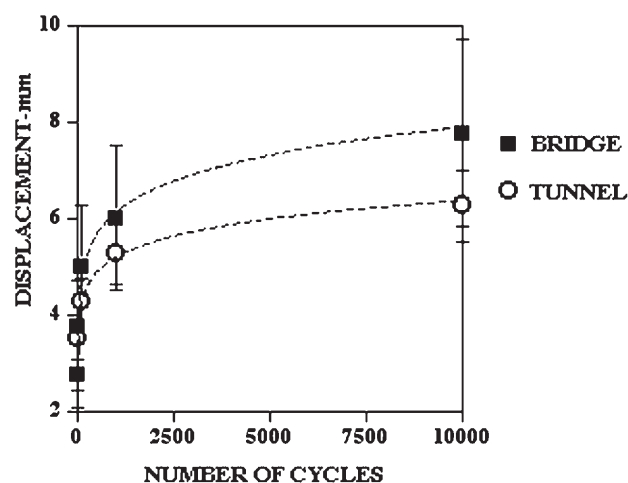
value of  $< 0.05$  was used for significance. Power analysis was performed using the same significance.

### Results

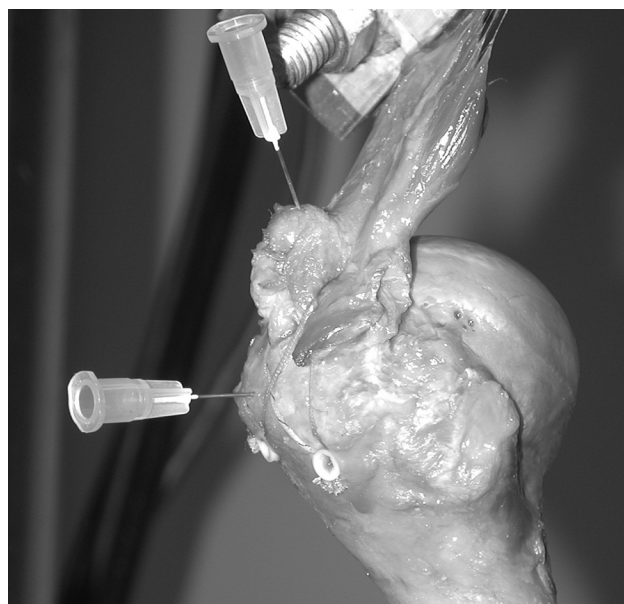
No specimens failed catastrophically during the cyclic loading portion of the experiment. The medial displacement in the anchor group (transosseous equivalent repair) was 2.6 mm (range: 1.4 to 3.7 mm) after the first cycle and in the bone tunnel group (transosseous repair) was 2.7 mm (range: 1.5 to 3.9 mm), which were not statistically different ( $p = 0.53$ ). The medial displacement between the first and last cycles in the anchor group (transosseous equivalent repair) was 5.3 mm (range: 2.5 to 9.4 mm) and 3.6 mm (range: 2.3 to 4.6 mm) in the bone tunnel group (transosseous repair) that were not statistically different ( $p = 0.19$ ). The power analysis indicated that 12 pairs would be needed to show significance with 95% confidence. The majority of medial displacement of the tendon occurred within the first 100 cycles, and this is evident in Figure 2. Figure 3 shows that the total amount of tendon movement medially at 10,000 cycles could compromise the original “footprint.”

The anchor group failed at an average of 309 N (range: 208 to 415 N), and the bone tunnel group failed at an average of 339 N (range: 259 to 445 N). This difference was not statistically significant ( $p = 0.22$ ). The power analysis indicated that 13 pairs would be needed to show significance with 95% confidence.

For the anchor group, two specimens failed by suture cut-out from tendon, one specimen by medial anchor pullout and lateral suture pullout, and three specimens by medial suture breakage and lateral suture pullout from anchors. In the bone tunnel group, three specimens failed by suture cut-out from



**Figure 2** Medial displacement of tendons (mm) for the two repairs as a function of loading cycles.



**Figure 3** Suture-bridge repair following 10,000 loading cycles. Marker needles started out parallel and close together (infrapinatus to left of repair).

tendon; three specimens failed by suture breakage at knots.

## Discussion

Our study suggests that there is no difference in fixation strength between these two arthroscopic repairs. There appeared to be less tendon displacement for the bone tunnel group after cycling; however, a power analysis revealed that at least six additional matched pairs would be needed to determine if this observation was statistically significant. Our data also suggests that suture cut-through of bone was not a significant cause of repair failure based on evaluation of the modes of failure. The bone tunnel groups failed by either suture cutting through the tendon or suture failure; no cutting of the bone at the tunnel ends was observed. It should be noted that although the suture patterns for both techniques are similar; the Xbox has a single medial, horizontal limb, whereas the suture-bridge has two horizontal mattresses of about the same length.

Biomechanical studies regarding the superiority of anchors versus bone tunnels have been mixed. Some studies have demonstrated superior<sup>4,7</sup> or equivalent<sup>5,8</sup> results with transosseous repair. Others studies have shown suture anchors to be superior.<sup>6</sup> Although Bisson's study<sup>3</sup> had a conclusion similar to ours, they found greater failure strengths for both techniques that were probably due to their using six anchors for the bridge technique and adding two anchors to the tunnel technique. One of the major problems previously seen with the transosseous technique has been suture cut-through the bone tunnel wall or suture abrasion by fretting against the bone. It is possible that the three sutures through each tunnel in this current technique share the load on the tendon and thus reduce the local stress at the bone interface; FiberWire® is also more resistant to abrasion by the bone than polyester sutures.

We have some concern about the amount of tendon movement that was observed. This disrupts the footprint contact area and could affect healing. Others have seen this type and similar amounts of movement in other testing models.<sup>3,7,10,11</sup> It appears that relying on the suture legs to provide fixation by compressing the lateral tendon to the bone is not sufficient and that some other means of fixation here would be more desirable.

Limitations of this study include small sample size and age of the specimen donors. The ability of a single biomechanical test model to accurately represent the clinical condition is always limited to some extent. In this case, we used open repairs rather than arthroscopic repairs to facilitate specimen preparation. The two suture techniques in this study are fairly complex; cuff repairs using either anchors or bone tunnels can also use different suture leg configurations that are simpler and more easily tied. Other factors, such as suture materials, the manner in which suture is passed

through the tendon, anchor types, and anchor sizes, can also affect fixation stability.

## Conclusion

This biomechanical testing suggests that arthroscopic, Xbox transosseous rotator cuff repair is similar in strength and stability to an arthroscopic transosseous equivalent, suture-bridge repair using suture anchors. It has a potentially lower cost. Both techniques had difficulty maintaining the position of the lateral edge of the tendon.

## Conflict of Interest

None of the authors have received outside funding for this research nor have any financial interest in the results of this study; none are consultants nor have any financial relationships to the companies cited in this article.

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