A Biomechanical Analysis of Point of Failure during Lateral-Row Tensioning in the Transosseous-Equivalent Rotator Cuff Repair Model

ABSTRACT

Purpose: The purpose of this study is to determine the maximum load to failure of the construct while tensioning the lateral row of a TOE repair model.

Methods: In 6 fresh-frozen human shoulders, a TOE rotator cuff repair was performed, with one suture limb from each of two medial anchors pulled laterally across the tendon. After preparing the lateral bone for anchor placement, the two limbs were passed through the PEEK eyelet of a bioabsorbable knotless anchor and tied to a tensiometer. The lateral anchor was placed into the prepared bone tunnel but not fully seated. Tensioning of the lateral row repair was simulated by pulling the tensiometer to tighten the suture limbs as they passed through the eyelet of the knotless anchor. The mode of failure and maximum tension were recorded. The procedure was then repeated for the second lateral row anchor.

Results: Each of the twelve constructs failed at the eyelet of the lateral anchor prior to any failure at the medial row. The average load to failure during lateral row placement in the TOE model was 80.8 ± 21.0 N (median= 83N, range= 27.2N – 115.8N).

Conclusions: Our results suggest the medial row repair does not appear “at risk” when tensioning the lateral row of a TOE rotator cuff repair. However, surgeons should exercise caution when tensioning the lateral row, especially when utilizing lateral row anchors with PEEK eyelets.

Clinical Relevance: Although the medial row is not at risk during lateral row tensioning of a TOE rotator cuff repair, PEEK eyelets appear to be at risk for early failure.

Introduction:

Arthroscopic rotator cuff repair has been successful in improving function and decreasing pain in patients with full thickness rotator cuff tears. However, some patients continue to have inferior results, typically due to failure of the repair.1,2,3,4,5,6,7,8  To improve clinical outcomes by decreasing re-tear rates, recent efforts have focused on improving the biomechanics and biology of tendon-to-bone healing.1,9,10,11 Differing anchor and suture repair techniques, including transosseous repair, single and double row constructs, and the transosseous-equivalent (TOE) repair have been studied to determine which of these best recreates a biomechanically superior footprint.12,13,14,15,16,17  Park and colleagues have shown that the arthroscopic TOE repair technique provides the highest pressurized coverage footprint area and is biomechanically superior to the double row repair. In their study, 77.6% of the anatomic footprint had pressurized coverage with the 4-strand TOE repair model in comparison to 39.6% of the footprint for the double-row construct. The mean load-to-failure of the TOE repair was 443N, which was significantly greater than the mean load-to-failure of the double-row repair, 299N.18,19

The arthroscopic transosseous-equivalent (TOE) rotator cuff repair technique was developed in an attempt to optimize the potential for healing of rotator cuff repairs by improving contact area dimensions and footprint pressures between the tendon and tuberosity. This is especially important for larger tears with poor tissue quality and tendon retraction.3,18,19 One version of the TOE construct- the Suture BridgeTM- consists of two medial row anchor sutures tied in a horizontal mattress pattern, and then “bridged” across the tendon by pulling the sutures over the tendon laterally. The sutures are then anchored into the bone with a second row of lateral, knotless anchors.

Despite the proven biomechanical and potential clinical benefits of the TOE repair model, it is unknown whether excessive strain occurs at the medial row construct during tensioning of the lateral row sutures. Possibilities for failure include medial anchor pullout, suture cut-out through the tendon, and suture cut-out through the anchor. Moreover, there is also the potential for lateral anchor failure during lateral row tensioning. Studies have estimated the force applied to the sutures during placement of the lateral anchor of the TOE repair19, but to our knowledge, no studies currently document the maximal manual tension to failure or the failure mechanism during tensioning of the lateral row sutures.

The purpose of this study is to determine the real-time maximal manual load-to-failure as well as the mechanism of failure during tensioning of the lateral row sutures in a TOE construct. We hypothesize that the medial row construct will fail during maximal load-to failure tensioning of the lateral row sutures.

Materials and Methods:

Six fresh-frozen human shoulders were initially obtained (average age 76.8, 4 male and 2 female). After thawing, dissection removed all soft tissues from the scapula and humerus except the rotator cuff myotendinous units, the tendon of the long head of the biceps and the joint capsule. The humeral shaft was cut 15 cm distal to the inferior edge of the articular surface and immobilized with the scapula (Figure 1A). The supraspinatus tendon was isolated and its entire insertion was sharply dissected from its anatomic footprint. The anterior-medial anchor position was marked 5mm posterior to the bicipital groove and just lateral to the articular cartilage. The posterior-medial anchor position was then marked 12.5 mm posterior to the anterior-medial mark with the use of a caliper, again just off the articular cartilage. The distal 10 mm of the supraspinatus tendon was sharply excised to replicate a rotator cuff tear, and the footprint was treated with a fine rasp. This technique is in accordance with the protocol described by Park et al.18,19

Two 5.5 mm titanium suture anchors loaded with #2 Fiberwire (Corkscrew, Arthrex Corporation, Naples, FL) were inserted at a 45⁰ angle relative to the long axis of the humeral shaft (Figure 1B). Utilizing an arthroscopic suture passer (Scorpion, Arthrex, Naples, FL) the anchor sutures were then passed through the tendon in a horizontal mattress configuration 5-7 mm apart, centered over each corresponding anchor. A surgeon’s knot and then three alternating half-hitches were used to secure each mattress suture. Two limbs, one from each of the two medial anchors, were then pulled together laterally over the tendon substance, creating the suture bridge pattern.

The two suture strands were passed through the PEEK eyelet of a 4.5mm knotless anchor (Bio Pushlock, Arthrex Corporation, Naples, FL) and then secured to the tensiometer (Dillon GL-500N, Dillon, Fairmont, MN) with a locking knot (Figure 1C). The placement of the knotless anchor was measured 1 cm distal to the lateral-most edge of the footprint in line with the medial anchors. The lateral row bone was prepared with a tap to the appropriate depth. The knotless anchor was then placed into position but not fully seated, and the tensiometer was then manually pulled to simulate tensioning of lateral row sutures (Figure 1D). The tensiometer was pulled until construct failure, noting the mode of failure and the maximal force applied. This was then repeated for the second of the two lateral anchors if possible, depending on the mode of failure of the first trial. If this was not possible, more cadaveric specimens were available to increase the number of specimens tested. The medial row anchors were both carefully inspected for any signs of implant loosening, suture loosening or gap formation. The initial lateral anchor (anterior versus posterior) tested for each specimen was randomly assigned.

Failure loads for lateral row tensioning from the anterior and posterior anchors were compared using a Wilcoxon signed rank test for matched pairs. This non-parametric alternative to the paired t-test does not assume normally distributed differences between pairs, and so is preferable for our data because of the small sample size (n = 6 pairs). A sample size of 6 specimens is in accordance with other similar studies, including that by Park et al.18,19 The null hypothesis of the Wilcoxon signed rank test is that the median difference between pairs of observations (i.e. the load-to-failure of lateral row tensioning from the anterior and posterior anchors) is zero. Data analysis was done using SAS 9.2 software (SAS Institute, Cary, NC).

Results:

All failures occurred through the PEEK eyelet of the lateral knotless anchor. After retrieving the eyelet from the trials, it was evident that the suture had cut through the eyelet during lateral row tensioning. There were no failures of the medial anchors or medial suture cut-out through the rotator cuff tendon during lateral row tensioning. There was no difference in failure load between anchor positions, regardless of which was tested first.

Individual and composite results for the mean, median, and range of load to failure are reported in Table 1. The overall mean load to failure was 80.8 ± 21.0 N and the overall median load to failure is 83.0 N (range: 27.2 – 115.8 N). The result of the Wilcoxon signed rank test revealed a *p-value = 0.84*, thus there is no statistically significant difference between the load-to-failure during lateral row tensioning for the anterior and posterior anchors.

Discussion:

Our results clearly indicate the PEEK anchors are the weak link of the TOE construct, as these anchors failed at a mean of 81N. During tensioning of the lateral row of a TOE repair, the medial row is possibly at risk for loosening or failure. The most informative comparison would be to compare the mean load to failure while tensioning the lateral row in our study (81N) to the pullout loads for the medial anchors. Pietschmann et al published pullout data on comparable anchors in both normal and osteopenic bone. These values were in the 200N range for normal bone and 150N for osteoporotic bone.20 Tingart and colleagues studied the pullout values in different areas of the proximal humerus, finding that the pullout values varied depending on the region of the greater tuberosity, but were all greater than 170N.21 Based on this data, one would not expect the medial row to fail during lateral row tensioning unless forces near or above 150N were generated. The highest force we generated in any of the specimens was 115N. All the constructs failed at the lateral eyelets at far lower force than the typical pullout strength for the medial anchors, even in osteoporotic bone, indicating that there is a very low chance of compromising the medial row of anchors during tensioning of the lateral row. As a side note, after the second trial of the lateral anchors on each specimen, we also tested manual pullout strengths of the medial anchors and were unable to pull out any of the medial anchors by hand, even after generating forces in the low-300N range.

Based on our results, the surgeon should exercise caution during tensioning of the lateral row sutures in a Suture BridgeTM TOE construct to prevent failure of the lateral row construct. As discussed, the estimated tension applied to the lateral sutures during a TOE repair is 40N18. In our study, construct failure occurred at an average of 81N during tensioning of the lateral row with the eyelet from the lateral anchor being the failure point in every instance. It is important to note that no studies have quantified the precise intraoperative forces applied to the suture during lateral row tensioning and the value of 40N is simply an estimate surmised by Park and colleagues18. Our results have clear clinical implications: over-tensioning of the lateral row during a TOE repair could potentially lead to lateral eyelet failure and the subsequent compromise of the entire contruct.

Of note, the posterior anchor in specimen #6 failed at only 27.2N, significantly lower than all other specimens. During review of this trial, we were unable to identify any sources of error to explain this significant outlier. One explanation may be a defect in the eyelet during manufacturing or packaging. Alternatively, the investigators may have inadvertently damaged the eyelet prior to employing it. Considering this value is far below the mean failure load for our study and the estimated "normal" tension, surgeons should be aware of the possibility of eyelet failure even at lower levels of tensioning.

Our results indicate the potential need for ongoing improvements in the technique and implants utilized during TOE repair. Stronger biomaterials (especially in the eyelets) that can withstand more force may help eliminate intraoperative failure of the lateral row construct. Intraoperative tensiometers can also be developed to measure the actual tension being placed on the sutures and the eyelet during lateral row tensioning. Finally, as TOE techniques evolve, more experience with the procedure should serve to decrease the chance of intra-operative complications.

There are obvious limitations to this study. It is possible that our results may have been different if performed on in vivo specimens. However, our intention was to develop a laboratory scenario most similar to in vivo conditions. There are several variables which could have been controlled. We could have standardized the depth of the lateral anchor, since it's depth could vary considerably with increasing tension (as the tension on the suture increases, the anchor tends to back out of the tapped hole, requiring the surgeon to push against this increasing resistance). This very well may have created a pistoning or saw-like effect, leading to eyelet failure. However, this same phenomenon is possible during actual surgery, which our study aimed to emulate.

Secondly, while tensioning the lateral row construct, for each lateral anchor both suture limbs were tied to the tensiometer effectively pulling both sutures at the same time. Per the manufacturer’s technique guide, the lateral strands can be tensioned together or separately. It is possible that the results may have been different if each suture limb was tensioned individually. Finally, our results indicate that on average, construct failure occurred at approximately 81N during tensioning of the lateral row. The apparent implication would be to not over tension the lateral row. The question then remains, how is the surgeon to know how much tension is required when pulling the lateral row construct intraoperatively? Unfortunately, currently there is no clear answer for this. As a general note, we noted the subjective force required to generate eyelet failure was significantly more than what would be typically applied in the operating room. Nonetheless, our data indicate that surgeons should be mindful of the force applied to the lateral row of a Suture BridgeTM TOE repair, especially when using PEEK eyelets in the lateral row anchor.

Conclusion:

Our results suggest the medial row repair does not appear “at risk” when tensioning the lateral row of a TOE rotator cuff repair. However, surgeons should exercise caution when tensioning the lateral row, especially when utilizing lateral row anchors with PEEK eyelets.

References:

1. [Boileau P](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Boileau%20P%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Brassart N](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Brassart%20N%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Watkinson DJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Watkinson%20DJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Carles M](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Carles%20M%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Hatzidakis AM](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Hatzidakis%20AM%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Krishnan SG](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Krishnan%20SG%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus) Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? [J Bone Joint Surg Am.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Am.');) 2005 Jun;87(6):1229-40.

2. [DeFranco MJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22DeFranco%20MJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Bershadsky B](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Bershadsky%20B%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Ciccone J](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Ciccone%20J%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Yum JK](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Yum%20JK%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Iannotti JP](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Iannotti%20JP%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Functional outcome of arthroscopic rotator cuff repairs: a correlation of anatomic and clinical results. [J Shoulder Elbow Surg.](javascript:AL_get(this,%20'jour',%20'J%20Shoulder%20Elbow%20Surg.');) 2007 Nov-Dec; 16(6):759-65.

3. Frank JB, ElAttrache NS, Dines JS, Blackburn A, Crues J, Tibone JE. [Repair site integrity after arthroscopic transosseous-equivalent suture-bridge rotator cuff repair.](http://www.ncbi.nlm.nih.gov/pubmed/18658021?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DefaultReportPanel.Pubmed_RVDocSum) Am J Sports Med. 2008 Aug; 36(8):1496-503.

4. [Huijsmans PE](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Huijsmans%20PE%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Pritchard MP](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Pritchard%20MP%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Berghs BM](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Berghs%20BM%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [van Rooyen KS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22van%20Rooyen%20KS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Wallace AL](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Wallace%20AL%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [de Beer JF](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22de%20Beer%20JF%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Arthroscopic rotator cuff repair with double-row fixation. [J Bone Joint Surg Am.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Am.');) 2007 Jun; 89(6):1248-57.

5. [Lafosse L](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Lafosse%20L%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Brozska R](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Brozska%20R%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Toussaint B](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Toussaint%20B%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Gobezie R](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Gobezie%20R%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). The outcome and structural integrity of arthroscopic rotator cuff repair with use of the double-row suture anchor technique. [J Bone Joint Surg Am.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Am.');) 2007 Jul; 89(7):1533-41.

6. [Levy O](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Levy%20O%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Venkateswaran B](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Venkateswaran%20B%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Even T](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Even%20T%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Ravenscroft M](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Ravenscroft%20M%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Copeland S](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Copeland%20S%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Mid-term clinical and sonographic outcome of arthroscopic repair of the rotator cuff. [J Bone Joint Surg Br.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Br.');) 2008 Oct; 90(10):1341-7.

7. [Millar NL](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Millar%20NL%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Wu X](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Wu%20X%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Tantau R](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Tantau%20R%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Silverstone E](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Silverstone%20E%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Murrell GA](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Murrell%20GA%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Open versus Two Forms of Arthroscopic Rotator Cuff Repair. [Clin Orthop Relat Res.](javascript:AL_get(this,%20'jour',%20'Clin%20Orthop%20Relat%20Res.');) 2009 Jan 30.

8. [Park JY](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Park%20JY%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Lhee SH](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Lhee%20SH%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Choi JH](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Choi%20JH%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Park HK](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Park%20HK%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Yu JW](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Yu%20JW%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Seo JB](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Seo%20JB%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Comparison of the clinical outcomes of single- and double-row repairs in rotator cuff tears. [Am J Sports Med.](javascript:AL_get(this,%20'jour',%20'Am%20J%20Sports%20Med.');) 2008 Jul; 36(7):1310-6.

9. [Kim DH](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Kim%20DH%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Elattrache NS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Elattrache%20NS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Tibone JE](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Tibone%20JE%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Jun BJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Jun%20BJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [DeLaMora SN](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22DeLaMora%20SN%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Kvitne RS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Kvitne%20RS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), et al. Biomechanical comparison of a single-row versus double-row suture anchor technique for rotator cuff repair. [Am J Sports Med.](javascript:AL_get(this,%20'jour',%20'Am%20J%20Sports%20Med.');) 2006 Mar;34(3):407-14.

10. [Ma CB](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Ma%20CB%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Comerford L](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Comerford%20L%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Wilson J](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Wilson%20J%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Puttlitz CM](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Puttlitz%20CM%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Biomechanical evaluation of arthroscopic rotator cuff repairs: double-row compared with single-row fixation. [J Bone Joint Surg Am.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Am.');) 2006 Feb;88(2):403-10.

11. [Mazzocca AD](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Mazzocca%20AD%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Millett PJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Millett%20PJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Guanche CA](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Guanche%20CA%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Santangelo SA](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Santangelo%20SA%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Arciero RA](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Arciero%20RA%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Arthroscopic single-row versus double-row suture anchor rotator cuff repair. [Am J Sports Med.](javascript:AL_get(this,%20'jour',%20'Am%20J%20Sports%20Med.');) 2005 Dec;33(12):1861-8.

12. [Cole BJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Cole%20BJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [ElAttrache NS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22ElAttrache%20NS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Anbari A](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Anbari%20A%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Arthroscopic rotator cuff repairs: an anatomic and biomechanical rationale for different suture-anchor repair configurations. [Arthroscopy.](javascript:AL_get(this,%20'jour',%20'Arthroscopy.');) 2007 Jun;23(6):662-9

13**.** Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg Am. 2004 Feb;86-A(2):219-24.

14. [Grasso A](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Grasso%20A%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Milano G](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Milano%20G%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Salvatore M](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Salvatore%20M%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Falcone G](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Falcone%20G%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Deriu L](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Deriu%20L%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Fabbriciani C](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Fabbriciani%20C%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Single-row versus double-row arthroscopic rotator cuff repair: a prospective randomized clinical study. [Arthroscopy.](javascript:AL_get(this,%20'jour',%20'Arthroscopy.');) 2009 Jan;25(1):4-12.

15. [Nelson CO](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Nelson%20CO%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Sileo MJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Sileo%20MJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Grossman MG](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Grossman%20MG%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Serra-Hsu F](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Serra-Hsu%20F%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Single-row modified mason-allen versus double-row arthroscopic rotator cuff repair: a biomechanical and surface area comparison. [Arthroscopy.](javascript:AL_get(this,%20'jour',%20'Arthroscopy.');) 2008 Aug;24(8):941-8.

16. [Smith CD](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Smith%20CD%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Alexander S](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Alexander%20S%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Hill AM](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Hill%20AM%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Huijsmans PE](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Huijsmans%20PE%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Bull AM](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Bull%20AM%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Amis AA](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Amis%20AA%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), et al. A biomechanical comparison of single and double-row fixation in arthroscopic rotator cuff repair. [J Bone Joint Surg Am.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Am.');) 2006 Nov;88(11):2425-31.

17**.** [Waltrip RL](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Waltrip%20RL%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Zheng N](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Zheng%20N%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Dugas JR](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Dugas%20JR%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Andrews JR](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Andrews%20JR%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Rotator cuff repair. A biomechanical comparison of three techniques. [Am J Sports Med.](javascript:AL_get(this,%20'jour',%20'Am%20J%20Sports%20Med.');) 2003 Jul-Aug;31(4):493-7.

18. [Park MC](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Park%20MC%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [ElAttrache NS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22ElAttrache%20NS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Tibone JE](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Tibone%20JE%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Ahmad CS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Ahmad%20CS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Jun BJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Jun%20BJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Lee TQ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Lee%20TQ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Part I: Footprint contact characteristics for a transosseous-equivalent rotator cuff repair technique compared with a double-row repair technique. [J Shoulder Elbow Surg.](javascript:AL_get(this,%20'jour',%20'J%20Shoulder%20Elbow%20Surg.');) 2007 Jul-Aug;16(4):461-8.

19. [Park MC](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Park%20MC%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Tibone JE](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Tibone%20JE%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [ElAttrache NS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22ElAttrache%20NS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Ahmad CS](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Ahmad%20CS%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Jun BJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Jun%20BJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Lee TQ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Lee%20TQ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Part II: Biomechanical assessment for a footprint-restoring transosseous-equivalent rotator cuff repair technique compared with a double-row repair technique. [J Shoulder Elbow Surg.](javascript:AL_get(this,%20'jour',%20'J%20Shoulder%20Elbow%20Surg.');) 2007 Jul-Aug;16(4):469-76.

20. [Pietschmann MF](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Pietschmann%20MF%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Fröhlich V](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Fr%C3%B6hlich%20V%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Ficklscherer A](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Ficklscherer%20A%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Gülecyüz MF](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22G%C3%BClecy%C3%BCz%20MF%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Wegener B](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Wegener%20B%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Jansson V](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Jansson%20V%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), et al. Suture anchor fixation strength in osteopenic versus non-osteopenic bone for rotator cuff repair. [Arch Orthop Trauma Surg.](javascript:AL_get(this,%20'jour',%20'Arch%20Orthop%20Trauma%20Surg.');) 2009 Mar;129(3):373-9.

21**.** [Tingart MJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Tingart%20MJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Apreleva M](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Apreleva%20M%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Zurakowski D](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Zurakowski%20D%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Warner JJ](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Warner%20JJ%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus). Pullout strength of suture anchors used in rotator cuff repair. [J Bone Joint Surg Am.](javascript:AL_get(this,%20'jour',%20'J%20Bone%20Joint%20Surg%20Am.');) 2003 Nov;85-A(11):2190-8.

Table 1. Load to failure data for lateral row tensioning of TOE rotator cuff repair model.

( n = 6 Shoulders)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***Load to Failure – Anterior (N)*** | ***Load to Failure – Posterior (N)*** | ***Pair Difference (N)*** | ***Rank*** |
|  | 76.2 | 78.4 | **-2.2** | **1** |
|  | 80.6 | 73.2 | **7.4** | **2** |
|  | 86 | 99.6 | **-13.6** | **3** |
|  | 87 | 69.8 | **17.2** | **4** |
|  | 85.4 | 115.8 | **-30.4** | **5** |
|  | 90.4 | 27.2 | **63.2** | **6** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***Anterior (N)*** | ***Posterior(N)*** | ***Pair Difference*** | ***Overall (N)*** |
| ***Mean:*** | *84.3* | *77.3* | *6.9* | *80.8* |
| ***Median:*** | *85.7* | *75.8* | *2.6* | *83.0* |
| ***Range:*** | *76.2 – 90.4* | *27.2 – 115.8* | *-30.4 – 63.2* |  |

Figure Legends:

Figure 1A. Immobilized specimen with initial dissection completed.

Figure 1B. Insertion of two medial row suture anchors.

Figure 1C. Placement of the first of two lateral row anchors. Note incomplete seating of anchor to allow tensioning of lateral row sutures. Medial sutures have been tied and one suture limb from each of the two medial anchors has been pulled across tendon substance to create the Suture Bridge pattern.

Figure 1D. Construct immediately prior to tensioning of lateral row sutures.