TENSOR TRANS-OS TUNNELEER
P/N 3000

SCIENTIFIC LITERATURE RELATED TO TRANS-OSSEOUS ROTATOR CUFF REPAIR
Cyclic loading of transosseous rotator cuff repairs: tension overload as a possible cause of failure.

Burkhart SS¹, Johnson TC, Wirth MA, Athanasiou KA.

Abstract
Previous experimental studies of failure of rotator cuff repair have involved a single pull to ultimate load. Such an experimental design does not represent the cyclic loading conditions experienced in vivo. We created 1 cm x 2 cm rotator cuff defects in 16 cadaver shoulders, repaired each defect with transosseous simple sutures, and cyclically loaded the repairs by a servohydraulic materials test system actuator at physiologic rates and loads (rate of 33 mm/sec to a load of 180 N.). A progressive gap was noted in each specimen, for a 100% rate of failure of the repairs. A 5 mm gap developed at an average of 25 cycles, and a 10 mm gap developed at an average of 188 cycles. The central suture always failed first and by the largest magnitude. This study suggests that rotator cuff tears that are repaired with a "tension overload" of a portion of the muscle-tendon units will undergo gradual failure with physiologic cyclic loading until the normal resting lengths of the muscle-tendon units are restored. This "controlled failure" of the repairs may explain residual defects that have been demonstrated by ultrasonography and by arthrography in patients with "successful" rotator cuff repairs. Clinical implications are that: 1) rotator cuff tears should be repaired without tension if possible; and 2) transosseous bone tunnels should ideally extend distal to the weak metaphysical bone so that purchase is obtained into cortical bone for greater fixation strength.

Strength of fixation with transosseous sutures in rotator cuff repair.

Caldwell GL¹, Warner JP, Miller MD, Boardman D, Towers J, Debski R.

Abstract
The effect of various configurations of placement of transosseous sutures on the immediate strength of fixation was studied in forty-five fresh-frozen humeri from cadavera of older individuals (mean age at the time of death, sixty-three years). The ultimate strength (the strength to failure) was significantly greater (p < 0.05) when the sutures were placed at sites more distal to the tip of the greater tuberosity or when the sutures were tied over a wider bone bridge. Cortical augmentation with use of a plastic button through which the transosseous sutures were tied increased the ultimate strength approximately 1.9-fold. The increase in the ultimate strength of the transosseous repair corresponded significantly with the increasing mean thickness of the cortical...
bone as the sutures were placed more distally along the lateral aspect of the humerus. We concluded that the strength of the fixation of a rotator cuff repair can be increased by placing the transosseous sutures at least ten millimeters distal to the tip of the greater tuberosity and by tying them over a bone bridge that is at least ten millimeters wide. When bone is very osteoporotic, cortical augmentation with a readily available plastic button strengthens the repair.

2001


**The parachute technique: valgus impaction osteotomy for two-part fractures of the surgical neck of the humerus.**

**Banco SP**, **Andrisani D**, **Ramsey M**, **Frieman B**, **Fenlin JM Jr**.

**Abstract**

Fourteen elderly patients with a two-part fracture, in osteopenic bone, of the surgical neck of the humerus were treated with a valgus impaction osteotomy and tension band fixation--that is, the parachute technique. Thirteen patients were followed, and all were able to perform activities of daily living without difficulty and were satisfied with the result of the surgery. The average age of these thirteen patients was sixty-eight years, and the average duration of follow-up was 18.5 months. Union was achieved in all patients, at an average of 45.5 days. No patient demonstrated osteonecrosis of the humeral head. This technique of valgus impaction osteotomy with Dacron-tape tension band fixation leads to rapid union. Patient satisfaction and function were excellent.

2002


**Rotator cuff tears: the effect of the reconstruction method on three-dimensional repair site area.**

**Apreleva M**, **Ozbaydar M**, **Fitzgibbons PG**, **Warner JJ**.

**Abstract**
PURPOSE:
To quantitatively determine the 3-dimensional (3-D) area of the original supraspinatus insertion and compare it with the repair-site area after 4 reconstructions of a simulated supraspinatus tear.

METHODS:
The outline of the original supraspinatus insertion was obtained in 10 human cadaveric shoulders using a 3-D digitizer. A supraspinatus tear was created and 4 repair techniques were evaluated: transosseous simple suture (TOS), transosseous mattress suture (TOM), suture-anchor simple suture (SAS), suture-anchor mattress suture (SAM). The 3-D outlines of the reconstructed supraspinatus insertion were digitized after each repair. The outlines of the original supraspinatus insertion and repair areas were superimposed onto humeral geometry obtained from a laser scanner, and surface areas were calculated.

RESULTS:
The original supraspinatus insertion area was larger than any of the repair-site areas (P <.05). On average, TOS provided a 20% larger repair-site area than the other repairs (P <.05). Repair-site areas were not different among TOM, SAS, or SAM repairs (P >.05) and covered 67% of the original supraspinatus insertion.

CONCLUSIONS:
None of the tested repairs restored the area of the original supraspinatus insertion. The larger repair-site area of the TOS repair suggests that this technique provides better potential for healing and, ultimately, greater strength of repair.


2003


Primary fixation strength of rotator cuff repair techniques: a comparative study

Mehmet Demirhan, M.D. Ata Can Atalar, M.D. Onder Kilicoglu, M.D.

Abstract
Purpose:
The goal of the study was to compare the primary fixation strength of transosseous suture, suture anchor, and hybrid repair techniques for rotator cuff repair.
Methods:
Thirty-two sheep shoulders were divided into 4 homogeneous groups, according to bone density and tendon dimensions. Infraspinatus tendons were transected from their insertions and reattached using 4 different techniques. Group 1 was repaired with a single Mason-Allen stitch and 2 transosseous tunnels for each end of the suture, knotted on the lateral cortex of proximal humerus; group 2 was repaired with double Mason-Allen stitches and 2 transosseous tunnels; group 3 was repaired with 2 Corkscrews (Arthrex, Germany); and group 4 was repaired with 2 Corkscrews combined with a single Mason-Allen transosseous suture. All specimens were tested for their fixation strengths with a material testing system.

Results:
The mode of failure in group 1 was mainly suture breakage. In groups 3 and 4, the tendons pulled out from the sutures. In group 2, sutures broke the bony bridge between the 2 tunnels. The mean load to failure value was 160.31 ± 34.59 N in group 1, 199.36 ± 11.73 N in group 2, 108.32 ± 15.98 N in group 3, and 214.24 ± 28.52 N in group 4. Anchor fixation was significantly weaker compared with other groups (P < .001). Combination of a transosseous suture and anchor fixation (group 4) was significantly stronger than the single transosseous suture (group 1) and double anchor techniques (group 3) (P < .001).

Conclusions:
Hybrid technique was the strongest among the tested rotator cuff repair techniques. With the addition of one transosseous suture to two anchors, the strength of the repair could be doubled.

http://www.arthroscopyjournal.org/article/S0749-8063(03)00126-9/fulltext

2005


Tendon-to-bone pressure distributions at a repaired rotator cuff footprint using transosseous suture and suture anchor fixation techniques.

Park MC1, Cadet ER, Levine WN, Bigliani LU, Ahmad CS.

Abstract
BACKGROUND:
Interface contact pressure between the tendon and bone has been shown to influence healing. This study evaluates the interface pressure of the rotator cuff tendon to the greater tuberosity for different rotator cuff repair techniques.

HYPOTHESIS:
The transosseous tunnel rotator cuff repair technique provides larger pressure distributions over a defined insertion footprint than do suture anchor techniques.

STUDY DESIGN:
Controlled laboratory study.

METHODS:
Simulated rotator cuff tears over a 1 x 2-cm infraspinatus insertion footprint were created in 25 bovine shoulders. A transosseous tunnel simple suture technique (n = 8), suture anchor simple technique (n = 9), and suture anchor mattress technique (n = 8) were used for repair. Pressurized contact areas and mean pressures of the repaired tendon against the tuberosity were determined using pressure-sensitive film placed between the tendon and the tuberosity.

RESULTS:
The mean contact area between the tendon and tuberosity insertion footprint was significantly greater for the transosseous technique (67.7 +/- 5.8 mm(2)) compared with the suture anchor simple (34.1 +/- 9.4 mm(2)) and suture anchor mattress (26.0 +/- 5.3 mm(2)) techniques (P < .05). The mean interface pressure exerted over the footprint by the tendon was also greater for the transosseous technique (0.32 +/- 0.05 MPa) compared with the suture anchor simple (0.26 +/- 0.04 MPa) and suture anchor mattress (0.24 +/- 0.02 MPa) techniques (P < .05).

CONCLUSION:
The transosseous tunnel rotator cuff repair technique creates significantly more contact and greater overall pressure distribution over a defined footprint when compared with suture anchor techniques.

CLINICAL RELEVANCE:
Stronger and faster rotator cuff healing may be expected when beneficial pressure distributions exist between the repaired rotator cuff and its insertion footprint. Tendon-to-tuberosity pressure and contact characteristics should be considered in the development of improved open and arthroscopic rotator cuff repair techniques.
between tendon and bone than does transosseous suture fixation.

**METHODS:**
Twelve fresh-frozen human cadaveric shoulders were tested in a custom device to position the shoulder in internal and external rotations with simulated supraspinatus muscle loading. Tendon motion relative to the insertional footprint on the greater tuberosity was determined optically using a digital camera rigidly connected to the humerus, with the humerus positioned at 60 degrees of internal rotation and 60 degrees of external rotation. Testing was performed for the intact tendon, a complete supraspinatus tear, a suture anchor repair, and a transosseous tunnel repair.

**RESULTS:**
Difference in tendon-bone interface motion when compared with the intact tendon was 7.14 +/- 3.72 mm for the torn rotator cuff condition, 2.35 +/- 1.26 mm for the suture anchor repair, and 0.02 +/- 1.18 mm for the transosseous suture repair. The transosseous suture repair demonstrated significantly less motion when compared with the torn rotator cuff and suture anchor repair conditions (P < .05).

**CONCLUSION:**
Transosseous suture repair compared with suture anchor repair demonstrated superior tendon fixation with reduced motion at the tendon-to-tuberosity interface.

**CLINICAL RELEVANCE:**
Development of new fixation techniques for arthroscopic and open rotator cuff repairs should attempt to minimize interface motion of the tendon relative to the tuberosity.


2008


**Failure analysis of rotator cuff repair: a comparison of three double-row techniques.**

Zheng N1, Harris HW, Andrews JR.

**Abstract**

**BACKGROUND:**
The use of suture anchors has made arthroscopic repair of the torn rotator cuff possible. However, objective evaluations have demonstrated high failure rates.
The goal of this study was to compare the modes and rates of failure of two double-row arthroscopic repair techniques and the mini-open double-row technique.

**METHODS:**
Thirty pairs of fresh-frozen human shoulders were used in this study. The specimens were prepared to simulate a cuff defect, which was then repaired. The repairs were done with three different lateral row techniques (Mason-Allen sutures passed through transosseous tunnels, the knotless anchor method, and the corkscrew suture anchor method) with the same medial row technique (corkscrew suture anchors). Cyclic tests were conducted at 33 mm/s with a cyclic force of 10 to 180 N. Specimens were cycled to 5000 cycles or to failure as defined as formation of a 10-mm gap at the repair. Failure rates and failure modes of the suture, tendon, and bone-anchor interface were compared for the medial and lateral rows and among the three techniques.

**RESULTS:**
Fourteen of the twenty repairs made with the transosseous technique, fifteen of the twenty repairs made with the knotless anchor technique, and ten of the twenty repairs made with the corkscrew anchor technique survived 5000 cycles. The failure rates for the medial row were not significantly different among the three repair techniques. For the lateral row, there was a significant difference ($p < 0.01$) in the rate of failure among individual transosseous tunnel-suture complexes (32%), knotless anchor-suture complexes (48%), and corkscrew anchor-suture complexes (75%), with a similar suture-tendon failure rate for all three techniques. The tendon and repair complexes with corkscrew suture anchors had the smallest displacement both at the first and the 5000th cycle.

**CONCLUSIONS:**
Although repairs made with the anchor techniques had higher individual failure rates, the survival rates for the anchor techniques at the 5000th cycle were similar to that for the transosseous technique during cyclic tests. Suture failure was the main failure mode for the transosseous technique, whereas failure at the anchor-bone interface was the main failure mode for the anchor techniques.

2009


**A Biomechanical Comparison of**
Transosseous–Suture Anchor and Suture Bridge Rotator Cuff Repairs in Cadavers

Leslie J. Bisson, MD* and Leslie M. Manohar, MD

From the University at Buffalo, Department of Orthopaedics, Buffalo, New York

Abstract

Background Several biomechanical studies comparing open and arthroscopic rotator cuff repair methods have shown inferior performance of arthroscopic repairs. Suture anchor–augmented transosseous repairs and suture bridge repairs have shown superior biomechanical performance when compared with other methods, but these 2 repair methods have not been directly compared.

Methods Eight paired cadaveric shoulder specimens (16 specimens) had creation followed by repair of a complete tear of the supraspinatus, with the first member of each pair undergoing repair by a transosseous–suture anchor technique and the second member undergoing repair by the suture bridge technique. Specimens were then cycled from 10 to 180 N for 200 cycles, followed by testing to failure at 33 mm/s. Elongation was measured during cyclic testing, and failure load and stiffness were obtained during load-to-failure testing. Failure method was recorded.

Results There was no significant difference between transosseous–suture anchor repairs and suture bridge repairs for elongation (4.0 ± 1.60 mm vs 3.5 ± 1.1 mm, P = .31), failure load (408 ± 93 N vs 419 ± 62 N, P = .70), or stiffness (58 ± 10 N/mm vs 58 ± 14 N/mm, P = .94). The most common mode of failure with each method was suture cutting through tendon.

Conclusion The suture bridge repair exhibited similar biomechanical performance during cyclic and load-to-failure testing as a transosseous–suture anchor repair, which historically has been performed in open or mini-open fashion.

http://ajs.sagepub.com/content/37/10/1991.abstract

2012


Initial Fixation Strength of Transosseous-Equivalent Suture Bridge Rotator Cuff Repair Is
Comparable With Transosseous Repair

Behrens et al, Rhode Island Hospital

Andrew Green, MD, Rhode Island Hospital, Department of Orthopaedic Surgery, 2 Dudley Street, Providence, RI 02903 (e-mail: agshoulder@aol.com).

Abstract

Background: The outcome of rotator cuff repair correlates with tendon healing. Early studies of arthroscopic rotator cuff repair demonstrate lower healing rates than traditional open techniques. Transosseous-equivalent repair techniques (suture bridge) were developed to improve the initial fixation strength.

Purpose: To compare the initial in vitro tensile fixation strength of a transosseous-equivalent suture bridge (TOE-SB) rotator cuff repair construct to a traditional transosseous (TO) suture construct.

Study Design: Controlled laboratory study.

Methods: Identical simulated rotator cuff tears were created on 8 matched pairs of humeri. Each matched pair underwent repair with 4 sutures using either the TOE-SB or TO technique. Initial fixation strength was tested in a custom testing jig. Each shoulder underwent 1000 cycles each of low and then high load testing. Gap displacement was measured at anterior and posterior sites of the repair with digital video tracking of paired reflective markers and recorded at predetermined cycle intervals.

Results: There were no statistically significant differences in gap formation at the repair sites under low or high load conditions between TOE-SB and TO techniques. The mean maximal gap formation of the repairs during low load testing in the TOE-SB and TO constructs was 0.93 ± 0.88 mm and 0.55 ± 0.22 mm, respectively (P = .505). The mean maximal gap formation during high load testing in the TOE-SB and TO constructs was 2.04 ± 1.10 mm and 2.28 ± 1.62 mm, respectively (P = .517). The most significant increase in gap distance occurred at the transition from low load to high load in both constructs. Most of the incremental displacement occurred within the first 100 cycles for both high and low load testing (P < .001).

Conclusion: The arthroscopic TOE-SB technique is comparable in initial fixation strength to the traditional TO simple suture repair technique.

Clinical Relevance: Arthroscopic techniques can achieve initial fixation strength comparable with traditional TO techniques performed without suture anchors.

http://ajs.sagepub.com/content/40/1/133.abstract

January 2012 – AAOS DVD Video

Arthroscopic Transosseous Rotator Cuff Repair (Multimedia Presentation)

Umasuthan Srikumaran, MD, Hanover, MD
Eric Black, MD, Boston, MA
Jessica Wells, Providence, RI
Jeffrey Tompson, BA, Boston, MA
Jon Warner, MD, Boston, MA
General Information

Area of Focus: Shoulder & Upper Extremity and Arthroscopy

The gold standard in the repair of rotator cuff tears is an open transosseous approach. Nevertheless, arthroscopy has become the preferred approach to rotator cuff repair, but this method relies on suture anchors for rotator cuff fixation. Drawbacks of anchors include retained hardware, risk of hardware migration, and risk of an adverse reaction to anchor biomaterials. Large rotator cuff tears require several anchors, but in revision surgery, poor bone stock often precludes the use of additional anchors. Emerging technology has allowed for a fully arthroscopic transosseous repair that eliminates the need for anchors. This approach blends the benefits of transosseous repair, including restoration of the anatomic footprint and compression across the rotator cuff tendon, with arthroscopic technique. In patients that require multiple suture anchors, a transosseous approach can provide substantial cost savings.

We reviewed the scientific literature and our experience with arthroscopic transosseous rotator cuff repair. We demonstrate a step-by-step video technique using several case examples. We also discuss indications and contraindications and demonstrate complications and their solutions. We identified 35 patients with an average age of 56 years who underwent arthroscopic transosseous rotator cuff repair. Of these procedures, 65% were primary repairs and 35% were revision repairs. We had three intraoperative complications including suture cut-out through the lateral bone tunnel. Early clinical outcomes were equivalent to rotator cuff repair with anchor fixation. This multimedia video presentation discusses and demonstrates arthroscopic transosseous rotator cuff repair. The orthopaedic surgeon will benefit from review of the surgical technique and potential complications.
Outcomes

- Harvard Shoulder Service Experience
  - 35 cases over past 1.5 years
  - ~65% primary repair, 35% revision
  - Average age = 56
  - 3 intra-operative complications
    - Suture cutout of lateral bone tunnel
  - Early outcome analysis demonstrating equivalent clinical results to RCR with anchors (Trans-osseous equivalent)

Discussion

- Many biomechanical studies show superior results with open transosseous tunnels compared to traditional arthroscopic repair with suture anchors
  - Schoenberger et al., 2002
  - Walribo et al., 2003
  - Toori et al., 2008
- Other studies show equivalent results
  - Cott et al., 1999
  - Testfjær et al., 2007
  - Rechmann et al., 2008
  - Borsboom et al., 2008
  - Teuber et al., 2011

http://www3.aaos.org/product/productpage.cfm?code=V12025

2013

ICJR 2013 Las Vegas Shoulder Course – Slide presentation
Arthroscopic Transosseous Cuff Repair

Faculty: Sumant G. Krishnan, MD

Eliminating Variables

Arthroscopic Transosseous RCR

Suture Anchors

Suture Cutting Through Bone

What would YOU choose?

Conclusions

TRANSOSSEOUS REPAIR or TOE SUTURE BRIDGE?

- The techniques demonstrate no statistical difference
- Initial fixation strengths are equivalent
- Failure modes are technique specific
  - Bone cutout at ultimate failure 11/14 TO repairs
  - Suture slippage thru lateral anchor 5/8 TOE repairs
- Surgical Technique Should be Based Upon Surgeon’s Preference

Arthroscopic Transosseous RCR

Conclusion

- 10,000+ cases worldwide
- Equivalent to Anchor RCR Methods
  - Repair Integrity
  - Biomechanical Strength
  - Reliable/Reproducible Technique
  - Multiple Sutures

Clinical Orthopaedics and Related Research®
November 2013, Volume 471, Issue 11, pp 3514-3522,
Advantages of Arthroscopic Transosseous Suture Repair of the Rotator Cuff without the Use of Anchors

Shigehito Kuroda MD, Noriyuki Ishige MD, Motohiko Mikasa MD

Background Although arthroscopic anchor suturing is commonly used for rotator cuff repair and achieves good results, certain shortcomings remain, including difficulty with reoperation in cases of retear, anchor dislodgement, knot impingement, and financial cost. In 2005, we developed an anchorless technique for arthroscopic transosseous suture rotator cuff repair.

Description of Technique After acromioplasty and adequate footprint decortication, three K-wires with perforated tips are inserted through the inferior margin of the greater tuberosity into the medial edge of the footprint using a customized aiming guide. After pulling the rotator cuff stump laterally with a grasper, three K-wires are threaded through the rotator cuff and skin. Thereafter, five Number 2 polyester sutures are passed through three bone tunnels using the perforated tips of the K-wires. The surgery is completed by inserting two pairs of mattress sutures and three bridging sutures.

Methods We investigated the retear rate (based on MR images at least 1 year after the procedure), total score on the UCLA Shoulder Rating Scale, axillary nerve preservation, and issues concerning bone tunnels with this technique in 384 shoulders in 380 patients (174 women [175 shoulders] and 206 men [209 shoulders]). Minimum followup was 2 years (mean, 3.3 years; range, 2–7 years). Complete followup was achieved by 380 patients (384 of 475 [81%] of the procedures performed during the period in question). The remaining 91 patients (91 shoulders) do not have 1-year postsurgical MR images, 2-year UCLA evaluation or intraoperative tear measurement, or they have previous fracture, retear of the rotator cuff, preoperative cervical radiculopathy or axillary nerve palsy, or were lost to followup.
Results Retears occurred in 24 patients (24 shoulders) (6%). The mean overall UCLA score improved from a preoperative mean of 19.1 to a score of 32.7 at last followup (maximum possible score 35, higher scores being better). Postoperative EMG and clinical examination showed no axillary nerve palsies. Bone tunnel-related issues were encountered in only one shoulder.

Conclusions Our technique has the following advantages: (1) reoperation is easy in patients with retears; (2) surgical materials used are inexpensive polyester sutures; and (3) no knots are tied onto the rotator cuff. This low-cost method achieves a low retear rate and few bone tunnel problems, the mean postoperative UCLA score being comparable to that obtained by using an arthroscopic anchor suture technique.


A laboratory comparison of a new arthroscopic transosseous rotator cuff repair to a double row transosseous equivalent rotator cuff repair using suture anchors.

NYU - Kummer FJ, Hahn M, Day M, Meislin RJ, Jazrawi LM.

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.

![Graph showing displacement of tendons as a function of loading cycles.](image)
Results

Cost Comparison: Breakeven Scenario Analysis - Anchor vs. Transosseous Rotator Cuff Repair

Conclusions

- Preoperatively, compared to the anchor group, the transosseous group had a greater number of larger size tears and overall worse patient reported outcomes.
- Despite this bias against the experimental group (Tunnels/ transosseous):
  - Postoperatively, there was no statistically significant difference between groups with respect to range of motion, pain, SSV score, or ASES score.
  - Postoperatively, both groups had statistically significant improvements in pain and patient reported outcomes (SSV/ASES scores) compared to preoperative measurements.

The transosseous approach dominates the anchored approach as transosseous repairs achieve the same clinical outcomes at lower costs (for > 1 anchor repairs).

Srikumaran, et al, Johns Hopkins
• The optimum tension for bridging sutures in transosseous-equivalent rotator cuff repair: a cadaveric biomechanical study.

Park JS, McGarry MH, Campbell ST, Seo HJ, Lee YS, Kim SH, Lee TQ, Oh JH.

Abstract

BACKGROUND:
Transosseous-equivalent (TOE) rotator cuff repair can increase contact area and contact pressure between the repaired cuff tendon and bony footprint and can show higher ultimate loads to failure and smaller gap formation compared with other repair techniques. However, it has been suggested that medial rotator cuff failure after TOE repair may result from increased bridging suture tension.

PURPOSE:
To determine optimum bridging suture tension in TOE repair by evaluating footprint contact and construct failure characteristics at different tensions.

STUDY DESIGN:
Controlled laboratory study.

METHODS:
A total of 18 fresh-frozen cadaveric shoulders, randomly divided into 3 groups, were constructed with a TOE configuration using the same medial suture anchor and placing a Tekscan sensing pad between the repaired rotator cuff tendon and footprint. Nine of the 18 shoulders were used to measure footprint contact characteristics. With use of the Tekscan measurement system, the contact pressure and area between the rotator cuff tendon and greater tuberosity were quantified for bridging suture tensions of 60, 90, and 120 N with glenohumeral abduction angles of 0° and 30° and humeral rotation angles of 30° (internal), 0°, and 30° (external). TOE constructs of all 18 shoulders then underwent construct failure testing (cyclic loading and load to failure) to determine the yield load, ultimate load, stiffness, hysteresis, strain, and failure mode at 60 and 120 N of tension.

RESULTS:
As bridging suture tension increased, contact force, contact pressure, and peak pressure increased significantly at all positions (P < .05 for all). Regarding contact area, no significant differences were found between 90 and 120 N at all positions, although there were significant differences between 60 and 90 N. The construct failure test demonstrated no significant differences in any parameters according to various tensions (P > .05 for all).

CONCLUSION:
Increasing bridging suture tension to over 90 N did not improve contact area but did increase contact force and pressure. Bridging suture tension did not significantly affect ultimate failure loads.
**CLINICAL RELEVANCE:**
Considering the risks of overtensioning bridging sutures, it may be clinically more beneficial to keep bridging suture tension below 90 N.

May 13, 2015 – ORTHOPEDICS - Volume 38 · Issue 5: e352-e358

**Arthroscopic Transosseous Rotator Cuff Repair: Technical Note, Outcomes, and Complications**

Eric M. Black, MD; Albert Lin, MD; Uma Srikumaran, MD; Nitin Jain, MD, MPH; Michael T. Freehill, MD

**ABSTRACT**

The goal of this study was to review the authors’ initial experience with arthroscopic transosseous rotator cuff repair. Thirty-one patients with full-thickness rotator cuff tears underwent arthroscopic transosseous rotator cuff repair over a 15-month period. Preoperatively, demographics and subjective scores were recorded. Postoperatively, pain levels, subjective shoulder values, satisfaction scores, American Shoulder and Elbow Surgeons (ASES) scores, complications, and reoperations were noted with a minimum 2-year follow-up. The relationships between pre- and intraoperative variables and outcome scores were determined with univariate analysis. Average patient age was 56 years, and 23 patients (74%) were men. Twenty patients (65%) underwent primary rotator cuff repair, and 11 patients (35%) underwent revision repair. Average time to follow-up was 26 months. Average preoperative pain level and subjective shoulder value were 5.1 of 10 and 35%, respectively. Average postoperative scores included pain level of 0.9 of 10, subjective shoulder value of 84%, satisfaction score of 90.6 of 100, and ASES score of 86.3 of 100. There were 3 (9.7%) major and 2 (6%) minor complications. Patients undergoing revision rotator cuff repair had significantly worse outcomes (pain level, subjective shoulder value, ASES score; *P*<.05) compared with those undergoing primary repair, and cortical augmentation did not significantly affect outcome. Overall, outcomes after arthroscopic transosseous rotator cuff repair are good, although patients undergoing revision repair do not have the same outcomes as those undergoing primary cuff repair. The procedure is not without complications (9.7% major, 6% minor complications). Cortical augmentation may be used to supplement fixation, although it does not necessarily affect outcomes. Patients without such augmentation may be at increased risk for suture cutout through the bone. [Orthopedics. 2015; 38(5):e352–e358.]
Arthroscopic Anchored versus Transosseous Rotator Cuff Repair: A Comparison of Clinical Outcomes and Structural Integrity

Uma Srikumaran MD, MBA, Casey Hannan BS, Kelly Kilcoyne, MD, Steve Petersen MD, Edward McFarland MD, Bashir Zikria MD

The Johns Hopkins University, Baltimore, Maryland, USA

**Introduction**: Recent advancements in surgical instrumentation have permitted an all-arthroscopic, anchorless transosseous repair, which reproduces the “gold standard” of open transosseous repair. To date, there is no published literature comparing all-arthroscopic, anchorless, transosseous repair to standard arthroscopic anchored techniques.

**Methods**: We conducted a retrospective case-control study of arthroscopic rotator cuff repair performed by a single surgeon from 2011 to 2014. The control group included anchored repair (double row, transosseous equivalent), while the case group included anchorless, transosseous repair. Baseline demographic data included age, sex, BMI, and classification of tear size. We collected numeric rating scale (NRS) pain score, Subjective Shoulder Value (SSV) score, range of motion, ASES score, procedural time and operative time.

**Results**: There were 49 patients in the anchored group and 55 patients in the anchorless, transosseous group. Baseline demographic data for BMI (P = 0.930) and sex (P = 0.855) did not differ between groups. Compared to the anchored group, the anchorless, transosseous group was found to be older (P < 0.001) and have significantly larger preoperative tear size (P < 0.001). At 12 month follow up, there was significant (P < .001) postoperative improvement in both groups with respect to SSV, NRS pain levels, and ASES scores compared to preoperative scores. There was no difference between the two groups with respect to ASES score (P = 0.261), SSV (P = 0.592), NRS pain score (P = 0.115), operating room time (P = 0.304), procedural time (P = 0.252), or ultrasound tendon integrity (P = 0.621)

**Discussion and Conclusion**: No significant differences in functional or patient reported outcomes were identified between arthroscopic standard anchored approaches and anchorless, transosseous techniques, despite significant bias in age and tear size against the anchorless, transosseous group.
‘Anchor vs. TransOsseous RCR: Equivalent outcomes, but higher cost and less favorable Type 2 failures with anchors’
Analysis of Direct Costs of Outpatient Arthroscopic Rotator Cuff Repair

Steven J. Narvy, MD, Avtar Ahluwalia, MBA, and C. Thomas Vangsness Jr, MD

Arthroscopic rotator cuff surgery is one of the most commonly performed orthopedic surgical procedures. We conducted a study to calculate the direct cost of arthroscopic repair of rotator cuff tears confirmed by magnetic resonance imaging.

Twenty-eight shoulders in 26 patients (mean age, 54.5 years) underwent primary rotator cuff repair by a single fellowship-trained arthroscopic surgeon in the outpatient surgery center of a major academic medical center. All patients had interscalene blocks placed while in the preoperative holding area. Direct costs of this cycle of care were calculated using the time-driven activity-based costing algorithm. Mean time in operating room was 148 minutes; mean time in recovery was 105 minutes. Calculated surgical cost for this process cycle was $5904.21. Among material costs, suture anchor costs were the main cost driver. Preoperative bloodwork was obtained in 23 cases, adding a mean cost of $111.04. Our findings provide important preliminary information regarding the direct economic costs of rotator cuff surgery and may be useful to hospitals and surgery centers negotiating procedural reimbursement for the increased cost of repairing complex tears.