

– locking knot compared to four surgical standards. Methods: Five knots were evaluated (Weston, Tennessee, Duncan, SMC, and the new San Diego knot) using two suture materials (No. 2 Ethibond or No. 2 Fiberwire). Ten samples were tested for each knot-suture configuration. All knots were tied by the same surgeon using an arthroscopic knot pusher. Knots were tied through a working cannula over a 38 mm diameter dowel to create loops of consistent diameter. Each knot was backed up by four reversed hitches over reversed posts. The suture loops were fixed inside a servohydraulic MTS858 machine, pre-tensioned to 10N and cycled between 10N and 45N for 1000 cycles. Intact knots were then loaded to failure. A two-way ANOVA ($P < .05$) with a Tukey's post-hoc test for multiple comparisons was used for statistical analysis. Results are presented as mean \pm SD. Results: Fiberwire had significantly higher load-to-failure (276 ± 24 N) compared to Ethibond (111 ± 13 N, $p < .001$). Overall, there was no statistically significant difference in these parameters as a function of knot configuration. However, marked sub-maximal "slippage" was noted in a subset of the knots tied with Fiberwire. Of the fifty Fiberwire knots, three failed by early slippage during cyclic load, and eight slipped at very low tension during load to failure. Early slippage was not observed with Fiberwire using the San Diego knot, and none of the Ethibond knots failed by early slippage. For knots that did not slip early, Fiberwire demonstrated approximately 50% less total loop elongation prior to failure compared to Ethibond ($p < .005$). Discussion: Although Fiberwire was considerably stronger than Ethibond, it also had a greater tendency for slippage at relatively low loads. This observation reflects the surface characteristics and internal construction elements that affect frictional resistance within the knot. Early slippage was not observed with the San Diego knot, which has a unique flip-loop mechanism that creates high internal knot friction. Although slippery suture is an advantage for sliding within anchor eyelets and for delivery of arthroscopic knots, it may come at a price in regard to knot security. Surgeons should understand the impact of handling characteristics, frictional properties, and ultimate failure load when selecting suture materials and knots for arthroscopic repair.

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Failure Mode of Suture Anchors as a Function of Insertion Depth in Human Cadaver Humeri (SS-48)

Rotator cuff integrity after repair is a major determinant of a good functional result and residual deficiencies have

been found in greater than 50% of complex tears. Different modes of suture anchor failure have been identified and may occur due to anchor displacement or pull-out, suture breakage, knot slippage, or suture pulling through the tendon. Recently, another mode of anchor failure has been identified in the bovine model by suture cutting through the bone when an anchor is placed deeper than recommended. However, this result has not been reproduced using human cadaveric shoulders. The purpose of this study was to evaluate the biomechanical stability of a suture anchor placed deep within the rotator cuff footprint of human cadaver humeri. Methods: Metallic screw-in anchors loaded with a single, number 2 braided nonabsorbable polyester suture were placed in the infraspinatus footprint of eight human cadaver humeri (87 ± 3 years) at two depths. Standard placement had the threads countersunk 3 mm below the bone surface. The deep anchors doubled this depth to 6 mm. The sutures were placed under 10 N of preload and the knots were placed equidistant from the bone hole exit and a smooth metallic rod used for mechanical testing. Specimens were cyclically loaded between 10 to 45 N to a maximum of 500 cycles and then, if still intact, loaded at 0.5 mm/sec to failure. Total displacement after cyclic testing (mm) and ultimate failure load (N) were analyzed with a one-way ANOVA ($P < .05$). Failure mode and location were recorded after testing. Results: The total displacement after cyclic loading was significantly different between repair depths. The deep anchors attained a total displacement of 8.4 ± 2.4 mm while the standard anchors had a final displacement of 5.7 ± 1.4 mm ($P < .03$). There was no difference in ultimate failure load between depths, with the deep anchors failing at 144 ± 14 N and standard anchors failing at 143 ± 13 N. The deep anchors were noted to translate to the cortical margin within the first few cycles. Both anchor positions seemed to rotate at the cortical surface due to the orientation of loading as testing progressed. Failure occurred at the eyelet in two tests, while the remaining tests exhibited anchor translation/rotation and some suture cut through. Discussion: Burying suture anchors beyond the specified insertion depth is inadvisable based on these data. Excessive anchor depth may lead to early clinical failure by the suture cutting through bone. Both anchor depths displayed rotation and translation at the cortical surface and some migrated above the joint surface during physiologic cyclic loading. The rotation and translation may induce early deficiencies in the cuff repair while the migration may limit joint range of motion and induce joint arthrosis. Due to poor bone quality, these rotations/translations are of specific concern in the osteoporotic population. Improved anchor eyelet designs may lessen

the possibility of abrasive degradation of the suture, and abrasion-resistant materials may decrease the risk of suture fretting.

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Arthroscopic Repair of Medium to Large Full-Thickness Rotator Cuff Tears: A Prospective Study of 30 Patients (SS-49)

This study prospectively evaluated the clinical outcome of 30 patients that underwent arthroscopic repair of large full-thickness rotator cuff tears. **Methods:** Thirty patients underwent arthroscopic repair of a full-thickness rotator cuff tear. Mean tear size was 2.4 cm (range: 2 to 5 cm) in the sagittal plane. Patients' mean age was 52 years (range: 34 to 71 years) and mean follow-up was 20 months (range: 16 to 30 months). Preoperative and postoperative range of motion, strength, pain, and satisfaction were evaluated. Function was assessed with a modified ASES Score. All 30 tears involved the supraspinatus tendon and 8 also involved the infraspinatus. Mean tendon retraction was 8 mm (range: 0 to 25 mm). Statistical analysis was carried out using Student *t* test and signed rank test. **Results:** Significant improvements were demonstrated for forward elevation (preoperative: 157° to postoperative: 168°, $P < .05$), forward elevation strength (3.7 to 4.8 out of 5, $P < .05$), ASES scores (44.9 to 93.5 points, $P < .01$), pain relief (8.7 to 1.6 points, $P < .001$), and satisfaction (2.8 to 9.1 points, $P < .001$). One patient developed postoperative adhesive capsulitis that resolved after several months of physical therapy. There was no incidence of recurrent rupture of the rotator cuff. Twenty-eight of 30 (93%) patients were satisfied with their outcome. There was no correlation between tear size or amount of retraction and clinical outcome. **Conclusions:** This study documented significant improvements in range of motion, strength, pain relief, function, and satisfaction after arthroscopic repair of medium to large full-thickness rotator cuff tears.

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Outcomes After Arthroscopic Rotator Cuff Repairs (SS-50)

Arthroscopic rotator cuff repair (RCR) was introduced for smaller tears but, has recently been applied to all sizes of tendon defects. This study reviews one surgeon's experience with arthroscopic RCR. **Methods:** A retrospective review was conducted of 107 consecutive patients who underwent arthroscopic rotator cuff repair. Preoperative and postoperative evaluation consisted of

history, patient questionnaires, physical examination and validated shoulder scores. Operative reports were reviewed for concomitant procedures, releases performed, tear size, and type and method of fixation. **Results:** 107 consecutive patients underwent arthroscopic RCR. Average follow-up was 24 months, (range 1 to 5 years). Average patient age was 62 years (range 30 to 86 years). There were 30 partial tears, 19 of which were completed, 57 tears < 3 cm, 46 tears > 3 cm. 32 of these 46 were massive (> 5 cm) tears. All tears were repaired with suture anchors at the lateral aspect of the rotator cuff footprint, with the number of sutures passed ranging from an average of 1.5 for small (< 3 cm) tears, to 2.8 for massive tears. In addition 47 tears were fixed medially with transfixing implants, and 11 of the massive tears utilized margin convergence medially. 41 patients received capsular releases. 38 had anterior and 25 had posterior interval releases. 59 patients had either a biceps tenotomy or tenodesis and 16 had a resection of the distal clavicle. There were no infections, nerve injuries, or hardware complications. Pain relief was dramatic for all tear sizes, with an overall improvement in visual analog pain from 5.6 to 1.7 ($P < .01$). Constant Score improved from 52.8 to 75 ($P < .01$) and ASES scores improved from 44.5 to 80.2 ($P < .01$). Overall strength (lbs) in elevation improved from 6.8 to 10.7 ($P < .001$), and external rotation strength improved from 10.9 to 13.6 ($P < .04$). Strength of elevation at follow-up was 13 lb for small (< 3 cm) tears and 7.9 lb for massive tears ($P < .001$). **Conclusions:** Arthroscopic rotator cuff repair yields excellent results for all tear sizes, although strength is less well restored for larger tears. Capsular and interval releases are very helpful for mobilizing retracted tendons. Our current technique utilizes two rows of anchors to maximize healing area to the footprint, and is under investigation.

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Pain Scores in the Management of Postoperative Rotator Cuff Surgery (SS-51)

Recent public opinion has focused on the lay perception that postoperative pain control is often inadequate. JCAHO has attempted to address this by mandating pain scores as part of the postoperative pain assessment. No studies exist to validate these scores in orthopedics. **Methods:** 99 patients over a 12-month period undergoing routine arthroscopic rotator cuff repair were followed and multivariate analysis assessed in regard to pain scores, objective physiologic correlates, complications, patient satisfaction, and MMPI scores. **Results:** All pro-