viable. Despite reducing symptoms, arthritic changes were observed to increase radiographically over time. It is unclear if these radiographic changes are related to the initial traumatic and what their future significance might be. The midterm clinical response was favorable for these patients. Further investigation of the long-term results is required.

F. Alan Barber, M.D., James C. Y. Chow, M.D.

Treatment of Large Osteochondral Defects in the Knee With Partial Condylar Transfer (SS-45)

This is a long-term follow-up study of about 53 patients over 5 to 15 years. Treatment of large and deep osteochondral lesions is very demanding. We use large autogenous osteochondral grafts from the most posterior partsof the lateral and medial femoral condyles as a partial condylar transfer (PCT). If necessary additional smaller grafts of the trochlea patellae can be used. Harvesting is done by a diamond cutting device. Between 1986 and 1996 we operated 53 patients with large osteochondral defects of the femoral condyles. Postoperative ingrowth control was done by MRI in all cases after 6 and 12 weeks. Only 1 case developed a wide necrosis of the transplants and had to be revised. This complication was due to technical error. Two cases showed small subchondral cysts of no clinical evidence. Clinical evaluation of the long-term follow-up was done by the Standard Cartilage Evaluation Form of the ICRS. More than 90% of the patients showed a significant improvement compared to the preoperative data. There was no morbidity of the posterior harvest side whereas the harvest side in the anterior parts cases problems in a few cases. The Kellgren and Lawrence Score was used for X-ray evaluation. There was only a mild degenerative progression in most of the cases. Patients with varus or valgus deformity showed more progression than those patients without malalignment. Advantage of our method is the possibility of immediate full weight bearing, little harvest morbidity and excellent long-term results.

Heinz Georg Laprell, M.D.

Rotator Cuff Repair With Ultrasonic Suture Welding (SS-46)

Rotator cuff repair techniques traditionally employ suture fixation of the tendon to both soft and bony tissues. The suture is tied by hand or arthroscopic knot pusher to provide secure loops to fix tissue to facilitate healing. A new technology allows the creation of secure loops with ultrasonic energy welding. This study was conducted to assess the clinical results of mini-open rotator cuff repair employing ultrasonic suture welding. Fifty consecutive patients treated by one surgeon were retrospectively evaluated with an average follow-up of 26 months. These patients were then compared to 55 patients treated by the same surgeon with a technique employing standard knot-tying with nonabsorbable suture with similar follow-up. The groups were similar in regard to age, sex, hand dominance and preoperative duration of symptoms. All procedures were performed in a hospital ambulatory surgery center in a lateral decubitus position. A glenohumeral arthroscopy and arthroscopic acromioplasty were performed in all cases. All patients were evaluated by an independent examiner using the UCLA scale; 47 of the 50 suture weld patients were available for evaluation. Preoperative UCLA score averaged 21.5 and postoperative 29.8. There were four failures in this group but two of the patients who failed had a significant postoperative traumatic events; a dislocation in one and a car accident in another. Both patients underwent revision cuff repair. At revision. both repairs had pulled through tendon without failure of the weld. 40 of the 55 patients treated with tied sutures were available for evaluation. Preoperative UCLA score averaged 13.2 and postoperative 31.6. There was one failure in this group of patients and none with postoperative trauma. Postoperative scores for the two groups did not differ significantly according to Student *t* test. An Analysis of Covariance (ANCOVA) of postoperative UCLA scores was also not statistically significant. Suture welding produces secure loops that allow for cuff repair with results similar to traditional knot-tying techniques. Welding technology may facilitate arthroscopic cuff repair by obviating the need to tie arthroscopic knots.

Louis F. McIntyre, M.D., Mirjam Norris, R.N., Bruce Weber, P.T.

Very Strong Sutures Can Still Slip: Evaluation of Five Knot Types and Two Suture Materials for Shoulder Arthroscopy (SS-47)

Persistent defects after arthroscopic rotator cuff repair may be due to the technical challenges associated with suture loop and knot security. Very strong suture materials decrease the incidence of suture breakage during knot tying, however these materials are not automatically more reliable in regard to slippage at sub-maximal loads. The purpose of this study was (1) to compare the performance of a standard suture material (No. 2 Ethibond [Ethicon]) with a newer material (No. 2 Fiberwire [Arthrex]) in regard to knot security and load to failure using multiple arthroscopic knot configurations, and (2) to evaluate the biomechanical performance of a new sliding

– 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 ± 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 though the tendon. Recently, another mode of anchor failure has been identified in the bovine model by suture cutting though 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