A Biomechanical and Radiographic Analysis of Standard and Intracortical Suture Anchors for Arthroscopic Rotator Cuff Repair

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Purpose: To compare the fixation strength and radiographic motion of an anchor designed for intracortical (IC) fixation (FT Anchor, Arthrex, Naples, FL) with that of standard anchors used for rotator cuff repair. **Type of Study:** In vitro human cadaveric biomechanical study. **Methods:** Four types of metallic suture anchors (8 per group) were randomly inserted into human cadaveric humeri using an IC anchor and 3 types of standard anchors. Anchors were inserted 45° to the humeral head surface and 90° to the rotator cuff line of action. Anchors were tested under physiologic loads for 500 cycles followed by a failure test. The number of cycles, failure mode, and failure load were recorded. Fluoroscopy was used to measure rotation and displacement of the anchor within the humeral head during testing. Data were analyzed using a 1-way analysis of variance with a correction for multiple comparisons. **Results:** There were no significant differences in anchor displacement or rotation measured by fluoroscopy after cyclic loading. Total construct displacement across anchors ranged from 4.9 to 7.8 mm, well beyond the 3-mm failure criterion reported in the literature. The IC anchor had a statistically significant greater failure load than the other devices. There was no significant difference in failure load between the other 3 anchors. The anchor had the greatest number of cycles to 3 mm of failure. This was not significantly different than the TwinFix anchor (Smith & Nephew, Andover, MA), but both values were significantly greater than both the Super Revo (Linvatec, Largo, FL) and Fastin RC (DePuy Mitek, Raynham, MA) anchors. **Conclusions:** Anchor motion accounted for about one third of total displacement of the suture/anchor construct. IC fixation anchors performed well compared with standard anchors in human cadaveric bone. **Clinical Relevance:** Fluoroscopic imaging showed both rotation and displacement of the anchor within the humeral head which may contribute to early gap formation after rotator cuff repairs. **Key Words:** Rotator cuff—Repair—Suture anchors—Biomechanics—Implant migration.

The science of arthroscopic rotator cuff repairs continues to advance, with new anchors, materials, and techniques. Despite good to excellent clinical results,[1–5] postoperative imaging studies suggest there is still room for improvement in arthroscopic rotator cuff repairs.[6] The quality of the rotator cuff repair may depend on the blood supply to the cuff and the quality of the tendon-bone interface.[7] The repair is also clearly affected by the suture material, type of anchor, and surgical technique.[8] One option available for the surgeon is to place the suture anchor deeper than recommended in an attempt to improve fixation. A recent study found that anchors placed deeper than the standard insertion depth actually may be associated with decreased biomechanical performance.[9] Data

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from that study indicated that the suture material could cut through the cortical bone and cause loss of fixation. Another potential explanation for this would be anchor translation/rotation within the cancellous bone of the humeral head. It is possible that the anchor would migrate within the humeral head when loaded if the bone-implant interface does not provide adequate stability.

Although it appears that deeper cancellous purchase does not provide improved fixation, anchor stabilization within the dense cortical bone of the humeral head may prove a viable option to limit anchor mobility. Adequate stabilization in this area may also prevent the potential for translation/rotation within the humeral head. For these reasons, a fully threaded intracortical (IC) anchor (FT Anchor) incorporating a recessed suture eyelet loop, which allows anchor placement flush with the cortical surface, has recently been developed by Arthrex, Inc, of Naples, Florida. The study hypothesis was that the IC anchor may provide improved biomechanical stability compared with traditional anchors used for arthroscopic rotator cuff repair. To address this hypothesis, the purpose of this study was to compare the fixation stability of a novel IC anchor compared with several standard anchors, evaluating both cyclic displacement and ultimate failure load as well as anchor motion within humeral head motion using fluoroscopy.

METHODS

Sixteen human cadaveric humeri (8 pairs) were sectioned at the mid-diaphysis and cleaned of soft tissue (age range, 57 to 81 years). Care was taken not to decorticate the supraspinatus tendon footprint on the humeral head. Bone density was measured with a Lunar Dual-Energy X-Ray Absorptiometry (DEXA) machine (GE Medical Systems, Waukesha, WI). These data revealed a relatively osteoporotic sample population (0.34 ± 0.09 g/cm^2) compared with previously reported densities (0.78 g/cm^2) for young male specimens.[10] Four types of anchors (n = 8 in each group) were randomly assigned to either anterior or posterior insertions within the supraspinatus footprint across specimens. Random allocation, using a Latin squares design to balance the treatment groups across the number of specimens, to anterior/posterior positions was performed to normalize for the varying bone density in the greater tuberosity.[11] The Arthrex IC anchor (FT Anchor) and 3 standard cancellous type suture anchors (Fastin RC, DePuy Mitek, Raynham, MA; Super Revo, Linvatec, Largo, FL; and TwinFix

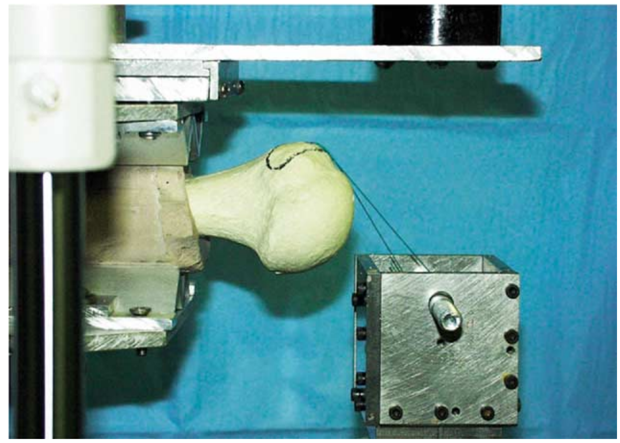

FIGURE 1. Mechanical testing setup.

Ti 5.0, Smith & Nephew, Andover, MA) were all inserted using the respective manufacturers' recommendations regarding anchor depth. Thus, each pair of shoulders received 1 type of anchor from each group (2 anchors per humerus). All anchors were metallic screw-in anchors. The IC anchor was preloaded with FiberWire suture (Arthrex) and the other anchors used No. 2 Ethibond suture (Ethicon, Somerville, NJ). Anchors within a single humeral head were separated by a minimum distance of 1.5 cm. Anchors were placed at 45° to the cortex of the supraspinatus footprint with the mechanical line of action 90° from the anchor long axis simulating the line of action of the rotator cuff (Fig 1). This insertion technique has been recommended previously to maximize anchor stability.[12] The method of loading has been used previously for biomechanical testing of anchor constructs.[13–15]

Sutures were tied with 7 square knots backing up a surgeon's knot over a 38-mm diameter dowel to create a closed loop. This knot was selected to minimize the risk of knot slippage during low cyclic loading. The humeri were potted in a 2-part epoxy resin (Bondo; Marhyde, Atlanta, GA) and held in place with a custom-designed fixation rig. The suture loop was then attached to an MTS machine (Materials Testing Systems, Eden Prairie, MN) to represent the loading direction of the supraspinatus tendon (Fig 1). The suture anchor construct was pretensioned to 10 N and any displacement offset eliminated. Each specimen was cyclically loaded from 10 to 45 N at 0.5 Hz to a maximum of 500 cycles. If still intact after cyclic loading, specimens were loaded at 0.5 mm/sec to failure. This biomechanical methodology has been used previously to evaluate depth of anchor insertion