INTRODUCTION

Total shoulder arthroplasty has been proven to be a successful procedure with good long-term results. Outcomes based on pain relief and function have shown success rates to be greater than 90%. Despite predictable results, various complications following shoulder arthroplasty have been reported. One reported complication is the loss of subscapularis function. Weakness in internal rotation and anterior instability may develop, if the repair of the subscapularis fails. A meticulous repair of the subscapularis muscle following total shoulder arthroplasty or humeral head replacement is essential for post-operative shoulder function. Few reports in the literature discuss the loss of subscapularis function after total shoulder arthroplasty. The incidence of subscapularis dysfunction reports ranges from 67% to 92%. Subscapularis deficiency manifests clinically as anterior glenohumeral instability, leading to implant failure. We sought to test three types of subscapularis repair methods under cyclic loading to determine the biomechanical strength of each method.

MATERIALS AND METHODS

Ten fresh-frozen human cadaveric shoulders were selected for this study. Before repair, each shoulder was analyzed for pre-existing tears of the subscapularis. Tears in the remainder of the rotator cuff tendons were thought not to be significant in the testing of the subscapularis. In all shoulders a standard circumferential release was performed, including a rotator interval release and separation of the subscapularis from the anterior and inferior capsule. Shoulders were divided into three groups based on the type of subscapularis repair.

Group I (Trans-tendonous repair): The subscapularis tendon and anterior capsule were incised 1 cm medial to the lesser tuberosity. A standard circumferential release was performed. The subscapularis was then repaired with an anatomic side-to-side repair using four #2 non-absorbable Fiberwire\textsuperscript{TM} sutures and a modified Mason-Allen stitch through the medial subscapularis tendon.

Group II (Repair to antero-medial cortex): The subscapularis tendon was incised off the lesser tuberosity and a standard circumferential release was performed. Drill holes were placed through the anterior medial humeral cortex. Four #2 non-absorbable Fiberwire\textsuperscript{TM} sutures were placed in the tendon using modified Mason-Allen stitches and tied over the drill holes.

Group III (Bone to Bone repair through transosseous tunnels over a rotator cuff plate): The subscapularis tendon was released with a small portion of the lesser tuberosity with an osteotome. Four #2 non-absorbable Fiberwire\textsuperscript{TM} sutures were anchored in the subscapularis tendon using a modified Mason-Allen suture. Drill holes were then made through the lesser tuberosity, exiting through the lateral humeral cortex. The sutures were then passed through the drill holes and tied over an Arthrotec rotator cuff plate.

In all shoulders, the length of the subscapularis tendon was measured before and after the repair. After preparing the specimen, the proximal stump of the subscapularis tendon was attached to soft-tissue clamp. The humerus was then potted into a custom rig and mounted on a servohydraulic-testing rig (Instron 8511, Instron Corp). In pilot tests, the tendon and bone interface of intact shoulders separated at approximately 700N. The maximum pullout strength for tendon-to-tendon repairs was approximately 450N. We chose 67% (300N) of the maximum repair strength for fatigue testing. Each specimen was initially loaded at 150N for 500 cycles, then at 300N for 2500 cycles at a frequency of 0.2 Hz. The relative displacement between the subscapularis tendon clamp and the head of the humerus was monitored throughout the test. The repair site was also imaged using a digital video camera (640 X 480 pixel resolution, 30 frames per second). Failure was defined as separation of the repair by 5 mm or more. The type and location of failure (through tendon, suture, or bone) were also documented.

RESULTS

Figure 1: After the repair, the length of the subscapularis tendon was decreased in groups I and III by 17% and 11%, while it increased by 9% in group II.

However, during the 300N cyclic loading test, two of the three specimens in Group I failed completely at the repair site. All four specimens in Group II failed at the bony side of the repair. In Group III one out of three specimens failed when the rotator cuff plate collapsed into the humeral head.

DISCUSSION

The tendon-to-tendon repair used in Group I shoulders is perhaps the easiest and most popular method of repair. This method however reduced the overall length of the tendon, which may result in restricting external rotation of the shoulder. The tendon to bone repair used in Group II shoulders seeks to overcome this limitation by anchoring the tendon at a more medial location to increase effective external rotation range of motion at the shoulder. The bone-to-bone repair used in Group III shoulders does not shorten the subscapularis tendon as much as Group I repairs. There may be the added advantage of improved bone-to-bone biologic healing. Finally, since the suture is tied over a rotator cuff plate, this may reduce the incidence of suture failure at the drill holes.

During the first 150 N phase of the testing, Group I showed the least separation at the repair site. However, during the second phase (300 N) all of Group II shoulders separated completely while only 1 each from Groups I and III failed completely. Given these findings, it appears that tendon to tendon repair has sufficient biomechanical strength, if the disadvantage of tendon shortening is acceptable. Bone-to-bone-repair has at least similar biomechanical strength and has the added advantages of reduced tendon shortening and a potential for better biologic healing.