**Rotator Cuff Repair with a Tendon-Fibrocartilage-Bone Composite Bridging Patch**

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**Disclosures:**  X. Ji: None. Q. Chen: None. A.R. Thoreson: None. J. Qu: None. K. An: None. P.C. Amadio: 4; Merck, J&J. 7; Elsevier, JBJS. S.P. Steinmann: None. C. Zhao: None.

**Introduction:** Surgical rotator cuff repair is the criterion standard treatment for rotator cuff tears. From 17% to up to 94% of patients are reported to have retears postoperatively (1, 2). Various mechanical and biological approaches to prevent retears have not been completely successful because of the unsatisfactory regeneration of the natural tendon-to-bone transition zone (3, 4). However, bone-patellar tendon-bone grafts strengthen healing by using a bone-to-bone healing interface instead of the weaker tendon-to-bone interface of anterior cruciate ligament reconstruction (5). In this study, we applied this concept to rotator cuff repair by replacing the dissimilar-tissue (tendon-to-bone) healing interface with similar-tissue healing interfaces (tendon-to-tendon and bone-to-bone). The purpose of this study was to examine the mechanical performance of rotator cuffs and compare those repaired with a patellar tendon-fibrocartilage-bone composite (TFBC) bridging patch technique versus the traditional repair method in an in vitro model.

**Methods:** Twenty shoulders and 10 TFBC were harvested from 10 mixed-breed dogs that were euthanized for other studies. All muscle attachments, except for the infraspinatus tendon and the infraspinatus muscle, were detached from the humerus for each shoulder. Each patellar tendon was trimmed to 10×15 mm with its bony attachment segment intact and cut horizontally into 2 layers. The anterior and posterior extent of the infraspinatus tendon were identified and then the tendon was sharply detached from the bone surface. 10 specimens were randomly assigned to the TFBC group and 10 to the control group. A schematic of the repairs is shown in Figure 1. In the TFBC group, the infraspinatus tendon was inserted between patella tendon layers. Modified Mason-Allen sutures of polyester braid and long-chain polyethylene (Fiberwire #2; Arthrex, Inc., Naples, FL, USA) were used to repair the patellar tendon to the greater tuberosity. Two parallel loops were sewn through the full thickness of the sandwich-like tendon with 3-0 polyglactin sutures (Vicryl; Ethicon, Inc., Bridgewater, NJ, USA). The bone fragment of the TFBC was fixed to the attachment point of the infraspinatus tendon using a metal wire threaded through 2 bone tunnels introduced into the humeral head. For the control group, the infraspinatus tendons were repaired with modified Mason-Allen sutures of Fiberwire #2 sutures through 2 bone tunnels.

After rotator cuff repair, the specimen was mounted on a servohydraulic test machine (858 MiniBionix II; MTS Systems Corp, Eden Prairie, MN, USA) for mechanical evaluation. Each repaired rotator cuff specimen was loaded to failure under displacement control at a rate of 0.5 mm/sec. Load and actuator displacement were recorded at a sample rate of 50 Hz. Ultimate tensile load was defined as the peak force observed during loading. Each specimen’s failure mechanism was also recorded. Specimen loading was video recorded (frame rate, 29 frames/second) throughout the testing. Videos were processed with image-analysis software (Analyze 11.0; Mayo Clinic) to measure marker displacement. Stiffness was calculated from the slope of the linear region of the load-displacement curve.
All data are presented as the mean (SD). The ultimate tensile load and stiffness for the 2 methods of rotator cuff repair were compared using the Student’s t-test. Statistical significance was set at P<0.05.

**Results:** No suture breakage was observed during testing in either group. For the control group, all 10 specimens failed by suture pullout from the tendon. Ultimate tensile load was significantly higher in the TFBC group than the control group (P<0.001) (Figure 2). The overall stiffness for the TFBC repair composite and conventional repair were not significantly different (P=0.43) (Figure 3). However, stiffness at the TFBC-greater tuberosity repair site was significantly higher than the control repair site (infraspinatus tendon to greater tuberosity) (P<0.001), and the stiffness at the TFBC-infraspinatus tendon repair site was also significantly higher than the control repair site (P=0.02). The stiffness at the TFBC-greater tuberosity repair site was significantly higher than the TFBC-infraspinatus tendon repair site (P=0.02).

**Discussion:** Because both sides of the infraspinatus tendon are covered by the patellar tendon, this telescoping structure guarantees contact between the 2 tendon tissues, provided that the relative displacement does not exceed the length of patellar tendon. The higher stiffness at the TFBC-greater tuberosity repair site (i.e., the shorter displacement compared with the traditional repair) provides a more secure environment for tissue healing. Furthermore, bone-to-bone and tendon-to-tendon healing are widely accepted to be relatively easier and faster to rebuild than tendon-to-bone healing. Based on these findings, we believe that the novel structure of the TFBC patch may improve healing of the repaired rotator cuff.

**Significance:** The TFBC bridging patch achieved higher ultimate tensile load and stiffness at the TFBC-greater tuberosity repair site compared with traditional repair in a canine model. TFBC augmentation can potentially serve as a scaffold for cell seeding to develop an engineered composite tissue, which could be used to enhance rotator cuff tendon healing. More importantly, this composite tissue transforms the traditional tendon-to-bone healing interface (with dissimilar tissues) into a pair of bone-to-bone and tendon-to-tendon interfaces, which may improve healing quality.
Figure 1  A) Repair with the Mason-Allen technique (control). B) Repair with the TFBC patch. GT indicates greater tuberosity; IPT, infraspinatus tendon; TFBC, tendon-fibrocartilage-bone composite. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved.)

Figure 2  Ultimate tensile load after tendon-fibrocartilage-bone composite (TFBC) or control repair.
Figure 3  Overall stiffness after tendon-fibrocartilage-bone composite or control repair. HP indicates stiffness of the TFBC repaired construct; GT, stiffness at the TFBC-greater tuberosity repair site; PG, stiffness at the TFBC-infraspinatus tendon repair site.

ORS 2015 Annual Meeting
Poster No: 1354