Comparison of Achilles Tendon Suture Repair Techniques: Krackow vs. Modified Mason-Allen Under Cyclic Loading in an *In-Vitro* Bovine Model

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INTRODUCTION: The annual incidence of Achilles tendon ruptures has been estimated to range between 5.5 and 9.9 ruptures per 100,000 people in North America [1]. Although the appropriate treatment for Achilles tendon rupture remains controversial, many surgeons opt for operative management in active young patients [2]. A good suture technique should provide a high tensile strength, high resistance to gap formation, and minimal suture material on the tendon surface so as not to interfere with tendon gliding and healing [3]. Minimal gap formation between the ends of the repaired tendon is believed to be important during the early post-operative stage in order to effectively facilitate the natural healing process. The Krackow technique is a locking loop suture technique commonly used in tendon repair. Although Krackow is known to produce excellent pullout resistance, it has poor resistance to gap formation [3]. The modified Mason-Allen technique has a less complex suture pattern and is less invasive on the tendon and the connecting tissues, but its use in the repair of acute Achilles tendon ruptures has not been well described in the biomechanical literature. This study compares the tensile strength and gap formation resistance of the modified Mason-Allen and Krackow suture technique in an *in vitro* bovine model to benchmark the potential use of the modified Mason-Allen technique clinically. In addition, the effect of two commonly used suture types, Fiberwire and Ethibond, will also be compared to assess their biomechanical performance in these procedures.

METHODS: Ten freshly slaughtered bovine Achilles tendons with attached calcaneus were obtained, and a mid-length tenotomy was performed with a scalpel approximately 3cm above the calcaneus. Two groups of 5 were randomly assigned and repaired with either the Krackow or the modified Mason-Allen techniques using a single Fiberwire suture, providing 2 core strands. The calcaneous was potted in bone cement, and the free tendon end was freeze-clamped just prior to testing. Each specimen was preloaded with 10N for 5 minutes to reduce creep associated with *in vitro* testing. All specimens were cyclically loaded with a 1 Hz sinusoidal waveform from 10N to 60N for 3000 cycles using a servohydraulic testing machine (Instron #8874, Canton, MA). Proximal and distal ends of the tenotomy site were marked at equal distances from the tenotomy site to the center of the tendon and tracked with video extensometry. Specimens were then pulled to failure at 1mm/sec. Failure was defined as a significant change in the slope of the tension-time curve. For the suture comparison study, five additional matched pairs (left and right) of bovine Achilles tendons were repaired with the modified Mason-Allen technique using either Fiberwire or Ethibond, and cyclically loaded and pulled to failure using the same testing techniques as before. Statistical differences between each group were assessed using paired Student-t tests (α=0.05).

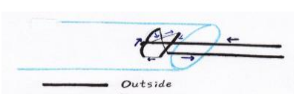

Figure 1. Modified Mason Allen Suture Technique

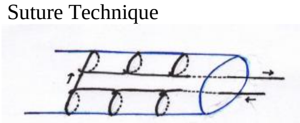

Figure 2. Krackow Suture Technique

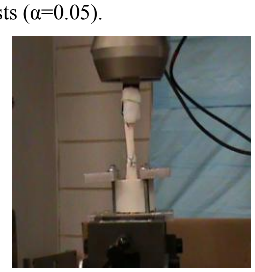

Figure 3. Tendon undergoing testing with freeze clamps in a servohydraulic testing machine

RESULTS: Cyclic loading resulted in an average gap of 7.72 ± 0.76mm for the Krackow group and 4.56 ± 0.77mm for the modified Mason-Allen group (p < 0.010). The average load at failure for the Krackow group was 239±33N and for the modified Mason-Allen group was 239± 63N (p = 0.999). Cyclic loading resulted in an average final gap of 4.64±0.48mm for the Fiberwire group and 4.58 ±0.29mm for the Ethibond group (p = 0.821). The average load at failure for the Fiberwire group was 242 ± 33N and for the Ethibond group was 118± 6N (p < 0.001).

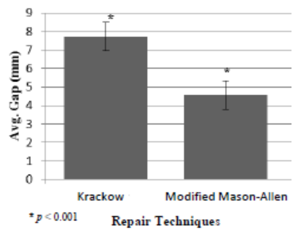

Figure 4. Average gap formation of the Krackow vs. the Modified Mason-Allen Suture Technique

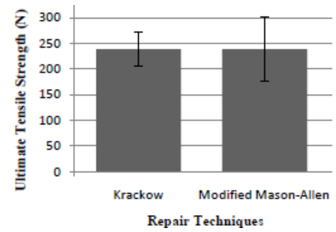

Figure 5. Average ultimate tensile strength of the Krackow vs. the Modified Mason-Allen Suture Technique

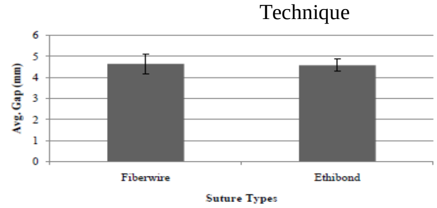

Figure 6. Average gap formation of the Modified Mason-Allen Technique using the Fiberwire vs. the Ethibond sutures.

DISCUSSION/ CONCLUSION: The results show that the modified Mason-Allen suture technique maintains a significantly smaller attenuation at the repaired ends under cyclic loading compared with the Krackow suture technique. The attenuation may be explained by both suture pull-out from the tendon repair construct (due to tightening of the loop and/or tearing of tendon fiber) and the amount of tendon and suture incorporated into each repair [4,5]. In this study, the ultimate tensile load in a repair may depend on the suture material and the number of core strands crossing the repair site more so than the suture technique or configuration [6,7]. However, as the number of sutures increases, it is also possible that the suture technique itself becomes the dominating factor since the pullout strength also depends on how well the suture technique holds the soft tissue and minimizes tissue tearing along the fibers at higher load. The suture comparison study shows that Fiberwire suture has a greater inherent tensile strength compared to Ethibond suture while both provide comparable resistance to repair attenuation. In the future, a prospective in vivo randomized controlled trial comparing the different repair techniques with identical accelerated rehabilitation protocols could be performed to demonstrate if a particular repair technique might yield superior clinical outcomes.

SIGNIFICANCE: Accelerated rehabilitation is becoming the standard of care following operative repair of acute Achilles tendon rupture. Therefore, the repair must be strong and sufficiently resistant to attenuation to permit application of early activity. Otherwise, a significant gap can hinder proper biological healing or lead to healing of the tendon in a lengthened position. When the repaired Achilles tendon heals in a lengthened position, the physiologic performance may be inferior to that of an Achilles tendon of normal length. This study provides comparative biomechanical data to assist surgeons in the selection of the optimal tendon rupture repair techniques.

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