Biomechanical Comparison of 3 Novel Repair Techniques for Radial Tears of the Medial Meniscus: The Two-Tunnel Transtibial Technique, a “Hybrid” Horizontal and Vertical Mattress Suture Configuration, and a Combined “Hybrid Tunnel” Technique

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Introduction

Background
Radial meniscus tears are oriented perpendicular to the circumferential fibers, leading to impairment of the meniscal ability to transmit circumferential hoop stresses during load bearing.

- Historical techniques for the repair of radial meniscal tears involve either an all-inside horizontal mattress repair or an inside-out repair with single, double, or crossed horizontal mattress sutures.

Due to their detrimental effect on the meniscus’ ability to maintain meniscal hoop stresses, complete radial tears have been described as functionally similar to a total meniscectomy, predisposing patients to early osteoarthritis and rapid joint degeneration when left untreated.

Natural History

Radial meniscal tears are challenging to treat and even more challenging to achieve complete healing. Historical techniques describe partial meniscectomy with poor results and high rates of salvage surgery in the form of meniscal transplantation. There is a renewed push for meniscal repair, and search for the ideal construct that combines biomechanical stability with biologic healing.

Methods

Study Design
30 male cadaveric knees (10 matched pairs, n = 20; 10 unpaired n = 10) utilized.

- A complete radial tear was made at the midbody of the medial meniscus. Repairs were then performed according to the described techniques.
- Specimens were potted and mounted on a universal material testing machine where each specimen was cyclically loaded for 1000 cycles before experiencing a pull to failure. Gap distances at the tear site, ultimate failure load, and failure location were measured and recorded.

Surgical Technique

Two-Tunnel: Two 2.4-mm tunnels were created in the tibia with a sheathed drill guide to exit at the meniscocapsular junction, with the center of the tunnels located 5 mm apart. No. 2 sutures were placed through the transosseus drill holes and passed through each limb of the radial meniscal tear with a nitinol wire lasso in a crisscross fashion. No. 2 suture was then tied over a cortical button on the anterior tibial cortex. Following accurate anatomic reduction, the repair was completed with 2 inside-out horizontal mattress sutures placed on the superior surface of the meniscus and 2 inside-out horizontal mattress sutures placed on the inferior surface.

Hybrid Repair: A vertical mattress suture configuration was performed, reducing both radial tears to the capsule. These vertical sutures function as a “rip stop” for the 4 horizontal mattress sutures that follow, which were placed with an inside-out technique perpendicular to, and over the top of, the vertical mattress sutures at the radial tear site.

Hybrid Tunnel: The hybrid tunnel technique was completed in the manner described for the two-tunnel technique with the addition of two 2-0 vertical mattress sutures, 1 on either side of the radial tear as in the hybrid technique to act as a rip stop for the horizontal sutures.

Results

There were no significant differences identified with respect to gap distances or load to failure measured at each of the cycle time points when the 2-tunnel, hybrid, and hybrid tunnel techniques were compared.

- The 2-tunnel technique (7 of 9, 78%) was significantly more likely to tear through the meniscus than the 2 groups utilizing the rip stop stitch (4 of 16, 25%).

Two-Tunnel Technique

“Hybrid” Repair Technique

“Hybrid” Tunnel Technique

Discussion

- The most important finding of this study was that the two-tunnel, hybrid, and hybrid tunnel radial meniscal repair techniques demonstrated equivalent biomechanical testing in regard to gap distance and pull-to-failure strength.

- The addition of the vertical mattress sutures to act as a rip stop suture was effective in preventing meniscal cut-out of the meniscus and may be utilized in poor quality tissue.

- On the basis of concomitant procedures, tear location, and tear extent, the surgeon can employ the appropriate technique that allows for the most optimal meniscal radial tear healing.