Effect of Repair of Radial Tears at the Root of the Posterior Horn of the Medial Meniscus With the Pullout Suture Technique: A Biomechanical Study Using Porcine Knees

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Purpose: Our purpose was to evaluate the result of radial tears at the root of the posterior horn of the medial meniscus (PHMM) in terms of tibiofemoral contact mechanics and the effectiveness of pullout sutures for such tears. **Methods:** Eleven mature pig knees each underwent 15 different testing conditions with an intact, simulated (incised) radial tear at the root of the PHMM and placement of pullout sutures in the radial tears of the medial meniscus at 5 different angles of flexion (0°, 15°, 30°, 60°, and 90°) under a 1,500-N axial load. A K-Scan pressure sensor (Tekscan, Boston, MA) was used to measure medial tibiofemoral contact area and peak tibiofemoral contact pressure. Data were analyzed to assess the difference in medial contact area and tibiofemoral peak contact pressure among the 3 meniscal conditions at various degrees of knee flexion. **Results:** The mean contact area was significantly lower, and the peak tibiofemoral contact pressure was significantly high in knees with simulated radial tears at all angles of knee flexion compared with knees with intact menisci ($P < .0001$). The peak tibiofemoral contact pressure after the pullout suture technique was significantly high at 0° and 15° of flexion ($P < .0001$) compared with intact knee specimens. Failure of sutures occurred in 45% of the specimens at 0° of flexion. **Conclusions:** Radial tears at the root of the PHMM in a porcine model significantly increased medial tibiofemoral contact pressure and decreased contact area. Although repair of tears of the PHMM with the pullout suture technique aids in significantly reducing tibiofemoral peak contact pressure between 30° and 90°, it remains significantly high at 0° and 15° of flexion. **Clinical Relevance:** Pullout sutures for radial tears at the root of the PHMM may lead to an increase in peak medial tibiofemoral contact pressure and may be prone to mechanical failure, especially during the stance (loading) phase of gait (mean, 15° of flexion). **Key Words:** Medial meniscus—Posterior horn—Radial tear—Root tear—Contact area—Contact pressure—Pullout suture.

The functions of the meniscus include compressive load transmission across the knee joint, increased tibiofemoral congruency, and joint stability.[1,2] The posterior portion of the medial meniscus carries a greater proportion of load compared with the anterior portion.[3] A radial tear of the posterior horn of the medial meniscus (PHMM) is not uncommon, especially in the Far East, where activities such as squatting and sitting on the floor with the legs folded require maximal knee flexion.[4] Radial tears at the root

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of the PHMM result in loss of meniscal circumferential hoop pressure and have been reported to be biomechanically equivalent to a total meniscectomy.[5-7] As a result, extrusion of the medial meniscus from the joint space occurs, which can lead to premature degenerative osteoarthritis due to decreased tibiofemoral contact area and increased contact pressure.[7-9] It is important to recognize these tears because they have important clinical implications with respect to meniscal function and tend to have a more ominous prognosis because they occur commonly in patients aged over 50 years, in whom the meniscal tissue may be degenerated and have low healing potential.[4,10,11]

Arthroscopic partial meniscectomy has been reported to result in partial relief of pain in patients with radial tears at the root of the PHMM.[4] However, this procedure is more suitable for elderly patients with previous joint degeneration. Recently, some authors have reported repair of the radial tear with pullout sutures and have hypothesized that this technique may promote healing and facilitate restoration of meniscal hoop tension.[12,13] Literature is lacking regarding the biomechanical effect of the repair of radial tears with pullout sutures, and we found only one study that analyzed the biomechanical effect of posterior root tears of the medial meniscus in cadaveric knees.[7] The aim of this in vitro study was to assess changes in medial tibiofemoral contact area and pressure after repair of radial tears with pullout sutures at the root of the PHMM and compare the repair of radial tears with pullout sutures with intact and resected menisci in porcine knees. We hypothesized that radial tears at the root of the PHMM result in a significant alteration in tibiofemoral contact mechanics and that pullout sutures may not be effective in optimally restoring it.

METHODS

In vitro biomechanical testing was carried out by use of 11 mature porcine knee joints from Yorkshire pigs (aged 3 years) with a mean body weight of 100.1 ± 5.4 kg. The specimens were stored in plastic sheathing at −20°C in a freezer. Before testing, each specimen was thawed at room temperature for 24 hours. The skin and subcutaneous tissue were removed around the joint, but the joint capsule, anterior and posterior cruciate ligaments, medial and lateral collateral ligaments, and patella were preserved to simulate the biomechanical properties of the human knee joint as closely as possible. The femur and tibia were cut 20 cm from the tibiofemoral joint line and mounted on an aluminum cylinder with dental acrylic resin (Dentimex, Zeist, The Netherlands).

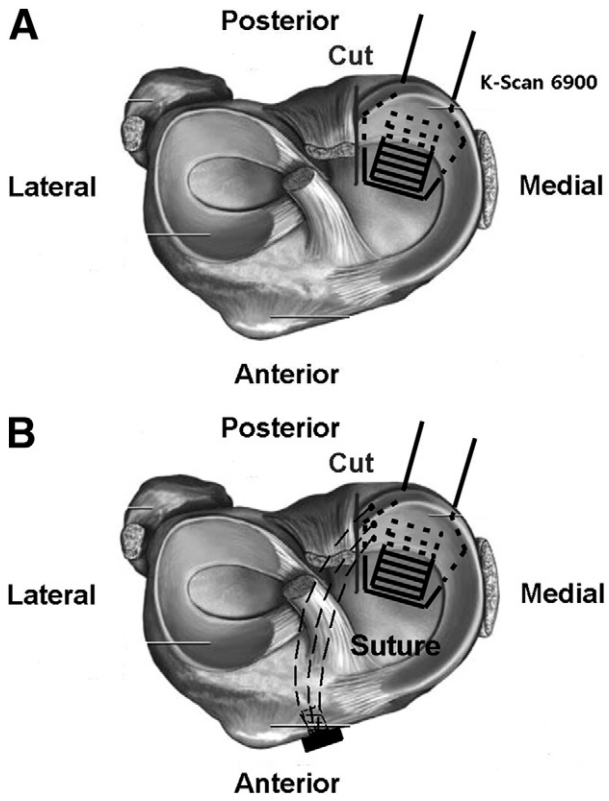

FIGURE 1. (A) Site of simulated radial tear of PHMM and position of K-Scan sensor. (B) Pullout sutures for radial tear of PHMM and position of K-Scan sensor.

The measurement of contact pressure was done by use of a thin (0.1-mm) pressure sensor (K-Scan 6900 sensor; Tekscan, Boston, MA) interfaced with a desktop personal computer that recorded and displayed the force and area values in real time (Fig 1). The posterior joint capsule was dissected transversely. The PHMM was exposed, and the posterior meniscotibial ligament was carefully isolated and incised. The K-Scan pressure sensor was then inserted between the undersurface of the PHMM and tibial condyle with the sensor surface kept parallel to the tibial articular surface. Both edges of the capsule were sutured for fixing the K-Scan pressure sensor during the knee motion. The entire loading jig was then mounted on a Bionix 858 closed-loop servohydraulic mechanical testing system (MTS, Minneapolis, MN). The loading jig consisted of fixtures that allowed translation and rotation of the knee joint in 6 degrees-of-freedom (DOF) and at each flexion angle; the movement of the tibia