Effects of Serial Sectioning and Repair of Radial Tears in the Lateral Meniscus

Introduction
Numerous long term clinical outcome studies of meniscectomized knees have reported clinical and radiographic arthrosis\(^2,3\). In a comparison of medial and lateral meniscectomy, it has been noted that there is an increase of arthrosis in the lateral compartment\(^4\). Furthermore, the lateral tibiofemoral compartment is thought to experience more rapid and dramatic deterioration after meniscectomy\(^5\). The aim of the present study was to characterize initial biomechanical changes resulting from serial radial transection of the lateral meniscus. The primary objective was to quantify the alteration in load transmission and contact area in the lateral compartment. An additional objective was to compare load transmissions following repair of a complete radial lateral meniscus tear with those of the intact state or all-inside meniscal repair.

Materials and Methods
Ten fresh-frozen human cadaveric knees (5 matched pairs, 1 femoral, 4 male, mean age 65 years, range 50 to 82 years) were dissected with removal of skin, muscle and the extensor mechanism keeping the lateral and posterior capsule intact. Before testing, an osteotomy of the lateral femoral condyle was performed in order to gain access to the lateral meniscus. In addition, small anterior and posterior horizontal arthrotonomies were created below the level of the menisci to allow for the insertion of dynamic pressure-sensitive film (K-Scan 4000, 1500 psi capacity, defined area of 28 x 33 mm; Tekscan Inc., Boston, MA).

Each specimen underwent the following sequence of test conditions: (1) intact lateral meniscus, (2) 50% radial section, (3) 75% radial section, (4) 100% radial section, (5) meniscal repair, and (6) complete meniscectomy. Surgical repair (step #5) was performed using either an inside-out repair using non-absorbable 2-0 suture (Fiberwire; Arthrex Inc., Naples, FL), or using an all-inside device (Meniscal Cinch; Arthrex Inc., Naples, FL). Repairs were randomly assigned, although each contralateral limb received the alternative repair technique. All of the repairs were performed using two horizontal mattress sutures.

Biomechanical Testing
In order to ensure even loading across the knee, the tibia of each specimen was placed in a dynamic external fixator (Taylor Spatial Frame; Smith & Nephew, Memphis, TN). The femur was affixed to a custom-made jig, which allowed for positioning of the knee in 0º or 60º of flexion. The construct was tested in a materials testing system (MTS Insight 5, Eden Prairie, MN), where the knees were subjected to 20N of compressive preload followed by an axial load of 800N. Each specimen was first tested in 0º of flexion for each test condition, followed by testing in 60º of flexion.

Sensors provided detailed pressure maps of the lateral meniscus. In addition, contact area, peak force, and contact pressure were calculated. In order to reduce the effects of anatomical variation between specimens, all data for a given knee were normalized to that of its intact state. Statistical analysis was performed using GraphPad Prism 5 (La Jolla, CA). 1-way ANOVA with repeated measures was used to compare the different test configurations for each knee angle. A Tukey’s post-hoc test was performed for multiple comparisons between each of the groups, when appropriate. The two repair constructs were compared using a two-tailed, unpaired t-test. Statistical significance was assumed for p < 0.05.

Results
Normalized Lateral Tibiofemoral Contact Area and Peak Force

Data presented is for 0º of flexion. The mean normalized contact pressure for each testing condition is illustrated in Figure 1. There was no statistical difference in contact pressure between 50% and 75% radial tears and the intact state (p>0.05). With 100% radial tear, there was a statistically significant increase in contact pressure relative to the intact state. After repairing the radial tear with either technique, the contact pressure decreased statistically relative to the 100% radial tear and was not statistically different from the intact state (p>0.05). No statistical difference was found between the all inside and the inside-out repair techniques. The contact pressure in the meniscectomized knee was significantly greater than that in all other groups (p<0.001), including the 100% tear.

Peak Force data demonstrated similar findings to that of contact pressure, although there was no statistical significance. There was an increase in peak force following 100% radial tear relative to the intact state. There was no difference found between repair techniques. Total meniscectomy resulted in an increase in peak force. Similar mean contact pressure and peak force results were found in 60º of flexion.

Discussion
The current study aimed to investigate biomechanical changes in load transmission and contact area of the lateral meniscus following radial tears and repair. At time zero, no differences in contact area, contact pressure, or peak force were found between intact and radial tears up to 75% of the lateral meniscus. Not until a 100% radial tear, did the contact pressure significantly increase and contact area significantly decrease. Repair of a complete radial tear significantly decreased contact pressure and increased contact area. The inside out and all inside repair techniques were noted to be biomechanically comparable. Total meniscectomy resulted in a greater contact pressure and lower contact area than any of the torn states. Thus, from a biomechanical perspective, preserving the meniscus is preferable to a total meniscectomy. The present results suggest a benefit to repairing a complete radial tear of the lateral meniscus. Although, clinical investigation is necessary to determine the long term performance of a repaired and radially torn lateral meniscus.

References

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