Contact area and pressure distribution changes in the medial tibial plateau in horizontal cleavage tears of the medial meniscus after repair

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Introduction: A horizontal cleavage tear of the meniscus presents a most challenging problem to the surgeon, and typically the response is to resect either of the leaves of the tear, or perform a segmental meniscectomy [1-2]. One of the aims of repair is to restore or at least maintain some residual function of the meniscus in its role as a shock absorber and pressure distributing system. With this criterion in mind, we quantified the changes in the tibial contact area in human cadaver knees by simulating a cleavage tear of the medial meniscus, and following it with several methods of repair.

Materials and Methods: Adult human cadaver knees (n=7, age: 55–70 yrs), transected 30-cm from the joint line at the femur and tibia/fibula, were used. The bone ends were potted in epoxy resin and then secured and aligned to the machine axis of a uni-axial mechanical testing machine. The knee was maintained in extension to allow loading to be in direct compression. A small pre-load no larger than 50-N was used to maintain this position. A medial parapatellar arthrotomy was made, to expose the medial compartment of the knee. The collateral ligaments were dissected away to gain access for the placement of standard 50-mm x 30-mm templates of pressure-sensitive film (Fuji Prescale Film) between the meniscus and the surface of the medial tibial plateau [3,4].

The specimens were then loaded in compression up to 740-N and maintained for a duration of 5-s, before unloading. The load was then increased to 1100-N (simulating 1.5 times body weight).

For each specimen, the knee was first loaded with the medial meniscus intact (Group-0). Subsequently a 1-cm horizontal cleavage tear in the medial aspect of the meniscus was created with a scalpel blade and the knee mechanically tested again with fresh Fuji film (Group-1). Following this step a sequence of repair procedures and tests (each with fresh Fuji film) were carried for each specimen. These procedures are listed as follows: Group-2, the meniscal tear was repaired with two vertical mattress sutures (3-0 Ethicon PDS) and mechanically tested; then either the upper (Group-3a, n=3) or the lower leaf (Group-3b, n=4) of the horizontal cleavage tear of the medial meniscus was removed and tested; and finally a segmental meniscectomy, removing the remaining leaf of the meniscus was performed and tested (Group-4).

All the Fuji film from the tests were collected and read by a Fuji Prescale Densitometer to obtain the intensity of the colour changes on the film, and this was directly translated to the mean applied pressure (MPa). Each template was also digitized and the average contact area was estimated using Adobe Photoshop tools.

Results: There was no significant change in contact area size and position in the medial compartment in the intact condition and after undergoing a horizontal cleavage cut. The contact area in both these cases was mainly confined to the region of the meniscus. Further, no significant changes in the contact area were noted following repair with the two vertical mattress sutures (Figure 1). In the case of repair by removal of the meniscal upper leaf (Group-3a), there was an increase in the mean pressure by 57% (Scheffe, p=0.19) compared with the unrepaird state. A significantly larger amount of pressure was recorded (Scheffe, p<0.001) in the anterior portion of the contact area in Group-3a. In Group-3b, i.e. lower-leaf meniscectomy, a higher mean pressure, twice as much that for the upper-leaf meniscectomy, was recorded. This difference was significant (Scheffe, p=0.003). Finally, with a segmental meniscectomy, a significant shift in the contact area was noted, increasing the mean contact pressure by 3.5 times in the region not protected by the meniscus (Fig. 1).

Discussion: Based on our findings, sacrificing either leaf of the meniscus in a horizontal cleavage tear will cause significant alteration in the contact area and pressure distribution in the medial compartment of the knee. Performing a segmental meniscectomy will drastically alter the load-bearing ability of the medial meniscus, resulting in more direct unprotected cartilage-to-cartilage contact. These methods of treatment of a horizontal cleavage tear of the meniscus are therefore not ideal. Repairing the horizontal cleavage tear with sutures appears to give the most favourable result for this experimental set-up.


Figure 1. Fuji film contact area maps from direct compression (1100-N) for a set of typical specimens tested. The top left map (Group-0) shows the intact-normal state where much of the contact is taken up by the meniscus. The bottom right map (Group-4) shows how contact area shifts towards the non-protected surface of the tibia plateaus when the meniscus has been segmented.