The objective of this study was to investigate the effect of partial longitudinal lateral meniscectomy on the mechanics of the articular cartilage. A 3D fibre-reinforced finite element (FE) model of the knee joint was considered for this purpose. The model includes bones, cartilages, menisci as well as four major ligaments. A fibre-reinforced fully saturated porous modeling was considered for the cartilages and menisci. Three different cases of partial removal of the lateral meniscus were considered. In each case, the changes in fluid pressurization of articular cartilage were compared with the results of the intact joint. It was found that fluid pressure increases significantly after partial lateral meniscectomy. Moreover, the rate of decay in fluid pressure was remarkably lower than the intact joint. Furthermore, the increase in removed area of the meniscus, amplified the fluid pressure level of the femoral cartilage.

In recent years, many computational studies have investigated the effects of partial meniscectomy on the knee joint. Significant changes in joint contact mechanics, such as stress distributions, were predicted for a partial meniscectomy joint [6]. The maximal stress in articular cartilage in meniscectomy joint was reported about double of that in an intact joint [4]. In terms of post-effects of meniscectomy, cartilage degeneration was reported to be possibly initiated from either surface or subchondral zones [7].

In published 3D computational studies, hydrated tissues of the knee joint (cartilages and menisci) are assumed as single phase materials [4,6]. Using this assumption, convergence difficulties associated with fluid pressure modeling have been omitted and yet comprehensive results have been obtained. The fluid pressure has been only modeled in simplified 2D and axisymmetric studies [7]. As a step towards developing recent FE studies, a real 3D FE model of the knee joint considering fluid pressurization for cartilages and menisci is used in the present work.
was about 27%, 45%, 67%, 76% and 77% of the maxima at t=100s, 1000s, 4000s, 8000s and 10000s, respectively (Fig. 4).

In all meniscectomy cases, the high-pressure region was observed in central area of the lateral condyle which is in direct contact with tibial cartilage (Fig. 3). In case of AL meniscectomy, the high-pressure region extended towards anterior-lateral direction as creep developed (up to 10000s, not shown). For CL and EL meniscectomy, the high-pressure region extended towards anterior-posterior direction.

Compare to the intact joint, the pressure level in femoral cartilage increased after meniscectomy (Fig. 4). For instance, at t=10s, the increase in peak pressure was about 20%, 24% and 26% for AL, CL and EL cases. The rate of decay in pressure was lower in meniscectomy cases compare to the intact joint (Fig. 4). In case of EL, the pressure level was considerably high even after 10000s. This high pressure level is consistent with the increase in removed area of the meniscus.

Figure 1: Finite element model of the knee joint

CONCLUSIONS
Effects of partial lateral meniscectomy on fluid pressurization of femoral cartilage was investigated using a 3D fibril reinforced FE model of the knee joint. Three cases of partial longitudinal meniscectomy were considered. It was found that partial lateral meniscectomy alters the contact mechanics of the joint. As a result, the fluid pressure in femoral cartilage increased significantly after partial meniscectomy. The highest increase in fluid pressure was observed in EL case, which is consistent with the increase in removed area of the meniscus. Moreover, the rate of decay in fluid pressure was remarkably lower than the intact joint. In case of extended meniscectomy, high-pressure levels were observed even after several thousand seconds of creep.

Figure 2: FE models of partial lateral meniscectomy: a) anterior, b) central, c) extended. Shaded elements are removed in each case to simulate the corresponding meniscectomy.

Figure 3: Fluid pressure in femoral cartilage (MPa) at t=10s; a) intact joint, b) AL, c) CL, d) EL.

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REFERENCES

Figure 4: Peak fluid pressure (MPa) in femoral cartilage vs. time for intact joint and meniscectomy cases.