STRESS DISTRIBUTION IN THE KNEE JOINT FOLLOWING A HIGH TIBIAL OSTEOTOMY

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14.1% of men & 22.8% of women over 45 years show symptoms of osteoarthritis OA of the knee [1]. Knee OA is usually associated with lower limb mal-alignment [2]; 5^0 of varus results in 70% - 90% increase in compressive loading of the medial tibio-femoral compartment [3] and OA worsening over 18 months [4]. High Tibial Osteotomy (HTO) enables preservation of bone stock and soft tissue structures and could be an attractive option to younger patients who wish to return to high level activity. However, results of HTOs are unpredictable, which could be due to patient selection or surgical techniques. The long-term aim of this work is to develop a predictive tool to aid the surgeon in the selection of optimal HTO geometry for improved and more consistent surgical outcomes. The first step in achieving our long-term goal was to determine whether stress predictions at the tibio-femoral articulation were sensitive to simulated high tibial osteotomy, using finite element (FE) method.

CT and MRI data of a cadaveric knee were used to create geometrically accurate 3D models of the femur, tibia, fibula, menisci and cartilage and tendon of the knee joint, using the Mimics V12.11 commercially-available software (Materialise, Belgium). The Simulation module was used to register the bones and the soft tissues. The resulting STL files were exported to CATIA V5R18 pre-processor to generate surface meshes and create the corresponding 3D solid and FE models of the osseous and soft tissues from the STL cloud of points.

The Young's moduli for cortical bone, cancellous bone, cartilages, menisci and ligaments were taken from literature as 17 GPa, 500 MPa, 12 MPa, 60 Mpa and 1.72 MPa respectively [5,6,7]. The Poisson's ratios for osseous and soft tissues were taken as 0.3 and 0.45, respectively [8]. The nodes between the bones and the corresponding cartilages were merged and surface contact was applied between the cartilages. The distal ends of the tibia and fibula were fixed and a load of 2.1 KN, corresponding to 3 x body weight, was applied perpendicularly to the proximal end of the femur. Results of finite element analyses show a reduction of 67 % in principal stresses in the knee joint following an open wedge HTO surgery simulating 10^0 varus correction.

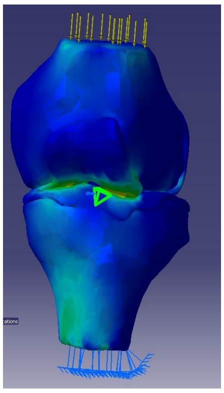
Fig. 1: Stresses in the knee joint following HTO

FE analysis results of this study show that HTO reduces stresses in specific regions of the knee (Fig. 1), which are associated with OA progression [4]. Our future works include corroborating our results with controlled cadaveric experiments and implementing optimisation techniques to predict optimum HTO geometries for patient-specific FE models.

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