COMPUTATIONAL BIOMECHANICS OF THE KNEE JOINT IN GAIT - OTEOARTHRITIC AND ASYMPTOMATIC SUBJECTS

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Introduction

Due to excessive loads and motions in daily activities, the human knee joint is at a high risk of Osteoarthritis (OA) which is the leading cause of pain and disability in the elderly. Earlier studies have identified marked differences in gait kinematics-kinetics between asymptomatic (N) and OA subjects. Knowledge of musculature activation and tissue stresses/strains in both subject groups is crucial in effective prevention and treatment of knee OA. In the current work, we use a validated finite element (FE) model [Adouni et al, 2012] to compute during the stance phase of gait lower extremity muscle forces and knee joint stresses/strains in both N and OA subjects. These FE analyses are driven by *in vivo* data collected during gait of N and OA subjects [Astephen et al, 2008]. Material properties of the articular cartilage/menisci are either left unchanged as in the N model or altered to represent OA diseased conditions.

Methods

An iterative kinematics-driven FE model that accounts for the knee passive structures and active musculature of the lower extremity is employed [Adouni et al, 2012]. The FE model presents nonlinear depth-dependent fibril-reinforced cartilage/menisci and ligaments with nonlinear properties/initial strains. Based on measurements [Astephen et al, 2008, Hunt et al, 2001], hip/knee/ankle joint rotations/ moments and ground reaction forces during gait of N and OA subjects drive both groups. Analyses are performed at 0% (heel strike), 5%, 25%, 50%, 75% and 100% (toe off) of the stance phase. Alterations in OA material properties are simulated at 5% and 50% with reduced cartilage/menisci fibril-matrix moduli.

Results

Muscle forces overall decreased in OA model (Fig. 1). Total contact forces increased in OA model only at the 50% period while contact areas generally increased. Contact stresses deceased with a larger portion transmitted via menisci. Alterations in material properties simulating OA had negligible effects on muscle forces but reduced contact pressures while increasing contact areas, cartilage strains and load transmission via menisci.

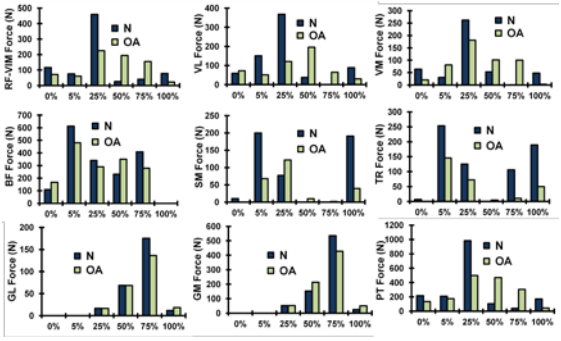

Figure 1 : Muscle forces in normal and OA groups.

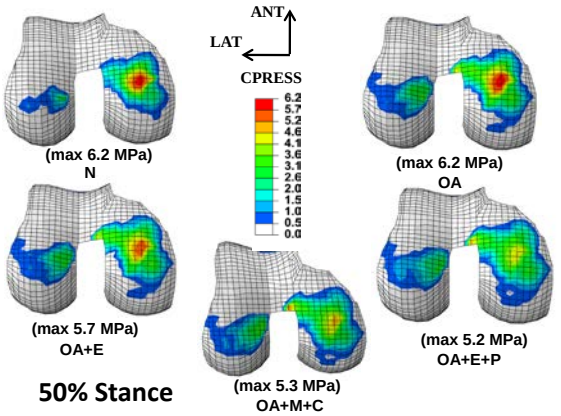

Figure 2 : Contact stresses on femoral cartilage in N and OA (without/with various reduced moduli).

Discussion

Alterations in rotations/moments in OA group recorded during gait influence muscle forces as well as contact forces/stresses and strains in the articular cartilage. Reductions in mean and peak contact stresses, increases in contact areas and cartilage superficial/deep strains as well as transfer of larger forces via menisci are due both to these altered kinetics-kinematics of gait and to deteriorations in cartilage/menisci material properties in OA group.

References

Adouni *et al*, J Biomech, 45:2149-56, 2012.
Astephen *et al*, J Orthop Res, 26:332-41, 2008.
Hunt *et al*, Clin Biomech, 16:592-600, 2001.