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The Effect of Foot Progression Angle on Human Lower Extremity

Authors : Sungpil Ha, Ju Yong Kang, Sangbaek Park, Seung-Ju Lee, Soo-Won Chae

Abstract : The growing number of obese patients in aging societies has led to an increase in the number of patients with knee medial osteoarthritis (OA). Artificial joint insertion is the most common treatment for knee medial OA. Surgery is effective for patients with serious arthritic symptoms, but it is costly and dangerous. It is also inappropriate way to prevent a disease as an early stage. Therefore Non-operative treatments such as toe-in gait are proposed recently. Toe-in gait is one of non-surgical interventions, which restrain the progression of arthritis and relieves pain by reducing knee adduction moment (KAM) to facilitate lateral distribution of load on to knee medial cartilage. Numerous studies have measured KAM in various foot progression angle (FPA), and KAM data could be obtained by motion analysis. However, variations in stress at knee cartilage could not be directly observed or evaluated by these experiments of measuring KAM. Therefore, this study applied motion analysis to major gait points (1st peak, mid –stance, 2nd peak) with regard to FPA, and to evaluate the effects of FPA on the human lower extremity, the finite element (FE) method was employed. Three types of gait analysis (toe-in, toe-out, baseline gait) were performed with markers placed at the lower extremity. Ground reaction forces (GRF) were obtained by the force plates. The forces associated with the major muscles were computed using GRF and marker trajectory data. MRI data provided by the Visible Human Project were used to develop a human lower extremity FE model. FE analyses for three types of gait simulations were performed based on the calculated muscle force and GRF. We observed the maximum stress point during toe-in gait was lower than the other types, by comparing the results of FE analyses at the 1st peak across gait types. This is the same as the trend exhibited by KAM, measured through motion analysis in other papers. This indicates that the progression of knee medial OA could be suppressed by adopting toe-in gait. This study integrated motion analysis with FE analysis. One advantage of this method is that re-modeling is not required even with changes in posture. Therefore another type of gait simulation or various motions of lower extremity can be easily analyzed using this method.

Keywords : finite element analysis, gait analysis, human model, motion capture
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