Title; EFFECT OF VARUS GAIT ON ANTERIOR CRUCIATE LIGAMENT: TO CLARIFY MECHANISM OF PATHOGENESIS OF KNEE OSTEOARTHRITIS

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a. Purpose

Knee osteoarthritis (OA) is one of the major health issues causing chronic disability. In clinical research, the instability of a knee joint results in both the joint structure changes and gait disorder. However the mechanism of pathogenesis of knee OA is unclear. Therefore we design a new hypothesis to explain mechanism of knee OA with quantitative analysis over the year. This study's objective is to estimate the effect of virtual varus gait patterns on knee ligaments by model of knee joint structure.

b. Methods

In this paper, effects of varus gait pattern on ligament are calculated using our developed musculoskeletal model. Firstly, knee joint model is developed considering characteristic anatomical structure, such as 6 degrees of freedom, 10 ligaments and 2 capsules. Next, our study uses inverse dynamics to calculate the effect of 10 different varus gait patterns on force generated in anterior cruciate ligament (ACL).

In order to calculate ligament force, we have developed three-dimensional musculoskeletal model which includes characteristic anatomical structure of knee joint. The model is composed of 12 segments; HAT, pelvis, femur, patella, tibia-fibula, talus and foot. The model of right knee joint is developed based on anatomical characteristics; it contains 10 bundles of ligaments and 2 capsules. The same number of bundles is used as the previous work of Blankevoort *et al*. Force of bundles of ligaments is obtained by multiplication of stiffness and strain whereas stain is calculated by changes of bundles of ligament length from its natural length. The same parameters are used for stiffness and strain as work of Shelburne *et al*. SIMM (MusculoGraphics Corp.) works as a simulator of the model. This simulator can calculate inverse dynamics with using arranged model. Moreover, our knee joint model has 6 degrees of freedom in order to calculate accurate force of ACL: anterior-posterior, medial-lateral and superior-inferior, varus-valgus, abduction-adduction and flexion-extension. Translational movement (slides of femur) of knee joint is also considered besides its rotation. It is known that translational movement strongly depends on flexion angle of knee joint. Therefore sequential X-ray photograph provided by DeFrate *et al*. is used to decide the translational movement at different flexion angle of knee. Therefore this model can represent the accurate 6 degrees of freedom knee joint movement without measurement of precise knee joint position.

In this study inverse dynamics is used to calculate the effect of gait patterns on ligaments using our developed model. Input data is gait pattern which has sequential three dimensional tracking data of markers on body and corresponded reaction force data by force plate. Output data is force of bundles of ligaments calculated by inverse dynamics calculation. Gait pattern is cropped from left leg toe off to right leg toe off which is half cycle of gait. Normal gait pattern is measured by optical motion capture system.

Twenty-five markers are used based on Helen Hayes marker set, and reaction force is also measured at the same time. Varus gait patterns are used to calculate their effect on bundles of ligaments. Ten different varus gait patterns are generated based on different knee joint position. Knee joint position is shifted from the original position during normal gait pattern to lateral direction from 10 mm to 100 mm by 10 mm. The same reaction force data is used because other body segments except knee joint are unchanged.

c. Results

The force of posterior part of ACL in each gait patterns was calculated. Figure shows the change of force in half of gait cycle. The legend in the figure indicates the distance of lateral shift. Varus gait pattern caused larger force on ACL because ACL was extended by abduction between femur and tibia due to lateral shift. The peak of force occurred in about 60 % of half gait cycle. It can be implied that knee joint structure change occurs on this peak point. Non-linear relationship between gait patterns and maximum force of ACL was clarified from our knee joint model.

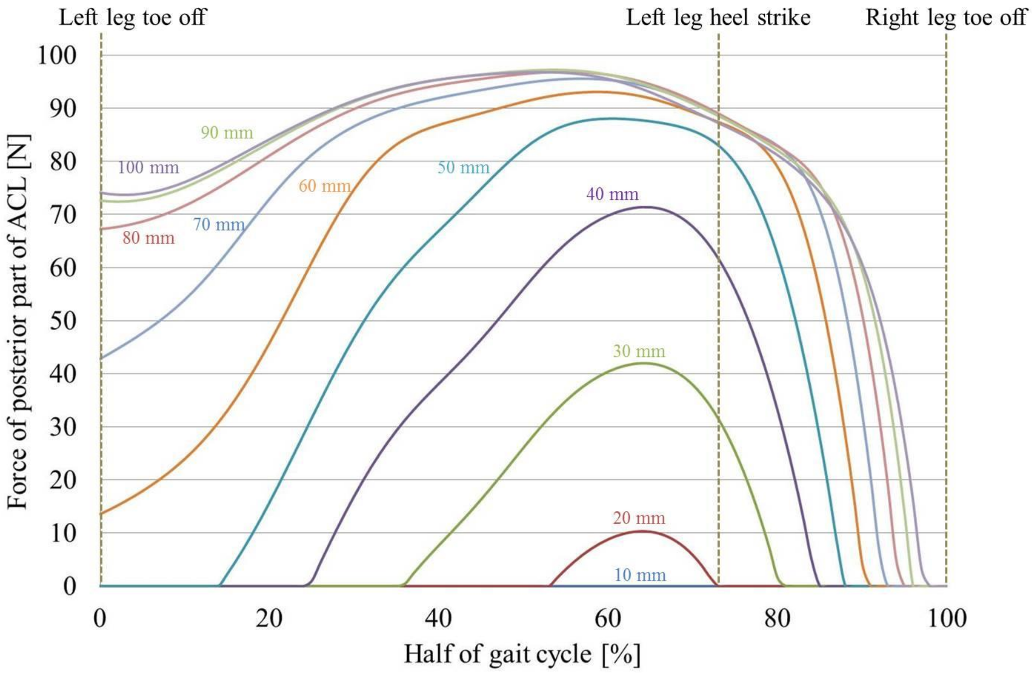

Figure: The force of posterior part of ACL

d. Conclusions

The effect of varus gait pattern on a knee ligament is clarified. Our future direction is to develop mechanical model of ligament and cartilage to analyze the effect of secular changes of them.