ANASYSIS OF ISOMETRICITY OF THE ANTERIOR CRUCIATE LIGAMENT DURING KNEE FLEXION-EXTENSION FOR OPTIMAL LIGAMENT RECONSTRUCTION

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INTRODUCTION: Anterior cruciate ligament (ACL) is liable to a major injury that often results in a functional impairment requiring surgical reconstruction. The success of reconstruction depends on such factors as attachment positions, initial tension of ligament and surgical methods of fixation. The purpose of this study is to find isometric area of the substitute during flexion/extension and to simulate successful ACL reconstruction position using MADYMO(MAthematical DYnamic MOdel) software.

METHODS: The distance between selected attachments on the femur and tibia was computed from a set of measurements using a 6 degrees-of-freedom magnetic sensor system(Fastrak, 3SPACE, Polhemus). The three-dimensional positions of the tibia were measured with respect to a femoral reference frame. Five young men were seated on a table and initial posture of the femur and the tibia was measured by touching the sensor to landmarks of the knee. A wooden fixture was mounted on the tibia to avoid skin movement. The sensor was attached on the top of the fixture which was below 2 cm from the tibial tuberosity. A three-dimensional knee model was constructed from CT images and was used to simulate length change during knee flexion/extension. This model was scaled for each subject. Twenty seven points on the tibia model and forty two points on the femur model were selected to calculate length change. Global coordinates of the tibial points from the sensor to selected tibial points were calculated by following expression.

$$\vec{r}_{TP} = \vec{r}_G + \vec{s}_G = \vec{r}_G + A(\Phi) \times \vec{s}_L$$

where $\vec{r}_{TP}$ is the vector from center position of the femur(CPF) to the tibia point, $\vec{r}_G$ is the vector from CPF to sensor, $\vec{s}_G$ is globally expressed vector of $\vec{s}_L$ (local vector) and $A(\Phi)$ is transformation matrix for rotation.

This study determined the maximum and minimum distances to the tibial attachment during flexion/extension and their difference, $d=d_{max}-d_{min}$, the maximum length change. All data were computed by a specially developed program using Microsoft Visual C++(OpenGL library). The results were displayed using contour maps that comprised contour colors, each with a single value of maximum length change.

RESULTS: Maximum length changes were computed for a total of 1134 cases (27x42). Minimum length changes were 1.9~5.8 mm (average 3.6 ± 1.4 mm). But the positions of minimum length change were not the same. To distinguish isometry, averaged length changes were plotted on 3D femoral surface. The results obtained show that highly isometric region was posterosuperior placement and anterior to the ACL's femoral attachment on the femur. This result was in a good agreement with that of Hefzy(1989).

DISCUSSION AND CONCLUSION: This study proposed a new methodology to find isometry region in vivo movement. Previous studies used cadaver knee to find isometric region. It is suitable to obtain precise knee motion data but they do not concern muscle activity and effect of complex knee structures. The proposed method can be utilized and applied to rehabilitation of ACL deficient knee.

REFERENCES:

Hefzy M.S., Grod E.S. & Noyes F.R. (1989). Factors affecting the region of most isometric femoral attachments. *The American Journal of Sports Medicine*, 17(2), 208-216.

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