CAN WE FIND SAFE HINGE LEVEL DURING OPENING WEDGE HIGH TIBIAL OSTEOTOMY USING HETEROGENEOUS TIBIAL MODELS?

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Introduction

Opening wedge high tibial osteotomy (OWHTO) is an established surgical procedure for treating patients with osteoarthritis (OA) of the medial knee with genu varum. Although the safety zone or wedge-cutting level, which can minimize the hinge fracture, have been introduced through previous studies, there is still controversy about the optimized safety zones. Therefore, the aim of this study was to analyze the stress distribution around the hinge levels at the lateral cortex of the tibia during OWHTO surgeries. It was hypothesized that if the hinge is located at the upper end of the articular cartilage of the proximal tibiofibular joint (PTFJ), stress at the lateral tibial cortex would be minimal, and fracture is least likely to occur because the hinge is at an anatomically independent position from the fibula.

Methods

Three-dimensional tibial models of a subject and three patients with medial compartment knee OA were reconstructed as heterogeneous finite models based on CT images using commercial software (Mimics 24.0 and 3-matic 16.0). To set heterogeneous material properties for each part of the model, Young's moduli of them were converted from Hounsfield's unit (HU) by applying empirical equation in existing studies. In each model, three different hinge levels (Proximal, 5 mm above the upper end of the PTFJ; Middle, upper end of the PTFJ; and Distal, 5 mm below the upper end of the PTFJ) were set. Between Middle and Distal level, we added three additional detailed hinge levels (1.25mm, 2.5mm, and 3.75mm distal from Middle level). The correction angles of each model were 5º, 10º, and 15º in the control subject and 6.9º, 7.7º, and 8.2º in the patients. Displacement at the posterior cut plane was applied referring to Hernigou's table considering deformity angle. In addition, the displacement at the anterior cut plane was applied two-thirds of the displacement applied to the posterior cut plane with the help of the clinician. All computational analyses were performed by using commercial software (ABAQUS 14.0)

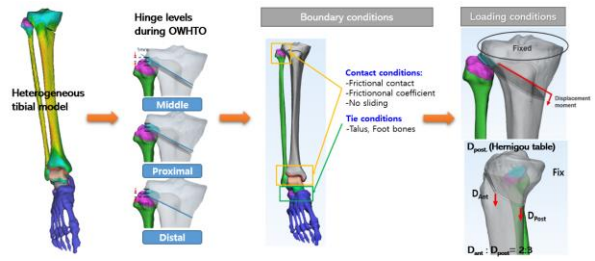

Figure 1: Procedure for heterogeneous tibial model

Results

For the control subject, as the correction angle increased, the maximum von Mises stress values in the lateral tibial cortex increased accordingly, regardless of hinge levels. In addition, the stress distribution area was smallest when the hinge was in the middle at each correction angle. For patients with a medial compartment knee OA, the trends of the maximum von Mises stress values were similar to those of the control subject. Although the maximum von Mises stress values of the distally located hinge were several times higher than the yield stress of the cortical bone, the values were relatively lower than those of the control subject.

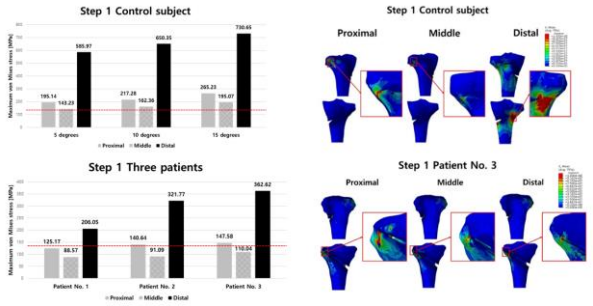

Figure 2: Stress distributions as hinge levels and correction angles for heterogeneous tibial models of the control and patients

Discussion

The results of this study confirmed the hypothesis that hinge at the point where the upper end of the articular cartilage of the PTFJ is located provides the least possibility of lateral tibial cortex fracture, as this is an anatomically independent position from the fibula. In addition, this study provides an opportunity to recall the meaning of safe hinge level and will be of great help in developing preoperative plans in clinical practice and reducing the occurrence of hinge fractures and related complications.

References

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