MECHANICAL PROPERTY OF THE APOPHYSEAL CALTILAGE SIGNIFICANTLY EFFECTS THE STRESS DISTRIBUTION AT THE TIBIAL TUBEROSITY

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INTRODUCTION:

During the growth period, the mechanical property of the tibial tuberosity changes along with bone growing; from cartliageous stage, apophyseal stage, epiphyseal stage, and to bony stage [3]. This change can lead the disease at the bone-tendon junction such as Osgood-Schlatter's disease (OSD) [1, 2]. In 1976, Ogden reported OSD as an avulsion fracture of segments of the second ossification center and eventual formation of extra bone between fragments[4], however onset and progression of the disease has not yet been anlayzed. The aim of this study is to analyze the stress distribution at the connection between patellar tendon and tibial tuberosity during the growth period using a 3D human-tibial tuberosity finite element model (3D FEM).

METHODS:

The subject was 12-year-old male who had OSD in left knee and was radiologically in apophyseal stage. After the informed consent, 3D MR images were obtaind from the knee using 1.5T machine (Signa, GE, USA). The contour of the each material around the tibial tuberosity was manually segmented in each image using a visualizing software AMIRA (TGS, USA). And then, this data was brought to FEM analysis software MARC/MENTAT (MSC Software, USA), where finite element analysis of 3D model was performed under the arbitrary load. At first, the material properties of the bone, cartilage and tendon were chosen from the data available in the recent literatures [5]. Then we changed the material property of the secondary ossification center and the cartilage linearly.

The loads and boundary conditions were defined as follows; to exclude the influence of boundary conditions, we fixed distal end of the tibia. A load of 2700 N was applied to the patellar tendon. The direction of the load was consistent with that of patellar tendon. We considered frictionless nonlinear contact problem in this study.

RESULTS:

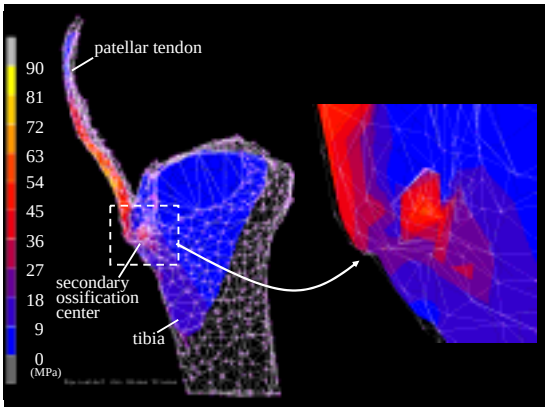

Figure1. The distribution of von Mises stress in a sagittal plane image including secondary ossification center.

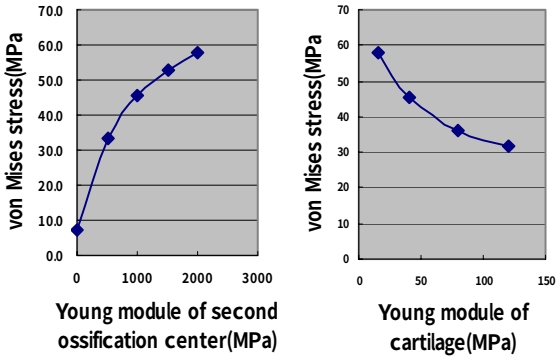

Figure 2. Changes of the von Mises stress at the tibial tuberosity under different material property of the secondary ossification center (**2A**) and the cartilage (**2B**)

When the material property of the secondary ossification center was close to the bone (young module=2000MPa), the secondary ossification center and its backward had higher stress than the cartilage around (Figure1). Figure 2A and 2B show the changes in the von Mises stress at the tibial tuberosity when we changed the material properties of the secondary ossification center and the cartilage respectively.

DISCUSSION:

In this study, we found the stress concentration in specific area (at posterior edge of the secondary ossification center) at the tibial tuberosity with a OSD patient's knee. (Figure2). The stress was increased when the material property of the second ossification center became larger (harder) or that of the cartilage became smaller (softer).

These facts indicate that OSD is caused by the characteristic structure of young tibial tuberosity where a hard ossification center is surrounded with soft cartilage during the apophyseal stage.

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