Is the Weight Bearing Alignment in the Existing Opening-Wedge High Tibial Osteotomy Surgeries appropriate for patients with Discoid Lateral Meniscus?

[#]Tae Soo Bae[1], Bo Won Jeong[1], Dai Soon Kwak[2]
[1]Jungwon University, Chungbuk, South Korea
[2]Catholic University, Seoul, South Korea
bmebae@jwu.ac.kr

Disclosures: Tae Soo Bae(N), Bo Won Jeong(N), Dai Soon Kwak (N)

INTRODUCTION: Open wedge tibial osteotomy is well known as an operation performed to reduce the load due to osteoarthritis on the medial compartment of the knee. The discoid lateral meniscus is one of the congenital mutations that have a thicker and wider shape than the lateral meniscus of normal people. When opening-wedge proximal tibial osteotomy (OWHTO) is performed in such patients, it is reported that the increased lateral compartment load may adversely affect the discoid lateral meniscus. Previous clinical studies reported that the correction angle should be reduced during tibial osteotomy since the discoid lateral meniscus is vulnerable to degenerative changes. However, biomechanical studies on joint load distribution for discoid lateral meniscus as correction angles are lacking. Therefore, this study attempted to analyze the biomechanical effect on the discoid lateral meniscus during open wedge proximal tibial osteotomy through computational analysis.

METHODS: Three-dimensional knee joint models (femur, tibia, patella, and meniscus, respectively) with medial osteoarthritis were reconstructed by using CT and MRI images using an image processing commercial program (Mimics, Materialise Inc., Belgium). Ligaments around the knee (ACL, PCL, MCL, LCL) were modeled with a spring. To apply the correction angle during proximal tibial osteotomy, three groups were set by a commercial editing program (3-Matic, Materialize Inc., Belgium) was used: under-correction (52.5%), acceptable-correction (62.5%), and over-correction (70%). The material properties of bone, cartilage(meniscus), and ligaments were referred to in previous studies. For the boneplate and screws, TomoFix (DePuy Synthes, USA) products were modeled with the material properties of the Ti-alloy (Ti4V6Al). All of finite element models were created using a 4-node tetrahedral element, contact conditions were given between femur and meniscus, and all other parts were set in a fixed state. A fixed boundary condition was set at the cutting tibial base, half of the weight was applied as a load in the direction of the mechanical axis, and static analysis was performed. Commercial software was used for finite element analysis, and the stress distribution for each correction angle was calculated and compared with each other.

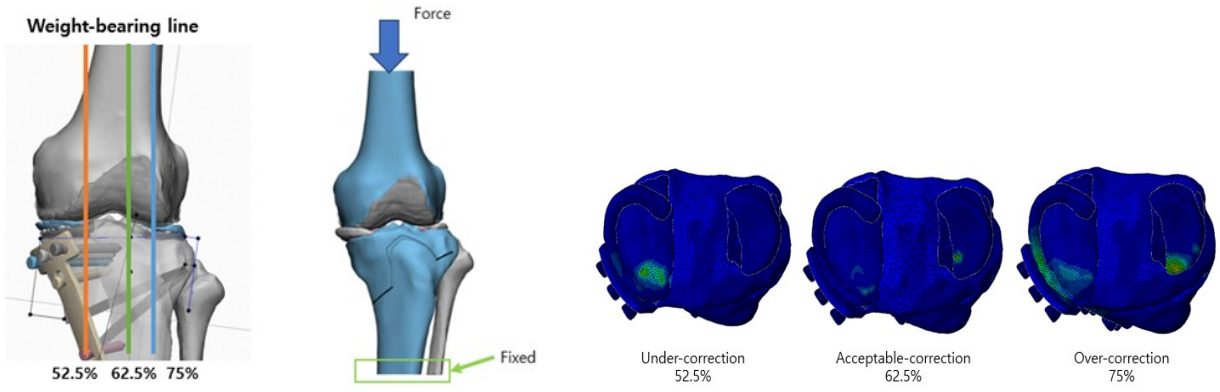
RESULTS: When three correction angles were applied to the discoid lateral cartilage model, the von-mises stresses on the medial and lateral meniscus were calculated and compared with each other. In the allowable correction, the internal and external stresses were similar, and it was confirmed that a 14% larger load than the medial load moved to the lateral meniscus. In the under-correction, the load on the medial showed more than 3.5 times larger than that on the lateral meniscus. The ratio of the load on the medial to the lateral meniscus was significantly reduced. Finally, in the case of the overcorrection group, it was calculated that about 70% of the medial load moved to the lateral meniscus.

DISCUSSION: When OWHTO surgery is performed with the existing weight-bearing alignment for a patient with discoid lateral meniscus, it gives unexpected excessive stress to the lateral cartilage of the knee rather than reducing the weight-bearing on the knee and an appropriate corrective effect can not be expected. Although adjusting the weight-bearing alignment was needed to solve these problems, there is still controversy in the clinical field due to the lack of biomechanical evidence. This study will provide an approximate direction for adjustment of weight-bearing alignment, and it is expected that additional studies will increase the success rate of HTO surgery in patients with discoid lateral meniscus by identifying the ratio of medial and lateral loads to alignment. However, considering the fact that the condition of the discoid lateral meniscus varies from patient to patient, additional research should be conducted according to the shape of the discoid lateral meniscus.

SIGNIFICANCE/CLINICAL RELEVANCE: It is expected to provide biomechanical evidence for the acceptable correction angle to prevent inappropriate body weight shift from medial to lateral meniscus for patients with a discoid lateral meniscus in the existing open proximal tibial osteotomy.

ACKNOWLEDGEMENTS: This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2022R1A2C1009995)

IMAGES AND TABLES:



(a) Three weight bearing alignment as correction angle (b) Von-mises stress distributions for three discoid lateral meniscus models

Fig.1 Computational Analysis for biplane OWHTO surgery. (a) Three correction angle as weight-bearing line (left) and load and boundary condition (right), (b) Comparison of von-mises stress on medial and lateral meniscus as correction angle