

Finite Element Analysis of the Biomechanical Effects of Rotational Alignment of Tibial Component

Ji Hoon Nam^{1,2}, Byung Woo Cho³, Kwan Kyu Park³, Yong Gon Koh⁴, Kyoung Tak Kang^{1,2}

¹Yonsei University, Seoul, Korea, ²Skyve R&D LAB, Seoul, Korea, ³Yonsei University College of Medicine, Seoul, Korea, ⁴Yonsei-Sarang Hospital, Seoul, Korea

2018njh@gmail.com

Disclosures: Ji Hoon Nam (Skyve Co.,ltd), Byung Woo Cho (N), Kwan Kyu Park (N), Yong Gon Koh (N), Kyoung Tak Kang (Skyve Co.,ltd)

INTRODUCTION:

To the best of our knowledge, there is a dearth of research exploring the variations in load distribution resulting from different rotational alignment methods of the tibial component in total knee arthroplasty (TKA). Therefore, the objective of this study is to examine the disparities in load distribution on the medial proximal tibial bone among various rotational alignment methods employed during TKA. Finite element analysis (FEA) will be utilized as a tool to investigate and analyze these differences.

METHODS:

This retrospective study examined 28 female patients diagnosed with end-stage osteoarthritis who underwent TKA using a standardized implant size. The mean age was 71.61 ± 5.90 years, mean height was 155.28 ± 4.61 cm, mean weight was 65.71 ± 8.35 kg, and mean body mass index (BMI) was 27.26 ± 3.33 kg/m². MRI segmentation was performed using K-Recon (AIES, Uijeongbu, KOREA). Surgical planning was conducted using Segmented 3D bone with K-Plan (Skyve, Seoul, Korea).

Four different rotational alignment methods were employed, including the Akagi line method, the medial third of the tibial tubercle (MTT) method, Cobb's anatomical tibial axis (Cobb's) method, and the maximal coverage (MC) method. FEA was conducted using both anatomical tibial component (ATC) and symmetric tibial component (STC). Persona knee implant system (Zimmer Biomet, Warsaw, Indiana, USA) is ATC and PNK knee implant system (SKYVE, Seoul, Korea) is STC. The study focused on measuring the average and peak von Mises stress (VMS) within the region of interest (ROI). The ROI was defined as the medial 5mm thickness of the cancellous bone based on the central line of each implant. The VMS measurements were collected for each subject, and their averages were calculated and compared among the different rotational alignment methods.

RESULTS SECTION:

There were no significant differences in the average VMS among the four rotational alignment methods for both STC and ATC ($p > 0.05$). However, across all rotational alignment methods, the mean VMS for ATC was significantly higher than that for STC. The peak VMS within the ROI did not differ significantly between the MTT and Cobb's methods for both STC and ATC. However, the MTT and Cobb's methods had significantly higher peak VMS values compared to the Akagi line method and lower values compared to the MC method. Notably, there were no significant differences in the peak VMS within the ROI between STC and ATC for all rotational alignment methods.

DISCUSSION:

Our study's key discovery is that there were no significant differences in the average load distribution within the medial proximal tibial bone based on the rotational alignment methods of the tibial component. Consequently, we can infer that rotational methods, as per existing literature, do not vary concerning the potential for stress shielding.

SIGNIFICANCE/CLINICAL RELEVANCE:

There were no significant differences observed among the rotational alignment methods of the tibial component in terms of average VMS on the medial proximal tibia. However, there were statistical differences in peak VMS, although the magnitude of these differences was not substantial. It is important to note that further studies are warranted to evaluate the clinical significance of these observed differences.

