

Comparative Analysis of Posterior Tibial Slope and Distal Tibial Rotation in Medial Open-Wedge High Tibial Osteotomy through 3D Simulation and Actual Surgery

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INTRODUCTION: After medial open wedge high tibial osteotomy (MOWHTO), changes in posterior tibial slope (PTS) and distal tibial rotation may occur, which can affect the biomechanics of the patellofemoral joint and may lead to anterior knee pain. The purpose of this study is to assess PTS change and the rotational change of distal tibia after MOWHTO through 3D simulation and actual surgery, and to identify factors that cause surgical errors.

METHODS: Patients who underwent MOWHTO from October 2019 to January 2023 and were evaluated by 3D-CT before and after surgery were retrospectively included in this study. Preoperatively, a 3D model of the original lower limb was reconstructed and a virtual osteotomy was performed perpendicular to the mechanical axis of the lower extremity by a corrective angle obtained using Miniaci method. After performing MOWHTO using the Patient Specific Instrumentation (PSI) gapper obtained through simulation, the postoperative 3D reconstruction model was compared with the preoperative or simulated 3D model to measure medial proximal tibial angle (MPTA), PTS, distal tibial rotation angle, and hinge axis angle.

RESULTS:

A total of 83 patients (aged 57.43 ± 6.23 years, 72.48% female, 52.21% right knee) were included. Preoperative PTS and rotation angles ($9.71^\circ \pm 2.61^\circ$, $16.09^\circ \pm 8.76^\circ$) were statistically significantly different compared to postoperative PTS and rotation angles ($1.71^\circ \pm 2.62^\circ$; $p < 0.001$, $3.56^\circ \pm 5.78^\circ$; $p = 0.006$). And compared to the simulation model, the actual surgery reduced the PTS by $1.65^\circ \pm 2.55^\circ$ ($p < 0.001$) and internally rotated the distal tibia by $3.51^\circ \pm 5.31^\circ$ ($p = 0.005$). The decreasing tendency of PTS between the simulation study and actual surgery was related to Δ hinge axis ($r = 0.37$, $p < 0.001$) and Δ MPTA ($r = -0.23$, $p = 0.02$). Additionally, the rotational angle correlated with the Δ MPTA ($r = -0.29$, $p = 0.003$).

DISCUSSION AND CONCLUSION:

Compared to the simulation model, posterolateral rotation of the hinge axis and an increased MPTA caused a decrease in PTS, and an increased MPTA caused more internal rotation of the distal tibia. The hinge axis and MPTA should be considered important independent variables for unintended changes in PTS and axial rotation changes during MOWHTO.