Correlation between Changes in Gait Biomechanics and Radiographic Alignment after High Tibial Osteotomy in Patients with Medial Knee Osteoarthritis

SANG JIN LEE[1]
[1]Orthopedic Surgery, Haeundae Paik Hospital, Inje University, Busan, Korea

INTRODUCTION: High tibial osteotomy is widely performed as a surgical treatment for osteoarthritis limited to the medial compartment of the knee joint. Although patient satisfaction after surgery is reported to be high, several studies have reported that the lower extremity alignment changed during surgery is not maintained and worsens again depending on the follow-up period. However, only an analysis of radiographic lower extremity alignment has been reported. There has been little research on the change patterns during actual walking.

The purpose of this study was to evaluate changes in gait biomechanics and correlation between gait parameters and radiographic outcomes during ground level walking before and two years more after medial opening wedge high tibial osteotomy.

METHODS:

Subjects: Twenty-four patients with medial knee osteoarthritis and varus malalignment are enrolled in the study. We retrospectively reviewed 27 patients who underwent medial opening wedge high tibial osteotomy and completed pre-operative and at 6 months and 24 months or more follow up gait analysis from department of orthopedic surgery of our institute for this study. We excluded 3 patients according to the following criteria: (1) operation of high tibial osteotomy in the contralateral limb within the following year (n=2); (2) total knee arthroplasty in the contralateral limb within the following year (n=1).

Gait analysis: Three-dimensional gait biomechanics were collected from motion analysis laboratory at our institution. Sixteen retro-reflective markers (diameter of 20 mm) were attached on the skin over the bilateral lower limbs of each subject in the following placements based on the Plug-in-Gait model (VICON Motion Systems Ltd, Oxford, UK). Kinetic data were recorded using two force plates (AMTI, Advanced Mechanical Technology Inc., Watertown, MA, USA) with a sampling rate of 1,000Hz and processed using low-pass filter with a cut-off frequency of 50 Hz. The data was synchronized with the kinematic data via a Nexus program (VICON, version 1.7). Spatiotemporal parameters, kinetic and kinematic data were calculated with each subject's anthropometric data such as height, weight, leg length, width of knee and ankle. Gait data were normalized to the gait cycle (GC), and timing of peak loading and angular variables was expressed as a percentage of the GC. Joint moments and powers were normalized to the body weight and height are reported as percentage body weight and height (%BW*Ht) and Watt/kg (W/kg), each. The peak values for each GC waveform in either a positive or negative direction were selected for analysis. All kinematic and kinetic data were expressed as positive values to simplify the interpretation of the results.

Data analysis: Kinetic and kinematic data of the knee and ankle joint in both operated and non-operated limbs were analyzed including static knee alignment, peak knee varus during stance phase and mean foot progression angle (toe-out), and peak knee adduction moments.

Radiographic assessment: Knee varus alignment was measured from the radiographic images that included both lower extremities, which were imaged from the pelvis to the ankle (a full□limb radiograph). The mechanical axis was defined as the angle formed by the intersection of a line from the center of the head of the femur to the center of the knee joint, and a second line from the center of the ankle joint to the center of the knee joint.

Additionally, correlation between gait parameters and radiographic coronal plane alignment was evaluated.

RESULTS: The varus angle and first peak adduction moment in mid-stance phase and radiographic alignment of the knee joint were significantly reduced ($p \leq 0.001$) but toe out angle was reduced slightly not significantly in operated limb at 6 months and more than 24 months (24-62, mean 34.8) after the operation ($p=0.246$, $p=0.796$).

There was no significant change of the varus angle and first peak adduction moment and radiographic alignment of the knee joint in operated limb from 6 months and at the last follow-up postoperatively ($p=0.684$, $p=0.174$). However, toe out angle in the operated limb was increased significantly at the last follow-up compared with 6 months after the operation ($4.34° \pm 5.64$ at 6 months after the operation, $5.81° \pm 6.07$ at more than 24 months follow-up period, $p=0.015$).

Meanwhile, in the group of the patients who has more than five degrees of valgus angle in the mid-stance phase at 6 months after operation (11 patients), the valgus angle was reduced, the adduction moment was increased and the radiographic alignment was improved significantly at the last follow-up compared with 6 months after the operation ($p=0.006$, $p=0.003$, $p=0.038$).

The varus angle & adduction moment in the mid-stance phase were correlated positively at 6 month and more than 24 months after the operation ($p=0.007$, $p=0.043$). The radiographic alignment was correlated positively with the varus angle of the knee joint at the last follow-up after the operation ($p=0.031$). But, the radiographic alignment had no correlation with

the varus angle of the knee joint at 6 months after operation and had no correlation with the adduction moment at 6 months and the last follow-up after the operation.

DISCUSSION AND CONCLUSION: In case the coronal angle of the knee joint in the mid-stance phase was more than five degrees of valgus after high tibial osteotomy in patients with medial knee osteoarthritis, adaptation was found over time. The radiographic alignment after high tibial osteotomy was not showed correlation with the adduction moment of the knee joint after the operation. Toe out gait as an adaptation to knee osteoarthritis decreased in the early postoperative phase but increased again after more than 24 months after medial opening wedge high tibial osteotomy.