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Unintended Rotational Changes of the Distal Tibia After Biplane Medial Open-Wedge High Tibial Osteotomy

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ABSTRACT

This study involved 35 knees undergoing biplane medial open-wedge high tibial osteotomy (OWHTO) to assess the axial rotation of the distal tibia. The distal tibiae were internally rotated by 3.0° ± 7.1° after OWHTO. The opening width showed a Pearson correlation coefficient of −0.743 ($P < .001$), and the tuberosity osteotomy angle showed that of −0.678 ($P < .001$) with distal tibial rotation. However, changes in hip-knee-ankle angle, medial proximal tibial angle, and posterior tibial slope were not significantly correlated with the change in distal tibial rotation. In conclusion, there was an unintended tendency of increasing internal rotation of the distal tibia after biplane medial OWHTO, and this tendency was positively related to the opening width and tuberosity osteotomy angle.

Medial open-wedge high tibial osteotomy (OWHTO) is a widely performed surgical treatment option for young and active adults with medial unicompartmental osteoarthritis (OA) of the knee joint with varus malalignment [1-4]. This procedure transfers the mechanical loading from the affected medial compartment to the healthy lateral compartment. Open-wedge high tibial osteotomy was first described by Debeyre in 1951 [5] and has become popular recently with efforts to decrease related complications [6-8]. Relatively satisfactory short- to mid-term outcomes have been reported after this procedure [9-11].

Achieving accurate alignment correction after high tibial osteotomy (HTO) is essential for satisfactory clinical outcome. In the past, surgeons focused on coronal plane correction without deep consideration of sagittal or axial plane changes during HTO [12]. The effects of HTO on the coronal plane have been studied extensively [13]. However, as the tibia is a 3-dimensional structure with a triangular shape, it is predicted that a 3-dimensional realignment may occur, including changes in the sagittal, coronal, and axial planes. Many authors have already demonstrated that alterations in the posterior tibial slope (PTS) occur with OWHTOs [14-16]. Accordingly, there have been several investigations with the aim of reducing unpredicted sagittal changes after OWHTOs [14,17].

Meanwhile, rotational malalignment after OWHTO has not been an important issue, and only a few studies have addressed axial tibial rotation after OWHTO [13,18,19]. However, in a clinical setting, a few patients complain of the rotational change in the lower leg or the change in the foot progression angle. Therefore, the purpose of the current study was to assess the change in axial tibial rotation after biplane medial OWHTO and to analyze the factors affecting the rotational change. The tibial rotations in the axial plane were determined using computed tomography (CT). We hypothesized that biplane medial OWHTOs would make unintended axial rotational changes in distal tibiae. In addition, we hypothesized that the amount of correction during OWHTOs would be related to the distal tibial axial rotation.

Materials and Methods

This research was approved by the institutional review board of our institution. The current study prospectively enrolled 35 patients (35 knees) who underwent biplane medial OWHTO between 2012 and 2014 in our medical center. All participants agreed with the study protocol including CT evaluation. Initially, 43 patients (44 knees) agreed to participate in the study; however, 8 patients (9 knees) did not take preoperative or postoperative CT scans and were consequently excluded from the study. Thus, the current study cohort consisted of 35 patients (35 knees). All operations were performed by a single senior surgeon. All patients were diagnosed with medial compartmental OA with varus malalignment. The mean age at the time of surgery was 57.2 years (range, 47-64 years). The enrolled patients were composed of 27 females and 8 males (Table 1). All knees were radiographically assessed preoperatively and postoperatively. Only the knees with both preoperative and postoperative CT scans were included in the study. The ineligible criteria for HTO were symptomatic lateral compartmental OA or patellofemoral OA, flexion contracture more than 10°, range of motion less than 100°, age older than 65 years, lateral collateral ligament laxity more than grade 3, and rheumatoid arthritis.

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Table 1
Preoperative Patients' Demographics.

Parameters	
Males/females	8:27
Age (y)	57.2 ± 4.2 (47-64)
Height (cm)	158.3 ± 6.8 (146-178)
Weight (kg)	64.6 ± 5.7 (43-84)
Body mass index (kg/m$^{2)}$	25.5 ± 6.2 (21.4-33.9)
Degrees of lower extremity deformity	Varus 7.6° ± 2.7° (varus 2.3°-13.2°)

Surgical Technique

Preoperative planning was conducted using a standing anteroposterior (AP) lower leg radiograph. The osteotomy site, degree of correction, and size of the osteotomy gap were measured according to a previously described method by Miniaci et al [20]. Arthroscopic examination was performed in all cases to assess the status of the articular cartilage, menisci, and cruciate ligaments. If necessary, meniscal procedures such as repair or meniscectomy were performed. Subsequently, a 5-cm anteromedial vertical skin incision was made approximately 2 finger breaths medial to the tibial tuberosity. The sartorial fascia was exposed by a sharp dissection, and the pes anserinus tendon was retracted distally with a blunt retractor. The distal fibers of the medial collateral ligament were then exposed and released distally with a Cobb elevator. The patellar tendon and its distal insertion to the tibial tuberosity were identified. Guide wires were inserted along the planned plane under fluoroscopic control, and the osteotomy was performed immediately distal to the guide wire to avoid proximal migration of the osteotomy into the joint. The referencing wires were kept parallel to the original PTS. The oblique osteotomy of the biplane osteotomy began at the medial tibial cortex (approximately 5-6 cm distal to the joint line) and terminated at the level of the tip of the fibular head. Under fluoroscopic guidance, osteotomes were advanced carefully to approximately 1 cm of the lateral cortex without breakage. The vertical osteotomy of the biplane osteotomy was performed at the posterior aspect of the tibial tuberosity preserving bony insertion of the patellar tendon and leaving most of the patellar tendon attached to the distal tibial fragment. Opening of the osteotomy site was carried out gradually to the planned width using chisels with caution for lateral cortical breakage. When the planned osteotomy width was achieved and the mechanical axis passed through 62% of the tibial plateau under fluoroscopic assessment, stabilization of the osteotomy site was achieved using a fixed angle plate with locking screws (Tomofix plate; Synthes, Bettlach, Switzerland). The opening width (OW) was checked and recorded after plate fixation in every case. To avoid an increased PTS, we followed the recommendations from previous studies [21,22]. First, the anterior gap was kept to 1/2 to 2/3 of the posterior gap. Second, complete posterior tibial osteotomy was performed, and lastly, a spreader was positioned as posterior as possible during opening the gap. The fixation was performed with the knee joint fully extended, and the posterior slope was also checked by fluoroscopy.

Radiographic Evaluation

Radiographic evaluation was performed using weight-bearing AP lower leg radiographs including the hip, knee, and ankle joint; standing true AP and lateral views of the knee joint; and rotation “Gunsight” CT scans of the lower extremities [23,24]. Radiographs were obtained 1 day before and 3 months after the index operation. Postoperative CT scans were taken at 3 days after operations. Radiological parameters evaluated in the current study were the hip-knee-ankle angle (HKAA), medial proximal tibial angle (MPTA), PTS, distal tibial rotation (DTR), and the tuberosity osteotomy angle (TOA). The HKAA, defined as the angle between a line from the femoral head center to the knee joint center and a line from the center of the ankle joint to the knee joint center, was calculated on the weight-bearing AP long leg view. The MPTA, defined as the medial angle between the anatomical axis of the tibia and the proximal tibial articular line, was also measured. The PTS, defined as the angle between the posterior inclination of the tibial plateau and the perpendicular line to the tibial mid-diaphysis, was measured on the true lateral view. The DTR and TOA were measured on CT scans. The DTR was assessed by measuring the angle between the proximal posterior tibial axis and the transmalleolar axis using CT scans (Fig. 1) [25]. The angle between the proximal posterior tibial axis and the osteotomy axis of tibial tuberosity was also measured on the CT scans. We called this angle the TOA (Fig. 2). The TOA indicated the direction of coronal osteotomy at the posterior aspect of the tibial tuberosity on the axial plane. If the osteotomy for the tibial tuberosity was performed in a more posterolateral direction, this angle (TOA) increased. Two independent orthopedic surgeons measured the parameters using a picture archiving and communication system (PACS, PiView STAR, version 5025; Infinitt, Seoul, Korea).

Statistical Analysis

The data were recorded using Microsoft Excel 2010 version (Microsoft Corp, Redmond, WA). All data were presented as the means ± SDs. The Kolmogorov-Smirnov test was carried out to test the normality of the distribution. Preoperative and postoperative comparisons for the MPTA, HKAA, PTS, and DTR were performed using a paired *t* test. Correlations among variables were assessed using Pearson correlation analysis. Subsequently, multiple linear regression analyses were conducted to investigate and predict the association between the variables and the change in the DTR after OWHTO. The stepwise selection procedure was used to identify significant variables for the change in the DTR, with the criterion for entry into the model being a level of 0.05 and for removal from the model being a level of 0.10.

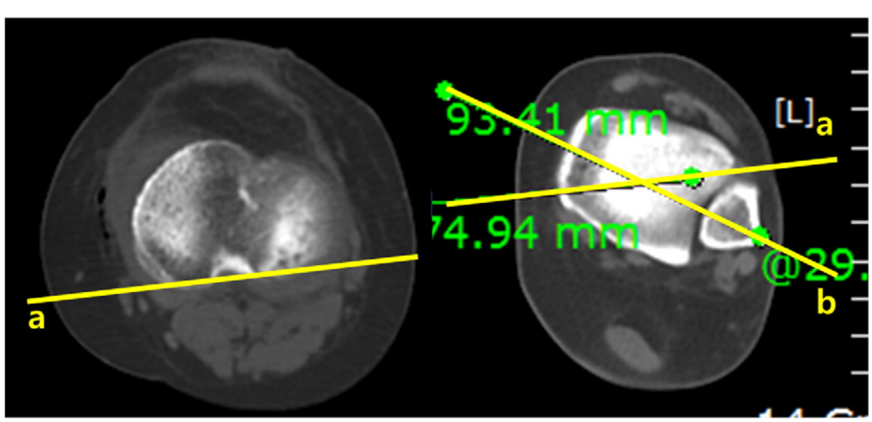

Fig. 1. Measurement of the DTR. It was assessed by measuring the angle between the proximal posterior tibial axis (A) and the transmalleolar axis (B) using CT scans.