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Alteration of Hindfoot Alignment After Total Knee Arthroplasty Using a Novel Hindfoot Alignment View

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ABSTRACT

This study examined the coronal alignment of the hindfoot in varus osteoarthritis of the knee before and after total knee arthroplasty (TKA) in 100 legs using a novel imaging method. We categorized the preoperative hindfoot alignment into varus (30 legs) and valgus (70 legs) groups; imaging of the hindfoot was conducted preoperatively and postoperatively, and the varus–valgus angle (VVA) was measured as the hindfoot alignment. The femorotibial angle improved significantly after TKA. We found that the VVA improved significantly after TKA in the hindfoot valgus group ($P < 0.001$), but not in the varus group ($P = 0.554$), and we speculate that the hindfoot alignment in the valgus group improved as a result of a residual compensatory capacity in the hindfoot.

The femorotibial angle (FTA) and the line connecting the femoral head to the center of the ankle joint, as determined by full-length radiographs of the lower extremities in a standing position, are used to evaluate the coronal alignment of the lower extremities [1,2]. However, in the lower extremities, motions in the coronal plane involve the participation of not only the hip joint but also the subtalar joint. Therefore, it is important that an assessment of lower limb coronal alignment also includes the hindfoot. Malalignment of the hindfoot is closely associated with deformities of the adjacent forefoot, midfoot, ankle joint, and knee joint, truly emphasizing the importance of evaluating hindfoot alignment.

Although various methods can be used to evaluate hindfoot alignment, assessments using plain radiographs are generally the most convenient for clinicians. Accordingly, the Cobey method and related applications are frequently used for the assessment of hindfoot alignment [3–6]. However, owing to the spiral form of the posterior articular surface of the subtalar joint, plain radiographs have a limited capacity for depicting the articular surface [7].

Chandler and Moskal previously reported that deformities in the knee joint and deformities of the foot are related to each other, and that there is a correlation between valgus hindfoot and varus osteoarthritis (OA) (varus deformities) of the knee joint [8]. Moreover, total knee arthroplasty (TKA) has been demonstrated to correct lower extremity alignment (mainly at the knee joint) and is believed to affect the alignment of the adjacent hindfoot [8,9]; and, accordingly, Mullaji and Shetty reported that preoperative hindfoot alignment showed improvement after TKA [9]. However, the assessment method used in their study was based on the amount of deviation from the center of the knee joint and the straight-line linking of 2 points, namely the center of the femoral head and the point where the calcaneus touches the ground. Because the valgus of the hindfoot was not directly measured, this method is considered insufficient for the assessment of alignment.

We have recently developed a new radiological evaluation method for the assessment of the coronal alignment of the hindfoot in the presence of a load based on the inclination of the subtalar joint [10]. This novel method allows for a clear visualization of the posterior middle articular surfaces of the subtalar and talocrural joints by performing plantar flexion of the midfoot and forefoot. Additionally, the inclination of the subtalar joint is determined by the 2 points that form the calcaneus, rather than by the articular surface. Thus, this inclination is considered useful in the assessment of the coronal alignment of the hindfoot.

Varus deformities due to diseases of the knee joint are believed to be associated with valgus hindfoot. However, in some cases, the hindfoot can be in varus position before surgery already. We have experienced cases of hindfoot pain newly developing after TKA, and consider that postoperative coronal alignment of the hindfoot was involved in this pain. The association between deformities of the knee joint and the coronal alignment of the hindfoot has not yet been fully explored [11], and, therefore, the purpose of this study was to examine the relationship between hindfoot alignment and varus OA of the knee by measuring preoperative hindfoot alignment in cases of varus OA of the knee using our novel method for imaging the hindfoot.

The Conflict of Interest statement associated with this article can be found at http://dx.doi.org/10.1016/j.arth.2014.07.026.

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A secondary objective of this study was to examine the effects of TKA on hindfoot alignment by classifying the preoperative coronal alignment of the hindfoot into varus and valgus groups and by examining the postoperative changes in coronal alignment in the 2 groups.

Materials and Methods

Subjects

The study was conducted on 100 legs of 82 patients who underwent TKA in our hospital between February 2007 and November 2011 for varus OA of the knee. The mean age at the time of surgery was 74.3 years (range, 58–87 years). Male participants accounted for 14 legs (mean age: 76.9 years), and female participants accounted for 86 legs (mean age: 73.6 years); right legs accounted for 49 cases, and left legs accounted for 51 cases. Patients with valgus OA of the knee, rheumatoid arthritis (RA), and post-traumatic OA, and patients who had previously been subjected to surgery on the knee joint on the same side, such as high tibial osteotomy, were excluded from our analysis. The study was reviewed and conducted in accordance with the ethical standards of our institution. The study protocol was approved by the institutional review board, and, after explaining the study in writing, we obtained written consent from all participants.

Surgical method

In all cases, TKA was the primary surgery, and was performed by the same surgeon. A midline longitudinal skin incision was made, and expansion was performed using a medial parapatellar or midvastus approach. In all cases, the femoral, tibial, and patellar components were cemented using the following PS-type implants: the Zimmer Nexgen LPS-FLEX mobile bearing ($n = 53$; Zimmer, Warsaw, USA), the Zimmer Nexgen LPS-FLEX fixed bearing ($n = 10$; Zimmer, Warsaw, USA), the Stryker Scorpio NRG ($n = 31$; Stryker Howmedica Osteonics, Mahwah, USA), and the Biomet Vanguard total knee system ($n = 2$; Biomet, Warsaw, USA) using the measured resection method.

Radiological evaluations

Full-length radiographs of the entire lower extremity in a standing position and imaging of the hindfoot were performed preoperatively and 3 weeks postoperatively [10]. To study the coronal alignment of the lower limb, the FTA was measured using full-length radiographs of the lower extremity in a standing position. The method used for the imaging of the hindfoot was as follows: the hindfoot was laid flat; an auxiliary tabletop for imaging was used to put the forefoot in 30-degree flexion with the metatarsal region; the participant was instructed to stand on both feet on the auxiliary tabletop for imaging; and an X-ray film was placed vertically on the side of the toes. The direction of the incident X-ray was inclined by 5° from the horizontal plane to the caudal side; imaging of the hindfeet was conducted from behind on both sides. The object distance was 120 cm. Hindfoot alignment was evaluated by measuring the angle between the long axis of the tibia and the line connecting the superior margin of the sustentaculum tali, which was determined from the imaging of the hindfoot to the lateral extremity of the calcaneus at the posterior surface of the talocalcaneal joint (varus–valgus angle, VVA) (Fig. 1). Two board-certified orthopedic surgeons performed the measurements using ImageJ software (NIH). Based on previous studies [10], an average value of 76° was defined as the cut-off value, and the preoperative hindfoot alignments were classified as either hindfoot valgus (VVA > 76°) or hindfoot varus (VVA ≤ 76°); changes in the hindfeet before and after surgery were measured.

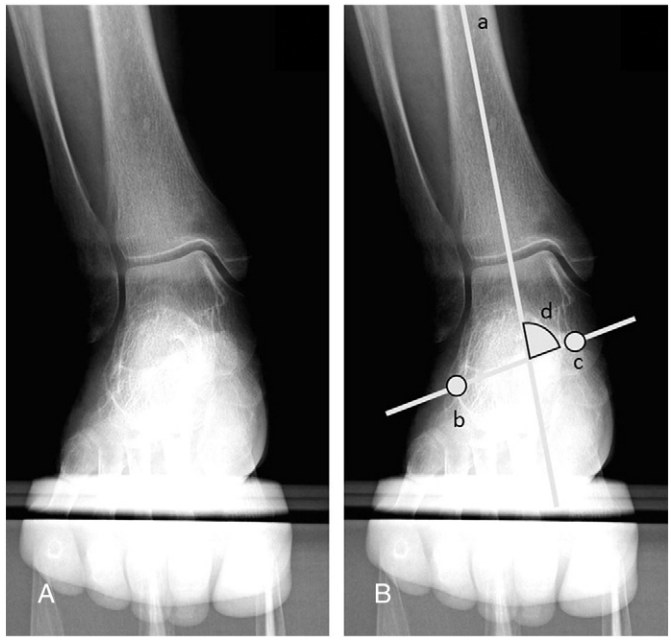

Fig. 1. New hindfoot view. (A, B) Line a shows the long axis of tibia. Point b shows the lateral extremity of the calcaneus at the posterior surface of the talocalcaneal joint. Point c shows the superior margin of the sustentaculum tali. Angle d shows varus–valgus angle, VVA.

Statistics

Statistical analyses of the changes in FTA and VVA after surgery were conducted using two-tailed paired Student's t-tests. JMP10 (SAS Institute Inc., Cary, NC USA) was used for all analyses, and significant differences were defined as $P < 0.05$.

Results

The overall FTA improved from 186.7 ± 4.6° pre-TKA to 174.4 ± 3.1° post-TKA ($P < 0.001$). The FTA improved in all patients, indicating good correction of the knee joint varus deformities. The mean VVAs were 78.8 ± 5.3° before surgery and 76.8 ± 4.2° after surgery ($P < 0.001$).

Preoperatively, the hindfoot valgus group accounted for 70 legs (35 right legs, 35 left legs; male participants: 10 legs, female participants: 60 legs; mean age: 73.6 ± 7.5 years) and the hindfoot varus group accounted for 30 legs (15 right legs, 15 left legs; male participants: 4 legs, female participants: 26 legs; mean age: 75.0 ± 6.6 years) (Table 1).

In the valgus group, the FTA improved significantly from 186.9 ± 4.8° pre-surgery to 174.1 ± 3.1° post-surgery ($P < 0.001$). In the varus group, the FTA improved from 186.1 ± 4.2° preoperatively to 175.0 ± 2.9° postoperatively ($P < 0.001$). No significant differences in

Table 1
Subject's Data.

		Valgus Group ($n = 70$)	Varus Group ($n = 30$)	*P* Value
Age (years)		73.6 ± 7.5	75.0 ± 6.6	0.33
Gender	Male	10	4	
	Female	60	26	
FTA (°)	Preope	186.9 ± 4.8	186.1 ± 4.2	0.38
	Postope	174.1 ± 3.1	175.0 ± 2.9	0.16

Value: Mean ± SD.
FTA: femolotibial angle.