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Original article

Influence of coronal bowing on the lower alignment and the positioning of component in navigation and conventional total knee arthroplasty

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ABSTRACT

Background: Coronal alignment is an important factor for the function and longevity of total knee arthroplasty (TKA). Coronal bowing of the lower extremity is common among Asians and it may pose a risk for malalignment of the lower leg and malposition of component.

Hypothesis: We hypothesized that coronal bowing itself has a risk for malalignment of the lower leg and malposition of femoral/tibial components and that navigation TKA is beneficial for patients with coronal bowing. We investigated the incidence of femoral/tibial bowing in patients treated with TKA and compared the radiographic parameters between the navigation group and the conventional group. Additionally, the influence of coronal bowing on these radiographic parameters was investigated.

Materials and methods: We enrolled 35 patients with knee osteoarthritis and 70 bilateral simultaneous TKAs. The patients underwent TKA with the use of a computer tomography-free navigation in one knee and conventional TKA in the contralateral knee. Preoperative coronal bowing were measured, and the subjects were divided into 2 subgroups, i.e. the bowing group and the non-bowing group. Lateral bowing was expressed as plus (+) and medial bowing was expressed as minus (−). Various radiographic parameters, including coronal bowing, lower leg alignment, component position, and outliers were compared between the navigation group and the conventional group.

Results: Femoral bowing varied from −7.4° to 10.9° with an average of 3.0°. Tibial bowing varied from −4.1° to 4.6° with an average of 0.4°. The femoral component was placed more properly in the navigation group. Number of outlier regarding to the coronal femoral component angle to the femoral mechanical axis was 14 cases (37.8%) in the bowing group and 6 cases (18.2%) in the non-bowing group ($P = 0.04$).

Discussion: In conclusion, coronal femoral bowing has an important effect on femoral bone cut in TKA. The navigated TKA was more consistent than conventional TKA in aiding proper alignments of femoral component.

Level of evidence: Level II, comparative prospective study.

1. Introduction

Total knee arthroplasty (TKA) is a reliable procedure to treat advanced knee osteoarthritis. The importance of accurate implant alignment after TKA and the greater risk of implant failure with malalignment have been well recognized [1,2]. Placing implant components within 3° of the mechanical axis in postoperative leg alignment has reduced risks of abnormal wear, premature loosening, and early implant failure [3]. While TKA performed with intra-/extramedullary alignment guides is one of the most successful procedures with high survival rates [4], the current alignment guides have several limitations. Malaligned components with an intra-/extramedullary alignment system have occurred in 25% of patients [5]. Because the valgus correction angle of the distal femur, i.e. the angle between the femoral mechanical axis and the femoral anatomical axis varies in an osteoarthritic population, it is recommended to adjust the distal femoral cut angle according to the individual valgus correction angle of the distal femur in order to achieve appropriate coronal alignment with intra-/extramedullary alignment guides [6]. In addition to the presence of femoral/tibial deformity, distortion of the bony canal, and variations of femoral individual anatomy, coronal bowing of the lower extremity might contribute to the malposition of components and limb malalignment. Traditional alignment guides do not

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correspond to the coronal bowing of the lower extremity, and establishing the valgus correction angle of the distal femur is difficult in patients with coronal bowing of the lower extremity. The differences of skeletal morphology are noted between Caucasian and Asian populations [7]. Coronal bowing of the lower extremity is common among Asians with advanced osteoarthritis of the knee [8–10]. The incidence of coronal femoral bowing is 88% in patients undergoing TKA and 77% in the age-matched normal knee group [8].

The computer-navigated surgery has improved the placement of implants and lower limb alignment and reduced the incidence of alignment outliers in TKA [11]. In contrast, some investigators have shown no significant differences between the navigation TKA and the conventional TKA [12–14]. The value of the navigation surgery in TKA remains debatable. In addition, few studies have investigated the effectiveness of navigation surgery in TKA for patients with coronal bowing [15,16].

We hypothesized that coronal bowing itself has a risk for malalignment of the lower leg and malposition of femoral/tibial components and that navigation TKA is beneficial for patients with coronal bowing. The aims of this comparative prospective study were (i) to investigate the prevalence of femoral/tibial bowing in patients with knee osteoarthritis; (ii) to assess the impact of femoral/tibial bowing on radiographic parameters; (iii) and to compare the radiographic parameters between the navigation group and the conventional group.

2. Materials and methods

2.1. Patients

Seventy simultaneous bilateral TKAs on 35 patients with knee osteoarthritis, Kellgren-Lawrence grade IV, were enrolled in this comparative prospective study. The Institutional Review Board approved the study, and all patients provided informed consent to participate in it. The patients included 3 men and 32 women aged 57 to 87. Preoperative data are provided in Table 1.

Surgeries were performed by two experienced orthopedic surgeons (H.K., Y.A.) who were skilled at both navigated TKA and conventional TKA. TKA was performed first with a computed tomography-free navigation system (precisioN Knee Navigation System Ver4.0, Stryker, Mahwah, NJ) in one knee, followed by the conventional TKA in the contralateral knee. The navigated side and the conventional side were decided by using sealed envelopes at the time of our preoperative planning, usually several days before operation, and the operated knees were divided into two groups : the navigation group and the conventional group. No significant differences were observed in the preoperative radiographic data, which included hip-knee-ankle angle (HKA), femorotibial angle (FTA), valgus correction angle, coronal femoral bowing angle, and coronal tibial bowing angle between the 2 groups (Table 2, Fig. 1).

2.2. Surgical technique

The basic operative procedure was same in both the navigation group and the conventional group. An anterior midline incision with a midvastus approach following the modified gap technique was used. After osteophytes were removed, the anterior cruciate ligament and posterior cruciate ligament were sacrificed. The modified gap technique was used to accomplish the accurate soft-tissue balance. After the proximal tibial osteotomy and the distal femoral osteotomy, the soft-tissue release was performed. A balancer was used to evaluate soft-tissue balances between the distal femur and the proximal tibia or between the posterior femur and the proximal tibia at both 0° extension and 90° flexion.

In the navigation group, the components were implanted under the guidance of the image-free navigation system. Two trackers were fixed for navigation with bicortical screws to the distal femur and proximal tibia. The registration of key anatomical landmarks was recorded using an instrumented pointer. After the registration of centers of hip, knee, and ankle joints, the distal femur and proximal tibia were cut to perform the accurate bone cuts where these cuts were performed perpendicular to their mechanical axes in the coronal plane. In the conventional group, prostheses were implanted using an intramedullar alignment guide for the femoral component and an extramedullar alignment guide for the tibial component. The proximal tibial osteotomy was perpendicular to the tibial mechanical axis. The angle of the distal femoral cutting block was adjusted according to the valgus correction angle of the distal femur, which was measured using a long-leg weight-bearing radiograph between the femoral mechanical axis and femoral anatomical axis. Scorpio NRG® posterior stabilized total knee prostheses (Stryker, Mahwah, NJ) were fixed with cement without resurfacing of the patella.

Table 1
Demographic characteristics of the enrolled patients.

	Series (n = 35)
M/F	3/32
Age (years)	76.5 (74.0–79.1)
Body height (cm)	149.8 (147.5–152.0)
Body weight (kg)	59.2 (55.8–62.6)
Body mass index (kg/m^2)	26.3 (25.1–27.5)

Data are expressed as means with 95% confidence intervals.

2.3. Clinical and radiographic evaluation

Anteroposterior full-length lower limb radiographs were obtained preoperatively and postoperatively with patients in the standing position. Radiographs were projected using the Fuji Computed Radiography system, and various parameters were measured using Fujifilm OP-A software (Fujifilm, Co., Ltd, Tokyo, Japan).

Preoperative coronal bowing of both femur and tibia (Fig. 1A) were measured following the method of Yau et al. [10]. Femoral bowing of more than 3°, either laterally (+) or medially (−), was considered substantial [17]. Similarly, tibial bowing of more than 2°, either laterally (+) or medially (−), was considered substantial [10]. The subjects were divided into 2 subgroups, i.e. the bowing group and the non-bowing group. In addition, the following angles were measured: preoperative/postoperative HKA (Fig. 1B and E), preoperative/postoperative FTA (Fig. 1C and F), valgus correction angle of the distal femur (Fig. 1D), coronal femoral/tibial component angles (α angle/β angle) described by Ewalds [18] (Fig. 1G), and coronal femoral component angle to the femoral mechanical axis (Fig. 1H). The mechanical femoral axis was defined as "the line joining the center of the femoral head and the center of the knee". The mechanical tibial axis was defined as "the line joining the center of the knee and the center of the dome of the talus". The center of the knee was defined as "the midpoint of the tibial spines preoperatively and the midpoint of the tibial plateaus postoperatively". The valgus correction angle of the distal femur was used in the conventional method as the distal femoral cutting angle to achieve a perpendicular distal femoral bone cut to the mechanical axis of the femur (Fig. 1D). The coronal femoral component angle to the femoral mechanical axis was measured as the angle between the femoral mechanical axis and tangent of the femoral component (Fig. 1H), with 90° considered as a target angle. Coronal femoral component angle to the femoral mechanical axis outside ± 3° range from a target angle was considered an outlier. The incidence of outliers was compared between subgroups. The measurement was performed twice by one examiner and once by another examiner on the 10 knees randomly