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Clinical Implications of Femoral Anthropometrical Features for Total Knee Arthroplasty in Koreans

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ABSTRACT

Anthropometric features of Asians femora and their clinical relevance with regard to TKA are not rigorously investigated. We attempted to determine how well current prostheses accommodate femoral anthropometric features of Koreans and whether the presence of condylar or trochlear overhang or underhang adversely affects functional outcomes. We hypothesized that current prostheses do not accommodate Korean female femora well, and that overhang or underhang would adversely affect outcomes. Condylar and trochlear mediolateral (ML) widths and condylar anteroposterior (AP) heights were measured, and ML/AP ratios were calculated in 1025 osteoarthritic knees that underwent TKA. Besides gender difference, wide individual variation exists in condylar and trochlear widths and ML/AP aspect ratios for given AP heights. Size options of current prostheses could not cover the wide ranges of ML widths for given AP heights. The knees with condylar overhang more than 4 mm showed lower maximum flexion angle postoperatively ($P = 0.005$).

Anthropometric features of the femur are important in terms of improving prosthetic designs and surgical techniques in total knee arthroplasty (TKA). In theory, femoral component sizing influences flexion–extension gap balancing, patellofemoral kinematics by altering the tension in the quadriceps mechanism, the quality of implant fixation with respect to the amount of bone coverage, and tension in soft tissue [1–3]. The use of implants with properly matched sizes can help reduce complications and maximize clinical outcomes [4–6].

Although the use of TKA is increasing in Asia, most contemporary TKA prostheses have been designed based on the anthropometric features of Western patients. Differences in anthropometric features between Asian and Western knees have been reported in several studies [6–12], and thus, it is likely that contemporary femoral prostheses do not accommodate well the anthropometric features of Asian knees. However, whether current femoral prostheses accommodate Asian femurs well or not and its clinical implication have not been thoroughly investigated.

Recently, gender differences in TKA, including anthropometric features, prevalence of overhang, and clinical outcomes, have been the subject of debate [1–3,5,7,13–18]. If the claimed clinical implications of gender differences are true, they are likely to be more important to Korean patients undergoing TKA, because the female gender dominance, which is about 95%, is remarkable in Korean patients [19–22]. However, although several studies have been performed to investigate gender issues, these have been undertaken mainly in Western patients, and gender-related studies in TKA have not been rigorously performed in Asian subjects.

Previous studies which reported gender difference of anthropometric features have their own limitations. The majority of previous studies did not investigate the associations between anthropometric features and clinical outcomes [1,3,5,7,18,23–26]. Other studies have limitations like small sample sizes [1,10], studies in normal (non-arthritic) knees [9,27], and indirect measurements on radiographic images [9,26,28–30]. In addition, although the design modifications for the gender issue include the anterior flange of a femoral component, no previous studies investigated whether overhang or underhang at the trochlea leads to clinically discernible problems.

Therefore, this study was conducted to report anthropometric features of femur in Koreans and their clinical implications in a large group of real patients with intraoperative measurements. In particular, we focused on anteroposterior (AP) and mediolateral (ML) dimensions of femoral condyles and trochlea, and respective ML/AP ratios. We aimed to determine; whether the anthropometric features of female and male femora differ in Korean patients undergoing TKA for advanced osteoarthritis, how well currently available femur prostheses accommodate

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Table 1
The Demographic Data of Male and Female Knees.

Parameter	Male (N = 50)	Female (N = 975)	Significance (*P* Value)
Age (year)	69.2 (7.5)	68.7 (6.1)	0.544
Height (cm)	165.7 (6.3)	151.7 (5.6)	<0.001
Weight (kg)	70.0 (8.4)	62.3 (9.7)	<0.001
Body mass index (kg/m^2)	25.5 (2.4)	27.0 (3.6)	<0.001

Data are presented as means with standard deviations in parenthesis.

anthropometric features of the femur in the Korean patients, and whether TKAs with overhang or underhang between prepared femora and implanted prostheses have poorer functional outcomes than those with no overhang or underhang. We hypothesized that the anthropometric features of the femora of Korean females and males differ. We also hypothesized that current prostheses accommodate the anthropometric features of male femurs well but not so for females, leading to a higher prevalence of overhang or underhang both at the condyle and at the trochlea in females. In addition, we hypothesized that TKAs with overhang or underhang have worse clinical outcomes.

Materials and Methods

One thousand and twenty five osteoarthritic knees treated by primary TKA between November 2004 and March 2008 with available intraoperatively measured femoral anthropometric dimensions were included in this study. Knees with a diagnosis other than primary osteoarthritis or with substantial bone loss affecting intraoperative measurements were excluded. All patients were ethnic Koreans, and there were 975 female and 50 male knees. Female and male patients had similar ages, but female patients were smaller and had greater body mass indices (kg/m^2) (Table 1). This study was approved by the institutional review board at our hospital, and an informed consent was obtained from all patients for the use of their medical information.

All surgeries were performed by a single surgeon (one of the authors) using the standard medial parapatellar approach. Four hundred and ninety six knees were implanted with a mobile bearing system (e.motion; B.Braun-Aesculap, Tuttlingen, Germany) and 529 with a fixed bearing knee (Genesis II; Smith & Nephew, Memphis, USA). All prostheses were posteriorly stabilized types. Femoral component sizes were selected based upon measured dimensions of posterior femoral condyles and anterior cortices of the distal femur. When a measured distance lies between two adjacent sizes, the larger component was considered first. However, a smaller component was selected when a substantial condylar overhang identified as being over 2 mm was obtained using a larger femoral component. When choosing a mediolateral position of femoral component, femoral component was positioned laterally as far as no apparent lateral overhang and impingement on the popliteus tendon were observed. When overhang arising from the selection of an upsized femoral component was inevitable to create equal flexion–extension gaps, the component was placed centrally so that the overhang could be symmetric. Special attention was paid to avoid impingement at the tibial side in selecting and positioning a tibia component. A gap balancing workflow was employed according to the measured resection technique. Gap balancing was performed after all bone resections were done. Selective medial release was done for knees with medial tightness, and the pie-crusting technique was used for knees with lateral tightness. Selection of tibial insert thickness was based on gap assessment and trial reduction test. A polyethylene insert providing both full extension and flexion stability was selected. All implants were fixed with cement, and all patellae were resurfaced.

All intraoperative measurements were performed at the mm level by the operating surgeon (one of the authors) using a microcaliper (special caliper for neuro-surgery [AA845R]; B.Braun-Aesculap, Tuttlingen, Germany) (Fig. 1). Anteroposterior (AP) dimensions were measured before bone resection at the lateral condyle, because the lateral condyle typically maintains a more normal anatomy than the medial condyle. Condylar mediolateral (ML) dimensions were measured at the anterior margin of posterior chamfer after all bone resections, namely, anterior, distal, anterior, and posterior chamfer cuts. Distal femur resection amounts were determined by taking component thickness and degree of flexion contracture into account and ranged from 7.0 to 13.5 mm. Trochlear ML dimensions were measured at the proximal border of the anterior chamfer. Condylar and trochlear ML/AP aspect ratios were calculated by dividing measured ML widths by measured AP condylar lengths.

All patients underwent the same rehabilitation protocols. Patients learned to perform quadriceps strengthening exercises and to use a walking aid at a physiotherapy unit preoperatively. On the operation day, the patients were encouraged to perform quadriceps strengthening exercises when they were returned to the ward. One day after surgery, patients were allowed to walk to the toilet using a walking aid and received a 50 minute CPM session at a range of motion of 0°–30°. Range of motion was increased gradually at subsequent CPM sessions to level of tolerance. On the second day, the patients began to dangle their legs and perform active ROM exercises. From the postoperative 3rd day to the discharge day (between 7 and 14 days), patients visited our rehabilitation center daily for physiotherapy.

All clinical information was prospectively collected using predesigned datasheets and maintained in a database by a single investigator (one of the authors). This clinical information included demographic data, preoperative clinical statuses, and postoperative outcomes evaluated at 12 months postoperatively. Preoperative clinical statuses and postoperative outcomes were evaluated using knee motion arc (flexion

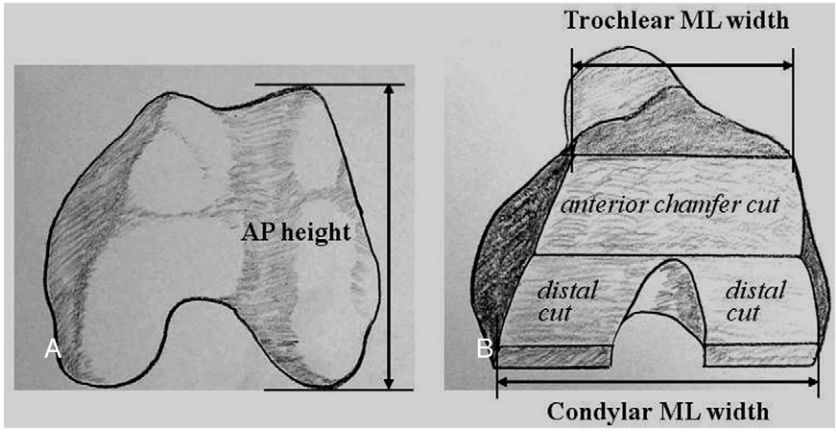

Fig. 1. Two schematic drawings showing how anteroposterior condylar dimensions (A) and mediolateral condylar and trochlear dimensions (B) were measured intraoperatively.