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Can Demographic Variables Accurately Predict Component Sizing in Primary Total Knee Arthroplasty?

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ABSTRACT

Background: As health care reform drives providers to reduce costs and improve efficiencies without compromising patient care, preoperative planning has become imperative. The purpose of this study is to determine whether height, weight, and gender can accurately predict total knee arthroplasty (TKA) sizing.

Methods: A consecutive series of 3491 primary TKAs performed by 2 surgeons was reviewed. Height, weight, gender, implant, preoperative templating sizes, and final implant sizes were collected. Implant-specific dimensions were collected from vendors. Using height, weight, and gender, a multivariate linear regression was performed with and without the inclusion of preoperative templating. Accuracy of the model was reported for commonly used implants.

Results: There was a significant linear correlation between height, weight, and gender for femoral ($R^2 = 0.504$; $P < .001$) and tibial sizes ($R^2 = 0.610$; $P < .001$). Adding preoperative templating to the regression analysis increased the overall model fit for both the femoral ($R^2 = 0.756$; $P < .001$) and tibial sizes ($R^2 = 0.780$; $P < .001$). Femoral and tibial sizes were accurately predicted within 1 size of the final implant 71%-92% and 81%-97% using demographics alone or 85%-99% and 90%-99% using both templating and demographics, respectively.

Conclusion: This novel TKA templating model allows final implants to be predicted to within 1 size. The model allows for simplified preoperative planning and potential implementation into a cost-savings program that limits inventory and trays required for each case.

Preoperative templating in total knee arthroplasty (TKA) provides surgeons the ability to anticipate final implant size and prepare for potential intraoperative difficulties or roadblocks that may occur along the way, such as severe deformity correction and the need for special equipment or nonstandard implants [1–3]. Accurate templating has become essential for surgical planning, particularly in community or outpatient settings where resources are more limited. Inaccurate or poor preoperative planning may result in the absence of the most appropriate implant for the patient at the time of surgery. This carries substantial morbidity and economic burden, and minimizing such scenarios is essential [4,5].

As we enter the new era of value-based health care, delivery of patient care in an accurate and affordable manner will prove paramount [6,7]. Traditional templating methods have demonstrated variable degrees of accuracy in regard to predicting final implant size and re-establishing coronal alignment, resulting in a push toward more reliable but potentially more costly and time-involved patient-specific instrumentation (PSI) [8–12]. The variability of standard templating and cost associated with preoperative computed tomography/magnetic resonance imaging in PSI has left surgeons to seek an accurate, time-efficient, and cost-effective method of templating in TKA. Whether component sizes can be predicted preoperatively by demographic variables alone has yet to be addressed in the literature.

We propose a novel method of templating in TKA based on a formula utilizing patient height, weight, and gender. The purpose of

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this study is to determine whether one can preoperatively predict the femoral and tibial sizes in primary TKA based on the patient's demographic data alone for multiple implant manufacturers. We also asked about the distributions of common sizes currently in use in our geographic area, which may guide implant manufacturers in production. Finally, we asked if the addition of preoperative templating to demographic data has any added value in predicting sizes for primary TKA.

Methods

We retrospectively reviewed a consecutive series of primary TKA procedures by 2 fellowship-trained arthroplasty surgeons between September 2010 and May 2016. This study obtained approval from our hospital's institutional review board, and no outside funding was obtained for this study. The surgeons in the study operated at 3 different hospitals and chose implants based on their comfort level with the instrumentation, availability at each operating room location, and preoperative planning. We queried each surgeon's individual database and collected demographic variables for each patient including gender, age, height, and weight. Implant data including manufacturer, type of prosthesis, and size of the components were noted. Preoperative electronic templating data were recorded when available. Radiographs were templated using Orthoview Preoperative Planning Software (OrthoView, Jacksonville, FL). Preoperative anteroposterior (AP) and lateral radiographs (Fig. 1) with a 25-mm calibration marker were uploaded to the software system. The femur was templated on the lateral radiograph according to the best-fit AP dimensions. The tibia was templated on the lateral radiograph to maximize tibial coverage and minimize overhang. Patients were excluded from the study if implant sizing or demographic data were unavailable. Each patient record was reviewed twice, documenting our measurements each time and reviewing any discrepancies in data with a third record review.

Sizing data for each implant was obtained using publically available data from each manufacturer. Implants included in the database were Persona (Zimmer Biomet, Inc, Warsaw, IN), NexGen (Zimmer Biomet, Inc, Warsaw, IN), Vanguard (Zimmer Biomet, Inc, Warsaw, IN), Journey (Smith & Nephew, Inc, Andover, MA), Attune (DePuy Synthes, Warsaw, IN), and Triathlon (Stryker Corp, Kalamazoo, MI). The documented size of each femoral implant was converted to millimeters in the AP plane. Tibial component sizes were converted to millimeters in the mediolateral (ML) direction.

We reviewed a consecutive series of 3402 primary TKA patients. Twenty-five patients (0.7%) were excluded from final analysis because of missing data, leaving 3377 patients for final analysis. There were 1258 men (37%) and 2119 women (63%) in the study with a mean height of 168 cm (±12 cm) and weight of 96 kg (±25 kg). The mean femoral size was 63.5 mm (±4.6 mm) in the AP direction, and the mean tibial size was 71.5 mm (±5.6 mm) in the ML direction. There were 1018 patients (30%) who had preoperative templating data available for both tibia and femur.

Statistical Analysis

We first performed an a priori power analysis to determine the appropriate sample size of our study. To generate a multivariate model to detect a small effect size in component dimensions ($f2 = 0.01$), we would need to enroll a total of 787 patients to achieve a power of 0.80 with a type I error rate of 0.05. A frequency table and graph were generated to determine the distribution of common implant sizes used in our patient population. We then performed multivariate linear regression to determine any correlation between height, weight, gender, and component sizes. Predicted femoral and tibial component dimensions in millimeters were recorded for each patient in the study and compared with the actual size of the prosthesis used in their surgery. Finally, we added preoperative templating to the multivariate model to determine its predictive effect on component sizing.

The model predicts a component size in millimeters (AP distance for femur and ML for tibia). We compared the predicted size in millimeters to the manufacturer's reported size in millimeters for each of the implant designs included in the study. The predicted size was deemed to be accurate it fell between 1 size below and 1 size above the actual size. Only 1 dimension (AP or ML) was used to

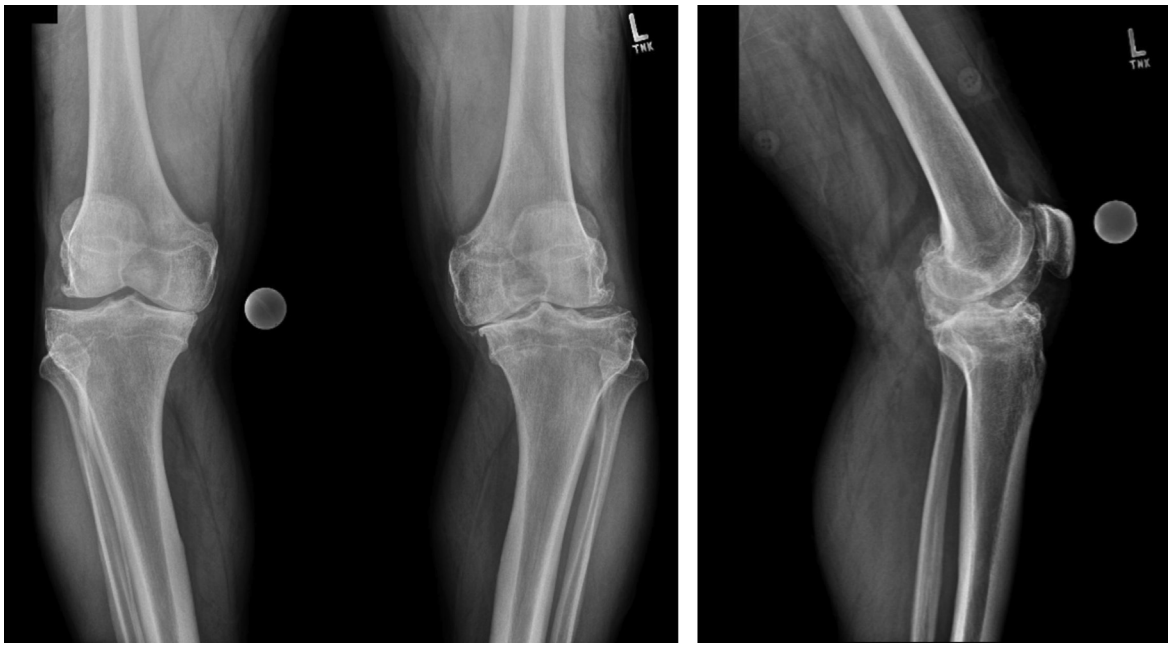

Fig. 1. Anteroposterior and lateral knee radiographs used for preoperative templating. The standardized marker for digital films can be seen in both images.