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Morphometrical measurements of resected surface of femurs in Chinese knees: Correlation to the sizing of current femoral implants

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Abstract

Morphometrical data were measured in the resected femurs of seventy Chinese patients who underwent total knee arthroplasties. Two measured parameters, the anterior–posterior length of the lateral condyle and the total width of the distal condyle, were compared to the anterior–posterior length and the medial-lateral width of five femoral implants currently used in Taiwan. Three implants (Duracon, NexGen and UKnee) have a larger medial-lateral width than the total width of the resected distal condyle for a given femoral implant anterior–posterior length. These implants tend to overhang the medial-lateral width of resected femurs from Chinese patients. In addition, one femoral implant (Duracon), which has previously been shown to be suitable for use in Caucasian patients, is not suitable in Chinese patients. Our results will allow manufacturers to design femoral implants better suited to Chinese patients.

Keywords: Morphometrical measurement; Resected femur; Knee dimensions; Total knee arthroplasty

1. Introduction

An important factor for long-term success in total knee arthroplasty is a good shape match between the prosthesis and the resected surface of the knee [1]. Using implants of precisely matched sizes can reduce complications and maximize survival rate [2]. Two major dimensions in the femoral implant, the anterior–posterior (AP) length and medial-lateral (ML) width, are used to select a suitable size for each patient. The AP length is widely used as the main parameter for implant sizing because it is strongly associated with normal gait motion and accurate ligamentous balancing in flexion and extension [3]. Therefore, an understanding of the relationship between the AP length and the ML width of the knee joint is very important for implant design.

Many researchers have studied knee morphology from cadavers or X-ray films of normal knees [4–7]. However, most osteoarthritic knees requiring total knee replacements are deformed and frequently have anatomical dimensions different from normal knees [8–10]. In addition, morphometrical data in resected bony surfaces is more useful than that of normal knees for implant design [1]. To the authors' knowledge, there are no studies in the literature investigating morphometrical parameters of the resected femurs in Chinese populations. The objective of this study was to measure the resected surfaces of the femur in osteoarthritic knees of Chinese patients and to compare these measurements with the dimensions of femoral implants in current use.

2. Material and methods

Between January 2002 and December 2002, 70 patients who underwent total knee replacements were involved. All subjects signed an informed consent document approved by the authors' hospital. There were 57 females and 13 males and the basic

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Table 1
Basic information of the subjects

Sex	Subject No.	Age (Years)	Weight (Kg)	Height (cm)
Male	13	67.1±7.3	75.8±12.2	167.6±5.5
Female	57	69.0±6.3	65.6±9.9	150.9±5.6
Total	70	68.6±6.5	67.8±11.0	154.0±8.6

information of these patients is shown in Table 1. The mean age was 68.6 years old, the mean body weight was 67.8 kg, the mean body height was 154.0 cm, and the mean body index was 28.6 kg/m^2. All patients were Taiwanese and all had osteoarthritic knees.

All knee operations and measurements were performed by one surgeon to eliminate the inter-observer bias. The anterior–posterior length of lateral condyle was measured before bony cutting and the total width of the distal resected femur was measured after anterior and distal cutting was completed. In addition, the widths of the medial, lateral femoral condyles and intercondylar notch were also measured (Fig. 1). The measured points on the medial condyle was 10 mm and on the lateral condyle was 8 mm from the lowest points on the medial and lateral posterior condyles to simulate the optimal cutting thickness [11]. All measurements were recorded in millimeters using slide calipers (Mitsutoyo Co., Tokyo, Japan) [1,8]. For restoration of natural knee anatomy after total knee replacement, the anterior–posterior length of the lateral condyle and the total width of the resected femur were used to present the anterior–posterior (AP) length and medial-lateral (ML) width for implant design. In analyzing the morphometrical data, a best-fit line was calculated by least-squares regression. In addition, a characterization of the aspect ratio (the ML dimension divided by the AP dimension × 100) was made [2]; this aspect ratio was compared with five prosthetic systems currently used in Taiwan; Duracon and Scorpio (Stryker Howmedica Osteonics), NexGen (Zimmer, Warsaw, Indiana), PFC Sigma (Depuy-Johnson and Johnson, Warsaw, Indiana) and UKnee (United Ortho Co., Taiwan).

3. Results

The mean anterior–posterior (AP) length of the lateral femoral condyle was 63.7 (SD 5.1) mm and the mean total medial-lateral

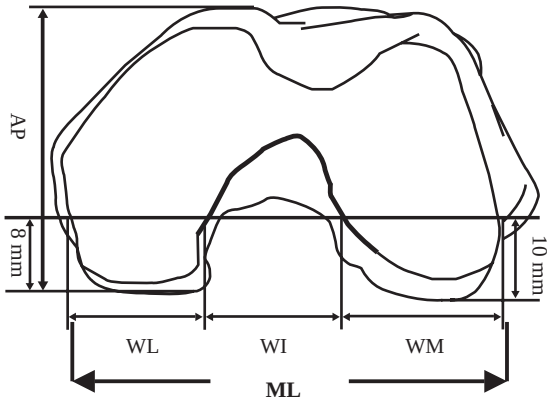

Fig. 1. Dimensions of resected distal femur. AP is the anterior–posterior length of lateral condyle. The ML, WL, WI, and WM are the widths of total distal condyle, lateral condyle, intercondylar notch and medial condyle, respectively.

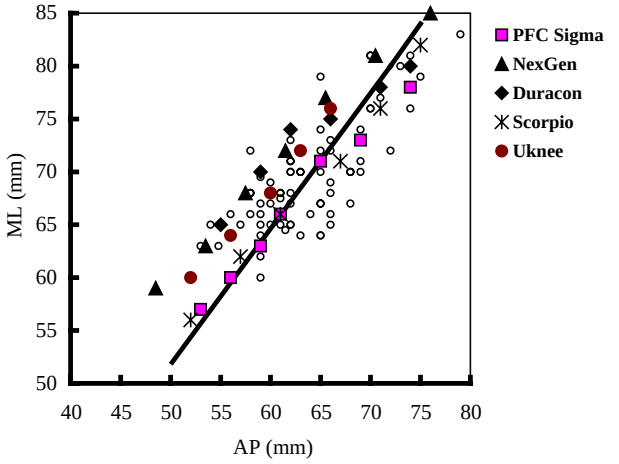

Fig. 2. The femoral anterior–posterior (AP) versus the medial-lateral (ML) measurements.

(ML) width of the resected femur was 70.2 (SD 5.4) mm. The widths of the medial condyle, intercondylar notch and lateral condyle were 26.7 (SD 2.7) mm, 18.2 (SD 2.3) mm and 25.3 (SD 2.6) mm, respectively. A graph showing the resected femoral ML width plotted against the AP length and the implant's AP and ML sizes are shown in Fig. 2. The Duracon, NexGen and UKnee systems had a larger ML width than the total width of the resected femur for a given femoral implant AP length. These implants tend to overhang the ML width of the resected femurs of Chinese patients. The mean femoral aspect ratio for the resected femur was 109% (SD 6%).

The mean femoral aspect ratio for the resected femur was 109%. The femoral aspect ratio for the resected femur showed a higher ratio for smaller knees and a proportionally lower ratio for larger knees, but the five implant systems showed little changes in the aspect ratio with AP length (Fig. 3).

4. Discussion

Some studies have demonstrated that Asian knees are generally smaller than Caucasian knees [6,7,12]. In those studies, femur specimens from normal cadavers were used to measure morphometrical data. The mean anterior–posterior length of the lateral femoral condyle was 63.3 (SD 4.7) mm for Chinese knees [6] and 64.2 (SD 3.4) mm for Singaporean knees [12]. In this study, the mean anterior–posterior length of the lateral condyle was 63.7 (SD 5.1) mm. For osteoarthritic knees, most of the lateral condyles are normal, which is why our results are similar to reports using measurements from normal Asian cadavers [6,12].

In measurements with normal cadavers, the total width of the femur is the distance between the most lateral and medial points of the respective condyles [6,7,13]. This is not suitable for femoral implant design because this width is different to the total width after distal femur cutting. In this study, we measured the total width of the femur after completion of femur distal cutting. These data may be useful

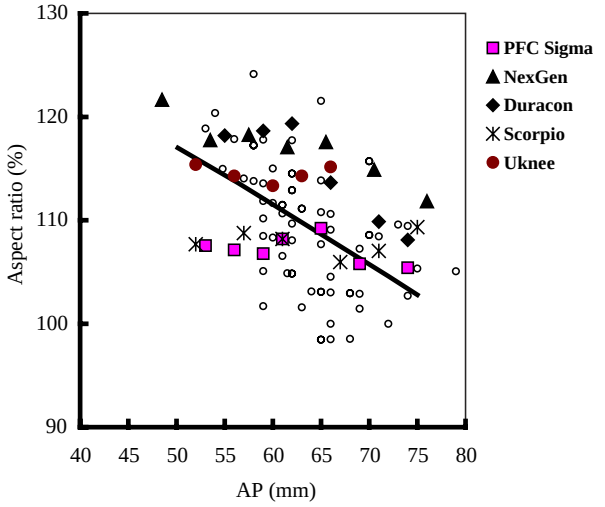

Fig. 3. The femoral aspect ratio versus the anterior–posterior (AP) measurements.

in designing implants for fully contact with the resected surface. The total width of the resected femur in this study was 70.2 mm, which is similar to Urabe et al's study (70.6 (SD 4.5) mm) using three-dimensional computer tomography to measure the resected femoral sections for Japanese patients [11]. However, the total width of the resected femur found in this study is larger than that in Huang's study (64.3 mm) where resected femoral surfaces were measured after completely bone cutting for the PCA (Howmedica, Rutherford, NJ, USA) knee system [8]. In this study 18.6% (13/70) of patients were males but only 6.5% (5/77) of subjects were males in Huang's study. It is well known that males have larger femurs than females and may explain why a larger total width was found in this study.

The range of the two measured dimensions in this study is widely distributed (Fig. 2). This finding is similar to studies done by Hitt et al. [2] and Urabe et al.'s [11]. Although the anterior–posterior lengths in some patients are approximately equal, the medial-lateral widths of these patients are not always equivalent. By contrast, most implant systems provide only one medial-lateral width for one anterior–posterior length. The implant component should be designed with several medial-lateral widths for one anterior–posterior length to obtain a better anatomical fit. The NexGen, Duracon and UKnee systems tend to overhang the medial or lateral condyles at a given implant anterior–posterior length. The size distributions for PFC Sigma and Scorpio are closer to the regression line than those of NexGen, Duracon and UKnee. This finding is consistent with Urabe et al.'s [11] study that NexGen and Duracon systems tend to overhang the medial and lateral femoral condyles while the PFC system showed a better design for Japanese patients. However, in Hitt's study [2], the size distributions of Duracon system were closer to the regression line than those of Scorpio and PFC Sigma systems for American patients. This finding demonstrates that one system suitable for use in Caucasian patients may not be suitable for Chinese patients. As a result, we believe that femoral implants with AP lengths from 50 to 75 mm in a 5-mm increments corresponding to the ML widths of 52.0, 58.3, 64.5, 70.8, 77 and 83.3 mm, respectively would be ideal for use in Chinese patients.

5. Conclusion

The length of the lateral femoral condyle and the total width of the distal femur of resected femurs in Chinese patients are different from the corresponding morphometrical measurements in Caucasian patients. The data in this study can be used as a guideline to design a femoral implant with a femoral aspect ratio better suited to Chinese patients.

Acknowledgement

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