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The tibial crest as a practical useful landmark in total knee arthroplasty

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ABSTRACT

Background: The middle one-third of the tibial crest in the coronal plane and the fibula in the sagittal plane are known as landmarks for extramedullary guides in total knee arthroplasty (TKA). However, there are few foundational anatomic studies about them. We conducted this study to confirm whether these landmarks are reliable.
Methods: We evaluated 100 Japanese knees using 3D imaging software. We examined our data for correlations between the angle of deviation from the mechanical axis and patient-specific factors (i.e. hip-knee-ankle angle, tibial length, tibial bowing, and tibial torsion) to determine whether there are any individual factors affecting their reliability.
Results: The mean angles between each of the axes defined by the fibula and the tibial crest with the mechanical axis were 2.9° ± 0.6° of valgus and 0.7° ± 0.9° of varus in the coronal plane and 2.2° ± 0.8° of posterior and 3.6° ± 1.0° of anterior inclination in the sagittal plane. The middle one-third of the tibial crest (TCL) was revealed as a useful landmark, especially in female patients, who possess TCLs that were within 3° of the tibial mechanical axis in the coronal plane. There were no patient-specific factors strongly affecting reliability of these landmarks.
Conclusions: We can use these landmarks even if the patient has tibial bowing or severe varus deformity. Although not considering soft tissue thickness, our study demonstrated that the tibial crest in the coronal and sagittal planes could be useful guidelines in performing TKAs.
Level of evidence: II

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1. Introduction

Total knee arthroplasty (TKA) survivorship depends upon proper alignment of the limb and prosthesis. Several studies have correlated poor outcomes with coronal malalignment of the components [2,11,14]. Proper sagittal alignment is also important, as the tibial slope affects anteroposterior stability, range of motion, and contact pressure within the tibiofemoral joint [3,5,9,20].

Intramedullary systems have been considered superior to extramedullary systems for making the femoral cut and arriving at an accurate and reproducible placement of the component [4,7,12,18,19]. However, for tibial alignment, there is still controversy as to whether intramedullary systems or extramedullary systems are more reliable. Although numerous bone and soft tissue landmarks have been advocated [6,16,17], it is not easy to align an extramedullary guide to the mechanical axis primarily due to the difficulty in finding the ankle center. Furthermore, most of those landmarks are readily affected by the position of the ankle joint [15]. The middle one-third of the tibial crest in the coronal plane and the fibula in the sagittal plane are known as landmarks to provide an extramedullary guide in TKA [8,13]. However, they seem to lack sufficient scientific foundational anatomic studies. In actual practice, the landmark expressed by a line connecting the two points on the tibial crest 10 cm and 20 cm distal to the knee joint line is easier to use than the landmark expressed by the middle one-third of the tibial crest. The points on the tibial crest 10 cm and 20 cm distal from the knee joint line approximate the proximal one-third and distal one-third of the tibia, respectively, in Japanese patients. We also wondered if the tibial crest in the sagittal plane and the fibula in the coronal plane could be reliable landmarks for alignment of the tibia.

We therefore conducted this study to determine (1) whether the anterior crest (a line connecting the two points on the tibial crest 10 cm and 20 cm distal to the knee joint line) and the fibula are reliable in coronal and sagittal alignment of the tibia and (2) whether there are any individual factors affecting their reliability.

2. Materials and methods

Our study investigated 100 knees in 89 consecutive patients scheduled for TKA. The population consisted of 85 knees in 75 females

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and 15 knees in 14 males. None of our patients had evidence of trauma, infection, tumour, or any congenital disorder. The mean age of all patients was 70.8 years (range 39 years to 88 years). Our study group included 76 patients with osteoarthritis (86 knees) and 13 patients with rheumatoid arthritis (14 knees). We performed preoperative high-resolution CT scans of all the affected lower limbs, including the whole tibia and fibula with a 16-detector CT unit (Toshiba Medical, Japan) in the helical mode in a 512 × 512 matrix, setting slice thickness at 1 mm as part of a routine exam for TKA. We used CT-based preoperative TKA planning software (ZedKnee® LEXI Co., Ltd., Tokyo, Japan) to determine the tibial mechanical axis (MA) and perform measurements of the accuracy of the tibial crest line and fibula for alignment. To our regret, we do not have full-length weight-bearing AP radiographs in about half of the patients. Therefore we used non-weight bearing CT data to measure the hip-knee-ankle angle using this software. We defined the tibial MA as a straight line from the center of the appropriate-size LCS® Complete™ (Johnson & Johnson, DePuy, Warsaw, IN, USA) tibial component without posterior slope to the center of the distal tibial plafond. The center of the distal tibial plafond was automatically calculated by the software with the aid of three peripherally defined points approximating the plafond to a circle (Fig. 1) The antero-posterior axis of the tibia was defined as a straight line connecting the mid-posterior cruciate ligament (PCL) attachment with the medial edge of the patellar tendon attachment [19]; the tibial crest line (TCL) as the line connecting the two points on the tibial crest 10 cm and 20 cm distal to the knee joint line (Fig. 2); the fibular line in the coronal plane (FLc) as a tangential line connecting the most prominent parts of the fibular head with the lateral malleolus; and the fibular line in the sagittal plane (FLs) as a line from the center of the fibular head to the center of the lateral malleolus (Fig. 3A and B). We measured the angle between the TCL and MA (TCL-MA angle) in both the coronal and sagittal planes; the angle between the FLc and the coronal MA (FLc-MA angle); and the angle between the FLs and the sagittal MA (FLs-MA angle). Preoperative TKA planning automatically measures the angle by dotting the reference points for the respective lines on reconstruction CT images. To test intra- and inter-observer reliability, each set of measurements was repeated three times on 10 randomly selected subjects by two of the authors (T.T. and T.L.).

We examined our data for correlations between the angle of deviation from the MA and patient-specific factors (i.e. hip-knee-ankle angle, tibial length, tibial bowing, and tibial torsion). Tibial length was measured from the proximal end (eminentia intercondylaris) to the ankle joint. Tibial bowing was determined by the angle between the lines drawn from the midpoint of the diaphysis at the apex of the bow to the center of the tibial component and to the center of the tibial plafond using the digital reconstruction radiography mode of the software (a positive value indicated laterally convex bowing). We detected the apex of the bow in this image as the most prominent cortex laterally or medially compared to the mechanical axis of the tibia, and defined the midpoint of the diaphysis by circle approximation in the axial plane (Fig. 4). We defined tibial torsion as the angle between the line perpendicular to the antero-posterior axis of the tibia and the transmalleolar axis (a positive value indicated outward rotation). The transmalleolar axis is the

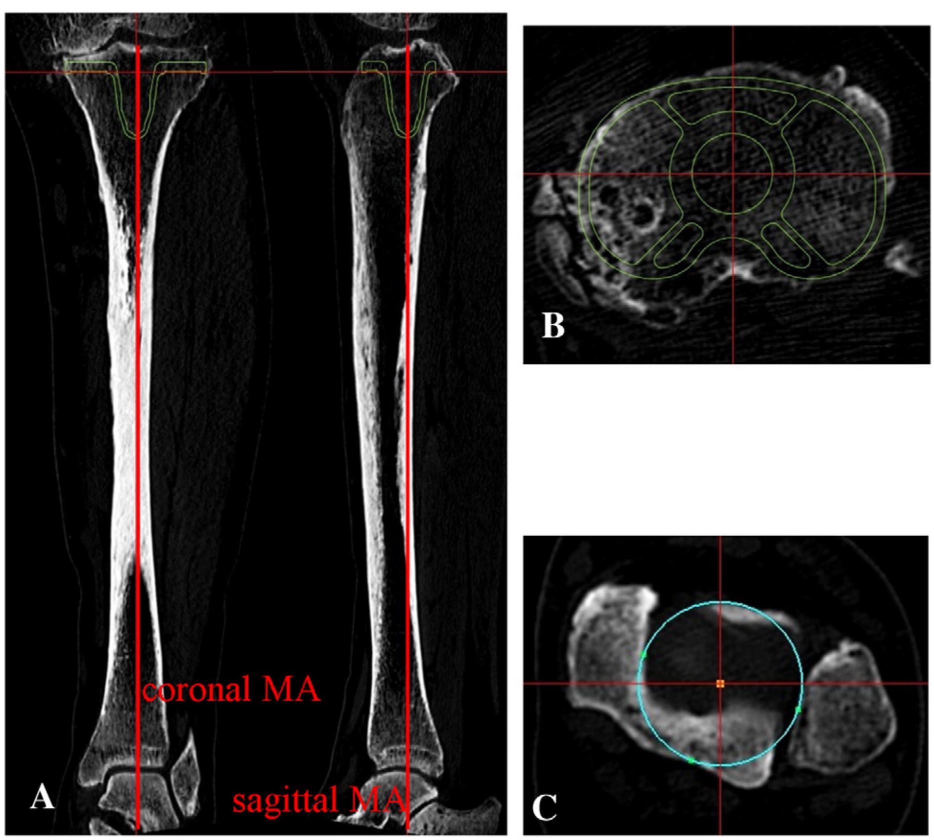

Fig. 1. The definition of the mechanical axis (MA) of the tibia. (A) The mechanical axis of the tibia was defined by connecting the points between the center of the proximal tibia and the center of the distal tibia. (B) Proximal tibial center. (C) The center of the distal tibial plafond was automatically calculated by the software with the aid of three peripherally defined points approximating the plafond to a circle.

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