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Accuracy of Proximal Tibial Bone Cut Using Anterior Border of Tibia as Bony Landmark in Total Knee Arthroplasty

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ABSTRACT

The purpose of our study was to evaluate the accuracy of the tibial bone cut in total knee arthroplasty using the anterior tibial border as a guide compared to using bony and soft tissue landmarks of the ankle joint. The extramedullary alignment guide was set parallel to a line connecting the proximal and distal one-thirds of the anterior border of the tibia while the rotational direction of the distal end of the guide was adjusted to the anteroposterior axis of the proximal tibia. Significant differences were detected in the ideal coronal tibial component angles with improvements from 87.2% to 95.9%. The anterior tibial border was a reliable landmark in total knee arthroplasty in clinical practice, as shown by our previous computer simulation.

Total knee arthroplasty (TKA) has become one of the most successful orthopedic procedures for providing pain relief and improving knee function. The rate of TKA failures is decreasing, with reported survival rates of greater than 90% after 15 years [1,2], however, many factors contribute to the risk of failures that necessitate TKA revision. It is important to position the femoral and tibial components accurately and to balance the soft tissues. Malpositioning of the components can lead to failure due to aseptic loosening, instability, polyethylene wear [3,4], and dislocation of the patella [5]. In particular, the importance of tibial alignment is well recognized. Many papers have recommended that the tibial component be implanted perpendicular to the tibial axis. Placement of the implants within 3° of the mechanical axis of the lower limb has been proven to reduce wear and early implant failure [6,7]. Berend et al [8] reported that the odds of failure increased up to 17.2-fold in cases with more than 3° of varus alignment of the tibial component.

Intramedullary and extramedullary guides are generally used to cut the tibia, and each has both advantages and shortcomings. It is difficult to use intramedullary guides in patients with severe post-fracture bowing and deformity [9]. In addition, many studies have reported increased risk of fat embolism with the use of intramedullary guides [10,11]. In contrast, extramedullary guides make it easier for surgeons to perform additional checks and to reposition the guides after set-up [12]. However, the use of extramedullary guides necessitates meticulous attention to accurately align the tray during TKA. The position of the distal end is defined subjectively, which can cause incorrect alignment because it is difficult to find the center of the ankle joint, especially in obese patients with an excess of soft tissue and in osteoarthritis patients with abnormal ankle anatomy [13]. The optimal placement within 3° was reportedly achieved in only 70% to 80% of patients when using extramedullary alignment guides, despite improvements in surgical techniques and jigs [14,15].

Several references for aligning extramedullary alignment guides have been reported [16–20]; however, these landmarks have varied widely among papers. It would be ideal to identify a stable landmark so as to allow surgeons to most accurately realize the tibial mechanical axis. We previously performed a three-dimensional computer simulation to evaluate the efficacy of the anterior border of the tibia as a reference for setting extramedullary alignment in TKA [21]. Our computer simulation showed that (1) the line connecting the proximal and distal one-third of the anterior border, and (2) the line connecting the medial one-third of the patellar tendon attachment and the distal one-fourth of the anterior border were similarly parallel to the mechanical axis in the coronal plane. Even though the anterior border of the tibia was reliable as a landmark in the simulation study, its efficacy has not been proven in a clinical setting. The purpose of the present study was to determine whether this method reduced the incidence of tray malalignment when compared to using bony and soft tissue landmarks of the ankle joint.

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Patients and Methods

Patients

Between January 2007 and September 2013, 513 osteoarthritic knees in 405 Japanese female patients underwent primary TKA. Fifty-eight knees (46 patients) with valgus deformity were excluded because our previous computer simulation included varus knees only, yielding 455 knees (359 patients). Full-length, weight-bearing anteroposterior (AP) radiographs were used to evaluate alignments accurately. We obtained both pre-operative and post-operative radiographs of 341 knees (248 patients). We standardized the implant used, and 191 knees (159 patients) were replaced with the Nexgen Legacy posterior-stabilized prosthesis (Zimmer, Warsaw, Indiana) using an extramedullary guide without computer-assisted navigation. All arthroplasties were performed by one special team for knee surgery at our institution.

We compared the accuracy of component positioning in two groups defined by the surgical technique used to position the distal end of the extramedullary guide. From January 2007 to March 2010, the distal end of the guide was positioned at the ankle center, which was defined based on the surgeon's subjective judgment using bony and soft tissue landmarks (Method A: 117 knees). View direction to the ankle center differed among the surgeons (e.g., there are multiple ways of viewing the ankle center in the direction of the AP axis of the ankle joint). From October 2010 to September 2013, the extramedullary guide was set parallel to a line connecting the proximal and distal one-third of the anterior border (Method B: 74 knees, Fig. 1). The reason for selecting the line was easiness and reproducibility among the surgeons compared to the line connecting the medial one-third of the patellar tendon attachment and the distal one-fourth of the anterior border of the tibia. Procedures during the subsequent 6 months (April 2010 to September 2010) were not included to avoid bias between Methods A and B. This study was approved by the Institutional Review Board and informed consent was obtained from all patients. Preoperative demographic data are shown in Table 1.

Table 1
The Preoperative Demographic Data.

	Method A (n = 117)	Method B (n = 74)
Mean age (years)	74.4 ± 7.3 (51 to 87)	76.8 ± 7.4 (57 to 91)
Mean hip–knee–ankle angle (°)	167.2 ± 5.4 (150.4 to 179.9)	166.4 ± 5.7 (151.0 to 179.2)
Mean body mass index (kg/m^2)	26.8 ± 4.2 (18.0 to 38.9)	26.6 ± 4.3 (15.6 to 38.3)
Maximum extension (°)	−7.8 ± 8.0 (−30 to 5)	−8.3 ± 7.0 (−20 to 20)
Maximum flexion (°)	118.3 ± 17.2 (70 to 155)	118.1 ± 17.5 (75 to 150)

Surgical Techniques

The standard medial parapatellar incision and approach were used. For the distal femur, the intramedullary alignment guide was inserted slightly medial to the midpoint of the femoral condyles. This entry point was determined as the position where the intramedullary line of the femoral canal exited the femoral condyles on the full-length AP radiographs [22]. The distal femoral cutting block was then attached to the alignment guide, with adjustment for the anatomical valgus angle of the femur. After cutting the distal femur, the cutting block was set parallel to the transepicondylar axis [23]. For cutting the proximal tibia, the extramedullary alignment guide was set at a level approximately 10 mm distal to the lateral articular surface of the tibia. First, we defined the AP axis that connected the center of the posterior cruciate ligament at the tibial attachment and the medial one-third of the border of the patellar tendon at the tibial attachment. The rotational direction of the proximal side of the guide was adjusted to the AP axis of the proximal tibia marked on the articular surface. All techniques other than setting the distal side of the guide were the same as mentioned above.

In Method A, the distal end of the guide was positioned at the ankle center, which was defined based on the surgeon's subjective judgment using bony and soft tissue landmarks. In Method B, the guide was set parallel to a line connecting the proximal and distal one-third of the anterior border while the rotational direction of the distal end of the guide was adjusted to the AP axis of the proximal tibia (Fig. 2). The planned sagittal alignment of the cutting of the tibia was parallel to the lateral tibial slope [24]. The surgeon was able to check the coronal alignment using the alignment rod with spacer block after cutting the proximal tibia. The rotational alignment of the tibial component was adjusted to the AP axis between the center of the cut surface and the border of the medial one-third of the tibial tuberosity [25,26]. The patella was resurfaced in all patients. All femoral, tibial, and patellar components were fixed with cement.

Evaluation of Post-Operative Alignment

All patients in both groups were evaluated using full-length, weight-bearing AP radiographs (Fig. 3). Care was taken to avoid rotational

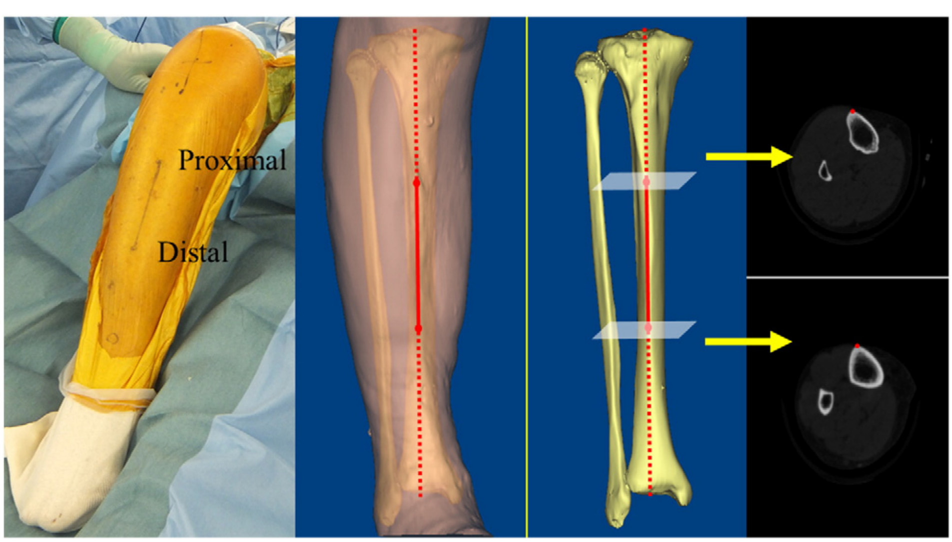

Fig. 1. Method B (using a line connecting the proximal and distal one-third of the anterior border). The extramedullary guide was set parallel to a line connecting the proximal and distal one-third of the anterior border. Solid line: a line connecting the proximal and distal one-third of the anterior border of the tibia.