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Anatomical landmarks of the distal femoral condyles are not always parallel to the tibial bone cut surface in flexion during total knee arthroplasty

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ABSTRACT

Background: Soft tissue balancing is crucial to the success of total knee arthroplasty (TKA). To create a rectangular flexion joint gap, the rotation of the femoral component is important. The purpose of this study is to determine whether or not anatomical landmarks of the distal femoral condyles are parallel to the tibial bone cut surface in flexion.

Methods: Forty-eight patients (three male and 45 female) with a mean age of 74 years were examined. During the operation, we estimated the flexion joint gap with the following three techniques. 1) a three degree external cut to the posterior condylar line (MR1), 2) a parallel cut to the surgical transepicondylar axis (MR2), and 3) a parallel cut to the anatomical transepicondylar axis (MR3).

Results: The flexion joint gap was 1.1 ± 3.0° (mean ± standard deviation (SD)) in internal rotation in the case of MR1, 0.9 ± 3.4° in internal rotation in the case of MR2, and 2.1 ± 3.4° in external rotation in the case of MR3. An outlier (flexion joint gap >3.0°) was observed in 12 cases (25%) in MR1, 13 cases (27%) in MR2, and 15 cases (31%) in MR3.

Conclusions: The anatomical landmarks of the distal femoral condyles are not always parallel to the tibial bone cut surface in flexion. To create a rectangular flexion joint gap, the rotation of the femoral component rotation is based not only on the anatomical landmarks but also on the ligament balance.

1. Introduction

Soft tissue balancing of the knee is crucial to the success of total knee arthroplasty (TKA). Creating rectangular extension and flexion joint gaps is considered one of the important goals in TKA, because it may facilitate functional restoration of the knee [1–5]. To prepare a rectangular flexion joint gap, the setting of the femoral component parallel to the tibial bone cut surface is important [6,7]. However, excessive internal rotation of the femoral component results in patellar mal-tracking [8], and excessive external rotation of the femoral component increases the risk of notching of the anterior femoral cortex [9].

Two major techniques are used for the rotation of the femoral component: the gap-balancing [10–12] and measured resection techniques [13–19]. In the gap-balancing technique, the rotation of the femoral component was based on the ligament balance in flexion. In the measured resection technique, however, the femoral component rotation was based on the anatomical landmarks of the distal femoral condyles [13–19]. From the standpoint of joint stability, the gap-balancing technique is advantageous. In terms of patellar tracking and anterior femoral notching, the measured resection technique is advantageous.

We hypothesize that the rectangular flexion joint gap can be prepared using the measured resection technique. The purpose of this study is to determine whether or not anatomical landmarks of the distal femoral condyles are parallel to the tibial bone cut surface in flexion.

2. Patients and methods

Consecutive patients who underwent TKA with a posterior-stabilized (PS) total knee prosthesis at our hospital between 2007 and 2009 were eligible for participation in the study. Patients with osteoarthritis and varus deformity of the knee were included. None of the patients had extra-articular tibial deformities. Patients without preoperative computed tomography (CT) scans of the whole leg and postoperative anteroposterior radiographs of the leg under fluoroscopic control as well as patients without intraoperative joint gap measurements were excluded. The study included 48 TKA procedures (47 patients). Three patients (three knees) were male, and 44 (45 knees) were female. The age at operation was 74 ± 6 years (mean ± standard deviation). The mean height and body weight were 150 ± 6 cm and 59 ± 9 kg, respectively. Each patient provided informed consent to participate in this study, which was approved by our institutional review board.

All of the procedures were performed by a single surgical team. The knees were exposed using a medial parapatellar approach, and the

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anterior and posterior cruciate ligaments were resected. After the bone was cut up to the distal femur and proximal tibia, and after osteophyte removal, stepwise medial soft tissue release was performed to create the rectangular extension joint gap. Before cutting into the posterior condyles, the angle of the flexion joint gap was measured using a tension device (True Tensor; Biomet Japan, Tokyo, Japan) at 120 N of distraction force (Figure 1) [20]. The joint distraction force was set at 120 N, because a previous report reported a mean distraction force of 126.8 N in extension and 120.7 N in flexion on application of the appropriate soft tissue tension, according to the expert surgeon [21]. The interobserver and intraobserver variabilities of this tenor device for 20 subjects were reported in a previous study [20]. The mean absolute value of the difference between two repeated measurements by one observer was 0.1° (95% confidence interval, −0.2° to 0.4°). The mean absolute value of the difference between the two observers was 0.2° (95% confidence interval, −0.1° to 0.4°).

The angle between the posterior condylar line (PCL) [13,14] and transepicondylar axes (surgical transepicondylar axis (sTEA) [13–15] and anatomical transepicondylar axis (aTEA) [18,19]) was measured on preoperative CT scans. Anteroposterior radiographs of the leg were obtained under fluoroscopic control postoperatively. The angle of the cut surface of the tibial bone, which is the angle between the cut surface of the tibial bone and the line perpendicular to the tibial mechanical axis, was measured. All of the CT images and radiographs were digitally captured and measured to one decimal place using the computer software Centricity RA1000 (GE Healthcare Japan, Tokyo, Japan). For 10 patients, all of the radiographic parameters were measured twice in an interval of 1 week to evaluate reproducibility. The mean absolute value of the difference between two repeated measurements was 0.4° (95% confidence interval, 0.3 to 0.6°) for the CT measurement and 0.7° (95% confidence interval, 0.4 to 1.0°) for the tibial implant alignment.

Two kinds of measured resection techniques are available: classical and adapted measured resection techniques [13–19]. In the classical measured resection technique, the femoral component rotation was set at three degrees external to the PCL [22]. In the adapted measured resection technique, the femoral component rotation was set parallel to the sTEA or aTEA [22–26]. In this study, we estimated the angle of the flexion joint gap with the following three measured resection techniques.

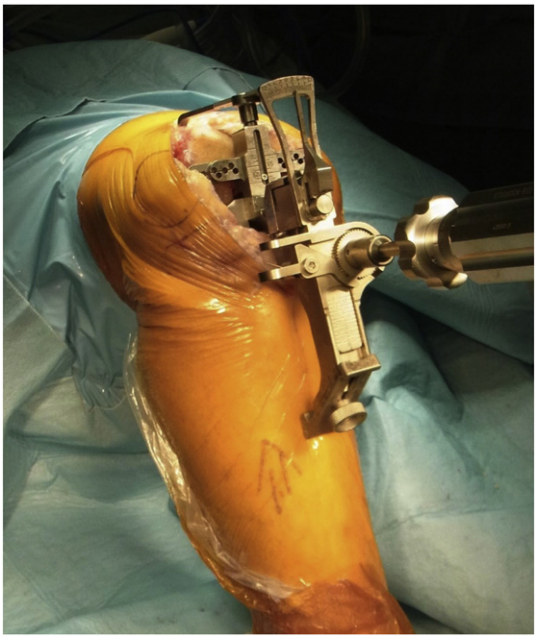

Figure 1. The flexion joint gap was measured using a tensor device (True Tensor; Biomet Japan, Tokyo, Japan). The angle between the posterior condylar line and cut surface of the tibial bone was measured.

1) Classical measured resection technique (MR1; Figure 2-A)
In the classical measured resection technique, the femoral component rotation was set three degrees external to the PCL [22]. The cutting error of the proximal tibia in the coronal plane also affected the angle of the flexion joint gap. Thus, we estimated the angle of the flexion joint gap with the classical measured resection technique as follows:

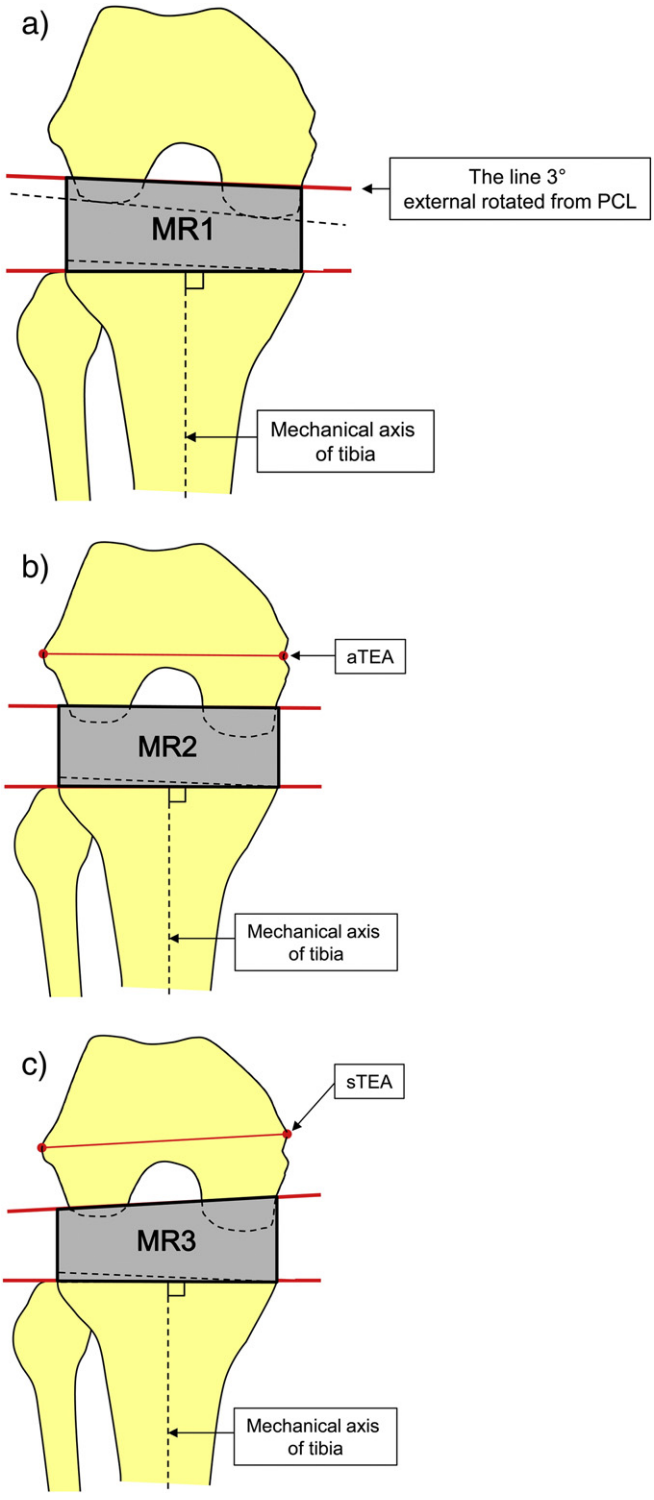

Figure 2. (A) The shape of flexion joint gap using the classical measured resection technique (MR1) was shown. (B) The shape of the flexion joint gap cut parallel to the surgical transepicondylar axis (sTEA) (MR2) was shown. (C) The shape of the flexion joint gap cut parallel to the anatomical transepicondylar axis (aTEA) (MR3) was shown.