Relationship Between Femoral Component Rotation and Total Knee Flexion Gap Balance on Modified Axial Radiographs

Kazuhisa Hatayama, MD, PhD,* Masanori Terauchi, MD, PhD,* Hiroshi Higuchi, MD, PhD,† Shinya Yanagisawa, MD,‡ Kenichi Saito, MD,* and Kenji Takagishi, MD, PhD‡

Abstract: Using modified axial radiographs, we investigated the relationship between femoral component rotation and flexion gap balance in 70 consecutive knees with varus osteoarthritis 1 year after they underwent cruciate-ligament–retaining total knee arthroplasty with the measured resection technique. We measured (1) the condylar twist angle, defined as the angle between the posterior condylar axis and the clinical epicondylar axis, and (2) the liftoff angle (LOA), defined as the angle between the posterior condylar axis and the tibial cutting surface. There was a significant positive correlation between the postoperative condylar twist angle (mean, 2.6°) and the postoperative LOA (mean, 1.8°). Our data suggest that a more accurate method of identifying the clinical epicondylar axis would lead to a smaller LOA as measured on modified axial radiographs.
Keywords: condylar twist angle, clinical epicondylar axis, femoral component rotation, flexion gap balance, liftoff angle, total knee arthroplasty.

Rotational positioning of the femoral component in total knee arthroplasty (TKA) should be carefully determined because it affects varus-valgus stability in flexion and patellar tracking [1-3]. Femoral component rotation during TKA can be commonly determined by 2 techniques. One is the tensioned gap technique, in which the soft-tissue structure of the knee is tensed in flexion using a tensor or a lamina spreader after ligament balance in extension has been achieved, and then an anteroposterior (AP) cut of the femur is made parallel to the tibial cut surface. The other is the measured resection technique, in which the AP cut of the femur is made on the basis of 3 anatomic landmarks on the femur: the AP axis, the posterior condylar axis (PCA), and the transepicondylar axis (TEA). Two different lines are defined as the TEA. The surgical epicondylar axis (SEA) is a line connecting the lateral epicondylar prominence and the medial sulcus, which is the attachment of the deep medial collateral ligament. The clinical epicondylar axis (CEA) is a line connecting the lateral epicondylar prominence and the most prominent point of the medial epicondyle, which is the attachment of the superficial medial collateral ligament (Fig. 1).

Fehring reported that compared with the tensioned gap technique, the measured resection technique, using the PCA as a landmark for rotational positioning, produced femoral rotational errors of at least 3° in 45% of patients [2]. Whiteside and Arima [3] concluded that patellofemoral problems were significantly reduced in the knees using the AP axis as a landmark compared with knees using the PCA. The PCA may be inappropriate as an anatomic landmark for rotational positioning of the femoral component during TKA because it is the axis affected by the loss of cartilage and bone of the femoral posterior condyles and by the patient's sex [2,4-6]. However, Olcott and Scott [7] demonstrated that the TEA most consistently recreated a balanced flexion space during TKA, but they did not clearly distinguish between the SEA and the CEA of the TEA. Berger et al [5] reported that the SEA is a useful landmark in determining the native neutral rotational orientation of the femoral component. Akagi et al [4] examined the relationship of these anatomic landmarks

*From the *Department of Orthopaedic Surgery, Social Insurance Gunma Central General Hospital, Maebashi, Gunma, 371-0025, Japan; †Department of Orthopaedic Sports Surgery, Asakura Sports Rehabilitation Clinic, Japan; and ‡Department of Orthopaedic Surgery, Gunma Graduate School of Medicine, Maebashi, Japan.*
Submitted October 27, 2009; accepted May 25, 2010.
No benefits or funds were received in support of the study.
Reprint requests: Kazuhisa Hatayama, MD, PhD, Department of Orthopaedic Surgery, Social Insurance Gunma Central General Hospital, 1-7-13 Koun, Maebashi, Gunma, 371-0025, Japan.

0883-5403/2604-0022$36.00/0
doi:10.1016/j.arth.2010.05.029

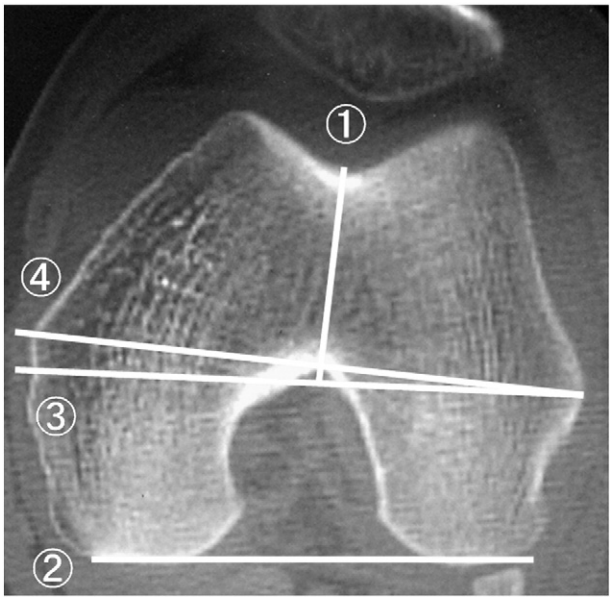

Fig. 1. Axial computed tomography image of distal femur: 1, AP axis; 2, PCA; 3, SEA; 4, CEA.

using computed tomography scans and concluded that the CEA was almost at a right angle to the AP axis and that the SEA had 3° internal rotation relative to the CEA. Because it has not been clarified which of the TEA, CEA, and SEA should be used as a rotational landmark, it seems that there is a need for confirmation in terms of postoperative clinical results and ligament balance in flexion; however, few researchers have evaluated postoperative ligament balance in flexion.

The importance of preparing rectangular gaps in extension and flexion during TKA is well recognized [8,9]; however, lateral tibiofemoral articulation is physiologically lax in flexion, and thus, the flexion gap in healthy knees is not rectangular [10]. Furthermore, in varus knees with arthritis, for which arthroplasty is generally performed, medial soft tissue is contracted and lateral soft tissue is slack [11]. Taking into account these characteristics in the natural knee, a more externally rotated positioning of the femoral component may be useful in achieving the appropriate flexion gap balance in the replaced knee. We hypothesized that femoral component positioning parallel to the CEA, which is more externally rotated than the SEA, is helpful in achieving an appropriate flexion gap balance. The purposes of this study were to investigate the relationship between femoral component rotation and flexion gap balance after TKA with the measured resection technique and to determine proper rotational alignment of the femoral component in terms of flexion gap balance.

Materials and Methods

In this prospective clinical cohort study, 63 consecutive patients (70 knees) with primary varus osteoarthritis undergoing cruciate-ligament–retaining TKA in our institute were included. There were 15 men and 48 women, and the patients' mean age at surgery was 74 years (range, 58-85 years; Table 1).

A single surgical team performed all of the surgery. The knees were exposed through a medial parapatellar arthrotomy. The distal femur was resected perpendicular to the mechanical axis using an intramedullary alignment rod. Anterior and posterior femoral resection was performed parallel to the CEA by marking the CEA on the distal cut surface of the femur in every case. The proximal tibia was resected perpendicular to the tibial axis in the coronal plane with 3° posterior slop in the sagittal plane using extramedullary alignment instrumentation. Tibial resection was done 8 or 10 mm below the compromised articular cartilage at the lateral tibial plateau. The posterior cruciate ligament was retained in all knees. After bone resection, the ligament balance in the coronal plane was evaluated using a spacer block in extension and 90° flexion. If the tightness of the medial joint gap was confirmed, a medial soft-tissue release was performed until a balance was achieved. The joint gap was then measured using a Knee Balancer (DePuy, Warsaw, Ind) in extension and 90° flexion. Final assessment of the ligament balance was achieved using trial components through the full range of motion (ROM). No knees required replacement of the patella or lateral retinacular release. The PFC Sigma (DePuy) knee system was implanted in all knees. The femoral prosthesis had the same sagittal geometry for the medial and lateral condyles, and the thickness of the distal aspect of the femoral component was 9 mm, whereas for the posterior aspect, it was 8 mm. We used a fixed-type bearing as a tibial insert; the thickness and geometry of the medial and lateral condyles for it were also the same.

All patients were monitored for a minimum of 1 year. The passive maximum ROM of the knee was measured with a goniometer for all knees both before and 1 year after surgery. The coronal tibial component angle was measured on routine plain radiographs after surgery, and knees with the tibial component positioned greater than 3° varus or valgus were excluded from this study. The mean tibial component angle was 89.8° (range, 87.3°-92.1°), and there were no outliers in this consecutive series.

Both rotational alignment of the distal femur and flexion gap balance were evaluated using modified axial

Table 1. Patient Demographics

Characteristic	Value
Age (y)	74 ± 5
Sex (male/female)	15/48
Height (cm)	153 ± 7
Weight (kg)	60 ± 9
Body mass index (kg/m^2)	25.8 ± 3.0
Preoperative femorotibial angle (°)	187 ± 6