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Interactive effect of femoral posterior condylar offset and tibial posterior slope on knee flexion in posterior cruciate ligament-substituting total knee arthroplasty

Hyuk-Soo Han [a], Seung-Baik Kang [b,*]

[a] Department of Orthopedic Surgery, Seoul National University Hospital, Seoul, South Korea
[b] Department of Orthopedic Surgery, Seoul National University Boramae Medical Center, Seoul, South Korea

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ABSTRACT

Background: This work aimed to evaluate the changes in the femoral posterior condylar offset (PCO) and tibial slope after posterior cruciate ligament (PCL)-substituting total knee arthroplasty (TKA), and to address the presence of any interactive effect between the two on knee flexion.

Methods: Fifty-two PCL-substituting TKAs were performed using a posterior referencing system. Three-dimensional reconstructed computed tomographic (CT) images were used to evaluate PCO and tibial slope before and after arthroplasty. Range of motion and clinical scores were evaluated at a mean of 3.1 years postoperatively. Multivariate linear model with interaction terms was used to evaluate and compare the relationships among changes in PCO, tibial slope, and postoperative knee flexion angles.

Results: The degree of change in PCO was greater in the lateral condyle than in the medial condyle (3.1 ± 2.5 mm and -0.5 ± 2.8 mm, respectively). Postoperative medial and lateral tibial slopes were $1.4° \pm 1.8$ and $1.4° \pm 2.0$, respectively. The mean degree of postoperative knee flexion was 125°. Analysis with interaction terms and covariate adjustment demonstrated that medial PCO and tibial slope were significantly related to knee flexion with interactive effect ($P = 0.011$). In cases with <3° posterior tibial slope, the postoperative PCO was positively correlated to the degree of knee flexion angle. However, in cases with >3° tibial slope, PCO was negatively correlated to knee flexion.

Conclusion: Medial femoral PCO and tibial slope showed interactive effect on knee flexion after PCL-substituting TKAs. Reconstitution of the proper PCO and avoiding excessive tibial slope may be necessary.

1. Introduction

It is well known that normal kinematic behavior of the knee is not restored after total knee arthroplasty (TKA) [1,2]. It is particularly difficult to increase the functional flexion angle without creating instability. Several key determinants of the final range of movement (ROM) have been proposed, these include: surgically modifiable parameters such as posterior condylar offset (PCO) [3,4], tibial slope [4–6], or level of the joint line [7]. Unmodifiable factors include pre-operative flexion, gender, or body mass index (BMI) [8].

* Corresponding author at: Department of Orthopedic Surgery, Seoul National University Boramae Medical Center, 20 Boramae 5th road, Dongjak-Gu, Seoul 07061, South Korea.
E-mail address: ssbkang@snu.ac.kr (S.-B. Kang).

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In normal knees, PCO is related to the tibial slope [9]. Spatial correspondence between the PCO and tibial slope is needed to avoid excessive joint tension or joint laxity. Proper restoration of PCO and appropriate sagittal inclination of the tibial component may secure the flexion space of the joint and prevent the knee from becoming too tight or loose in flexion. This correlation can be different in the medial and lateral femoro-tibial compartments, due to the different anatomical and mechanical features. Most studies have evaluated the individual effects of PCO or tibial slope on knee flexion in TKAs; however, few studies have analyzed whether any relationship exists between the two after TKA.

In the cruciate-retaining TKA, restoration of the PCO and tibial slope has been shown to delay tibiofemoral impingement and increase postoperative knee flexion angle [3]. However, the effects of PCO and tibial slope on the knee flexion angle after posterior cruciate ligament (PCL)-substituting TKA are still debated [10,11], and it is difficult to identify independent factors that affect the postoperative flexion angle because many variables are involved, and there is interaction among them. Although several investigations have evaluated the influence of PCO and tibial slope on knee flexion after TKA [4,12–15], none have analyzed whether any relationship exists between the two in PCL-substituting TKA.

The present study aimed to assess, on reconstructed computed tomography (CT) images, the posterior offsets of the medial and lateral femoral condyles and sagittal slopes of the medial and lateral tibial plateaus, and analyze whether the effect of PCO on knee flexion was related to the degree of sagittal tibial slope after PCL-substituting TKA. It was hypothesized that PCO and tibial slope may have an interactive effect on knee flexion after PCL-substituting TKA.

2. Materials and methods

From July 2010 to February 2011 52 consecutive TKAs were performed on 36 female patients and one male patient who were prospectively enrolled into the current study. Inclusion criteria were a diagnosis of osteoarthritis, neutral or varus deformity, and severe cartilage loss with pain requiring TKA. Patients were excluded if they had a history of fracture or osteotomy, rheumatoid, posttraumatic, or pyogenic arthritis of the knee joints, or if they refused to participate in this study. Four patients were excluded due to previous osteotomy history and rheumatoid arthritis. Mean subject age at the time of surgery was 67.4 years (range 57–75) and mean BMI was 27.3 kg/m^2 (range 22.1–36.5).

All knees were operated on by using total intramedullary alignment cutting guides for both tibial and femoral cuts, and Triathlon prostheses (Stryker, Mahwah, NJ, USA) substituting the PCL with fixed tibial bearing prostheses. This femoral prosthesis design provides the same thickness for both the medial and lateral posterior condyles. All TKAs were performed by a single senior surgeon. An anterior midline approach and parapatellar arthrotomy were used in all cases, and all alignment instruments were set to achieve an ideal varus/valgus angle of 0° in the coronal plane and a tibial slope of 0° in the sagittal plane. Tibial cutting was performed first. Femoral component rotation was set three degrees external to the posterior condylar axis, which resulted in removal of an asymmetric portion of bone from the posterior femoral condyles. Femoral sizing and positioning were performed by using the posterior referencing technique to minimize the change in PCO; the center of rotation was on the medial posterior femoral condyle. Continuous passive motion was started on the first postoperative day.

Clinical evaluation included ROM, Knee Society Knee and Function score, and Hospital for Special Surgery (HSS) score. The mean duration of follow-up was 3.1 years (range 2.0–6.2). Pre-operative and postoperative knee extension and flexion of each knee were assessed. Measurements of knee extension and flexion angles were performed with the use of a goniometer. Postoperative follow-up was performed at six weeks, three months, six months, one year, and annually thereafter. It included radiographic evaluation: anteroposterior with the patient standing, lateral, Merchant patellar, and whole lower extremity standing radiographs. All

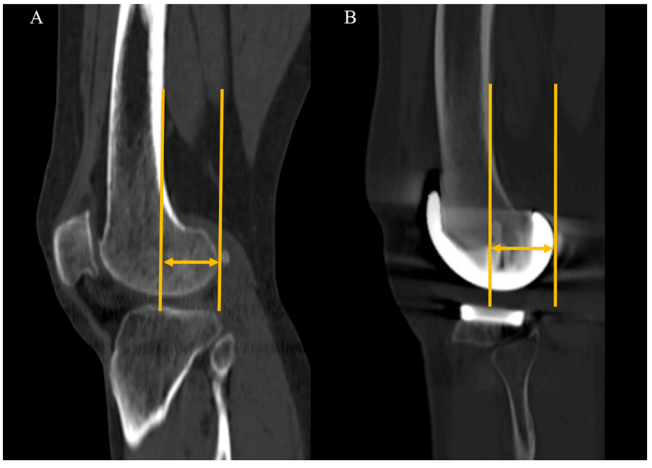

Figure 1. Pre-operative (A) and postoperative (B) posterior femoral condylar offsets are evaluated by measuring the maximal thickness of the posterior condyles projected posteriorly to the tangent of the femoral popliteal surface on a three-dimensional reconstructed sagittal plane computed tomography image of the distal femur.

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