Original Article

Rotational Mismatch of Self-Align Technique in Posterior-Stabilized Total Knee Arthroplasty

Thanainit Chotanaphuti MD[1], Montri Choowong MD[1], Artit Laoruengthana MD[2], Piti Rattanaprichavej MD[2]

[1] Department of Orthopedics, Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand
[2] Orthopedic Department, Faculty of Medicine, Naresuan University, Phitsanulok, Thailand

Background: Rotational malalignment of a femoral component may lead to chronic pain, patellar maltracking, knee instability, and early failure of a total knee arthroplasty [TKA]. The transepicondylar axis of the femur is widely accepted as a good reference for rotational alignment of a tibial component, although it is more controversial for a tibial component.

Objective: This study aimed to determine the degree of rotational mismatch between femoral and tibial components implanted using the center-post self-align technique.

Materials and Methods: Patients who underwent TKA for osteoarthritis of the knee were enrolled to have postoperative CT scans for determination of the rotational alignment. The study included 51 patients (60 knees), 5 males and 46 females, with a mean age of 64.0 years (range 58 to 73). The posterior cruciate ligament substituting tibial component position was set using the center-post self-align technique. CT digital images in the supine position with the knee at full extension were evaluated.

Results: Of the 60 TKAs, the mean rotational mismatch between tibial and femoral prostheses was 2.00° (SD±0.34°, range 0.1° to 5.8°). The femoral component was rotated externally and internally within 1.5° while the tibial component was within 2.59° relative to the transepicondylar axis. All knees had good patellar tracking intraoperatively without any lateral release procedure.

Conclusion: The center-post self-align technique can achieve good compatibility of rotational alignment between the femoral and tibial components with low variability, particularly with the knee in the extended position.

Keywords: Total knee arthroplasty; Rotational alignment of tibial component; Rotational mismatch; Self-align technique; Range of movement technique

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A rotational malalignment of prostheses in a total knee arthroplasty [TKA] may lead to chronic pain, patellar maltracking, knee instability, and early failure of the TKA[1-3]. Plastic deformation and gross damage of the polyethylene post occurring from anterior or posterior impingement against the femoral component has been well documented[4,5]. Several studies have reported higher revision rates and less favorable clinical results in patients with a greater rotational mismatch between the femoral and tibial components[6-8].

The transepicondylar axis of the femur is widely accepted as the functional flexion-extension axis of the knee[9-11]. For that reason, the transepicondylar line is used as a reference for the rotational alignment of the femoral component. However, there is a lack of consensus on a standard reference for the rotational alignment of the tibial component. Currently, two techniques are widely used[12]. The first is an anatomical landmark technique that uses the tibial tuberosity, the posterior condylar line of the tibia, and the malleolar axis of the ankle as reference. The second is a center-post self-align or range-of-movement [ROM] technique, in which the knee is put through a full range of flexion

Correspondence to:
Rattanaprichavej P, 99 Moo 9 Thapho, Phitsanulok 65000, Thailand.
Phone: +66-86-9966995, **Fax:** +66-55-965105
E-mail: pt-rp@hotmail.com

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and extension, allowing the trial tibial knee component to orientate itself in the best position relative to the femoral component[13]. This study aimed to determine the degree of rotational mismatch between the femoral and tibial components implanted using the center-post self-align technique which is based on the premise that rotational mismatch between the femoral and tibial components should approach zero degrees if both components are ideally implanted.

Materials and Methods

The study protocol was approved by the local independent ethics committee. All participating patients signed an informed consent agreement before being included in the study.

Consecutive patients who had primary or secondary osteoarthritis of the knee, were more than 55 years old, had had no previous unicompartmental or total knee arthroplasty done, had a deformity between 15° of varus and 5° of valgus without severe instability, and who had no history of knee infection were enrolled in the study. A total of 51 patients (60 knees), 5 males and 46 females, and mean age 64.0±1.7 years (range 58 to 73) who met the inclusion criteria were enrolled.

All TKAs were performed by the same senior surgeon (TC) using a medial parapatellar approach. The tibia was cut first using an extramedullary guide, followed by the distal femoral bone which was cut using an intramedullary guide. Femoral component rotation was set using the transepicondylar axis (the line traversing the sulcus of the medial epicondyle and the bony prominence of the lateral epicondyle) as a reference. Following a femoral component trial, the center-post self-align technique was used to set the tibial component rotation. The knee was passively flexed and extended five times to permit the unsecured tibial trial component to set its own rotation. This orientation was marked on the anterior tibial cortex (Figure 1). The tibial rotational axis is the line intersecting the anterior cortical mark and the middle of the posterior cruciate ligament [PCL]. The final implantion of the tibial component was aligned with this axis. A posterior cruciate ligament substitution total knee prosthesis (Press Fit Condylar [PFC] Sigma, Depuy, Warsaw, Indiana, USA) was implanted in all patients with patellar resurfacing.

All patients received radiographic and computerized tomography scan (CT scan) assessment between 5 and 7 days after the surgery. Radiographic evaluation of the leg axis and alignment of the components was performed at that time. The patellar

Figure 1. The landmark for the tibial component was marked after the self-align technique.

tilt and displacement were measured on a Laurin view radiograph. Patellar tracking was defined as neutral if the tilt was within 10° and the displacement was less than 5 mm[14]. The CT digital images were evaluated in the supine position with the knee in full extension and were interpreted using ID. PACS Release 3.6 software (Image Devices, Idstein, Germany). The rotational alignment of the femoral and tibial components was defined as a line projected parallel to the posterior edge of each component. The rotational alignment of the femoral and tibial components was then superimposed on the CT images. The femoro-tibial rotational mismatch was defined as the difference (in degrees) between the femoral and the tibial rotational alignment. A positive value indicated that the tibial component was externally rotated relative to the femoral component. Rotational alignment of the patellar component was defined as a line along the surface of the bone cut above the polyethylene component. All reference lines were compared with the transepicondylar axis of the femur (Figure 2).

Results

Femoro-tibial rotational mismatch

The mean rotational mismatch between the femoral and tibial prostheses was 2.00° (SD ±0.34°, extreme range 0.1° to 5.8°) (Table 1). Almost all the femoro-tibial rotational mismatches in the present study were ≥5° with the exception of one knee which was 5.8°.

Axial alignment of components

When the rotational alignment of the

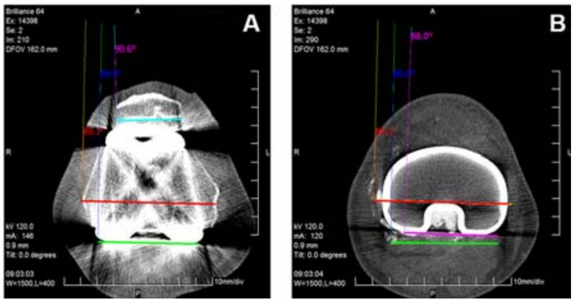

Figure 2. CT digital images were evaluated with the knee in full extension. The transepicondylar axis (red line), femoral component (green line) and patellar component (blue line) rotational alignment were drawn (A). The tibial component rotational alignment (purple line) was drawn and then superimposed on the transepicondylar axis and femoral component rotational alignment to determine the femoro-tibial rotational mismatch (B).

Table 1. Summary of radiographic results

Rotational alignment	Mean (°)	No. (%)
Femoro-tibial mismatch	2.00±0.34	-
Femoral component		
External rotation	1.15±0.44	29 (48.3)
Internal rotation	1.53±0.42	29 (48.3)
Neutral	-	2 (3.4)
Tibial component		
External rotation	2.03±0.72	25 (41.7)
Internal rotation	2.59±0.49	34 (56.7)
Neutral	-	1 (1.6)
Patellar component		
External rotation	5.85±1.32	38 (63.4)
Internal rotation	4.12±2.01	22 (36.6)
Neutral	-	0 (0)

components was compared to the transepicondylar axis with the knee in the full extension position, 48.3% of the femoral components were in an externally rotated position with a mean of 1.15° (SD ±0.44°, range 0.1° to 4.9°), 48.3% in an internally rotated position with a mean of 1.53° (SD ±0.42°, range 0.2° to 3.8°) and 3.4% were in a neutral position. Using the same reference line, 41.7% and 56.7% of the tibial components were in an externally or internally rotated position with means of 2.03° (SD ±0.72°, range 0.2° to 6.7°) and 2.59° (SD ±0.72°, range 0.3° to 6.7°), respectively. One tibial component was in the neutral position. Of the patellar components, 63.33% and 36.67% were in the externally or internally rotated position with means of 5.85° (SD ±1.32°, range 0.6° to 18.8°) and 4.12° (SD ±2.01°, range 0.2° to 17.2°), respectively.

Patellar tracking

Patellar tracking was evaluated intra-operatively. All 60 knees had good patellar tracking based on testing using the "No thumb test" technique[15] without any lateral release procedure. Radiographic evaluation of the patella was done in the Laurin position. Ninety percent of the patellas were within the normal range which was defined as ±10° of patellar tilting and less than 5 mm of displacement.

Discussion

Rotational mismatch of components can result in subluxation of the femoro-tibial joint, premature wear or breakage of the polyethylene insert, early failure of the TKA, as well as a disturbance of gait pattern, e.g., toe-in or toe-out gait. In addition, the rotational relationship of components can affect patellar stability and function. The tibial polyethylene post can accommodate up to 8° of internal or external rotational mismatch before impinging against the femoral box. A biomechanical study demonstrated an increase in tibial cortex strain when the rotational mismatch reaches approximately 10 degrees[16]. An increase in torque can also occur because of box-post impingement, which a peak torque of 17 to 18 N-m generated at 12° to 14° of rotational mismatch. A small change in the relationship between the femoral and tibial rotational alignment can generate more than twice that amount of torque. Thus, the correlation of the femoral and tibial rotational alignment is an important factor influencing clinical and functional outcomes[17,18].

The rotational axis of the tibial component remains controversial and is considered to be a main factor in femoro-tibial rotational mismatch[19]. The commonly used anatomical landmark, the medial one-third of the tibial tuberosity, has been reported to be result in excessive external rotation in some cases. Eckhoff et al[20] reported an average of 19° of external rotation of the tibial component compared to the femoral component using the tibial tuberosity as a reference. Sun et al[21] used CT scans to evaluate the anteroposterior [AP] axis of the femur and the tibia in osteoarthritic and healthy Chinese knees. They found a tendency toward external rotation of the tibial component if the medial one third of the tibial tuberosity is used as a reference, particularly in varus and valgus osteoarthritic knees. Uehara et al[22] using CT scans to demonstrate a rotational mismatch between the tibial axis and the femur according to the medial one third of the tibial tuberosity and the transepicondylar axis of the femur could occur in almost 50% of the subjects in their study. They also found a tendency for the tibial component to be aligned in an external rotation position, and suggested that medial torsion of the tibia could be a cause. A previous CT scan investigation[23] described the relationship between the position of the tibial tuberosity in the axial plane and the degree of medial torsion of the tibia. The tibial tuberosity was more externally rotated when the degree of medial tibial torsion was greater. That finding agrees with a study by Nagamine et al[24] who reported that a foot could severely rotate internally if the medial one third of the tibial tuberosity were used as a reference in patients with severe medial torsion of the tibia.

Another commonly used landmark has been proposed by Akagi et al[25]. They described the axis traversing the medial border of the patellar tendon to the posterior cruciate ligament as having the lowest variability. However, their measurements were made on a non-osteoarthritic knee. Some studies have reported lower reliability using that axis in osteoarthritic knees. L□tzner et al[26] found that only 3.8% and 15% of TKAs had a femoro-tibial mismatch of less than 5 and 10 degrees, respectively, when the medial border of the tibial tuberosity was used as a reference. In a previous study[27], the authors compared the rotational axis in TKA of the tibial component between two methods, the center-post self-align technique and the Akagi's line, using computer-assisted navigation. That comparison found the center-post self-align technique resulted in 3 degrees more external rotation of the tibial component than Akagi's line. Furthermore, the self-align technique displayed significantly less variability in the navigation study. Conversely, Ikeuchi et al[28] reported a wide variability and possibility for error when using the self-align technique. Another difference between the two studies was that Ikeuchi also found that the axis of the self-align technique was more frequently internally rotated compared to the anatomical axis (Akagi's line). One reason for this difference could be that Ikeuchi and colleagues used an asymmetrical tibial tray their study, while the present study used a symmetrical tibial tray (PFC Sigma). The symmetry of the tibial component combined with soft tissue tension can theoretically affect the rotational position of the tibial component with the ROM technique. Another potential factor is that in the Ikeuchi study, the digital images of the proximal tibial cut were made and the angle of the axis was measured using computer software, whereas the CT scans in the present study used consistent referential landmarks, particularly the PCL, the patellar tendon, and the posterior condyle axis of the tibial component.

The present study used the center-post self-align technique to achieve a reliable tibial rotational alignment which resulted in an average 2 degrees (SD = ±0.34°, range 0.1° to 5.8°) of femoro-tibial rotational mismatch with the knee in the extended position. This result is comparable to a tibial component alignment with an anatomical axis of 1.1 degrees (range -5° to 8°)[28]. Most of the rotational mismatch in the present study occurred within 5° with minimal variability. That technique can also achieve good patellar tracking: intraoperatively, 90% of the patellas were within 10° of tilt and less than 5 mm of displacement as shown in the radiographs. However, the present study was not able to evaluate the degree of femoro-tibial rotational mismatch throughout the range of knee motion and in various weight bearing positions. A second limitation was that 90.2% of the patients in the study (46 out of 51 patients) were female, so some anatomical differences may be gender specific.

Conclusion

The center-post self-align technique can produce good rotational alignment compatibility between the femoral and tibial components with less variability, particularly with the knee in the extened position.

What is already known on this topic?

Previous reports shown that anatomical landmark technique and center-post self-align technique were widely use to determine rotational axis between femoral and tibial component. However, a standard technique for rotational reference remains controversial.

What this study adds?

This study demonstrated that center-post self-align technique could reproduce a good compatability of rotational alignment between the femoral and tibial component with the mean of rotational mismatch was less as 2.00°.

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Potential conflicts of interest

The authors declare no conflict of intereset.

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