Comparative Study of Anatomical Landmark Technique and Self-aligned Tibial Component Rotation Determined by Computer-Assisted TKA

Thanainit Chotanaphuti MD*,
Watcharin Panichcharoen MD*, Artit Laoruengthana MD**

** Department of Orthopaedics, Phramongkutklao Hospital, Bangkok, Thailand*
*** Department of Orthopaedics, Faculty of Medicine, Naresuan University, Phitsanulok, Thailand*

Background: *An improper femoral and tibial component rotation is one of a major reason leading to a failed TKA. There is controversial on determination of rotational alignment particularly on a tibial component. An anatomical landmarks and a self-aligned technique have been proposed. It is the authors' purpose to determine the difference between two techniques in setting the rotation of tibial component.*

Material and Method: *The authors conducted a prospective, comparative study of 30 consecutive primary total knee arthroplasty. There were 4 men and 26 women with mean age of 68.6 years. All procedures were performed by a single surgeon with a navigation system. The degree of rotation of the tibial trial component established by a just-medial to the tibial tuberosity and self-aligned technique was compared.*

Results: *A mean of the degree of the tibial component rotation with the self-aligned of the center-post technique was 3° more externally rotated than the just-medial to the tibial tuberosity technique. The self-aligned technique had standard deviations of 4.41°, of which was significantly less variable ($p < 0.05$) than 5.94° of the just-medial to the tibial tuberosity technique.*

Conclusion: *The authors conclude that establishment of the tibial component rotation by using the self-aligned of the center-post technique will rotate the component more external compared with the just-medial to the tibial tuberosity technique.*

Keywords: *Tibial component, Rotational alignment, Self-aligned of the center-post technique, Total knee arthroplasty, Navigation system*

J Med Assoc Thai 2012; 95 (Suppl. 10): S37-S41
Full text. e-Journal: *http://jmat.mat.or.th*

Despite a current high success rate of total knee arthroplasty (TKA), patello femoral complications remain the most common cause of revision total knee arthroplasty[1-3]. Of which, an improper surgical technique particularly incorrect femoral and tibial component rotation is one of a major reason leading to patellar subluxation, dislocation and wear[4-6].

Although the importance of proper rotational alignment in total knee arthroplasty is recognized, determination of rotational malignment is controversial when compared with the determination of axial alignment[7]. Traditionally, rotational alignment of the femoral and tibial components has been determined separately based on the bony landmarks. The transepicondylar axis, Whiteside's line and posterior condylar axis of femur are widely use for aligning the femoral component rotation[8]. The anatomical landmarks commonly used for tibial component are the tibial tuberosity, the posterior condylar line of the tibia and the malleolar axis of the ankle[9,10].

By using the fixed anatomical references, it is possible that the rotational alignments of both components are not in complete accordance leading to the rotational mismatch[11]. Therefore, another method to avoid the discordance is a range-of-movement (ROM) or self-aligned technique, in which the knee is moved through a full range of flexion and extension. The tibial trial is allowed to orientate itself relatively to the femoral component[12].

It is the author's purpose to determine the difference between anatomical landmark and self-aligned technique in setting the rotation of tibial component.

Correspondence to:
Laoruengthana A, Department of Orthopaedics, Faculty of Medicine, Naresuan University, Phitsanulok 65000, Thailand.
Phone: 08-5110-2799
E-mail: artitlao@gmail.com

Material and Method

The authors conducted a prospective, comparative study of 30 consecutive primary posterior cruciate ligament substituting total knee arthroplasty (PFC Sigma, Depuy, Warsaw, Indiana) with an all-polyethylene patellar component. There were 4 men and 26 women with degenerative osteoarthritic knee enrolled in the present study. The mean age of the patients at the time of surgery was 68.6 ± 7.4 years (range, 61-76 years). The mean weight of the patients at the time of surgery was 66.5 ± 6.5 kilograms (range, 60-73 kgs).

Surgical technique

All procedures were performed by a senior surgeon (TC). A midline skin incision and medial parapatellar approach was performed.

The navigation system (Vector Vision image-free knee; BrainLAB, Munich, Germany) was used and controlled by a draped touch-screen monitor. Two reference arrays with passive marker spheres were rigidly attached to the femur and tibia through our standard approach. Registration of the hip center, malleoli, tibial plateau and distal femoral surface was performed. The system would generate a planning proposal for the orientation of the components. A bone resection started first on the tibial side. The orientation of the cutting blocks and the definition of the cutting planes were determined by the navigation system. The axis of the leg, the range of movement and the stability were checked again with the trial implants in place.

A line connecting a center of a posterior cruciate ligament (PCL) and a medial border of the tibial tuberosity described as a just-medial to the tibial tuberosity technique was drawn. Thus, prosthetic trial was assembled and the knee was passive flexed and extended five times allowing the unsecured tibial trial to seek its own rotation described as a self-aligned of the center-post technique. The difference of the degree of rotation of the tibial trial between 2 techniques was compared with the navigator system while the knee was kept in full extension position.

Statistical analysis

The degree of tibial component rotation between self-aligned and anatomical landmark technique was compared using a paired Student's t-test with the assumption of homogeneity of the variance.

Box-and-whisker plots were used to compare the degree of tibial component rotation between two techniques using median quartiles and interquartile ranges (IQR) while the Mann-Whitney U-test was used to compare the deviations. Two-tailed values of $p < 0.05$ were considered to be statistically significant. Analysis of the data was performed using the SPSS statistical package version 11.5 (SPSS Inc., Chicago, Illinois).

Results

Total of 30 primary posterior cruciate ligament substituting TKA, the authors found a mean of the degree of the tibial component rotation with the self-aligned of the center-post technique was 3° more externally rotated than the just-medial to the tibial tuberosity technique, but it was not statistically significant, Fig. 1. The self-aligned technique had standard deviations of 4.41°, of which was significantly less variable ($p < 0.05$) than 5.94° of the just-medial to the tibial tuberosity technique.

Discussion

The rotational relationship between the femoral and tibial components is an important factor affecting the overall function and durability of a TKA. The rotational mismatch between both components could result in subluxation of the patellar and tibiofemoral joint, premature wear or breakage of the polyethylene and excessive toe-in or toe-out gait[1-6].

Three different methods determining rotational axis of the femoral component including the posterior condylar axis, the midtrochlear line (so called "Whiteside's line") and the transepicondylar axis (TEA) are generally accepted[1]. The Whiteside's line and TEA are approximately perpendicular to each other in most

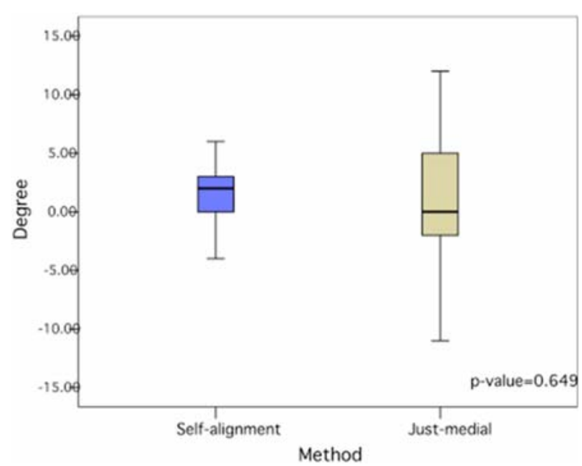

Fig. 1 The box plot graph reveals that the tibial component rotation of just-medial technique is about zero degree and which of self-aligned technique is about 3°

of the knee and it is reported as being more reliable than the posterior condyle axis particularly in valgus or severely varus knee[13].

In contrast to the femur, the rotational axis of the tibial component is more equivocal[2,14]. Insall advocated that the tibial component should be aligned to the line connecting between medial 1/3 of the tibial tuberosity and the center of posterior cruciate ligament[9]. Akagi et al[15] demonstrated that medial border of patella tendon attachment at the tibia instead of the medial 1/3 of tibial tuberosity is more reliable. The transcondylar line of tibia[2] and the posterior tibial condylar line[16] have also been suggested as a guide for the reference axis of tibial rotation. Although anatomical landmarks described above seem to be acceptable, the rotational mismatch may occur because it is determined separately. Siston et al[17] showed high variability in the tibial rotational alignment associated with all techniques. They found only 13.1% (72 of 550) of the axes identified in the present study were rotated less than 5° from the reference axis. The rotational alignment that was respected to the reference axis ranged from 44° of internal rotation (with the medial border of patellar tendon-PCL technique) to 46° of external rotation (with medial 1/3 of tibial tuberosity-PCL).

There are several reports demonstrated that aligning the tibial component with the medial 1/3 of the tibial tuberosity might result in excessive external rotation[11,12]. Eckhoff et al[12] reported an average of 19° of external rotation of the tibial component relative to the femoral component when the tibial tuberosity was used as a reference and might account for posteromedial wear of the polyethylene. Uehara et al[11] reported rotational mismatch in nearly 50% of the subjects who the axis of medial 1/3 of the tibial tuberosity and the transepicondylar axis of femur was used for aligning the tibial and femoral component rotation, respectively. The tibial component had a tendency of more external rotation demonstrated by a computed tomography.

Some of the anatomical variation may affect the accordance between the components. Nagamine et al[18] demonstrated that the foot could be severely rotated internally if the medial 1/3 of the tibial tuberosity was used in patients with severe medial torsion of the tibia that is not uncommon in East Asian population. Tong et al[19] demontrated that the anteroposterior axis of tibia intersected at 10% of the patellar tendon width from the medial side in healthy Chinese knees, where as the axis intersected at 20% and 30% of the patellar tendon width from the medial side in varus and valgus osteoarthirtic knees, respectively. The self-aligned technique for tibial component has been reported as a useful alternative method, although it may be technically difficult to mark the proper position on the anterior tibial cortex[12,20]. In the present study, such a technique will put the tibial component rotated 3° more external with significantly less variable compared to just-medial to the tibial tuberosity technique.

Conclusion

The authors conclude that establishment of the tibial component rotation by using the self-aligned of the center-post technique will put the tibial component more externally rotated than the just-medial to the tibial tuberosity technique. This technique may provide a reliable tibiofemoral rotational accordance with less variable in the posterior cruciate ligament substituted TKA.

Potential conflicts of interest

None.

References

1. Berger RA, Crossett LS, Jacobs JJ, Rubash HE. Malrotation causing patellofemoral complications after total knee arthroplasty. Clin Orthop Relat Res 1998; 144-53.
2. Eckhoff DG, Brown AW, Kilcoyne RF, Stamm ER. Knee version associated with anterior knee pain. Clin Orthop Relat Res 1997; (339): 152-5.
3. Rand JA. Extensor mechanism complications following total knee arthroplasty. J Knee Surg 2003; 16: 224-8.
4. Akagi M, Matsusue Y, Mata T, Asada Y, Horiguchi M, Iida H, et al. Effect of rotational alignment on patellar tracking in total knee arthroplasty. Clin Orthop Relat Res 1999; (366): 155-63.
5. Puloski SK, McCalden RW, MacDonald SJ, Rorabeck CH, Bourne RB. Tibial post wear in posterior stabilized total knee arthroplasty. An unrecognized source of polyethylene debris. J Bone Joint Surg Am 2001; 83-A: 390-7.
6. Colizza WA, Insall JN, Scuderi GR. The posterior stabilized total knee prosthesis. Assessment of polyethylene damage and osteolysis after a ten-year-minimum follow-up. J Bone Joint Surg Am 1995; 77: 1713-20.
7. Incavo SJ, Coughlin KM, Pappas C, Beynnon BD. Anatomic rotational relationships of the proximal tibia, distal femur, and patella: implications for

rotational alignment in total knee arthroplasty. J Arthroplasty 2003; 18: 643-8.
8. Berger RA, Rubash HE, Seel MJ, Thompson WH, Crossett LS. Determining the rotational alignment of the femoral component in total knee arthroplasty using the epicondylar axis. Clin Orthop Relat Res 1993; (286): 40-7.
9. Insall JN, Easley ME. Surgical technique and instrumentation in total knee arthroplasty. In: Insall JN, Scott WN, editors. Surgery of the knee. 3rd ed. Philadelphia: Churchill-Livingstone; 2001: 1553-620.
10. Chowdhury EA, Porter ML. How is the tibial tray aligned to the femoral prosthesis in a total knee arthroplasty? A survey of opinion from BASK? Knee 2005; 12: 79-80.
11. Uehara K, Kadoya Y, Kobayashi A, Ohashi H, Yamano Y. Bone anatomy and rotational alignment in total knee arthroplasty. Clin Orthop Relat Res 2002; 196-201.
12. Eckhoff DG, Metzger RG, Vandewalle MV. Malrotation associated with implant alignment technique in total knee arthroplasty. Clin Orthop Relat Res 1995; (321): 28-31.
13. Churchill DL, Incavo SJ, Johnson CC, Beynnon BD. The transepicondylar axis approximates the optimal flexion axis of the knee. Clin Orthop Relat Res 1998; (356): 111-8.
14. Akagi M, Mori S, Nishimura S, Nishimura A, Asano T, Hamanishi C. Variability of extraarticular tibial rotation references for total knee arthroplasty. Clin Orthop Relat Res 2005; (420): 172-6.
15. Akagi M, Oh M, Nonaka T, Tsujimoto H, Asano T, Hamanishi C. An anteroposterior axis of the tibia for total knee arthroplasty. Clin Orthop Relat Res 2004; (226): 213-9.
16. Moreland JR. Mechanisms of failure in total knee arthroplasty. Clin Orthop Relat Res 1988; 49-64.
17. Siston RA, Patel JJ, Goodman SB, Delp SL, Giori NJ. The variability of femoral rotational alignment in total knee arthroplasty. J Bone Joint Surg Am 2005; 87: 2276-80.
18. Nagamine R, Miyanishi K, Miura H, Urabe K, Matsuda S, Iwamoto Y. Medial torsion of the tibia in Japanese patients with osteoarthritis of the knee. Clin Orthop Relat Res 2003; (408): 218-24.
19. Sun T, Lu H, Hong N, Wu J, Feng C. Bony landmarks and rotational alignment in total knee arthroplasty for Chinese osteoarthritic knees with varus or valgus deformities. J Arthroplasty 2009; 24: 427-31.
20. Lee DH, Seo JG, Moon YW. Synchronisation of tibial rotational alignment with femoral component in total knee arthroplasty. Int Orthop 2008; 32: 223-7.

การศึกษาเปรียบเทียบระหว่างการวางแกน tibial component ในระนาบการหมุนโดยวิธีกำหนดจุดตามกายวิภาคและการหมุนหาจุดโดย tibial component เองเมื่อประเมินจากระบบคอมพิวเตอร์ช่วยในการผ่าตัดเปลี่ยนข้อเข่าเทียม

ธไนนิธย์ โชตนภูติ, วัชรินทร์ พานิชเจริญ, อาทิตย์ เหล่าเรืองธนา

วัตถุประสงค์: *การผ่าตัดเปลี่ยนข้อเข่าเทียมมีความจำเป็นที่จะต้องวางชิ้นส่วนข้อเทียม (prosthetic component) ส่วนต่างๆ ให้ได้ตำแหน่งที่เหมาะสมเพื่อลดภาวะแทรกซ้อน การวางตำแหน่งชิ้นส่วนข้อเทียมในแนวแกนหมุน (rotational alignment) ยังไม่มีข้อสรุปที่แน่ชัดว่าการวางด้วยวิธีใดจึงจะเหมาะสมที่สุดโดยเฉพาะชิ้นส่วนทางด้าน tibia (tibial component)*

วัสดุและวิธีการ: *การศึกษานี้เปรียบเทียบการวางตำแหน่งของ tibial component ในแนวแกนหมุนระหว่างวิธีกำหนดจุดตามกายวิภาค just-medial to tibial tuberosity และการหมุนหาจุดที่เหมาะสมโดย tibial component trial เอง (self-aligned of the center-post technique) การศึกษานี้ประกอบด้วยผู้ป่วยหญิงจำนวน 26 ราย และผู้ป่วยชาย 4 ราย อายุเฉลี่ย 68.6 ปี ซึ่งได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมโดยอาศัยคอมพิวเตอร์ช่วยการผ่าตัด และเปรียบเทียบมุมของ tibial component trial ในแนวแกนหมุนที่เกิดขึ้นจากวิธีการวางทั้ง 2 แบบ*

ผลการศึกษา: *พบว่าการวาง tibial component trial ด้วยวิธี self-aligned จะทำให้ tibial component trial อยู่ในตำแหน่งที่หมุนออกนอก (external rotation) มากกว่าวิธีกำหนดจุดตามกายวิภาค just-medial to tibial tuberosity ประมาณ 3 องศา (p-value = 0.649) และมีค่าเบี่ยงเบนมาตรฐานน้อยกว่าอย่างมีนัยสำคัญ (4.41 องศา กับ 5.94 องศา, p-value < 0.05)*

สรุป: *การวาง tibial component ด้วยวิธี self-aligned จะทำให้ได้ตำแหน่งในแนวแกนหมุนที่หมุนออกนอก (external rotation) มากกว่าวิธีกำหนดจุดตาม just-medial to tibial tuberosity และมีความเบี่ยงเบนน้อยกว่า*