Rotational Alignment of Femoral Component between Custom Cutting Block and Conventional Technique in Total Knee Arthroplasty

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Objective: *Rotation of femoral components could be optimized to improve function and durability of the knee joint. The purpose of the present study was to assess rotational alignment of femoral component comparing between CT-based, custom cutting blocks and the contemporary total knee arthroplasty, instrument technique.*

Material and Method: *The prospective control study of 80 patients underwent total knee arthroplasty by using PFC Sigma PS total knee design. Rotation of femoral component was analyzed in all patients using postoperative CT scan. Forty patients were performed on by using CT-based, patient-specific cutting blocks with femoral rotational axis relative to transepicondylar axis while forty patients were performed on by using contemporary instrumentation with alignment at 3 degrees external rotation from posterior condylar line. The rotation of the femoral component with external rotation of more than 3 degrees or internal rotation was considered outlier.*

Results: *There was no statistically significant difference among ages, gender, BMI, pre-operative mechanical axis between the two groups. There were eleven outliers in conventional group (range, 5 degrees of external rotation to 3 degrees of internal rotation), three femoral components were in excessive external rotation with the angle of more than 3 degrees and eight femoral components were in internal rotation. In contrast with custom cutting block group was no outliers of femoral rotation. The average rotational alignment was 1.04°±0.62° external rotation from epicondylar axis in custom cutting group and 1.58°±1.75° in contemporary group.*

Conclusion: *Custom cutting, block technique significantly reduced the outlier of the femoral component rotation and aided in positioning of the femoral component in optimal alignment. The improvement of femoral rotation showed no difference in clinical outcome between the two groups.*

Keywords: *Patient-specific instrument, Rotational alignment, Femoral component, Total knee arthroplasty*

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Failures in total knee arthroplasty are related to prosthetic malposition and malalignment. The rotation of the femoral component is difficult to obtain due to the variableness of the knee anatomy and reliable landmarks. In addition, anatomical reference axes in the distal femur may deviate individually. Accurate rotational alignment of the femoral component becomes necessity and it is important as alignment in other planes because an error in an internal rotation of the femoral component will affect the patellofemoral joint and flexion gap[1]. As a result of poor outcomes, many axes have been applied to guide the rotation of the femoral component. Transepicondylar axis is commonly used and the most preferable one; however, this axis has inter-observer and intra-observer variability[2]. Result of poor indicator of this axis, CT scan can provide acceptable and reliable measurement[3].

Conventional instrumentation is universal equipment to apply to the patients with different bone shapes and anatomical variations. Optimal component alignment could be found only 70-80% in conventional surgery[4]. Navigation or computer assisted orthopedic surgery can improve the accuracy and consistency of component positioning and alignment[5,6]. However, the navigation data are insufficient to support rotational alignment.

CT based patient specific cutting blocks were introduced and produced by pre-operative CT scan measurement to fit to the individual knee shape to improve accuracy of reference axes in the femur and tibia[7]. The rotation of femoral component could be

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pre-operatively set to fit with transepicondylar axis or parallel to the tibial cut. Surgical planning settled pre-operatively also reduced the number of surgical steps and duration of surgery.

Additional data are still needed to validate the efficiency of the patient specific cutting block technology. The current study aims to compare the femoral component rotation of CT-based patient specific instrumentation with the conventional method.

Material and Method

The present study was approved by institutional review boards at the Phramongkutklao Hospital. Consent to participate in this research was obtained for all patients. Patients, who underwent total knee replacement surgeries between August 2011 and August 2012 at Phramongkutklao Hospital, were enrolled in the prospective study. All patients were randomized and divided into two groups, namely Group 1, to be applied with custom cutting blocks (TruMatch™ Personalized Solutions; DePuy, Warsaw, Ind) and Group 2, to be applied with conventional instrumentation (HP instrument; DePuy, Warsaw, Ind). The patients were implanted with Posterior Stabilized Prosthesis (PFC Sigma, DePuy, Warsaw, Ind).

All patients, in group 1, had pre-operative CT images and planning for bone resection by using the software with setting up the femoral rotation to be paralleled to the epicondylar axis. The tibial cut was perpendicular to the mechanical axis and had 3° of posterior slope while all patients in Group 2 were used extramedullary method and setting perpendicular to the mechanical axis for the tibial cut and intramedullary femoral guide with 6° valgus resection of distal femur and 3° of external rotation which were set relatively to posterior condyle of femur for femoral cut.

Both groups had similar operative setting and postoperative care. CT scan of the knee was operated 6 weeks after the surgical operation to check for the alignment and the rotation of prosthesis. The angle between the line connecting from lateral epicondylar prominence to medial epicondylar sulcus and the line connecting both posterior condyle by Berger technique was measured and recorded[1] (Fig. 1). The outlier defined as the rotational alignment of femoral implant had more than 3° of external rotation or relative internal rotation to the transepicondylar axis.

Data analysis was performed by using SPSS software for Windows, version 15.0. Pearson Chi-square test, Student's t-test, and Fisher exact test were used to compare the baseline characteristics between the two groups. Results were considered to be significant at $p<0.05$.

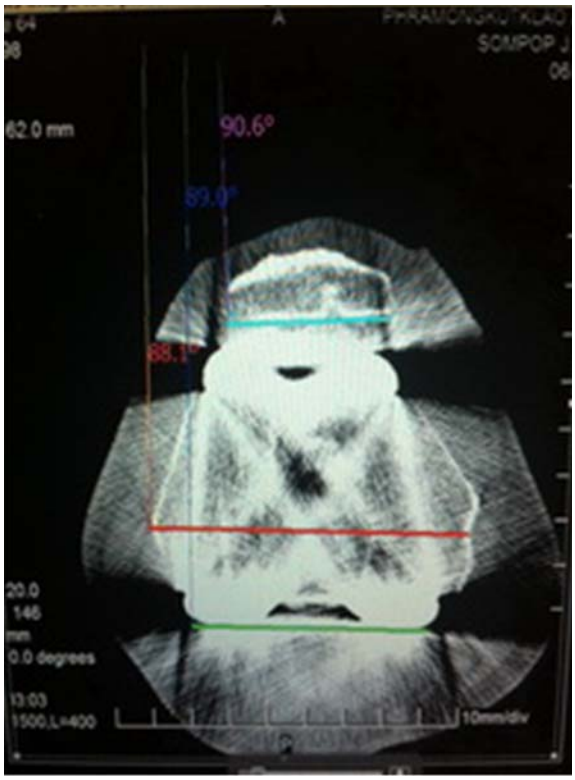

Fig. 1 Postoperative CT analysis of rotational alignment of the femoral component; (upper line: patello-femoral joint, middle line: transepicondylar axis, lower line: posterior condylar axis).

Results

There were no statistically significant differences in ages, body mass index, and pre-operative mechanical alignment between the two groups (all *p*-value >0.05). Pre-operative rotation of the femur relative to the posterior condylar axis varied in a range from 0 to 7 degrees.

The average rotational alignment of femoral implant was 1.04°±0.62° external rotation from epicondylar axis in the cutting block group and 1.58°±1.75° in the conventional group. As a result, the cutting block group demonstrated less mean value than with smaller standard deviation.

There was statistically significant differences in outline between the two groups ($p<0.05$). There were 11 knees out of 40 that were considered an outlier in the conventional group. Eight knees were regarded as internal rotation and the remaining three knees were

diagnosed as having external rotation with the angle of more than 3° (range -2.8° to 4.9°). There were no outliers in the 40 patients in the CT-based, cutting block group (range 0-2.5°).

Discussion

Femoral rotational alignment is one of principal indicators in total knee replacement surgery[8]. Internal rotation and excessive external rotation can cause patellofemoral complications and flexion instability[1,9]. In addition, the anatomy of the distal femur is unique and different in each patient. According to our records, we found that pre-operative femoral rotation had a wide range from 0 to 7 degrees of external rotation relative to posterior condyle. Performing regular femoral cut in every patient without considering the individual anatomy leads to unacceptable rotation of femoral component. Moreover, there was inconsistency in femoral cut because human and technical error can occur in the conventional technique. The authors concluded that outlier significantly occurred more often in conventional than the cutting block group.

Flexion gap balance was affected not only by rotation of femoral component, but also by the sizing of femoral component. However, there were a some literature which revealed data about femoral rotation in CT-based, cutting block instruments. Pruk et al showed a wide range of femoral component rotation in well-balanced total knee arthroplasty[12]. In well-balanced flexion gap, Itokawa et al reported femoral component should be set to 3 degrees of external rotation[10], but it can vary by nation; Tang et al demonstrated that Chinese patients required 5 degrees of external rotation of the femoral component to obtain a rectangular flexion gap[11].

In a previous study by Heyse et al, they studied femoral rotation accuracy using patient-specific instrumentation (PSI) and reported improvement of femoral rotation with only one outlier (2.2%) when compared to the conventional instrumentation with eleven outliers (22.9%)[13]. The authors' results were similar; there was no outlier in the specific cutting blocks group when compared to eleven outliers in the conventional group (27.5%). However, the authors used CT scan for pre-operative planning which was different from pre-operative MRI imaging from the prior study. No data, at present time, showed proof and the advantages between pre-operative CT and MRI imaging, but in the PSI template for total knee replacement, the bone models generated by CT scan were dimensionally more accurate than those generated by MRI scan[14,15].

Even though patient-specific instrumentation technique can improve femoral rotation, we found no significant differences in the clinical results between the two groups. In addition, functional outcome scores and postoperative knee scores were similar between the two groups. No patient reported patellofemoral problems in the conventional group.

Conclusion

Specific cutting block was accurate in terms of femoral rotation. Human errors can cause improper cutting techniques and blades while using conventional techniques. However, improvement of femoral rotation may not show a clinically significant difference between the two groups.

Potential conflicts of interest

None.

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การประเมินตำแหน่งการหมุนของ femoral component ที่ได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมโดยใช้อุปกรณ์เฉพาะบุคคลช่วยผ่าตัดเปรียบเทียบกับวิธีธรรมดา

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วัตถุประสงค์: ตำแหน่งการหมุนของข้อเข่าเทียมส่วน femur ที่ดีมีผลต่อการใช้งานข้อเข่าและระยะเวลาการใช้ข้อเข่าเทียม การศึกษานี้จึงทำเพื่อเปรียบเทียบตำแหน่งการหมุนของข้อเข่าเทียมส่วน femur ในกลุ่มที่ใช้อุปกรณ์เฉพาะบุคคลช่วยผ่าตัดและในกลุ่มที่ใช้วิธีแบบดั้งเดิม

วัสดุและวิธีการ: ทำการศึกษาในผู้ป่วย 80 ราย ที่ได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมและได้ทำการวัดมุม ของการหมุนของข้อเข่าเทียมส่วน femur โดยผู้ป่วย 40 ราย อยู่ในกลุ่มที่ใช้อุปกรณ์เฉพาะบุคคลช่วยผ่าตัดได้รับการออกแบบด้วยภาพถ่ายรังสีคอมพิวเตอร์ (CT SCAN) โดยตั้งแกนการหมุนของ femur ไปตามแกนของ epicondyle และผู้ป่วยอีก 40 คนที่ผ่าตัดเปลี่ยนข้อเข่าเทียมวิธีดั้งเดิมโดยตั้งแกนหมุน external rotation 3 องศา จากเส้นที่ลากจาก posterior condyle สองข้างผู้ป่วยทั้งหมดได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมชนิดตัดเอ็นไขว้หลังรุ่น PFC Sigma หลังการผ่าตัดได้ทำภาพถ่ายรังสีคอมพิวเตอร์เพื่อวัดมุมของการหมุนของข้อเข่าเทียมส่วน femur

ผลการศึกษา: ไม่มีความแตกต่างใน อายุ, เพศ, ดัชนีมวลกาย, mechanical axis ก่อนการผ่าตัดถ้าตำแหน่งการหมุนของข้อเข่าเทียมส่วน femur มี external rotation มากกว่า 3 องศาหรือมีตำแหน่งการหมุน internal rotation ถือว่าอยู่เป็น outlier พบว่ามี 11 เข่าที่อยู่นอกขอบเขตในกลุ่มที่ผ่าวิธีธรรมดาแบ่งเป็น 3 เข่าที่มีการหมุน external rotation มากเกินกว่า 3 องศา และ อีก 8 เข่าที่หมุน internal rotation ไม่พบการหมุนที่ออกนอกขอบเขตในกลุ่มที่ใช้อุปกรณ์เฉพาะบุคคลค่าเฉลี่ยของมุมการหมุนในกลุ่มที่ใช้อุปกรณ์เฉพาะบุคคลคือ $1.04^{\circ}\pm0.62^{\circ}$ external rotation จากแกนของ epicondyle และ $1.58^{\circ}\pm1.75^{\circ}$ ในกลุ่มที่ผ่าตัดวิธีธรรมดา

สรุป: อุปกรณ์เฉพาะบุคคลในการผ่าตัดข้อเข่าเทียมสามารถช่วยการตั้งแนวแกนหมุนของ femoral component ไม่ให้ออกนอกขอบเขตได้อย่างมีนัยยะสำคัญและช่วยให้การวางตำแหน่งได้อย่างถูกต้อง อย่างไรก็ตามไม่พบว่ามีความแตกต่างในการใช้งานและปัญหาแทรกซ้อนระหว่างทั้งสองกลุ่ม