Effect of Surgeon Handedness on Coronal Alignment in Total Knee Arthroplasty

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Purpose: *To study the effect of surgeon handedness by comparing coronal alignment in total knee arthroplasty (TKA) between left and right sides.*
Methods: *This study retrospectively reviewed the medical records and knee radiographs of patients who underwent total knee arthroplasty using conventional techniques from 2010 to 2012. There were 49 right knees and 47 left knees in 78 patients. The knee radiographs taken before and after surgery were used to measure the tibiofemoral angle and the coronal alignment of the femoral and tibial components. A value within the optimum ±3º was defined as "acceptable" and a value over the optimum ±3º was defined as an "outlier".*
Results: *The postoperative tibiofemoral angle showed outliers in 7 right TKAs and 11 left TKAs. The coronal alignment of the femoral component showed outliers in 9 right TKAs and 7 left TKAs. The coronal alignment of the tibial component showed outliers in 2 right TKAs and 10 left TKAs. There was a significant difference in the outliers of coronal alignment of the tibial component between right and left TKAs.*
Conclusion: *Surgeon handedness affects the coronal alignment of the tibial component. There were more outliers of the coronal alignment of the tibial component in left knees when performed by right-handed surgeons.*

Keywords: *Surgeon handedness, coronal knee alignment, total knee arthroplasty*

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Introduction

Currently, total knee arthroplasty (TKA) is a common procedure which is increasingly performed in Thailand. The survival and functional outcomes of TKAs are related to the alignment[1,2]. Malalignment may cause pain, a limited range of motion, joint instability, wear of the polyethylene liner and prosthesis loosening[1,3-5]. Numerous general surgical literatures had documented the effect of handedness on operative psychomotor performance[6-8]. In orthopaedic surgery, handedness and laterality play a larger role but few orthopaedic literatures mention handedness and laterality as a major factor affecting outcomes. In 2007, Mehta and Lotke[9] reported that right TKAs had a better functional outcome at the 1 year follow up than left TKAs performed by a right-handed surgeon.

However, there has been no report showing the effect of surgeon handedness on the coronal alignment of TKAs. Therefore, the purpose of this study was to evaluate the effect of surgeon handedness by comparing coronal alignment between right TKAs and left TKAs. We hypothesized that right TKAs had a more optimal coronal alignment than left TKAs when performed by right-handed surgeons.

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Patients and methods

The medical records and the knee radiographs of every patient treated with total knee arthroplasty from January 2010 to December 2012 in Samutsakhon Hospital were reviewed. All operations were performed by the same right-handed surgeon team. Conventional intramedullary femoral and extramedullary tibial guiding systems were used in all cases. Exclusion criteria were revision total knee arthroplasty, unicondylar arthroplasty, extra-articular deformity and loss of the medical records or the radiographs. The parameters used included gender, age, body mass index, operative time, complication, pre- and postoperative tibiofemoral angle and the coronal alignment of the femoral and tibial components. All patient data were categorized based on the side of procedure. This study was approved by the ethical committee of Samutsakhon Hospital.

Surgical technique

The surgeon performed the procedure standing on the side of the knee to be operated on. The patient was in a supine position. The operation was carried out through a midline incision via a medial parapatella approach. The patients who underwent total knee arthroplasty used cemented mobile-bearings, PS design (e.motion® PS, B Braun, Aesculap, Tuttlingen, Germany) under gap technique and cemented fixed bearings, PS design (Nexgen LPS, Zimmer, Warsaw, United States) under measure resection technique. Conventional

intramedullary femoral and extramedullary tibial guiding systems were used in all cases. The posterior cruciate ligament was sacrificed in all cases. The femoral component was aligned to 6° of valgus using an intramedullary guide inserted just medial to the trochlea groove, approximately 1 cm anterior to the femoral insertion of the posterior cruciate ligament. A proximal tibial cut was set perpendicular to the mechanical axis of the tibia. All patellae were not resurfaced. All implants were fixed with a cemented technique. Operations were performed by 3 general orthopaedic surgeons. They had, on average, 5 years' experience in TKA.

Radiological measurements

The pre- and postoperative standardized weight-bearing anteroposterior knee radiographs were reviewed and the angles were manually measured by a goniometer. The weight-bearing anteroposterior knee radiograph used an 11×14 inch film with the knee in full extention. The tube-to-film distance was 100 cm with usual exposure setting of 50 kV and 3.2 mA. All radiographs were obtained with the same technique and standard position. Before measurements were taken, all radiographs were blinded for patient identity and side, and then were evaluated by three individuals who did not know about the details of this study. The mean of each parameter were recorded and used for evaluation in the study.

The tibiofemoral angle was formed by the intersection of the line of the proximal shaft of the tibia and a line through the femoral midcondylar point and the center of the distal femoral shaft.

The coronal alignment of the femoral component was measured as the angle between the femoral shaft and transcondylar line of the femoral component.

The coronal alignment of the tibial component was measured as the angle between the mechanical axis of the tibia and the tibial base plate (Fig. 1).

Fig. 1 Measurement of component alignment in the coronal plane; α, the coronal alignment of the femoral component; β, the coronal alignment of the tibial component

A value of parameters within the optimum ±3º was defined as "acceptable" and a value over the optimum ±3º was defined as an "outlier".

Statistical analysis

Analysis of the data was performed using the statistical package for social sciences (SPSS) software, version 11.5 (SPSS Inc., Chicago, Illinois). The continuous variables between the two groups were compared using an independent sample *t*-test. The categorical variables between the two groups were compared using Pearson Chi-square and Fisher's exact test. Statistical significance was considered when the *P*-value was < 0.05. The inter-observer reliability was analyzed using level of agreement and a 95% limit of agreement (Bland and Altman, 1986).

The sample size calculation was based on an alpha error of 0.05, a beta error of 0.2, the probability to have outlier in right TKAs was 5% and the expected outlier in left TKAs was 25%. The overall sample size was 38 patients per group ($N = [2(Z_\alpha+Z_\beta)^2 P(1-P)]/(P_1-P_2)^2$).

Results

There were 31 right TKAs and 29 left TKAs and 18 bilateral TKAs of 78 patients with a mean age of 63.1 years (ranging from 50-77 years). The age, number of cases, body mass index, operative time, preoperative tibiofemoral angle and the prosthesis design of the two groups were not statistically significant. Cemented mobile-bearings, PS design (e.motion® PS, B Braun, Aesculap, Tuttlingen, Germany) were used in 23 right TKAs and 22 left TKAs. Cemented fixed bearings, PS design (Nexgen LPS, Zimmer, Warsaw, United states) were used in 26 right TKAs and 25 left TKAs (Table 1).

The postoperative tibiofemoral angle, coronal alignment of femoral component and coronal alignment of tibial component were not statistically different (Table 2).

As shown in table 3, the postoperative tibiofemoral angle (optimum=186°) showed 7 outliers (14.3%) in right TKAs and 11 outliers (23.4%) in the left TKAs group (*P*=0.25). The coronal alignment of the femoral component (optimum=96°) showed 9 outliers (18.4%) in right TKAs and 7 outliers (14.9%) in left TKAs (*P*=0.65). The coronal alignment of the tibial component (optimum=90°) showed 2 outliers (4.1%) in right TKAs and 10 outliers (21.3%) in left TKAs (*P*=0.01). The complication rate was not significantly different between groups (*P*=0.11). There were 2 cases (4.3%) of patella tendon tear and 1 case (2.1%) of periprosthetic fracture of the tibia in the left TKAs.

Table 1 Demographic data of TKA patients

	Right	**Left**	***P*-value** [c]
Age (years)	63.2 ± 7. 1	63.0 ± 6.9	0.85
No. of cases (male/female)	9/40	3/44	0.12 [b]
Body mass index	26.8 ± 4.3	25.5 ± 5.0	0.16
Operative time (minutes)	108.9 ± 20.9	108.1 ± 25.0	0.87
Preoperative tibiofemoral angle	173.2 ± 6.7	173.7 ± 7.2	0.74
Prosthesis design (e.motion®PS/Nexgen LPS)	23/26	22/25	0.99 [a]

[a] χ^2 test (Pearson Chi-square) comparing between the categorical variables of the two groups

[b] χ^2 test (Fisher's exact test) comparing between the categorical variables of the two groups when data in cell have an expected count of less than 5

[c] Independent sample *t*- test comparing the two groups

Table 2 Coronal alignment angulation between right TKAs and left TKAs

	Right	**Left**	***P*-value** [c]
Postoperative tibiofemoral angle	185.5 ± 2.3	185.2 ± 3.1	0.59
Coronal alignment of femoral component	95.0 ± 2.2	94.8 ± 2.0	0.62
Coronal alignment of tibial component	90.4 ± 1.5	90.4 ± 2.8	0.92

[c] Independent sample *t*- test comparing the two groups

Table 3 Coronal alignment outlier between right TKAs and left TKAs

	Right	**Left**	***P*-value**
Postoperative tibiofemoral angle	7 (14.3%)	11(23.4%)	0.25 [a]
Coronal alignment of the femoral component	9 (18.4%)	7(14.9%)	0.65 [a]
Coronal alignment of the tibial component	2 (4.1%)	10(21.3%)	0.01 [b]

[a] χ^2test (Pearson Chi-square) comparing between the categorical variables of the two groups

[b] χ^2 test (Fisher's exact test) comparing between the categorical variables of the two groups when data in cell have an expected count of less than 5

Table 4 Reliability and agreement of coronal alignment angulation.

Variables	Intraclass correlation coefficient	Standard error	Difference		95% Limits of agreement
			Average	Standard deviation	
Preoperative tibiofemoral angle					
- Observer A vs B	0.97	0.01	-0.81	1.49	-3.73, 2.11
- Observer A vs C	0.95	0.01	-1.28	2.01	-5.22, 2.66
Postoperative tibiofemoral angle					
- Observer A vs B	0.84	0.03	-1.35	1.33	-3.96, 1.25
- Observer A vs C	0.41	0.05	-3.33	2.33	-7.89, 1.23
Coronal alignment of the femoral component					
- Observer A vs B	0.88	0.02	-0.51	0.99	-2.45, 1.44
- Observer A vs C	0.56	0.056	-1.65	1.75	-5.07, 1.77
Coronal alignment of the tibial component					
- Observer A vs B	0.84	0.03	-0.82	1.01	-2.81, 1.16
- Observer A vs C	0.61	0.05	-1.67	1.58	-4.77, 1.43

The results of the inter-observer reliability of measurement using level of agreement and a 95% limit of agreement were moderate to high reliability and agreement (Table 4).

Discussion

The surgical performance and outcomes had been affected by three factors (kinematic restriction, reduced tactile feedback and increased perceptual processing consequent on operating from a direct image of the operating field)[6]. Mehta and colleagues[9] offer the laterality of the operative site with respect to the surgeon handedness as a fourth factor. Handedness is a tendency to use one hand rather than the other and laterality is the preference of using one side of the body over the other. There were numerous studies in general surgery documenting the effect of handedness as an independent factor affecting surgical techniques and outcomes[6-8]. Adusumilli et al.[10] examined left-handed surgeons and reported that 3% of left-handed surgeons had received specific mentoring, 10% of medical schools have laterality training programs and 13% provide left handed instruments. Handedness and laterality not only affected left-handed surgeons but also right-handed surgeons. Surgeons may prefer to perform an operation on one side over the other because they feel more comfortable and it is easier to perform the operation.

There are few reports in orthopaedic surgery that mentioned handedness and laterality although they played a significant role. Maloney et al.[11] reported that left side sliding hip screws in the fractured neck of the femur had more technical failures than right side sliding hip screws when performed by right handed surgeons. Mehta and Lotke[9] reported that right TKAs had better functional outcomes at a 1 year follow up than left TKAs performed by a right-handed surgeon standing on the side of the operative procedure.

The results of this study showed that the surgeon handedness affects the coronal alignment of TKAs. The left TKAs had significantly more outliers of coronal alignment of the tibial component than right TKAs when performed by right-handed surgeons standing on the side of the operative procedure. The reason for these differences may be due to misvisual perception during setting the extramedullary tibial guide and inaccurate bone resection due to using the non-dominant hand to perform the tibial cut. Lui and colleagues[12] found that right-handed orthopaedic surgeons do not tend to reposition themselves to utilize their dominant hand when performing an operation but instead use their non-dominant hand. For example, when performing a left TKA, a right-handed surgeon tended to use the left hand to perform the tibial cut. The outliers of coronal alignment of the femoral component were not statistically different but it was more than the outliers of coronal alignment of the tibial component (16.7% vs 12.5%). The outliers of coronal alignment of the right femoral component may be caused by inaccurate bone resection due to during the procedure the surgeons had changed position with the assistants and used their non-dominant hand to perform the distal femoral cut. However, the outliers of coronal alignment of the left femoral component may be caused by visual misjudgment of the entry point of the intramedullary femoral guiding system. Visual misjudgment of the entry point may have less effect on alignment than using a non-dominant hand to perform the bone cut.

The outliers of coronal alignment of TKAs arise not only from the alignment system, but also from factors related to the surgeons and patients. The handedness and laterality including surgical experience may produce malalignment. In previous studies, postoperative alignment of the limb exceeded a range of ±3º in up to 30% of cases[13-15]. In this study, the overall outliers of the postoperative tibiofemoral angle were 18.8%. These findings agree with those of Petersen and Engh[13] and Mahaluxmivala et al.[15] that showed 26% and 25% outliers of postoperative tibiofemoral angle, respectively. In a recent meta-analysis of 29 studies comparing computer navigation to conventional instrument TKA, 31.8% of conventional TKA had more than 3° of varus and valgus alignment[16]. The overall outliers of coronal alignment of the femoral component were 16.7% and the overall outliers of coronal alignment of the tibial component were 12.5%. Similar results were reported by Kim et al.[17] in 520 TKAs. They found 10% of outliers of coronal alignment of the femoral component and 15% of outliers of coronal alignment of the tibial component. Although the surgeons in this study had, on average, 5 years' experience in TKA, there is no difference in the results of overall coronal alignment outliers of TKA between this study and previous studies from specialist centers[13,14,17].

In the present data, all complications were found in the left TKAs including patella tendon tear and periprosthetic fracture. These complications may be caused by some difficulties in the approach of left TKAs by the right-handed surgeon standing on the left side.

Long-leg weight-bearing radiographs have been the gold standard for assessing overall limb alignment but they are not routinely used due to the added cost and difficult techniques. A previous study had shown the correlation between anatomical and mechanical axes. There is no significant difference between measurements from standard knee and hip to ankle radiographs[13]. Although the inter-observer reliability of measurement in this study was moderate to high reliability and agreement, there may be some errors

of measurement caused by misidentification of the landmarks or misinterpretation of the goniometer. These errors can be reduced by using modern digital radiographs and measuring by computerized analysis tools.

To avoid the potential problems when operating on the non-dominant side, orthopaedic surgeons should have non-dominant hand training, familiarity with surgical technique and prosthesis, adjust one's body position during surgery and special precautions when handling soft tissue or making a bone cut[9]. Now computer assisted surgery has a significant role in orthopaedic surgery. It may decrease technical errors that come from the effects of handedness and laterality

This study has some limitations. It is a retrospective study, with a small sample size, and lack of clinical data to correlate with handedness. Further study designs evaluating the effect of surgeon handedness should use large sample sizes including outcomes from left-handed surgeons and a prospective study with clinical results.

Conclusion

There were more outlying results of the coronal alignment of the tibial component of left TKAs when performed by right-handed surgeons. Surgeon handedness does have an effect on coronal alignment of TKAs. Surgeons should concern about the effect of handedness and laterality to prevent unexpected results when performing on their non-dominant side. The results from this study could be useful for preventing coronal malalignment in TKAs which are related to the survival outcome and functional outcome.

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Potential conflict of interest

None

References

1. Rand JA, Coventry MB. Ten-year evaluation of geometric total knee arthroplasty. Clin Orthop Relat Res 1988; 232: 168-73.
2. Ranawat CS, Boachie-Adjei O. Survivorship analysis and results of total condylar knee arthroplasty. Eight-to 11-year follow-up period. Clin Orthop Relat Res 1988; 226: 6-13.
3. Bargren JH, Blaha JD, Freeman MA. Alignment in total knee arthroplasty. Correlated biomechanical and clinical observations. Clin Orthop Relat Res 1983; 173: 178-83.
4. Ritter MA, Faris PM, Keating EM, Meding JB.Postoperative alignment of total knee replacement. Its effect on survival. Clin Orthop Relat Res 1994; 299: 153-6.
5. Wasielewski RC, Galante JO, Leighty RM, Natarajan RN, Rosenberg AG. Wear patterns on retrieverd polyethylene tibial inserts and their relationship to technical considerations during total knee arthroplasty. Clin Orthop Relat Res 1994; 299: 31-43.
6. Hanna GB, Drew T, Clinch P, Shimi S, Dunkley P, Hau C, Cuschieri A. Psychomotor skills for endoscopic manipulations: differing abilities between right and left handed individuals. Ann Surg. 1997; 225: 333-8.
7. Pouw L, Tulloh B. Laparoscopic cholecystectomy for the left-handed surgeon. Br J Surg. 1995; 82: 138.
8. Schueneman AL, Pickleman J, Freeark RJ. Age, gender, lateral dominance, and prediction of operative skill among general surgery residents. Surgery 1985; 98: 506-15.
9. Mehta S, Lotke PA. lmpact of surgeon handedness and laterality on outcomes of total knee arthroplasties: should right-handed surgeons do only right TKAs ? Am J Orthop 2007; 36: 530-3.
10. Adusumilli PS, Kell C, Chang JH, Tuorto S, Leitman IM. Left-handed surgeons: are they left out? Curr Surg 2004; 61: 587-91.
11. Moloney D, Bishay M, Ivory J, Pozo J. Failure of the sliding hip screw in the treatment of femoral neck fractures: 'left-handed surgeons for left-sided hips'. Injury 1994; 25 Suppl 2: S9-13.
12. Lui DF, Baker JF, Nfilfa G, Perera A, Stephens M. Hand dominance in orthopedic surgeons. Acta Orthop Belg 2012; 78: 531-7.
13. Petersen TL, Engh GA. Radiographic assessment of knee alignment after total knee arthroplasty. J Arthroplasty 1988; 3: 67-72.
14. Mielke RK, Clemens U, Jens Jh, Kershally S. Navigation in knee endoprosthesis implantation: pleliminary experiences and prospective comparative study with conventional implantation technique. Z Orthop Ihre Grenzgeb 2001; 139: 109-16.
15. Mahaluxmivala J, Bankes MJ, Nicholai P, Aldam CJH, Allen PW. The effect of surgeon experience on component positioning in 673 press fit condylar cruciate-sacrificing total knee arthroplasties. J Arthroplasty 2001; 16: 635-40.
16. Mason JB, Fehring TK, Estok R, Banel D, Fahrbach K. Meta-analysis of alignment outcomes in computer-assisted total knee arthroplasty surgery. J Arthroplasty 2007; 22: 1097-106.
17. Kim YH, Park JW, Kim JS. Computer-navigated versus conventional total knee arthroplasty: a prospective randomized trial. J Bone Joint Surg (Am) 2012; 94: 2017-24.

ผลของมือข้างถนัดของศัลยแพทย์ต่อแนวแบ่งหน้าหลังในการผ่าตัดเปลี่ยนใส่ข้อเข่าเทียม

โอภาส ไชยมหาพฤกษ์, พบ

วัตถุประสงค์: *เพื่อศึกษาผลของมือข้างถนัดของศัลยแพทย์ต่อแนวแบ่งหน้าหลัง (coronal) โดยเปรียบเทียบระหว่างการผ่าตัดเปลี่ยนใส่ข้อเข่าเทียมข้างขวากับข้างซ้าย*

วิธีการศึกษา: *ทำการศึกษาย้อนหลังจากเวชระเบียนและภาพถ่ายรังสีของผู้ป่วยที่ทำการผ่าตัดเปลี่ยนใส่ข้อเข่าเทียมตั้งแต่มกราคม พ.ศ.2553 ถึง ธันวาคม พ.ศ.2555 ในผู้ป่วยจำนวน 78 ราย เป็นข้อเข่าขวา 49 ราย ข้อเข่าซ้าย 47 ราย ภาพถ่ายรังสีก่อนและหลังการผ่าตัดได้ถูกนำมาวัดมุม tibiofemoral, coronal alignment of femoral component และ coronal alignment of tibial component ค่ามุมที่เหมาะสม ± 3º ให้นิยามว่า รับได้ (acceptable) ส่วนค่ามุมที่เหมาะสมมากกว่า ±3º ให้นิยามว่า นอกแนว (outlier) นำค่าที่วัดได้มาเปรียบเทียบระหว่างข้อเข่าเทียมข้างขวากับข้างซ้าย*

ผลการศึกษา: *พบนอกแนว (outlier) ของมุม tibiofemoral ภายหลังการผ่าตัดเปลี่ยนใส่ข้อเข่าเทียมข้างขวา 7 ราย ข้อเข่าเทียมข้างซ้าย 11 ราย นอกแนว (outlier) ของ coronal alignment of femoral component ในข้อเข่าเทียมข้างขวา 9 ราย ข้อเข่าเทียมข้างซ้าย 7 ราย นอกแนว (outlier) ของ coronal alignment of tibial component ในข้อเข่าเทียมข้างขวา 2 ราย ข้อเข่าเทียมข้างซ้าย 10 ราย พบว่ามีความแตกต่างอย่างมีนัยสำคัญทางสถิติของนอกแนว (outlier) ของ coronal alignment of tibial component ระหว่างข้อเข่าเทียมข้างขวากับข้อเข่าเทียมข้างซ้าย*

สรุป: *มือข้างถนัดของศัลยแพทย์ มีผลกระทบต่อแนวในระนาบ coronal ของข้อเข่าเทียม โดยพบว่ามีนอกแนว (outlier) ของ coronal alignment of tibial component ในข้อเข่าเทียมข้างซ้ายมากกว่าข้อเข่าเทียมข้างขวาอย่างมีนัยสำคัญทางสถิติในการผ่าตัดโดยศัลยแพทย์ถนัดมือขวา*