Radiographic Assessment in Bilateral Primary Total Knee Arthroplasty: Computer-Assisted Surgery vs. Conventional Surgery

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Objective: *The purpose of this retrospective study is to compare the efficiency of computer-assisted surgery (CAS) and conventional method (CONV) in TKA using mechanical axis (MA) and component alignment measured on the post-operative radiograph in the same patient by different technique for TKA on both sides of the knee.*
Material and Method: *Fifty-two TKA in twenty-six patients with primary osteoarthritis of both knees that underwent stage bilateral TKA by computer-assisted surgery one side and conventional method on the other side were inclusion criteria. Digital long-leg weight-bearing radiographs were taken. The mechanical axis (MA), femoral component in coronal plane (FFC), tibial component in coronal plane (FTC), femoral component in sagittal plane (SFC) and tibial component in sagittal plane (STC) were measured and compared.*
Results: *The MA indicated that computer-assisted surgery (CAS) is significantly improved accuracy compared with conventional method (178.12° $\pm$ 1.56° and 176.15° $\pm$ 1.85° respectively, $p = 0.00$). For FFC alignment, the results showed that CAS group is significantly more accurate than CONV group (88.58° $\pm$ 1.30° and 87.38° $\pm$ 2.02° respectively, $p = 0.07$). CAS group showed less distribution and fewer outliers of data than CONV group. For FTC, SFC and STC alignment, the means of both groups were no difference ($p > 0.05$). Otherwise, the numbers of outlier CONV group trend toward greater than CAS group (FTC 3.8% and 0%, SFC 30.8% and 0%, respectively). There was no report of change in the navigator group procedure to conventional method during surgery and no perioperative or postoperative complications were noted.*
Conclusion: *Computer-assisted surgery (CAS) is a safe and useful intraoperative tool for total knee arthroplasty to improve accuracy of mechanical axis, good implant position and reduce number of postoperative implant outlier. Clinical studies will be required for clinical outcome assessment.*

Keywords: *Computer-assisted surgery, Arthroplasty, Total knee replacement*

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Total knee arthroplasty (TKA) has been established treatment for advanced stage of the knee osteoarthritis. Many factors are affected to long-term result such as surgical technique, implant design, malposition/orientation of the prosthesis, perioperative care and patient selection[1-3]. Some authors purposed that the most important factor influence that improves implant survival is postoperative leg axis[4,5]. Besides, they also concluded that the mechanical axis (MA) which is outlier more than 0 $\pm$ 3° can lead to unfavorable outcome for patients. For example, early polyethylene wear, or component loosening[4,6-8].

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Nowadays, the navigation system has become more popular to obtain more accurate cutting guides and bone resections including improve soft tissue balancing. These could result in improved MA and component alignment[9-12]. Miclke et al[13] reported that component alignment in computer-assisted surgery (CAS) is significantly improved compared with conventional instrument surgery (CONV). However, several authors reported that no difference result between two methods. Besides, CAS was considered that more time-consuming and more risk of complication than conventional method[14,15].

The purpose of this retrospective study was to compare the efficiency of CAS and conventional method in TKA by comparison of the mechanical axis (MA) and component alignment from the postoperative radiograph in patient who CAS-TKA were performed on one side and conventional method on the other side.

Material and Method

The present study was approved by the ethics committee in Rajavithi hospital (ID number 034/2555). The inclusion criteria was the patient diagnosed with primary osteoarthritis at knee that underwent stage primary total knee arthroplasty both sides by different methods (computer-assisted surgery one side and conventional method on the other side) during the period between February. 2011 to January 2012. Fifty-two TKA in twenty-six patients were matched with inclusion criteria; all patients were performed TKA by single experience author (PS). The medical records and radiological data for all patients were reviewed retrospectively.

Surgical techniques

All TKAs were performed with minimal invasive surgery (MIS) under spinal anesthesia, used midvastus arthrotomy and stated with tibia bone cute first. No patellar were resurfaced in either group. The postoperative protocols were identical in both groups.

Most patients who underwent TKA with conventional method used cemented fixed-bearing, PS design (PFC Sigma, Depuy, Johnson and Johnson, Leeds, UK) under measure resection technique and some cases used mobile-bearing, PS design (e.motion® PS, BBraun, Aesculap, Tuttlingen, Germany) under gap-balance technique. Extramedullary tibial guide and intramedullary femoral guide were used for proximal tibial and distal femoral bone cute, respectively, according to a standardized protocol.

For computer-assisted TKA, all cases used cemented mobile-bearing, PS design (e.motion® PS, BBraun, Aesculap, Tuttlingen, Germany). Schantz pin with reflection array were applied to proximal tibia and distal femur and then, registration step by step under image-free navigation system (OrthoPilot® 4.3, Aesculap, Tuttlingen, Germany) to create virtual image on screen display. Real-time bone cutting were performed under the navigation system and used gap-balance technique to equal flexion and extension gap.

Digital long-leg weight-bearing radiographs were taken when patients had full extension of the knee, average one to three months post-operatively. The mechanical axis of lower limb was determined by angles between the mechanical axis of femur and the mechanical axis of tibia. The line of mechanical axis (MA), femoral component in coronal plane (FFC) and Tibial component in coronal plane (FTC) were measured in anteroposterior films, whereas the femoral component in sagittal plane (SFC) and tibial component in sagittal plane (STC) were measured in lateral flexion films (Fig. 1). The outlier of the component in each radiographic was setting base on 0° $\pm$ 3° varus/valgus and 0° $\pm$ 3° flexion/extension. All radiographs were measured by independent observer with digital radiographic software on personal computer (Synapse-PACS system, Fujifilm Medical Systems USA, Inc.).

Statistical analysis

Data were analyzed on SPSS ver 17 (SPSS Inc. Chicago, Illinois). Descriptive results of continuous variables were expressed as mean, standard deviation (SD) and categorical variables were expressed as number and percent. Intergroup comparisons were made using pair t-tests for normal distribution data and using Wilcoxon test for non-normal distribution data. The p-value < 0.05 was set for statistically significant.

Results

The mean value, standard deviations and percent of outlier of the digital long-leg weight-wearing

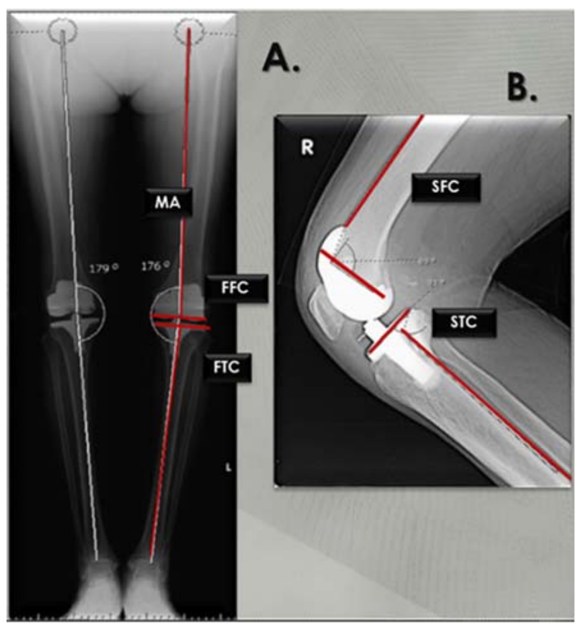

Fig. 1 Digital long-leg weight-bearing radiographs. The line of mechanical axis (MA), femoral component in coronal plane (FFC) and Tibial component in coronal plane (FTC) were measured in anteroposterior films (A.), the femoral component in sagittal plane(SFC) and tibial component in sagittal plane (STC) were measured in 90° flexion lateral films

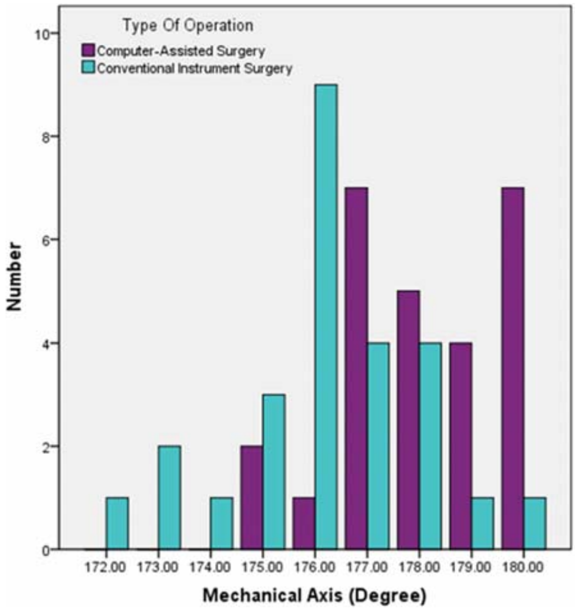

Fig. 2 Distribution of mechanical axis measured on anteroposterior film

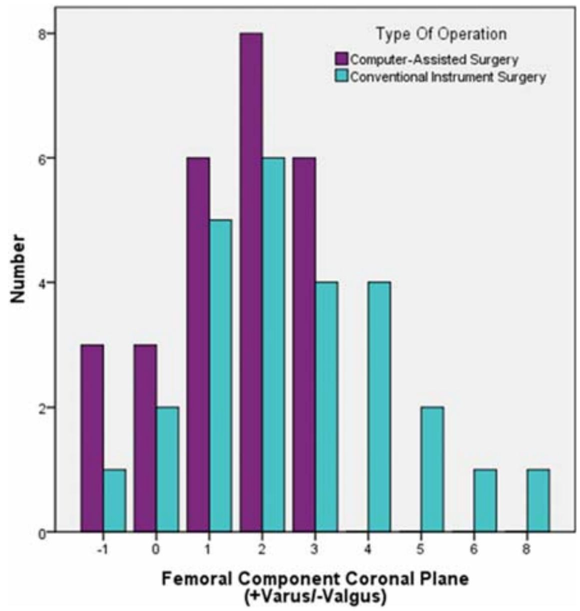

Fig. 3 distribution of the frontal femoral component measured on anteroposterior film

radiographic measurement are shown in Table 1. The MA of the lower limb indicated that there are significant improve accuracy on the CAS group when compare with CONV group (178.12° $\pm$ 1.56° and 176.15° $\pm$ 1.85° respectively, p = 0.00). Number of TKA in the CAS group was less outlier than CONV group (11.5% and 61.5%, respectively).

For FFC alignment, the results showed that CAS group is significantly more accurate than CONV group (88.58° $\pm$ 1.30° and 87.38° $\pm$ 2.02°, respectively, p = 0.07). There were fewer outliers in the CAS than CONV group (0% and 30.8%, respectively).

For the other digital radiographic results, the means of both groups were no statistically significant difference. From the anteroposterior film, the FTC alignment of the CAS group and the CONS group were 89.54° $\pm$ 1.07° and 88.81° $\pm$ 1.58° (p = 0.44) respectively. From the lateral film, the SFC alignment of the CAS group and the CONS group were 91.04° $\pm$ 2.07° and 91.77° $\pm$ 3.15° (p = 0.39) respectively. The STC alignment of the CAS group and in the CONS group were 90.54° $\pm$ 1.55° and 91.31° $\pm$ 2.83° (p = 0.12) respectively. Otherwise, the numbers of outlier CONV group trend toward greater than CAS group (FTC 3.8% and 0%, SFC 26.9% and 15.4%, respectively).

The distribution of mechanical axis (MA) and femoral component in coronal plane (FFC) were shown in Fig. 2 and Fig. 3. CAS group showed distribution of data less than CONV group.

In operative note and OPD card, no change in the navigator group procedure to conventional method during surgery and no perioperative or postoperative complications were noted.

Discussion

Generally, the long-term clinical outcomes of total knee arthroplasty were claimed that depend on good postoperative mechanical axis and component alignment[16,17]. Moreover, malposition of TKA implants resulted in early loosening and increased polyethylene wear[1,4,8]. Navigation systems have been developed to improve the accuracy of bone cutting, precise component alignment, well soft tissue balancing, equal of flexion and extension gap including the MA[9,12,18,19]. Thus, many current studies evaluated preoperative alignment[20], bony deformity[21], or situation in case of revision TKA[22]. The result from these studies reported that computer-assisted surgery can significantly improve the component alignment and the MA.

In the present study showed that post-operative alignment of TKA in the same patient by different technique were different on both sides of the knee. According to the other studies, the postoperative alignment in the CAS group was superior to CONV group. Besides, MA and FFC alignment were also presented in the present data. In the case that outliers are present, the authors found that there are smaller present of outlier in the CAS than CONV group.

Table 1. Postoperative alignment measured form digital radiographs

	Computer-Assisted Surgery			Conventional method			p-value
	(%)	Mean (°)	SD	(%)	Mean (°)	SD	
Coronal radiographs							
MA		178.12	1.56		176.15	1.85	0.00
Outlier (%)	11.5			61.5			
FFC		88.58	1.30		87.32	2.02	0.07
Outlier (%)	0			30.8			
FTC		89.54	1.07		88.81	1.58	0.44
Outlier (%)	0			3.8			
Sagittal radiographs							
SFC		91.04	2.07		91.77	3.15	0.39
Outlier (%)	15.4			26.90			
STC		90.54	91.31		91.31	2.83	0.12

However, the authors did not compare the STC (tibial slope) alignment due to the difference type of tibial prosthesis.

Although some complications of CAS including infection or intraoperative fracture have been reported, however, no complications were found in the present study.

The limitations of the present study are that only a small number of subjects and lack of clinical outcomes. Future study designs evaluating the effect of CAS are likely to be challenged by large sample sizes and prospective study with clinical result following will be need to demonstrate clinical outcome difference.

Conclusion

Computer-assisted surgery (CAS) is a safe and useful intraoperative tool for total knee arthroplasty to improve accuracy of mechanical axis, good implant position and reduce number of postoperative implant outlier. Clinical studies will be required for clinical outcome assessment

Potential conflicts of interest

None.

References

1. Jeffery RS, Morris RW, Denham RA. Coronal alignment after total knee replacement. J Bone Joint Surg Br 1991; 73: 709-14.
2. Stindel E, Briard JL, Merloz P, Plaweski S, Dubrana F, Lefevre C, et al. Bone morphing: 3D morphological data for total knee arthroplasty. Comput Aided Surg 2002; 7: 156-68.
3. Ek ET, Dowsey MM, Tse LF, Riazi A, Love BR, Stoney JD, et al. Comparison of functional and radiological outcomes after computer-assisted versus conventional total knee arthroplasty: a matched-control retrospective study. J Orthop Surg (Hong Kong) 2008; 16: 192-6.
4. Rand JA, Coventry MB. Ten-year evaluation of geometric total knee arthroplasty. Clin Orthop Relat Res 1988; 168-73.
5. 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; 6-13.
6. Bargren JH, Blaha JD, Freeman MA. Alignment in total knee arthroplasty. Correlated biomechanical and clinical observations. Clin Orthop Relat Res 1983; 178-83.
7. Ritter MA, Faris PM, Keating EM, Meding JB. Postoperative alignment of total knee replacement. Its effect on survival. Clin Orthop Relat Res 1994; 153-6.
8. Wasielewski RC, Galante JO, Leighty RM, Natarajan RN, Rosenberg AG. Wear patterns on retrieved polyethylene tibial inserts and their relationship to technical considerations during total knee arthroplasty. Clin Orthop Relat Res 1994; 31-43.
9. Pang HN, Yeo SJ, Chong HC, Chin PL, Ong J, Lo NN. Computer-assisted gap balancing technique improves outcome in total knee arthroplasty, compared with conventional measured resection technique. Knee Surg Sports Traumatol Arthrosc 2011; 19: 1496-503.
10. Shinozaki T, Gotoh M, Mitsui Y, Hirai Y, Okawa T,

Higuchi F, et al. Computer-assisted total knee arthroplasty: comparisons with the conventional technique. Kurume Med J 2011; 58: 21-6.

11. Anderson KC, Buehler KC, Markel DC. Computer assisted navigation in total knee arthroplasty: comparison with conventional methods. J Arthroplasty 2005; 20: 132-8.
12. Blakeney WG, Khan RJ, Wall SJ. Computer-assisted techniques versus conventional guides for component alignment in total knee arthroplasty: a randomized controlled trial. J Bone Joint Surg Am 2011; 93: 1377-84.
13. Mielke RK, Clemens U, Jens JH, Kershally S. Navigation in knee endoprosthesis implantation—preliminary experiences and prospective comparative study with conventional implantation technique. Z Orthop Ihre Grenzgeb 2001; 139: 109-16.
14. Kim YH, Kim JS, Yoon SH. Alignment and orientation of the components in total knee replacement with and without navigation support: a prospective, randomised study. J Bone Joint Surg Br 2007; 89: 471-6.
15. Cheng T, Pan XY, Mao X, Zhang GY, Zhang XL. Little clinical advantage of computer-assisted navigation over conventional instrumentation in primary total knee arthroplasty at early follow-up. Knee 2012; 19: 237-45.
16. Hoffart HE, Langenstein E, Vasak N. A prospective study comparing the functional outcome of computer-assisted and conventional total knee replacement. J Bone Joint Surg Br 2012; 94: 194-9.
17. Choong PF, Dowsey MM, Stoney JD. Does accurate anatomical alignment result in better function and quality of life? Comparing conventional and computer-assisted total knee arthroplasty. J Arthroplasty 2009; 24: 560-9.
18. 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.
19. Zhang GQ, Chen JY, Chai W, Liu M, Wang Y. Comparison between computer-assisted-navigation and conventional total knee arthroplasties in patients undergoing simultaneous bilateral procedures: a randomized clinical trial. J Bone Joint Surg Am 2011; 93: 1190-6.
20. Mullaji A, Kanna R, Marawar S, Kohli A, Sharma A. Comparison of limb and component alignment using computer-assisted navigation versus image intensifier-guided conventional total knee arthroplasty: a prospective, randomized, single-surgeon study of 467 knees. J Arthroplasty 2007; 22: 953-9.
21. Huang TW, Hsu WH, Peng KT, Hsu RW. Total knee replacement in patients with significant femoral bowing in the coronal plane: a comparison of conventional and computer-assisted surgery in an Asian population. J Bone Joint Surg Br 2011; 93: 345-50.
22. Perlick L, Bathis H, Perlick C, Luring C, Tingart M, Grifka J. Revision total knee arthroplasty: a comparison of postoperative leg alignment after computer-assisted implantation versus the conventional technique. Knee Surg Sports Traumatol Arthrosc 2005; 13: 167-73.

การประเมินภาพถ่ายรังสีของผู้ป่วยที่ได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมทั้งสองข้างด้วยการใช้คอมพิวเตอร์ช่วยผ่าตัดเปรียบเทียบกับวิธีธรรมดา

นที เรืองทอง, พรภวิษญ์ ศรีภิรมย์

***วัตถุประสงค์**: เพื่อศึกษาเปรียบเทียบประสิทธิภาพของการผ่าตัดเปลี่ยนข้อเข่าเทียมโดยวิธีใช้คอมพิวเตอร์ช่วยในการผ่าตัดและการผ่าตัดโดยวิธีธรรมดา โดยการเปรียบเทียบมุม mechanical axis (MA) และมุม component alignment ในผู้ป่วยที่ได้รับการผ่าตัดเปลี่ยนข้อเข่าทั้งสองข้าง โดยเป็นการผ่าตัดวิธีธรรมดาหนึ่งข้างและเป็นการใช้คอมพิวเตอร์ช่วยผ่าตัดในเข่าอีกข้างหนึ่ง*

***วัสดุและวิธีการ**: ศึกษาในจำนวนข้อเข่าทั้งหมด 52 เข่า จากผู้ป่วยจำนวน 26 ราย ในช่วงระหว่างเดือนกุมภาพันธ์ พ.ศ. 2554 ถึง มกราคม พ.ศ. 2555 ที่ได้รับการวินิจฉัยว่าเป็นข้อเข่าเสื่อมทั้งสองข้างและได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมทั้งโดยการผ่าตัดวิธีธรรมดาหนึ่งข้างและวิธีใช้คอมพิวเตอร์ช่วยผ่าในด้านตรงข้าม นำผู้ป่วยมาถ่ายภาพรังสีท่ายืนในระบบดิจิตอล แล้วทำการวัดและเปรียบเทียบมุม mechanical axis (MA), femoral component in coronal plane (FFC), tibial component in coronal plane (FTC), femoral component in sagittal plane (SFC) และมุม tibial component in sagittal plane (STC)*

***ผลการศึกษา**: พบว่าการผ่าตัดโดยวิธีใช้คอมพิวเตอร์ช่วยเพิ่มความแม่นยำของมุม MA มากกว่าการผ่าตัดวิธีธรรมดาอย่างมีนัยสำคัญทางสถิติ ($178.12^{\circ} \pm 1.56^{\circ}$ และ $176.15^{\circ} \pm 1.85^{\circ}$ ตามลำดับ, $p = 0.00$) ส่วนมุม FFC นั้นพบว่ามีความแม่นยำสูงในการผ่าตัดโดยวิธีใช้คอมพิวเตอร์ช่วยผ่าเมื่อเทียบกับการผ่าตัดวิธีธรรมดาอย่างมีนัยสำคัญทางสถิติ ($88.58^{\circ} \pm 1.30^{\circ}$ และ $87.38^{\circ} \pm 2.02^{\circ}$ ตามลำดับ, $p = 0.07$) และในกลุ่มการผ่าตัดโดยวิธีใช้คอมพิวเตอร์ช่วยผ่าพบมีการกระจายของข้อมูลและค่า outliers น้อยกว่ากลุ่มที่ได้รับการผ่าตัดแบบธรรมดา ส่วนมุม SFC และ STC นั้นไม่พบความแตกต่างของทั้งสองวิธีการผ่าตัด ($p > 0.05$) แต่พบว่าค่า outlier ของกลุ่มที่ได้รับการผ่าตัดแบบธรรมดานั้นมีแนวโน้มที่มากกว่ากลุ่มการผ่าตัดโดยวิธีใช้คอมพิวเตอร์ช่วย (FTC 3.8% และ 0%, SFC 26.90% และ 15.4% ตามลำดับ) โดยผู้ป่วยทั้งหมดในการศึกษานี้ไม่มีการเปลี่ยนกลุ่มการผ่าตัดโดยวิธีใช้คอมพิวเตอร์ช่วยผ่ามาเป็นการผ่าตัดแบบธรรมดา และไม่พบภาวะแทรกซ้อนทั้งในขณะผ่าตัดและหลังผ่าตัด*

***สรุป**: การใช้คอมพิวเตอร์ช่วยในการผ่าตัด เป็นเครื่องมือที่ปลอดภัยและช่วยเพื่อความแม่นยำของ MA ทำให้ตำแหน่งการวางข้อเข่าเทียมดีขึ้น รวมทั้งยังลดจำนวนของ outlier หลังการผ่าตัด การศึกษาผลทาง clinical รวมถึงการรวบรวมตัวอย่างที่มากขึ้นเป็นสิ่งจำเป็นในการศึกษาครั้งต่อไป*