

Comparative Mechanical Axis Deviation after TKA between Conventional and CAS Procedure

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Objective: The purpose of the present study was to report the results of radiographic comparisons made between CAS-TKA and conventional TKA.

Material and Method: The authors retrospectively compared 102 knee radiographs from conventional TKA to 84 knees from CAS-TKA.

Results: The mean mechanical axis deviation was 2.77° for conventional TKA and 1.80° for CAS-TKA ($p = 0.0002$). For conventional TKA 42.2% of the results were considered to be outliers versus only 14.3% outlier frequency among the CAS-TKA procedures ($p < 0.0001$). Only 54.4% of scanograms were proper for the presented analysis due to improper anterior-posterior positioning. Implementation of a corrective standing block eliminated this issue.

Conclusion: CAS-TKA significantly reduces both margins of error in knee alignment and frequency of outlier compared with conventional TKA. Further investigation to compare long-term results of CAS-TKA with conventional TKA is recommended.

Keywords: Computer assisted surgery, Total knee arthroplasty, Total knee replacement

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Computer assisted surgery (CAS) provides an alternative to conventional total knee arthroplasty (TKA). Though CAS-TKA entails higher cost and longer time of operation, it has potential in reducing errors in bone alignment. Alignment is tantamount to the overall success of arthroplasty. Minimal misalignment in either the varus or valgus orientation can decrease implant longevity⁽¹⁻⁷⁾. Misalignment within TKA can result in numerous complications, including lowered strength and stability of the prosthetic knee⁽⁸⁾. Using prosthetics that are designed to focus on reducing the contact stress is one option for improving the overall results of the procedure. In addition, use of CAS is increasingly becoming an effective and common tool available to surgeons worldwide. However, from current research, there appears to be differing results of CAS' usefulness. There is evidence that supports the use of CAS, demonstrating its potential for better knee alignment

in comparison to the conventional technique⁽⁸⁾. Conversely, studies also exist that find no significance in the alignment of knees treated by CAS versus conventional TKA^(2,7).

Use of CAS-TKA was first introduced in Thailand in July 2004. Prior to this, all knee arthroplasties were performed with the conventional method. In the present study, the authors report the results of radiographic comparisons between CAS-TKA and conventional TKA (performed by the author).

Material and Method

The ethical committee approved the present study prior to commencement of the study. Radiographs of 102 knees that underwent conventional TKA were retrospectively compared with knee radiographs from 84 Computer-Assisted Surgeries (CAS-TKA) performed between October 2006 and January 2007. All subjects were receiving treatment for diagnosed osteoarthritis (OA). All procedures, both conventional and computer-assisted, were performed at Bhumibol Adulyadej Hospital and Vejthani Hospital in Bangkok, Thailand. Only DePuy Low Contact Stress (LCS® Knee) mobile

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bearing system (cemented) implants were used in the present study. The computer-assisted surgeries were all performed through use of Ci™ Software (DePuy International Ltd).

In addition to normal precautions required for scanogram filming, subjects were also asked to stand on a corrective standing block specifically designed for the purpose of positioning the knees in an orientation proper for performing a scanogram. Afterward, the radiograph was digitally photographed with a Cannon Powershot S45 at a resolution of 2,272 x 1,704 pixels by an independent orthopedic surgeon. After digital images of scanograms were taken, mechanical axis deviations were measured using AutoCAD® 2005 software. Statistical tests were completed with Microsoft® Excel 2000. Statistical method chosen to compare the ratios of male to female and left to right knees between both groups were independent proportion ratios. A z-ratio was calculated from the difference between the independent proportions; and a two-tailed probability value (P) was generated to determine significance among the proportion ratios of the two study groups. Mechanical axis deviation was tested for significance using the Student's t-test and a p-value was generated. Non-parametric Chi-square statistical tests were used for analysis of outlier occurrence.

Results

The average age at the time of surgery was 65.8 years and 65.3 years for the conventional TKA group and CAS-TKA group respectively (Table 1). The Student's t-test revealed no significant difference between the two groups with regard to average age at the time of surgery ($p = 0.7663$). The proportion of male and female patients was similar between the two groups, with females representing the large majority of subjects. Pre-operative deformities were documented for 55 of the 102 conventional TKA subjects, and the

mean mechanical axis deviation was 12.6° (ranging from 25° varus to 5° valgus).

Basic demographic pre-operative data was not significantly different between the conventional TKA and CAS-TKA groups (Table 1). Age and female-male ratios were unbiased between the two groups. The subjects comprised of 88 females and 14 males versus 74 females and 10 males for the conventional TKA and CAS-TKA groups, respectively. The higher female-male ratio is reflective of current similar studies^(1,2,5,7). Testing for significance between the two independent proportions (via two-tailed test) expressed strong probability that no significant difference existed between the female-male ratios within the conventional TKA and CAS-TKA subjects ($z\text{-ratio} = -0.3690$, $p = 0.7121$). With conventional TKA patients, there were 49 left knees and 53 right knees that underwent arthroplasty procedures. Maintaining consistency, there were 41 left knees and 43 right knees among the group of CAS-TKA patients. These two independent proportions (via two-tailed test) for left-right knee ratios between the groups demonstrated a high probability that no significant difference existed between them ($z\text{-ratio} = -0.105$, $p = 0.9164$). There were no complications among any subjects in either group during or after surgery. However, it was observed and collaboratively acknowledged that computer-assisted procedures were lengthier.

Any post-operative knee that demonstrated a mechanical axis deviation in excess of 3° (either varus or valgus orientation) was deemed as an outlier. The results are summarized in Table 2.

In addition to the differences in axis deviation, a comparison of outlier frequency between these two groups also demonstrated significant results. A non-parametric test was necessary for looking at outlier frequency; therefore the Chi-squared test was utilized. Results yielded significantly higher occurrence of outliers among the conventional TKA subjects in our

Table 1. Pre-operative demographic data for CAS-TKA and conventional (TKA)

	CAS-TKA	Conventional (TKA)	Proportion (P)	p-value
Number of subjects	84	102	-	-
Mean age (years)	65.3	65.8	-	0.7663
Male (%)	10 (11.9%)	14 (13.7%)	0.7121	-
Female (%)	74 (88.1%)	88 (86.2%)		
Left (%)	41 (48.8%)	49 (48.0%)	0.9164	-
Right (%)	43 (51.2%)	53 (52.0%)		

Table 2. Results of CAS-TKA versus conventional (TKA) alignment

	CAS-TKA			Conventional (TKA)			p-value
	Varus	Valgus	Total	Varus	Valgus	Total	
Mean (degrees)	2.04	1.23	1.80	3.04	1.56	2.77	0.0002
Std dev	1.56	1.10	1.48	2.00	1.20	1.96	-
Median	1.59	1.30	1.49	2.91	1.62	2.40	-
Min	0.21	0.03	0.03	0.00	0.08	0.00	-
Max	5.94	3.73	5.94	7.68	4.43	7.68	-
Outlier (%)	11.9	2.38	14.3	40.2	1.96	42.2	<0.0001

study ($p < 0.0001$) (Fig. 1, 2). Post-operatively, the ratio of varus to valgus knees was higher in both the CAS-TKA and conventional TKA groups. For the CAS-TKA subjects, the percentages were 70.2% varus and 29.8% valgus. Similarly, in the conventional TKA group, varus knees accounted for 81.4% versus 18.6% of knees being in valgus orientation.

Regarding radiographs, the initial scanograms were relatively unsuccessful prior to implementing a corrective standing block for scanogram filming. The most common problem the author encountered was that the feet were not positioned properly during the scanogram (Fig. 3a). Secondly, upon viewing, not all radiographs allowed for full anatomical visibility of the presented subjects. The author applied a corrective standing block, which coerced the subject into the correct position necessary for a successful image that could be further analyzed (Fig. 3b). From the initial radiographs taken, only 54.4% were determined to be suitable for the presented analysis (Fig. 3c). Using corrective standing block for scanograms virtually eliminated the problem of the subjects' feet being externally rotated during imaging (Fig. 3d). Another problem was that the head of the femur was not clearly visible among all subjects after the images were taken. This was simply solved by immediately reviewing the radiographs. If upon immediate review, the head of the femur was not clearly visible; the subject was asked to re-take another scanogram until the image was acceptable.

Discussion

The presented study is similar to other TKA studies, which have discussed conclusive verification that CAS TKA can offer better precision via a higher frequency of proper varus and valgus alignment⁽¹⁰⁾. The average age from the present study is in accord with several other knee arthroplasty studies in recent

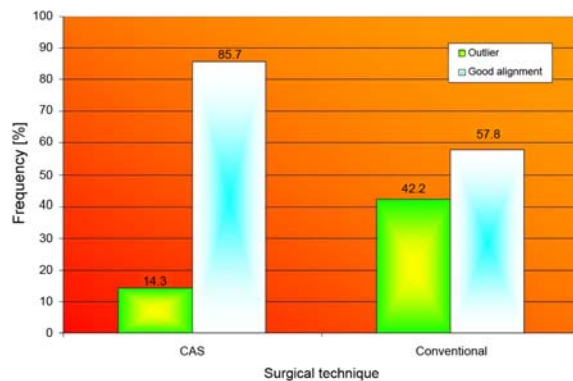


Fig. 1 Mechanical axis deviation: the percentage of good alignment and outliers (those $\geq 3^\circ$ of misalignment) between the CAS-TKA and conventional TKA groups

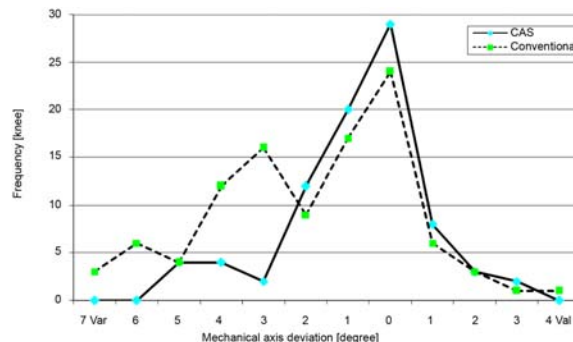


Fig. 2 Distribution of mechanical axis deviation (in degrees varus or valgus) in CAS-TKA versus conventional (TKA)

years⁽¹⁻⁷⁾. The mean pre-operative deviations in alignment were in relative agreement with other recent TKA studies^(7,9). Other studies have consistently noted a significantly longer operating time in computer-assisted surgeries^(4,5,9,10).

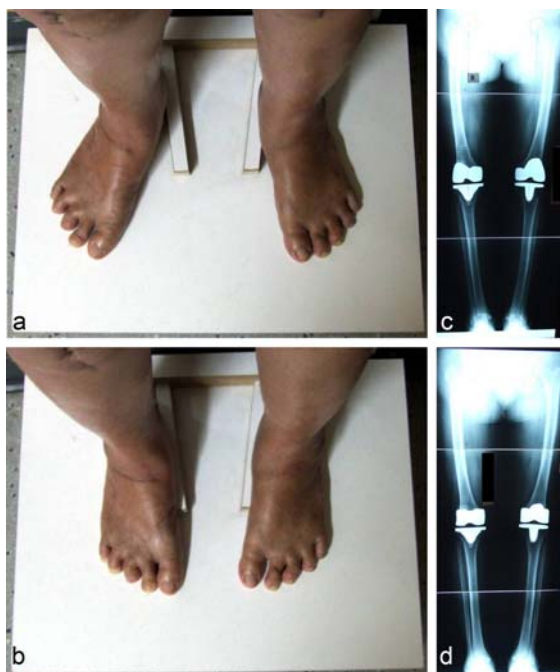


Fig. 3 Scanograms and photographs demonstrating importance of proper stance and corrective standing block implementation
a) Example of subject standing incorrectly during scanogram procedure, feet externally rotated
b) Example of subject standing on the corrective standing block, in the correct position with proper anterior-posterior alignment
c) Scanogram of subject standing with feet externally rotated
d) Scanogram of subject standing in the correct position

From the current results observed in the presented study, the authors can conclude several important observations that clearly support the advantages of CAS-TKA. If the varus and valgus orientation is accurate, it ensures a higher potential to establish equilibrium within the soft tissue. Therefore, the long-term results can enhance the durability of the prosthesis⁽¹¹⁾. Although this may not guarantee patient fulfillment of post-operative results, and patients may need pre-operative counseling; good alignment can maximize the functional capability of the knee⁽¹²⁾.

In the present study, analysis of the post-operative knee alignments generated noteworthy results. The authors found statistical significance between CAS-TKA and conventional TKA with respect to precision in knee alignment by observing

the differences in mean mechanical axis deviations between the two groups in the present study. Another obvious and more impressive difference noted in our study was that by adding a computer-assisted component to TKA, a very large reduction in the frequency of outliers resulted. Additionally, the authors noticed that scanogram analysis could only be meaningfully performed when care is taken to ensure proper knee positioning during the radiographic procedure.

The authors observed neither peri-operative nor post-operative complications associated with either CAS-TKA or the conventional TKA group. Complications such as systemic embolic phenomena have been documented during TKA⁽¹³⁻¹⁵⁾. A recent study witnessed significantly fewer systemic embolic phenomena among CAS-TKA subjects⁽¹⁰⁾.

The authors intend to continue observation of these 2 groups of subjects so that comparisons of long-term outcomes can be made between CAS-TKA and the conventional TKA techniques. Furthermore, additional research is needed to determine whether the clinical benefits obtained from CAS-TKA outweighs its increased cost and longer operating time.

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การเปรียบเทียบความคลาดเคลื่อนของ *mechanical axis* หลังจากการผ่าตัดข้อเข่าเทียม ระหว่างการผ่าตัดโดยใช้คอมพิวเตอร์ และการผ่าตัดแบบธรรมดา

จำรูญเกียรติ ลีลเศรษฐพร

วัตถุประสงค์: จุดประสงค์ของงานวิจัยนี้ต้องการที่จะรายงานผลการเปรียบเทียบภาพถ่ายทางรังสีวิทยา ระหว่างการผ่าตัดเปลี่ยนข้อเข่าเทียมโดยใช้คอมพิวเตอร์ช่วยและแบบธรรมดา

วัสดุและวิธีการ: โดยการเปรียบเทียบภาพถ่ายทางรังสีวิทยาแบบย้อนหลัง ทั้งนี้ในกลุ่มที่ได้รับการผ่าตัดแบบธรรมดามีจำนวน 102 เข่า และในกลุ่มที่ได้รับการผ่าตัดแบบใช้คอมพิวเตอร์ช่วยมีจำนวน 84 เข่า

ผลการศึกษา: ค่าเฉลี่ยของการเบี่ยงเบนของ *mechanical axis* ในกลุ่มที่ได้รับการผ่าตัดแบบธรรมดาคือ 2.77 องศา และ 1.80 องศา ในกลุ่มที่ได้รับการผ่าตัดโดยใช้คอมพิวเตอร์ช่วย ($p = 0.0002$) สำหรับการผ่าตัดแบบธรรมดามีร้อยละ 42.2 ของผลลัพธ์ที่ได้ถือเป็นค่าผิดปกติ เมื่อเปรียบเทียบกับค่าร้อยละ 14.3 ของผลลัพธ์ที่ได้จากการผ่าตัดโดยใช้คอมพิวเตอร์ช่วย ($p < 0.0001$) เนื่องจากการวางตำแหน่ง anterior-posterior ไม่ถูกต้อง ทำให้เพียงร้อยละ 54.4 ของ scanogram สามารถนำมาใช้วิเคราะห์ผลลัพธ์ได้ การใช้แท่นยืนในการถ่ายภาพรังสีวิทยาได้แก้ปัญหานี้

สรุป: จากงานวิจัยชี้ว่าการผ่าตัดข้อเข่าเทียมโดยใช้คอมพิวเตอร์ช่วยมีประโยชน์ เพราะสามารถช่วยลดข้อผิดพลาดในการวางตำแหน่ง และความถี่ของค่าผิดปกตินอกจากนี้การวางตำแหน่งเข่าอย่างถูกต้อง ระหว่างการถ่ายภาพทางรังสีวิทยาก็สำคัญมากสำหรับการวิเคราะห์หลังการผ่าตัดอย่างแม่นยำ แนะนำให้มีการวิจัยเพิ่มเติมเพื่อเปรียบเทียบผลลัพธ์ระยะยาวของการผ่าตัดเปลี่ยนข้อเข่าโดยใช้คอมพิวเตอร์ช่วยและแบบธรรมดา นอกจากนี้ผลประโยชน์ทางการรักษาที่ได้จากการผ่าตัดเปลี่ยนข้อเข่าโดยใช้คอมพิวเตอร์ช่วย ยังมีมากกว่าผลเสียของค่าใช้จ่ายที่แพงกว่าและระยะเวลาการผ่าตัดที่เพิ่มขึ้น
