A Comparison of Blood Loss in Minimally Invasive Surgery with and without Electromagnetic Computer Navigation in Total Knee Arthroplasty

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Objective: *To compare the blood loss after minimally invasive surgery total knee arthroplasty (MIS-TKA) between the procedures performed with and without electromagnetic computer navigation.*

Material and Method: *Eighty patients were recruited for a cohort study of the minimally invasive surgery total knee arthroplasty (MIS-TKA) for the treatment of osteoarthritis. They were divided into two groups, 40 patients had a computer-assisted surgery procedure for the minimally invasive surgery total knee arthroplasty (CAS-MIS-TKA) and the other 40 patients had a conventional procedure for the minimally invasive surgery total knee arthroplasty (MIS-TKA). The surgery in both groups was carried out by a single surgeon at one institution using a uniform approach. The blood loss in each group was evaluated and analyzed for the statistical difference.*

Results: *The result showed that the mean blood loss from the drainage of the CAS-MIS-TKA group (389.88 ± 215.57 milliliters) was slightly lower than the MIS-TKA group (425.25 ± 269.40 milliliters), which had no significant difference (p-value 0.519). Moreover, the whole blood loss in the CAS-MIS-TKA group (948.45 ± 431.63 milliliters) was slightly lower than the MIS-TKA group (1,075.32 ± 419.02 milliliters). The difference was also not statistically significant.*

Conclusion: *Electromagnetic computer-assisted surgery did not reduce blood loss in the minimally invasive surgery total knee arthroplasty (MIS-TKA).*

Keywords: *Electromagnetic computer-navigation procedure, Minimally invasive surgery, Total knee arthroplasty, Blood loss*

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Standard total knee arthroplasty (TKA) has been achieved the excellent long-term satisfactory results for 20 years according to the follow-up studies(1-6). The Minimally Invasive Surgery (MIS) has been developed for the knee arthroplasty in an effort to decrease early morbidity and improve the patient outcomes. The minimally invasive surgery total knee arthroplasty (MIS-TKA) is typically defined as a small incision surgery, down-sized instruments, decrease dissection of soft tissue, no patellar eversion and tibiofemoral joint dislocation(7-9). This technique might result in decreased pain and blood loss, faster recovery, greater quadriceps muscle strength, improved cosmetic appearance, and higher patient satisfaction(8,10,11). However, MIS-TKA might associate with bone cutting error, malposition of the implant and the longer operative times(8,10,12,13) due to the small exposure.

Currently, the emerging technology called "computer-assisted navigation surgery: (CAS)" has been developed to aid the surgeon to achieve the

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improved alignment in arthroplasty, presumably leading to better short-term and long-term outcomes[14-16]. Since MIS-TKA may associate with bone cutting error and malposition of implant, the computer-assisted surgery for the minimally invasive surgery total knee arthroplasty (CAS-MIS-TKA) is the additional technique to reduce the alignment error. Moreover, the surgeon did not have to perform intramedullary canal drilling by using CAS-MIS-TKA, which might decrease the blood loss[17].

Two types of computer-assisted navigation surgery are the optical tracking system which requires rigid bicortical fixation with pins, and the electromagnetic tracking system which is the small tracker and needs only single cortical fixation[18]. According to the requirement of only single cortical fixation of the electromagnetic computer navigation, it tends to less blood loss.

The purpose of this study is to compare the quantity of whole blood loss between 2 techniques (electromagnetic CAS-MIS-TKA and MIS-TKA) used in the patients. The CAS-MIS-TKA technique was expected to lower the blood loss of the patient than the MIS-TKA technique. The result of this study would be the benefit in choosing the optimal surgical technique for the patients with TKA.

Material and Method

We prospectively followed two groups of patients in our institution that underwent TKA between March 2007 and February 2008. Forty patients (40 knees) had TKA by a surgeon (ST) using electromagnetic (Medtronic) computer-assisted surgery with minimally invasive surgery total knee arthroplasty technique (CAS-MIS-TKA) and the other group of 40 patients (40 knees) had TKA by the same surgeon using the same minimally invasive surgery total knee arthroplasty (MIS-TKA) technique without the navigation. The inclusion criteria were the patients who had osteoarthritis of the knee and failed in non-operative treatment. The exclusion criteria were the patients with history of bleeding tendency, abnormal coagulogram, liver disease and taking anticoagulant. The CAS-MIS-TKA group consisted of 33 female and 7 male who had a mean age of 70.8 years (49-82) and the mean hematocrit of 37.91% (30-46.8). The MIS-TKA group consisted of 34 female and 6 male who had a mean age of 70.15 years (52-83) and the mean hematocrit of 37.67% (30.1-44.5). Preoperative height, body weight and Knee Society scores (KSS)[19] of each patient were also measured (Table 1). Institutional Review Board approval was obtained for this study.

Table 1. Demographic and preoperative data of the study patients

Demographic information	Operation technique		p-value
	CAS-MIS-TKA (n = 40)	MIS-TKA (n = 40)	
Age (years)			
Mean (SD)	70.8 (7.84)	70.15 (7.76)	0.710
Median (min, max)	72 (49, 82)	71 (52, 83)	
Sex			
Female	33 (82.5%)	34 (85%)	0.765
Male	7 (17.5%)	6 (15%)	
Height (cm)			
Mean (SD)	154.6 (8.87)	156.47 (7.30)	0.305
Median (min, max)	153 (138, 178)	155 (140, 173)	
Body weight (kg)			
Mean (SD)	64.82 (11.39)	64.67 (10.10)	0.949
Median (min, max)	63.50 (46.50, 96)	64 (45, 87.5)	
Knee Society score (point)			
Mean (SD)	37.17 (13.67)	35.84 (14.31)	0.672
Median (min, max)	38.25 (12.25, 70)	35.37 (1.88, 63.5)	
Preoperative hematocrit			
Mean (SD)	37.91 (3.46)	37.67 (3.17)	0.810
Median (min, max)	38.5 (46.8, 30)	37.9 (30.1, 44.5)	

All procedures were performed using the same fixed-bearing posterior stabilized implant (Nexgen LPS, Zimmer, Warsaw, IN) together with the minimally invasive surgery technique. Patients had a regional anesthesia unless being contraindicated by a medical issue. The tourniquet pressure was 280 mmHg in all cases. The incision with typically less than 9 cm long, represented no more than twice the length of the patella. A minimidvastus was made, to allow the exposure of the knee without evertion of the patella. The CAS-MIS-TKA was performed using the electromagnetic (Medtronic) computer-assisted navigation system. The femoral tracker was placed beneath the vastus medialis obliquus muscle at the midsagittal line about 4 centimeters from the joint and the tibial tracker was placed on the medial tibial flare. The navigation was used throughout the procedure to guide the bone cuts in both coronal and sagittal plane as well as to verify the final component position (Fig. 1). For the MIS-TKA group, the distal femoral resection was performed using the intramedullary technique and the proximal tibial resection was performed by extramedullary technique (Fig. 2). All components (femoral, tibial, and patellar) were cemented. The size of 10 drains was placed in all cases for 24 hours, and clamped for 2 hours after the operation.

Both patient groups had the same postoperative pain control and rehabilitation consisting of a multimodal approach, which aims to avoid the parenteral narcotics and to achieve the early postoperative mobilization. The blood loss from the drain, volume of blood transfusion, and the operative time were recorded. The 3 milliliters of patients' blood at 48 hours post-operation were collected for the calculation of the whole blood loss. The hematocrit less than 30 percent was the indication for blood transfusion. The whole blood loss was calculated by the following equations of Nadler et al[20-22].

Whole blood loss = (Total red blood cell volume loss x 100) / Average hematocrit

where

Total red blood cell volume loss (milliliters) = [PBV x ($Hct_{pre\text{-}op}$-$Hct_{post\text{-}op}$)] + PRC

PBV = patient blood volume (milliliters)

PBV = [k_1 x height (m)^3] + [k_2 x weight (kg)] + k_3

$k_1 = 0.3669$, $k_2 = 0.03219$, $k_3 = 0.6041$ for the male patient

$k_1 = 0.3561$, $k_2 = 0.03308$, $k_3 = 0.1833$ for the female patient

$Hct_{pre\text{-}op}$ = preoperative hematocrit

$Hct_{post\text{-}op}$ = 48 hours postoperative hematocrit

PRC = volume of blood transfusion (ml)

Fig. 1 The use of the electromagnetic computer navigation (CAS-MIS-TKA) for the guide to resect distal femur

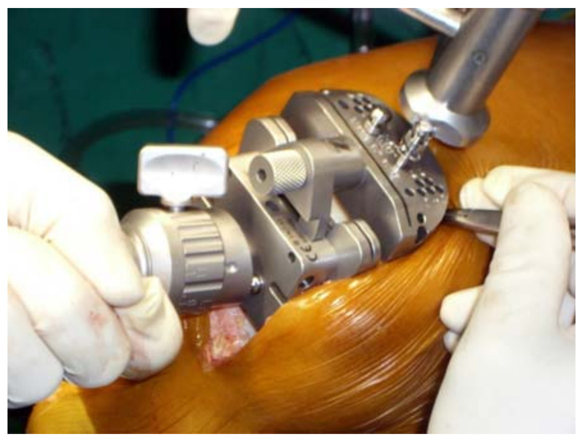

Fig. 2 The use of the intramedullary cutting guide to resect distal femur with the technique MIS-TKA

Statistical analysis

Demographic and preoperative data of both groups of patients were compared using independent t-test (student t-test) and Chi-square. The whole blood loss of both groups were compared with independent t-test with statistically significance when p-value ≤ 0.05. We used SPSS version 10 (SPSS Inc, Chicago, IL) for all analyses.

Results

Demographic data of studied patients which there was no any factor considered having significant

Table 2. Comparative analysis of blood loss (data shown as mean and standard deviation)

Variable	CAS-MIS-TKA (n = 40)	MIS-TKA (n = 40)	p-value
Whole blood loss (ml)	948.45 (431.63)	1,075.32 (419.02)	0.186
Blood transfusion (ml)	142.50 (168.14)	176.75 (175.83)	0.376
Blood loss from the drainage (ml)	389.88 (215.57)	425.25 (269.40)	0.519
Operative time (min)	157.00 (21.57)	139.00 (24.92)	<0.001

different was shown in Table 1. The mean blood loss from the drainage, the mean whole blood loss and the mean blood transfusion of the CAS-MIS-TKA group were less than those of the MIS-TKA group but there was no significance difference. The mean blood loss from the drainage was about 389.88 $\pm$ 215.57 ml in the CAS-MIS-TKA group and 425.25 $\pm$ 269.40 ml in the MIS-TKA group, which were not significant different (p-value = 0.519). The mean whole blood loss was about 948.45 $\pm$ 431.63 ml in the CAS-MIS-TKA group and 1075.32 $\pm$ 419.02 ml in the MIS-TKA group (p-value 0.186), which was not significantly different. The mean blood transfusion of the CAS-MIS-TKA group was 142.50 $\pm$ 168.14 milliliters and that of the MIS-TKA group was 176.75 $\pm$ 175.83 milliliters, which were also not significantly different (p-value = 0.376). The mean operative time of the MIS-TKA group was lower than that of the CAS-MIS-TKA group about 18 minutes resulting in a significant difference (p-value < 0.001) (Table 2).

Discussion

It was found that using the electromagnetic computer navigation in MIS-TKA (CAS-MIS-TKA) with cemented prosthesis did not significantly reduce the quantity of blood loss from the surgery.

Conteduca and associates[23] reported that the computer-assisted surgery in total knee arthroplasty (CAS-TKA) could be useful in reducing the overall blood loss. It was found that the average blood loss in the patients who were treated by a TKA without the computer's navigation (conventional technique) was 1,974 ml (450-3,930 ml) whereas in the patients who have surgery using by the computer-assisted technique was 1,677 ml (500-2,634 ml).

Kalairrajah and associates[17] reported a mean postoperative drainage of 1,351 ml in the CAS-TKA group comparing to 1,747 ml in the conventional group. They suggested that to minimize the blood loss, the violation of the medullary canal with CAS should be avoided. The result from this study differed from those reported in the studies of Conteduca and Kalairajah.

Our study showed the lower mean of blood loss observed in CAS-MIS-TKA group comparing to MIS-TKA, however, these differences were not statistical significant. In addition, comparing to those reported in Conteduca and Kalairajah's studies, we observed the lower blood loss in two groups.

The limitation of this study included the non-randomization of patients participated in the study, however, we found there is no statistical difference in all demographic variables among two patients group.

The computer-navigated surgery and minimally invasive surgery of TKA are both emerging technologies that have their own strengths and weaknesses. The computer navigation technique provided greater accuracy of the component position and alignment but it took more operative time[14-16], whereas the minimally invasive TKA can effectively reduce the postoperative pain, shorten the recovery time, and improve patients' knee function. However, it has been associated with a higher number of complications and failures[8,10,12,13]. The combination of computer-assisted surgery and MIS in TKA is an attempt to improve the patient outcomes. More experience in performing this technique and longer follow-up period for patients will give us further detailed clinical evidence

References

1. Ranawat CS, Flynn WF Jr, Saddler S, Hansraj KK, Maynard MJ. Long-term results of the total condylar knee arthroplasty. A 15-year survivorship study. Clin Orthop Relat Res 1993; (286): 94-102.
2. Stern SH, Insall JN. Posterior stabilized prosthesis. Results after follow-up of nine to twelve years. J Bone Joint Surg Am 1992; 74: 980-6.
3. 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.
4. Malkani AL, Rand JA, Bryan RS, Wallrichs SL. Total knee arthroplasty with the kinematic condylar prosthesis. A ten-year follow-up study. J Bone Joint Surg Am 1995; 77: 423-31.
5. Scott RD, Volatile TB. Twelve years' experience with posterior cruciate-retaining total knee arthroplasty. Clin Orthop Relat Res 1986; (205): 100-7.
6. Ritter MA, Herbst SA, Keating EM, Faris PM, Meding JB. Long-term survival analysis of a posterior cruciate-retaining total condylar total knee arthroplasty. Clin Orthop Relat Res 1994; (309): 136-45.
7. Bonutti PM, Mont MA, McMahon M, Ragland PS, Kester M. Minimally invasive total knee arthroplasty. J Bone Joint Surg Am 2004; 86-A (Suppl 2): 26-32.
8. Seyler TM, Bonutti PM, Ulrich SD, Fatscher T, Marker DR, Mont MA. Minimally invasive lateral approach to total knee arthroplasty. J Arthroplasty 2007; 22: 21-6.
9. Tria AJ Jr. Minimally invasive total knee arthroplasty: the importance of instrumentation. Orthop Clin North Am 2004; 35: 227-34.
10. Huang HT, Su JY, Chang JK, Chen CH, Wang GJ. The early clinical outcome of minimally invasive quadriceps-sparing total knee arthroplasty: report of a 2-year follow-up. J Arthroplasty 2007; 22: 1007-12.
11. Tashiro Y, Miura H, Matsuda S, Okazaki K, Iwamoto Y. Minimally invasive versus standard approach in total knee arthroplasty. Clin Orthop Relat Res 2007; 463: 144-50.
12. Chin PL, Foo LS, Yang KY, Yeo SJ, Lo NN. Randomized controlled trial comparing the radiologic outcomes of conventional and minimally invasive techniques for total knee arthroplasty. J Arthroplasty 2007; 22: 800-6.
13. King J, Stamper DL, Schaad DC, Leopold SS. Minimally invasive total knee arthroplasty compared with traditional total knee arthroplasty. Assessment of the learning curve and the post-operative recuperative period. J Bone Joint Surg Am 2007; 89: 1497-503.
14. Chin PL, Yang KY, Yeo SJ, Lo NN. Randomized control trial comparing radiographic total knee arthroplasty implant placement using computer navigation versus conventional technique. J Arthroplasty 2005; 20: 618-26.
15. Ensini A, Catani F, Leardini A, Romagnoli M, Giannini S. Alignments and clinical results in conventional and navigated total knee arthroplasty. Clin Orthop Relat Res 2007; 457: 156-62.
16. Seon JK, Song EK. Navigation-assisted less invasive total knee arthroplasty compared with conventional total knee arthroplasty: a randomized prospective trial. J Arthroplasty 2006; 21: 777-82.
17. Kalairajah Y, Simpson D, Cossey AJ, Verrall GM, Spriggins AJ. Blood loss after total knee replacement: effects of computer-assisted surgery. J Bone Joint Surg Br 2005; 87: 1480-2.
18. DiGioia AM 3rd. Surgical navigation and robotics for adult reconstruction and trauma. Instructional Course Lecture. Rosemont, IL: American Academy of Orthopaedic Surgeons. 2002.
19. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989; (248): 13-4.
20. Nadler SB, Hidalgo JU, Bloch T. Prediction of blood volume in normal human adult. Surgery 1962; 51: 224-32.
21. Bourke DL, Smith TC. Estimating allowable hemodilution. Anesthesiology 1974; 41: 609-12.
22. Gross JB. Estimating allowable blood loss: corrected for dilution. Anesthesiology 1983; 58: 277-80.
23. Conteduca F, Massai F, Iorio R, Zanzotto E, Luzon D, Ferretti A. Blood loss in computer-assisted mobile bearing total knee arthroplasty. A comparison of computer-assisted surgery with a conventional technique. Int Orthop 2008 Sep 2. DOI 10.1007/s00264-008-0651-7.

การศึกษาเปรียบเทียบปริมาณการเสียเลือดจากการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมแบบเนื้อเยื่อบาดเจ็บน้อยระหว่างการใช้และไม่ใช้การนำร่องด้วยคอมพิวเตอร์แบบอิเล็กทรอแมกเนติก

สาธิต เที่ยงวิทยาพร, เดชชาติ จันทร์ศรี, อารี ตนาวลี

วัตถุประสงค์*: เพื่อศึกษาเปรียบเทียบปริมาณการเสียเลือด จากการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมแบบเนื้อเยื่อบาดเจ็บน้อย ระหว่างการใช้และไม่ใช้คอมพิวเตอร์แบบอิเล็กทรอแมกเนติกนำร่อง*

วัสดุและวิธีการ*: เป็นการศึกษาโดยการสังเกตเชิงวิเคราะห์ชนิดไปข้างหน้า โดยตรวจวัดและเปรียบเทียบปริมาณการเสียเลือดในผู้ป่วยโรคข้อเข่าเสื่อมจำนวน 80 คน ที่ได้รับการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมแบบเนื้อเยื่อบาดเจ็บน้อย โดยแบ่งเป็นกลุ่มใช้คอมพิวเตอร์นำร่องจำนวน 40 คน และกลุ่มไม่ใช้คอมพิวเตอร์นำร่องจำนวน 40 คน ผู้ป่วยทั้งสองกลุ่มจะได้รับการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมโดยศัลยแพทย์คนเดียวกัน และใช้วิธีการเดียวกันในการเปิดเข้าหาข้อเข่ารวมถึงการดูแลทั้งก่อนและหลังผ่าตัด*

ผลการศึกษา*: ปริมาณเลือดจาก drain ของกลุ่มผู้ป่วยที่ใช้คอมพิวเตอร์นำร่องพบว่า มีปริมาณน้อยกว่ากลุ่มที่ไม่ใช้คอมพิวเตอร์นำร่อง (389.88 $\pm$ 215.57 มิลลิลิตร และ 425.25 $\pm$ 269.40 มิลลิลิตร) แต่ไม่มีนัยสำคัญทางสถิติ และปริมาณการเสียเลือดทั้งหมดของกลุ่มที่ใช้คอมพิวเตอร์นำร่องก็น้อยกว่ากลุ่มที่ไม่ใช้คอมพิวเตอร์นำร่อง (948.45 $\pm$ 431.63 มิลลิลิตร และ 1,075.32 $\pm$ 419.02 มิลลิลิตร) แต่ไม่มีนัยสำคัญทางสถิติเช่นกัน*

สรุป*: ปริมาณการเสียเลือดจากการผ่าตัดเปลี่ยนข้อเข่าเทียม แบบเนื้อเยื่อบาดเจ็บน้อยโดยวิธีใช้คอมพิวเตอร์แบบอิเล็กทรอแมกเนติกนำร่อง และวิธีไม่ใช้คอมพิวเตอร์นำร่องไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ*