Accuracy of Postoperative Leg Alignment and Postoperative Parameters between Three Different Techniques, Conventional, Computer-Assisted Navigation, and Minimally Invasive Navigation Technique

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Objective: Compare conventional total knee arthroplasty [TKA], image-free computer-assisted navigation technique [CAN]-TKA, and combined CAN and minimally invasive surgery technique [MIS-CAN] TKA in terms of postoperative leg alignment and the following postoperative parameters, blood loss, time to start walking, pain score, and hospital stay. The secondary objective is to compare safety and early adverse events between conventional, CAN, and MIS-CAN TKA.

Materials and Methods: Patients with osteoarthritis that underwent TKA in Vejthani TJR Center, Vejthani Hospital and satisfied the eligibility criteria were included in the present study. The patients were classified intro three groups based on the surgical procedure employed, Group 1, conventional surgical TKA technique, Group 2, CAN-TKA, and Group 3, MIS-CAN TKA.

Results: Comparison of mean mechanical axis between the three techniques showed that the conventional technique (mean 1.529, SD 2.241) appeared to have more varus as compared to CAN (mean 0.795, SD 1.232) and MIS-CAN (mean 0.803, SD 1.304). However, the mean differences were not statistically significant ($p = 0.06$). Accuracy of postoperative leg alignment (within ±3°) was best observed in CAN group (98.28%) as compared to MIS-CAN group (93.15%) and conventional group (80.71%) ($p<0.001$). MIS-CAN had the longest operative time ($p<0.001$) with a mean difference of about 10 minutes from conventional group ($p<0.001$) and CAN group ($p<0.001$). Post-operative blood loss was lower for MIS-CAN group than conventional group ($p<0.001$), but no statistical significant differences were seen between conventional and CAN groups ($p = 0.19$), and MIS-CAN and CAN groups ($p = 0.06$). In the present study, operative time was not statistically different between CAN and conventional groups ($p = 0.51$). Time to start walking, and length of hospital stay were lower for MIS-CAN group as compared to conventional ($p<0.001$) and CAN groups ($p<0.001$). Complications or adverse events such as revision for any reason, pin tract fracture, deep infection, or deep venous thrombosis or pulmonary embolism were not observed within two years post-surgery. Superficial infection was observed in one patient (0.7%) in the conventional group and two patients (0.9%) in the MIS-CAN group.

Conclusion: Postoperative leg alignment accuracy (within ±3°) was shown to be best in CAN with conventional approach as compared to MIS-CAN and conventional groups. In MIS-CAN group, computed assisted navigation can prevent increase in potential outliers and improve accuracy of surgical procedure when compared with conventional group ($p = 0.003$), and can maintain the benefit of MIS approach in term of less blood loss, shortest operative duration length of hospital stay, and time to ambulate post-operation. CAN in TKA was proved to be safe without noted increase in complications within two years post-surgery.

Keywords: Total knee arthroplasty, Computer-assisted navigation, Minimally-invasive navigation

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Minimally invasive surgery [MIS] for total knee replacement has been performed with the aim of achieving faster recovery time, less pain, less blood loss, and shorter incision length[1,2]. However, MIS has been reported to induce possible complications, including early implant failure from implant malposition[3]. Computer-assisted navigation [CAN] in total knee replacement, on the other hand, has been demonstrated to increase accuracy of implant placement and soft tissue balance with more reproducible component alignment compared to the conventional technique[4-6]. The combination of CAN and MIS techniques has been reported in several studies with varying results[7-9]. In one study, it was reported that the higher incidence of complications, in addition to the longer operative time in the navigated group may outweigh any potential

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radiographic benefits[7]. In another study, it was reported that computer-assisted total knee arthroplasty [TKA] provides a better correction of alignment of the leg compared with jig-based TKA when combined with a minimally invasive surgical approach[8] and CAN combined with MIS in TKA maintain the accuracy of component alignment despite the minimally invasive approach[9]. The objectives of this study were, 1) to compare conventional TKA, CAN-TKA, and MIS-CAN TKA in terms of postoperative leg alignment, blood loss, time to start walking, pain score, and hospital stay, and 2) to compare safety and early adverse events between conventional, CAN, and MIS-CAN TKA.

Materials and Methods

Patients with osteoarthritis that underwent total knee replacement between January 2009 and August 2011, in Vejthani TJR Center, Vejthani Hospital were invited to participate in this research. Those who satisfied the eligibility criteria in Table 1 were included in this study. The patients were classified intro three groups based on the surgical procedure employed, Group 1, conventional surgical TKA technique, Group 2, image-free CAN technique, and Group 3, combined CAN and MIS technique. All operations were performed by a single surgeon. The benefits and risks of the three surgical procedures were explained to the patients and each patient decided their preferred surgical procedure. Ethical approval was granted by the same hospital. The procedure was performed under tourniquet, which was inflated before the surgery started and deflated after the dressing was applied. Surgical approach in Group 1 and Group 2 were done through midline incision medial retinacular approach. In Group 1, conventional jig instrument technique was performed. In Group 2, image-free CAN technique by the Brainlab Ci system (Brainlab AG, Feldkirchen, Germany) with gap technique workflow was done while in Group 3, a combination between image-free CAN technique and minimally invasive mid-vastus approach was performed. Arrays in Group 2 and 3 were fixed outside the skin incision by two-pin technique. Patella was not resurfaced for all surgeries performed. LCS Complete and P.F.C Sigma knee system (DePuy Orthopaedics, Inc., Warsaw, IN) with cemented fixation were used for all knee replacements. Compressive dressing and Redivac™ drain (UC Components, Inc., Morgan Hill, CA) were removed when blood content was less than 50 cc/hour in the last 2 hours. The criteria to remove foley catheter were based on urine output, stability of vital signs, and plan to start walking. The patients were allowed to walk after foley catheter and drain were removed, when general condition was stable, and when patient had shown willingness to walk. Criteria to discharge patients were ability to get in and get up of bed independently, ability to walk with walker for at least 15 meters, acceptable wound condition, pain score less than 5, and stable medical condition. All outcomes were collected prospectively. The postoperative leg alignment was quantified based on radiographic measurement of postoperative mechanical axis. Total knee prosthesis operative time (minutes), total blood loss (ml), length of hospital stay (days), and time to start walking (days) were also recorded. Postoperative radiographic (digital film scannogram) measurement of leg alignment in coronal plane (mechanical axis) was done by a single person using a blinded technique. Outliers were identified as those having leg alignment measurement less than -3 degrees or greater than 3 degrees. Occurrence of intraoperative and postoperative complications or revision by any reason within two years post-surgery was recorded. Comparison of interval or ratio variables were analyzed using Kruskall-Wallis test and multiple comparisons using Mann-Whitney U test with Bonferonni correction were performed. Non-parametric tests were performed since Shapiro-Wilk test and Bartlett's test suggested that the variables were not normally distributed, and variances were not homogenous. Chi-square test or Fisher's exact test was performed to compare categorical variables. Bonferroni corrections were performed for multiple tests. All parameters were analyzed using Stata version 13 (StataCorp, College Station, TX).

Table 1. Inclusion criteria and exclusion criteria

Inclusion criteria	Exclusion criteria
Age 40 to 85 years old	Inflammatory joint disease
Deformity varus <20 degrees	Previous knee surgery in operate site
Deformity valgus <20 degrees	Failure of computer-assisted navigation for any reason
Flexion contracture <20 degrees	

Results

The demographic data of participants in the three groups are presented in Table 2. Mean (SD) of operative time (minutes), post-operative blood loss (cc), time to start walking (hours), length of hospital stay (days), and post-operative pain score (10 point pain scale) per group are presented in Table 3. Comparisons between the three groups for these outcomes (Figure 1) were all statistically significant ($p<0.001$) except for pain score ($p = 0.16$). MIS-CAN had the longest operative time (79.68) with a mean difference of about 11 to 12 minutes from conventional group ($p<0.001$) and CAN group ($p<0.001$). On the other hand, time to start walking, and length of hospital stay were lower for MIS-CAN group as compared to conventional ($p<0.001$) and CAN groups ($p<0.001$). Post-operative blood loss was lower for MIS-CAN group compared to conventional group ($p<0.001$), but no statistical significant differences were seen between MIS-CAN and CAN groups ($p = 0.06$). Accuracy of postoperative leg alignment (within ±3 degrees) was best observed in CAN group (98.28%) as compared to MIS-CAN group (93.15%) and conventional group (80.71%) ($p<0.001$).

Comparison of mean mechanical axis between the three techniques showed that the conventional technique (mean 1.529, SD 2.241) appeared to have more varus as compared to CAN (mean 0.795, SD 1.232) and MIS-CAN (mean 0.803, SD 1.304) (Table 4). However, the differences were not statistically significant ($p = 0.06$). Complications or adverse events such as revision for any reason, pin tract fracture, deep infection, or deep venous thrombosis or pulmonary embolism were not observed within the two years post-surgery. Superficial infection was observed in one patient (0.7%) in the conventional group and two patients (0.9%) in the MIS-CAN group.

Table 2. Demographic data

Demographic data	Group 1 (conventional)	Group 2 (CAN)	Group 3 (MIS-CAN)	*p*-value
Total cases (n)	140	58	219	
Average age (year)				0.001*#
Mean (SD)	68.36 (8.81)	64.79 (9.23)	64.84 (8.30)	
Range	32 to 86	39 to 81	43 to 86	
Sex, n (%)				0.330†
Male	39 (27.86)	40 (68.97)	169 (77.17)	
Female	101 (72.14)	18 (31.03)	50 (22.83)	
BMI (kg/m^2)				0.389‡
Mean (SD)	31.16 (7.34)	30.24 (8.61)	30.29 (6.16)	
Range	19.76 to 64.5	16.9 to 69.4	16.83 to 53.4	

CAN = computer-assisted navigation; MIS = minimally invasive surgery; BMI = body mass index

* Statistically significant, # Oneway ANOVA, † Chi-square test, ‡ Kruskall-Wallis test

Table 3. Intraoperative and postoperative data and outcomes

Data collection	Group 1 (conventional)	Group 2 (CAN)	Group 3 (MIS-CAN)	*p*-value
Operative time (minutes), mean (SD)	68.12 (20.23)	69.13 (16.94)	79.68 (18.25)	<0.001
G1 vs. G2 (Conventional vs. CAN)				0.511
G2 vs. G3 (CAN vs. MIS-CAN)				<0.001*
G1 vs. G3 (Conventional vs. MIS-CAN)				<0.001*
Postoperative blood loss (cc), mean (SD)	494.02 (218.92)	448.62 (199.64)	392.28 (187.49)	<0.001
G1 vs. G2 (conventional vs. CAN)				0.191
G2 vs. G3 (CAN vs. MIS-CAN)				0.055
G1 vs. G3 (conventional vs. MIS-CAN)				<0.001*
Time to start walking (hours), mean (SD)	42.86 (15.58)	39.90 (11.17)	21.51 (7.19)	<0.001
G1 vs. G2 (conventional vs. CAN)				0.383
G2 vs. G3 (CAN vs. MIS-CAN)				<0.001*
G1 vs. G3 (conventional vs. MIS-CAN)				<0.001*
Hospital stay (days), mean (SD)	7.70 (3.73)	7.26 (2.94)	5.35 (1.32)	<0.001*
G1 vs. G2 (conventional vs. CAN)				0.551
G2 vs. G3 (CAN vs. MIS-CAN)				<0.001*
G1 vs. G3 (conventional vs. MIS-CAN)				<0.001*
Postoperative pain score, mean (SD)	3.42 (1.25)	2.96 (1.34)	3.56 (1.55)	0.177
G1 vs. G2 (conventional vs. CAN)				0.164
G2 vs. G3 (CAN vs. MIS-CAN)				0.096
G1 vs. G3 (conventional vs. MIS-CAN)				0.942

CAN = computer-assisted navigation; MIS = minimally invasive surgery

* Statistically significant

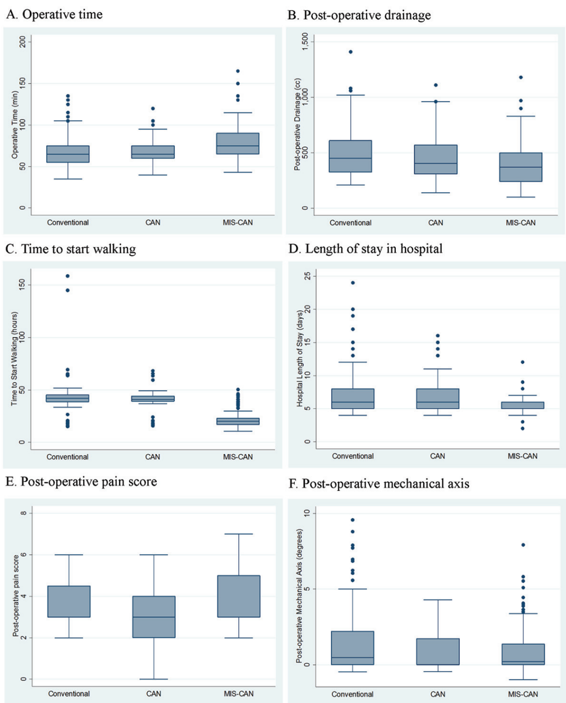

Figure 1. Comparison of intraoperative and postoperative outcomes.

Discussion

This research showed the benefit of MIS-CAN over conventional surgery and/or MIS on post-operative leg alignment and postoperative outcomes. Postoperative blood loss was shown to be lower in MIS-CAN group than the two groups. This is similar to a previously reported study in Thailand that there was less postoperative blood loss in MIS-CAN (541 cc) than CAN groups (588 cc)[10]. Blood loss in Group 2 was less than in Group 1 because gap technique work flow was performed in CAN, which resulted into more accurate soft tissue balance with less soft tissue trauma. In the study of Lüring et al, MIS group had a lower intraoperative blood loss (hemoglobin: 2.1 g/dl), followed by conventional (2.5 g/dl), and CAS-MIS (2.5 g/dl)[11]. Operative time difference between Group 1 and 2 were similar, which suggested that TKA with CAN for an experienced surgeon did not increase operative time as compared to conventional TKA surgical procedure. Albeit MIS-CAN TKA operative time was longer than conventional technique by 12 minutes, the difference was not large, especially when the potential benefits of CAN with MIS in preventing complications as compared to MIS alone

Table 4. Postoperative mechanical axis

Postoperative mechanical axis	Group 1 (conventional) n = 140	Group 2 (CAN) n = 58	Group3 (MIS-CAN) n = 219	*p*-value
Neutral alignment within -1<0<1 degree (±0.99 degrees), n (%)	82 (58.57)	40 (68.97)	151 (68.95)	0.110†
G1 vs. G2 (Conventional vs. CAN)				0.170†
G2 vs. G3 (CAN vs. MIS-CAN)				0.998†
G1 vs. G3 (Conventional vs. MIS-CAN)				0.045†
Leg alignment within -1 ≤ 0 ≤ 1 degree (±1 degrees), n (%)	82 (58.57)	40 (68.97)	157 (71.69)	0.080†
G1 vs. G2 (Conventional vs. CAN)				0.170†
G2 vs. G3 (CAN vs. MIS-CAN)				0.680†
G1 vs. G3 (Conventional vs. MIS-CAN)				0.010†
Leg alignment within -2 ≤ 0 ≤ 2 degrees (±2 degrees), n (%)	100 (71.43)	54 (93.10)	187 (85.39)	0.001*†
G1 vs. G2 (Conventional vs. CAN)				0.001*†
G2 vs. G3 (CAN vs. MIS-CAN)				0.120
G1 vs. G3 (Conventional vs. MIS-CAN)				0.001*†
Leg alignment within -3 ≤ 0 ≤ 3 degrees (±3 degrees), n (%)	113 (80.71)	57 (98.28)	204 (93.15)	0.001*†
G1 vs. G2 (Conventional vs. CAN)				0.001*†
G2 vs. G3 (CAN vs. MIS-CAN)				0.140††
G1 vs. G3 (Conventional vs. MIS-CAN)				0.003*†
Outlier: <-3 degrees or >3 degrees (outside ±3 degrees), n (%)	27 (19.29)	1 (1.72)	15 (6.85)	0.001*†
G1 vs. G2 (Conventional vs. CAN)				0.001*†
G2 vs. G3 (CAN vs. MIS-CAN)				0.140††
G1 vs. G3 (Conventional vs. MIS-CAN)				0.003*†
Mean mechanical axis, mean (SD)	1.529 (2.241)	0.795 (1.232)	0.803 (1.304)	0.060‡
G1 vs. G2 (Conventional vs. CAN)				0.049‡‡
G2 vs. G3 (CAN vs. MIS-CAN)				0.550‡‡
G1 vs. G3 (Conventional vs. MIS-CAN)				0.040‡‡

CAN = computer-assisted navigation; MIS = minimally invasive surgery

* Statistically significant, † Chi-square test, †† Fisher's exact test, ‡ Kruskall-Wallis test, ‡‡ Mann-Whitney U test

was taken in consideration. Duration of time to ambulate was faster for MIS-CAN versus CAN, which had similar results to the previous study wherein there was an approximately 20 hours difference between groups[10]. Length of hospital stay was shorter by two days for MIS-CAN versus CAN, similar to the results of the study by Biasca et al[12]. The difference of pain score between groups were not statistically significant, which may be because pain score was only recorded at the time of discharge, and patients who underwent MIS-CAN were reported to have experienced more pain especially at night. Postoperative accuracy of MIS-CAN had been demonstrated elsewhere in other studies[10-12]. In the present study, accuracy of postoperative leg alignment were shown to be highest in CAN as compared to MIS-CAN and conventional groups ($p<0.001$). Thus, the CAN technique may be recommended for the surgeon with an average experience. Furthermore, the combination of CAN and MIS techniques did not increase complications. MIS has been associated with rapid and early recovery after operation in previous studies[13]. However, the number of complications observed from low to medium volume surgeons were unacceptably high, especially in malposition and instability of prosthesis that caused early failure and early revision surgery[13]. In the present study, CAN was helpful to MIS-TKA in terms of increased accuracy of bone cut and gap balance in real time during operation, which improved accuracy of position of the prosthesis, less soft tissue injury, less blood loss, and good soft tissue balance. No early failure or early revision was presented. Therefore, a combination of CAN with MIS approach is recommended based on accuracy of postoperative leg alignment and no increase in complications. One limitation of the present study is that no randomization was performed. However, surgeons and staff were not involved in allocating the subjects into groups. Patients were allowed to self-select on the surgical procedure they wished to receive after they received information about the technique. This current research had a larger sample size as compared to previous studies[10-12]. All patients in the three groups were operated by a single experienced surgeon in both navigation and minimal invasive technique, within the same period of time. Functional outcomes after surgery was not within the scope of the present study and will be reported in the future studies.

Conclusion

Postoperative leg alignment accuracy (within ±3 degrees) was shown to be best in CAN with conventional approach as compared to MIS-CAN and conventional groups. In MIS-CAN group, computed assisted navigation can prevent increase in potential outliers and improve accuracy of surgical procedure when compared with conventional group ($p = 0.003$), and can maintain the benefit of MIS approach in term of less blood loss, shortest operative duration, length of hospital stay, and time to ambulate post-operation. CAN in TKA was proved to be safe without noted increase in complications within two years post-surgery.

What is already known on this topic?

Total knee replacement is one of the most popular procedure in orthopedic surgery that can improved the quality of life of the osteoarthritis knee patients. MIS for the total knee replacement has been performed with the aim of achieving faster recovery time, less pain, less blood loss, and shorter incision length[1,2]. However, MIS has been reported to induce possible complications, including early implant failure from implant malposition[3]. CAN in total knee replacement has been demonstrated to increase accuracy of implant placement and soft tissue balance with more reproducible component alignment compared to conventional technique[4-6]. The combination of CAN and MIS techniques has been reported in several studies with varying results[7-9].

What this study adds?

From this research, postoperative leg alignment accuracy (within ±3 degrees) was shown to be best in CAN with conventional approach as compared to MIS-CAN and conventional groups. In MIS-CAN group, computed assisted navigation can prevent increase in potential outliers and improve accuracy of surgical procedure when compared with conventional group and can maintain the benefit of MIS approach in term of less blood loss, shortest operative duration, length of hospital stay, and time to ambulate post-operation. CAN in TKA was proved to be safe without noted increase in complications within two years post-surgery. MIS and computed assisted navigation are helpful for the improvement of the total knee replacement results for the patients.

Potential conflicts of interest

None.

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การศึกษาเปรียบเทียบถึงความถูกต้องของแนวขา และตัวชี้วัดอื่น ๆ ของเทคนิคการผ่าตัดผิวข้อเข่าเทียม 3 วิธี คือ แบบดั้งเดิม แบบชนิดใช้คอมพิวเตอร์นำร่องในการผ่าตัด และชนิดบาดเจ็บน้อยร่วมกับใช้คอมพิวเตอร์นำร่องในการผ่าตัด

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วัตถุประสงค์: เพื่อ 1) ศึกษาเปรียบเทียบถึงความถูกต้องของแนวขา และตัวชี้วัดอื่น ๆ หลังการผ่าตัด เช่น การสูญเสียเลือด เวลาที่เริ่มลงเดิน ระดับความเจ็บปวด และระยะเวลาที่อยู่ในโรงพยาบาล ของเทคนิคการผ่าตัดผิวข้อเข่าเทียม 3 วิธี คือ แบบดั้งเดิม (conventional) แบบชนิดใช้คอมพิวเตอร์นำร่องในการผ่าตัด (computer-assisted navigation [CAN]) และชนิดบาดเจ็บน้อยร่วมกับใช้คอมพิวเตอร์นำร่องในการผ่าตัด (minimally invasive navigation technique [MIS-CAN]) และ 2) เพื่อเปรียบเทียบถึงความปลอดภัย และผลอันไม่พึงปรารถนาของเทคนิคการผ่าตัดผิวข้อเข่าเทียม 3 วิธี คือ แบบดั้งเดิม แบบชนิดใช้คอมพิวเตอร์นำร่องในการผ่าตัด และชนิดบาดเจ็บน้อยร่วมกับใช้คอมพิวเตอร์นำร่องในการผ่าตัด

วัสดุและวิธีการ: เก็บข้อมูลผู้ป่วยข้อเข่าเสื่อมที่ได้รับการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมที่โรงพยาบาลเวชธานี โดยได้รับความเห็นชอบจากคณะกรรมการจริยธรรมการวิจัยโรงพยาบาลเวชธานี และผู้ป่วยได้เข้าร่วมในการศึกษาด้วยความเต็มใจ ซึ่งจะแบ่งผู้ป่วยตามเทคนิคที่ได้รับการผ่าตัดเป็น 3 กลุ่ม ดังนี้ คือ กลุ่มที่ 1 ผ่าตัดโดยวิธีแบบดั้งเดิม กลุ่มที่ 2 ผ่าตัดโดยวิธี CAN และกลุ่มที่ 3 ผ่าตัดโดยวิธี MIS-CAN

ผลการศึกษา: เมื่อเปรียบเทียบแนวแกนกลศาสตร์ของขา (mechanical axis) ของทั้ง 3 วิธี พบว่าแบบดั้งเดิม มีค่าเฉลี่ย 1.529, SD 0.241 องศา ซึ่งจะค่าเอียงโก่ง (varus) มากกว่า CAN ซึ่งมีค่าเฉลี่ย 0.795, SD 1.232 องศา และ MIS-CAN ซึ่งมีค่าเฉลี่ย 0.803, SD 1.304 องศา แต่ก็ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p = 0.06$) ในเรื่องของความถูกต้องของแนวขาหลังการผ่าตัด (ผิดพลาดไม่เกิน 3 องศา) พบว่าจะดีสุดใน CAN (98.28%) รองมา คือ MIS-CAN (93.15%) และแบบดั้งเดิมอยู่ที่ (80.71%) (ค่า $p<0.001$) ในตัวชี้วัดเรื่องระยะเวลาที่ใช้ในการผ่าตัด MIS-CAN ใช้เวลานานสุด และนานกว่าทั้ง 2 กลุ่มที่เหลืออย่างมีนัยสำคัญทางสถิติ ($p<0.001$) แต่ก็มากกว่าทั้ง 2 วิธี เฉลี่ยเพียง 10 นาที แต่ถ้าเปรียบเทียบระหว่างแบบดั้งเดิม และ CAN ไม่แตกต่างอย่างมีนัยสำคัญทางสถิติ ($p = 0.51$) ในตัวชี้วัดเรื่องการสูญเสียเลือด พบว่า ใน MIS-CAN เสียเลือดน้อยกว่าแบบดั้งเดิมอย่างมีนัยสำคัญทางสถิติ ($p<0.001$) แต่การสูญเสียเลือดไม่แตกต่างอย่างมีนัยสำคัญทางสถิติเมื่อเทียบระหว่างแบบดั้งเดิมกับ CAN ($p = 0.19$) เช่นเดียวกับเมื่อเปรียบเทียบระหว่าง CAN และ MIS-CAN ($p = 0.06$) ในการศึกษานี้ ระยะเวลาที่ใช้ในการเริ่มเดินหลังผ่าตัด และระยะเวลาที่อยู่ในโรงพยาบาล MIS-CAN ใช้น้อยกว่าเมื่อเทียบกับอีกทั้ง 2 กลุ่ม อย่างมีนัยสำคัญทางสถิติ ($p<0.001$) ในเรื่องภาวะแทรกซ้อน และภาวะอันไม่พึงประสงค์ เช่น การผ่าตัดแก้ไขใหม่ (revision) ไม่ว่าด้วยเรื่องใด ๆ ก็ตาม หรือ ภาวะกระดูกหักที่ตำแหน่งปักหมุดที่กระดูก หรือ การติดเชื้อ หรือ การเกิดการอุดตันของหลอดเลือดดำที่ขา การเกิดการอุดตันของลิ่มเลือดที่ปอด ทั้งหมดนี้ไม่มีเกิดขึ้นที่ 2 ปี หลังการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมในการศึกษานี้ แต่มีการพบติดเชื้อใต้ผิวหนังชนิดตื้น 1 ราย ในแบบดั้งเดิม (0.7%) และพบ 2 ราย ใน MIS-CAN (0.9%)

สรุป: ความถูกต้องของแนวขาหลังการผ่าตัด (ผิดพลาดไม่เกิน 3 องศา) พบว่าจะดีสุดในกลุ่มที่ 2 ผ่าตัดโดยวิธี CAN (98.28%) เมื่อเปรียบเทียบกับอีก 2 เทคนิคในการศึกษานี้ เทคนิคผ่าตัดโดยวิธี MIS-CAN นี้ สามารถที่จะช่วยในการป้องกันการผิดพลาดของแนวขาและยังช่วยเพิ่มความถูกต้องของการผ่าตัดเปลี่ยนผิวข้อเข่าเทียมเมื่อเทียบกับเทคนิคแบบดั้งเดิม ($p = 0.003$) และยังคงช่วยรักษาประโยชน์ของเทคนิคการผ่าตัดแบบบาดเจ็บน้อย ในปัจจัยเรื่องการสูญเสียเลือดหลังการผ่าตัดลดลง ลดระยะในการนอนโรงพยาบาล และสามารถเริ่มเดินได้เร็วขึ้นหลังการผ่าตัดเปลี่ยนผิวข้อเข่าเทียม การใช้คอมพิวเตอร์นำร่องในการผ่าตัดเปลี่ยนผิวข้อเข่าเทียม พิสูจน์แล้วว่ามีความปลอดภัยและไม่ก่อให้เกิดภาวะแทรกซ้อน และภาวะอันไม่พึงประสงค์เกิดขึ้นที่ 2 ปี หลังการผ่าตัดเปลี่ยนผิวข้อเข่าเทียม