

Superior alignment but no difference in clinical outcome after minimally invasive computer-assisted unicompartmental knee arthroplasty (MICA-UKA)

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Abstract

Purpose Variety of clinical trials have been published comparing the alignment of MICA-UKA with MI-UKA. However, to the best of our knowledge, no published study has showed whether radiological alignment by MICA-UKA has influence on the clinical results. The present study was conducted to compare the short-term results of MICA-UKA with MI-UKA. It was hypothesized that better alignment as well as clinical results was achieved by MICA-UKA as compared to MI-UKA.

Methods The clinical and radiological results of 87 subjects who underwent primary UKA using either minimally invasive and computer-assisted technique (45 patients, Group A) or minimally invasive technique (42 patients, Group B) were reported. Knee Society scores (KSSs), Knee Society functional scores (KSFSs), range of motion (ROM), and radiographic results were assessed and reported preoperatively and at 24-month follow-up. Total blood loss, operative time, and length of skin incision were compared.

Results The accuracy of the implantations in relation to the coronal mechanical axis in Group A was significantly superior to that of Group B ($P = 0.033$). The femoral rotational profile revealed the prosthesis in Group A that was implanted with significantly less internal rotation than Group B ($P = 0.025$). Clinical results, with regard to ROMs and KSSs, as well as KSFSs were equally good in both the groups. The average blood loss in patients of Group A was significantly reduced as compared to patients of Group B.

No significant difference was detected in terms of operative time or length of skin incision.

Conclusions It is suggested that MICA-UKA improves the implant alignment without increasing clinical results versus MI-UKA. We advocate that computer navigation should be considered when minimally invasive unicompartmental knee arthroplasty is performed.

Level of evidence Therapeutic study, Level II.

Keywords Unicompartmental knee arthroplasty · Minimally invasive surgery · Clinical outcome · Short-term results · Computer assisted

Introduction

Unicompartmental knee arthroplasty is a treatment option for unicompartmental osteoarthritis with a long-term survival rate of about 95 %, which is similar to the survival rate of total knee arthroplasty [12, 14]. After its introduction as a minimally invasive technique, UKA has attracted considerable attention.

Unfortunately, minimally invasive techniques can make implant positioning more difficult by limiting visualization of anatomical landmarks [15, 20, 24]. Recently, after initial enthusiasm, some authors have recommended caution while using mini-invasive techniques for UKA [20]. It has been stated that although UKA performed using a minimal incision may possess some early advantages, minimal incisions can impede surgeons' vision and may influence component alignment and possibly compromise long-term outcome.

The rationale for combining computer-assisted UKA and mini-invasive techniques is that the reduction in perioperative morbidity and the improvement in early

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post-operative function that are achieved with less invasive exposures can be realized while retaining the accuracy of implant and limb alignment that can be achieved with computer techniques, even when crucial surgical anatomical landmarks are not visible [1, 4–7, 17, 19, 21]. Despite some encouraging evidence in the literature, the clinical benefits of MICA-UKA are still unclear. For instance, in a review conducted by Nair et al. [13], it was demonstrated that in the navigated group, implant alignment was optimal in the desired angular range more often, and there were fewer outliers; however, the groups did not differ with respect to clinical knee scores, survival rates, or range of motion, while Lim et al. [7] did not demonstrate any improvement in post-operative axial limb alignment measurement in using a computer navigation system compared to conventional non-navigation technique.

The purpose of this present study was to present the results of a prospective, randomized study which compare the 24-month results of MICA-UKA with MI-UKA. It is hypothesized that the excellent alignments achieved using MICA-UKA would improve short-term clinical results versus MI-UKA.

Materials and methods

We conducted a prospective, randomized short-term clinical study, which was approved by ethic committee of the Affiliated Taizhou people's Hospital of Nantong University. All subjects who were candidates for UKA at our institution from January 2006 to December 2010 were considered for inclusion. The inclusion criteria were pain in a single compartment secondary to osteoarthritis or necrosis, age >60 years, weight <82 kg, sedentary lifestyle, range of motion >90°, flexion contracture <5°, and angular deformities <10°–15°. Exclusion criteria included systemic or inflammatory arthritis (i.e. rheumatoid or gouty arthritis), knee instability or subluxation, fixed flexion contracture, loss of anterior or posterior cruciate ligaments, and intraoperative finding of eburnated bone in either the patella or the opposite compartment. Written informed consent was taken by all subjects.

After an informed consent, subjects were randomly assigned to either the computer-assisted MI-UKA group (Group A) or traditional MI-UKA group (Group B) choosing one of two closed envelope by a nurse (YQD) not involved in the study, just prior to the skin incision. All UKAs were conducted by two of the authors (Z.X.Z. and W.Z.). All knee components were Zimmer MG II (Zimmer, Warsaw, IN). In MI-UKA group, a 7- to 9-cm skin incision was made from the superior medial edge of the patella and extended distally. In the MICA-UKA group, the implant was positioned and monitored by CT-free

computer-assisted alignment system (Vector Vision, version 1.52, BrianLAB, Munich, Germany), and the same minimally invasive surgical approach was performed. All prostheses were implanted using dedicated smaller instruments including cutting blocks specifically designed for minimally invasive surgery. All the implants were cemented, and the same preoperative and post-operative rehabilitation protocols were used for each case. Early weight bearing as tolerated was encouraged in all subjects. The duration of surgery was documented in each patient.

A total of the 87 subjects were enrolled in this study and randomized to the two groups, and 81 patients were available for the 24-month follow-up. In Group A, there were 40 subjects (18 men and 22 women) and the mean age was 62.4 ± 5.62 years. The dominant leg was affected in 19 patients. In Group B, there were 41 subjects (19 men and 22 women) and the mean age was 61.9 ± 6.11 years. The dominant leg was affected in 20 patients. No significant differences with regard to age, gender, affected leg, or BMI were detected when the two groups were compared (Table 1). No cases of infection, no neurovascular complications, and no patients need revision surgery in either group.

Anteroposterior, long leg, weight-bearing undigitized radiographs (a 320-mA, 0.03-s exposure at 80–100 kV, depending on soft tissue thickness) were taken. The coronal mechanical axes of the long leg just after operation and at 6-month follow-up were taken and evaluated. In addition, axial radiographs of the distal femur were taken at 24-month follow-up. The radiograph is an accepted method of evaluation of femoral component rotation with comparable reproducibility and correlated with CT results [14]. The coronal mechanical axis was the line drawn from the centre of the femoral head to the centre of the talocrural joint (Fig. 1). The angle between the clinical epicondylar axis (CEA, a line that connects the medial and lateral epicondylar prominences) and the posterior condylar axis (PCA) was defined as the condylar twist angle (CTA) in the radiographs (Fig. 2).

Table 1 Patient demographics

	Group A	Group B
No. of cases	40	41
Mean age (year)	62.4 ± 5.62	61.9 ± 6.11
Men/women	18/22	19/22
Mean height (m)	1.67 ± 0.12	1.66 ± 0.14
Mean weight (kg)	70.6 ± 7.11	73.1 ± 5.98
Mean BMI (kg/m^2)	24.3 ± 2.01	25.7 ± 2.32
Leg (left/right)	19/21	20/21

No significant difference was detected



Fig. 1 Coronal radiograph of lower extremity is shown. The coronal mechanical axis was the *line* drawn from the centre of the femoral head to the centre of the talocrural joint

ROM was measured preoperatively and at post-operative 24 months by one orthopaedic surgeon. The Knee Society clinical rating system, including evaluations of Knee Society score (KSS) and Knee Society functional score (KSFS), was evaluated at a preoperative visit as well as at post-operative 24-month follow-up. Moreover, adverse events, such as any complications or need for revision surgery, were recorded. Total blood loss, operative time, and length of skin incision were analysed. Intraoperative blood loss was estimated by weighing the sponges used, and the blood volume collected by suction. Post-operative blood loss was estimated by measuring the drain output until removal of the drain at 48 h.

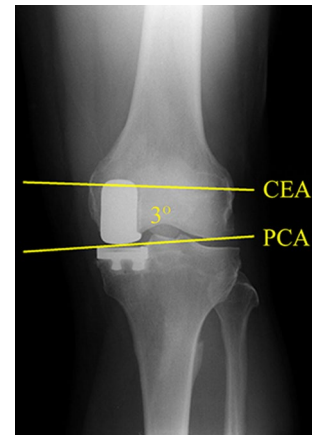


Fig. 2 Coronal radiograph of CTA is shown. The angle between the clinical epicondylar axis (a *line* that connects the medial and lateral epicondylar prominences) and the posterior condylar axis was defined as the condylar twist angle (CTA) in the radiographs

All evaluations were performed at least three times in each subject by two authors (L.X.Z. and Q.S.L.) blinded to clinical information, and the final judgment was defined based on these data.

Statistical analysis

Results were analysed statistically using a statistical software package (Stat Mate III; ATMS Co., Ltd., Tokyo, Japan). The differences in the clinical and radiographic results between the two groups were analysed using the non-paired Student's *t* test. Results in the same group at different time points were analysed using the paired Student's *t* test. Differences of $P < 0.05$ were considered statistically significant. Sample size calculated was 40 in MICA-UKA group and 41 in MI-UKA group.

Results

A significant improvement in terms of KSS score, the mean KSFS score, the mean pain score as well as mean ROM was investigated at 24-month follow-up examination in both groups showed as comparison to preoperative status, while no significant difference was detected between the two groups (Table 2).

The radiographic evaluations (Table 2) revealed that the preoperative coronal mechanical axis between the two groups was almost the same. The alignment of Group A at 24-month follow-up was significantly more varus than Group B. The mean angle differences between post-operation and 24-month follow-up were $0.8^\circ \pm 0.05^\circ$ and $0.7^\circ \pm 0.03^\circ$ in Group A and Group B, respectively. No statistically significant difference was noted between the two

Table 2 Clinical outcomes within and between Group A and Group B preoperatively and at 24-month follow-up

	Group A			Group B			Post-op
	Preop	Post-op	<i>P</i>	Preop	Post-op	<i>P</i>	<i>P</i>
KSS	47.5 ± 2.45	87.2 ± 3.22	<0.001	41.4 ± 1.43	87.2 ± 2.33	<0.001	n.s.
KSFS	48.2 ± 2.34	82.2 ± 4.2	<0.001	51.3 ± 2.5	82.2 ± 4.7	<0.001	n.s.
Pain	3.44 ± 0.32	8.55 ± 1.42	<0.001	4.21 ± 0.34	9.23 ± 1.43	<0.001	n.s.
ROM	108.1 ± 3.7	124.1 ± 4.9	0.038	106.1 ± 6.3	121.7 ± 7.4	0.015	n.s.
CMA ^a	6.2 ± 0.45	-2.9 ± 0.15	0.002	6.1 ± 0.44	2.7 ± 0.14	0.029	0.033
CTA ^b	-	1.2 ± 0.13	-	-	5.0 ± 0.44	-	0.025

KSS Knee Society score, KSFS Knee Society functional score, ROM range of motion, CMA coronal mechanical axis, CTA condylar twist angle

^a Positive values indicate varus alignment, and negative values indicate valgus

^b Positive values indicate internal rotation, and negative values indicate external rotation

groups. The CTA in Group A was significantly smaller than Group B at 24-month follow-up. The obtained results indicated that the femoral prosthesis in Group A was implanted with significantly less internal rotation in relation to the clinical epicondylar axis than Group B. Long leg mechanical axis at 24-month follow-up demonstrated that the rate of outliers over 3° varus/valgus from the mechanical axis was 32.1 % in Group B, but only 16.1 % in Group A.

The estimated total blood loss was 122.6 ± 10.8 ml in Group A versus 159.9 ± 12.2 ml in Group B, and a significant difference was investigated in terms of total blood loss between the two groups. The mean operating time was 59.4 ± 6.1 min in Group A and was 62.1 ± 5.5 min in Group B; no significant difference was detected. The mean skin incision length was 7.8 ± 0.3 cm in Group A versus 8.1 ± 0.7 cm in Group B.

Discussion

The most important finding of the present study was that MICA-UKA significantly improved the accuracy of the implantations in relation to the coronal mechanical axis and condylar twist angle. However, no significant difference was found between any functional parameters in the two groups at 24-month follow-ups. The results, which partly support our hypothesis, indicated that better alignment and similarity of good clinical results at short-term follow-up may provide subjects who receive MICA-UKA with long-term endurance of their implants, which is in line with the findings published by Nair et al. [13].

While it has been reported that minimally invasive UKA can provide good radiographic outcomes such as mechanical alignment and femoral or tibial component positioning [2, 8, 10], concerns remain regarding component malalignment due to the limited surgical field of vision provided by this approach [1, 6, 7, 11, 19]. Munk et al. [11] reported that four of 39 mini-midvastus patients

had tibial component varus malalignment >3°, while none of 39 limited medial parapatellar patients had such surgical outliers. In the current study, we found that the accuracy of the implantations in relation to the coronal mechanical axis in MICA-UKA group was superior to that of MI-UKA group, and the femoral rotational profile revealed the prosthesis in MICA-UKA group that was implanted with significantly less internal rotation than MI-UKA group. The senior author of the present study is a joint arthroplasty surgeon with 5-years' experience in navigation UKA. The minimally invasive approach has been routinely used in our hospital in an effort to minimize the incision size, patellar eversion, and tibia translation. The senior author also performed approximately 100 UKAs using the minimally invasive approach before the present study in order to eliminate bias due to the learning curve. It is believed that better alignment at 24-month follow-up may provide subjects who receive MICA-UKA with long-term endurance of their implants. Further studies on longer-term outcomes and functional improvements are required to validate these possibilities. Our results are in line with a recent meta-analysis performed by Weber et al. [22], which concluded that the use of navigation systems in UKA leads to a more precise component position, and it remains unknown whether the more accurate component position leads to a better clinical outcome or a better long-term survival of the implants.

Blood loss in minimally invasive UKA is an essential issue but is commonly underestimated. All the subjects enrolled in the present study are older than 60, and concomitant pathological conditions, such as diabetic disorders, hypertension, heart disease, are frequently investigated. The operative and post-operative risks can be increased by blood loss during and after operation. Researchers have recommended a variety of solutions to minimise intraoperative bleeding, such as use of a tourniquet, the insertion of a bone block to plug the entry hole made by the femoral intramedullary alignment rod, diathermy coagulation, prophylactic administration of antifibrinolytic agents, control of knee position, and, more importantly,

minimally invasive surgery [3, 9, 15, 16, 18, 23]. Fisher et al. [3], using an autologous bone graft to plug the femoral hole, demonstrated a significant difference in post-operative suction drainage between plugged and unplugged groups but no difference in the requirement for transfusion. In accordance with these findings, Schindler et al. [18] indicated same results using an acrylic cement plug to seal the femoral hole. Mullaji et al. [9], in a similar study, displayed that sealing the femoral canal is effective in reducing haemoglobin decrease and transfusion requirement. As a matter of fact, the reason for the smaller amount of blood loss in Group A in our study is probably due to the less invasive approach to the intramedullary canal with the computer-assisted technique even if it involves the drilling of multiple bicortical pins. This is very important because using a standard technique the intramedullary femoral hole can be easily plugged with bone, in contrast to the computer-assisted technique in which the smaller incision and the deepest part of the bicortical hole cannot be reached. The bicortical pin approach seems to be a safe procedure even if the risk of haematoma over the thigh cannot be excluded.

There are some limitations of the present study. First, although the KSS scores were obtained, the utility of KSFS scores to determine outcome has been criticized. Whereas the KSFS score has been validated, other validated, condition-specific, knee clinical outcome scores may be preferred. However, when we commenced data collection, KSFS scores were customary and their use allowed preoperative and post-operative comparisons. Second, the number of the patients is limited, and the follow-up is quite short.

The study shows that MICA-UKA improves the implant alignment without increasing clinical results versus MI-UKA. We promote that computer navigation should be considered when minimally invasive unicompartmental knee arthroplasty is performed.

Conclusion

In conclusion, alignment improvement of UKA components has been shown with the use of computer navigation. Whether this improved alignment results in better clinical results in the long term has yet to be proven.

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