Original Article

Femoral Component Alignment with a New Extramedullary Femoral Cutting Guide Technique

Abstract

Background: Intramedullary (IM) or extramedullary (EM) mechanical guides are used as alignment tools during total knee arthroplasty (TKA) surgery. The EM guide is less invasive; however, the IM mechanical guide is the preferred option since it has shown superior outcomes in several studies. Picture archive and communication system (PACS) images, if available, are extensively used for preoperative planning and intraoperative guidance. This retrospective study compared TKA outcomes using the conventional IM guide and a new EM technique which uses PACS image for preoperative and intraoperative assessment bone resection. To the best of our knowledge, this is the first study with the new EM technique. **Materials and Methods:** The study was performed on 205 knees (190 patients) for TKA from 2011 to 2013. The perioperative blood loss and the postoperative alignment angles were assessed for both mechanical guides. The angles were measured on the radiographs of the patient. The blood loss was assessed by the blood accumulated in the hemovac drain during the surgery and until 3 days after the surgery. **Results:** The new EM guide provided similar postoperative alignment as that obtained with the IM guide. **Conclusion:** The EM-guided method for femoral bone cutting using PACS films in TKA is as good as the IM method. The additional advantages of less injury to the bone and less fat emboli load to the cardiopulmonary system with the EM method makes it an attractive choice for routine, especially in the elderly and/or simultaneous bilateral, TKA in hospitals without modern computer-assisted navigation systems.

Keywords: *Extramedullary guide, intramedullary guide, total knee arthroplasty*

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Introduction

The long term success of total knee arthroplasty (TKA) depends on proper positioning of the knee prosthesis and the alignment of the bones during surgery. There are two main types of mechanical alignment guide, namely, intramedullary (IM) and extramedullary (EM). The IM guide systems require the placement of a rod inside the medullary canal of the femur along its anatomic axis. However, the EM guide systems do not necessitate invasion of the medullary canal of the femur and hence, avoid the complications of fat embolism[1] and increased blood loss.[2] Therefore, an EM guide is considered under minimally invasive surgery (MIS).[3] The early EM-guided methods produced less favorable outcomes of the surgery for femoral alignment.[4,5] Computer-assisted navigation systems for TKA, which uses the EM principle[6,7] can improve bone alignment. However, the high cost and longer surgical time have discouraged surgeons from adopting this new technology.[8] Consequently, the conventional mechanical alignment IM guide is still the most popular device used by the surgeons during TKA.[9-13] This may be about to change as recent advancements in the EM guide design may improve its surgical outcomes. A recently developed EM-guided technique for femoral bone cutting based on measurements on long leg radiograph, designed and manufactured by the United Orthopedic Corporation, is gaining popularity among surgeons. To the best of our knowledge, no study has compared the outcomes of the EM guide technique and the conventional IM guide.

This study evaluated TKA outcomes with a new EM guide technique and the conventional IM guide. The outcomes were measured as the femoral alignment, perioperative blood loss, and surgical time. Such a study will help surgeons in assessing the benefits of EM over IM or vice versa and hence, in the selection of the most appropriate medullary guide for the TKA.

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Materials and Methods

Patients

205 TKA on 190 patients operated by the same surgeon between 2011 and 2013 were included in this retrospective study. All patients were operated with MIS midvastus approach under air tourniquet. The mean age and sex ratio of the patients included in the study is presented in Table 1. Institutional review board approval was obtained for the study.

The inclusion criteria for the patients were as follows: (1) age from 40 to 90 years; (2) diagnosis of primary or secondary osteoarthritis and underwent minimally invasive TKA using posterior stabilized implants; (3) minimally invasive TKA was performed using either the IM guide or the EM guide by the same surgeons; (4) the patient had received well positioned and exposed preoperative and postoperative long leg anterior-posterior (AP) X-ray films, and (5) the patient had received lateral knee film postoperatively. The study excluded patients who underwent TKA for any cause other than primary or secondary osteoarthritis and flexion contracture of the knee >30°.

Radiograph acquisition

All lower leg X-rays were acquired with the patient standing with parallel feet on a flat surface with printed shoe soles on it [Figure 1]. In the cases of toe-in deformity, the patella of the concerned leg was pointed toward the X-ray tube. Empirically, it was observed that on X-ray simulation from knee computed tomography (CT) data of 16 volunteers, with knees externally rotated up to 30°, the difference between simulated X-ray and true AP position was minimal.

Operative procedure

The IM guide surgical technique is a standard method for TKA. In this method, the entry point of the IM rod is medial and superior to the intercondylar notch of the femur. The valgus/varus angle of the knee was measured preoperatively on the long leg radiograph.

The EM guide [Figures 2-4] surgical technique used the preoperative long leg radiograph on the computer monitor to measure the femoral cut. On the image, the line passing through the center of the femur head and the midpoint of the intercondylar line was defined as the mechanical axis (MA) of the femur (MA). A line was drawn perpendicular to the MA of the femur through the midpoint of the intercondylar line. The distances from the most distal points of both the condyles to this perpendicular line were measured. The femoral cutting thickness was based on the difference between those distances. A cartilage thickness of 2 mm was also considered for the final cutting.[14,15] During the surgical procedure, the relatively normal distal femoral condyle was cut by 9 mm (thickness of the implant) and replaced with a 9 mm thick prosthesis at the distal condyle. After debridement of the joint, the anterior femoral condyle was trimmed perpendicular to the Whiteside line flush with the anterior cortex of the femur. The EM guide [Figure 2] stylus (10 cm long) was slid upward under the quadriceps muscle and over the anterior cortex of the femur which is parallel to the distal anterior cortex of the femur. The tension of quadriceps muscle held the stylus and the cutting block assembly sitting on the cutting surface of the anterior femur. The thickness blades selected for medial and lateral condyles were inserted into the cutting slot and were adjusted to touch the most distal point of both condyles. After appropriate tension in the blades and the position of the stylus tip, the pins were inserted through the pin holes of the cutting block. The resected thickness of the condyles and the sagittal alignment were checked with jigs. Then, the distal femoral cutting was performed, and the thickness of the resected bone slice was measured. The resection was extended if its thickness was less than the planned thickness by >2 mm. If the resection was more than the planned thickness by >2 mm, a chamfer cut was performed with an elevation of the four-in-one cutting block to compensate for the extra resection, and the gap was filled with a bone slice or cement during fixation of the prosthesis. The rotation of the femoral components and posterior cutting used the posterior condylar line as a reference in both groups. Bone cutting of tibia in both of groups was performed using the EM guide. The posterior-stabilizing knee prosthesis was used in all cases.

The first anterior cut was made perpendicular to the Whiteside line and parallel to anterior distal femoral cortex

Table 1: Mean age and sex ratio of the patients included in the study

Gender	IM guide	EM guide
Female	82	84
Male	18	21
Total patients	100	105
Mean age (years)	68.6±6.8	69.2±7.5

IM=Intramedullary, EM=Extramedullary

Figure 1: Position of a patient during X-ray

by eyeballing since it was only for placing the cutting block and no absolute accuracy is required at this stage. One should be careful about avoiding notching the anterior lateral cortex at this point. Cutting for femoral rotation depended on the posterior condylar line or could be transepicondylar axis if preferred by the surgeon. Moreover, flexion/extension gap balancing was not the focus of this study, and it would depend on the preference of surgeons. In this study, a mediolateral balancing was done. The tight capsule and collateral ligament were released as it was needed to reach a <2 mm difference from medial to lateral compartment. If the flexion was too tight, the tibial slope was increased. Rarely, a bone cut had to be done for a tight extension gap.

Study design

All preoperative and postoperative radiographs were evaluated for the alpha angle on AP view and gamma angle on the lateral view. The anatomical axis refers to a line drawn along the length of the IM canal of either the femur or the tibia. The alpha angle (α) is the medial angle between the anatomical axis of the femur and a line drawn parallel to the femoral component condyles [Figure 5]. The gamma angle (γ) is the proximal angle between the femoral anatomical axis and a line drawn perpendicular to the distal cement interface of the femoral component in the lateral X-ray [Figure 6].

The outcome of the surgery with the IM guide was compared to the outcome with EM guide in terms of the alpha angle, gamma angle, and perioperative blood loss. Perioperative blood included the sum of the intraoperative blood loss and the blood loss until the postoperative day 3. The blood loss was measured using the amount collected in the hemovac drain entered in the medical record. Surgical time was the time recorded from the OR record of time from the start of skin incision to the end of the closure. The significance of the difference in mean for each measurement was tested with the Student's *t*-test with a 95% confidence interval (CI) (P = 0.05). To avoid Type I error in the *t*-test, 4 linear equations were fitted to the angle data, and their slopes were compared. The analysis was performed using SAS statistical analysis software (SAS Institute Inc., NC, USA).

Figure 2: Extramedullary guide

Results

The results of the analysis to evaluate the outcomes of TKA with the IM and the EM guides are summarized in Table 2. There were no significant differences between the average alpha (P = 0.86, 95% CI: −0.7154–0.5982) and gamma angles (P = 0.4466, CI: 0.4466–0.2987) or average blood loss (P = 0.6051, CI: −178.4449–104.2621) in the perioperative period between two groups; however, the CI for average blood loss was very wide. The intercepts and slopes of linear equations fitted to different angles in IM were very close to those in EM [Table 3].

Discussion

This study compared the outcomes of femoral alignment in TKA with the conventional IM guide to those with a new EM-guided technique. Most of the earlier studies have reported that the IM guide provides better femoral alignment than the EM guide. However, this study did not find any significant difference in terms of femoral alignment.

In this study, the alignment of the femoral component was measured in terms of the alpha and gamma angles.

Table 2: Comparison of the outcomes of the knee surgery using the extramedullary guide and the intramedullary guide

Measurement	IM (87)	EM (82)	*P*
Alpha angle	90.18±1.96	90.13±2.36	0.86
Gamma angle	3.80±4.09	4.18±3.15	0.45
Blood loss (ml)	736.70±458.47	699.61±472.20	0.61

IM=Intramedullary, EM=Extramedullary

Table 3: Slopes and intercepts for linear equations fitted to the alpha and beta angles with the intramedullary and the extramedullary guide

Angle	IM (slope, intercept)	EM (slope, intercept)
α	0.08, 86.17	0.07, 86.25
β	0.11, 80.49	0.13, 79.35

IM=Intramedullary, EM=Extramedullary

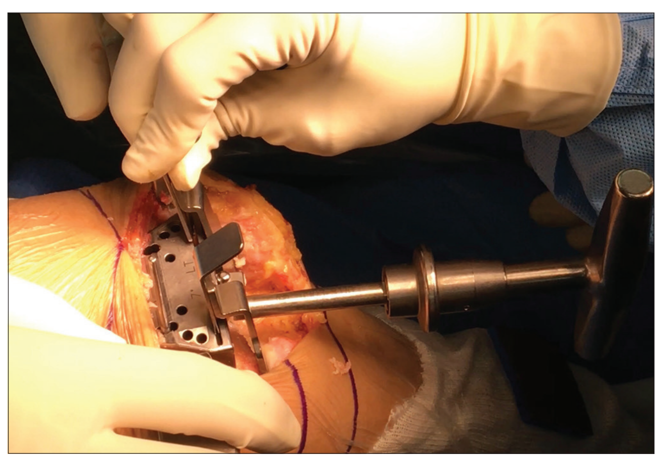

Figure 3: Extramedullary guide during surgery with a superior view

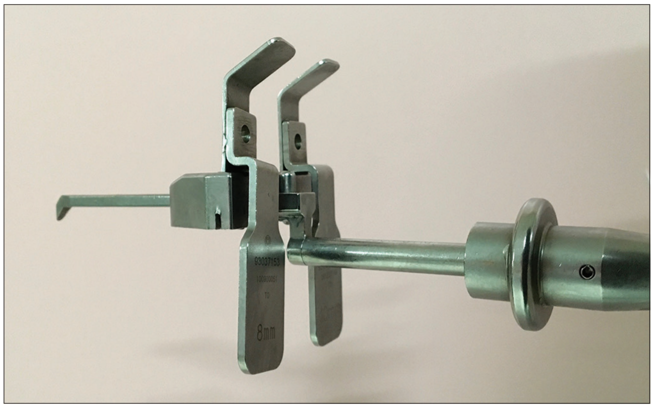

Figure 4: Side view of extramedullary guide

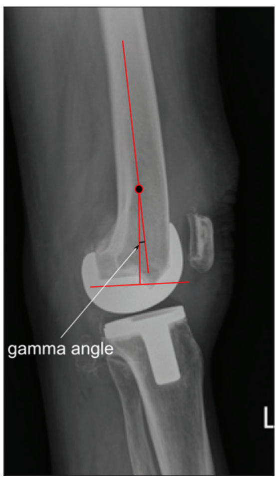

Figure 5: Gamma angle

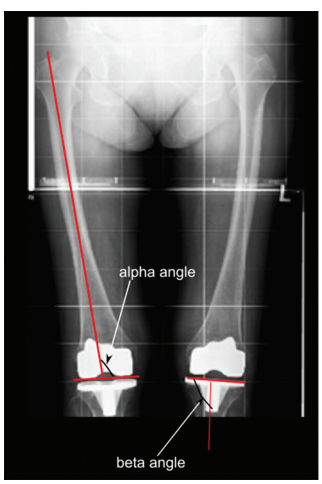

Figure 6: Alpha and beta angle

These angles have been used in several other studies to assess the femoral component alignment after TKA.[4,16-21] Most of the previous studies have reported a superior alignment of the femoral component in cases where the IM guide was used.[4,16-21] However, this study did not detect any differences in the alignment angles achieved with the EM and IM guides. A comparative study for IM and EM alignment[22] in total knee arthroplasty, using tibiofemoral angle as the alignment criteria, reported better alignment with the IM guide than the EM guide. A 15-year followup study to compare survival[12] of TKA with EM and IM guides suggested that the alignment with the EM guide was not as precise as with the IM guide. In contrast to the preoperative measurements of the radiological images used in this study, the previous EM technique required these measurements to be performed during the surgery by palpating the bones which are prone to error that may lead to further misalignment of the femoral component. A study in a Korean population[23] compared TKA alignment with a newly developed EM guide with those with the conventional IM guide using femoral flexion angle as alignment criteria and reported that the newly developed EM guide was as good as the IM. Our study differs from the Korean study with regard to the calculation to decide the femoral cutting and the approach of the incision. Moreover, in our technique the longer anterior cortex is preserved compared to the previous EM techniques.

Several studies on different joint replacements have reported less blood loss with the EM technique compared to the IM technique.[2,21,24-26] Kandel *et al*.[2] and Jeon *et al*.[27] compared blood loss between the EM and IM techniques for femoral cutting, reporting less blood loss in the EM technique. Less blood loss in the EM technique has been attributed to its less invasive procedure for placing the guide as the device does not need to be placed inside the medulla of bone. In our study, the average blood loss with EM was not significantly different to that of the IM technique ($P > 0.05$). However, the CI for the *t*-test was very wide which makes the level of significance inconclusive and requires further investigation. Moreover, previous few studies also reported no difference in blood loss between EM-guided and IM-guided surgery.[15,28]

This study lacked diversity in the study population, including only patients from our country with a diagnosis of degenerative arthritis. Moreover, intergroup differences regarding fat embolisms or postoperative complications, such as hypoxia and pain, were not included in the study. The study included two different manufacturer's IM guides so comparing other conventional IM guides with the new EM guide may provide more insight into the differences in their outcomes. The IM technique has been reported to be prone to more complications, such as fat or IM particle embolism.[1] Moreover, femurs with significant extra-articular deformities or prior surgery or fractures may not be suitable for IM guides. Such femurs would require the use of EM guides.[19] Although most of the previous studies suggested IM to be superior to EM for the alignment of bones, the results from our study suggest that the newly developed EM guide is as good as an IM in the alignment of the femoral component of TKA and may replace the IM guide for all kind of femurs. Such a replacement would further reduce the complications due to the IM technique.

However, this EM guide technique would not work well in the cases of revision TKA and flexion contracture >15°, and if the X-ray is not taken in the proper leg position. The X-ray may not produce a useful image when the leg is not facing forward if the patella is extremely rotated and not facing forward. Moreover, the technique may be further improved if the two-dimensional radiograph is replaced by three-dimensional CT or magnetic resonance imaging images which may add to the cost and higher dose of radiation (in case of CT only) exposure.

Conclusion

This study compares the alignment of the femoral component and perioperative blood loss in TKA performed using a conventional IM guide and a new technique using an EM guide. The results suggest that the new technique using EM is as good as the conventional IM technique. We propose that this new EM technique may be a good alternative to conventional IM. A study on a more diverse population with different knee pathologies would further strengthen the results.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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