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Radiographic evaluation of tibial component alignment in total knee arthroplasty following extramedullary and intramedullary tibial referencing

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ABSTRACT

Background: Long term survivorship of total knee arthroplasty (TKA) is significantly dependant on prostheses alignment. The debate on optimal referencing for femoral component is largely resolved with Intra-medullary jigs reproducing superior alignment. However there is still a contention about whether intramedullary or extramedullary jigs are better for tibial referencing. This study aims to compare the accuracy of tibial component alignment in TKA using intramedullary and extramedullary tibial referencing jigs.

Methods: Between December 2012 and September 2014, 66 primary conventional cemented TKAs were performed using Nexgen-LPS Flex (Zimmer) implants in 55 patients, 50-80 y old (mean 65.54 y) with osteoarthritis/rheumatoid arthritis. Intramedullary and extramedullary tibial referencing was used in alternate patients undergoing TKA after excluding patients with BMI $\geq$35 kg/m^2, knee deformity $\geq 15^0$, excessive tibial bowing, previous fractures/surgeries/retained metalwork around knee. Postoperatively, tibial component alignment (TCA) in coronal plane was assessed using AP radiograph of leg. A 3° cutoff from neutral mechanical axis (i.e., 90^o±3^o) was considered acceptable.

Results: The intramedullary group (n=33) had 4 outliers (TCA >93° or <87°) whereas the extramedullary group (n=33) had 7 outliers (p=0.511). The difference in mean TCA between intramedullary and extramedullary groups was not statistically significant [90.70±2.43 and 90.55±2.17 (p=0.790)]. There were no significant per-operative/post-operative complications in either group.

Conclusions: We conclude that both intramedullary and extramedullary tibial referencing guides can be used to achieve desired tibial component alignment (90±3°) in TKA. However the surgeon should appreciate the benefits and deficiencies of either types of tibial referencing and use whichever is suited in a particular case.

Keywords: Intramedullary, Extramedullary, Tibial component, Tibial referencing guide, TKA

INTRODUCTION

Total knee arthroplasty (TKA) is a successful procedure for treatment of pain and function of an arthritic knee.[1,2] Alignment of the lower extremity, particularly in the frontal plane, has proven to be a critical factor in the long-term success of TKA.[3-6] Negative effects of component malalignment include poor clinical outcomes, excessive polyethylene wear, implant loosening, and early revision arthroplasty.[7]

In a standard TKA, the articulating surfaces of distal femur, proximal tibia and patella are prepared for implantation of individual prosthesis by taking different bone cuts. Optimal alignment and appropriate implant sizing and position can be achieved using traditional jigs and alignment guides, or by the use of computer assisted navigation technology. The manual reference guides or jigs for both femur and tibia are available in two types viz., intramedullary and extramedullary reference guides. Intramedullary guides for femur have proved to provide superior alignment as compared to extramedullary guides.[8] Hence the optimal referencing system for femoral alignment is largely undebated. With respect to tibial referencing, both types of guides have specific advantages and disadvantages. Extramedullary guides may be easier to use, due to the long familiarity with standard knee replacements. Intramedullary guides have direct access to tibial canal and hence the anatomical axis, and are supposed to be more accurate. Most knees are suitable for either technique although extramedullary jigs are unreliable in patients with abnormal anatomy of the ankle, excess of soft tissue, obesity and intramedullary systems are inappropriate when there is excessive tibial bowing, previous fracture or retained hardware. Since there exists a lack of consensus on which of the tibial cutting guides gives better accuracy of cuts for component placement, this study is intended to compare the intramedullary and extramedullary tibial reference guides in achieving desired tibial resection and subsequent component placement.

METHODS

Between December 2012 and September 2014, 66 primary conventional cemented TKAs were performed in alternate patients, 50-80 years old (mean 65.54 years) with a diagnosis of primary osteoarthritis/rheumatoid arthritis. Patients with BMI > 35 kg/m^2, knee deformities >15° (coronal and sagittal plane deformity), excessive tibial bowing, previous fractures around the knee, previous surgeries and retained metal work around the knee were excluded from the study. Institutional ethical committee clearance was taken and all patients participating in the study gave written informed consent. All patients underwent cruciate sacrificing posterior stabilized TKA with Nexgen-LPS Flex (Zimmer) implants, by a standard midline medial para-patellar approach. All patients received combined spinal epidural anaesthesia, before positioning supine on the operation table. An electronic pneumatic tourniquet was used on the limb being operated and was raised just before the skin incision and deflated after application of a sterile compression dressing following wound closure. The tourniquet time was monitored and noted after each case. Intramedullary jig was used in all cases for distal femoral preparation. Proximal tibial cut was taken using either intramedullary or extramedullary referencing, depending on the group of the patient.

The extramedullary cutting guide had a proximal tibial cutting block along with a clamp around the ankle, both of which were interconnected by a connecting rod which was positioned parallel to the shin anteriorly. The rotation was set with an alignment rod referencing the medial third of tibial tubercle proximally and transmalleolar axis distally. The cutting block with a posterior slope of zero degree was assembled to the alignment rod and fixed to anterior surface of proximal tibia using pins. For anterior posterior alignment, the anterior surface of tibia was used as a reference. A stylus was used to estimate the thickness of bone resection. After cutting block fixation with pins, bone was cut with an oscillating saw. All the adjustments were based on visual judgement only.

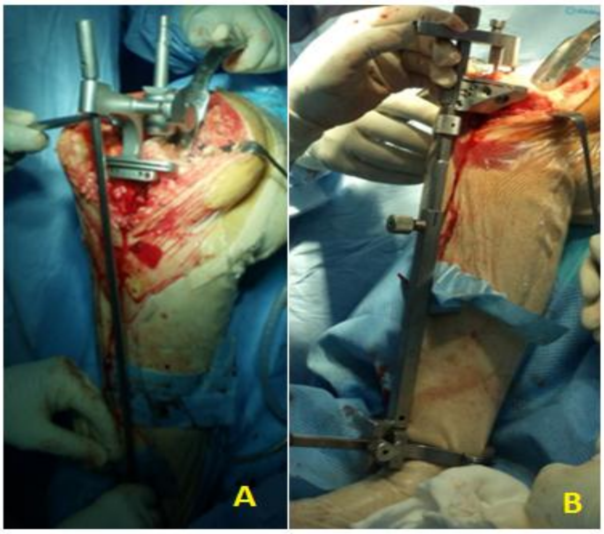
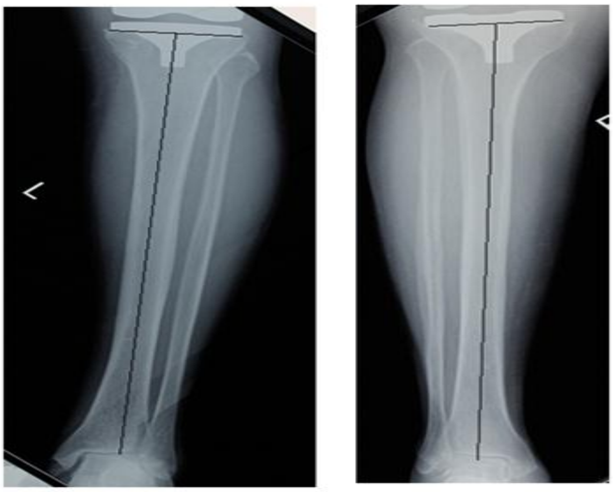


Figure 1: A- Proximal tibial cut taken using intramedullary alignment guide, B- Proximal tibial cut taken using extramedullary alignment guide.



The mechanical axis of the tibia was marked as a line from the centre of the cut surface of the proximal tibia to the centre of the talar dome. A second line was drawn parallel to the lower clearly visible margin of tibial baseplate. Now the angle formed between these two connecting lines at the proximal tibia on the lateral side of the knee was measured manually using a goniometer.

Figure 2: Measurement of tibial component coronal plane alignment from postoperative anteroposterior X-ray of leg.

In the intramedullary group, an entry hole was made in the anterior third of the tibial articular surface near the base of the tibial spine. An intramedullary guide assembly was inserted to align itself along the medullary canal of tibia. Rotational alignment was referenced to tibial tubercle. The cutting block with a posterior slope of zero degree was assembled to the intramedullary guide assembly. The design of the guide allowed a bone cut perpendicular to the intramedullary rod. A stylus was used to estimate the thickness of bone resection. The cutting block was secured to the tibia with pins and bone cut taken using an oscillating saw.

Patella was selectively resurfaced with or without circumpatellar cauterization depending on surgeon's decision. Rest of the surgery was completed in a conventional manner.

Intraoperative and postoperative complications in the form of fat embolism, thromboembolism, bone cement implantation syndrome (BCIS), iatrogenic fractures, untoward soft tissue or neurovascular injury and infection if any were noted.

Prophylactic antibiotics were administered 15-30 minutes prior to skin incision and continued postoperatively for a period of 24 hours. Patients also received thrombo-prophylaxis with low molecular weight heparin administered subcutaneously, starting 12 hours prior to surgery and continuing up to 14th postoperative day or till discharge (which ever was earlier) and were put on oral Aspirin thereafter for a period of four weeks unless contraindicated. Postoperatively all patients were rehabilitated as per institutional rehabilitation protocol. Three months postoperatively the tibial component alignment in coronal plane was assessed using plain antero-posterior radiograph of the leg with knee in full extension. A tibial component alignment (TCA) of 90º±3º was considered acceptable.

Statistical analysis

The statistical analysis was done using SPSS software (Version 20). Chi square test was used to assess demographic data like gender distribution. Preoperative diagnosis, BMI, age, tourniquet time and mean TCA in the two groups were compared using 2 independent sample t-test. Fisher exact test was used to compare the number of cases with acceptable TCA between the groups. The statistical significance was set at p-value $\leq$0.05.

RESULTS

66 primary conventional posterior stabilized TKAs were performed in 55 patients, assigned to two groups, to undergo intramedullary or extramedullary tibial referencing for proximal tibial resection. Out of 66 TKAs, 16 (24.2%) were performed in male patients and 50 (75.8%) were performed in female patients. 33 patients including 9 male and 24 female underwent intramedullary tibial referencing. 33 patients including 7 male and 26 female underwent extramedullary tibial referencing. There was no statistically significant difference between the groups in terms of gender distribution (p=0.566).

The mean age of the study population was 65.5 years with a range of 52 years to 78 years. The group wise age distribution of patients in the study is as shown in Table 1. There was no statistically significant difference between the groups in terms of age distribution (p=0.711).

The mean BMI of the study population was 26.59 kg/m^2. There was no statistically significant difference between the groups in terms of mean BMI (p=0.783) (Table 1).

Table 1: Comparison of mean age, BMI, tourniquet time (TT) and tibial component alignment (TCA) between the 2 groups of tibial referencing.

Parameters	Extramedullary group (n=33) (Mean±SD)	Intramedullary group (n=33) (Mean±SD)	P value
Age	65.24±7.28	65.91±7.30	0.711
BMI	26.65±1.84	26.53±1.63	0.783
TT	100.27±9.26	97.27±8.47	0.174
TCA	90.70±2.43	90.55±2.17	0.790

Table 2: Distribution of patients with acceptable TCA between the groups.

Corrected TCA	Tibial referencing		Total	P value
	Extramedullary	Intramedullary		
Yes (90°±3°)	26	29	55	0.511
No (>93° or <87°)	7	4	11	
Total	33	33	66	

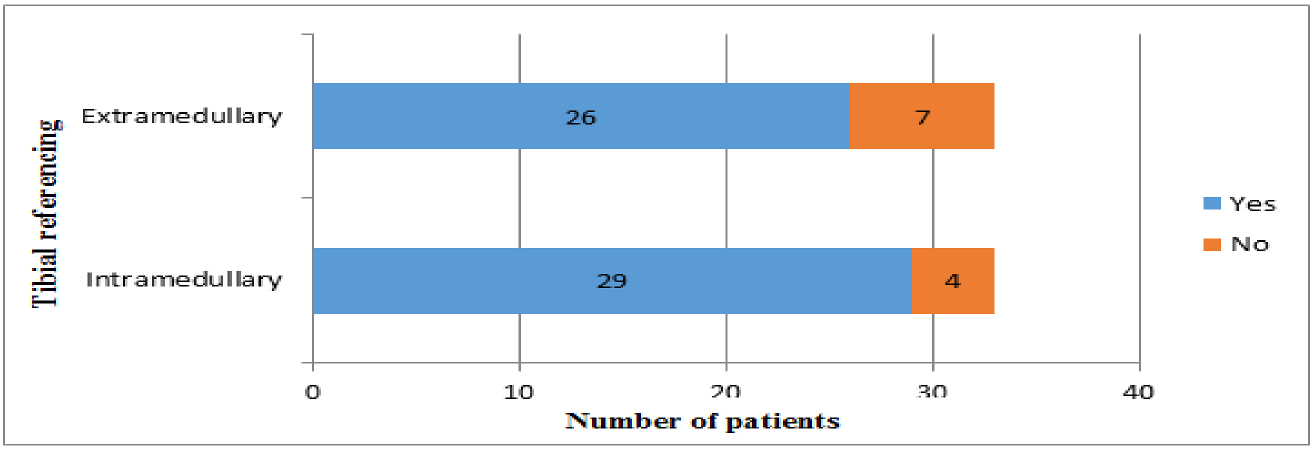


Figure 3: Distribution of patients with correct TCA between the groups.

In this study, the mean tourniquet time of all the TKAs performed was 98.77 minutes (Both types of tibial referencing). The mean tourniquet time in intramedullary group was 97.27±8.47 minutes and the mean tourniquet time in extramedullary group was 100.27±9.26 minutes. It was observed that the two groups were not statistically different from each other in their mean tourniquet time (p=0.174) (Table 1).

The mean TCA of all the TKAs performed was 90.62º. The mean TCA in intramedullary group was 90.55º±2.17º and in extramedullary group was 90.70º±2.43º. There was no statistically significant difference between the groups in terms of mean TCA (p=0.790) (Table 1).

In the intramedullary group, 29 knees had acceptable TCA (90º±3º) with 4 outliers (85º, 94º, 94º and 95º) (1 varus and 3 valgus). In the extramedullary group, 26 knees had acceptable TCA (90º±3º) with 7 outliers (85º, 85º, 94º, 94º, 94º, 94º and 95º) (5 varus and 2 valgus). No statistically significant difference could be established (p=0.511) between the groups in terms of the number of acceptable TCA. (Table 2 and Figure 3)

There was no incidence of perioperative or postoperative complications in the form of periprosthetic fractures, intraoperative/postoperative fat embolism or thrombo-embolism, bone cement implantation syndrome, iatrogenic neurovascular injury and infection in either of the groups.

DISCUSSION

Many studies have suggested the requirement of proper alignment of the lower extremity particularly in the frontal plane for long term survival of TKA.[3-6] Ritter et al and Fang et al followed up primary TKAs and found increased failure rates in malaligned TKAs.[9,10] Proper alignment of TKA prosthesis requires that the tibial component stem be parallel to mechanical axis of tibia. As the tibial component base plate aligns itself along the cut plane, an accurate alignment of the cut plane with respect to the anatomical axis of the bone becomes very important. The cut should be perpendicular to the anatomical axis of the tibia. The study by Kim et al showed an increased failure rate of 3.4% in TKAs with a tibial component alignment other than neutral, compared to 0% failure in neutrally aligned tibiae.[11]

On the femoral side, intramedullary referencing has shown to provide superior alignment.[8] It is also difficult to use an extramedullary reference guide for femur, keeping in view the bulk of thigh musculature and difficulty in aligning the guide using palpable bony landmarks of femur. Hence the debate on the optimal referencing system for femoral alignment is now largely resolved and the intramedullary reference guide is widely used.

On the tibial side, both types of resection guides have specific advantages and limitations. Extramedullary guides may be easier to use due to the long familiarity with standard knee replacements and they also don't disturb the medullary canal of the tibia. Intramedullary guides have direct access to tibial canal and hence the anatomical axis, and are supposed to be more accurate. Most knees are suitable for either technique although extramedullary jigs are unreliable in patients with abnormal anatomy of the ankle, excess of soft tissue, obesity. Intramedullary systems are inappropriate when there is excessive tibial bowing, previous fracture or retained metalwork. This study excluded all such patients who were unsuitable to be operated by any one of the tibial resection guides.

Lozano et al reported longer tourniquet time in the extramedullary tibial referencing group as compared to intramedullary tibial referencing group.[12] This is justified by the fact that the positioning and orientation of the tibial cut with intramedullary referencing is carried out more rapidly as anatomical references are not needed and the correct orientation is guided by the anatomical axis of the tibia. In our study the mean tourniquet time of all the TKAs performed was 98.77 minutes (both types of tibial referencing). The tourniquet times in the extramedullary and intramedullary groups were 100.27±9.26 and 97.27±8.47 respectively. Though the mean tourniquet time in EM group was longer than that in IM group the difference was not statistically significant (p=0.174). No tourniquet related complications like neurovascular compromise, deep vein thrombosis, soft tissue bruising or metabolic complications were noted in either of the groups.

D'Lima et al demonstrated an almost three fold increase in wear in implants mounted with a 3° varus malalignment.[13] Berend et al studied 3152 TKAs and identified that failure due to medial bone collapse was associated with a varus tibial component alignment >3^0.[4] Werner in his cadaveric study showed tibial malposition >3° greatly altering the distribution of pressure between the medial and lateral compartments.[14] The present study considered a deviation of 3^0 from neutral alignment (Range 87^0-93^0) as the end point for an acceptable TCA. Any TCA <87^0 was considered valgus alignment and any TCA >93^0 was considered varus alignment. The percentage of acceptable TCA in intramedullary and extramedullary groups was 87.88% and 78.79% respectively. Bono et al in a cadaver study found that passage of the intramedullary rod to the distal epiphyseal scar significantly improved component alignment.[15] In our study, the intramedullary guide was passed as distal as possible with an attempt to reach the level of the distal physeal scar of tibia, however this was not confirmed on an image intensifier. Dennis et al had excellent results from extramedullary tibial alignment as compared to intramedullary alignment and recommended that the extramedullary alignment rod be centred about 3 mm medial to the mid-point of the ankle for correct alignment.[16] This was based on the fact that, centre of the mechanical axis of the tibia runs through the mid-point of the talus and not the mid-point of the ankle. Our study included this refinement for extramedullary referencing.

One proposed disadvantage of intramedullary systems is the risk of venous and fat embolism. Parmet et al in 1995 have addressed this issue and concluded that the incidence of a large and symptomatic embolism doesn't differ with the alignment technique and similarly in our study, we did not have any reported cases of fat embolism or thromboembolism.[17]

Brys et al revealed statistically superior ideal tibial component alignment in the intramedullary group as compared to extramedullary group.[18] Maestro et al in 1998 also showed statistically superior results with respect to tibial component alignment in the intramedullary group as compared to extramedullary group.[19] The results of the study by Maestro et al could have been due to the error that occurs in extramedullary alignment system when one takes the midpoint of the ankle joint as the distal reference point rather than the centre of the talar dome which lies slightly (approximately 3 mm) medial to the centre of the ankle joint.[19] Yang et al and Rottman et al in their retrospective study found no significant differences in the tibial component alignment between intra and extramedullary tibial referencing groups.[20,21] Similar to the above said studies we found no significant difference between the extramedullary and intramedullary groups in terms of achieving a desired tibial cut with subsequent tibial component alignment in our study.

Strengths of the study

- It was a prospective study however randomization was not done.
- All surgeries were primary conventional posterior stabilized TKAs performed using the same implant design of a single company i.e., NexGen LPS (Zimmer).

Limitations of the study

- The sample size was small for wider generalization of results.
- The sagittal plane alignment and rotational alignment was not measured or considered for comparing the groups.

CONCLUSION

With the above observations, we conclude that both intramedullary and extramedullary tibial referencing guides can be used in TKA to achieve desired coronal plane tibial component alignment ($90^0 \pm 3^0$), provided that the patients are properly selected. It is also important for the surgeon to appreciate the benefits and deficiencies of each guide and to use whichever is suited appropriately in each particular case.

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Ethical approval: The study was approved by the institutional ethics committee

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