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Comparison of Extramedullary Versus Intramedullary Referencing for Tibial Component Alignment in Total Ankle Arthroplasty

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Abstract

Background: The majority of total ankle arthroplasty (TAA) systems use extramedullary alignment guides for tibial component placement. However, at least 1 system offers intramedullary referencing. In total knee arthroplasty, studies suggest that tibial component placement is more accurate with intramedullary referencing. The purpose of this study was to compare the accuracy of extramedullary referencing with intramedullary referencing for tibial component placement in total ankle arthroplasty.

Methods: The coronal and sagittal tibial component alignment was evaluated on the postoperative weight-bearing anteroposterior (AP) and lateral radiographs of 236 consecutive fixed-bearing TAAs. Radiographs were measured blindly by 2 investigators. The postoperative alignment of the prosthesis was compared with the surgeon's intended alignment in both planes. The accuracy of tibial component alignment was compared between the extramedullary and intramedullary referencing techniques using unpaired *t* tests. Interrater and intrarater reliabilities were assessed with intraclass correlation coefficients (ICCs).

Results: Eighty-three tibial components placed with an extramedullary referencing technique were compared with 153 implants placed with an intramedullary referencing technique. The accuracy of the extramedullary referencing was within a mean of 1.5 ± 1.4 degrees and 4.1 ± 2.9 degrees in the coronal and sagittal planes, respectively. The accuracy of intramedullary referencing was within a mean of 1.4 ± 1.1 degrees and 2.5 ± 1.8 degrees in the coronal and sagittal planes, respectively. There was a significant difference ($P < .001$) between the 2 techniques with respect to the sagittal plane alignment. Interrater ICCs for coronal and sagittal alignment were high (0.81 and 0.94, respectively). Intrarater ICCs for coronal and sagittal alignment were high for both investigators.

Conclusions: Initial sagittal plane tibial component alignment was notably more accurate when intramedullary referencing was used. Further studies are needed to determine the effect of this difference on clinical outcomes and long-term survivability of the implants.

Level of Evidence: Level III, retrospective comparative study.

Keywords: total ankle arthroplasty, intramedullary referencing, extramedullary referencing, component alignment, tibial component

In total knee arthroplasty (TKA), proper alignment of the components is critical to patient satisfaction and to long-term survival of the implants.[7,9] In TKA, the tibial bone cut is often made perpendicularly to the mechanical axis of the tibia in the coronal plane. The amount of posterior slope of the proximal tibial cut is often determined by surgeon preference and implant design. Most TKA systems provide surgeons with a choice of either using intramedullary (IM) or extramedullary (EM) referencing guides. However, in a

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recent randomized prospective study of 100 TKAs in which patients were suitable for both IM and EM techniques, IM referencing was notably more accurate than EM referencing for tibial component alignment.[8]

Long-term evidence with current ankle implant designs is not yet available to guide proper component positioning. Most surgeons who perform total ankle arthroplasty (TAA) prefer to align the tibial component so that it is perpendicular to the mechanical axis of the tibia in the coronal plane and perpendicular to, or with a slight anterior opening slope in, the sagittal plane.[1,5] Unlike TKA surgery, during TAA surgery the ankle cannot be dislocated. Therefore, most TAA systems are limited to EM alignment guides. However, at least 1 TAA system is available that uses IM referencing for alignment of the tibial component. Currently, there are no reports comparing these 2 alignment techniques with respect to the accuracy of tibial component alignment in TAA.

The purpose of this study was to compare the accuracy of initial tibial component positioning between EM referencing and IM referencing techniques in patients who underwent TAA with fixed-bearing prostheses. It was our hypothesis that the use of IM referencing would result in greater accuracy of tibial component alignment in patients undergoing TAA with a fixed-bearing prosthesis.

Methods

This study was approved by the institutional review board at the investigator's institution (Duke University Medical Center). The medical records of 277 consecutive patients who underwent TAA with a fixed-bearing prosthesis between July 2007 and June 2010 were reviewed. Patients received either an Inbone (Wright Medical Technology Inc, Arlington, TN) or a Salto Talaris (Tornier, Edina, MN) prosthesis. All surgeries were performed by 1 of 3 experienced TAA surgeons using a similar operative technique. Intraoperative fluoroscopy was used to aid in component placement. Forty-one patients with a history of tibial diaphyseal or pilon fractures, tibial deformity, or insufficient radiographs were excluded, leaving a study population of 236 patients.

Patients were divided into 2 groups based on the type of referencing used for component alignment. The Salto Talaris used an EM referencing guide for tibial component placement. The Inbone prosthesis relied on the alignment of an IM reference drill to guide tibial component placement. The reference drill was advanced from the plantar aspect of the foot, through the calcaneus and talus, and centered within the tibial plafond in both the coronal and sagittal planes. The drill was then advanced 8 to 10 cm into the distal tibia. Positioning was confirmed with intraoperative fluoroscopy. Patients who received a Salto Talaris prosthesis were placed in the EM group, and patients who received an Inbone replacement were placed in the IM group.

Radiographs were taken of all ankles in a standardized fashion. Patients were asked to stand on a slotted platform with equal weight on both legs and their feet shoulder-width apart. A 24 × 30-cm cassette was placed vertically in the slot on the platform. The beam was positioned 102 cm from the cassette and oriented perpendicularly to the cassette. For the anteroposterior (AP) ankle radiograph, the beam was directed to the midportion of the tibiotalar joint, midway between the malleoli, and 1 cm proximal to the tip of the medial malleolus. For the lateral radiograph, the patient was turned so that the medial malleolus was positioned directly against the cassette. The patient was asked to slightly flex the knee and dorsiflex the ankle, and the beam was directed toward the lateral malleolus. Tibial component alignment was assessed on the first postoperative weight-bearing AP and lateral radiographs (performed at 6 weeks) using a standardized method as previously described.[6,10-12] The mechanical axis of the distal tibia was calculated in the AP and lateral planes as previously described.[2] Briefly, a circle was drawn and positioned to fit between the medial and lateral cortices at the proximal extent of the tibial shaft. A second circle was drawn at the distal tibia and positioned to fit between the medial and lateral metaphyseal flares and the distal extent of the component. A line was drawn to connect the center of both circles and extended distally to the most distal aspect of the component providing the mechanical axis of the tibia. A second line was drawn parallel to the base of the tibial component. In the AP view, the medial angle formed by the intersection of the mechanical axis of the distal tibia and the flat portion of the tibial component was designated as the coronal implant angle (Figure 1A). On the lateral view, the anterior angle formed by the intersection of the distal tibial mechanical axis and the flat portion of the tibial component was designated as the sagittal implant angle (Figure 1B). The angles were measured to the nearest 1/10 of a degree using a PACS system (General Electric Healthcare, UK) loaded with TraumaCad digital templating software (Voyant Health, Columbia, MD). All radiographs were assessed by 2 fellowship-trained foot and ankle surgeons who were not involved in the treatment of the patients. The reviewers were blinded to the treating surgeon. The measured values from each reviewer were summed and divided by 2. In addition, a subset of 20 radiographs was selected at random to assess intrarater reliability in measuring the radiographic angles for each reviewer. For this assessment, the coronal and sagittal plane implant angles were measured in triplicate and in random order 2 weeks apart. The interrater and intrarater intraclass correlation coefficients (ICCs) for the coronal and sagittal implant angles were calculated.

Three surgeons performed the total ankle replacements in this study. There was no definitive evidence as to the optimal position of the tibial component in the coronal or sagittal planes; therefore, each surgeon served as his own

Figure 1. Calculation of the coronal implant angle (A) and the sagittal implant angle (B). A circle was drawn and positioned to fit between the medial and lateral cortices at the proximal extent of the tibial shaft (center A). A second circle was drawn at the distal tibia and positioned to fit between the medial and lateral metaphyseal flares and the distal extent of the component (center B). A line was drawn connecting the center of both circles (line AB) and extended distally to the most distal aspect of the component (point E) providing the mechanical axis of the tibia (line AE). A second line was drawn parallel to the base of the tibial component (line CD). The coronal and sagittal implant angles were measured from angle AEC in each plane.

control to determine the accuracy of the referencing techniques. In cases without deformity, all 3 surgeons preferred to place the tibial component of both fixed-bearing implants in a position perpendicular to the mechanical axis of the tibia in the coronal plane. Two of the surgeons placed the tibial component of the 2 fixed-bearing implants in a position perpendicular to the mechanical axis in the sagittal plane as well. The third surgeon placed the Inbone tibial component in a position perpendicular to the tibial mechanical axis in the sagittal plane and the Salto Talaris with 4 degrees of anterior opening slope.

The coronal and sagittal implant angles were measured in all tibial components postoperatively. The difference between the measured angle and surgeon-specific intended angle for each component was then calculated. The absolute magnitude of this difference was used to determine the accuracy of alignment of each technique (EM and IM). The term *accuracy* in this article refers to the closeness of the measured value to the surgeon's intended placement (true value). The accuracy of alignment in both the coronal and sagittal planes was compared between techniques using unpaired Student *t* tests. A 2-way random effects model with single measures was used to determine ICCs for intrarater and interrater reliability. Intraclass correlation coefficients less than 0.40 were deemed poor, 0.40 to 0.59 fair, 0.60 to 0.74 good, and greater than 0.74 excellent.[4] All statistical analyses were performed using SPSS software (version 21; SPSS, Chicago, IL). An alpha level of .05 was deemed statistically significant.

Table 1. Interrater and Intrarater Intraclass Correlation Coefficients With Confidence Intervals for Tibial Coronal and Sagittal Implant Angles.

	Coronal Implant Angle (95% CI)	Sagittal Implant Angle (95% CI)
Interrater ICCs	0.815 (0.767-0.853)	0.943 (0.926-0.956)
Intrarater ICCs		
Reviewer 1	0.957 (0.912-0.981)	0.986 (0.971-0.994)
Reviewer 2	0.983 (0.965-0.993)	0.995 (0.989-0.998)

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient.

This was a study of a cohort of consecutive patients who underwent TAA between 2007 and 2010, and therefore the sample size was fixed. Our data were used to perform a post hoc power analysis, which indicated that 25 patients in each group would provide 90% power to detect a 1-degree difference between groups for accuracy of coronal alignment (alpha = .05).

Results

Two-hundred thirty-six patients were included for statistical analysis. There were 83 patients in the EM group and 153 patients in the IM group. Intraclass correlation coefficients demonstrated excellent interrater and intrarater reliability for coronal and sagittal implant angles (Table 1). The mean coronal implant angle was 90.0 ± 2.1 degrees for the EM group and 90.0 ± 1.8 degrees for the IM group. The mean sagittal implant angle was 84.7 ± 2.7 degrees for the EM group and 88.0 ± 2.3 degrees for the IM group. When corrected for each surgeon's intended tibial component alignment, the accuracy of alignment for the EM group was within a mean of 1.5 ± 1.4 degrees and 4.1 ± 2.9 degrees in the coronal and sagittal planes, respectively. In the IM group, the accuracy of alignment was within a mean of 1.4 ± 1.1 degrees and 2.5 ± 1.8 degrees in the coronal and sagittal planes, respectively. The distribution of the measured accuracy in coronal and sagittal alignment is shown in Figure 2. There was not a significant difference in accuracy between the 2 alignment referencing techniques with respect to the coronal plane alignment (P = .37). However, implants placed with the IM technique were found to be more accurate in sagittal alignment than implants placed with the EM technique (P < .001).

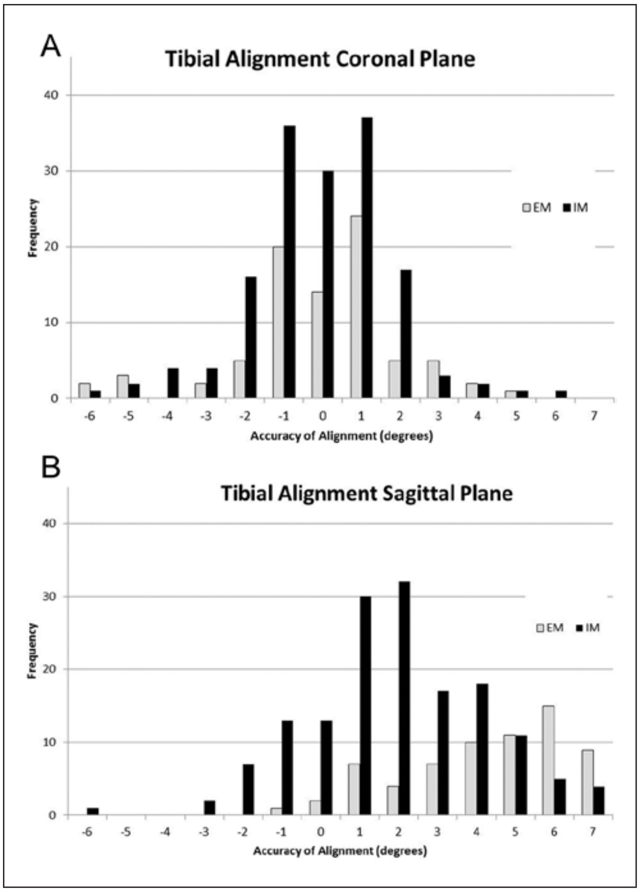

Figure 2. Accuracy of alignment of the tibial components in the coronal (A) and sagittal (B) planes. Accuracy of alignment is defined as the difference between the measured and intended coronal and sagittal implant angle. In the coronal graph, a negative value denotes valgus alignment and a positive value denotes varus alignment. In the sagittal graph, a negative value indicates posterior opening slope and a positive value indicates anterior opening slope. EM, extramedullary referencing; IM, intramedullary referencing.

Discussion

Several studies in the total knee literature have compared the accuracy of tibial component placement using EM or IM alignment guides. Brys et al[3] demonstrated 94% accuracy with IM guidance and 85% accuracy with EM guidance. In a randomized trial, Reed et al[8] demonstrated notably more accurate coronal plane placement of the tibial component with IM guidance. To our knowledge, ours is the first study to compare the accuracy of these 2 referencing techniques for tibial component alignment in total ankle arthroplasty.

As the ankle joint cannot be dislocated during surgery, the majority of ankle replacement systems use EM guides for tibial component positioning. With these implants, the external alignment rods are either strapped around the tibia or fixed in place with threaded pins. Confirmation that the guide roughly parallels the mechanical axis of the tibia is performed with intraoperative fluoroscopy. The Inbone prosthesis relies on the alignment of an IM reference drill in the distal tibia for tibial component positioning. After exposure of the tibiotalar joint and soft tissue balancing, a laminar spreader is placed within the tibiotalar joint to distract and correct the deformity. The foot is then secured to the Inbone foot holder. The IM reference drill is advanced through the plantar aspect of the foot and into the center-center position of the tibial plafond. One problem with this IM technique is the penetration of a sometimes healthy subtalar joint. The long-term effects of this technique are not yet known but must be taken into consideration when IM referencing is chosen. Once positioning is confirmed with intraoperative fluoroscopy, the IM reference drill is advanced into the distal tibia. The cutting block is then positioned using the IM drill for reference.

In TAA, unlike TKA, there are no clinically based recommendations for tibial component positioning with respect to component survival. Most surgeons who perform TAA prefer to align the tibial component in a position perpendicular to the mechanical axis of the tibia in the coronal plane and perpendicular to or with a slight anterior opening slope in the sagittal plane.[1,5] For the purposes of our study, each of the 3 treating surgeons served as his own control. Each surgeon defined his intended alignment of the tibial component based on the type of implant. Although 1 of the surgeons differed in his intended alignment of the tibial component in the sagittal plane, all other techniques for performing the procedure and implanting the prosthesis were similar for the 3 surgeons. The final tibial component alignment was compared with the intended position for each surgeon to determine the accuracy of alignment in degrees.

Our results demonstrate that there was not a statistically significant difference in the accuracy of tibial component positioning in the coronal plane. However, the IM referencing technique demonstrated significantly improved accuracy of tibial component placement in the sagittal plane. The mean difference in accuracy between the 2 techniques, however, was 1.6 degrees, and the clinical significance of this difference remains unclear. Further studies are needed to determine the optimal component position for long-term implant survival and the effects that slight component malposition (less than 2 degrees) might have on outcomes. In addition, we were able to demonstrate excellent interrater and intrarater reliability for both the coronal and sagittal implant angles.

In TKA, it is generally accepted that EM referencing is unreliable in patients with abnormal ankle structure or excess soft tissue, and IM referencing is unreliable in severe tibial deformity, previous fracture, or the presence of retained metal in the tibial canal.[1] While these recommendations may hold true for TAA, the data presented in this study do not allow us to make any recommendations about the optimal referencing technique in cases of severe tibial deformity, excessive soft tissue, or abnormal anatomy. We attempted to isolate a population of patients in whom both EM and IM referencing techniques were suitable. This allowed for a true comparison of the accuracy between the 2 referencing techniques. In TAA systems, unlike TKA systems, EM and IM referencing techniques are not interchangeable, and there is no single total ankle system that allows the surgeon to choose between IM and EM referencing for tibial component placement. Therefore, the decision to perform EM or IM referencing in TAA must be part of the preoperative planning. In this study population, only a small difference in obtaining intended alignment was recognized. Additional studies are needed to determine whether these results hold true for patients with severe deformity.

In this retrospective study, one limitation is the absence of full-length tibial films to assess the mechanical axis of the tibia. Patients with a history of tibial diaphyseal or pilon fractures and patients with clinically evident tibial deformity were excluded. Although it is possible that the measured mechanical tibial axes in this study would be different with full-length tibial radiographs, the radiographs used in this study are a more accurate representation of the intraoperative fluoroscopic field of view of the tibial shaft at the time of prosthesis placement. In addition, obtaining full-length tibial films prior to total ankle arthroplasty for patients without a history of trauma to the lower extremity and without clinical deformity is not the standard of care, thus making this study more clinically applicable. Another limitation to the study was the need to include 2 different prostheses with different instrumentation systems in order to compare IM and EM referencing techniques. It is also important to point out that the 3 treating surgeons in this study were experienced TAA surgeons with experience with both TAA systems.

In conclusion, both EM and IM referencing techniques provide good overall accuracy for tibial component placement in TAA in both the coronal and sagittal planes. Satisfactory alignment can be achieved with both techniques. Given these data and the available information on component alignment, we cannot make any recommendations for one technique over the other. Further studies are needed to determine the optimal component position in TAA and the effects that component malposition might have on long-term implant survival.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Editor's Note

The authors are to be congratulated for evaluating a potentially important issue with TAA instrumentation systems. I would agree with their feelings that evaluating only a single EM and IM instrumentation system is a notable weakness. It is possible that a different EM instrumentation system for a different prosthesis may have fared better or worse.

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