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The extensor hallucis longus tendon as the distal reference point in total knee arthroplasty and tibial alignment

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Objective: The aim of this study was to compare the effects on tibial alignment of the use of the extensor hallucis longus (EHL) tendon with the use of the 2nd metatarsal as a reference in total knee arthroplasty (TKA) using the extramedullary technique.

Methods: The study evaluated 100 postoperative radiographs of 79 patients who underwent primary TKA between 2004 and 2008. Patients were grouped according to the distal anatomical landmark used during surgery. There were 36 patients (mean age: 68.3 years, range: 56 to 82 years) in the EHL-referenced (ERT) group and 43 patients (mean age: 70.2 years, range: 54 to 78 years) in the 2nd metatarsal-referenced (MRT) group. There were 47 components in the ERT group and 53 in the MRT group. Frontal alignments of the tibial components were measured. Angles of 90±2° were accepted as the normal boundaries while those above that value were labeled as 'varus' and those below as 'valgus'.

Results: Average frontal alignment was 88.57° in the MRT group and 89.17° in the ERT group. The number of tibial components in the normal range was significantly higher (p=0.017) and the number of varus-oriented components significantly lower (p=0.024) in the ERT group. There were no significant differences in valgus-oriented outliers between groups (p=1.000).

Conclusion: The use of the EHL tendon as a reference improves coronal tibial alignment. The EHL is a reliable anatomical landmark to use with extramedullary guide systems.

Key words: Anatomical landmark; coronal tibial alignment; extensor hallucis longus tendon; extramedullary guide; total knee arthroplasty.

Cemented total knee arthroplasty (TKA) is one of the most successful orthopedic procedures with patients achieving tremendous functional recovery. The success of TKA depends on several factors related to both the patient and surgeon.[1,2] Foremost of those related to the surgeon are the selection of an appropriate implant, achieving soft tissue balance and ideal mechanical axis.[3,4] It has been shown that varus-oriented alignment has a negative effect on the implant lifespan.[5-7] However, sufficient examination into the effect of implant alignment on function has not been performed.[8]

Aseptic complications, including mechanical loos-

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ening and component failure, remain the most common reasons for TKA revision.[9] Several studies have shown the relationship between implant loosening and the extremity axis.[4,7,10,11] Aseptic loosening is the result of osteolysis occurring as an immune response to the wear particles in the component-bone or cement-bone interface. Studies have shown that malpositioning of the component increases particle wear.[12]

Intraoperative measurement and guide use are of utmost importance as there is a high error rate in the radiographs used in preoperative planning, and the correlation of the radiographs with the actual anatomy encountered in surgery is reduced greatly as deformity increases.[13] Intramedullary and extramedullary guide systems are currently in use for tibial and femoral component placement. Both techniques have advantages and disadvantages and neither shows any clear superiority over the other.[14] For extramedullary systems, the level of the 2nd metatarsal has traditionally been used as the distal tibia reference point. However, the 2nd metatarsal is not as reliable since the foot and ankle cannot always be stabilized during surgery.[15]

Other possible anatomical landmarks are the anterior tibial crest, tibialis anterior (TA) tendon, extensor hallucis longus (EHL) tendon, dorsalis pedis artery (DPA) and bimalleolar prominences.[15-19] Among these reference points, the EHL is of particular interest as it has been shown to lie very close to the talus center in cadaver studies.[20]

This study aimed to compare the effect on tibial alignment of the use of the extramedullary EHL-referenced technique (ERT) with that of the traditional extramedullary 2nd metatarsal-referenced technique (MRT).

Patients and methods

This retrospective case control study examined the early postoperative AP radiographs of 100 TKAs belonging to 79 patients with primary osteoarthritis who underwent primary TKA between 2004 and 2008. Patients were grouped according to the distal anatomical landmark used during surgery. There were 36 patients (mean age: 68.3 years, range: 56 to 82 years) in the ERT group and 43 patients (mean age: 70.2 years, range: 54 to 78 years) in the MRT group. There were 47 components in the ERT group and 53 components in the MRT group. The standard MRT method was applied for all patients operated prior to 2006. All patients undergoing TKA in 2006 and after were operated using the ERT method. Patients with bone stock loss requiring the use of bone graft or a metal wedge were excluded from the study.

All patients underwent cemented TKA. Operations were performed by the same senior surgeon. Although all prostheses were cemented, different brands were used according to product availability at the time of surgery. The skin from the toe to the site of the tourniquet was prepared with a povidone-iodine solution. Two layers of surgical gloves were applied to the foot, leaving the anterior of the ankle joint exposed and the tendons easily palpable. Transparent adhesive drapes were wrapped around the extremity, beginning from the ankle and covering the entire operative field. In the ERT group, the EHL was palpated and its location marked with a permanent marker pen. In the MRT group, distal referencing was made using the level of 2nd metatarsal with the foot in the neutral position. In both groups, femoral and tibial cuts were made using the classic method in which the tibial cut was made perpendicular to the tibial anatomic axis.

Long cassette, standing knee radiographs taken in the early postoperative period were used in the evaluation of tibial component alignment. Measurements were made by a single researcher outside the surgical team. The alpha angle was determined by drawing the tibia anatomical axis and tibial component horizontal axis on the AP radiographs. The angle on the medial side was measured using goniometry. Angles of 90±2° were accepted as the normal boundaries; those below were labeled as 'varus' and above 'valgus'. The mean alpha values and the number of outliers were noted. As the effect of deviation from the neutral position differs depending on its varus or valgus orientation, outliers were further grouped as varus or valgus.[5-7]

Statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, IL, USA) software. The differences in mean angular values between the two groups were analyzed using the independent t-tests. The rate of optimally implanted components and those in varus and valgus orientation were assessed using the chi-square test. P values of less than 0.05 were considered significant.

Results

Mean alpha angles, number of outliers in varus and valgus direction are outlined on Table 1. The average frontal alignment of the tibial component was 88.57° (range: 84° to 93°) in the MRT group and 89.17° (range: 84° to 93°) in the ERT group. There was no significant difference in mean alpha angles between groups (p=0.124). The number of tibial components with alpha angles in the normal range was significantly higher in the ERT group (p=0.017). There was no significant difference between groups in terms of valgus-oriented outliers

Table 1. Coronal alignment of the tibial components.

	Mean±SD α	Normal Range	Outliers		Mean α of Varus Outliers (α<88)
		88<α<92	α<88 varus	α>92 valgus	
ERT Group (n=47)	89.17±1.74° range: 84°-93°	n=42 (%89.4)	n=4 (%8.5)	n=1 (%2.1)	86.80±3.70°
MRT Group (n=53)	88.57±2.11° range: 84°-93°	n=37 (%69.8)	n=15 (%28.3)	n=1 (%1.9)	86.44±1.20°
p	0.124	0.017*	0.024*	1.000	0.719

*Statistically significant. SD: standard deviation.

(p=1.000). The number of varus-oriented components was significantly lower in the ERT group (p=0.024). Patients in the varus range were further analyzed and there was no difference between the two techniques in terms of mean alpha angles of varus outliers (Table 1).

Discussion

The long-term success of TKA is closely related to the surgical technique used. Obtaining normal lower limb alignment is necessary for long-term success.[1-3] Although the effect of alignment on the survival of new implant designs and patient satisfaction has been questioned by some authors, more recent studies point to the importance of both overall and individual component alignment on implant survival and functional outcome.[3,21] Longstaff et al. and Ritter et al. emphasized the importance of placing each component within the ideal limits.[8,22] The findings from their studies showed a relationship between the deviation from normal alignment of the individual components and the length of hospital stay with one-year postoperative Knee Society Scores (KSS). Failure rates are increased with additional deviation from normal in the attempt to compensate for a misalignment. Similarly, Fang et al. and Berend et a. rejected previous arguments that the normalization of a poorly aligned limb axis by additional component malpositioning will increase the lifespan of the prosthesis.[3,6]

Patients with poor component positioning in the coronal or sagittal plane tend to be less symptomatic than those with rotational malalignment and can go unnoticed until the presentation of component-related problems in the mid- or long-term.[23] It has been reported that lower limb alignment or component placement is 3 degrees or more valgus or varus in 10 to 30% of TKA patients.[1,24] To keep this rate as low as possible, it is necessary to use intramedullary or extramedullary guides for tibial and femoral component placement. Both techniques have advantages and disadvantages and neither shows any clear superiority over the other for tibial component placement.[14] In our practice, extramedullary guide systems are used for tibial components due to increased risk of fat embolism and of varus placement when the rod used in the intramedullary guide system is short or narrower than the medullary canal.[1]

In extramedullary systems, it is generally aimed to place the tibial component at 90° perpendicular to the tibial mechanical axis. The basis of extramedullary guiding is to use the center of the ankle or the level of the 2nd metatarsal to define the distal point. However, the tibial mechanical axis passes through the center of the talus, not of the ankle and placements using the center of the ankle may lead to errors in coronal alignment of the tibial component. It is quite difficult to palpate the center of the talus after draping. Although the 2nd metatarsal is in line with the center of the talus in anatomical position, the level of the metatarsal during surgery is affected to a great extent by foot rotation. Other possible anatomical landmarks are the anterior tibial crest, TA tendon, EHL tendon, DPA and bimalleolar prominences.[15-19] The EHL crosses the ankle joint very close to the center of the talus, much closer than the TA and is easily palpable. Its position does not change with foot position. Location of the EHL can be marked before or after tourniquet inflation, as opposed to the DPA, and it requires no additional measurements or instrumentation to estimate the talus center once the tendon is palpated. In our clinic, this anatomic landmark has been used since 2006 and no intraoperative problems in finding the EHL with a single layer of draping at the ankle level have occurred.

Following TKA, the mechanical or anatomic axis can be taken as a reference to evaluate alignment. Although it is thought that the mechanical axis is more important, there is a high rate of correlation of long cassette mechanical axis measurements with measurements made using the anatomical axis of the femur and tibia.[3,6,25] As the tibial anatomical and mechanical axes are parallel and the anatomical landmark of the mechanical axis in the proximal tibia is removed after joint replacement, we have taken the tibial anatomical axis as our reference for evaluation of the component position. The amount of deviation from neutral that can be accepted as normal is controversial. General opinion is that for tibial components, more than 3 degrees valgus or varus affects the lifespan of the implant.[1,4,6,10,26,27] Other publications consider the boundary of good alignment to be 2 degrees.[20,28,29] Additionally, the ideal degree of varus or valgus has been shown to vary according to the component model.[6] To be able to make a more detailed examination of the differences between the two guide techniques, the boundary of 2 degrees of varus or valgus was accepted for this study.

Despite its negative effects, components are usually placed in the varus range, although almost always in acceptable limits.[1,24,29,30] In the current study, mean alpha angles of both groups were slightly in varus (89.17° for ERT and 88.57° for MRT), yet they were considered to be in the normal range ($88<\alpha$). This is comparable to other studies with mean tibial coronal alignment ranging from 88 to 89.6 degrees.[1,14,24,29,30] The number of arthroplasties with coronal tibial alignment in the optimal range was significantly higher in the ERT group. The percentage of cases in the <2° valgus/varus range was 89.4% in the ERT group, while this ratio dropped to 69.8% in the MRT group. Similar numbers were reported in studies on computer assisted surgery by Teter et al. and Pang et al., where both authors achieved 94% optimal alignment using navigation systems within the 3° valgus/ varus range.[14,30]

In general, varus-oriented alignment impairment has a worse effect on implant lifespan.[5-7,22] Finite element analyses and retrieval studies have revealed that varus alignment generates greater strains and bone fatigue.[31] In our study, ERT's real efficiency was in reducing the number of varus outliers. It is important to remember that reducing the number of varus outliers also reduces alignment problems that are most likely to cause mechanical and component wear problems. Patients in the varus range were further analyzed to determine if the ERT method resulted in a fewer number of outliers with higher degrees of deviation from normal. However, there was no difference between the two techniques in terms of mean alpha angles of varus outliers.

This study was performed retrospectively with all the limitations of a retrospective study. Other possible limitations were the lack of functional analysis in a long-term follow-up and limited number of patients. Further studies with a greater number of patients are necessary to verify our results.

In conclusion, the EHL tendon is a reliable anatomical landmark to use with extramedullary guide systems and improves coronal alignment. Since ERT is a modification of the existing extramedullary guide system, it brings no extra cost and is applicable with all existing extramedullary guide systems. The ERT method does not prolong the operation time and its efficacy in reducing the number of outliers was comparable to computer-assisted systems in some series.

Conflicts of Interest: No conflicts declared.

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