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Functional References for Tibial Axial Rotation in Total Knee Arthroplasty

Andrew Shimmin[1], David Liu[2], Brett Fritsch[3], David Parker[3], Ishaan Jagota[4], Joshua Twiggs[4] and Brad Miles[4]
[1] Melbourne Orthopaedic Group, Melbourne, Australia
[2] Gold Coast Centre for Bone and Joint Surgery, Gold Coast, Australia
[3] Sydney Orthopaedic Research Institute
[4] 360 Med Care, Sydney, Australia
ishaan.jagota@360med.care

Abstract

Excessive post-operative tibiofemoral rotational mismatch can result in inferior patient outcomes. This highlights the importance considering the femoral axial alignment during tibial axial alignment. This study investigates different tibial rotational references including Insall's axis, Cobb's axis, and the projection of the TEA on the proximal tibial plateau in the CT, weightbearing and extension distracted positions.

All patients obtained a pre-operative long-leg supine CT scan, weightbearing antero-posterior radiograph and an extension distracted radiograph. Each CT scan was segmented and landmarked, and the resulting 3D bone models were registered to the two radiographs. The position of Insall's axis was determined relative to Cobb's axis and the projection of the surgical TEA on the proximal tibia in the supine CT, weightbearing and extension distracted positions.

From the 325 joints analysed, the mean external rotation of Insall's axis relative to Cobb's axis and the projection of the TEA in the CT, weightbearing and extension distracted positions was 4.84°±3.37°, 9.67°±4.71°, 9.65°±6.59° and 8.31°±6.44°, respectively.

Although numerous tibial rotational reference axes exist, there is a lack of consensus amongst surgeons on which is most appropriate during TKA. Since tibial and femoral axial rotation mismatch is associated with post-operative knee pain, it is important to consider references for axial rotation which can be used to align both femoral and tibial components. A better understanding of the different tibial rotational reference axes including functional axes may assist the industry in reaching a consensus on a single or few reference axes for reporting purposes.

1 Introduction

Post-operative tibial and tibiofemoral malrotation can result in pain[1], stiffness[2], patellar instability[3] and excessive poly component wear[4]. Malrotation directly accounts for 2.3% of revision surgery in Australia, but this number may be as high as 30% when we consider the aforementioned factors in aggregate[5]. Furthermore, studies have outlined that excessive tibial internal rotation and tibiofemoral rotational mismatch can result in inferior patient pain and functional outcomes[1, 6-8]. This highlights the importance of accounting for the femoral axial alignment whilst axially aligning the tibial component. Some studies have even suggested using the projection of the transepicondylar axis (TEA) on the proximal tibial plateau as a reference for tibial rotation[9-10]. However, this analysis is generally performed using a supine CT scan and therefore does not represent a functional position. This study investigates different tibial rotational references by comparing Insall's axis to Cobb's axis, as well as the projection of the TEA on the proximal tibial plateau in the CT, weightbearing and extension distracted reference frames.

2 Methods

A retrospective study comprised of 325 knee joints was performed. All patients obtained a pre-operative long-leg supine CT scan, weightbearing antero-posterior radiograph and an extension distracted radiograph. Each CT scan was segmented and landmarked, and the resulting 3D bone models were registered to the two radiographs. The position of Insall's axis was determined relative to Cobb's axis as well as the projection of the surgical TEA on the proximal tibia in the CT, weightbearing and extension distracted positions. A summary of the process is displayed in Figure 1.

3 Results

A total of 325 joints were analysed and the mean external rotation of Insall's axis relative to Cobb's axis was 4.84° (± 3.37°). The mean external rotation of Insall's axis relative to the projection of the TEA in the CT, weightbearing and extension distracted positions was 9.67° (± 4.71°), 9.65° (± 6.59°) and 8.31° (± 6.44°), respectively (Figure 2).

4 Discussion

Although numerous tibial rotational reference axes exist, there is a lack of consensus amongst surgeons on which is most appropriate during TKA. It has also been noted in literature that tibial and femoral axial rotation mismatch is associated with post-operative knee pain. Therefore, it is important to consider references for axial rotation which can be used to align both femoral and tibial components. There have been prior efforts to establish femoral references for tibial rotation, which also involved the projection of the TEA onto the tibial plateau using either 2D CT slices[9] or 3D CT reconstructions[10]. However, these prior protocols analyse the knee joint in a supine CT position and fail to consider functional tibiofemoral alignment. The study weightbearing and extension distracted TEA projections provide a more functional position in which to assess the tibiofemoral axial alignment. The variability of these functional TEA projections were consistent with published results[9, 10].

It is important to highlight the variation between different tibial rotational reference axes as these ultimately influence component alignment is targeted and/or reported. A better understanding of the different tibial rotational reference axes including functional axes may assist the industry in reaching a consensus on a single or few reference axes for reporting purposes.

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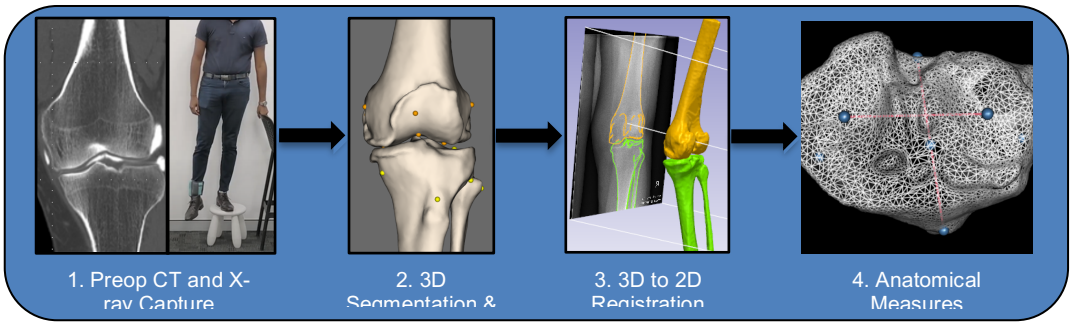

Figure 1. *Anatomical measurement process involves 1. Pre-operative capture of pre-operative long-leg lower-limb CT scans and two functional radiographs. 2. The CT scans are then segmented and landmarked followed by 3. Registration of 3D bone models to the 2D radiographs. 4. These reconstructions are used to take anatomical measures and determine the position of the reference axes*

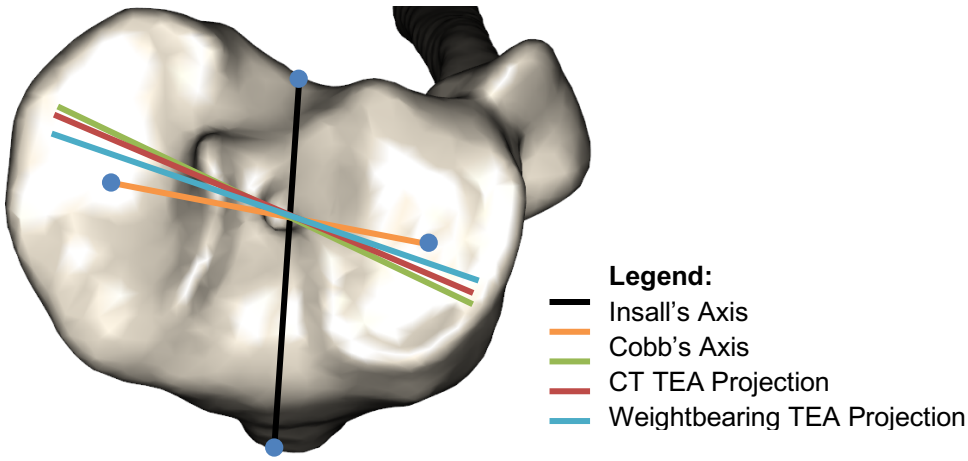

Figure 2. *Representation of the mean alignments of Cobb's Axis and the Supine, Weightbearing and Extension Distracted TEA projections relative to Insall's Axis.*