Identification of the safe zones for landmark registration with an imageless navigation system during total knee arthroplasty

Pereira GC¹, Amanatullah DF¹, Meere PA², Di Cesare PE³

¹Department of Orthopaedics, U C Davis Medical Center, Sacramento, USA
²Department of Orthopaedics, Hospital for Joint Diseases, New York, USA
³Department of Orthopaedics, New York Hospital Queens, Flushing, USA

gper11@aol.com

Introduction: During any Computer Assisted Total Knee Arthroplasty (CA-TKA), the spatial orientation of the femur and tibia somehow need to be fed into the computer for analysis. In using ‘Imageless’ CA-TKA, the surgeon does this by registration of certain anatomic bony landmarks, which are wirelessly transmitted to the computer for analysis and determination of the spatial orientation of the femur and tibia from which the bone cuts can be accurately calculated. There are a number of potential sources of error in imageless CA-TKA. Providing the array pins don’t move during surgery, the act of landmark registration is the only surgeon-dependent procedure and is highly critical in the success of the next step of the operation i.e., the bone cuts. Studies have shown that there is an inter-observer error in landmark registration and that this can lead to errors in placement of the TKR components. However, no study has quantified how far from these landmarks the surgeon can safely register a point such that the accuracy of the bony cuts would be limited to an acceptable level.

Aim: The aim of this study was to identify zones around the correct anatomical landmark within which if the surgeon registered a point, it would give rise to less than or equal to 1° of change to the bony cut and hence to the implant position.

Method: Using the Stryker Navigation System, we set up a sawbones model of the knee with the infrared trackers on the femur and tibia to simulate a TKA. All bony landmarks were marked with a marker pen and registered according to the workflow. These default landmarks were the femoral epicondyles, femoral and tibial centers and both malleoli. Bony cuts were made to obtain a mechanical alignment of 0° Varus/Valgus in the coronal plane and 0° tibial slope. These were the ‘correct positions’ of the bone cuts and the tool tracker that measured the accuracy of the cuts was left in place. Next we marked out points at 2mm intervals in four directions from the previously marked bony landmarks. We then went back through the workflow and in sequence, ‘incorrectly’ registered each landmark, leaving the others ‘correctly’ registered. The computer worked out the position of the new bony cut and the tool tracker, which was still in the ‘correct’ bony cut position, would now show a deviation. We repeated the process at...
2mm intervals in 4 directions until we found a change of 1° in any parameter.

**Results:** We found that the distal femoral epicondyles had the narrowest safe zones, which were about 2mm in the Anterior to posterior direction. The other bony landmarks were more forgiving.

Medial malleolus – 28mm diameter
Lateral malleolus – 20 mm diameter
Centers of tibia and femur- 12mm diameter
Medial and lateral epicondyles – 2mm in the AP direction.

**Conclusions:** It is imperative to pay close attention to registering the epicondyles of the femur. We suggest adding Whiteside’s line registration to countercheck the epicondylar axis registration. We only measured errors in single landmarks. We warn that combined errors are likely to be cumulative. Our observation that there is less than 2 mm of safe zone in the anterior-posterior direction during registration of the epicondyles may also explain, in part, why clinical outcomes following CA-TKA have not been consistent.