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Original research

A computer-assisted, tibia-first technique for improved femoral component rotation in total knee arthroplasty

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ABSTRACT

Background: The use of navigation for total knee arthroplasty (TKA) improves limb alignment in the coronal and sagittal planes. However, similar improvements in femoral and tibial component rotation have not yet been realized using currently available systems.

Methods: We developed a modified navigated TKA technique in which femoral rotation was set using the resected tibial plane as the reference with the aim of achieving a rectangular flexion gap. Limb alignment was assessed in a cohort of 30 knees using the navigation system. Post-operative limb alignment was measured using long-leg standing radiographs. Computed tomography was used to determine post-operative component orientation.

Results: Sagittal alignment data improved from a mean of 7.8° varus (pre-operative) to 0.0° (post-operative), assessed by intra-operative navigation. Post-operative hip-knee-ankle axis alignment was 0.9° valgus (mean; standard deviation [SD] 1.7°). Mean femoral component rotation was 0.5° internally rotated (SD 2.6°), relative to the surgical transepicondylar axis. Mean tibial component rotation was 0.9° externally rotated (SD 5.5°). No soft tissue releases were performed.

Conclusions: These results confirm that the desired femoral rotation, set using a tibia-first approach with the resected tibial plane as the reference, can be achieved without compromising overall limb alignment. Femoral component rotation was within a narrow range, with a moderate improvement in achieving more consistent tibial component rotation compared with other techniques. This technique may prove to be useful for surgeons wishing to employ a tibia-first philosophy for TKA while maximizing the benefits associated with computer-assisted navigation.

Introduction

Since the introduction of computer-assisted surgery systems to perform total knee arthroplasty (TKA) in the mid-2000s, the use of such systems has become widespread. There has also been a corresponding increase in the number of individual studies that have generated clinical evidence about their surgical utility and effects on patient outcomes. Recent meta-analyses have combined data from these studies to provide greater awareness of what has and what has not been validated by multiple studies [1,2]. Benefits include improved limb alignment in the sagittal and coronal planes, more accurate placement of femoral and tibial components in some planes, reduced revision rates, and so on.

Despite these benefits, several authors have reported an inability to consistently and accurately position the femoral component in terms of internal/external rotation in the axial plane [3]. This is largely due to limitations in defining appropriate reference axes accurately, regardless of the use of a computer navigation system [4-7].

Many different surgical philosophies and instrumentation systems have been developed to achieve the correct femoral component rotation for a specific implant design, including the use of various reference axes such as the transepicondylar axis (TEA) (both anatomical and surgical), the trochlear anterior/posterior or AP axis (aka Whiteside's line), and the posterior condylar axis [8].

There is no consensus as to which is the most reliable reference to use, and each has potential limitations, including inter-observer

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and intra-observer errors. There are often situations where one method may be preferable to another, as influenced by factors such as the pre-operative alignment, underlying anatomy, disease state, implant design, and so on.

Similarly, many different methods have been used to set tibial component rotation but none have been shown to provide consistent results [9-11]. Poor femoral and tibial component rotation has been demonstrated to affect patellar tracking and associated poor clinical outcomes [4,12]. The avoidance of excessive internal rotation of the femoral and tibial component has been reinforced as a key element of TKA surgical technique [12,13].

Current computer navigation systems present one or more (or combinations) of these axes as options for the surgeon to select and use as a guide for positioning the femoral cutting block. Despite the potential advantage of using a system that can provide detailed and accurate 3-dimensional positions, many such systems still rely on manual identification of the relevant anatomical landmarks, for example, medial and lateral femoral epicondyles and posterior femoral condyles, in a manner similar to conventional instrument systems. Therefore, they can suffer the same limitations such as inconsistency and inaccuracy, again resulting in a limited ability to accurately and reliably position the femoral component in axial rotation [14].

Other manual techniques include the so-called "tibia-first" technique that uses the tibial resection plane to guide femoral component rotation, sometimes combined with the use of spacer blocks and/or tensioning devices to assess and assist with soft tissue balancing [8,15,16]. This method removes the need for identification of individual landmarks on the distal femur to identify a reference axis. The cut tibial surface will serve as a reference plane for further femoral resections. However, there is a requirement for accurate positioning of the proximal tibial cutting guide and the bony resection. Using the accuracy of a navigation system to perform this resection may offer improved accuracy over the traditional manual technique. The accuracy of computer navigation for the coronal plane is well established in the literature [1,2]. We are taking advantage of the strength of this coronal accuracy of the computer to bypass the inaccuracy of the computer for axial rotation.

The aim of this study is to develop a tibia-first approach for use with a computer navigation system and to assess the surgical outcomes of this technique in a cohort of 30 TKAs. In addition, we also aim to assess the validity of the tibial-first technique by using computed tomography (CT) measurements.

Material and methods

Patient cohort

Surgical procedures were performed on 30 knees in 20 consecutive patients (mean age 64.9 years; range 53-79 years; sex: 16 female, 4 male) scheduled for navigated TKA from November 10, 2014 to September 21, 2015. The primary diagnosis was osteoarthritis in 18 patients (27 knees) and rheumatoid arthritis in 2 patients (3 knees). Approval for this study was granted by the Independent Ethics Committee, and all patients provided written, informed consent (Reference 201503.1).

Surgical technique

All procedures were performed by a single surgeon (CML). An image-free navigation system was used to perform TKA (eNlite

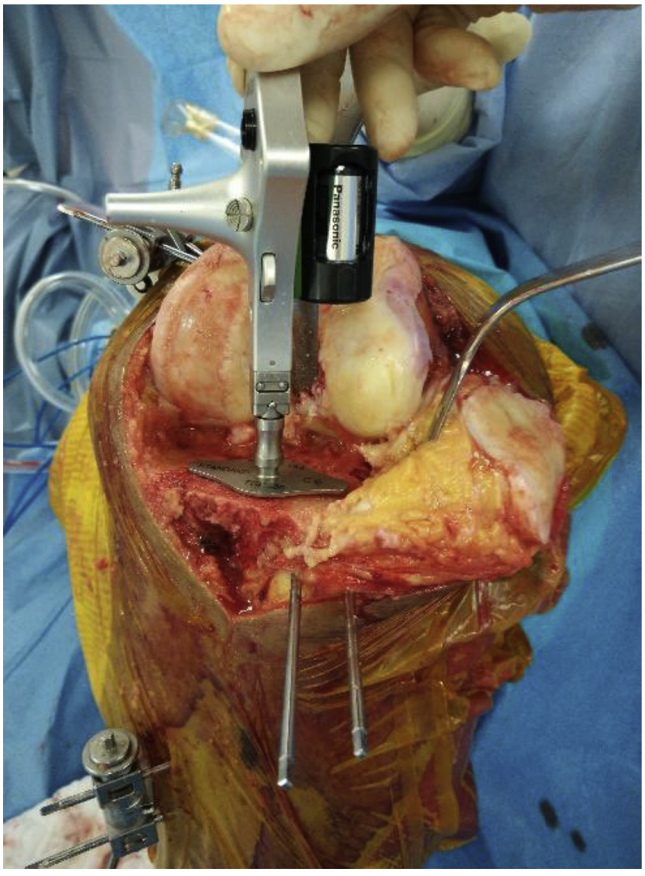

Figure 1. Proximal tibial resection performed and verified using navigation.

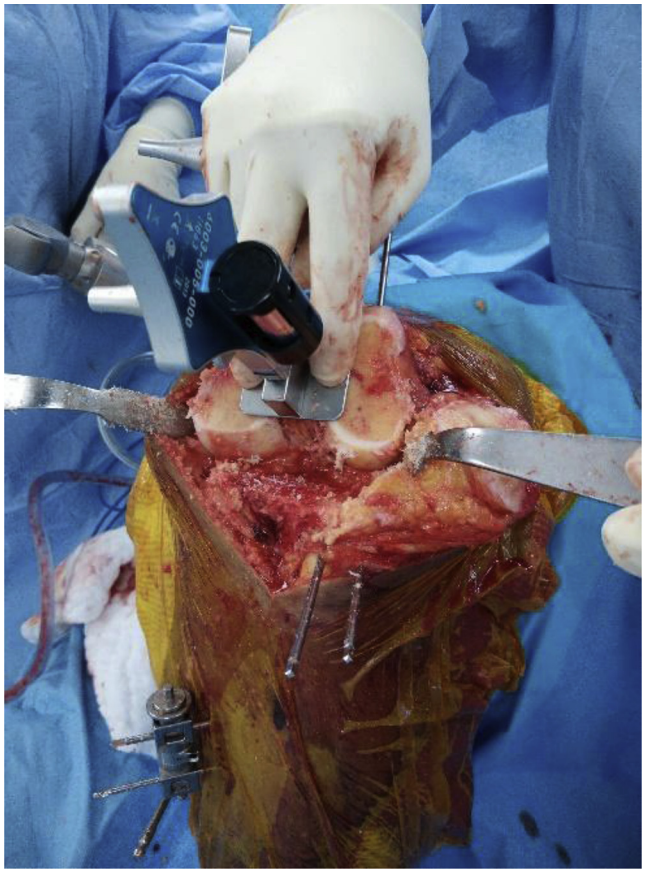

Figure 2. Distal femoral resection performed and verified using navigation.