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# A cadaveric investigation of the accuracy of a new, computer-assisted navigation system for total knee arthroplasty: A comparison with computed tomography imaging

Ran Schwarzkopf [1], Brian M. Culp [2], Michael P. Bradley[3], and Emily I. McIntosh[4*]

[1] NYU Langone Orthopedic Hospital, New York, NY, USA
[2] Princeton Orthopaedic Associates, Princeton, NJ, USA
[3]Orthopedics Rhode Island, Wakefield, RI, USA
[4]Intellijoint Surgical, Kitchener, ON, Canada
e.mcintosh@intellijointsurgical.com

**Abstract**

Despite the success of total knee arthroplasty (TKA), malalignment continues to be a problem which often leads to post-operative complications. The aim of this study was to investigate the accuracy of a novel, imageless, optical surgical navigation tool to assist with the alignment of femoral and tibial cuts performed during total knee arthroplasty. Six board-certified orthopedic surgeons performed TKA procedures on 9 cadavers (17 knees total), using a novel, imageless navigation system (Intellijoint KNEE, Intellijoint Surgical). Varus/valgus, femoral flexion, tibial slope, and rotation measurements from the device were compared with angular measurements calculated from post-operative computed tomography (CT) images. Navigation measurements were highly correlated with those obtained from CT scan in all three axes. For the femoral cuts, the absolute mean difference in varus/valgus was 0.83° (SD 0.46°, r = 0.76), in flexion was 1.91° (SD 1.16°, r = 0.85), and in rotation was 1.29° (SD 1.01°, r = 0.88) relative to Whiteside's line and 0.97° (SD 0.56°, r = 0.81) relative to the posterior condylar axis. For the tibia, the absolute mean difference in varus/valgus was 1.08° (SD 0.64°, r = 0.85), anterior/posterior slope was 2.78° (SD 1.40°, r = 0.60), and rotation was 2.98° (SD 2.54°, r = 0.79). Intraoperative monitoring with the imageless navigation tool accurately measures femoral and tibial cuts in TKA and may help to increase component alignment.

* Corresponding author

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# 1 Introduction

Total knee arthroplasty (TKA) is the most common orthopedic surgery, with approximately one million knee replacements performed annually in the United States[1]. Despite the success of primary TKA, revisions account for up to 7.8% of the annual surgical procedures[1]. Complications commonly present in the form of component loosening, instability, infection, dislocation, and fracture[2]. Approximately 20% of patients also experience continued chronic pain following surgery[3]. Component malalignment has been linked to stiffness[4], pain[5], flexion asymmetry[6], and patellar mal-tracking[7]. With the expected increased demand for TKA as the population ages, there is an opportunity for new technology such as computer-assisted navigation to assist in delivering consistent surgical results. To assess the initial accuracy of the device, we performed a cadaver study to compare intraoperative device measurements to post-operative computed tomography (CT) images.

# 2 Methods

Six board-certified orthopedic surgeons operated on seventeen cadaveric knees using their preferred surgical approaches. All procedures were performed using an imageless, computer-assisted navigation system (Intellijoint KNEETM, Intellijoint Surgical, Kitchener, ON). The navigation system consists of a portable camera, optical tracker and computer workstation. The camera captures movements of the trackers within its field of view and displays data on cut angles for varus/valgus, femoral flexion/tibial slope, and axial rotation on the workstation in real-time

Cadaveric specimens were analyzed using CT imaging. Long leg CT scans from the acetabular roof to the talar dome were obtained pre- and post-operatively. Scans were segmented in 3D Slicer to create 3D models of the femur and tibia. The mechanical and rotational axes were registered using anatomical landmarks. Angles of the bone cuts on the post-operative CT scan were calculated in MATLAB and based on the plane of best fit in relation to the registered mechanical and rotational axes.

Mean absolute differences between the navigation tool measurements and values calculated from CT scans were determined for the surgical cuts in each plane. The level of agreement between the intraoperative device measurements and the resulting CT scan calculations was also examined using a Bland-Altman analysis.

# 3 Results

Measurements with the navigation tool were highly correlated with those derived from the CT scan in all three axes. For the femoral cuts, the absolute mean difference in varus/valgus was 0.83° (SD 0.46°, r = 0.76), in flexion was 1.91° (SD 1.16°, r = 0.85), and in rotation was 1.29° (SD 1.01°, r = 0.88) relative to Whiteside's line and 0.97° (SD 0.56°, r = 0.81) relative to the posterior condylar axis. For the tibia, the absolute mean difference in varus/valgus was 1.08° (SD 0.64°, r = 0.85), anterior/posterior slope was 2.78° (SD 1.40°, r = 0.60), and rotation was 2.98° (SD 2.54°, r = 0.79). Bland-Altman analyses demonstrated that 100% of paired varus/valgus measurements and 95% of paired femoral flexion/tibial slope and rotational measurements were within the statistical limit for agreement.

# 4 Discussion

Accurate alignment of components in TKA is critical to ensure a successful procedure and minimize future complications. Alignment to within ± 3° of the mechanical axis is a generally accepted goal of TKA[8]. The present study found that imageless navigation was able to measure cuts in all three planes within acceptable parameters compared to CT measurements for both tibial and femoral cuts. The accuracy of the current device was comparable to cadaver studies of other navigational devices,[9] and to recent clinical studies of computer navigation.10 One recent study noted mean differences of 1.64° in coronal alignment, 2.07° in slope and 1.38° in rotation when comparing intraoperative values with post-operative CT, findings that mirror those of our study.[10] As such, the accuracy afforded by computer-assisted navigation may contribute to the successful alignment of components and decrease complications for patients while increasing surgeon confidence.

| | Femur | | | | Tibia | | |
|---|---|---|---|---|---|---|---|
| | Varus/ Valgus | Flexion Angle | Rotation Whiteside's | Rotation PCA | Varus/ Valgus | Anterior/ Posterior Slope | Rotation AP axis[1] |
| Absolute Mean Difference | 0.83˚ | 1.91˚ | 1.29˚ | 0.97˚ | 1.08˚ | 2.78˚ | 2.98˚ |
| Standard Deviation | 0.46˚ | 1.16˚ | 1.01˚ | 0.56˚ | 0.64˚ | 1.40˚ | 2.54˚ |
| Pearson's Correlation (r) | 0.76 | 0.85 | 0.88 | 0.81 | 0.85 | 0.60 | 0.79 |

**Table 1:** Angular intraoperative values from Intellijoint Knee's use during cadaveric laboratories compared to post-operative CT scan results. Values are reported as absolute mean differences between the two methods, standard deviation, and correlations.

[1] The Tibial Rotation AP axis was defined by the line connecting the PCL insertion with the medial third of the tibial tuberosity.

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