Fidelity of preoperative planning to intraoperative execution in total knee arthroplasty: an analysis of customized instrumentation

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Introduction: Customized instrumentation (CI) is an emerging technology in total knee arthroplasty (TKA). Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) scans are utilized to evaluate the unique anatomy of each patient. Preoperative mapping software is then used to fabricate custom guides to help increase the accuracy and efficiency of intraoperative boney resection. With this new technology, traditional measurements performed in the operating room are instead performed in a virtual environment outside of the operating room. There has been no study to date evaluating whether what is planned outside the operating room is what is executed in the operating room. In thus study we evaluated the fidelity of preoperative planning to intraoperative execution in TKA utilizing CI.

Methods: Two surgeons performed two hundred and twenty-four TKA utilizing the Patient Specific Instrumentation (PSI) system. Calipers were used in the operating room to measure bone resections from the distal and posterior femur and the tibial plateau. Prior to guide block placement, each surgeon drew his assessment of Whiteside's Line (WSL). This was then compared to a ridge on the femoral guide block that indicated the MRI based determination of WSL (see Figure 1). Anterior notching was also assessed on all patients during the operation.

Results: In 224 patients, medial, lateral, distal and posterior femoral resections were on average within 1mm of the preoperative plan. The average deviation from the plan and the corresponding standard deviations are summarized in Table 1. Posteromedial femoral resection and distal medial femoral resection were often greater than planned ($P<0.001$) but still within 1 mm. Medial and lateral tibial resections, were on average, within 1 mm for all patients however more bone was resected than planned ($p<0.001$). The anterior femoral cut was flush in 96.9% of patents. WSL was congruent with the surgeon's assessment of WSL in 97.8% of patients.

Figure 1: Correlation of Whiteside's Line (WSL) between femoral guide block and surgeon's perception. On the left, the customized guide block has been marked in the center where a ridge indicates the planning software's assessment of WSL. In the middle, the surgeon has drawn his own assessment of WSL prior to femoral resection. On the, after placement of the femoral guide block, it is apparent that the surgeon's and the software's assessment of WSL are congruent.

Discussion: Customized instrumentation is an emerging but unproven technology in TKA. We sought to examine how well preoperative plans translated to the operating room. In our study, all bone resections were, on average, within 1mm of the preoperative plan in all 224 patients. There was a tendency to resect more posterior-medial femoral bone than planned and more proximal tibial bone

than planned. However, the average magnitude of this over resection was 0.82 mm on the femur and 0.87 and 0.74 mm on the medial and lateral tibia respectively. The trend for greater than planned resection on the posteromedial femoral condyle may express the surgical tendency to avoid internal rotation of the components. The trend for greater than planned resection on the tibia might be related to a conservative approach on the tibia in an attempt to preserve bone stock and maximize tibial component sizing. The use of traditional cutting blocks then allows the surgeon to easily perform further resection if desired. The planning software's assessment of WSL was highly correlated to the surgeon's perception of WSL. Our study indicates that there is a high fidelity of preoperative planning to intraoperative execution in TKA utilizing CI.

Bone Resection	Difference from Preoperative Plan	Standard Deviation	P Value
Posterior Femur - Medial	0.82 mm more bone resected	1.65 mm	P <0.001
Posterior Femur - Lateral	0.12 mm less bone resected	2.16 mm	P = 0.408
Distal femur – Medial	0.36 mm less bone resected	1.3 mm	P < 0.001
Distal Femur – Lateral	0.17 mm more bone resected	1.48 mm	P = 0.095
Tibia – Medial	0.87 mm more bone resected	1.42 mm	P <0.001
Tibia - Lateral	0.74 mm more bone resected	1.55 mm	P <0.001

Summary of Bone Resections, Standard Deviations, and P-values.