Malpositioning of Tibial Trays in TKR: The Effect of Implant Asymmetry

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Introduction Malpositioning of the tibial and/or femoral components is a common error in TKR, and has been frequently cited as the cause of pain, effusions, soft-tissue tightness, leading to clinical symptomatic failure of these procedures. Correct rotational placement of the tibial component is especially challenging, primarily because the anatomic landmarks on the tibia are highly variable and are poorly correlated with the motion axis of the knee during functional activities. Short of custom implants and instruments, anatomically contoured tibial trays could potentially improve rotational alignment by providing a better match to the shape of the resected tibial surface. However, the inherent variability of tibial anatomy and the 3-5mm increments between sizes of these components may result in minimal benefit, despite the increased cost and size of inventory.

This study was undertaken to test the hypotheses:
1. Use of an anatomically contoured tibial tray can reduce the prevalence of malrotation and cortical overhang in TKA while increasing coverage of the resected tibial surface, and
2. Component shape has more influence on the results of surgical trainees compared to experienced surgeons.

Materials and Methods A standard symmetric design of tibial tray was developed from the profiles of 3 widely used contemporary designs. Corresponding asymmetric profiles were generated to match the average shape of the resected surface of the tibia based on a detailed morphometric analysis of anatomic data. The AP asymmetry (lateral vs medial depths) of the anatomic design averaged 6mm. Both designs were proportionally scaled to generate a set of 7 different sizes spanning the shape of the resected tibial surface. However, the inherent variability of tibial anatomy and the 3-5mm increments between sizes of these components may result in minimal benefit, despite the increased cost and size of inventory.

Computer models of eight tibias were selected from a large anatomic collection. A proximal resection plane was constructed perpendicular to the canal axis in the coronal plane with a posterior slope of 5 degrees. Eleven experienced joint surgeons and twelve trainees individually determined the ideal placement of both the symmetric and asymmetric trays on each of the 8 tibias. The software employed in this project allowed selection of any size of tray and adjustment of its internal/external rotation and in AP and ML position on the tibial surface. After the implantation exercise, the placement of each component was quantified in terms of (1) its rotational alignment with respect to the motion axis of the knee (as previously determined by cadaveric testing); (2) the degree of coverage of the resected bony surface, and (3) the extent of overhang of the tray beyond the cortical boundary. Differences in the parameters defining the implantations of the surgeons and trainees were evaluated statistically.

Results Coverage of the tibial resection was significantly greater in cases using the asymmetric tray vs. the symmetric design (87.0±4.1% vs. 75.6±4.0%; p<0.0001). Coverage was less than 75% in 37% of symmetric components vs. 43% of the asymmetric (p=0.0001). Cortical overhang was regarded as clinically significant (>1mm) in 35% of symmetric vs. 11% of asymmetric cases (p=0.0001). Similarly, the maximum cortical overhang averaged 0.89±0.91mm for the symmetric implant vs. 0.35±0.56mm for the asymmetric trays (p=0.0001).

Discussion 1. The prevalence of malrotation was substantially reduced when surgeons and trainees positioned anatomically shaped trays. 2. The asymmetric design was also associated with a large reduction in cortical overhang and increased coverage of the resected tibial surface. 3. There was no overall difference between the performance of trainees and experienced joint surgeons, regardless of the design of the implant. This suggests that current training and surgical guides are inadequate in achieving correct positioning of the tibial component in TKR.

Significance Surgeon performance in positioning the tibial tray in TKR is affected by the asymmetry of the component. An asymmetric, anatomically-shaped tray is more reliably positioned with reduced incidence of internal rotation, decreased cortical overhang and increased plateau coverage. These benefits appear to be independent of surgeon experience.

Figure 1: Profiles of the symmetric (top-left) and asymmetric (bottom-left) trays. Asymmetric tibial tray profile on top of a resected tibial specimen (right) shown with a coordinate trackball used to adjust the position of the tray.

Figure 2: Breakdown of cases exhibiting overhang by anatomic quadrant (left). Comparison of the resection surface coverage from both types of trays (right).

On average, the asymmetric tray was placed in 4.1±3.7° of external rotation vs. 1.6±4.6° for the symmetric tray (p=0.0001). The tray was implanted in some degree of internal rotation in 24% of cases, 15% for the asymmetric design vs. 33% for the symmetric (p=0.0001). Almost one tenth (9.2%) of all symmetric trays and almost no (0.5%) asymmetric trays were placed in severe internal rotation (>5°) (p=0.0001). Only 1.1% of symmetric trays were placed in excessive external rotation (>10°) vs. 5.4% of the asymmetric design (p=0.0189).

Figure 3: Distribution of values showing probability of malrotation

There was minimal difference between the results of implantations performed by trainees vs. experienced surgeons, in terms of tibial coverage (p=0.245), cortical overhang (p=0.735), or the prevalence of internal rotation (p=0.147). Trainees placed 6.3% of all cases in severe internal rotation (>5°) compared with 12.5% of surgeon cases (p=0.154).

Poster No. 1015  •  ORS 2012 Annual Meeting