Accuracy of Arthroplasty Surgeons in Estimating Flexion and Extension Gaps in Total Knee Arthroplasty

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INTRODUCTION:

Use of robotic and navigation technology in total knee arthroplasty (TKA) complements the manual estimation of knee joint gaps. The accuracy of surgeons in estimating gaps in TKA is not well established. An understanding of this can help determine the utility of assistive technology in the assessment of TKA balance and stability. The aims of this study are to determine the accuracy of surgeons in manual estimation of gaps in TKA.

METHODS:

Seven pelvis-to-toe fresh, human cadaver specimens (5 females, 2 males, age 73±6.8 years) were implanted with standard posterior stabilized (PS) TKA trial implants by an experienced arthroplasty surgeon. Markers for motion capture were rigidly fixed to the femur and tibia and registered to 3D virtual models from a CT scan (Fig. 1). Five arthroplasty surgeons (range 6-24 years in practice) and a chief resident independently assessed ligament balance and estimated 4 gap magnitudes (medial and lateral gaps in flexion and extension) for each cadaver.

The error in gap estimation (i.e., accuracy) was calculated as the difference between estimated gaps (via manual inspection) and measured gaps (via gold standard motion capture).

RESULTS:

Gap estimation error (i.e., accuracy) across all surgeons and specimens was ≤1 mm in 72% of observations and ≤2 mm in 94% of observations (Fig. 1). Mean differences in error ranged from 1.2 mm (medial extension gap) to 1.8 mm (lateral flexion gap) ($p \leq 0.012$) (Fig. 2). Surgeons underestimated gaps by up to 1.1 mm, 1.4 mm, and 1.0 mm on average in the medial and lateral extension gaps, and the medial flexion gap, respectively ($p \leq 0.047$) (Fig. 2).

DISCUSSION AND CONCLUSION:

Most (72%) gap estimation errors were in a range (≤1 mm) where surgeons would not consider changing the polyethylene insert size (Fig. 1). The lowest errors (1.0 and 1.1 mm) were in the medial extension and flexion gaps, respectively, which are the most important for balancing a TKA.

Surgeons in this cohort tended to underestimate gaps (up to 1.4 mm), which could be explained by unrecognized motion between the trial polyethylene liners and tibial baseplates. Furthermore, the largest error was found in estimation of the flexion lateral gap, which could be attributed to a larger native gap size overall or view obstruction by the patella.

In conclusion, the highest accuracy in gap estimation during TKA was in the medial flexion and extension gaps, which are the most crucial when balancing a TKA.

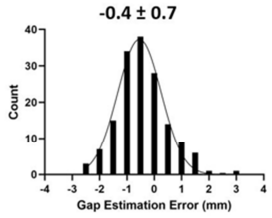

Figure 1: Histogram of gap estimation errors for gap estimates across all specimens and surgeons. Mean and standard deviation is listed above the histogram. A negative error indicates surgeon underestimation of gap sizes compared to motion capture.

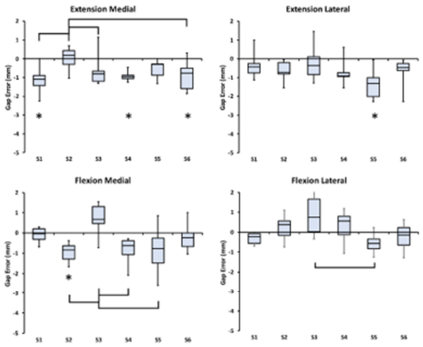

Figure 2: Box plots describing gap estimation errors. A negative gap error indicates surgeon underestimation of gap sizes compared to motion capture. *Indicates gap estimation errors that were different than zero error ($p<0.05$). Brackets indicate differences between surgeons in gap estimation errors ($p<0.05$).