

The Impact of Surgical Workflow on Bone Cut Parameters Evolution in Total Knee Arthroplasty: Transitioning from Measured Resection to Gap Balancing Surgical Workflow

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INTRODUCTION: One singularity of the total knee arthroplasty (TKA) compared to other joint replacements relates to the large panel of surgical workflows depending on the order of the bone cuts and the assumed references. For example, the measured resection (MR) workflow employs anatomical landmarks for guiding bone cuts, while the full gap balancing (GB) workflow utilizes collateral ligament tension from extension to flexion to define the bone cuts. Due to these differences in reference definitions, both the position and orientation of the final implants are expected to fluctuate between these two workflows. Although existing literature often emphasizes change in femoral axial rotation angle between these two techniques¹, limited information is available about the other parameters. This study evaluates implant cut parameters in terms of both position and orientation within the context of surgeons transitioning from a femur-first MR workflow to a tibia-first GB workflow during TKA, all using the same computer-assisted surgery (CAS) system.

METHODS: A total of 8 surgeons using a modern CAS system switched their surgical workflow from MR to GB. Seven bone cut parameters associated with the femoral preparation for both workflows were compared. These included targeted position parameters (distal resection, posterior medial resection, posterior lateral resection, anterior offset) and targeted orientation parameters (femoral implant flexion, varus & valgus, axial rotation). The evaluation was performed at three distinct timepoints: the last 20 TKAs performed using the MR protocol (MR proficient group), first 20 TKAs performed using the GB protocol (GB learning group), and the last 20 TKAs performed using the GB protocol (GB proficient group). While the comparison between the MR proficient group and the GB learning group provides insights regarding the technique change, the comparison between the GB learning group and the GB proficient group adds another layer of information regarding the impact of the experience on the evolution of the cut parameters. For three groups, mean and standard deviation (SD) were computed for each surgeon and bone cut parameter to compare the differences. The non-parametric Fligner-Killeen (FK) test was conducted to evaluate whether the variances across three groups with 20 cases each differed statistically for each parameter within every surgeon. The corresponding p-values are recorded. Post FK-test, Wilcoxon signed-rank tests were employed to facilitate pairwise comparisons between two groups combinations (MR proficient – GB learning, GB learning – GB proficient, and MR proficient – GB proficient) to assess if there exists significant difference in the distribution of the two evaluated groups. Following statistical tests, the SDs of three groups within each surgeon for each parameter were compared to evaluate linear transition of bone cut parameters range: a) whether GB learning group SD is higher than MR proficient group SD, and b) whether GB proficient group SD is higher than GB learning group.

RESULTS SECTION: The findings are visually presented through bar plots (Figures 1 and 2), illustrating the mean and SD of three groups for both position and orientation cut parameters for each surgeon. Figure 1 reveals that 3 to 4 surgeons displayed statistically significant ($p \leq 0.05$) variance difference across three groups for position parameters. Conversely, a higher number of surgeons, specifically 7 surgeons exhibited statistically significant variance across three groups in relation to femoral implant flexion and femoral implant varus and valgus (V&V) angles. Wilcoxon signed rank tests results (as marked in Figures 1 and 2) demonstrates a relatively statistically significant difference in the distribution of groups for orientation parameters, especially femoral implant axial rotation, when compared to position parameters. Overall, a clear trend observed in both position and orientation cut parameters (Figures 1 and 2), showing that most of the surgeons exhibited lower SD in the MR proficient group when compared to the GB groups (learning and proficient). Between GB learning and GB proficient groups for position parameters, 4 out of 8 surgeons demonstrated higher SD in GB proficient phase compared to GB learning phase. For orientation parameters, 5 out of 8 surgeons demonstrated higher SD in GB proficient phase compared to GB learning phase.

DISCUSSION: Examining the SD values for MR proficient and GB learning groups among surgeons, it becomes apparent that most of the surgeons tend to broaden both position and orientation cut parameters ranges when transitioning from MR to GB groups. Notably, around half of the surgeon cohort further broaden the cut parameters range as they gain experience, as reflected in the SD values of the GB learning and GB proficient groups. This study demonstrates that the surgical technique has an impact of the femoral cut parameters and surgeons seeking to switch from MR to GB should be aware of these changes. The limited sample size in each group constitutes a limitation of this study. A larger sample size would yield more comprehensive insights.

SIGNIFICANCE/CLINICAL RELEVANCE: This study holds clinical relevance for total knee arthroplasty (TKA), shedding light on how surgeon planned intraoperative cut parameters evolve during the transition from one surgical workflow to another, and from learning phase to proficient phase within the same workflow.

REFERENCES:

1. Heesterbeek PJ et al. Effects of the Balanced Gap Technique on Femoral Implant Rotation in TKA. Clinical Orthopaedics and Related Research. 2009; 467:1015-1022

IMAGES AND TABLES:

Figure 1: Position parameters mean and SD for 8 surgeons. Pairwise comparisons statistical significance NS ($p > 0.05$), * ($p \leq 0.05$), ** ($p \leq 0.01$), *** ($p \leq 0.001$)

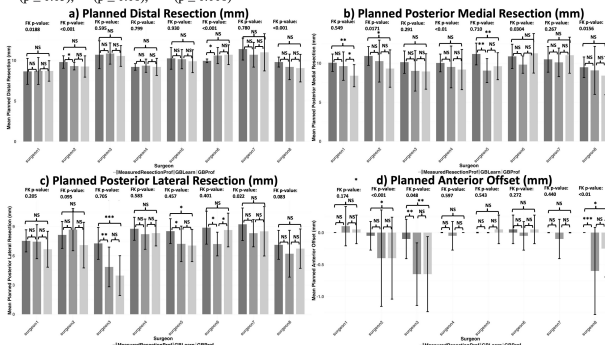


Figure 2: Orientation parameters mean and SD for 8 surgeons. Pairwise comparisons statistical significance NS ($p > 0.05$), * ($p \leq 0.05$), ** ($p \leq 0.01$), *** ($p \leq 0.001$)

