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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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Abstract

This study investigated the impact of (1) the transition from an MR workflow to a GB workflow as well as (2) the adoption of the GB workflow on the bone cut parameters during TKA. The findings demonstrated that both the transition and the adoption have an impact on the bone cut parameters and surgeons seeking to switch from MR to GB surgical workflow should be aware of these changes.

1 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 as well as the definition of the references used for the set-up of the bone cuts.

Regarding the first aspect, there exists the possibility of starting with the femoral cuts and then the tibial cut (femur first workflow) or the opposite (tibial first workflow). Regarding the second aspect, the measured resection (MR) workflow leverages anatomical landmarks for guiding bone cuts, while the full gap balancing (GB) workflow utilizes collateral ligament tension in both extension and flexion to define the bone cuts.

Due to these differences in terms of the sequence of the bone cuts and the definition of the references, both the position and orientation of the final implants are expected to vary based on these workflow options. Although existing literature often emphasizes changes in femoral axial rotation angle between these two techniques [1-3], limited information is available about the impact on the other bone cut 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.

2 Material and Methods

A retrospective review was performed on a proprietary cloud-based database associated with a CAS system, using the intra-operative data from a cohort of 8 surgeons, who switched their surgical technique for TKA from a femur first MR workflow to a tibial first GB workflow. Seven bone cut parameters associated with the femoral preparation for both workflows were compared. These included targeted position parameters (i.e., distal resection, posterior medial resection, posterior lateral resection, anterior offset) and targeted orientation parameters (i.e., femoral implant flexion, frontal alignment, axial rotation).

The evaluation was performed at three distinct timepoints: the last 20 TKAs performed using the MR protocol (MR proficient group), the 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 surgical workflow change, the comparison between the GB learning group and the GB proficient group adds another layer of information regarding the impact of the experience with the GB workflow on the evolution of the cut parameters.

2.1 Statistical analyses

For the 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 were recorded. Post FK-test, Wilcox 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 a 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 the 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.

3 Results

The findings are visually presented through bar plots (Figures 1-2), illustrating the mean and SD of the three groups for both position and orientation femoral cut parameters for each surgeon. For the position parameters, 3 to 4 surgeons displayed statistically significant ($p \leq 0.05$) variance differences across the three groups (Figure 1). Conversely, a higher number of surgeons, specifically 7 and 8 surgeons exhibited statistically significant variance across three groups in relation to the flexion and the axial rotation of the femoral component, respectively (Figure 2). Wilcox signed rank test results (as marked in Figures 1 and 2) demonstrate a relatively statistically significant difference in the distribution of the groups for orientation parameters, especially the axial rotation, when compared to position parameters.

Overall, a clear trend is observed in both position and orientation cut parameters (Figures 1-2), 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.

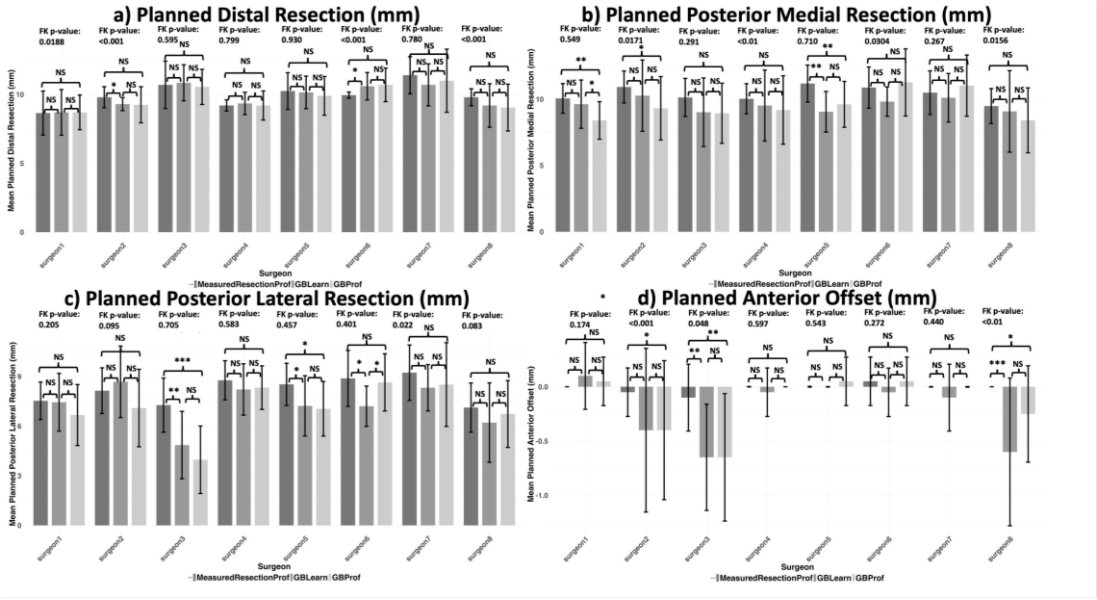

Figure 1: Position parameters mean and SD for 8 surgeons. Pairwise comparisons statistical significance NS (p>0.05), * (p≤0.05), ** (p≤0.01), *** (p≤0.001)

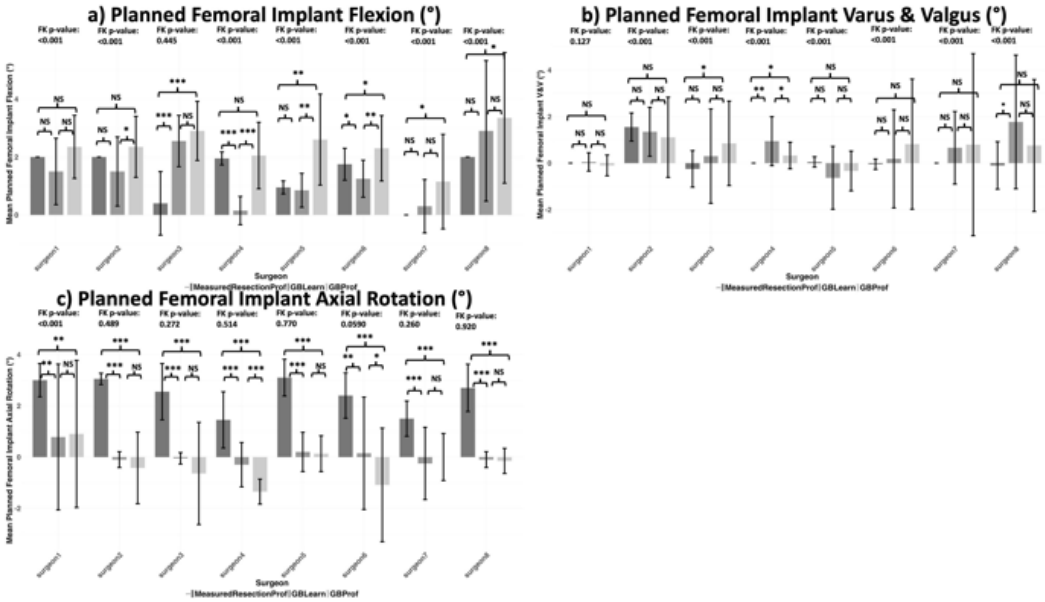

Figure 2: Orientation parameters mean and SD for 8 surgeons. Pairwise comparisons statistical significance NS (p>0.05), * (p≤0.05), ** (p≤0.01), *** (p≤0.001)

4 Discussion and conclusion

This study evaluates the impact of first transitioning from MR to GB surgical workflow and then adopting the GB workflow on the femoral cut parameters during a TKA. First, examining the SD values

for the MR proficient and the GB learning groups, it becomes apparent that most of the surgeons tend to broaden both their position and orientation cut parameters ranges when transitioning from MR to GB groups. While the scientific literature tends to focus on the impact of the transition from MR to GB on the sole axial rotation parameter [1-3], this study sheds light on the evolution of the other cut parameters associated with the implantation of the femoral component during TKA too. Aside from the axial rotation where all the surgeons experience a significant variance, 88% of the surgeons exhibit significant variance of at least one of the other cut parameters.

In addition, around half of the surgeon cohort further broadened the cut parameters range as they gained experience, as reflected in the SD values of the GB learning and GB proficient groups. As part of the adoption, the most impacted parameter relates to the flexion of the femoral component; which allows for further control of the flexion-extension gaps [4-7].

This study demonstrates that the surgical technique has an impact on the bone 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.

5 References

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