# Operative Time Learning Curve for an Image-Free Robotic-Assisted Total Knee Arthroplasty

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INTRODUCTION: Robotic-assisted total knee arthroplasty (RA-TKA) allows for more precise and accurate bone resection, implant position, and joint alignment compared to manual TKA (M-TKA). The learning curve associated with the adoption of RA-TKA should be carefully considered, as it may lead to disruptions in operating room efficiency, increased complications, and higher costs. The current study aims to assess the operative time learning curve of RA-TKA analyzing a single-surgeon cohort.

METHODS: The first 80 consecutive RA-TKA cases and last consecutive 80 M-TKA cases were assessed. The robotic cases included in this study represent the first imageless robotic cases of a single surgeon after transitioning from exclusively M-TKA. The learning curve cumulative summation (CUSUM) analysis was conducted to evaluate the RA-TKA operative times. This statistical tool quantifies the running total of differences between individual data points and the mean of all data points to assess stabilization of the surgical times. Three distinct phases constitute the learning curve: 1) the initial learning curve, 2) the plateau of the learning curve or period of increased competence, and 3) the post-learning period. The case number by which the CUSUM value entered the plateau was defined as the number of cases to proficiency. RA-TKA cases were further subdivided into sequential groups of 20 cases and compared to all M-TKA cases. Continuous variables were described with mean ± standard deviation and an independent t-test was conducted to compare surgical times between both techniques.

RESULTS: Two distinct breakpoints (9 and 53) and three distinct phases were identified on the learning curve CUSUM plot (Fig.1). Phase 1 (initial learning): the number of cases to proficiency was 9. Phase 2 (increased competence): a plateau between cases 10-52 indicates a stabilization of operative times. Phase 3 (post-learning): a downtrend of operative times between cases 53-80 depicts a period of optimized performance. The mean surgical time for RA-TKA was 42.4 ± 8.7 minutes, whereas the M-TKA group had a mean value of 35.3 ± 7.0 minutes ($p<.001$). Mean operative times for the first 20 RA-TKA cases and the last 20 RA-TKA cases were 48.0 versus 38.5 minutes ($p< 0.05$). Surgical times of the last RA-TKA group (cases 61-80) were similar when compared to the M-TKA group ($p= 0.06$).

DISCUSSION AND CONCLUSION: The RA-TKA is an enabling surgical tool that can be integrated efficiently into a surgical workflow with a rapid learning curve of 9 cases.

Figure 1. The CUSUM plot shows the cumulative sum of differences in surgical time compared to mean surgical time for RA-TKA. Red lines represent breakpoints at 9.44 and 52.71 (representing cases 9 and 53, respectively). Phase 1 represents the number of cases to proficiency. Phase 2 represents the competence phase. Phase 3 represents the period of optimized performance.