Evaluation of the Learning Curve Associated with Advanced Intra-Operative Planning for Total Knee Arthroplasty

François Boux de Casson[1], Laurent Angibaud[2], Wen Fan[2], Amaury Jung[1], James Huddleston[3]
[1]Blue-Ortho, Meylan, FR, [2] Exactech, Gainesville, FL, USA, [3]Stanford University Medical Center, Stanford, CA, USA
laurent.angibaud@exac.com

Disclosures: F. Boux de Casson: 3A; Blue-Ortho. L. Angibaud: 3A; Exactech. W. Fan: 3B; Exactech. A. Jung: 3A; Blue-Ortho. J. Huddleston: 3B; Exactech.

INTRODUCTION: New technologies used for total knee arthroplasty (TKA) have the potential to improve procedural consistency and ultimately patient outcomes. On the other hand, their adoption may impact surgeons' habits. Recent technology developments enable the intra-operative planning of the bone cut parameters in terms of size, alignment, as well as advanced laxity considerations. The purpose of this study was to evaluate the surgeons' learning curve when integrating this new technology into their daily practice.

METHODS: A retrospective review was performed on a proprietary cloud-based database that archives cases logs performed using an instrumented computer-assisted surgery (CAS) system allowing the acquisition of the comprehensive knee joint laxities throughout the full arc of motion under quasi-constant distraction force and then the intraoperative advanced planning of the femoral cut parameters based on size, alignment, as well as soft-tissue considerations. For each selected surgeon, their first 50 cases were considered. For each surgery log, the CAS system recorded the number of accesses to the planning page (when the user repeatedly returns to it) as well as the active time spent on setting up the planning (from the first to the last interaction). The learning curve was assessed for each surgeon by performing a cumulative summation analysis (CUSUM) of the time spent on the set-up of the intraoperative planning. The CUSUM values were then plotted in chronological order to evaluate the surgeon-specific learning curve. The perfect learning curve would follow a bell-shaped curve pattern, with the asymptote representing the number of cases required to achieve competence. So, this inflection point in the CUSUM graph is defined as the transition between the learning and the proficiency phases. The duration of the learning phase was analyzed per surgeon and globally (mean ± SD) and its Pearson correlation coefficient with the time required to achieve the first 50 surgical procedures was investigated. Independent samples Student t-test was used to compare continuous variables when assuming equal variance and corrected t-test otherwise. Statistical significance was set at $p<0.05$.

RESULTS SECTION: A total of 450 cases performed by 9 individual surgeons were considered, corresponding to surgeries performed worldwide from August 2021 to April 2023, so a total period of 597 days with a mean by surgeons of 239±98 days to perform their 50 first cases (Table 1).
The CUSUM learning phase varied from 2 to 11 cases, with a mean of 6.4±2.8 cases. For all surgeons combined, the total intraoperative planning mean time in the learning phase was 82 seconds longer than in the proficiency phase (132 vs. 49 sec; $p < 0.0001$) but, individually, this difference was only significant for 5 of the 9 surgeons. The correlation coefficient between the learning phase and completion time for the first 50 cases was 0.75 (p=0.0203, 95% CI 0.17 to 0.94, see Figure 1).

DISCUSSION: CUSUM analysis allows the data collected to be presented in a fashion that enables the assessment of the progression of learning and retrospective analysis of deviations from that progression. Notably, it allows for avoiding the high level of noise of simple duration curve. Recent studies on robot-assisted TKA using CUSUM analysis showed learning curves for total operative time to range from 11 to 43 cases for high volume surgeons only[1,2] (>70 cases) and that the operative time after the learning curve did not differ significantly from the conventional technique[3]. With another robotic system, that number reaches a mean of 8.7 cases[4]. In the present study, the adoption was quicker, with an average of 6.4 cases to achieve the asymptote. Furthermore, while the previous studies have compared the overall operative time, we focused on analyzing the intraoperative planning stage duration only, the stage where the technology has been added. Our study shows that the average planning time is more than halved after the learning phase. Finally, the correlation coefficient analysis seems to show that the faster the 50 first cases are achieved, the shorter the learning curve.

REFERENCES

1. Vermue H, et al. Robot-assisted total knee arthroplasty is associated with a learning curve for surgical time but not for component alignment, limb alignment and gap balancing. Knee Surg Sports Traumatol Arthrosc. 2022;30(2):593-602.
2. Tay ML, et al. Robotic-arm assisted total knee arthroplasty has a learning curve of 16 cases and increased operative time of 12 min. ANZ Journal of Surgery. 2022;92(11):2974-2979.
3. Jung HJ, et al. Learning curve of robot-assisted total knee arthroplasty and its effects on implant position in asian patients: a prospective study. BMC Musculoskeletal Disorders. 2023;24(1):332.
4. Bolam SM, et al. Introduction of ROSA robotic-arm system for total knee arthroplasty is associated with a minimal learning curve for operative time. J Exp Orthop. 2022;9(1):86.

SIGNIFICANCE/CLINICAL RELEVANCE: This study demonstrated that the average planning time is more than halved after a short learning phase and that the faster the 50 first cases are achieved, the shorter is that learning curve.

IMAGES AND TABLES:

	Time required for the first 50 surgical procedures (days)	Number of cases for the learning phase (CUSUM)
Surgeon 1	305	11
Surgeon 2	154	5
Surgeon 3	197	6
Surgeon 4	389	9
Surgeon 5	148	4
Surgeon 6	362	6
Surgeon 7	262	9
Surgeon 8	108	2
Surgeon 9	225	6
Mean (SD)	239 (98)	6.4 (2.8)

Table 1 Duration of first 50 surgeries and learning phase

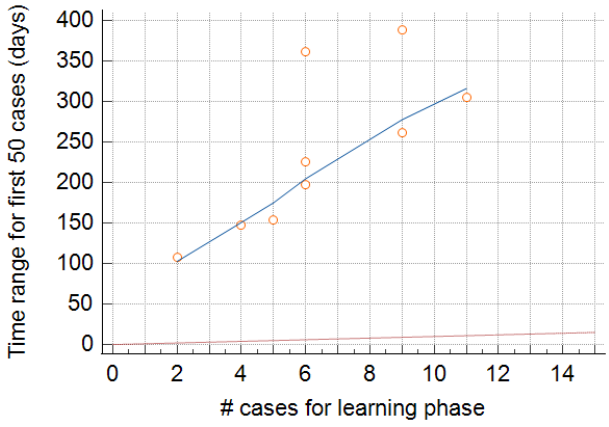

Figure 1 Relationship between the duration of first 50 surgeries and learning curve number of cases