Improving Operating Room Turnover Efficiency Through Real-Time Perioperative Workflow Coordination: A Systems-Based Analysis

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ABSTRACT

Purpose: Operating room (OR) turnover time (TOT) represents a significant source of surgical inefficiency, contributing to increased costs, reduced surgical capacity, and workforce dissatisfaction. This study evaluated the impact of the S1 Pit Crew™ proprietary software, a real-time, role-based OR workflow management platform, on TOT efficiency using spine surgery as a representative test environment for the system-level intervention.

Methods: This study examined prospectively collected perioperative workflow data from 51 consecutive elective adult degenerative spine surgery cases performed at a single hospital following platform implementation. Baseline TOT was derived from institutional records of cases performed over the year preceding implementation. Time durations included Stage 1: Perioperative Time Interval #1 (dressing to wheels-out); Stage 2: TOT (wheels-out to wheels-in); Stage 3: Perioperative Time Interval #2 (wheels-in to incision); and total elapsed skin-to-skin time. Cases were stratified into initial (n = 26) and subsequent (n = 25) cohorts to assess efficiency with continued platform use. Time durations were compared across procedure types.

Results: Mean TOT decreased 30.3% from 38.0 minutes at baseline to 26.5 minutes following implementation. TOT decreased significantly between the initial cohort (28.9±7.7 minutes) and subsequent cohort (23.9±3.7 minutes; p=0.02). Perioperative time intervals did not differ significantly between cohorts. Time durations were similar across spine procedure types.

Conclusion: After implementation of the S1 Pit Crew™ platform, mean TOT was 30.3% lower than the prior institutional baseline, with improvement observed with continued use and similar time durations across procedure types. These findings support real-time workflow coordination as a scalable, systems-based approach to OR optimization with broad applicability across surgical environments.

Key Words:

Turnover time; Operating room efficiency; Perioperative Workflow; Spine surgery; Quality improvement

INTRODUCTION

Operating room (OR) efficiency represents a critical determinant of surgical productivity, cost-effectiveness, and patient access to care.[1–3] Among the modifiable components of operating room efficiency, OR turnover time (TOT), defined as the interval between patient exit and subsequent patient entry, has emerged as a key target for operational improvement.

TOT accounts for 39-42% of total non-operative time between cases, which can reach 40-60% of total room utilization.[2,4,5] Combined with other non-operative delays, TOT contributes to surgeons spending approximately 25% of their workday in non-operative delays and less than 50% of a 10-hour surgical day operating.[6–8] Consequently, prolonged turnover time has been identified as a leading source of job-related frustration in national surgeon surveys, with OR inefficiencies and delays being cited as the most frequent well-being threat among surgeons.[9,10] The financial implications of TOT are also substantial, with OR time estimated to cost between $36 and $150 per minute.[1,3] Beyond direct costs, prolonged TOT diminishes patient throughput and surgical capacity, contributing to extended surgical wait times and patient dissatisfaction.[2,3,11,12] Collectively, these findings highlight TOT optimization as a high-yield strategy to increase surgical capacity, reduce staff burden, and lower institutional costs across surgical specialties.[3,4,13]

Despite its importance, turnover remains highly variable, arising from the fact that OR turnover requires coordination of multiple sequential and parallel tasks across housekeeping, nursing, anesthesia, and surgical teams, each with distinct roles and timing constraints. Prior studies have highlighted team motivation, familiarity, and role clarity as key drivers of efficiency.[4,14] Breakdowns in coordination, such as delayed housekeeping entry or conflicts between floor-cleaning processes and sterile instrument setup, lead to cascading delays.[14] A recent systematic review by Cohen et al.[15] demonstrated that interventions focused on process redesign, parallel task execution, clear role delineation, and improved team communication achieved the largest reductions in turnover time (up to 62%), whereas education or financial incentives alone showed inconsistent benefit. Together, these findings suggest that turnover inefficiency is primarily driven by coordination failures.

Prior OR turnover interventions have included pit crew models[3], retrospective data reporting[13], systems-based redesign[16], and surgeon-led approaches.[17] Many of these strategies involve procedural modifications, staffing changes, or sustained reliance on local leadership and manual adherence by OR personnel to maintain effectiveness. Moreover, institutional inertia and ingrained organizational norms frequently impede implementation. For example, the "Performance Improvement Team" intervention, which deployed lean and value stream mapping methodologies, required the elimination of seven institutional dogmas and the modification of three hospital policies, relied on dedicated personnel, and faced labor-related constraints that limited scalability and sustainability.[3]

To overcome these barriers, a system-level intervention that targets real-time coordination of existing tasks without altering surgical technique, staffing models, instrumentation, or care pathways was developed embedding coordination directly into perioperative workflows. The S1 Pit Crew™ platform is a real-time, role-based operational coordination system that provides live task visibility and shared situational awareness within a universal, reproducible workflow protocol during case turnover and perioperative stages. Accordingly, the primary goal of this study was to evaluate the impact of S1 Pit

Crew™ platform implementation on OR TOT in adult degenerative spine surgery as a representative test environment, with secondary analyses examining additional perioperative stages to assess broader workflow effects. We hypothesized that implementation of this platform would significantly reduce OR turnover time, with progressive improvement observed over continued use.

METHODS

Study Design and Setting

This study was a retrospective analysis of prospectively collected perioperative workflow data from consecutive elective spine surgical cases performed at a single regional major hospital center from (September 30, 2025–December 17, 2025) following implementation of the S1 Pit Crew™ Proprietary Software, a real-time OR workflow management platform. A total of 51 consecutive surgical cases performed by seven fellowship-trained spine surgeons over a three-month period were included. Eligible cases were limited to adult degenerative, non-deformity spine procedures and operating rooms with more than one scheduled case per day to necessitate a turnover interval. Cases involving spinal deformity (more than four levels), trauma, tumor, infection, emergent procedures, or operating rooms with a single scheduled case per day were excluded. This project involved de-identified perioperative workflow data without access to protected health information and was determined to constitute quality improvement non–human subject research; therefore, institutional review board oversight and informed consent were not required.

Operational Workflow Platform and Training

The S1 Pit Crew™ platform is a real-time, role-based operational coordination system designed to improve OR efficiency during turnover and perioperative transitions. Unlike retrospective reporting tools, the platform provides live task visibility, role-specific prompts, and shared situational awareness across surgical, anesthesia, and nursing teams during case turnover.

Initial training on the application was provided by the spine surgeon who developed the platform. Formal onboarding required approximately 15 minutes per nurse using a mobile device. However, based on anecdotal feedback, nurses typically require 2–3 operative turnovers to become fully comfortable and synchronized with app usage in real-world workflow. Subsequent dissemination of training across operating room staff occurred through peer-to-peer, nurse-led instruction. Overall, nurses described the application as “easy” to use and “easy” to teach.

Time Interval Definitions and Data Collection

The primary outcome of interest was operating room TOT. Secondary analyses explored performance across other perioperative intervals. Perioperative workflow data were prospectively recorded using two devices: one hospital-issued mobile iPad on a rolling stand in the operating room and one hospital-issued iPhone used by the circulating nurse. The surgeons had the app downloaded on their individual devices. Typically, the OR included one surgical tech, one surgical tech float, one circulating nurse, one circulating nurse float, one surgical representative, one radiology tech, one neurophysiologist, one anesthesiologist, one surgeon, one physician’s assistant, and two environmental service employees. The tasks were input as complete either by the person responsible for that task or by someone who inputted the task as completion by proxy on the mobile iPad. If the task completion was input by proxy, the involved role player would verbalize the completion of the task, and then the person closest to the mobile iPad would complete the activity. Typically, the activities of the scrubbed surgical techs were completed by proxy. If the circulating nurse was in the room during the perioperative time, they could also input the completed tasks.

A total of 24 time parameters were collected from skin to skin, including 10 discrete events within the turnover interval alone. These 24 time stages were aggregated and categorized into four standardized key time intervals of interest: Stage 1: Perioperative Interval #1, the time from placement of the initial sterile dressing to wheels-out of the patient; Stage 2: Turnover Time, the time from wheels-out of the preceding patient to wheels-in of the subsequent patient; Stage 3: Perioperative Interval #2, the time from wheels-in to skin incision of the subsequent case; Total Elapsed time from skin to skin, the cumulative time from sterile dressing placement of the prior case to incision of the subsequent case. These intervals were selected to isolate discrete operational phases common to all surgical cases.

Baseline TOT was defined as the institutional average spine turnover time prior to platform implementation. This value was derived from cases performed by the same seven fellowship-trained spine surgeons over the preceding year using identical inclusion criteria to the study cohort and served as a descriptive comparison.

Procedure Type and Delay Classification

Surgical cases were categorized by subsequent-case procedure type based on the primary operative intervention performed. Procedure categories included anterior cervical discectomy and fusion or artificial disc replacement (ACDF/ADR), decompression (including microdiscectomy or laminectomy), anterior lumbar interbody fusion with posterior spinal fusion

(ALIF/PSF), anterior lumbar interbody fusion or artificial disc replacement (ALIF/ADR), hardware removal, posterior cervical decompression and fusion (PCDF), sacroiliac joint fusion, and robotic lumbar fusion. This classification was used to describe the distribution of procedures within the cohort and to assess key time intervals across procedure types.

Delays were prospectively recorded and categorized by stage and delay type. Stage 1: Perioperative Time Interval #1 delays were classified as post-anesthesia care unit (PACU) holds or non-PACU delays. PACU holds were recorded as discrete events with associated duration, whereas non-PACU delays were documented categorically by primary cause without time duration. Delays occurring during Stage 2: Turnover Time and Stage 3: Perioperative Time Interval #2 were similarly documented categorically by primary cause without time duration.

Statistical Analysis

All continuous variables are reported as mean ± standard deviation (range). To evaluate changes in workflow efficiency over time, utilizing the S1 Pit Crew™ platform, cases were stratified into an initial (first 26 cases) and subsequent case cohorts (next 25 cases). Cohort stratification was prespecified to evaluate workflow maturation and learning-curve effects associated with platform adoption. Normality of continuous data was assessed using the Shapiro–Wilk test, and between-cohort comparisons for non-normally distributed data were performed using the Mann–Whitney U test. Baseline turnover time (institutional average over the preceding year) was used for descriptive comparison only and was not included in inferential testing. To assess whether key workflow intervals differed by procedure type, nonparametric Kruskal–Wallis tests were used to compare durations of Stage 1: Perioperative Time Interval #1, Stage 2: Turnover Time, Stage 3: Perioperative Time Interval #2, and total elapsed time from skin-to-skin across procedure types. Procedure types represented by a single case were excluded from inferential testing. Statistical significance was defined as $p < 0.05$, and all analyses were conducted using SPSS Version 30.0.0.0 (IBM Corp., Armonk, NY)

RESULTS

Study Cohort

A total of 51 consecutive degenerative adult spinal surgery cases utilizing the S1 Pit Crew™ platform were included in the study. The cohort comprised subsequentcase procedures of ACDF/ADR (N = 20), decompression (N = 13), ALIF/PSF (N = 8), ALIF/ADR (N = 5), hardware removal (N = 2), PCDF (N = 1), sacroiliac joint fusion (N = 1), and robotic lumbar fusion (N = 1).

S1 Pit Crew, Inc™ Turnover Time Compared With Baseline Turnover Time

Mean turnover time decreased from 38.0 minutes at baseline to 26.5 minutes following implementation of the S1 Pit Crew, Inc™ platform, representing a 30.3% reduction, as demonstrated in Figure 1.

Key Time Interval Durations Across All Cases

Across all 51 spine cases, the duration of Stage 1: Perioperative Time Interval #1 was 12.2 ± 5.1 minutes (4.0–30.7), with results demonstrated in Table 1. The duration of Stage 2: Turnover time was 26.5 ± 6.6 minutes (17.1–50.0). The duration of Stage 3: Perioperative Time Interval #2 was 55.6 ± 17.9 minutes (19.6–138.1). The total elapsed time from skin-to-skin was 82.1 ± 17.7 minutes (55.9–172.8).

Delays During Key Time Intervals

During Stage 1: Perioperative Time Interval #1, 17.6% (n = 9) of cases had PACU holds, with a mean duration of 5.5 ± 5.5 minutes (0.6–16.4). In addition to PACU holds, 11.8% (n = 6) of cases had non-PACU delays occur during this stage, attributed to local anesthetic application 3.9% (n = 2), block performed after surgery 3.9% (n = 2), anatomical constraints 2.0% (n = 1), and extubation delay 2.0% (n = 1).

During Stage 2: TOT, 27.5% (n = 14) of cases had a delay occur, including patient restroom use 5.9% (n = 3), translator use 5.9% (n = 3), procedural delay of surgeon 3.9% (n = 2), limited staff 2.0% (n = 1), sterile processing issue 2.0% (n = 1), procedural delay of anesthesia 2.0% (n = 1), procedural delay of surgeon and anesthesia 2.0% (n = 1), and other causes 3.9% (n = 2). During Stage 3: Perioperative Time Interval #2, 0.0% (n = 0) of cases had a delay occur.

Key time interval durations comparing initial implementation to subsequent implementation cohorts

Cases were stratified into an initial implementation cohort and a subsequent implementation cohort, representing the first 26 cases and subsequent 25 cases utilizing the S1 Pit Crew, Inc™ platform, respectively, with results summarized in Table 2. Stage 1: Perioperative Time Interval #1 was similar between the initial implementation cohort, 12.0 ± 4.9 (4.1–25.8), and the subsequent implementation cohort, 12.4 ± 5.4 (5.8–30.7); p = 0.93. Stage 2: TOT was significantly lower in the subsequent implementation cohort, 23.9 ± 3.7 minutes (17.1–30.1), compared to the initial implementation cohort, 28.9 ± 7.7 (18.9–50.0); p = 0.02, as demonstrated in Figure 2. Stage 3: Perioperative Time Interval #2 was similar between the initial implementation cohort, 53.1 ± 22.4 minutes (19.6–138.1), and the subsequent implementation cohort, 58.3 ± 11.3 (41.5–85.9); p = 0.30. Total elapsed time from skin to skin was similar between the initial implementation cohort, 82.0 ± 21.5 (55.9–172.8), and the subsequent implementation cohort, 82.3 ± 13.2 (64.7–114.9); p = 0.73.

Key Time Interval Durations by Subsequent Case Procedure Type

Key time interval durations stratified by subsequent case procedure type are summarized in Table 3.

For Stage 1: Perioperative Time Interval #1, mean durations (in minutes) were 5.1 for PCDF, 9.7 for sacroiliac joint fusion, 9.9 ± 3.1 (4.1–14.6) for ALIF/PSF, 11.9 ± 2.8 (8.3–18.5) for decompression, 13.0 ± 5.0 (5.8–25.8) for ACDF/ADR, 13.3 ± 5.7 (8.9–22.4) for ALIF/ADR, 13.4 minutes for robotic lumbar fusion, and 17.7 ± 18.5 (4.6–30.7) for hardware removal. There were no significant differences in Stage 1: Perioperative Time Interval #1 across procedure types (H(4) = 1.75, p = 0.782).

For Stage 2: Turnover Time, mean durations (in minutes), were 23.4 for sacroiliac joint fusion, 24.6 ± 6.8 (17.1–44.1) for ACDF/ADR, 25.1 ± 3.6 (19.9–30.6) for decompression, 26.8 ± 2.5 (24.5–30.4) for ALIF/ADR, 28.3 ± 5.4 (24.1–39.3) for ALIF/PSF, 34.7 for PCDF, 36.9 for robotic lumbar fusion, and 37.6 ± 17.4 (25.3–50.0) for hardware removal. There were no significant differences in Stage 2: Turnover Time across procedure types (H(4) = 7.85, p = 0.097).

For Stage 3: Perioperative Time Interval #2, mean durations (in minutes) were 30.5 for robotic lumbar fusion, 47.0 for sacroiliac joint fusion, 52.7 ± 9.9 (32.9–74.3) for decompression, 52.9 ± 28.6 (32.7–73.1) for hardware removal, 53.7 ± 13.8 (21.0–85.9) for ACDF/ADR, 53.8 ± 15.1 (19.6–72.0) for ALIF/PSF, 65.4 ± 12.1 (48.2–82.0) for ALIF/ADR, and 138.1 for PCDF.

There were no significant differences in Stage 3: Perioperative Time Interval #2 across procedure types ($H(4) = 4.31$, $p = 0.366$).

For total elapsed time from skin to skin, mean durations (in minutes) were 67.3 for robotic lumbar fusion, 70.4 for sacroiliac joint fusion, 77.9 ± 10.2 (55.9–94.3) for decompression, 78.3 ± 12.4 (64.7–114.9) for ACDF/ADR, 82.2 ± 11.6 (58.9–99.9) for ALIF/PSF, 90.5 ± 11.2 (82.6–98.5) for hardware removal, 92.2 ± 13.3 (73.0–110.4) for ALIF/ADR, and 172.8 for PCDF. There were no significant differences in total elapsed time from skin to skin across procedure types ($H(4) = 8.07$, $p = 0.089$).

DISCUSSION

This study demonstrates that real-time, role-based workflow coordination can produce a substantial and durable reduction in operating room turnover time without altering staffing models or procedural complexity. Implementation of the S1 Pit Crew™ platform demonstrated a 30.3% lower mean turnover time compared with baseline institutional performance, with further improvement observed as teams continued to use the platform. These findings indicate that turnover inefficiency is primarily driven by coordination failures rather than technical or procedure-specific factors and that embedding coordination directly into perioperative workflows can meaningfully improve operating room efficiency.

Operating room turnover represents a uniquely coordination-dependent phase of surgical care. Unlike intraoperative efficiency, which is largely determined by surgeon technique and expertise, case complexity, and anatomical factors, turnover requires the synchronized execution of parallel tasks across nursing, anesthesia, environmental services, and surgical teams[16]. Delays during this phase are rarely attributable to the duration of individual tasks themselves, but instead arise from latency between task initiation, unclear role ownership, and fragmented situational awareness.[14,18] Previous research has demonstrated that real-time communication interventions, including hands-free mobile platforms, daily safety huddles, and preoperative briefings, enhance team situational awareness, restore perioperative staff control, and reduce workflow disruptions.[26–29] By providing real-time task visibility and aligning role-specific actions within a shared operational framework, the S1 Pit Crew™ platform directly addresses these underlying sources of inefficiency, enabling teams to reduce idle time between interdependent tasks rather than accelerating task execution. The resulting efficiency gains offer substantial financial savings while addressing OR inefficiency, a leading well-being threat and source of surgeon frustration, with broader implications for workforce wellness and patient satisfaction.[1,3,4,9,10,13,16]

The observed improvement in turnover performance with continued platform use suggests a behavioral adaptation rather than a transient intervention effect. As teams became familiar with the workflow structure and role expectations embedded within the platform, coordination shifted from reactive to anticipatory, resulting in progressively shorter turnover times. Importantly, efficiency gains were isolated to the turnover interval, which is characterized by highly interdependent, multi-role tasks that are sensitive to improvements in shared situational awareness and coordination. In contrast, perioperative intervals before and after turnover involve sequential, role-specific tasks, particularly anesthesia-led processes such as extubation and induction, that are appropriately constrained by patient safety and provider expertise. The absence of change in these intervals supports the interpretation that observed efficiency gains were driven by reductions in coordination-related idle time rather than by task compression or redistribution, reinforcing turnover as the perioperative phase most responsive to real-time coordination.

The consistency of turnover performance across spine procedure types further supports a systems-based interpretation of these findings. In our study, turnover times were similar across case types despite substantial differences in procedural complexity, surgical approach, and equipment requirements. This contrasts with prior literature demonstrating longer turnover times for more complex procedures with greater equipment demands.[13,23] The lack of procedure-related differences observed in this cohort suggests that the S1 Pit Crew™ platform may mitigate complexity-driven variability through improved coordination. Because turnover is a universal phase of surgical care, independent of specialty or technique, coordination-based interventions such as the S1 Pit Crew™ platform have the potential for broad applicability across surgical environments without requiring procedure-specific customization. These findings position real-time, role-based workflow coordination as a scalable strategy for operating room optimization with implications for surgical capacity, operational efficiency, and workforce sustainability.

While real-time coordination reduced mean turnover time, some residual delays reflected factors requiring complementary process interventions. Importantly, the time-stamped data generated by the platform enables systematic identification of such delays, creating opportunities for targeted quality improvement beyond coordination alone.

Qualitative observations suggested rapid behavioral adoption, with teams transitioning from fragmented communication to shared real-time workflow awareness within weeks. Initial concerns regarding task burden diminished as staff recognized the collaborative nature of task entry and shared accountability. From a scalability standpoint, the mobile-based platform facilitated remote training, with successful adoption requiring two nursing champions to train remaining staff and full behavioral adoption achieved within four to six weeks. Administrative support is essential, as consistency across all team members is necessary for optimal coordination.

This study has several limitations. First, although we descriptively compared TOT following platform implementation with baseline institutional averages, case-level baseline data were not available for inferential statistical comparisons. Additionally, baseline data for the perioperative stages were not collected, precluding comparison with post-implementation times. Future studies should collect comprehensive baseline data across all perioperative stages to enable robust statistical comparisons. Second, device availability limited real-time task tracking, resulting in task completion being recorded by proxy rather than by the individual performing the task at times. This may have introduced latency in documentation and coordination, potentially attenuating full efficiency gains. Future studies will investigate whether optimization improves with full implementation across individual devices for all OR staff.

Conclusion

Following S1 Pit Crew™ platform implementation, the mean turnover time was 30.3% lower than the institutional baseline, with progressive improvement observed with continued use and consistent key time interval durations across spine procedure types. The platform serves as a behavioral coordination tool that establishes universal, reproducible workflow protocols, ensuring every team member operates within a standardized framework regardless of OR assignment. Granular time-stamped data enables real-time identification of bottlenecks for targeted education and process improvement, while shared task visibility fosters transparency and accountability—mechanisms that inherently drive efficiency gains. The S1 Pit Crew™ platform offers a scalable approach to OR optimization with implications for surgical capacity, cost reduction, and workforce satisfaction.

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TABLES

Table 1. Durations of Key Time Intervals Utilizing the S1 Pit Crew™ Platform Across All Spine Cases (N=51)

Time Interval	**Duration**[a]
Stage 1: Perioperative Time Interval #1[b]	12.2 ± 5.1 (4.0–30.7)
Stage 2: Turnover Time[c]	26.5 ± 6.6 (17.1–50.0)
Stage 3: Perioperative Time Interval #2[d]	55.6 ± 17.9 (19.6–138.1)
Total Elapsed time from skin to skin[e]	82.1 ± 17.7 (55.9–172.8)

[a]Values reported as mean (minutes) ± standard deviation (range)
[b]Time interval from initial sterile dressing placed to wheels-out
[c]Time interval from wheels-out to wheels-in
[d]Time interval from wheels-in to next incision
[e]Total time interval from initial sterile dressing placed to next incision for subsequent case

Table 2. Durations of Key Time Intervals Comparing Initial and Subsequent Case Cohorts Utilizing the S1 Pit Crew™ Platform[a]

Time Interval	**Initial Cohort (N=26)**[b]	**Subsequent Cohort (N=25)**[b]	**P-Value**[c]
Stage 1: Perioperative Time Interval #1[d]	12.0 ± 4.9 (4.1–25.8)	12.4 ± 5.4 (5.8–30.7)	0.93
Stage 2: Turnover Time[e]	28.9 ± 7.7 (18.9–50.0)	23.9 ± 3.7 (17.1–30.1)	**0.02**
Stage 3: Perioperative Time Interval #2[f]	53.1 ± 22.4 (19.6–138.1)	58.3 ± 11.3 (41.5–85.9)	0.30
Total Elapsed time from skin to skin[g]	82.0 ± 21.5 (55.9–172.8)	82.3 ± 13.2 (64.7–114.9)	0.73

[a]To evaluate changes in workflow efficiency over time utilizing S1 Pit Crew™ platform; Cases were stratified into first 26 cases (initial cohort) and subsequent 25 cases (subsequent cohort)
[b]Values reported as mean (minutes) ± standard deviation (range)
[c]Between-group comparisons were performed using the Mann–Whitney U test; bolded values indicate statistical significance ($p < 0.05$)
[d]Time interval from initial sterile dressing placed to wheels-out
[e]Time interval from wheels-out to wheels-in
[f]Time interval from wheels-in to next incision
[g]Total time interval from initial sterile dressing placed to next incision for subsequent case

Table 3. Duration of Key Time Intervals by Subsequent Case Procedure Type Utilizing the S1 Pit Crew™ Platform (N=51)[a]

Procedure Type	Stage 1: Perioperative Time Interval #1[b]	Stage 2: Turnover Time[c]	Stage 3: Perioperative Time Interval #2[d]	Total Elapsed time from skin to skin[e]
ALIF/ADR (N=5)	13.3 ± 5.7 (8.9–22.4)	26.8 ± 2.5 (24.5–30.4)	65.4 ± 12.1 (48.2–82.0)	92.2 ± 13.3 (73.0–110.4)
ALIF/PSF (N=8)	9.9 ± 3.1 (4.1–14.6)	28.3 ± 5.4 (24.1–39.3)	53.8 ± 15.1 (19.6–72.0)	82.2 ± 11.6 (58.9–99.9)
Decompression (N=13)	11.9 ± 2.8 (8.3–18.5)	25.1 ± 3.6 (19.9–30.6)	52.7 ± 9.9 (32.9–74.3)	77.9 ± 10.2 (55.9–94.3)
ACDF/ADR (N=20)	13.0 ± 5.0 (5.8–25.8)	24.6 ± 6.8 (17.1–44.1)	53.7 ± 13.8 (21.0–85.9)	78.3 ± 12.4 (64.7–114.9)
PCDF (N=1)	5.1	34.7	138.1	172.8
Hardware Removal (N=2)	17.7 ± 18.5 (4.6–30.7)	37.6 ± 17.4 (25.3–50.0)	52.9 ± 28.6 (32.7–73.1)	90.5 ± 11.2 (82.6–98.5)
Sacro-Iliac Joint Fusion (N=1)	9.7	23.4	47	70.4
Robotic Lumbar Fusion (N=1)	13.4	36.9	30.5	67.3

[a]Values reported as mean (minutes) ± standard deviation (range). Procedures with N=1 are reported as single observed values without standard deviation and range
[b]Time interval from initial sterile dressing placed to wheels-out
[c]Time interval from wheels-out to wheels-in
[d]Time interval from wheels-in to next incision
[e]Total time interval from initial sterile dressing placed to next incision for subsequent case
ALIF, Anterior Lumbar Interbody Fusion; ADR, Artificial Disc Replacement; PSF, Posterior Spinal Fusion; ACDF, Anterior Cervical Discectomy and Fusion; PCDF, Posterior Cervical Decompression and Fusion;

FIGURE LEGENDS

Figure 1. Mean Turnover Time (TOT) in minutes at Baseline Compared to mean TOT Utilizing the S1 Pit Crew™ platform. Mean turnover time decreased by 30.3% from 38 to 26.5 minutes (n = 51).

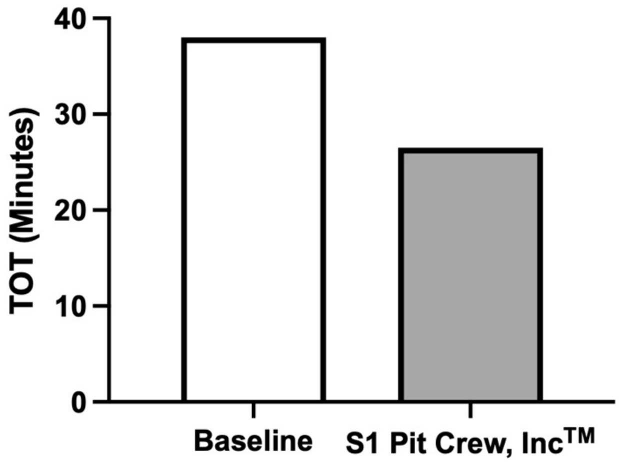

Figure 2. Mean Turnover time (TOT) in minutes for the first 26 cases (initial cohort) compared to the subsequent 25 cases (subsequent cohort), all performed using the S1 Pit Crew™ platform. Mean TOT decreased significantly from 28.9 ± 7.7 minutes in the initial cohort to 23.9 ± 3.7 minutes in the subsequent cohort ($p = 0.02$). Error bars represent standard deviation