



Original research

Intraoperative Scrub Nurse Handoffs Are Associated With Increased Operative Times for Total Joint Arthroplasty Patients

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ARTICLE INFO

Article history:

Received 10 February 2021
Received in revised form
11 April 2021
Accepted 16 May 2021
Available online xxx

Keywords:

Total hip arthroplasty
Total knee arthroplasty
Hospital efficiency
Intra-operative handoffs
Hospital staffing

ABSTRACT

Background: Surgeons typically remain scrubbed in for the duration of a surgical case, while scrub nurses are shift-workers who handoff mid-operation. These handoffs can intuitively create inefficiencies, but currently, no orthopedic research has studied the impact of these handoffs. This study analyzed the effect of intraoperative scrub nurse handoffs on operative times for total joint arthroplasties (TJAs).

Methods: A retrospective chart review was performed for primary total hip (THA) and total knee arthroplasties (TKA) performed between May 2014 and May 2018. Operative times, number of scrub nurse handoffs, surgeon, and patient information were collected. A multivariable linear regression was performed to assess the association between patient and surgeon characteristics, intraoperative handoffs, and operative times.

Results: A total of 1109 TKA and 1032 THA patients were identified. Multivariable linear regression demonstrated that for TKAs, 1 handoff was associated with a 3.89-minute longer operative time (P value = .02), and 2+ handoffs were associated with a 15.99-minute longer case (P value < .001). For THA patients, 1 handoff was associated with a 6.20-minute longer operative time (P value < .001), and 2+ handoffs were associated with an 18.52-minute longer case (P value < .001).

Conclusions: Although causation cannot be established, when controlling for multiple confounders, intraoperative scrub nurse handoffs were associated with statistically significant increases in operative times for TJAs. Optimizing scrub nurse staffing models to decrease intraoperative handoffs could thus have practical ramifications on TJA patients.

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Introduction

A well-functioning orthopedic operating room (OR) requires the coordination of a myriad of critical health-care providers. These providers may include the attending surgeon, resident physicians, physicians' assistants, medical students, circulating nurses, and scrub nurses or surgical technicians—some or all of whom may be in the OR simultaneously to assist in patient care. Although each provider plays a critical role in affording patients good-quality health care, staffing models vary significantly among fields of practice.

Although surgeons are expected to remain scrubbed in for the duration of a surgical procedure, the assisting surgical nurses ("scrub nurses" or "scrub technicians") at many academic medical centers are shift-workers and have frequent intraoperative handoffs. These scrub nurse intraoperative handoffs (turnovers) are common in hospitals across America. Surgeons may perceive these handoffs as potentially dangerous because of a lack of continuity of care as the incoming scrub nurse may be unaware of the stage of the case and the subsequent procedural steps. For orthopedic surgeons, this can be frustrating because surgeries often involve complex, multistep medical devices, surgeon-variable tool preferences, and time-sensitive steps such as cementing. The necessity for the new scrub nurse to "catch up" with the surgical team can cause subjective increases in operative times and surgeon frustration.

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Identifying objective structural causes of increased surgical times is critical for optimizing patient care. Increased OR times can increase health-care delays, systemic costs, and associated clinical risks such as infection and bleeding [1–3]. Studies have shown that each additional minute in an OR can cost \$62, and even 15 extra minutes in an OR can increase the risk of infection by 13% [2,3]. One well-explored area of OR operational improvement is intraoperative anesthesiologist handoffs. Intraoperative handoffs among anesthesiologists have shown to increase the odds of prescription errors and all-cause deaths [4–6]. Very few studies have analyzed the effects of intraoperative nurse handoffs, however. The limited existing literature demonstrates that intraoperative scrub nurse handoffs increase operative times and complication risks [7–10]. No studies have analyzed the effect of these intraoperative handoffs on orthopedic procedures. The high-volume, streamlined nature of total joint arthroplasties (TJAs) makes them a prime target for investigating this issue.

Total hip (THA) and total knee arthroplasties (TKA) are among the most common procedures in the United States, with roughly 0.2% of the US population currently undergoing TKA annually and a projected 1.5 million TJA being done in the United States by 2030 [11,12]. This large volume of procedures means small inefficiencies can translate into a significantly increased health-care burden. Moreover, increased TJA operative lengths by even 15 minutes can increase a patient's risk of wound complications and postoperative urinary tract infection [13,14]. This study sought to analyze the effects of intraoperative scrub nurse handoffs on operative times among THA and TKA patients. We hypothesized that intraoperative handoffs will be significantly associated with increased operative times for TJAs.

Material and methods

Cohort selection

This study was designed as a retrospective cohort study, and our protocol was approved by our institutional review board. Study population was identified via chart review from our large, urban, academic medical center. We identified all patients who underwent primary TKA or THA between May 2014 and May 2018 by searching hospital billing data for Current Procedural Terminology (CPT) codes 27,447 and 27,130 (TKA and THA, respectively). Patients who were younger than 21 years, had more than 4 intraoperative scrub nurse handoffs, and had a 0.22 CPT code complexity modifier were excluded, as these likely represented complex cases that could confound any handoff effects. To ensure comparable surgeon competency, patients were included only if their surgeon was arthroplasty fellowship trained and conducted on average >50 TJAs annually. Operative times (incision to skin closure), number of scrub nurse handoffs, operating surgeon's arthroplasty fellowship status, and patient demographical information (age, sex, body mass index [BMI], American Society of Anesthesiologists (ASA) score, self-reported race, and insurance status) were recorded for each patient. To ensure our study was appropriately powered, a priori and post-hoc power analyses were conducted using an estimated effect size from the literature of 10% [8]—both demonstrated greater than 0.95 power for THA and TKA groups. Before all analyses, data normality was grossly assessed using histograms.

Scrub nurse staffing and training

At our institution, scrub nurses hand off approximately every 2 hours for mandated breaks, and there are no restrictions on when handoffs may occur, that is, during cutting block placement, cementation, or final component placement. Handoffs also can

occur in between the 2-hour windows for personal reasons (ie, for bathroom breaks). Our orthopedic scrub nurses are trained in assisting TJAs; however, nonorthopedic scrub nurses occasionally relieve the primary scrub nurse. Training is provided informally by a more senior scrub nurse who specializes in orthopedic procedures. The scrub nurse specialty is not recorded in any hospital documentation.

Statistical analyses

First, we analyzed the association between demographic variables (age, sex, BMI, ASA score, language, and so on) with our exposure (scrub nurse handoffs) and outcome (operative times) independently. Number of scrub nurse handoffs was treated as a categorical variable and divided into 3 groups: cases with 0 intraoperative scrub nurse handoffs, 1 intraoperative scrub nurse handoffs, or 2+ intraoperative handoffs. The association between baseline, demographic characteristics, and scrub nurse handoffs was analyzed using chi-squared tests.

The effect of scrub nurse handoffs on operative times for each patient demographic use was then analyzed using one-way analyses of variance (ANOVAs). Finally, to control for possible confounders, a multivariable linear regression (MLR) model was built to determine the effect of intraoperative handoffs in both TKAs and THAs. Coefficients with 95% confidence intervals were calculated for each variable to estimate effect size on operative times. *P* values of less than 0.05 were considered significant. All statistical analyses were performed in R (version 3.6.2; Rstudio, Boston, MA)

Results

Demographics and identification of confounders

Our search criteria yielded 1109 TKA and 1032 THA patients (Table 1). Among TKA patients, 487 (43.9%) had 0 intraoperative scrub nurse handoffs, 459 (41.4%) had 1 handoff, and 163 (14.7%) had 2+ handoffs. Among THA patients, 544 (52.7%) had 0 intraoperative scrub nurse handoffs, 375 (36.4%) had 1 handoff, and 113 (10.9%) had 2+ handoffs. Mean operative times were 116.0 (standard deviation, ±26.5) minutes for TKAs and 104.0 (standard deviation, ±26.5) minutes for THAs.

As seen in Table 1, no demographic variables were significantly associated with increasing scrub nurse handoffs for TKA patients. For THA patients, an ASA score of 3–4 was significantly associated with increased scrub nurse handoffs (Table 1). Among TKA patients, increasing scrub nurse handoffs was associated with increased operative times among almost all groups. Our ANOVA analyses demonstrated statistically significant operative time differences in all groups except patients aged >80 years, “other” race patients, patients with a BMI > 35, and Medicare patients. Upon direct comparison between 0 and 1 intraoperative scrub nurse handoffs, operative times were statistically significantly increased for ASA 1–2 patients only (Fig. 1).

Among THA patients, increasing number of scrub nurse handoffs was also associated with increased operative times for almost all groups. Our ANOVA analyses for THA patients demonstrated statistically significant operative time differences in all groups except patients aged >80 years, black or “other” race patients, ASA 3–4, and patients with a BMI of >35. Upon direct comparison between 0 and 1 intraoperative scrub nurse handoffs, operative times were statistically significantly increased for multiple patient groups, including those aged <60 years, white race patients, male patients, ASA 1–2, BMI = 25–30, private insurance, and Medicaid patients (Fig. 2). This association of ASA scores of 3–4 with both the

Table 1
Patient demographics stratified by number of scrub nurse handoffs.

Patient information	Total knee arthroplasty patients (n = 1109)			P value	Total hip arthroplasty patients (n = 1032)			P value
	0 scrub nurse handoffs	1 scrub nurse handoff	2+ scrub nurse handoffs		0 scrub nurse handoffs	1 scrub nurse handoff	2+ scrub nurse handoffs	
Total (%)	487 (43.9)	459 (41.4)	163 (14.7)		544 (52.7)	375 (36.3)	113 (10.9)	
Age (y)								
<60	76 (15.6)	81 (17.6)	31 (19.0)	.568	165 (30.3)	123 (32.8)	29 (25.7)	.548
60–80	360 (73.9)	330 (71.9)	110 (67.5)		324 (59.6)	218 (58.1)	75 (66.4)	
>80	51 (10.5)	48 (10.5)	22 (13.5)		55 (10.1)	34 (9.1)	9 (8.0)	
Sex								
Female	356 (73.1)	323 (70.4)	119 (73.0)	.613	288 (52.9)	211 (56.3)	66 (58.4)	.432
Male	131 (26.9)	136 (29.6)	44 (27.0)		256 (47.1)	164 (43.7)	47 (41.6)	
Race								
White	206 (42.3)	207 (45.1)	76 (46.6)	.285	314 (57.7)	198 (52.8)	62 (54.9)	.277
Hispanic	125 (25.7)	114 (24.8)	32 (19.6)		55 (10.1)	49 (13.1)	19 (16.8)	
Black	39 (8.0)	37 (8.1)	17 (10.4)		47 (8.6)	33 (8.8)	12 (10.6)	
Other	14 (2.9)	18 (3.9)	1 (0.6)		11 (2.0)	5 (1.3)	3 (2.7)	
Unknown	103 (21.1)	83 (18.1)	37 (22.7)		117 (21.5)	90 (24.0)	17 (15.0)	
ASA score								
1–2	312 (66.4)	282 (62.4)	107 (65.6)	.428	378 (70.9)	231 (62.8)	76 (67.3)	.037
3–4	158 (33.6)	170 (37.6)	56 (34.4)		155 (29.1)	137 (37.2)	37 (32.7)	
BMI								
<25	88 (18.1)	75 (16.3)	25 (15.3)	.523	162 (29.8)	125 (33.3)	30 (26.5)	.212
25–30	163 (33.5)	137 (29.8)	45 (27.6)		223 (41.0)	117 (31.2)	42 (37.2)	
30–35	133 (27.3)	130 (28.3)	50 (30.7)		97 (17.8)	83 (22.1)	25 (22.1)	
35–40	63 (12.9)	69 (15.0)	30 (18.4)		41 (7.5)	34 (9.1)	11 (9.7)	
>40	40 (8.2)	48 (10.5)	13 (8.0)		21 (3.9)	16 (4.3)	5 (4.4)	
Insurance type								
Private	266 (54.6)	249 (54.2)	84 (51.5)	.973	361 (66.4)	232 (61.9)	71 (62.8)	.476
Medicare	133 (27.3)	127 (27.7)	48 (29.4)		70 (12.9)	65 (17.3)	16 (14.2)	
Medicaid	37 (7.6)	39 (8.5)	12 (7.4)		36 (6.6)	30 (8.0)	11 (9.7)	
Self-pay	51 (10.5)	44 (9.6)	19 (11.7)		77 (14.2)	48 (12.8)	15 (13.3)	

Bolded P values are statistically significant (<.05).

exposure and outcome raised concerns for possible confounding effects.

Multivariable linear regression

An MLR was performed and used to identify multiple variables that had a statistically significant impact on operative times. For both TKA and THA groups, 1 and 2+ scrub nurse handoffs were associated with increased operative times ($P < .01$) (Table 2). For TKA patients, 1 scrub nurse handoff was associated with a 3.89-minute longer case ($P = .02$), and 2+ scrub nurse handoffs associated with a 15.99-minute longer case ($P < .001$). For THA patients, 1 scrub nurse handoff was associated with a 6.20-minute longer operation ($P < .001$), and 2+ scrub nurse handoffs associated with an 18.52-minute longer operation ($P < .001$). A separate MLR was performed which included each individual surgeon as a variable. This MLR found that when also controlling for individual surgeons, our findings remained the same. For this reason, we chose to not present these data to preserve surgeon anonymity.

Discussion

Summary of existing literature

During any operation, team cohesion and communication are critical to providing patients with efficient and consistently high-quality health care. When team communication breaks down, there is often an increase in both operative times and the rate of medical errors [15]. These impacts can cumulatively translate into a massive increase in US health-care expenditure and increased rate of surgical complications. Although surgical team optimization is a very well-studied field, few studies have analyzed the effects of intraoperative scrub nurse handoffs.

Giugale et al. in 2017 studied the impact of nursing handoffs on minimally invasive sacrocolpopexy operative times [8]. This study found that each scrub nurse handoffs translated to a 13.6-minute increase in OR time, and each circulating nurse handoff increased OR times by 9.4 minutes [8]. Doll et al. in 2017 also studied the effects of intraoperative scrub nurse handoffs in gynecologic oncology patients [7]. This study found that cases with one scrub nurse handoff had 2.12-times the odds of having a surgical complication; however, this only trended toward significance [7]. This study found that the rates of complications significantly increased between cases who had 1 scrub nurse handoff when compared with more than 1 scrub nurse handoff. When looking at cardiac procedures, Bloom et al. in 2019 found that 2 or more scrub nurse handoffs significantly increased the rate of intraoperative sharp count errors [10]. Bloom et al. found having a sharp count error was associated with an average increased case length of 1.3 hours and an increased in-hospital mortality odds ratio [10]. Notably, 0 of the 732 cases where scrub nurses had incorrect sharp counts yielded radiographic evidence of a retained body.

Discussion of study findings

In our level III, retrospective study, the data supported our initial hypothesis that intraoperative scrub nurse handoffs were associated with statistically significant increases in operative times for both THA and TKA patients. When looking at the overall relationship between our patient groups and operative times, almost every group had statistically significant differences when stratified by increasing scrub nurse handoffs (Figs. 1 and 2). When conducting direct comparisons between individual patient demographic groups, our results indicated that having 1 scrub nurse handoff (vs 0) was significantly associated with increased operative times for certain groups. These include TKA patients with an ASA score 1–2,

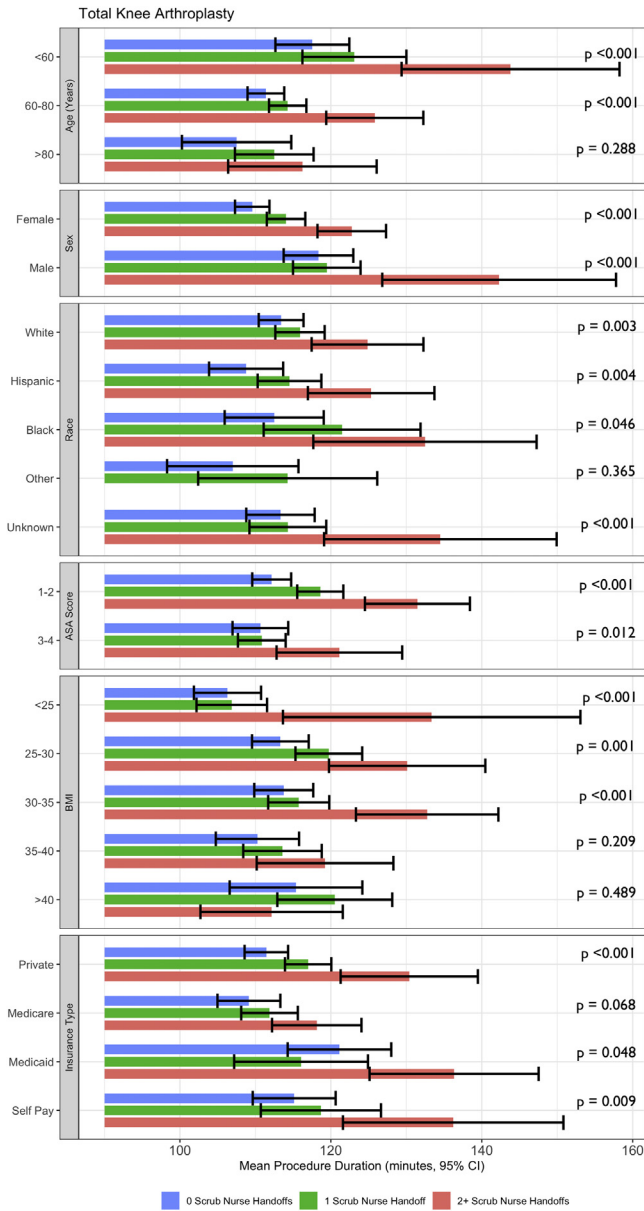


Figure 1. Operative times (minutes) for TKA patient demographic groups, stratified by number of intraoperative scrub nurse handoffs (0, 1, 2+). Error bars represent 95% confidence intervals. P values for one-way ANOVA for each group is listed on the right side of grouped columns.

and THA patients with ASA 1-2, BMI 25-30, and aged <60 years (Figs. 1 and 2).

Statistically significant differences in these groups also support our initial hypothesis. When patients are young and healthy, subtle factors which could increase operative times are more noticeable because operations should be able to occur at maximum efficiency. In these cases, a simple staffing handoff may more noticeably affect operative times. For cases with more complex medical problems or anatomy, operative times would already be prolonged, and therefore, the effect of a single scrub nurse handoff may be less profound.

The results of our multiple linear regression demonstrated that increased scrub nurse handoffs were associated with increased operative times in a dose-dependent fashion (Table 2). Scrub nurse handoffs appeared to have a more significant effect on THA patients, with 6.20-minute ($P < .001$) and 18.52-minute ($P < .001$) increases in operative times for 1 and 2+ handoffs, respectively,

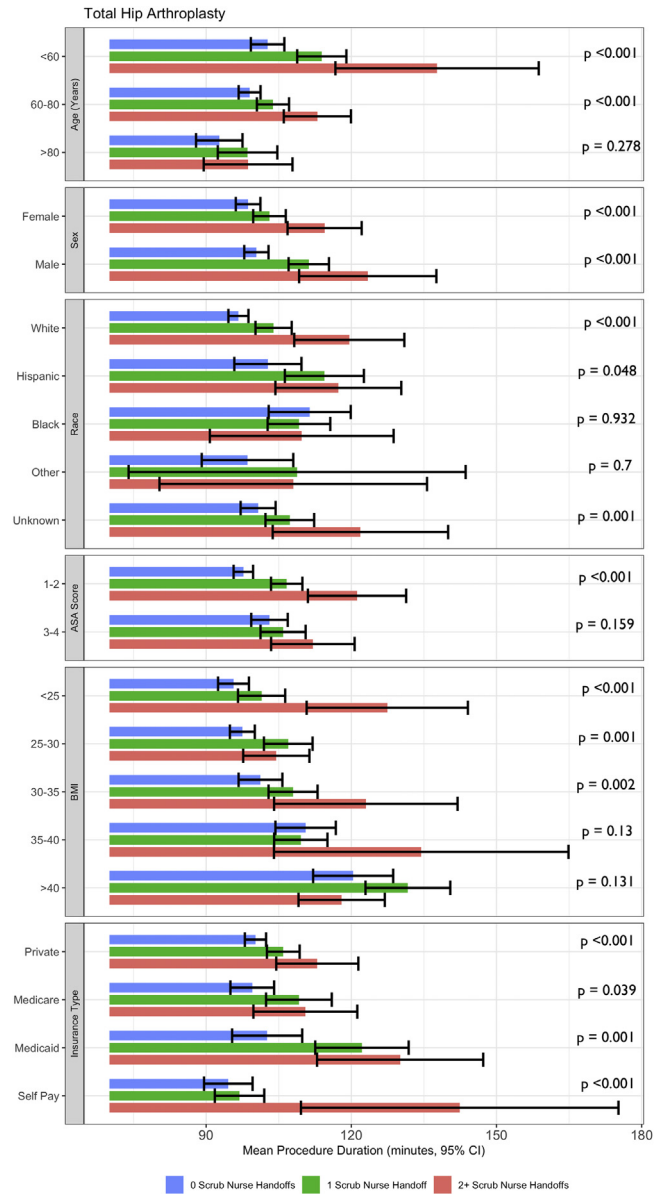


Figure 2. Operative times (minutes) for THA patient demographic groups, stratified by number of intraoperative scrub nurse handoffs (0, 1, 2+). Error bars represent 95% confidence intervals. P values.

than on TKA patients, with 3.89-minute ($P < .001$) and 18.52-minute ($P < .001$) increases. As demonstrated in the existing literature, even these small differences in operative times can increase a patient's risk for postoperative complications [13,14].

Our study also identified an ASA score of 3-4 as a possible confounding variable in THA patients. No confounders were identified for TKA patients among the variables studied. The significant association of ASA scores 3-4 with THA patients but not TKA patients speaks to the indications for each operation. THAs commonly occur in the setting of fractures and should usually be operatively managed within 24-48 hours regardless of a patient's existing comorbidities. Although hip fracture-related hemiarthroplasties are coded using a different CPT code (27,236) compared with the THA code (27,130), our methodology did not allow us to separate out THAs performed for fractures vs electively performed procedures. TKAs on the other hand are almost always performed electively in otherwise relatively healthy patients suffering from osteoarthritis and aim to improve quality of life. These different indications introduce a selection bias in the

Table 2
Coefficient values for multivariable linear regression for both TKA and THA patients.

Patient information	Total knee arthroplasty patients		Total hip arthroplasty patients	
	Coefficient (95% CI)	P value	Coefficient (95% CI)	P value
Age (y)				
<60	-	-	-	-
60-80	-6.62 (-10.99 to -2.24)	.003	-7.15 (-10.68 to -3.62)	<.001
>80	-8.99 (-15.33 to -2.64)	.006	-11.32 (-17.29 to -5.35)	<.001
Sex				
Female	-	-	-	-
Male	7.80 (4.29 to 11.32)	<.001	4.86 (1.66 to 8.06)	.003
Race				
White	-	-	-	-
Hispanic	-1.89 (-6.07 to 2.29)	.376	2.21 (-2.99 to 7.41)	.405
Black	2.22 (-3.68 to 8.12)	.460	4.12 (-1.60 to 9.85)	.158
Other	-1.21 (-10.35 to 7.93)	.795	-2.30 (-13.78 to 9.18)	.695
Unknown	0.68 (-3.50 to 4.86)	.749	1.75 (-2.16 to 5.67)	.380
ASA score				
1-2	-	-	-	-
3-4	-4.59 (-7.86 to -1.31)	.006	0.86 (-2.56 to 4.28)	.623
BMI				
<25	-	-	-	-
25-30	6.20 (1.60 to 10.81)	.008	-2.05 (-5.88 to 1.78)	.293
30-35	5.72 (1.05 to 10.40)	.016	3.60 (-0.86 to 8.06)	.114
35-40	2.21 (-3.24 to 7.65)	.427	9.62 (3.46 to 15.78)	.002
>40	6.63 (0.16 to 13.10)	.045	20.93 (12.71 to 29.15)	<.001
Insurance type				
Private	-	-	-	-
Medicare	-1.94 (-5.72 to 1.83)	.313	1.36 (-3.27 to 5.98)	.565
Medicaid	5.07 (-0.93 to 11.08)	.097	6.78 (0.57 to 12.99)	.032
Self-pay	4.89 (-0.33 to 10.11)	.066	-1.66 (-6.25 to 2.93)	.478
Scrub nurse handoffs				
0	-	-	-	-
1	3.89 (0.61 to 7.17)	.02	6.20 (2.86 to 9.53)	<.001
2+	15.99 (11.44 to 20.54)	<.001	18.52 (13.45 to 23.59)	<.001

Bolded P values are statistically significant (<.05).

patient populations and may explain why ASA score 3-4 is a confounding variable among THA patients only.

These findings, that intraoperative scrub nurse handoffs increasing operative times, may seem intuitive for orthopedic surgeons, yet this study provides statistical evidence that supports these beliefs. After all, when an intraoperative handoff occurs, the new scrub nurse can understandably be initially and temporarily out of sync with the rest of the team. This is especially true when the relieving scrub nurse is not primarily an arthroplasty nurse because the literature has shown that dedicated scrub technicians can improve operative efficiency and patient outcomes.

Murgai et al. in 2020 studied the effect of dedicated orthopedic spine scrub nurses on patient outcomes and found that when <60% of nurses or scrub techs were dedicated to the spine service, OR times increased by 34 minutes on average; there was also 30% more estimated blood loss and 113% more allogeneic transfusions required [16]. Similarly, Henaux et al. in 2019 found that dedicated surgical teams can improve team satisfaction by significantly decreasing subjectively reported workflow disruptions [17]. Although this study presents data that support intuitive conclusions, there are multiple limitations to this study.

Strengths and limitations

The retrospective study design makes us unable to make causal claims regarding the relationship between intraoperative handoffs and operative times. Although the causal link cannot be

demonstrably proven, the effect of one intraoperative handoff on TJA operative times was only a few minutes, however. We find it unlikely that the 4-minute longer TKAs and 6-minute longer THAs resulted in such a systematic increase in the number of handoffs. Intraoperative complications, such as periprosthetic fractures or difficult soft tissue balancing, could explain why some cases take significantly longer and require 2+ scrub nurse handoffs. Intraoperative complication and surgical complexity data were not available in our data set, however.

A further limitation of this study is the lack of data regarding surgical indication and approach. Regarding surgical indication, the vast majority of TJAs performed at our institution are to treat standard osteoarthritis. However, some THAs will be indicated for other reasons (ie, osteonecrosis). When discussing THAs specifically, a surgeon's choice to use a posterior vs anterolateral vs direct anterior approach could also significantly affect operative times, for example. These data were unavailable in our system, and therefore was not able to be considered. We do hope the large sample size would help reduce the impact of this unknown. In addition, this study did not record the specialty of scrub nurses. In complicated total joint operations, nonorthopedic scrub nurses could require more assistance, and thus increase the operative time. Finally, a major limitation of this study is that we did not present outcomes data that can better correlate decreased surgical efficiency with decreased patient care. This is a promising area for future research.

Conclusions

This study analyzed a large cohort of TJA patients and determined that intraoperative scrub nurse handoffs were significantly associated with increasing operative times for both TKAs and THAs. Although a causal link cannot be stated, the study provides evidence to defend intuitive surgeon beliefs and shines light on an area of important further research. Although definitive outcome measures were not reported, for high-volume orthopedic procedures such as TJAs, decreasing operative times by even a few minutes could save the US health-care system millions of dollars and potentially decrease rates of postoperative complications significantly. Orthopedic surgeons should advocate for staffing models that minimize intraoperative handoffs whenever possible.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: W. N. Levine is an unpaid consultant for Zimmer Biomet, is in the medical/orthopedic publication editorial/governing board of Journal of the American Academy of Orthopedic Surgeons, and is a board/committee member in American Shoulder and Elbow Surgeons. T. R. Hickernell is in the board of directors of New York State Society of Orthopedic Surgeons.

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