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Inclusion of Medical Students in the Operating Room, Are Patients at Risk? A Retrospective Comparison of Short-Term Patient Outcomes Following Total Knee Arthroplasty

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Introduction: With the advent of virtual clerkships, the ability of medical students to be involved in direct patient care continues to be scrutinized. One such area that has come under scrutiny is the role medical students should play in the operating room. The major critiques brought up by OR staff and surgeons are potential increases in contamination rates and operative times. In this study, we hope to reveal that medical students do not significantly increase postoperative infections or operative times for total knee arthroplasty (TKA).

Methods: TKA cases were collected from 3 separate surgeons between 2021 and 2022. Operative times for TKA were compared when medical students were present and when students were not. The same was then done to compare the 2 groups for 30-day and 90-day emergency department (ED) visits and readmissions as well as 1-year deep/superficial infection rates.

Results: Five hundred eighty-five cases met inclusion criteria. When averaging the operative times of the 3 surgeons with and without medical students, we found that medical student–assisted cases took 84.6 minutes and without students took 80.1 minutes (p value = 0.0056). Complication rates were higher in the student group (3.73% vs 11.67%, p-value = 0.004). When comparing infection rates, we found that there was a slight reduction in infection rate, 0.37% vs 0.63% with students present (student vs no student; p-value = 1.00).

Discussion: This study appears to reassure hospital systems and operating room staff that medical students do not significantly alter infection rates in TKA. In addition, while they do extend operative times, on average, it was less than 5 minutes per case, which seems to be a reasonable amount of time to sacrifice in light of no increase to aggregate complications within 1 year.

Introduction

With the advent of virtual clerkships, the need for in-person, hands-on medical student clerkship has come into question. Primarily these virtual rotations have either been in primary care or other nonoperative specialties[1-4]. Despite this decrease in direct patient care, medical students graduate every year and

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become resident physicians, joining an ever demanding and complex workforce. With this reduction in hands-on training, the question must be asked, were these new residents well prepared by virtual and remote educational alternatives?

There does not appear to be a clear-cut answer to this question, but it has forced medical academia to investigate virtual options as a proxy for in-person experiences. This is especially true with surgical training. Ottinger et al. described all the virtual options medical students have had for training. The aim of this robust selection of virtual training was to mitigate the lost opportunities from in-person rotations but ultimately fails to replicate real-life scenarios[5]. Haws et al. demonstrated that a virtual rotation in orthopaedic surgery can be seen as a valuable entity for prospective residents to evaluate a program and get to know the faculty but also showed that it fails to give that real-life experience that is needed for a smooth transition to residency training.

While virtual medical education has begun to remove medical students from the operating room (OR), it is not the first time that medical students in the OR have been questioned. Ji et al. demonstrated through a formal survey at a single institution that only 71.23% of OR staff believe that medical students should be able to observe in the OR. In addition, only 69.7% of OR staff responded saying that they enjoyed working with students. While it is reassuring that most respondents support medical students, a large minority would prefer medical students out of the OR. The main complaints are lack of sterile awareness and lack of knowledge, leading to extended operative times[6].

The universal experience that medical students share is that they often feel ignored by staff and are unwelcome[7]. However, this depends on the teaching ability of the surgeon and the general demeanor of the OR staff[8]. Conversely, not all medical student experiences in the OR are poor; there are multiple opinion editorials describing medical students as helpful in the OR[7,9].

In this study, we aim to demonstrate that medical student participation in the OR does not negatively affect patient outcomes or operative times when assisting in total knee arthroplasties (TKA). We reviewed the short-term complications including infections, readmissions, and operative times for TKA when medical students assisted alongside residents and compared against short-term complications and operative times when only residents were assistants. TKA was chosen as the representative procedure in this study as it is not only one of the most common major orthopaedic surgeries[10,11] but remains an extremely time-conscious procedure carrying devastating consequences for deep infections[12-14]. To our knowledge, no study exists to objectively evaluate complications and operative times for medical student assistance (MSA).

Materials/Methods

A retrospective review was performed on patients undergoing primary TKA over 2 years from January 2021 to December 2022 at a single community hospital by 3 orthopaedic surgeons. Six hundred ninety-six patients were pulled, 585 of who met the inclusion criteria of primary total knee arthroplasty, a resident assisting or a resident and student assisting, and no prior prosthetic joint infection (PJI). One hundred eleven cases were omitted due to confounding assistance of a physician assistant. This single center community hospital is the primary site for an orthopaedic surgery residency and is part of a large academic health system, which includes 3 independent orthopaedic surgery residencies based in different cities. In addition, this community hospital is certified by the Joint Commission as an advanced hip and knee replacement center.

Complications involved any readmission within 30 days of surgery, readmission within 90 days of surgery, ED visits within 90 days, any incision-related complications within 90 days, or PJI within 1 year. For consistency of data collection, any patient who had a 30-day readmission through the ED was not counted as 90-day ED visit or 90 day readmission. The composite demographic data are presented in Table I. In addition, the number of individual complications in Tables II through V does not add up to the number of total composite complications because PJI were either duplicated in the 30-day or 90-day readmissions, and the incision-related complications are duplicated in the 90-day ED visits. Exhaustive list of unique reasons for ED visits or readmissions included the following: PJI, congestive heart failure exacerbation, superficial cellulitis, chest pain, peritonsillar abscess laceration to nonoperative extremity, shortness of breath, dizziness, constipation/ileus/stool impaction, back pain, pulmonary embolus, pain control, superficial wound dehiscence, gastrointestinal bleed, wound drainage, rodent bite, rhabdomyolysis, and new onset arrhythmia. Operative times were collected from recorded times on the electronic health record (EHR). The presence of student and/or resident was collected from manual input of assistants into the EHR by the OR circulator. All complications were presented as composite outcomes with select individual complications

TABLE I Patient Demographics

Total No. of Patients	585	
Age, mean (standard deviation), range	67.1 (8.9)	36-89
Gender		
Male	256	43.66%
Female	329	56.34%
BMI, mean (SD), range	33.3 (6.3)	20.6-57.2
BMI category, no.%		
Healthy weight, 18.5 to <25	53	9.08%
Overweight, 25 to <30	145	24.83%
Obesity, 30-40	288	49.32%
Morbid obesity, 40 or greater	98	16.78%
Charlson score = 10-yr survival percentage, no.%		
0-21.63%	121	20.72%
53.39%-77.48%	367	62.84%
90.15%+	96	16.44%

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TABLE II All Surgeons Complications*

	RA		MSA		p
Total no. of cases	268		317		
Total composite complications, no.%	10	3.73%	37	11.67%	0.0004
30-d readmission, no.%	3	1.12%	11	3.47%	0.0638
90-d readmission, no.%	1	0.37%	4	1.26%	0.3817
PJI (<1 yr), no.%	1	0.37%	2	0.63%	1.0000
Incision complications	0	0.00%	5	1.58%	0.4220
ED visit within 90 d w/o admission, no. %	6	2.24%	22	6.94%	0.0080

*MSA = medical student assistance, PJI = prosthetic joint infection, and RA = resident assistance.

highlighted in Tables II through V of the results section. Average operative times for each surgeon and composite operative times of all surgeons are provided in Table VI.

We reported continuous variables as mean, standard deviation, and range and categorical variables as number (percent). We used the Student *t*-test to analyze between-group differences for the continuous variables. When it was determined that variances for the comparisons of continuous data were unequal, Welch-Satterthwaite *t* test statistics were used. We used χ^2 test to analyze between-group differences for the categorical variables. The Fisher exact test was used when any of the expected frequencies was 5 or less. All tests were 2-sided with criterion for statistical significance at a p value of less than 0.05. All the analyses were done by SAS 9.4 (SAS Institute).

Results

Five hundred eighty-five patients met inclusion criteria during the study period. Of these, 317 patients had their procedure performed with MSA. The remaining 268 patients had their procedure performed with resident assistance (RA). Demographic data between the MSA and RA groups was similar in terms of gender, body mass index (BMI), smoking status, Charlson Comorbidity Index, preoperative ambulatory status, diabetes history, and chronic kidney disease history. General combined patient demographics are available in Table I.

The MSA procedures on average, across 3 surgeons, took 84.6 vs 80.1 minutes in the RA procedures with a p-value = 0.0056, which are presented in Table VI. Of note, surgeon 1 and surgeon 2 did not have statistically significant changes in the operative times (65.9 minutes vs 66.0 minutes, p-value = 0.9675; 97.3 minutes vs 99.0 minutes, p-value = 0.7003) while surgeon 3 had significantly slower operative times with medical students (90.9 minutes vs 84.7 minutes, p-value = 0.0006).

The MSA group was also found to have significantly increased number of complications when compared with the RA group (11.67% vs 3.73%, p-value = 0.0004) provided in Tables II through V. In addition, the MSA group had more visits to the ED within 90 days of procedure without requiring admission (6.94% vs 2.24%, p-value = 0.008). Readmission rates were similar between the 2 groups, as was PJI rate. Surgeon 1 was found to have a higher complication rate in the MSA group and 90-day ED visits. Surgeon 2 had no differences between the 2 groups for all complications while surgeon 3 only had an increase in complications in the MSA group when compared with the RA group.

Discussion

As previously discussed, the role of the medical student in the OR has been in question for years due to perceiving them as a nidus for potential complication[6]. For this reason, we felt the need to quantify some short-term outcomes of patients who had

TABLE III Surgeon 1 Complications*

	RA		MSA		p
Total no. of cases	97		104		
Total composite complications, no.%	5	5.15%	15	14.42%	0.0283
30-d readmission, no.%	2	2.06%	4	3.85%	0.6839
90-d readmission, no.%	1	1.03%	2	1.92%	1.0000
PJI (<1 yr), no.%	1	1.03%	1	0.96%	1.0000
Incision complications	0	0.00%	0	0.00%	n/a
ED visit within 90 d w/o admission, no. %	2	2.06%	9	8.65%	0.0400

*MSA = medical student assistance, PJI = prosthetic joint infection, and RA = resident assistance.

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TABLE IV Surgeon 2 Complications*

	RA		MSA		p
Total no. of cases	40		93		
Total composite complications, no.%	3	7.50%	13	13.98%	0.3901
30-d readmission, no.%	1	2.50%	5	5.38%	0.6679
90-d readmission, no.%	0	0.00%	0	0.00%	n/a
PJI (<1 yr), no.%	0	0.00%	1	1.08%	1.0000
Incision complications	0	0.00%	5	5.38%	0.4226
ED visit within 90 d w/o admission, no. %	2	5.00%	8	8.60%	0.7226

*MSA = medical student assistance, PJI = prosthetic joint infection, and RA = resident assistance.

students assist in their surgery. While we found that operative times were less than 5 minutes longer, we suggest this represents necessary time to teach the next generation of hopeful orthopaedic surgeons.

We also found that the rate of acute (<1 year) infections was not significantly affected. This information leads us to believe that medical students have a low role in affecting final outcomes of patients. The infection rate is multifactorial and also affected by the patient's preoperative risk factors. While there were statistically significant increases within the MSA group for total complications and 90-day ED visits, most of these ED visits and complications were for issues not directly pertaining to the surgery itself (cardiac and gastrointestinal symptoms).

While it seems that medical student participation in live surgery is an appropriate practice, little support exists outside of our study. That said, when review of literature reveals support for increasing participation among residents in the OR. Uecker et al. showed that there were no statistically significant changes to operative times when a surgical resident was the primary surgeon compared with an attending operating without a resident[15]. In addition, Gorelik et al. looked at the patient outcomes of a trauma center both before and 6 months after the institution of a general surgery residency and found no statistical difference in mortality, complications, or readmission rates[16].

Second, allowing medical students to participate in live rotations from the orthopaedic perspective is imperative for transition to residency as residents are expected to have basic funds of knowledge. The intensity of orthopaedic surgery residency cannot be understated and often postgraduate year 1 (PGY–1) residents find the transition grueling and anxiety provoking. To add, OR incompetency to the mix of transitioning to residency would only further exacerbate this. Survey studies have shown that medical student's competency in the OR improves with active participation, and students become assets with enough experience[9,17]. In addition, surveys found that further exposure to the OR allowed for better understanding of traffic flows and basic surgical skills. Most respondents also stated that medical students responded well to feedback from staff and surgeons alike. The main complaint was that students lacked basic surgical skills to be helpful which further indicates that students increased exposure to prepare for the transition to residency.

Further exposure adds an additional benefit for surgical residencies looking to select their next class. As many surgeons in academia are aware, it is extremely difficult to delineate which students will be productive for future residents and, at times, many feel this is left up to chance[18]. In fact, some have suggested giving students personality assessments to identify appropriate candidates for residency, but pitfalls exist to this, including "shading" their responses to appear desirable[19]. However, the longer attendings have direct exposure to prospective residents,

TABLE V Surgeon 3 Complications*

	RA		MSA		p
Total no. of cases	131		120		
Total composite complications, no.%	2	1.53%	9	7.50%	0.0209
30-d readmission, no.%	0	0.00%	2	1.67%	0.2276
90-day readmission, no.%	0	0.00%	2	1.67%	0.2276
PJI (<1 yr), no.%	0	0.00%	0	0.00%	n/a
Incision complications	0	0.00%	0	0.00%	n/a
ED visit within 90 d w/o admission, no. %	2	1.53%	5	4.17%	0.2641

*MSA = medical student assistance, PJI = prosthetic joint infection, and RA = resident assistance.

TABLE VI Procedure Duration by the Presence of Medical Student*

	MSA			RA			
	No. of Cases	Mean (SD)	Range	Total No. of Cases	Mean (SD)	Range	p
Overall	317	84.6 (20.4)	46-172	268	80.1 (18.7)	48-207	0.0056
Surgeon 1	104	65.9 (12.8)	46-120	97	66.0 (12.9)	48-140	0.9675
Surgeon 2	93	97.3 (17.9)	64-148	40	99.0 (23.5)	69-207	0.7003
Surgeon 3	120	90.9 (15.6)	62-172	131	84.7 (12.2)	63-114	0.0006

*MSA = medical student assistance, and RA = resident assistance.

the more likely they are to assess candidates' fitness for residency[20]. This is not a unique perspective but is an important perspective when attempting to maintain longitudinal quality in a residency[21,22]. This fact is directly implemented at our residency as students seeking an interview are encouraged to complete a 2-week to 4-week rotation.

Tooley et al. attempted to identify which students would become excellent residents by retrospectively evaluating the current residents at a 5-year ophthalmology residency. They found that the most predictive domains to succeed as a resident and pass boards were their performance during clerkships, step 1 score, and their score increase from United States Medical Licensure Exam (USMLE) step 1 to USMLE Step 2 Clinical Exam[23]. With USMLE step 1 becoming pass or fail, 2 domains for selecting residents have been eliminated, putting a greater demand on clinical clerkships; making time in the OR become increasingly important for medical student to display their efforts in both preparation and execution of basic skills.

Our study has multiple limitations. First, this is a retrospective study and subject to the inherent bias therein. The study was limited to a single type of procedure, TKA. The cases were drawn from 3 separate surgeons at a community center, which allowed for variation between their personal techniques that can make the data volatile with each surgeon's results, depending largely on their own personal techniques and experiences. The sample size was on the smaller end, and split between 2 arms of the study makes the data difficult to interpret. Another possible confounding limitation was that every case with a medical student included an orthopaedic surgery resident. These residents assisting potentially protected the students from sterility breaks, representing another set of trained eyes. Therefore, the results present in this study may have suffered a washout effect by having residents in the MSA cases. There were no TKAs performed at this center without residents; therefore, a solo medical student arm of this study was not possible.

The presence of medical student was confirmed by chart review of manually entered data assistants by OR circulator and may represent incomplete data if the circulator failed to document appropriately. In addition, the variance in operative times from surgeon to surgeon could be attributed to the amount of involvement the surgeon allows his or her trainees. The MSA data are primarily from the early academic year when student rotate, which is confounding the data as that time of year residents settle into their new PGY level and are less experienced than they will be later in the academic year when less students rotate. Finally, the data are noncontinuous as 181 cases were removed from this study as they included a physician associate.

Conclusion

We provide evidence that including students in total knee arthroplasties does not significantly affect infection rates. However, there were slightly longer operative times within the medical student group only represented 5 minutes of increased operative time on average. We strongly believe that the training of medical students, in preparation for their transition to residents, in a high-volume orthopaedic surgery residency can be appropriately implemented without negatively affecting patient outcomes. ■

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