Surgical Skills Course for Fourth Year Medical Students
Entering an Orthopaedic Surgery Residency [version 1]

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Abstract
Surgical skills training outside of the operating room is a critical component of surgical education. There has been little incorporation of these programs for medical students entering orthopaedic surgery residencies. As such, there is concern that incoming orthopaedic residents matriculate with skills below residency programs' expectations. This study aimed to assess the need for an orthopaedic surgical skills course during the 4th year of medical school. An anonymous electronic survey was emailed to 1457 orthopaedic surgery residents and 732 current orthopaedic residency applicants using application data from a single orthopaedic residency program during the 2015-2016 through 2017-2018 cycles. 200 resident and 31 applicant emails were returned undeliverable, resulting in distribution to 1257 residents and 701 applicants. 135 junior residents (11% response rate) and 181 applicants (26% response rate) completed portions of the survey. 76 of 117 (65%) residents and 170 of 181 (94%) applicants did not participate in a formal orthopaedic surgical skills course. 110 of 118 (93%) residents and 160 of 171 (94%) applicants indicated that implementing such a course before entering residency would be beneficial. Applicants rated basic fracture reduction (95%; 171/180), casting/splinting (94%; 170/180), and reading basic x-rays (90%; 162/180) as the most important potential course components. Most respondents were not exposed to an orthopaedic skills course prior to residency. Participants indicated that such a course would be beneficial to incoming orthopaedic residents. Pilot programs should be developed to optimize an orthopaedic preparatory skills course for 4th year medical students pursuing careers in orthopaedic surgery.

Keywords
surgical skills, orthopaedic surgical skills, medical students, orthopaedic surgery
Introduction

Surgical skills training outside of the operating room is a critical component of surgical education and has been widely implemented in surgical residency training curricula (Zeng, Woodhouse and Brunt, 2010). However, there has been little to no incorporation of these programs for senior medical students entering surgical residencies (Zeng, Woodhouse and Brunt, 2010). The majority of medical students’ exposure to surgery stems from 3rd year general surgery clerkships with varying experiences within and between different institutions (Amini et al., 2016). Although some basic surgical skills training occurs in the operating room, medical students have few opportunities to develop their technical skills during clinical clerkship years (Amini et al., 2016). Given the lack of standardization in undergraduate surgical education, there is growing concern that 4th year medical students matriculating into surgical residencies graduate with skills that are below the expectations of residency programs (Amini et al., 2016).

In 2004, the American Surgical Association (ASA) Blue Ribbon Committee evaluated medical student surgical education within the United States and found that there was a need for students to increase their preparedness for surgical residency during the final year of medical school (Tocco et al., 2013). The ASA reported that the biggest hindrance to student preparation was an absence of structure within the 4th year curriculum (Debas et al., 2005). The ASA believes not utilizing this time for surgical skills training represents a lost opportunity in medical student education. They concluded that a formal 4th year surgical skills course, along with increased availability of faculty mentorship, would sustain medical student interest in general surgery and improve preparation for surgical residency (Debas et al., 2005).

As a result, the American College of Surgeons (ACS) Division of Education sought to standardize surgical education for students entering general surgery residency. In doing so, the ACS designated a core set of fundamental skills that senior medical students should obtain prior to residency and using this framework, multiple institutions created preparatory courses for students (Successfully Navigating the First Year of Surgical Residency, 2005). Studies evaluating the effectiveness of such programs have reported significant improvements in student skill and confidence while performing intern-level responsibilities, including managing acute on-call problems, emergent and non-emergent bedside procedures, basic suturing, and knot tying (Zeng, Woodhouse and Brunt, 2010), (Karam et al., 2013), (Westerling et al., 2014). In 2009, Zeng et al. evaluated the efficacy of Washington University College of Medicine’s general surgery preparatory program for 4th year medical students (Zeng, Woodhouse and Brunt, 2010). Using data from the first four years of the program (2006-2009), the authors found that the average time spent on each task, which included knot tying, central line placement, intubation, chest tube placement, and basic laparoscopy, as well as the total time for all the tasks were significantly decreased at the end of the course when compared to pre-course results (p<0.001). Moreover, students reported increased post-course confidence in completing these tasks compared to pre-course (Zeng, Woodhouse and Brunt, 2010). Recognizing the effectiveness of these individual programs, the ACS released a universal curriculum in 2015 currently being pilot tested in 47 institutions nationwide. The ACS aims to eventually create a standardized program to be implemented at all U.S. medical schools that will appropriately train senior students in the basic skills necessary for surgical residency (Naylor et al., 2010).

Similarly, a study by Karam et al. surveyed orthopaedic residency program directors (PDs) and residents regarding a potential surgical skills curriculum for orthopaedic surgery interns. Survey responses demonstrated an overwhelming consensus for the need to incorporate a PGY-1 surgical skills curriculum focused on basic skills and the use of simulation technology (Peyre et al., 2006). In July 2013, the Accreditation Council for Graduate Medical Education (ACGME) and the American Board of Orthopaedic Surgery (ABOS) mandated that residency programs implement a formal, curriculum-based training program for PGY-1 residents (Teo et al., 2011). Numerous studies have demonstrated the efficacy of these surgical skills training programs (American Board of Surgery et al., 2014), (Dougherty and Marcus, 2013), Butler et al. implemented a didactic and simulation-based educational module to train PGY-1s and MS4s on closed reduction and percutaneous pinning of pediatric supracondylar humeral fractures (Butler et al., 2017). After the course, an evaluation of knowledge surrounding management of supracondylar fractures showed no significant difference between the interns and sub-interns who completed the module and a group of PGY-2 to PGY-5 orthopaedic residents. Furthermore, interns and PGY-2 to PGY-5 residents did not differ in a post-course skills test fractures (Butler et al., 2017).

Given the success of 4th year general surgery training programs and the orthopaedic module reported by Butler et al., senior medical students entering orthopaedic residency may benefit from a 4th year orthopaedic preparation course fractures (Butler et al., 2017). The purpose of this study was to survey 4th year medical students pursuing orthopaedic surgery and junior orthopaedic residents to determine the necessity and usefulness of a 4th year orthopaedic surgical skills training course.

Methods

After receiving Internal Review Board (IRB) approval from the senior author’s institution, 2 surveys were created via SurveyMonkey (San Mateo, CA). One survey was designed specifically for medical students applying to orthopaedic
surgery, and the other was designed for junior orthopaedic surgery residents (PGY1 and PGY2). Junior orthopaedic surgery residents were particularly chosen due to potential similarities in surgical skills competency with 4th year medical students. Moreover, junior residents who have recently graduated medical school are better equipped to assess the training needs of 4th year students when compared to their senior resident peers. Surveys consisted of questions regarding the participants’ medical school demographics, exposure to an orthopaedic surgical skills course during medical school, and opinions about the utility and implementation of such a course. Surveys were distributed via email to all individuals who applied to the orthopaedic surgery residency program at our institution from the 2015-2016 academic year to the 2017-2018 academic year (Supplementary File 1). Email addresses were obtained by reviewing archived residency applications for 2189 applicants. Surveys were sent to recipients beginning in February 2018, with reminder emails sent at 2 weeks and 4 weeks after initial request. Descriptive statistics were utilized to analyze the applicant and resident survey responses.

Results/Analysis

Demographic Characteristics

Orthopaedic Surgery Residency Applicants

Thirty-one applicant emails were returned as undeliverable, resulting in a total of 701 surveys distributed to current 4th year medical students. Of the 701 applicants who received the survey, 181 responded (response rate of 26%). 171 of 181 applicants (95%) were 4th year medical students. The 10 applicant respondents who were not 4th year students were either already residents (2), a post-graduate (1), a research fellow (1), a re-applicant (1), graduates (4), and skipped this question (1). All demographic results seen in Table 1.

Current Junior Orthopaedic Surgery Residents

Two-hundred resident emails were returned as undeliverable, resulting in distribution of 1257 surveys to orthopaedic surgery residents. Of the 1257 PGY1 and PGY2 residents who presumably received the survey, 138 responded (response rate 11%). Further demographic details demonstrated in Table 1.

Survey Results

Applicant Survey

170 out of 181 (94%) of respondents indicated that their medical school did not offer an orthopaedic surgical skills course during the 4th year of medical school. Eleven applicants (6%) had a skills course offered at their medical school and all of these students had or planned to take part in the course. One of the eleven (9%) applicants indicated that he or she had yet to participate in the course. Among the 10 respondents who had participated in the orthopaedic surgical skills curriculum at their institution, 9 (90%) believed that the course better prepared them for an orthopaedic surgery residency. 160 of 171 (94%) of applicant respondents agreed that implementing an orthopaedic surgical skills course into the 4th year medical school curriculum would be beneficial. Applicants rated basic principles of fracture reduction (95%; 171/180), casting/splinting (94%; 170/180), reading basic x-rays (90%; 162/180), and instrument identification (76%; 136/180) as the most important components to be included in such a curriculum (Figure 1).

Residents indicating importance of specific skills: Applicants indicated which skills should be included in an orthopaedic surgical skills curriculum to improve their performance prior to entering residency

Additionally, 48 out of 180 applicants (27%) indicated that an orthopaedic surgical skills course should be structured as four to six 1-hour sessions spread out over 4 weeks. Other structures for such a course that applicants felt would be appropriate were four to six 1-hour sessions spread out over 1 week (22%; 40/180), and one full day from 8a-4p (18%; 32/180) (Table 2). Of note, 13 applicants made suggestions for how to structure a surgical skills course with pertinent examples seen in Table 3.

Resident Survey

41 of 117 (35%) residents indicated that they participated in a surgical skills course prior to residency, although an orthopaedic specific course was not listed as a response. Residents strongly agreed that taking a basic skills course in reading x-rays (77/117; 66%), casting/splinting (83/117; 71%), and fracture reduction (82/117; 70%) would have improved their performance during the first two years of residency. Additionally, residents strongly agreed that a course in reading x-rays (72/117; 62%), casting/splinting (78/117; 67%), and fracture reduction (78/117; 67%) would have improved their confidence during the junior years of residency. Other skills that residents suggested would have been improved had they participated in a skills course included instrument identification, instrument handling, suturing, and knot tying (Figure 2).
Resident Confidence and Performance: Residents indicated whether or not a course in each specific skill would have improved their confidence and/or performance during residency. On a Likert scale of 1-5, 1 indicates “strongly disagree,” 2 is “disagree,” 3 represents “neutral,” 4 is “agree,” and 5 represents “strongly agree.”

110 of 118 junior residents (93%) believed implementing an orthopaedic surgical skills course during the 4th year of medical school would have been beneficial. Most residents indicated that such a course should either be structured as four to six 1-hour sessions spread throughout 4 weeks (34%; 39/115) or as four to six 1-hour sessions spread out over 1 week (31%; 30/115). Additionally, 2 residents provided “other” suggestions for an effective course structure (Table 1).

**Discussion**

Our study demonstrated that applicants and junior orthopaedic surgery residents believe that an orthopaedics specific surgical skills course would improve both confidence and performance during the first two years of residency. Directly surveying current and future orthopaedic surgeons provided this study with a baseline consensus, laying the groundwork for the development of future surgical skills pilot programs. These results were similar to those of previous studies in

| Table 1. Respondent Demographics. |
|-----------------------------------|
| **Applicants** | **Number (%)** | **Residents** | **Number (%)** |
| Age (years) | | | |
| 21-24 | 2 (1.1) | 21-25 | 0 (0.0) |
| 25-28 | 152 (84.0) | 26-30 | 96 (82.1) |
| 29-32 | 18 (9.9) | 31-35 | 19 (16.2) |
| 33+ | 9 (5.0) | 36+ | 2 (1.7) |
| Sex | | Male | 147 (81.2) |
| Female | 34 (18.8) | Female | 27 (23.1) |
| Geographic Location of Medical School (%) | | Northeast - New England (CT, ME, MA, NH, RI, VT) | 10 (5.6) |
| Northeast - Middle Atlantic (NJ, NY, PA) | 26 (14.5) | Northeast - Middle Atlantic (NJ, NY, PA) | 23 (19.7) |
| Midwest - East North Central (IN, IL, MI, OH, WI) | 20 (11.2) | Midwest - East North Central (IN, IL, MI, OH, WI) | 22 (18.8) |
| Midwest - West North Central (IA, KS, MN, MO, NE, ND, SD) | 15 (8.4) | Midwest - West North Central (IA, KS, MN, MO, NE, ND, SD) | 8 (6.8) |
| South - South Atlantic (DE, DC, FL, GA, NC, SC, VA, WV) | 45 (25.1) | South - South Atlantic (DE, DC, FL, GA, NC, SC, VA, WV) | 19 (3.4) |
| South - East South Central (AL, KY, MS, TN) | 22 (12.3) | South - East South Central (AL, KY, MS, TN) | 4 (3.4) |
| South - West South Central (AR, LA, OK, TX) | 31 (17.3) | South - West South Central (AR, LA, OK, TX) | 20 (17.1) |
| West - Mountain (AZ, CO, ID, NM, MT, UT, NV, WY) | 5 (2.8) | West - Mountain (AZ, CO, ID, NM, MT, UT, NV, WY) | 8 (6.8) |
| West - Pacific (AK, CA, HI, OR, WA) | 5 (2.8) | West - Pacific (AK, CA, HI, OR, WA) | 7 (6.0) |
| Year in School/Program | MS1 | 0 (0.0) | PGY-1 | 59 (50.0) |
| MS2 | 0 (0.0) | PGY-2 | 47 (48.3) |
| MS3 | 0 (0.0) | PGY-3 | 2 (1.7) |
| MS4 | 171 (95.0) | Other | 0 (0.0) |
| Other | 9 (5.0) | | |
Figure 1. Skills Identified as Being Important by Applicants

Table 2. Applicants’ opinion on how an orthopaedic surgical skills course should be structured.

| Course Structure                                      | Number of Applicants (%) |
|-------------------------------------------------------|--------------------------|
| One Full Day (8a-4p)                                  | 32 (17.8)                |
| One Half Day (8a-12p)                                 | 8 (4.4)                  |
| Four to six 30-minute sessions spread out over 1 week | 6 (3.3)                  |
| Four to six 1-hour sessions spread out over 1 week   | 40 (22.2)                |
| Four to six 30 minute sessions spread out over 4 weeks| 12 (6.7)                 |
| Four to six 1-hour sessions spread out over 4 weeks  | 48 (26.7)                |
| Four to six 30 minute sessions spread out over the academic year | 1 (0.6)                  |
| Four to six 1-hour sessions spread out over the academic year | 20 (11.1)                |
| Other                                                 | 13 (7.2)                 |

Table 3. Applicant and Resident “Other” Suggestions for the Structure of an Orthopaedic Surgical Skills Course.

| Applicants                                                                 | Residents                                                                 |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Four 1 hour sessions per month for 6 months                               | One week                                                                  |
| Anything would be beneficial, but it should only be offered after the match for 4th year students. This way no time is wasted and no spots in the curriculum/course are wasted. | None. This is learned on the job. Students are more benefited from learning sterile technique. The point of surgical residency is to learn the skills. This is outside the realm of medical school, where you are learning other important things and not supposed to be focused on specialty needs. |
| 2-3 one hour blocks per week for one month.                               |                                                                           |
| Half days for two weeks.                                                  |                                                                           |
| 2-3 full days; gaining a regular schedule (e.g. 4 meetings over a month) is challenging with 4th year schedules. |                                                                           |
| A one month course.                                                       |                                                                           |
general surgery. The general surgery surgical skills pilot programs implemented in the 4th year curriculum at 50 US allopathic medical schools have improved junior resident confidence and performance in surgical skills (Naylor et al., 2010), (Peyre et al., 2006). Such a program has not been established for students beginning careers in orthopaedic surgery. However, previously implemented surgical skills courses for junior orthopaedic surgery residents have been viewed favorably (Butler et al., 2017), (Ford, Patt and Scannell, 2016), (Sonnadara et al., 2011).

In 2013, Karam et al. distributed online surveys to both orthopaedic surgery residency program directors and residents to assess the interest in an orthopedic surgery skills course (Karam et al., 2013). The surveys were sent to 185 program directors (PDs) and 4,549 residents with 86 of 185 (46%) and 687 of 4,549 (15%) responding, respectively. Of participants, 80% of program directors and 86% of residents agreed that surgical skills simulations should become a required part of training. Furthermore, 82% of program directors and 76% of residents were interested in a standardized surgical skills curriculum. The most cited barrier to the implantation of such a course was lack of funding.6 The results of our study are similar, in that 110 of 118 (93%) residents believe in the implementation of a surgical skills program during the 4th year of medical school.

Previous studies have demonstrated that there is a strong interest in the development and analysis of orthopaedic specific surgical skills programs. At the University of Iowa, authors developed and implemented a month-long, standard curriculum for six PGY-1 residents, which consisted of 31 modules, each taking residents approximately six hours to complete (Karam et al., 2013). At the end of the month, residents were given questionnaires to rate their experience. Of participants, 83% reported that the program improved their surgical skills and would enhance their operating room safety. In addition, 100% of the participants agreed that the course improved their orthopaedic training and felt that such a program should be a permanent fixture in resident education. The total cost for the month was approximately $22,500 (Karam et al., 2013).

Similarly, Westerlind et al. developed a one month surgical skills training program for PGY-1 general surgery residents (Westerlind et al., 2014). During the entire month, six PGY-1 residents worked full time on the surgical skills course and were free of clinical responsibilities. Eighteen separate skills topics formed the framework of the month-long curriculum. The six PGY-1 residents who completed the course indicated that their surgical skills improved after the course and 86% believed the course would enhance their operating room safety. 100% of residents felt the course improved their orthopaedic training and that such a course should be a permanent part of surgical education. The total cost of their month-long program was $21,864 (Westerlind et al., 2014). Ford et al. and Sonnadara et al. describe the incorporation of similar

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**Figure 2. Orthopaedic Resident Confidence and Performance**

![Graph showing orthopaedic resident confidence and performance](image-url)
programs at their respective institutions, with variable results (Ford, Patt and Scannel, 2016), (Sonnadara et al., 2011). Course details for each orthopaedic surgical skills pilot program offered to current residents are outlined in Table 4. Our study demonstrated that orthopaedic applicants, 4th year medical students, should be a target group as well.

Applicant and resident respondents had similar ideas regarding which skills should be included in an orthopaedic-specific surgical skills course. Both groups suggested that the most important skills to be included in the curriculum should be basic principles of fracture reduction, casting/splinting, reading basic x-rays, and instrument identification. Suturing, knot tying, consenting a patient, and sterile technique were deemed less important by both applicant and resident respondents. The skills rated lower by the respondents are important for future orthopaedic surgery residents to master, but are likely learned during the 3rd year clerkships and perfected during residency. Excluding these from a 4th year skills course may decrease the costs of these programs to medical schools. Additionally, a 2018 study performed in the UK by Bennett et.al., demonstrated that medical student-to-medical student peer-assisted learning was an effective and feasible method for teaching surgical skills and improved confidence among healthcare undergraduates; possibly a less expensive bridge to an expansive orthopaedic surgical skills program (Bennett, Morris and Mirza, 2018).

There are several limitations to this study. First, given the low response rate from the junior orthopaedic surgery residents it is not possible to make definitive conclusions about their opinions on incorporating a surgical skills curriculum into the 4th year of medical school. Busy resident schedules, a heavy survey burden, and changes in resident email addresses are all possible contributing factors to this low response rate. While the response rate was low, the data obtained was in line with the data received from the applicants. Second, this was a survey-based study and is subject to all of the inherent limitations of this study design. We acknowledge that there exists a certain level of variability in how questions and responses are interpreted by both respondents and survey administrators. Additionally, a response bias may exist, as residents and applicants could choose to respond to various questions. Because the survey did not require a response to move on to the next question, there was an uneven number of responses to the different questions. Future research should evaluate the cost of an orthopaedic surgical skills curriculum to medical schools. It will be important to understand whether medical schools (or orthopaedic departments specifically) are willing to pay for such a program, as this is a major determining factor in the viability of a surgical skills course for 4th year medical students entering orthopaedic surgery residency.

Conclusion
Currently, there is no standardized surgical skills curriculum for medical students pursuing a career in orthopaedic surgery. Pilot programs should be developed to optimize and, eventually, standardize an orthopaedic preparatory course. Both current residents and applicants believed that such a program would benefit junior residents by increasing confidence, performance, and preparedness for an orthopaedic surgery residency.

Take Home Messages
Current residents and medical students agree that implementing an orthopaedic specific surgical skills course into the curriculum of the 4th year of medical school would be beneficial to confidence and performance as a junior resident.

Table 4. Summary of Orthopaedic Surgery Surgical Skills Courses.

| Authors        | Participants | Description                                                                 | Results                                                                 | Cost Per Course |
|----------------|--------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------|-----------------|
| Karam et al.   | PGY-1 Residents | 19 individual modules over 1 month                                           | 100% resident agreement that curriculum enhanced orthopaedic training | $22,500         |
| Westerlind et al. | PGY-1 Residents | 19 individual modules over 1 month                                           | 93% comprehensive resident satisfaction                                | $21,864         |
| Ford et al.    | PGY-1 Residents | Multiple modules totaling 89 hours                                           | Every session was rated as at least “good” (98%), with 32% of modules achieving an “excellent” rating. | $8,100          |
| Sonnadara et al. | PGY-1 Residents | Randomized controlled trial with study group undergoing a 30-day intensive surgical skills course. Control groups continued with standard orthopaedic residency curriculum (on and off-service) | Study group performed significantly better on post course assessment than control groups (ISL-on-service difference = 7.648, P < .05; ISL-off-service difference 9.161, P < .01) | N/A             |
Notes On Contributors

- Lucy E. Meyer is a 4th year medical student at Tulane University School of Medicine.
- Ocean V. Thakar is a 1st year orthopaedic surgery resident at MedStar Union Memorial Hospital in Maryland. He attended Drexel University College of Medicine at the time this project was performed.
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- Dr. Mary K. Mulcahey is an assistant professor of orthopaedic surgery at Tulane University School of Medicine.

Declarations
The author has declared that there are no conflicts of interest.

Ethics Statement
IRB was obtained from Tulane University School of Medicine under the approval/reference number 2017-815. Ethical guidelines conducted utilizing the Survey Ethics section of the Encyclopedia of Survey Research Methods. These guidelines state, “these procedures are essential to the research process so that explicit care is taken that (a) no harm is done to any survey respondent, and (b) no survey respondent is unduly pressured or made to feel obligated to participate in a survey.” Lavrakas, P. J. (2008). Encyclopedia of survey research methods Thousand Oaks, CA: Sage Publications, Inc. doi: 10.4135/9781412963947.

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Trevor Gibbs
AMEE

This review has been migrated. The reviewer awarded 4 stars out of 5

This was a very well researched paper, very clear and well written and certainly shows that the authors had researched the subject extensively. I thought that they explained the positive and negative aspects of their work well. However, to me it felt like the work up for a more important piece of work which related to the development of a much needed course and its evaluation - a more valuable piece of educational work that would have greater impact. Despite my reservations, I would recommend that this paper is read by all those involved with surgical curricula development.

Competing Interests: No conflicts of interest were disclosed.

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Julie Hunt
Lincoln Memorial University

This review has been migrated. The reviewer awarded 3 stars out of 5

The authors report the results of a survey of fourth year medical students and PGY 1 and 2 orthopedic surgical residents which asks about the potential addition of a surgical skills course during the fourth
year of medical school. Despite a somewhat predictably low response rate, the overall number of responses was adequate for drawing conclusions. The study probably gives a reasonably accurate estimation of how many students have already taken an orthopedic surgical skills course during medical school (6%), but it is likely less to be accurate at predicting how many medical students would like to take an orthopedic surgical course, as the surveyed students are those who have already applied to an orthopedic surgical residency program. Surveying those interested in a particular specialty will nearly always result in them requesting more training in their area of interest; the problem is finding curricular time to accommodate everyone’s areas of interest.

I think this article is a helpful read for those in this specialty field, as it suggests the specific tasks that medical students would like to have included in an orthopedic surgical skills course. I agree with the authors that such a course would better prepare students for starting an orthopedic surgery residency, if time could be found for it in the medical school curriculum.

**Competing Interests:** No conflicts of interest were disclosed.