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A Virtual Curriculum to Prepare Medical Students to Achieve Accreditation Council for Graduate Medical Education Level-1 Milestones in Orthopaedic Surgery

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Investigation performed at Cooper University Healthcare, Department of Orthopaedic Surgery

Abstract

As a part of the American healthcare system's response to the Coronavirus Disease 2019 (COVID-19) global pandemic, the Association of American Medical Colleges recommended that medical schools temporarily remove students from clinical settings and transition to an entirely online learning environment. This posed an unprecedented challenge to students in the clinical years of their medical education. To address this unexpected shift, we modified an in-person workshop to teach orthopaedic trauma basics to 5-week virtual course for third year medical students from several schools in New Jersey and Pennsylvania. We focused on moving students toward the Level-1 milestones for basic fracture care with a combination of weekly lectures and virtual interactive small group sessions, all conducted via WebEx and proctored by an orthopaedic attending or resident. The course was well received by students. Participation in the course was completely voluntary and did not count for credit at any institution. The course was valuable to students because the students who registered chose to fully complete the 5-week course and no student missed more than one small group session. On a postcourse survey, 100% of students said they would be highly likely to recommend the course to a future student, and the average rating for educational value of the course was 4.98 of 5. Given the current limitations in clinical education because of the COVID-19 pandemic, our course provides a reasonable alternative to clinical experience and prepares students with the knowledge and many of the skills that are required to succeed as orthopaedic interns. Furthermore, the success of our course this year suggests that similar programing may be a useful adjunct to clinical experiences even when it is safe to return to more traditional medical school scheduling.

The shift of medical education to an entirely virtual setting has profoundly affected orthopaedic education for fourth year medical students who rely on subinternships to gain clinical experience and practical knowledge in preparation for intern year[1]. With the Association of American Medical Colleges recommendation to temporarily remove students from the clinical setting and transition to an online learning environment, it was unclear how medical students would gain this experience[2-4]. Even

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when "normal" schedules resume, virtual online education has the advantage of effectively delivering standardized content to medical students from multiple schools[5,6].

The availability of high-quality orthopaedic education to all students can reduce some of the marked disparities in students' opportunities for education before being evaluated on their subinternship rotations[7,8]. In the current system, students with more academically active orthopaedic departments have significantly different experiences and opportunities in the first 3 years of medical school than students from schools with small or absent orthopaedic programs, which positions them to perform better than their peers on audition rotations. In addition, a standardized and widely available curriculum provides an entry point for students who would typically be underrepresented in an orthopaedic department, including women and students of color, who may not be able to easily network within the orthopaedic community[9]. The availability of a formal orthopaedic curriculum may encourage more students who perceive an initial barrier to entry to become interested in orthopaedics and may help to "level the playing field" in audition rotations and to prepare students more equitably for residency.

The current Accreditation Council for Graduate Medical Education (ACGME) milestones project clearly delineates expectations for incoming interns, some of which require clinical experience, but many of which can be met through virtual education[10]. With that in mind, we created a 5-week virtual course for 3rd year medical students from several schools in New Jersey and Pennsylvania to teach the basics of orthopaedic trauma. We focused on moving students toward the Level-1 milestones for basic fracture care with a combination of weekly lectures and virtual interactive small group sessions proctored by an orthopaedic attending or resident.

Methods

Participants

Students were contacted via email by the resident leader of the course (M.M.) and registered electronically. Participation in the course was completely voluntary, and no academic credit was given by any institution. There were no grades assigned or formal evaluations of student performance. Board-certified orthopaedic surgeons served as volunteer proctors. All had experience in medical student and resident education. Fifty students from 10 different institutions registered for the course. Forty-nine completed the full 5-week course, and no student missed more than one small group session.

Curriculum

The curriculum was designed for third year medical students who had little or no clinical orthopaedic experience with the goal of moving them toward the Level-1 milestones for residents published by the American Association of Medical Colleges in conjunction with the American Academy of Orthopaedic Surgeons. The framework describes Level 1 as "milestones expected of an incoming resident" and includes skills such as basic history taking, physical examination, ordering appropriate imaging studies, fracture reduction and splinting, and basic patient education, as well as knowledge of anatomy, physiology, and treatment options. We chose to focus on orthopaedic trauma cases because in many programs the first indirectly supervised activity for which interns are responsible is trauma call.

The course consisted of weekly lectures hosted by the leader of the course via Webex (Cisco Systems), followed later in the week by small group discussions of 5 or fewer students proctored by an attending or the resident course leader. Lectures aimed to help students build frameworks for thinking about orthopaedic care and introduced students to high yield resources that they could use for self-study and case preparation, including the Arbeitsgemeinschaft für Osteosynthesefragen (AO) surgery reference and the Orthobullets website.

The first week of the course was focused on reading radiographs. The lecture introduced the basic concepts of how density projects to a 2 dimensional image, a systematic way to approach looking for fractures by tracing the cortical lines, a structure for formally presenting an image, and a bank of descriptive terms to describe fracture morphology and displacement (Fig. 1). In the small group setting, students practiced reading radiographs of long bone fractures with an emphasis on vocabulary, with real-time interactive feedback from the proctor.

The second week of the course introduced concepts of orthopaedic hardware and bone healing. Students learned about plating constructs and how screws can be used, including the concepts of lag by technique, lag by design, and understanding the difference between locking and nonlocking constructs. The weekly small group activity asked students to again describe a radiograph, reinforcing the content from the previous week, and then to suggest which type(s) of hardware constructs might be used to stabilize the fracture.

In the third week, the course transitioned from abstract discussions of fractures and surgical implants to more realistic discussion of patient care. The lecture for the week used the example of a distal radius fracture to introduce students to an orthopaedic evaluation of a patient and highlighted pertinent parts of the history and physical examination about an upper extremity injury. In the context of the patient presentation, we also discussed the radiographic parameters for a distal radius, the process of setting up for and performing a reduction, appropriate technique for splinting a wrist, and common methods of fixation for distal radius fracture. Students were explicitly asked to prepare for small group by using Orthobullets or the AO surgery reference online to learn the specific measurements for the radiographic parameters of a distal radius and the surgical indications. In the proctored session, the group worked through 2 cases of distal radius fractures as if they were seeing the consult in the emergency department. With guidance from the proctor, they determined which questions would be most important to ask the patient, how the information gathered would inform the patient's care, which physical examination maneuvers would be most important, what (if any) further imaging they would order, how they would approach reduction and stabilization, and what would be most appropriate as definitive treatment for the patient. These critical skills align with the ACGME Level-1 milestones for

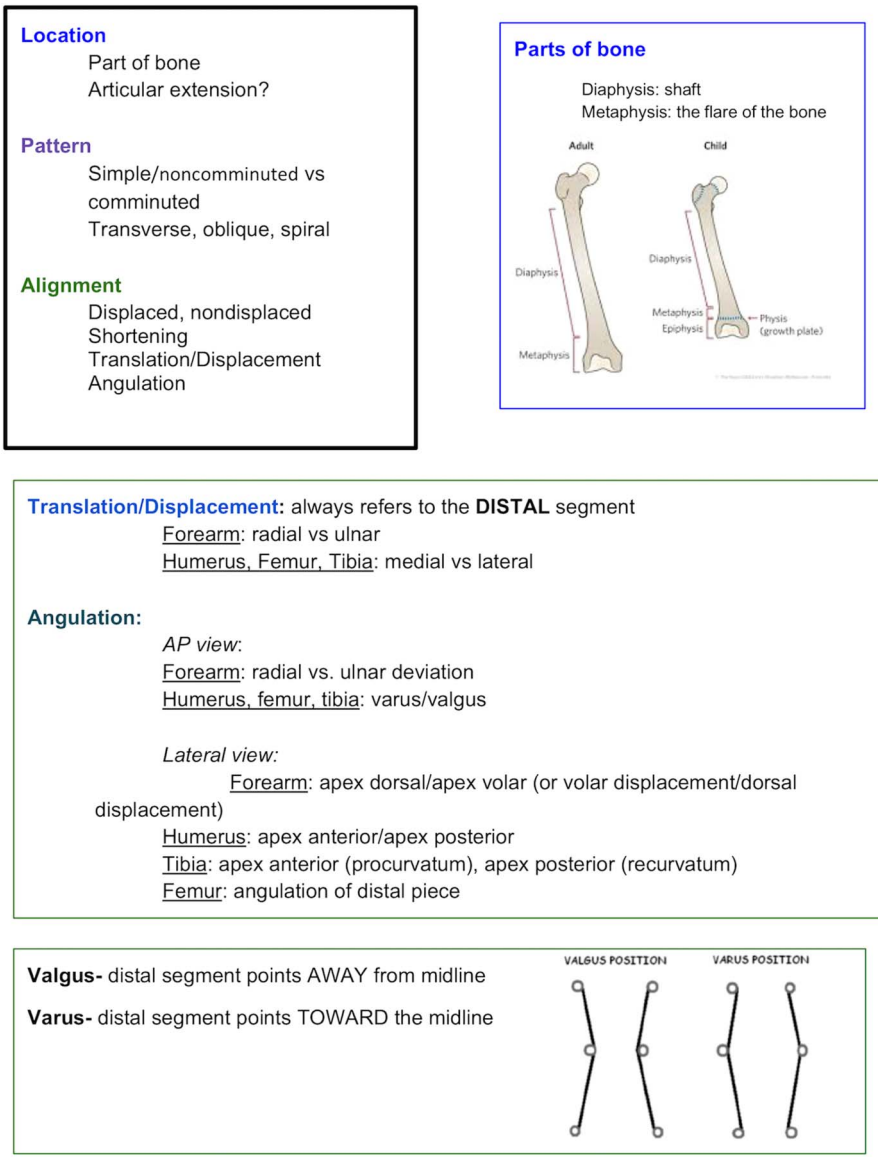

Fig. 1

Week 1 reading radiographs educational material

distal radius fracture care. We chose this discussion format because case-based learning has been well established to be a positive experience for learners and educators[11] and to help students to master knowledge more effectively than traditional lecture learning[12] or problem-based learning[13]. In addition, case-based learning encourages students to do more independent reading and discovery[14] and to appreciate the complexities of real-world patient care[15].

The fourth week was similarly case-based but instead focused on ankle fractures. In the lecture, students reviewed important parts of the history and physical examination of the lower extremity, learned about patterns of ankle fractures, and were introduced to surgical approach planning. We discussed bimalleolar, trimalleolar, bimalleolar equivalent, isolated medial and lateral malleolus, and pilon fractures, as well as introducing the concepts of internervous and intermuscular planes that define surgical approaches. In preparation for the proctored session, students were assigned to independently read about the surgical approaches to the ankle and were expected to know which neurovascular structures were at risk with each approach. The small group activity was designed similarly to the previous week. Because much of the history and physical was a review from the previous week, the discussion was more heavily weighted toward surgical fixation. Students were challenged to synthesize their knowledge of reading radiographs, classifying fractures, planning appropriate hardware constructs, and identifying safe surgical approaches to develop a treatment plan. Included in the slide deck for the small group, which was available to students both before and after the session, was a history and physical examination, a preoperative radiograph, representative slices of a computed tomography scan (if available), a postoperative image, and a copy

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TABLE I Pre and Post Course Survey Results in Different Educational Domains

	Precourse (n = 42)		Postcourse (n = 48)		p
Subinternship	3.976	1.732	7.896	1.259	<0.00001
Reading X-rays	4.262	1.849	8.375	1.104	<0.00001
Bone healing	3.905	1.708	8.896	1.153	<0.00001
Fracture fixation methods	3.69	2.147	8.271	1.144	<0.00001
Fracture classification	3.19	2.063	7.417	1.412	<0.00001
Treatment plan based on X-ray	3.024	1.473	7.563	1.165	<0.00001
Using online resources	5.476	2.133	8.917	1.145	<0.00001
Consult presentation	3.786	2.078	7.875	1.196	<0.00001

of the surgical note from the case. Many students found it helpful to review the surgical note as a way to understand the attending surgeon's logic and to get a sense for the flow of the case.

For the culminating activity, students were assigned one of 3 "mock consults" ahead of time and independently prepared to present to the proctor. To maximize feedback, these Webex sessions were limited to only 3 students. Each student was given a brief history and physical examination, medical history, and a radiograph several days before their session. In their presentation, they were expected to describe the image and classify the fracture if appropriate, highlight the most pertinent parts of the history and physical examination, have a plan for immediate management (reduction, immobilization, etc) in the acute setting, and a plan for definitive management. Students were encouraged to use online resources in preparation for the case to be able to discuss surgical indications, possible surgical approaches, suggest fixation constructs, and make a plan for postoperative care. This activity challenged students to think through a full case and practice the skills that they had learned previously in the course and simulated the way that they might prepare for a surgical case in an actual clinical setting.

Results

Precourse and postcourse surveys were conducted and filled out by 47 and 48, respectively, of the 49 students who completed the course. On a scale of 1 to 5, students rated the overall educational value of the course as 4.98, and 100% of surveyed students said that they would highly recommend the course to future students. Before and after the course, students were asked to rate their confidence in the following domains: preparation for subinternships, reading radiographs, understanding primary and secondary bone healing, ways in which orthopaedic interventions can lead to bone healing, using classification systems to describe fractures, making a treatment plan based on radiographs, using online resources to prepare for a surgical case, and presenting an orthopaedic consult to an attending. Students showed significant increases in confidence in all domains when compared with the results of the survey taken before the course (Table I, Fig. 2).

Student comments frequently highlighted 3 themes. First, many students valued the alternating lecture and small group format, noting that they appreciated the ability to learn and then apply content with personalized, real-time feedback. Second, participants appreciated having a low-stress experience focused on education rather than assessment and reported that they felt comfortable asking questions and making mistakes. Finally, students frequently mentioned the importance of the interaction with attending proctors, noting that they learned a great deal by having an expert explain their thought process when approaching a patient. These comments highlight the importance of the interactivity of the course and the value of the participation of the attending proctors.

Challenges

An online content-focused course has obvious shortfalls in students' ability to practice hands-on skills such as casting, splinting, and physical examination; does not provide operating room experience; and precludes students from conducting histories and physical examinations on real patients. We attempted to address some of these deficits by explicitly discussing the relevant aspects of a history and physical and by describing appropriate

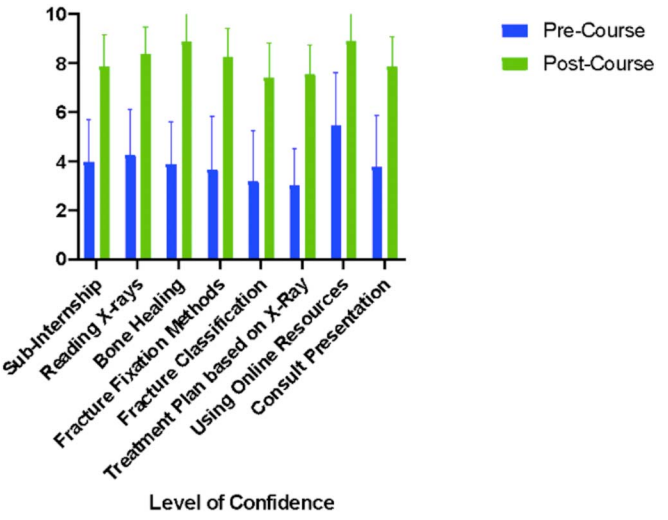

Fig. 2
Reported level of confidence pre and post course in educational domains.

reduction maneuvers for wrist and ankle fractures, but ultimately, there is no perfect substitute for real-world experience. We have not yet experimented with teaching physical skills in a virtual environment but hope to explore these possibilities in the next iteration of our course. One of the biggest challenges of this course was logistics—the administrative burden was quite high as we had to work with multiple attendings whose schedules were in flux with the hospital's response to COVID-19, create online meetings and invitations for multiple groups on a weekly basis, and have flexibility to deal with unexpected technical issues and availability changes. In this initial iteration of our course, a resident handled all of the administrative work, but presumably, in the future a medical student or nonclinical member could reasonably take on this role.

Discussion

The online, case-based, orthopaedic trauma basics curriculum provided 3rd and 4th year medical students with educational experience during the Coronavirus Disease 2019 (COVID-19) pandemic and established a basic foundation of orthopaedic knowledge. Based on the feedback from the participants, the course was well received and felt to be valuable. The primary objective of preparing students to achieve many of the ACGME Level-1 milestones was achieved, instilling confidence in the students as they move forward through the final year of medical school and begin to prepare for residency.

To address the concern that musculoskeletal medicine is adequately taught in medical school[12]. The United States Bone and Joint Initiative has successfully increased the prevalence of required musculoskeletal education in the medical school curriculum[16]. However, musculoskeletal medicine by their definition can include orthopaedic surgery, rheumatology, or physiatry. There remains a significant disparity between students' exposure to clinical orthopaedic education based on the availability of an orthopaedic surgery department at their home institution and varying degrees of elective time provided to medical students. For students at schools with no orthopaedic surgery department, gaining meaningful clinical experience before high-stakes away rotations can be very challenging. Even for schools with an active department, it may be unfeasible or disproportionately time consuming to execute a full curriculum for the small handful of students who aspire to be orthopaedic surgeons. A structured, low-stress educational experience such as our course may help to "level the playing field" for students before being evaluated on their clinical rotations. In addition, given the lack of formal curricula for orthopaedics, many opportunities for development and advancement are heavily dependent on personal relationships, mentorship, and networking. Forging such connections may be more challenging for minority and female students[9], which can place them at an educational disadvantage. However, previous research has demonstrated the efficacy of structured curricular opportunities in increasing minority students' interest in a field and success in matching[17-20]. With the field becoming more competitive to enter and greater emphasis placed on the fourth-year subinternship as an "audition," the differences in musculoskeletal education that students are afforded before these rotations may pose a barrier to entry for some students. A virtual didactic curriculum such as the one we provided is highly accessible and easily delivered to all medical students.

In addition to making orthopaedic education more equitable, an online curriculum may be more effective in preparing students for residency than clinical rotations alone. Since the fourth-year subinternship rotations are frequently treated as an "audition," students and faculty alike have acknowledged that the relative educational value of these rotations can be low[21]. As highlighted in the students' responses to the course, a virtual education forum allows for a safe environment focused on education, not evaluation, where questions may be asked without fear of being judged and skills can be practiced without anxiety. Meeting students at their current level of knowledge with opportunities to practice skills, receive feedback, and ask questions is a fundamental component of education and creates a favorable learning environment for students' growth[22]. This ungraded course as an adjunct to the critically evaluated clinical experience will help to level the current imbalance of evaluation to education in the fourth year of medical school.

Conclusion

The COVID-19 pandemic has fundamentally changed the current state of medical education. The current state of affairs provides a unique opportunity to rethink the preexisting educational model. In the field of orthopaedic surgery, similar to most competitive surgical subspecialties, the subinternship and audition rotations are the primary opportunity for students to develop relationships, acquire skills, and expand their knowledge base while simultaneously serve as an extended audition for residency where student performance can be an important factor in the match process. The high-stakes nature of these rotations can compromise the value of the educational experience. Courses such as the one outlined above can supplement these clinical experiences by using skill-based and case-based formats to explicitly teach foundational concepts in orthopaedics, provide opportunity for practice and feedback, and give students the skills to continue self-directed education during their clinical rotations. It also provides the opportunity for all medical students interested in orthopaedic surgery to start auditions with the same fundamentals regardless of circumstances related to their race, gender, or resources at their medical school. We aim to broaden our outreach with this virtual content, to make orthopaedic education equitable and accessible to all medical students. ■

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References

1. Rose S. Medical student education in the time of COVID-19. JAMA. 2020;323(21):2131-2.
2. Ferrel MN, Ryan JJ. The impact of COVID-19 on medical education. Cureus J Med Sci. 2020;12(3):e7492.
3. Calhoun KE, Yale LA, Whipple ME, Allen S, Wood DE, Tatum R. The impact of COVID-19 on medical student surgical education: implementing extreme pandemic response measures in a widely distributed surgical clerkship experience. Am J Surg. 2020;220(1): 44-7.
4. Coronavirus (COVID-19) and the VSLO Program. Available at: https://students-residents.aamc.org/attending-medical-school/article/coronavirus-covid-19-and-vslo-program/. Accessed May 27, 2020.
5. Ehrlich H, McKenney M, Elkbuli A. We asked the experts: virtual learning in surgical education during the COVID-19 pandemic—shaping the future of surgical education and training. World J Surg. 2020:44(7):2053-5.
6. Everard KM, Schiel KZ. Learning outcomes from lecture and an online module in the family medicine clerkship. Fam Med. 2020;52(2):124-6.
7. Freedman KB, Bernstein J. Educational deficiencies in musculoskeletal medicine. J Bone Joint Surg Am. 2002;84(4):604-8.
8. Boutefnouchet T, Budair B. The perceptions and attitudes of medical students towards trauma and orthopaedic teaching: a cross-sectional study. SICOT J. 3:8.
9. Campbell KM, Rodríguez JE. Mentoring underrepresented minority in medicine (URMM) students across racial, ethnic and institutional differences. J Natl Med Assoc. 2018;110(5):421-3.
10. Stern P. The orthopaedic surgery milestone project. Available at: https://www.acgme.org/portals/0/PDFs/milestones/orthopaedicsurgerymilestones.pdf. Accessed May 27, 2020.
11. Srinivasan M, Wilkes M, Stevenson F, Nguyen T, Slavin S. Comparing problem-based learning with case-based learning: effects of a major curricular shift at two institutions. Acad Med. 2007;82(1):74-82.
12. Gade S, Chari S. Case-based learning in endocrine physiology: an approach toward self-directed learning and the development of soft skills in medical students. Adv Physiol Educ. 2013;37(4):356-60.
13. Hassoulas A, Forty E, Hoskins M, Walters J, Riley S. A case-based medical curriculum for the 21st century: the use of innovative approaches in designing and developing a case on mental health. Med Teach. 2017;39(5):505-11.
14. Kassirer JP. Teaching clinical reasoning: case-based and coached. Acad Med. 2010;85(7):1118-24.
15. O'Connor PJ, Sperl-Hillen JM, Johnson PE, Rush WA, Asche SE, Dutta P, Biltz GR. Simulated physician learning intervention to improve safety and quality of diabetes care: a randomized trial. Diabetes Care. 2009;32(4): 585-90.
16. Bernstein J, Garcia GH, Guevara JL, Mitchell GW. Progress report: the prevalence of required medical school instruction in musculoskeletal medicine at decade's end. Clin Orthop Relat Res. 2011;469(3):895-7.
17. Nellis JC, Eisele DW, Francis HW, Hillel AT, Lin SY. Impact of a mentored student clerkship on underrepresented minority diversity in otolaryngology-head and neck surgery. Laryngoscope. 2016;126(12):2684-8.
18. O'Connor MI. Medical school experiences shape women students' interest in orthopaedic surgery. Clin Orthop Relat Res. 2016;474(9):1967-72.
19. Bernstein J, Dicaprio MR, Mehta S. The relationship between required medical school instruction in musculoskeletal medicine and application rates to orthopaedic surgery residency programs. J Bone Joint Surg Am. 2004; 86(10):2335-8.
20. Mason BS, Ross W, Ortega G, Chambers MC, Parks ML. Can a strategic pipeline initiative increase the number of women and underrepresented minorities in orthopaedic surgery? Clin Orthop Relat Res. 2016;474(9):1979-85.
21. O'Donnell SW, Drolet BC, Brower JP, LaPorte D, Eberson CP. Orthopaedic surgery residency: perspectives of applicants and program directors on medical student away rotations. J Am Acad Orthop Surg. 2017;25(1):61-8.
22. Gleason BL, Peeters MJ, Resman-Targoff BH, Karr S, McBane S, Kelley K, Thomas T, Denetclaw TH. An active-learning strategies primer for achieving ability-based educational outcomes. Am J Pharm Educ. 2011;75(9):186.