



AOA Critical Issues in Education

A Surgical Skills Rotation for Mid-Level Residents

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Introduction: The University of Iowa orthopaedic residency previously designed a month-long surgical skill rotation for postgraduate year (PGY)-1 residents. This successful initiative has become a model of interest for other teaching institutions. In addition to the intern year, an important phase in residency occurs during the transition from PGY2 to PGY3, when residents assume greater responsibility and autonomy in leading surgical procedures.

Methods: To directly address this transition and assess residents' readiness, our residency program established a week-long PGY2 surgical skills rotation. This rotation serves as a training checkpoint and focuses on both training and evaluation of level-appropriate skills in joint arthroplasty, trauma, arthroscopy, and wire navigation. The primary objective of the PGY2 surgical skills rotation is to enhance orthopaedic residents' operative skills and experience by providing increased exposure and practice of requisite technical skills. Similar to the Orthopedic In-Training Examinations that assess residents' knowledge, this week-long program, aimed at assessing residents' proficiency in fundamental orthopaedic technical skills, occurs before their PGY3 year.

Results: Faculty-led training and assessment sessions in each area offer residents many opportunities for dedicated practice and improvement. Transferring these acquired skills from the laboratory to the operating room is essential for a training program. To confirm improvement, the final day of the surgical skills rotation was exclusively dedicated to structured performance evaluations, with a specific emphasis on establishing proficiency benchmarks.

Conclusion: We herein describe the University of Iowa's PGY2 surgical skills rotation, providing insights into its development, implementation, and outcomes. By sharing our experience, we offer a framework for other academic departments seeking to optimize surgical skills education and ensure the successful transition of mid-level residents.

Background

Conceptualization

The Residency Program at University of Iowa Department of Orthopedics and Rehabilitation was motivated to create a

structured pathway to prepare orthopaedic residents for the transition from the second to third year of residency¹⁻³. As a result, a detailed orthopaedics skills training course for second-year resident physicians was developed during an education

The skills program was supported primarily by alumni and donor philanthropy. The development of this rotation was also supported in part by the Agency for Healthcare Research and Quality (R18 HS025353 and R18 HS028778), the American Board of Orthopaedic Surgery, and a University of Iowa Graduate Medical Education (GME) innovation grants program. Additionally, several medical device companies provided support with the use of personnel, instrumentation, and implants for procedure-specific practice.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJSOA/A644>).

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curriculum restructuring during the pandemic of 2020. The idea was supported by the department chair and program director. We planned for a scheduled and protected 1-week period during which postgraduate year (PGY)-2 residents participated in a surgical skills rotation. The core objective of this program was to deliver a hands-on, intensive procedural-based educational opportunity. It aimed to equip or reinforce the necessary skills and confidence to successfully navigate the enhanced autonomy required in more senior years of residency (Fig. 1). By adopting this approach, residents benefited from tailored feedback from faculty and focused practice which was felt instrumental in their growth and development.

Curriculum Development

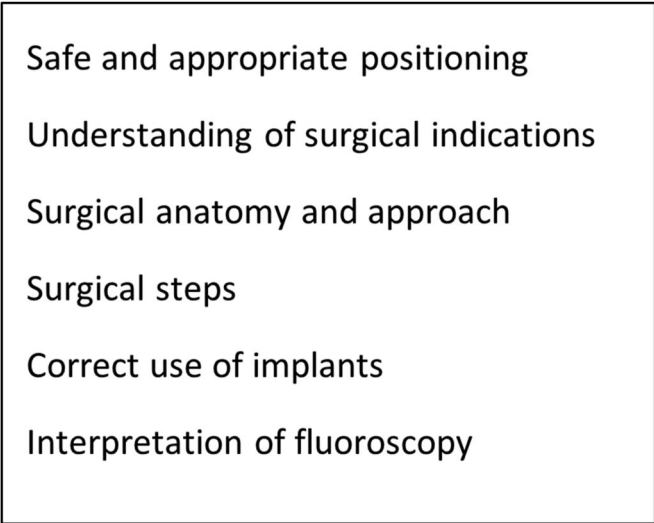
To develop the week-long rotation, residency program leaders enlisted a multidisciplinary team comprised of select orthopaedic surgeon faculty, simulation engineers, and laboratory administrators. Over the course of 6 months, the team met to discuss training topics that emphasized subspecialties vital to mid-level residents. This served as a needs assessment to develop the surgical skills training week curriculum. A portion of this curriculum was specifically focused on anatomy with a special focus on relevant surgical approaches in chosen subject areas. The rotating calendar for PGY-2 residents was evaluated, and a mockup schedule was created to determine clinical service coverage needs and address call responsibilities for the rotation. Where possible given advanced notice provided to our service teams, the schedule was amended so that other residents or advanced practice providers (APPs) provided clinical service coverage. PGY2 residents still had night call responsibilities during the week. However, after the first year of this program, the call before the final day of assessment was covered by another resident class. The week was designed with an emphasis on total joint arthroplasty (specifically hip and knee),

arthroscopy (knee and shoulder), wire navigation skill training and simulation, and procedural training on upper and lower extremity trauma. The culmination was on the final day which included evaluations of technical proficiency. Faculty in each subspecialty prepared the curriculum for their specific area. An emphasis on arthroplasty was to ensure residents were prepared for their Adult Reconstruction and Veteran Affairs Hospital rotations. Wire navigation training built on previous work^{1,4-7}. Wire navigation simulations were focused primarily on trauma-related procedures such as 1) intramedullary nail (IMN) starting points and sliding hip screw placement, percutaneous pin placement for pediatric supracondylar humerus fractures, and percutaneous screw placement across the sacral-iliac joint.

The schedule and curriculum for the rotation were finalized to allow faculty to adjust their schedules accordingly (Fig. 2).

Implementation

The first PGY2 surgical skills rotation was implemented in 2021 and has continued annually for the past 3 years. Activities for the week took place in different locations at the University of Iowa Hospitals and Clinics, including the “Arthroscopy and Surgical Skills Laboratory”. This is a 600-foot facility and provides residents with many features of an operating room (OR) environment, including arthroscopy towers, operative tables, and instruments, and is also equipped to handle cadaveric specimens⁸. A dedicated skills laboratory director ensured simulators and activity stations were prepped a night in advance for the upcoming day's session. Additional OR table lighting and procedure-recording cameras further enhanced the learning environment. Diverse teaching tools, ranging from upper limb (shoulder with arm) and lower limb (pelvis to toe) cadaver specimens to surrogate bone models such as pediatric elbow and femur sawbones, were utilized. Faculty collaborated seamlessly with volunteers and laboratory staff to confirm the availability of all essential supplies and specimens. Specific details of the curriculum have been improved annually. The most recent skills rotation took place at the beginning of May 2023. The first 2 days of the rotation consisted of presentations on suture techniques and case study reviews in the mornings, with the afternoon dedicated to practicing the skills of total knee arthroplasty and total hip arthroplasty on both bone surrogate models (Sawbones) and cadaveric specimens. The third day highlighted upper limb procedures including distal radius fracture fixation and carpal tunnel release, along with arthroscopy and wire navigation simulations. The practice of upper limb procedures was conducted on bone surrogate models (Sawbones) and cadaveric specimens. Simulations were based on previously established curricula, including the Fundamentals of Arthroscopic Surgery Training curriculum (FAST) for evaluating arthroscopy skills⁹. A VirtaMed FAST system was utilized to execute the arthroscopy curriculum. The Core Requisites of Wire Navigation Skills curriculum was utilized for training and evaluating different wire navigation skills^{6,10}. The wire navigation simulators (Iowa



Safe and appropriate positioning
 Understanding of surgical indications
 Surgical anatomy and approach
 Surgical steps
 Correct use of implants
 Interpretation of fluoroscopy

Fig. 1
 Essential learning objectives in planning the curriculum.

2021 PGY2 Surgical Skills Week Schedule					
Day	<u>Day One:</u> Total Hip Arthroplasty	<u>Day Two:</u> Total Knee Arthroplasty	<u>Day Three:</u> Hand Trauma/Scope	<u>Day Four:</u> Trauma training	<u>Day Five:</u> Assessments
AM	Library: Didactic lectures on technique	Library: Didactic lectures on technique	Anatomy Lab 1. Distal radius 2. Carpal tunnel	Anatomy Lab 1. Retrograde Femur 2. Compression Hip Screw 3. Cephalomedullary Nail	Simulation Lab 1. Compression Hip Screw simulator 2. Intramedullary Nail 3. Pediatric elbow pin 4. Pediatric elbow fracture reduction
PM	Anatomy Lab with cadavers/ instruments	Anatomy Lab with cadavers/ instruments	Library 3. Arthroscopy simulator Evaluation	Anatomy Lab 1. Tibia Intramedullary Nail 2. Ankle ORIF 3. Tibial plateau ORIF	Anatomy Lab 1. Carpal Tunnel 2. Distal Radius 3. Tibia Intramedullary Nail
Equipment Needs	<u>Cadaver:</u> pelvis to toe specimen (2) <u>Instrumentation:</u> Fluoroscopy, powered drills/saws	<u>Cadaver:</u> pelvis to toe specimen (2) <u>Instrumentation:</u> Fluoroscopy, powered drills/saws	<u>Cadaver:</u> 3-4 shoulder with arm <u>Instrumentation:</u> Distal radius plates, hand trays, small fluoroscopy	<u>Cadaver:</u> 3-4 lower extremity <u>Instrumentation:</u> Fluoroscopy, radiolucent table, vendor trauma equipment, powered drills/saws	<u>Cadaver:</u> 6 upper extremity, 6 lower extremity <u>Instrumentation:</u> vendor distal radius plates, vendor trauma equipment, hand trays, Fluoroscopy – large and small
Education	Technique guides	Technique guides	Technique guides Arthroscopy module directions	Trauma technique guides/Articles	Simulator info
Assessments	Intro OSATS/ O&P Scores		Distal Radius/Carpal tunnel checklists	Trauma checklists	O&P Scores IDEA scores VirtaMed Sim Score

Fig. 2

2021 skills week schedule. IDEA = score image-based decision error analysis, ORIF = open reduction and internal fixation, OSATS = objective structured assessment of technical skills, and O-Score = Ottawa surgical competency operating room evaluation.

Simulation Solutions) were used for this portion of training. This simulator includes specific modules developed for training on closed reduction percutaneous pinning (CRPP) of hip fractures, IMN starting points, and pediatric supracondylar humerus CRPP. The fourth day of skills training was completely focused on orthopaedic trauma. This day consisted entirely of fracture fixation (implant placement) in cadaveric specimens. Days 1 to 4 of the skills week commenced with faculty-led topic

case studies, integrating patient histories and radiographic analyses, followed by practice sessions on simulators or cadavers.

On the final day, residents underwent procedural assessments (Fig. 3). These assessments were designed to assess residents' performance in key surgical skills. The wire navigation simulator (Iowa Simulation Solutions) provided residents with a summative score that is a computer-generated automatic score at the end of each session. The cadaveric-based

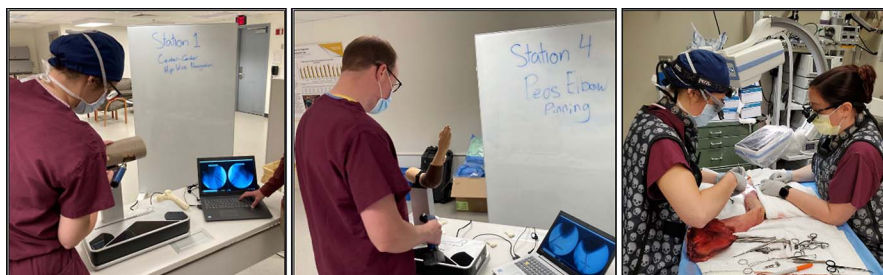


Fig. 3

PGY2 residents completing skills laboratories and simulations on assessment day.

assessments were overseen and scored by a faculty member. Assessment criteria included the O&P-score—a global rating scale recently endorsed by the American Board of Orthopedic Surgeons (ABOS) as a new standard of competency assessment for residents¹¹. Assessments also included the wire navigation score which is comprised of total time, number of fluoroscopy images, and pin placement (IDEA Score)⁵. Performance levels were then compared with previously established proficiency benchmarks to identify areas where additional training may be needed¹². Residents completed a survey regarding the format, training, feedback, and overall effectiveness of the skills week. Postassessment, each resident was provided a scorecard with their individual results (Fig. 4).

Costs

The skills week does come with associated costs when working with cadavers, sawbones, and equipment. Cost of 20

cadaveric specimens totaled approximately \$13,300 (see Fig. 2 for a breakdown of cadavers used). During the first 4 days of the program, residents shared cadaveric specimens for demonstrations and skills practice. On the final assessment day, each resident received their own upper and lower extremity specimens to perform the evaluated procedures. Approximately \$2,216 was allocated for cadaveric specimens for each of the 6 residents in our PGY2 class. The surrogate bone model (Sawbones) added approximately \$700 to the expenses for bones used with the wire navigation simulator. We received significant support in terms of instruments, implants, power tools, and other procedure specific activities generously donated from local representatives and medical device companies. Finally, the simulators used to evaluate different wire navigation and arthroscopy skills are owned by our residency program; however, there were initial procurement costs associated with them. We acknowledge that

Resident:

	Carpal Tunnel	Distal Radius	Tibial Nail
O-Scores			
Pre-procedure plan		4	
Case preparation	4	4	5
Knowledge of procedural steps	4	3	5
Technical performance	3	3	4
Visuospatial skills	4	3	4
Post-procedure plan			
Efficiency and flow	3	3	4
Communication	4	4	5
P-Score	III High Intermediate	III High Intermediate	III High Intermediate
Time: 35:39:00			

Arthroscopy Assessments			
Trace the Curve L	80	46	0.58
Trace the Curve R	80	33	0.41
Probing: wide field L	110	102	0.93
Probing: wide field R	110	95	0.86
# probing: easy L	100	15	0.15
# probing: easy R	100	43	0.43
Collet the stars L	120	118	0.98
Collect the stars R	120	101	0.84

WIRE NAV SIMULATOR	Hip IDEA Score	Hip TAD	Hip Images	Hip Decision Errors	Hip Time		Peds Elbow Score	Peds Elbow AP spread	Peds Elbow Images	Peds Elbow Time
Trial 1	0.66	13	22	9	117		-0.41	0.49	79	502
Trial 2	0.63	17	15	5	85		-0.39	0.41	72	462
Trial 3	0.66	12	22	10	129		0.45	0.42	43	324
Avg	0.65						-0.12			

	IM Nail Score	IM Nail start pt Dist	IM Nail Trajectory	IM Nail Images	IM Nail Time	IM Nail Incorrect Adjust	
Trial 1	0.48	4	3.36	26	180	7	
Trial 2	-0.53	12.14	10.6	11	62	1	
Trial 3	-0.57	7.9	7.9	39	327	11	
Avg	-0.21						Overall Score
							0.11

Fig. 4

Scorecards provided detailed assessments to the residents on each of the procedures assessed on the last day of the week. The O&P score provides detailed feedback on the cadaveric assessments with grades of 1 to 5 (5 indicating highest performance) on various categories identified in evaluating performance. The arthroscopic scores are based on different elements such as procedure duration, camera path length, probe path length, and camera alignment. The feedback on the wire navigation simulator tasks is based on a combination of the time to complete the procedure, the number of fluoroscopy images taken during the task, the accuracy of the pin position, and the path that is taken to achieve the pin position. A summative score combines these elements to provide an overall grade, with positive scores indicating a stronger performance and negative scores indicating room for improvement.

Rating	Description
1	"I Had to Do"
2	"I had to talk them through"
3	"I had to prompt them from time to time"
4	"I needed to be in the room just in case"
5	"I did not need to be there"

Fig. 5
O-Score Scale.

each program may have different resources and space at their disposal which may affect the direct and indirect costs of skills training activities. There are several well-known, cost-effective surgical skills exercises reported in the literature that can be used in place of simulations. In addition, industry sponsorship for educational activities is often utilized in many programs.

Generally, our department has valued this week for our second-year residents. Therefore, senior level residents have been willing to cross-cover as needed. In addition, given advanced scheduling notice, APPs modified their schedule during the week to ensure adequate clinical service coverage. This helps prevent costs associated with additional APP shifts and lost clinical productivity. Where possible, we are flexible with scheduling such that the training week's events fall on administrative days for clinicians involved.

Outcomes

Resident Assessments

The simulator assessments used during the week examined resident arthroscopy and wire navigation skills. Using the VirtaMed arthroscopic simulator, the objective was to achieve a 75% score on each task for both hands. While many of the residents met this target, several residents did not and were required to utilize the laboratory for additional practice. In these cases, this involved approximately 1 to 2

hours of additional training to ensure the resident was comfortable with these skills. The VirtaMed simulator is available to residents 24/7, and all data are automatically saved to their profiles, making it easy to track progress. Wire navigation assessments, conducted using the WireNav Sim, underscored the importance of reaching benchmark scores. Data indicate that a score of 0.5 or higher on the hip CRPP and Pediatric Elbow Pinning modules, have been shown to correlate with enhanced performance in the operating room⁹. In the past 2 years, we have had 77% of residents achieve the required benchmark on the hip CRPP module and 75% of residents on the pediatric elbow pinning module during skills rotation. Similar to the arthroscopy simulation, residents falling short of these benchmarks were required to come in for additional practice (1-2 hours) on the WireNav. This preparation ensures they are equipped to participate fully and even lead relevant procedures in the operating room during their PGY3 year.

On the final day of the week, residents were assessed using the O&P scale, a method developed by the ABOS. This combined scale draws inspiration from the works of Hamstra with the Ottawa Surgical Competency Operating Room Evaluation (O-tool) and Zwischenberger Zwisch scale (P-tool)¹¹. Currently, the O&P scale is used as an assessment tool for residents in the orthopaedic residency program at the University of Iowa.

The O-score evaluation encompasses 8 distinct domains of a surgical procedure: Preprocedure Plan, Case Preparation, Technical Performance, Knowledge of Specific Procedure Steps, Visuospatial Skills, Postprocedure Plan, Efficiency and Flow, and Communication. These are rated on a scale of 1 to 5 (Fig. 5). Meanwhile, the P-score offers a summative evaluation of the procedure, ranging from novice (I) to advanced (V) (Fig. 6).

In the past 2 years, residents achieved an average O score of 3.9 for carpal tunnel release, 3.8 for distal radius fracture, and 4.2 for tibial nail assessment. These scores indicate that residents rarely needed corrective feedback from supervising faculty. In a real-time procedure, this suggests that residents

Rating	Description
I Novice	Attending provides maximum assistance; resident demonstrates knowledge of anatomy, demonstrates basic operative skills
II Low Intermediate	Resident performs approach with minimal assistance, identifies most critical steps, proficiency with technical skills, increasing ability to perform different key parts of operation, demonstrates room setup and equipment management
III High Intermediate	Resident can perform the approach and almost all critical steps, proficiency with component technical skills, assistance is required for the most challenging portions of the procedure
IV Supervision only, competent	Resident knows steps and transitions easily, can direct and assist a junior resident, can manage patient safety and coordinate the operative team, perform the procedure in practice independently
V Advanced Expertise, proficient	Performance matches that of an advanced surgeon, capable of performing complex procedures independently, and of independent management of intraoperative complications

Fig. 6
P-Score Scale.

could perform the majority of the procedure independently, with supervising faculty only needing to be present in the room in case of an unexpected complication. A score of 3 to 4 correlates with the expected skill level of a third-year resident.

Across all residents and assessments, 88% received a global P score of “III High Intermediate”. This score indicates that residents were able to complete almost all critical steps and demonstrated proficient technical skills. However, they may require assistance for the most challenging portions of the procedure. A score of “III High Intermediate” correlates with the expected skill level of a third-year resident. These O&P scores indicate that our PGY2 residents were performing at a more advanced level than expected at the end of the skills week, given that they were about to begin their third year of residency.

Research

Currently residents are asked to request O&P assessments from faculty following select procedures. However, the reliability of the O&P score, both interobserver and intraobserver, remains to be rigorously evaluated, especially when juxtaposed against more objective performance metrics such as procedure duration, use of fluoroscopy, and implant position. A preliminary analysis of O&P scores gathered between July 2022 and April 2023 revealed significant variability. Notably, different faculty often gave varying scores for the same cases, and identical procedures performed by the same resident sometimes received different scores from the same faculty member. While the O&P scores seemed effective in predicting a resident's preparedness and surgical skill level based on their residency year, a more standardized assessment procedure may be needed to ensure objectivity and reliability, less subject to the assessing faculty.

During the most recent skills rotation in May 2023, residents' cadaveric assessments were recorded, with their faces blurred in the videos to eliminate potential biases. While the residents performed surgical procedures, faculty members actively supervised, but did not provide coaching, and evaluated live performances using the O&P scores. Our intention is for multiple faculty members to review these recordings and grade performances using the same rating scale. This approach allows us to ascertain both the interrater and intrarater reliability of the O&P score. Furthermore, by correlating O&P scores with objective surgical performance metrics—like the duration of surgery, fluoroscopy usage, and implant position—we aim to strengthen the validity and application of these evaluations. The insights gained from this analysis will be instrumental in deciding the future implementation of O&P scores during resident assessments.

The Experience

Prior survey data regarding surgical skills training programs implemented at Iowa has consistently highlighted positive endorsements by both residents and faculty. In the 3 years since the skills week's inception, only 2 residents have required technical remediation, as indicated by the final day

assessments. Before specific training on these technical skills, residents generally progressed, however, did not achieve the same level of surgical autonomy and required high levels of supervision.

Lessons Learned and Suggestions for Improvement

While the foundational structure of the week has remained consistent since its inception in 2020, our annual reviews have identified opportunities for refinement. Several of these areas of refinement include

1. **Minimizing Clinical Obligations.** To ensure residents remain primarily focused on skill acquisition, we found it crucial to minimize their clinical and call service demands during the rotation.
2. **Incorporating Contextual Learning.** To enhance comprehension and application based on resident feedback, we integrated more case studies and scenarios, providing richer context for procedural learning.
3. **Strategies for Ensuring Equipment Preparedness.** During the inaugural year, some laboratories were lacking crucial instruments on the assessment day. To address this, we implemented an instrument checklist, reviewing it before the start of each laboratory to ensure all necessary supplies are readily available for the cases.

We acknowledge that our initial design when analyzing this surgical skills training week lacked a control group of residents, hindering our ability to directly assess the correlation between test scores and efficiency or demonstrate clinically significant improvements. Including a control group in future studies would be valuable for better understanding the impact of our training intervention. We also plan to address this gap through follow-up studies aimed at examining pre-training and posttraining scores to better understand the impact of our training program on competence and skill improvement.

Summary

The implementation of a PGY2 surgical skills rotation has allowed our mid-level residents the ability for dedicated practice more advanced tasks during an important transition in our residency training program. Residents found the week to be extremely beneficial and reported more confidence entering their third year of residency. Assessments showed that for carpal tunnel release, distal radius fracture fixation, and IMN fixation of the tibia, residents had achieved level-appropriate performance metrics. Several of the arthroscopic and wire navigation assessments exposed technical skill deficiencies requiring additional practice to achieve proficiency. Residents have positively endorsed this new program, and faculty have remained eager to engage and contribute to the ongoing development of skill training in our program. While improvements to the rotation will continue, it has represented the next logical advancement in simulation and skills training

for orthopaedic residents. It may provide a framework for other institutions considering a mid-level program with skill assessment to proficiency. ■

NOTE: We acknowledge the efforts of our faculty and staff, particularly Dr. Jacob Elkins, Dr. Kyle Duchman, and Dr. Matthew Hogue, who have made the implementation of the skills week a success. Additionally, we also express our appreciation for the efforts of the residents in diligently engaging with the skills training activities and assessments throughout the week.

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