Surgical Simulation in Orthopedic Surgery Residency

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The training model for orthopedic resident education has been transformed. Surgeon factors, patient expectations, financial and legal concerns, associated costs, and work hour restrictions have put pressure on resident autonomy in the operating room.[1,2] At the end of resident training, the expectation is that board-eligible surgeons will have the surgical skills necessary to perform a wide range of surgical procedures.[3,4] Helping residents become proficient for independent practice requires a multidisciplinary approach.[5] This approach, regardless of its details, requires investment in time, resources, expertise, and funding.

Many residency programs are trying to bridge the gap between observation and autonomy with surgical simulation. According to one study, 76% of residency programs have a surgical skills laboratory, and 46% have a structured surgical skills curriculum.[6]

Surgical skills preparation is available in different modalities. Synthetic bones, virtual reality, and arthroscopic simulators represent potential opportunities for practice. Through these modalities, residents become more comfortable with the tools used in orthopedic procedures. Cadaveric dissection allows them to practice surgical approaches in the setting of real anatomy.[1] Independent dissection helps them appreciate the planes, layers, and proximity of crucial body structures and understand important surgical anatomy.[4]

Surgical simulation can be expensive, and funding comes in many forms. Cadaver laboratories require investment in specimens, facilities, and time away from clinical obligations.[4] Cadaver availability varies with regional resources, and the cost of a cadaver ranges from $1000 to $2000.[7,8] Arthroscopic simulators and virtual reality programs are expensive as well. These modalities range from a less expensive video box (with standard arthroscopic equipment) to a virtual reality haptic simulation costing a residency program as much as $80,000.[9] Synthetic bone simulations are less expensive but require investment in faculty time and outside implants and instrumentation.[10] The cost of simulation raises the question of funding sources.

Funding surgical simulation is a challenge. In a national survey of program directors, conducted by Karam and colleagues,[6] 87.3% of residencies cited lack of funding as the most significant barrier to a formal surgical skills program. Simulation can be residency-sponsored, industry-sponsored, or specialty-sponsored. Karam and colleagues[6] found that department, hospital, and industry funding were the 3 main sponsors of surgical simulation. Each funding mechanism brings its own set of challenges and opportunities. Industry-sponsored simulation provides a cost-effective outlet for residency programs. However, this type of funding is under scrutiny, as industry funding for education becomes more transparent. In addition, industry funding typically limits the technology that can be used during the simulation to the sponsor's technology. Courses offered by the American Academy of Orthopaedic Surgeons (AAOS) and a number of subspecialty societies provide less conflicted simulation at reasonable cost.

If residents, residency programs, hospitals, industry, subspecialty societies, and the AAOS are going to invest in resident education through simulation, then the effect of simulation on resident education must be understood. Intuitively, simulation as a modality for improving resident skills makes sense. For residency programs to invest in simulation and surgical skills, different modalities must be objectively evaluated and their utility validated. If simulation is to become valuable, first it must be done correctly.

Kneebone[11] proposed a framework for evaluating simulation. In this framework, simulation should allow for sustained, deliberate practice in a safe environment. It should provide access to expert tutors when appropriate. It should map

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onto real-life clinical experience. Last, it should provide a supportive, motivational, learner-centered milieu. Residents and program directors should consider this framework when deciding which simulation exercises to engage in and which resources to supply for exercises. Having supportive supervision during simulation can lead to a positive outcome. Likewise, learning incorrect techniques or bad habits or having inexperienced teachers can have the opposite effect.

Several authors have reviewed the evidence and found simulation to be an important part of orthopedic resident education.[1,2,4,9,12,13] They have evaluated cadaveric simulation, synthetic bone simulation, arthroscopic simulation, and virtual reality simulation. Their studies demonstrated that simulation is an effective tool and provided objective criteria for evaluating residents on a larger scale. In a blinded, randomized study by Howells and colleagues,[14] junior residents were either trained on a knee simulator or received no training before evaluation. Those who received the training scored significantly better than their peers on validated assessment measures.

The literature on different modalities shows simulation is an effective teaching tool for general orthopedic surgical skills[5]; knee, shoulder, and ankle arthroscopy[14-21]; spine surgery[22]; and orthopedic trauma surgery.[23-26] Investigators in several other surgical specialties have studied the utility of simulation, and many are incorporating simulation into their resident curricula.

More effective simulation seems correlated with a yearlong structured curriculum rather than with intermittent, isolated experiences.[3] Dunn and colleagues[27] evaluated arthroscopic shoulder simulation 1 year after a training exercise. The group that received formal training did better than the control group on an initial arthroscopic surgery skill evaluation tool. At 1 year, however, the gains made through training were lost.

Simulation is a new paradigm for resident education. It offers multiple opportunities and challenges for residents, residency programs, industry partners, specialty and subspecialty societies, and medical examiners. The Accreditation Council for Graduate Medical Education's *ACGME Program Requirements for Graduate Medical Education in Orthopaedic Surgery* requires of residency programs a didactic curriculum dedicated to basic motor skills in addition to a dedicated space for facilitating basic surgical skills training.[28] Residency programs must demonstrate to ACGME their commitment to surgical skills training and simulation. Implementation of simulation for resident education has many variables, including funding, type of simulation, demonstrated efficacy, provision of supervision, resident time, and establishment of a formal curriculum. Residents and residency programs should embrace this changing paradigm to bridge the gap between observation and autonomy in orthopedic surgical and arthroscopic technique.

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