I. Introduction
   a. July 2013 → curriculum changes to the post-graduate year 1 (PGY-1) orthopaedic surgery resident curriculum as mandated by the American Board of Orthopaedic Surgery (ABOS) and Residency Review Committee (RRC) for Orthopaedic Surgery, including mandatory programs for the development/improvement of surgical skills
   b. Goals of simulator training → enable the trainee to develop a surgical motor skillset that will promote the delivery of safe, effective, and efficient patient care.
   c. Ability to transfer skills learned on simulation models to skills in the OR → unknown

II. Challenges specific to arthroscopy
   a. Triangulation
   b. Hand-eye coordination
   c. Variability of devices and implants
   d. Arthroscopic knot tying
   e. Difficulty learning in the OR →
      i. Unnatural motions
      ii. Need for efficiency
      iii. Iatrogenic injury (articular surface, soft-tissues, etc.)
      iv. Anesthesia time
      v. Patient safety

III. Key questions concerning arthroscopic simulator models →
   a. Do they make trainees better at surgery, or better at simulator performance?
   b. Are more experienced trainees better on the simulators than less experienced trainees, regardless of simulation training experience?
   c. Are simulators translatable enough to be routinely used as a training tool?
   d. Is there standardization among simulators?
   e. Are simulator metrics validated?

IV. Historical Perspective →
   a. General Surgery Fundamentals of Laparoscopic Surgery (FLS) training program¹
      i. Education model that was designed for surgical trainees and practicing physicians “to learn and practice laparoscopic skills to have the opportunity to definitely measure and document those skills”
   b. Multiple reports → demonstrate connection between training on a simulator and improved performance in the operating room²⁻⁶
   c. American Board of Surgery requires surgeons seeking board certification to successfully complete the FLS training program¹
   d. Examples:
      i. 2012 → Stefanidis et al³ demonstrated significantly improved operative performance in subjects having undergone participation in the FLS suturing task module compared to controls.
      ii. 2013 → Gallagher et al⁴ performed a randomized clinical trial comparing performance of both novices and experiences laparoscopic surgeons either with or without virtual reality laparoscopic simulation.
         1. In both groups, despite experience level, subjects in the simulation group performed significantly better than the controls.

V. Available studies describing arthroscopic simulation models
   a. Knee⁷⁻²⁰
   b. Shoulder¹,¹²,¹⁷,²¹⁻²⁸
   c. Hip²⁹
   d. Ankle³⁰
   e. Arthroscopy basics and knot tying³¹⁻³⁴
   f. Expert Opinion³⁵,³⁶
g. Systematic Review

h. Copernicus FAST model

i. Key studies

   i. Translatability \( \rightarrow \) Howells et al. JBJS Br 2008

      1. 20 junior orthopaedic residents randomized to either receive a standardized protocol of knee arthroscopy simulator training, or no training at all
         a. The training program consisted of three sessions of six simulated arthroscopies over the course of one week

      2. All residents evaluated on ability to perform a diagnostic knee arthroscopy on an actual patient by a blinded senior surgeon in the operating room

      3. Residents were evaluated using the Orthopaedic Competence Assessment Project score intraoperatively (United Kingdom)

      4. Results \( \rightarrow \) statistically significant improvement in the simulator group compared to the control group

   ii. Retention, Learning Curve \( \rightarrow \) Howells et al. JBJS Am 2009

      1. 6 fellowship-trained lower extremity surgeons given standardized instruction for performing an arthroscopic Bankart repair on a laboratory-based simulator.

      2. All performed 3 single Bankart sutures on each of 4 occasions, 1-2 weeks apart.

      3. 6 months later \( \rightarrow \) all repeated the study without further guidance

      4. Results \( \rightarrow \) learning curve showing significant and objective improvement in performance was demonstrated for all outcome parameters in both experiments (\( p < 0.005 \)).
         a. HOWEVER \( \rightarrow \) the learning curve at 6 months was a repeated learning curve showing no significant difference from the initial learning curve \( \rightarrow \) loss of initial improvement

   iii. Validity and Reliability Testing \( \rightarrow \) Jacobsen et al. JBJS 2015

      1. 26 physicians (13 novices, 13 experienced arthroscopists) \( \rightarrow \) performed 5 arthroscopic procedures on a knee simulator

      2. Performance evaluated by obtaining predefined metrics from the simulator for each procedure, and z-scores, describing suboptimal performance, were calculated from the metrics.

      3. A pass-or-fail standard was set with use of the contrasting groups method

      4. Results \( \rightarrow \) total mean z-score was 38.6 ± 27.3 points for the novices and 0.0 ± 9.1 points for the experienced surgeons (\( p < 0.0005 \)). The pass-or-fail standard was set at a total z-score of 15.5 points, resulting in two of the novices passing the test and a single experienced surgeon failing the test.
         a. Study showed feasibility of creating a valid, reliable, and feasible test of basic arthroscopic competency and to establish a credible pass-or-fail standard.
         b. Translatability to OR \( \rightarrow \) not studied

iv. Incorporation of cadavers \( \rightarrow \) Henn et al. Arthroscopy 2013; Martin et al. JBJS Am 2013

      1. Henn et al. \( \rightarrow \) randomized 17 first-year medical students to either receive simulator training or not (control)
a. All students completed a baseline arthroscopy on a cadaveric shoulder, and then either received simulator training or received no training
   i. Training → 6 sessions over 3 months
b. All students then repeated the cadaver arthroscopy 3 months after the initial arthroscopy
c. Results → no significant differences in baseline skills between the groups, however at final cadaveric session, while both groups improved, the simulator group was significantly faster at completing the tasks compared to the control group. Further, no difference between the groups with subjective assessment of technical performance.

2. Martin et al25 → studied 15 residents and 4 surgeons
   a. All underwent an orientation and 5-minute practice session with the Insight Arthro VR (Immersion, San Jose, California) shoulder simulator, followed by testing on the model
   b. Each subject then was tested on a cadaveric model at least two weeks following the simulator model test.
   c. Results → strong correlation with performance time on the simulator and performance time on the cadavers, and noted the time required to complete tasks on the simulator to be a significant predictor of the time required to complete the same tasks on the cadaver.
   d. By using cadaveric shoulders as a proxy for actual patient shoulders, this study does suggest that simulator performance may correlate with actual operative performance.

v. Systematic Review → Frank et al. Arthroscopy 201337
   1. 19 studies (465 subjects) → 9 shoulder, 9 knee, and 1 hip
   2. Common arthroscopic tasks → probing identified structures, throwing a suture, hook-manipulation of identified structures, and shaving/burring
   3. 8 studies (42%) evaluated task performance before and after simulator training
      a. Six (75%) of these studies showing improvement after training
      b. One study (6%) noted no difference in performance after one hour of training
   4. 12 studies (63%) compared task performance of different levels
      a. 100% correlation between experience and simulator performance

Examples of Sawbone simulator models (knee, shoulder, and hip) and VR simulator model
VI. Summary
   a. More experienced subjects → perform better on simulators than less experienced subjects
   b. Training on arthroscopic simulators → improves performance on arthroscopic simulator
   c. There is little evidence to correlate performance on simulators with performance in the OR → skill transfer to the OR is feasible, but not yet proven

VII. References


