

# Fundamentals of Arthroscopic Surgery Training Program Improves Knee Arthroscopy Simulator Performance in Arthroscopic Trainees



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**Purpose:** To determine the effectiveness of a nonanatomic simulator in developing basic arthroscopy motor skills transferable to an anatomic model. **Methods:** Forty-three arthroscopy novice individuals currently enrolled in medical school were recruited to perform a diagnostic knee arthroscopy using a high-fidelity virtual reality arthroscopic simulator providing haptic feedback after viewing a video of an expert performing an identical procedure. Students were then randomized into an experimental or control group. The experimental group then completed a series of self-guided training modules using the fundamentals of arthroscopy simulator training nonanatomic modules including camera centering, tracking, periscoping, palpation, and collecting stars in a three-dimensional space. Both groups completed another diagnostic knee arthroscopy between 1 and 2 weeks later. Camera path length, time, tibia and femur cartilage damage, as well as a composite score were recorded by the simulator on each attempt. **Results:** The experimental group ( $n = 22$ ) showed superior performance in composite score (30.09 vs 24,  $P = .046$ ) and camera path length (71.51 cm vs 109.07 cm,  $P = .0274$ ) at the time of the second diagnostic knee arthroscope compared with the control group ( $n = 21$ ). The experimental group also showed significantly greater improvement in composite score between the first and second arthroscopes compared with the control group (14.27 vs 4.95,  $P < .01$ ). Femoral and tibial cartilage damage were not significantly improved between arthroscopy attempts ( $-0.86\%$  vs  $-1.45\%$ ,  $P = .40$ ) and ( $-1.10$  vs  $-1.27\%$ ,  $P = .83$ ), respectively. **Conclusions:** The virtual reality-based fundamentals of arthroscopy simulator training nonanatomic simulator is beneficial in developing basic motor skills in arthroscopy novice individuals resulting in significantly greater composite performance in an anatomic knee model. Based on the results of this study, it appears that there may be benefit from nonanatomic simulators in general as part of an arthroscopy training program. **Level of Evidence:** Level II, randomized trial.

With recent advancements in technology, in addition to limitations on resident working hours, there has been a heightened interest in using virtual

reality simulators for arthroscopy skill development.<sup>1-3</sup>

Simulators have been developed to model a number of different joints. They offer advantages such as flexibility to fit the schedule of residents and the ability to track skill development over time. Simulators also provide objective measurements of performance and allow trainees to practice a variety of arthroscopic procedures in a safe, controlled environment with no risk of harm to the patient.<sup>4-7</sup> Despite the advantages that high-fidelity arthroscopic simulators offer, one of the major drawbacks is the high initial cost, which may account for the lower utilization of high-fidelity simulators in training programs.<sup>8</sup> The approximate cost of the simulator used in this study was \$125,000.

Previous studies have shown anatomic knee and shoulder simulators to be valuable training tools leading to the development of an arthroscopy skillset transferable to cadavers as well as the operating room.<sup>9-12</sup> However, there is conflicting evidence on the effectiveness of

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**Table 1.** Study Participant Demographics

|                                                                 | Control      | FAST         | P Value |
|-----------------------------------------------------------------|--------------|--------------|---------|
| Age (yr)                                                        | 25.81 (2.94) | 25.13 (1.42) | .3513   |
| Year in medical school (1/2/3/4)                                | 12/3/3/3     | 11/4/5/2     | .8789   |
| Male/Female                                                     | 14/7         | 15/7         | .9156   |
| Right handed/Left handed                                        | 20/1         | 19/3         | .6069   |
| Listed surgical/nonsurgical specialty as No. 1 interest pretest | 10/11        | 16/6         | .0923   |
| Time between knee arthroscopies                                 | 9.48 d       | 8.86 d       | .1969   |
| Total number of subjects                                        | 21           | 22           |         |

NOTE. For the purpose of this study, surgical specialties included general surgery, neurosurgery, ob-gyn, orthopaedic surgery, vascular surgery, cardiothoracic surgery, otolaryngology, ophthalmology, and urology.

FAST, fundamentals of arthroscopy simulator training.

nonanatomic simulators. Therefore, it remains unclear how useful they are for learning the basic motor skills necessary for arthroscopy and whether or not simulators are sufficient when compared with conventional skill development techniques.<sup>13-15</sup>

The purpose of this study was to determine the effectiveness of a nonanatomic simulator in developing basic arthroscopy motor skills transferable to an anatomic model. Our hypothesis was that participants completing a series of 5 self-guided fundamentals of arthroscopic surgery training (FAST) modules would perform significantly better in terms of time, cartilage damage, camera path length, and composite score compared with a control group. We also hypothesized that trainees would find the FAST module to be desirable and valuable in arthroscopy skill development for the novice trainee.

## Methods

After the institutional review board's approval was obtained, 43 medical students were recruited from a single allopathic medical school to participate in this prospective randomized study between April 2016 and April 2017. Our pilot data showed that the mean composite score difference between 2 groups was approximately 8.5 with standard deviations 9 and 10, respectively. Assuming  $\alpha = 0.5$ , then 42 participants would be needed to have a power of 0.81 for the study. Post hoc analysis revealed a power of 0.791 for the study based on the main outcome improvement in composite score. Exclusion criteria consisted of previous arthroscopy experience, previous training with arthroscopy simulators, inability to use the simulator, and inability to return after 1 week for the follow-up trial. Demographic data for study participants including sex, age, year in medical school, and hand dominance are shown in Table 1.

Participants were randomized to a control group or experimental group using a random number generator.

Both groups viewed a video of the diagnostic knee arthroscopy they were about to complete performed by a sports medicine fellowship-trained orthopaedic surgeon. Subjects in both groups then completed a self-guided orientation PowerPoint familiarizing them with the principles of basic arthroscopy with instructions on how to use the ArthroS knee and FAST simulator. Subjects were given 1 minute to familiarize themselves with the arthroscope before each diagnostic knee arthroscopy. The experimental group performed a diagnostic knee arthroscopy and subsequently completed a series of 5 self-guided training modules using the FAST simulator in which participants had to get a rating of 3 out of 3 stars to progress to the next module, and otherwise no feedback was given to participants after the first attempt. Although the simulator performed automated scoring of the individual attempts, the participants were monitored during the attempts by one of the study authors. The simulator setup along with the knee and FAST module are shown in Figures 1 and 2. The FAST modules, shown in Figures 3-8, included linear tracking, curved tracking, periscoping, palpation, and collecting stars using the grasper in a three-dimensional simulated environment. The control group performed the same diagnostic knee arthroscopy initially but did not complete the FAST



**Fig 1.** The setup for the nonanatomic fundamentals of arthroscopic surgery training virtual reality simulator used in this study.

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