Validity Evidence for a Low-Cost Shoulder Arthroscopy Partial Task Trainer (L-CASTT)

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Objectives: To develop and validate a novel, low-cost shoulder arthroscopy partial task trainer.

Study Design: Cross-sectional study

Methods: A low-cost arthroscopy model was created to simulate navigation and triangulation skills in conjunction with ABOS-certified Orthopaedic surgeons' input. Each participant performed three trials of simulated labral repair and performance data was compared between experienced surgeons and novice medical students.

Results: A total of 8 orthopaedic surgeons in the experienced group and 18 medical students in the novice group participated in the study. The average age of the experienced group was 43.1 years old, with 8.3 years of post-residency experience. The average age of the novice group was 24.3 years. The experienced group completed the simulation task faster than the novice group (16.6±7.6 vs. 96.4 ±102.2 seconds; $p<0.001$).

Conclusion: The shoulder arthroscopy model demonstrated significant differences in performance between experienced orthopaedic surgeons and novices when used to assess a standardized basic arthroscopic technical skill. This low-cost trainer discriminates between varying skill levels and may be an effective option for simulation training of arthroscopic fundamentals to novice learners.

Level of Evidence: III, Case Control

Keywords: Arthroscopy, Simulation, Validity Evidence, Orthopaedics, Graduate Medical Education

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INTRODUCTION

Surgical simulation training is progressively emphasized throughout medical training, both during initial skill acquisition and in the maintenance of surgical skills. There are many examples of validated assessments of proficiency and ability in various surgical and technical fields of medicine. One of the most well-known examples is the Fundamentals of Laparoscopic Surgery (FLS), which has been used for over a decade in general surgery for board eligibility.[1,2] It is a widely accepted tool for improving laparoscopic skills in learners at all levels of training and has recently been required by the American Board of Obstetrics and Gynecology for board eligibility.[3]

While orthopaedic surgery residencies have begun to implement simulation to teach complex skills, the specialty lags behind the multiple simulation curricula and high-stakes certifications adopted by others.[4] Some early adopters of arthroscopic simulators in residency programs have published their findings.[5,6] Current orthopaedic simulators range from partial task trainers to augmented reality simulators. Simulator use in residency training provides ease of access to fundamental trainings, and a low-risk training environment to learn that does not impact patient safety.

Simulation-based training is increasingly becoming an integral part of surgical residency training programs, and thus requires examination of its utility in orthopaedic surgery.[7,8] There are commercially available simulators; however, the majority are difficult to procure due to financial constraints. This study aims to develop and optimize the low-cost shoulder arthroscopy task trainer (L-CASTT) and ensure validity by showing that it can reliably differentiate arthroscopists at different levels of training.[9,10]

METHODS

Model Development

A Shoulder arthroscopic partial task trainer was developed at the Val G. Hemming Simulation Center, an affiliate of Uniformed Services University of the Health Sciences (Bethesda, MD) in conjunction with board-certified orthopaedic surgeon guidance and feedback. The final product (L-CASTT) consisted of: The glenoid base and labrum were digitally sculpted using Pixiologic™ zBrush and Autodesk® 3D Studio Max (Figure 1). Left and right-side versions of the models were created. The 3D models for the glenoid base were then exported to be printed in polylactic acid (PLA) plastic on a MakerBot® Z18 (Makerbot, Brooklyn, NY) and 5th Generation 3D printers.

After post-processing, molds of these prints were created using Smooth-On Mold Star 16 FAST silicone. Casts of the bony structures were created with Smooth-On™ Smooth-Cast 300 liquid plastic. The 3D labrum model was exported and individually 3D printed using the FormLabs™ Form2 using their elastic resin. These were attached to the glenoid base using Smooth-On™ Silicone Adhesive and a single anterosuperior labral tear was created. The glenoid base design was inserted in the commercially available Sawbones® *Dome Holder,* which was selected for ease of training and testing (Sawbones, Vashon, WA, USA) (Figure 2).

Table 1. scoring and comments by expert reviewers of L-CASTT

Face Validity Criteria	Mean Score (n = 8, max = 5)	Expert Comments
Q1. Anatomic Fidelity	4 (80%)	"good appearance + tactile representation"
Q2. Synthetic Composite Fidelity	3.8 (76%)	"Excellent labrum"
Q3. Synthetic Labrum Fidelity	3.7 (74%)	"Softer, Labral lesion not representative, good consistency"
Q4. Surgical Approach	2.5 (50%)	"30° scope + the plumber scope doesn't give you a good background light. It can only focus on one thing at a time making it hard to see the instrument in the background." *

* Use of a 30° arthroscope surrogate was suggested unanimously across all eight responding experts

Black felt was added to the *Dome Holder* to eliminate external visibility. A 0° plumber's endoscope was used as a proxy for an arthroscopic camera and made rigid by housing it within a metal straw(Figure 2).

Figure 1: L-CASTT glenoid

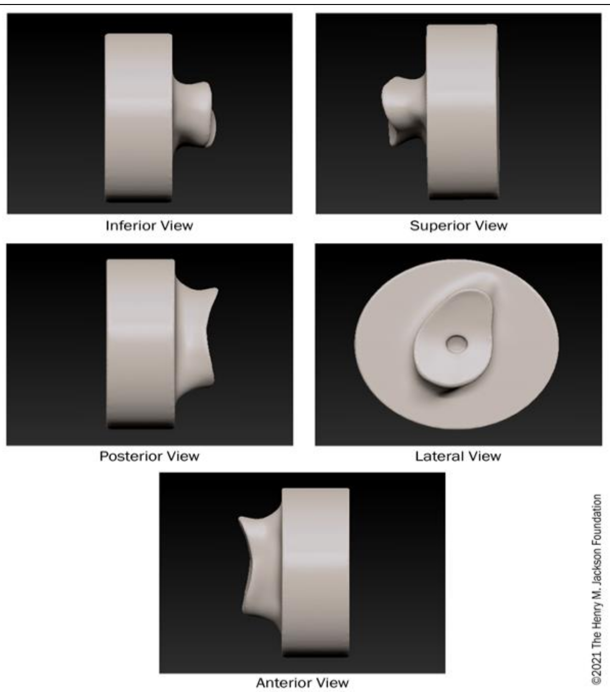


Figure 2: 3d printed labrum, glenoid base, and fully assembled L-CASTT

Simulation Task

Two specific skills were identified (navigation and triangulation) and a simulated task was developed for training purposes. The task required visualization of the glenoid fossa with the camera in the right hand, identification of the avulsion of the labrum from the glenoid rim, followed by insertion of a 45° suture passer with the left hand under the avulsed labrum without losing visualization of the instrument.

Subjects

Eight board-certified orthopaedic surgeons and 18 medical students partook in the study. Orthopaedic surgeons were included if they actively performed arthroscopic surgery as part of their practice and consisted of fellowship and non-fellowship trained surgeons. Medical students without any prior arthroscopic experience were chosen as the comparison group.

Procedure

Informed consent was obtained along with basic demographic information for each participant. The simulation task was explained in a standardized fashion and directions were available at any time through the simulation. Time from when the camera entered the simulator to when the instrument was visualized passing under the labrum was measured and collected. A single recorder was used throughout the case. Three trials were performed by each participant, and average time was used for comparison.

Survey

After task performance, all participants in the experienced group provided standardized feedback regarding the task trainer (appendix 1). The survey gathered information on the anatomic and material fidelity, as well as the task trainer surgical approach, on a Likert scale (1-5).

Statistical Analysis

Normally distributed, continuous variables were compared between the experienced group and the novice group using Welch's unequal variances t-test and Levene's test to examine the equality of variances on score differences between the experience and novice groups. The effect size was calculated with a Hedges' *g* test. Feedback surveys were analyzed using central tendency metrics.

RESULTS

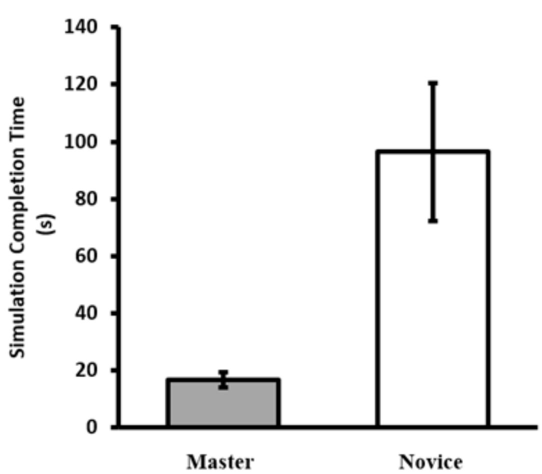
A total of 26 participants were enrolled with 25/26 (96.2%) completing all portions of the evaluation. One member of the experienced group did not attempt the timed trial due to schedule constraints, but their comments on the task trainer were included. Demographic data for intergroup testing are displayed in Table 2.

Table 2: Demographic data for simulation testers

Group	Gender (m/f)	Age (y)	Years practice	Sports Fellowship (y/n)	Sim Experience (y/n)
Mastery	8/-	43.1	8.3	4/4	7/1
Student	10/8	24.2	-	-	0/18

The novice group (n = 18) was associated with a task completion time of 96.4 ±102.2 seconds. By comparison, the experienced group (n = 8) was associated with a simulation completion time of 16.6 ± 7.60 seconds (Figure 3). Descriptive statistics are in Table 3. All groups were normally distributed. Variances were not homogeneous, $p<.001$, and equal variances were not assumed. A difference was found between the novice and experienced groups, $p< .00005$. The corrected effect size was noted by Hedges' $g = 0.93$, indicative of a strong degree of practical significance.

Figure 3: Task completion time for each group



Of the experienced group, 7/8 participants (87.5%) completed all portions of the feedback survey (Table 1). The anatomic fidelity was rated as similar, the material fidelity of the bone material and labrum was rated as similar, and the surgical approach was rated as somewhat similar.

DISCUSSION

Today's orthopaedic educational environment is becoming more difficult with growing complexity of surgical techniques, increasing medicolegal concerns, and changes to daily practice and workflow highlighting the utility of augmenting the residency operative experience.[4,10,11] Simulation-based education in surgical training helps to overcome limitations of routine intraoperative training and enhances the surgical skills-learning curve.[12] Current evidence suggests that simulation training increases resident proficiency and decreases the time needed to master new skills.[7,8,13]

A 2020 literature review of surgical simulation in orthopaedic training suggests that simulators can be a valuable tool for future generations of orthopaedic surgeons, but that substantial work is needed to validate its use and the current cost of simulators is a barrier to implementation.[14] Critics of simulation-based education express the need for improvement in multiple domains including: course validation, expense, and standardization of assessment techniques.[15] The objective of our study was to demonstrate the validity of a low-cost partial task trainer, thus addressing the concerns of validity and financial feasibility for implementation.

L-CASTT demonstrates construct validity while also addressing financial concerns inherent to most training programs. This task trainer demonstrates the ability to distinguish participant task performance by experience level – the key measure of construct validity. The survey response data demonstrated generally positive ratings and evaluations from the experienced group. The most prevalent suggestion was the implementation of a 30° arthroscope, which would improve the fidelity of the simulated surgical approach. The task trainer costs approximately $20.27 to create a 3D print/mold and $5.04 to create the actual glenoid insert, which is hundreds of dollars less than comparable commercially available trainers. This model makes simulation-based training more financially feasible for medical students and junior residents, and is a platform that can be used to improve foundational arthroscopic skills. The outcome of this study introduces an opportunity for the development of a simulation-based curriculum using this simulator to train learners of all levels of basic skills required for arthroscopic surgery.

This study is limited by a small sample size and only two groups of varying skill levels were included. Regardless of this limitation, we demonstrated profound differences in each group that suggests this model can adequately discriminate between skill level. Additionally, surgical simulation training does not directly measure operative performance and it is unknown whether training with this model will translate intp operative skill. While this model serves as a platform for skills testing, coaching, and feedback, it is not necessarily a substitute for real operative experience. However, it does serve to support and augment training,

Table 3: Descriptive statistics of simulation trials compared by groups

Group	*n*	Trials	Median (s)	Mean (s)	VAR (s)	Total SD (s)	CI, (z=1.96)	SEM	Q1	Q3	IQR
Mastery Group	8	24	12.65	16.6	98.8	7.6	8.6	2.7	9.1	19.1	10.0
Novice Group	18	54	40.69	96.4	1.9×10^4	102.2	115.6	24.1	24.7	87.5	62.8

specifically in an environment with limited operative exposure.

Future directions include the creation of a simulation-based curriculum using the L-CASTT model. This curriculum could be used to train novice learners in basic arthroscopic skills with the ability to quantify skill improvement overtime. Additionally, and most importantly, it is important to determine the transfer of the skills developed with the L-CASTT to the operating room.

CONCLUSION

The shoulder arthroscopy model demonstrated significant differences in performance when comparing experienced orthopaedic surgeons and novices when used to assess a standardized basic arthroscopic technical skill. This low-cost trainer discriminates between varying skill levels and may be an effective option for simulation training of arthroscopic fundamentals to novice learners.

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