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Cost Analysis of an In-House Arthroscopic Skills Simulator

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Objectives: To compare objective costs between an in-house developed arthroscopy simulator and commercially available options.

Design: Cost analysis.

Setting: Orthopaedic graduate medical education.

Patients/Participants: Eight board-certified orthopaedic surgeons and nineteen novice learners.

Intervention: Simulation Training.

Main outcome measurement: Cost difference between an in-house developed simulator and a commercially available simulator.

Results and conclusions: Significant price differences exist between in-house simulator production cost and commercially available simulators. Low-cost, in-house simulators improve access to arthroscopic simulation training for novice learners by reducing up front cost by 29% and reducing recurring costs by over 90% when compared to a similar commercially available option.

Level of Evidence: IV; Cost Analysis
Keywords: Education; Simulation; Orthopaedics; Arthroscopy; Simulation Based Learning Theory
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INTRODUCTION

The acquisition of arthroscopic skills in graduate medical education (GME) continues to be an important challenge for many trainees. The technical challenge of operating in disparate visuo-spatial dimensions proves to be a difficult skill to master and relies heavily on appropriate clinical volume, oversight, and training resources. Barriers to developing universally competent trainees include a lack of standardization between preceptors and institutions, varying patient populations, and insufficient surgical volume and breadth.[1,2]

Surgical simulation is used across many disciplines to augment the current GME training model by providing a high-throughput and low-stakes training environment while simultaneously maximizing patient safety. [3,4] However, access to commercially available surgical simulators is often limited by the financial cost of the technology, which ranges from $44.12 for low-fidelity task trainers to $114,000 for highly sophisticated virtual reality simulators (Table 1).[5-7] Other options for surgical simulators include tangible modules, computer software programs, and augmented reality simulators.[8-12]

Table 1. Commercially available orthopaedic simulators and associated costs. PM (Physical model) VR (Virtual reality)

Simulator	Cost	Type
Cigar Box Arthoscopic Trainer[20]	$44	PM
Arthroscopic meniscectomy sim[19]	$72	PM
Arthroscopy surgical simulator[18]	$79	PM
FORS board[17]	$350	PM
SawBones® FAST	$1,154	PM
EoSim® Surgtrac	$1,657	PM
PrecisionOS® Orthopedic Sim	$3,500 annual + $299/headset	VR
OSSimTech® TSym	*	VR
Simbionix® Arthro Mentor	$73,000	VR
VirtaMed® ArthroS	$114,000	VR

*Cost not publicly available

This study seeks to analyze the fiscal aspects of developing and implementing an easily reproducible, low-cost, tangible model orthopaedic simulator to train novice learners in basic arthroscopic skills including navigation and triangulation. We hypothesize that the upfront and recurrent costs of an in-house simulator are significantly less than a comparable commercially available simulator.

METHODS

Our group has previously developed a low-cost arthroscopic shoulder task trainer (L-CASTT) to simulate shoulder arthroscopy. The L-CASTT combines 3D printing from biologic models and rubber casting applied to commercial bone models and was completed with commercially available products including a semirigid 0° plumber's endoscope housed within a metal straw. The simulator was modified in an iterative fashion after receiving feedback from board-certified orthopaedic surgeons. A suture lasso serves as the surgical instrument for the simulator (Figures 1-3).

The goal of the task trainer was to develop arthroscopic navigation and triangulation skills through completion of the task to pass a suture passer through the labrum. Eight board-certified orthopaedic surgeons reviewed and piloted the simulator for expert opinions that guided modifications. These surgeons and nineteen novices (arthroscopy naïve medical students) then trialed the simulator to collect performance data to gather construct validity evidence which showed graded performance based on skill level. After construct validation, the upfront and recurring costs associated with the development of our model were compared to the Sawbones® *MagneFAST Shoulder Kit* that we identified as a comparable simulator.

Table 2. Cost comparison between in-house and commercially available simulator

	L-CASST	FAST
Industrial endoscope	$69.95	-
Sawbones dome holder	$190.75	-
Black adhesive felt	$19.99	-
Steel straw (4 pack)	$8.94	-
Camera tripod	$19.99	-
Base 3D print/mold	$20.27	-
MagneFAST Shoulder	-	$1,154
Glenoid Insert	$5.04	$62.25
Total Cost	**$329.89**	**$1,216.25**

RESULTS

The completed L-CASST requires an initial investment of $329.89 per simulator with recurring costs of $5.04 to create additional glenoid/labrum models when necessary (Table 2). The Sawbones® *MagneFAST Shoulder Kit* requires an initial investment of $1,154 per module with recurring costs of $62.25 to replace the Sawbones® *MagneFAST Glenoid Insert* when needed. Subsequently, developing an in-house simulator has a calculated initial cost-savings of $824.11 and recurring cost savings of $57.21 when compared to a commensurate commercially available simulator.

Figure 1 Three-dimensional rendering of the L-CASST glenoid base in all views

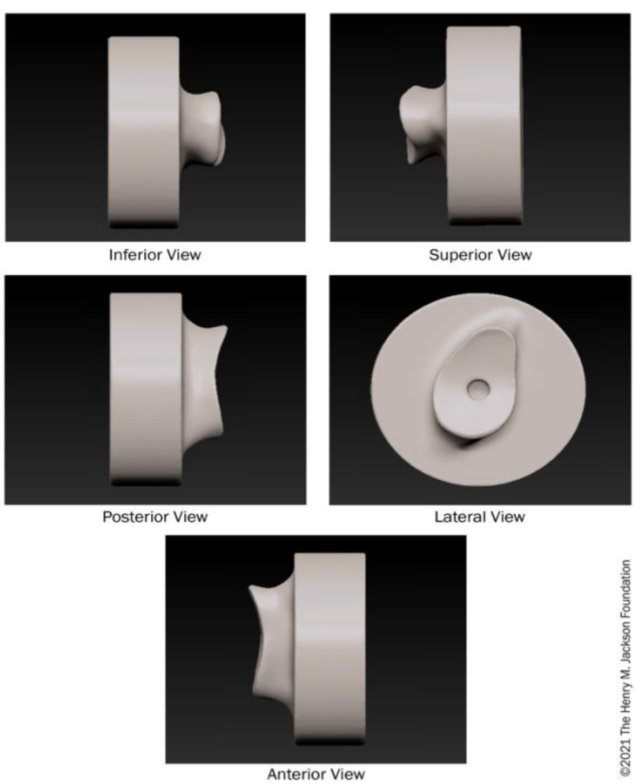

Figure 2: Glenoid base used for the L-CASST simulator

DISCUSSION

Simulation in surgical education has been shown to benefit learners and simplifying complex surgical tasks decreases the time needed to master new operative skills.[13-15] There has recently been an accelerated push to improve orthopaedic surgical skills simulation due to restricted hours, cost pressures, patient safety, and the growing number of minimally invasive and technical procedures.[16] The technology used for surgical simulation varies widely in both complexity and cost. Given the demonstrated benefit of goal-oriented simulation to novice learners, simulator procurement and refurbishment should not be a barrier to education, and learners should be exposed to simulation training early and often in their training. These basic skills are known to facilitate complex skill acquisition, and learners need frequent access to these training simulators to maximize benefit. However, cost is a limiting factor to a learner's access to simulators and task trainers that cannot be overlooked.

In this study, our group created an orthopaedic partial task trainer designed for the arthroscopy naïve learner for 29% of the initial investment of a commercially available option with reduced recurring costs of over 90%. The cost analysis of our in-house arthroscopic skills task trainer demonstrates that access to simulation education for medical student groups and residency programs can be greatly improved without excessive financial investment.

While our study is limited by the small sample size used to demonstrate construct validity of the trainer, our data is consistent with similar simulators. And while our task trainer demonstrates construct validity, further trails are necessary to demonstrate efficacy in training the targeted skills and subsequent skill transfer to the operating room. The accessibility of our simulator is limited by the availability of a 3D-printer, which is not available to all orthopaedic training programs. Regardless, this work successfully shows in-house simulators are a cost-effective substitute for budget limited orthopaedic training programs that wish to support and progress simulation training for their undergraduate surgical education program.

Figure 3: Complete L-CASST simulator

CONCLUSION

Simulation-based training has been well established as an effective learning model for more complex invasive surgical procedures. In-house task trainers and simulators serve as a potential platform for skills testing, coaching, and feedback in training programs. Simulators that are created in-house can be readily produced and easily distributed. Given that they require only 29% of the initial cost and 8.3% of the recurring costs of commercially available options, in-house skills simulators represent a more accessible option for simulation-based training that is feasible even in the absence of significant funding or presence of patient-based limitations.

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