HoloLens in Suturing Training

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ABSTRACT

PURPOSE: A training module for basic suturing training called Suture Tutor was developed by combining video instruction and voice commands with the Microsoft HoloLens software. We put forth two hypotheses: Trainees find the HoloLens helpful and 2.) HoloLens helps the trainees to achieve a better score in objective skill assessment tests.

METHODS: Software module was developed to show instructional video in the HoloLens under voice command. Thirty-two participants were split into the control group or the HoloLens group. The control group used videos displayed on a computer during training while the HoloLens group practiced with Suture Tutor. Each group was given seven minutes to train with their assigned training method before testing. Testing involved replication of a running locking suturing pattern with a time limit of five minutes and was video recorded. The videos were expert reviewed. Participants in the HoloLens group filled out a usability survey.

RESULTS: The trainees found the Hololens to be usable and realistic, and the HoloLens group used the instructional videos more than the control group did ($p = 0.0175$). There was no difference in the skill assessment test scores between the HoloLens and the control group and their rates of completion in the allotted time was similar.

CONCLUSION: Participants found the Suture Tutor to be a user friendly and helpful adjunct. The study was unable to determine if the Suture Tutor helps trainees in achieving a better score in skill assessment testing.

KEYWORDS: Microsoft HoloLens, Augmented reality, Suturing training, Medical education, Surgical skills, Video instruction, Self-directed medical education

PURPOSE

Suturing is a basic surgical skill that is essential across several specialties. However, not all medical students get sufficient exposure and many do not achieve proficiency[1].The most common method of teaching basic suturing skills is workshop format in a laboratory environment with a faculty expert present. The sessions often do not provide sufficient practice and demonstration time. In addition, these sessions tend to have student-to-instructor ratios that exceed the 3:1 ratio previously shown to be effective for surgical tasks[2]. It can be expensive and time-consuming to supply a sufficient amount of expert clinicians at these training sessions. As a result, there has been increased interest in self-directed learning.

Self-directed learning of basic surgical skills often involves use of computer-based video instruction, text materials, or a combination of both. It was found that although trainees perceived the presence of a faculty instructor to be beneficial to learning, there was almost no difference in performance between groups who learned independently and those who were faculty directed[3]. There was also no significant difference in learning among those who attended a traditional live instruction workshop and those who practiced with computer-based video[4]. Although instructional feedback has been linked to better performance in basic surgical skills[5], computer-based video instruction with proficiency goals has been shown to be a cost-effective method for suturing training to proficiency[6].

A curriculum for basic suturing training that involves progression through video instruction with the ability to slow, pause, and skip steps for the technical skill was found to be an effective method of learning suturing and knot tying skill[7]. Furthermore, it was also found that students who followed a self-directed practice schedule using videos played on a computer showed a learning advantage compared to those who practiced suturing at random intervals[8]. These studies demonstrate that self-directed computer- and video-based instruction is an effective tool for suturing training. However, the use of a computer or tablet for basic skills training can cause trainees to break their flow of practice when interacting with the instructional material.

Augmented reality based training systems are emerging as effective tools in medical education. Augmented reality involves projections of virtual images in the users' real environment. This can help medical trainees understand relevant spatial relationships, develop hand-eye coordination and ultimately shorten learning curves for various skills[9]. Zhu et al. also found that learners can accept augmented reality as a useful learning tool in healthcare education. We sought to determine if combining video instruction with augmented reality is useful and preferred method to an external computer for medical students learning suturing skills.

Microsoft HoloLens is a headset with 3D holographic capabilities (Figure 1). The device hardware includes 4 environment understanding cameras, 1 depth camera, and 4 microphones that support gaze tracking, gesture input and voice commands[10]. We created a voice-controlled video-based instruction module for simple running locking sutures. In this study, instructional videos rendered on the HoloLens are placed within the field of view to create a virtual reality display around the user. This allows the user to interact with the instructional material by moving their eyes and using voice commands only. We set out to prove two hypotheses: 1.) Trainees find the HoloLens helpful and 2.) HoloLens helps the trainees to achieve a better score in objective skill assessment tests.

Fig 1. Microsoft HoloLens headset (left. The four environment understanding cameras and one depth camera built into the HoloLens (right)[10].

METHODS

Suture Tutor was developed for use on the HoloLens to supplement practice of simple running locking suture technique. The training module includes four short instructional videos, one for each of the major steps in the procedure (opening instrument tie, running stitch, locking stitch, and closing instrument tie) (Figure 2). The user can repeat, slow, skip and pause videos using voice commands. The module keeps a log of each voice command used in order to measure the number of views each video had and the time spent learning each step. The Suture Tutor module was developed using Unity.

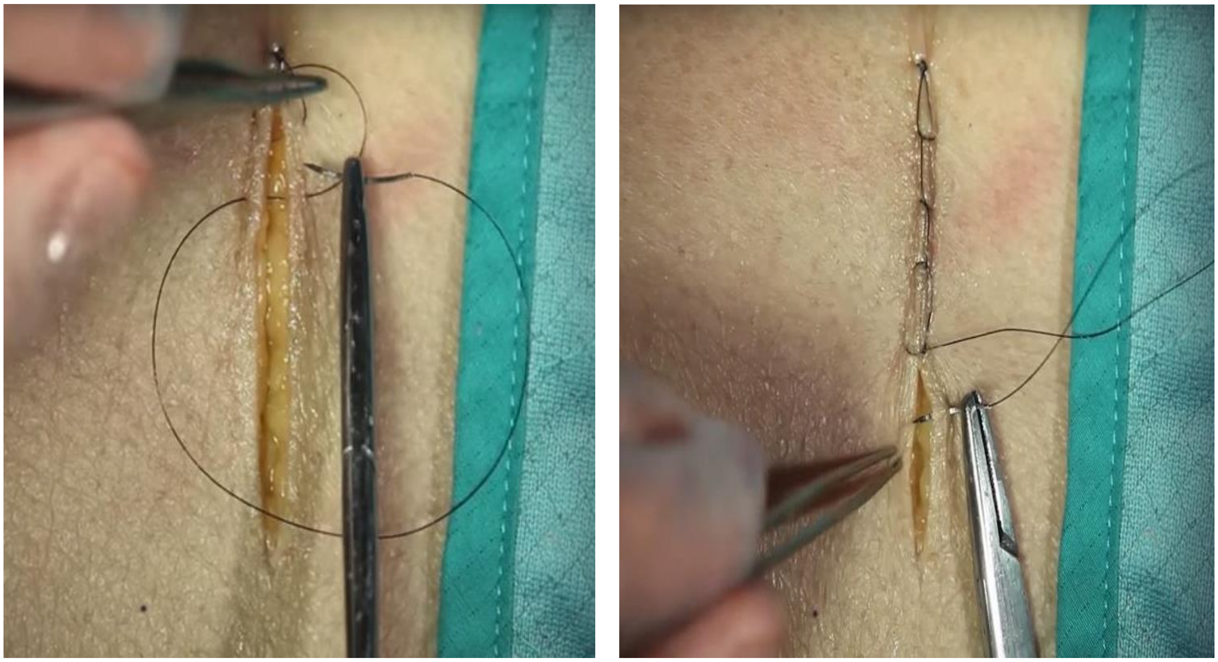

Fig 2. Screenshots of the video participants viewed with instructional narration[11]

This study was approved by the Queen’s University Health Sciences Review Ethics board. Thirty-six second year medical students have been recruited on a voluntary basis during the Surgical Skills & Technology Electives Program (SSTEP) at Queen’s University. This program is designed to provide opportunity for medical students to practice surgical and procedural skills.

Participants were split into either the HoloLens group or the control group. There was variation of previous experience among the participants indicating that they did not undergo standardized training to practice basic surgical suturing. The HoloLens group trained with the Suture Tutor while the control group had access to the same four videos on a laptop (Figure 3).

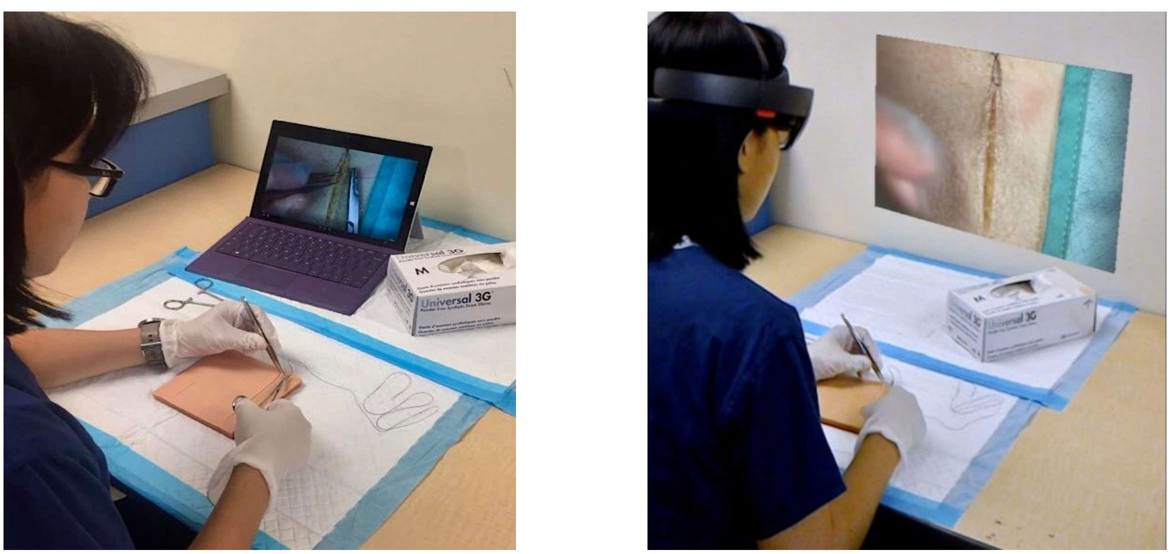

Fig 3. Setup of the HoloLens group (left) and the control group (right)

First, all participants were shown two videos on a laptop, one describing simple running suturing and the other describing simple locking suturing[11]. Next, each participant was given five minutes to replicate a suture pattern that combined the running and locking techniques (Figure 4). The participants were asked to rate their confidence from 1 (low confidence) to 5 (high confidence) before beginning. The first attempt was video recorded as their baseline test. The participants were then given seven minutes to practice with their assigned training method. For the control group, the time spent practicing each step and the number of times each video was repeated was recorded using a stopwatch. For the HoloLens group, the Suture Tutor recorded this data in the voice command log. After the practice session, all participants rated their confidence and were given 5 minutes to replicate the same pattern with no aid. This was video recorded as their final test. The HoloLens group was given a survey evaluating usability and realism to complete at the end of the session.

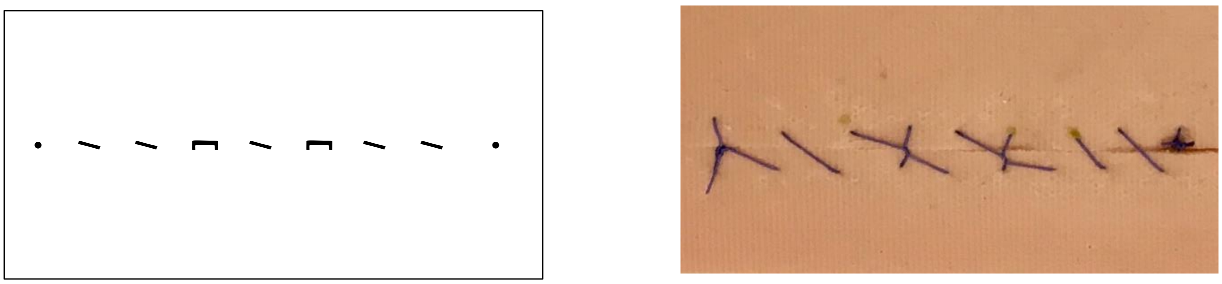

Fig. 4. Representation of running locking stitching pattern for participants to replicate where **.** indicates instrument tie, \ indicates a running stitch, and **]** indicates a locking stitch (Left). An attempt by a novice at recreating the pattern (Right)

RESULTS

Participants of the HoloLens group agreed that the Suture Tutor was useful. The HoloLens group used the instructional videos more than the control group participants did ($p = 0.0175$). On both the usability and realism surveys, the median response for each question was four or five, indicating that the participant agreed or strongly agreed with the statement presented (Table 1).

Usability Survey Results	
Question	**Median**
Global impression of setup	4
Instructions/explanations	4
Demonstration videos	4
Improvement of suture technique	4
In the training of medical students	4
In the training of residents	4
In the training of specialists	4
Realism Survey Results	
Question	**Median**
Global impression of setup	4
Clarity of instruction	4
Demonstration videos	5

Table 1. Usability and realism survey results. Data are presented as a median. The scores were assigned on a Likert scale defined as 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Additionally, 85% of the participants who used the Suture Tutor either agreed or strongly agreed that it is useful in the training of medical students. 95% of respondents agreed or strongly agreed that the demonstration videos used in Suture Tutor were realistic. Upon expert review, participant performance did not show a significant difference in technical skill between the two groups. Additionally, there was no significant difference for completion of the sequence.

DISCUSSION

Previously, it had been shown that computer-based video instruction and augmented reality techniques, separately, were each useful in the training of medical students. We set out to prove through two hypotheses that combining the two techniques together in a single system yields a superior training method.

The first hypothesis, that trainees consider the HoloLens a helpful adjunct in suturing training, was found to be true. We were, however, unable to prove the second hypothesis, that HoloLens helps the trainees to achieve better score in skill assessment tests. Two surgical residents evaluated the videos of each participants' performance using a previously validated Global Rating Scale[12]. No significant difference in technical skill was found despite increased use of training material. An analysis of the scores showed that overwhelming majority of trainees failed the suturing test, in both groups. This indicates that the participants were asked to complete a task that was too difficult for the given pool of participants with their prior training and instruction.

We suspect that the allotted practice time was insufficient. We plan to redesign the study, keeping in mind that a one-hour intensive practice session should significantly improve performance in suturing skill[2]. We also think that the inexperience of the participants with the Microsoft HoloLens was also a limiting factor. From the open-ended questions, we saw that some participants found it difficult to adjust to the virtual images. One student reported, "I personally found it very distracting having the videos play while I was suturing", while another reported, "I did not like having to switch between watching the videos on the HoloLens and practicing". Similar results were found in a study using patient simulation with Google Glass, another augmented reality headset[13], suggesting that this is common issue when adjusting to this new technology. We assume that trainees would benefit from more time learning to fit the headset and practicing navigation between videos before starting practice with HoloLens.

In conventional video instruction, the trainee must break the flow of practice in order to navigate the video which can discourage maximal exposure to the training material. With HoloLens, however, it was seen that the participants who trained with Suture Tutor spent more time interacting with the videos than the control group did. Interaction with instructional material in the Suture Tutor does not require a change in position or stoppage of practice, which may have led to the increased use of training material.

In the open-ended questions of our survey, it was found that the participants felt the HoloLens to be ergonomically challenging. The nature of the suturing is such that the head is tilted down. Much of the weight of the HoloLens lies in the front of the headset. This could have contributed to the neck pain some participants felt. Moreover, the discomfort may be a result of improper use of the HoloLens. Participants were unfamiliar with the technology, and may have rushed to fit the device. Improper positioning of the HoloLens may enhance the discomfort. For this, increased time for training and proper fitting should be given in future studies. Furthermore, we may explore a Suture Tutor module with demonstration of training material that does not require tilting of the head to increase the comfort of trainees.

It has been found that repetitive suturing practice at the bench can improve a student's ability to multi-task[14]. When practicing at the bench, there are few distractions. However, in clinical practice, there are often many distractions related to noise, surrounding activity, and the patient. The deliberate practice Suture Tutor allows can increase the student's multitasking ability. In addition, further versions of Suture Tutor can include simulation of a distracting environment to train students to cope appropriately. The feature would be most effective with students approaching suturing proficiency.

Next steps should include a longer training session with a separate training module to allow ample time for participants to familiarize themselves with the new technology. This can be implemented as a separate module that helps participants determine if the headset is properly placed, as well as practice using the voice commands and interacting with the virtual content. In the future, 3D modelling could be used to further enhance trainee's understanding of anatomy and hand motions relevant to the suturing task. Study design that includes more time for deliberate practice should be used in order to determine the effectiveness of Suture Tutor.

Finally, for Suture Tutor to be included in the competency based medical education program, it should include methods of evaluation and specific feedback for the trainee. This would allow the trainee to practice independently and deliberately while receiving information about their performance to enhance their learning. We envision a self-guided learning station that includes Suture Tutor and allows the trainee to practice even when a faculty expert is not available.

CONCLUSION

We configured the Microsoft HoloLens for suturing training of medical students. It was found that medical students agreed that video based instruction with HoloLens is useful for suturing training. However, there are limitations to the Suture Tutor relating to the use of new technology and length of training session. The difficulty of the task given the time each participant had did not allow for significant improvement in either group. Thus, our study is inconclusive in terms of effectiveness in training.

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