Utilizing Intraprocedural Interactive Video Capture With Google Glass for Immediate Postprocedural Resident Coaching

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BACKGROUND: Video coaching has been found to be an effective teaching method because it incorporates many of the established principles of successful adult learning. The goal of our study was to assess the feasibility and effectiveness of using a point-of-view video camera (Google Glass) to improve the surgical skills education of orthopaedic surgery residents.

METHODS: Forty-two residents from 4 institutions participated in a partially blinded randomized control trial performing an intra-articular distal tibial fracture reduction task while wearing Google Glass to record the performance. Participants underwent a structured coaching session with 20 participants (intervention group) using the recorded video to augment this session, and 22 participants (control group) receiving verbal coaching alone. The task was repeated again immediately after the coaching session. Performance was scored using an Objective Structured Assessment of Technical Skills checklist, Global Rating Scale, fluoroscopic usage, and reduction quality. A semistructured interview was then performed to assess experience of participants.

RESULTS: There was no significant difference ($p > 0.05$) seen in score improvement in the Objective Structured Assessment of Technical Skills checklist, Global Rating Scale, fluoroscopic usage, or reduction quality between the control and intervention groups. Thematic analysis of interview showed majority of participants found video coaching increased effectiveness in understanding of goals, developing techniques and strategies, and process of self-reflection. Their involvement was seen overall as a positive experience, with participants wanting to see more inclusion of video coaching within surgical education.

CONCLUSIONS: No difference in performance improvement between the 2 groups was seen, but majority of participants found the video coaching sessions valuable and could have potential beneficial role in education. (J Surg Ed 76:607−619. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: surgical training, simulation, video-coaching, education, Google Glass, modeling

COMPETENCIES: Patient Care, Medical Knowledge, Interpersonal and Communication Skills, Practice-Based Learning and Improvement

INTRODUCTION

Video coaching, modeling, and review are effective teaching methods because they incorporate many of the established principles of successful adult learning.[1-9] Video coaching has the potential to foster active learning by engaging the visual senses and allowing a shared perspective with a mentor.[8,10-13] On top of that, video coaching after a surgical procedure allows internalization and reflection away from distractions.[8,14-20] For these reasons, video learning, and specifically video coaching, has the potential to be a powerful tool in surgical education.

Our review of the literature published to date shows mixed results when utilizing video coaching in orthopedic simulation training. Backstein et al., showed no

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difference in technical skill improvement when incorporating video feedback into coaching sessions after residents completed 3 technical skills,[21] while Karam et al., found a significant performance improvement when coaching sessions were augmented with video feedback.[22] Thus while these techniques have shown promise in areas outside of medical training, their utility in surgical education is unclear.

Use of this technology in an operating theatre can be cumbersome and require overhead cameras or additional personnel in the operating suite to record the procedure of interest. This strategy can be costly, require constant repositioning, and leads to increased operating room traffic.[23,24] Recently studies have begun to look into the utility and effectiveness of using point-of-view video obtained through head mounted video capturing devices. These devices have shown promise in the educational realm, due to the ability to capture video while bypassing logistical barriers presented by third person cameras.[25,26]

Adaptation in current orthopedic surgical education strategy is necessary to meet the changing demands of an increasingly complex field in an evolving training environment. Work hour restrictions and changes in resident autonomy are but a few of the obstacles that the training physician now faces on his/her way to becoming a practicing orthopaedic surgeon.[27-30] These changes may lead to a decrease in the surgical caseload of residents graduating in this new era of medical training, thus highlighting the need for streamlining the training process.[28,31,32] By implementing educational strategies aimed at improving retention, efficiency, and understanding, the gap between educational demands and time available for training may be decreased.

The goal of our study was to assess the feasibility and effectiveness of using a point-of-view video camera (Google Glass) to improve the surgical skills education of orthopaedic surgery residents by comparing it to standard verbal feedback. Our hypotheses were that (1) participants who undergo a video coaching session in a simulated environment will have greater improvement in performance compared to participants who receive verbal feedback alone and (2) participants will find value in the video experience.

METHODS

Participants

This multi-institution study was performed using orthopaedic surgery residents at Dartmouth Hitchcock Medical Center, University of Missouri at Kansas City, Rush University, and Loyola University. IRB approval was obtained at all participating institutions prior to beginning the trial at each site. Participation in the study was done on a voluntary basis with informed consent obtained for each resident participant. In all, 42 residents from the 4 institutions completed the study, spanning all 5 postgraduate years. Table 1 presents the baseline characteristics of the 2 groups (Table 1).

Study Design

The study was a partially blinded randomized control trial (block randomization technique) consisting of 2 groups (control and intervention arms) (Fig. 1). Both groups wore the Google Glass, which is a wearable video recording device used to capture point-of-view video, while performing a fracture reduction simulation task and were scored in real-time by an evaluator. Both groups then received coaching from an experienced surgeon (single coach at each location) with only the intervention group using a laptop computer to view the Google Glass video to augment the session. These coaches were attending orthopaedic surgeons involved in resident education. A set of guidelines for effective feedback was given to each surgical expert, standardizing the way the coaching sessions were performed." After the feedback session was complete, both groups repeated the task again and were again scored by the same blinded evaluator.

TABLE 1. Characteristics of Resident Participants From Dartmouth-Hitchcock Medical Center, Loyola University, Rush University, University of Missouri Kansas City ($n = 42$)

	Standard Coaching	Video Coaching	p Value[1]
# of participants	22.0	20.0	
PGY average	2.3	2.7	0.40
Gender (% female)	18.0	30.0	0.38
Initial OSATS checklist score	4.4	4.5	0.84
Initial GRS score	22.8	21.2	0.39
Initial fracture step off (mm)	8.0	5.8	0.43
Initial fracture diastasis (mm)	7.2	5.4	0.39
Initial fluoroscopy usage (s)	48.6	48.5	0.99

[1] Statistical analysis done with *t* test.

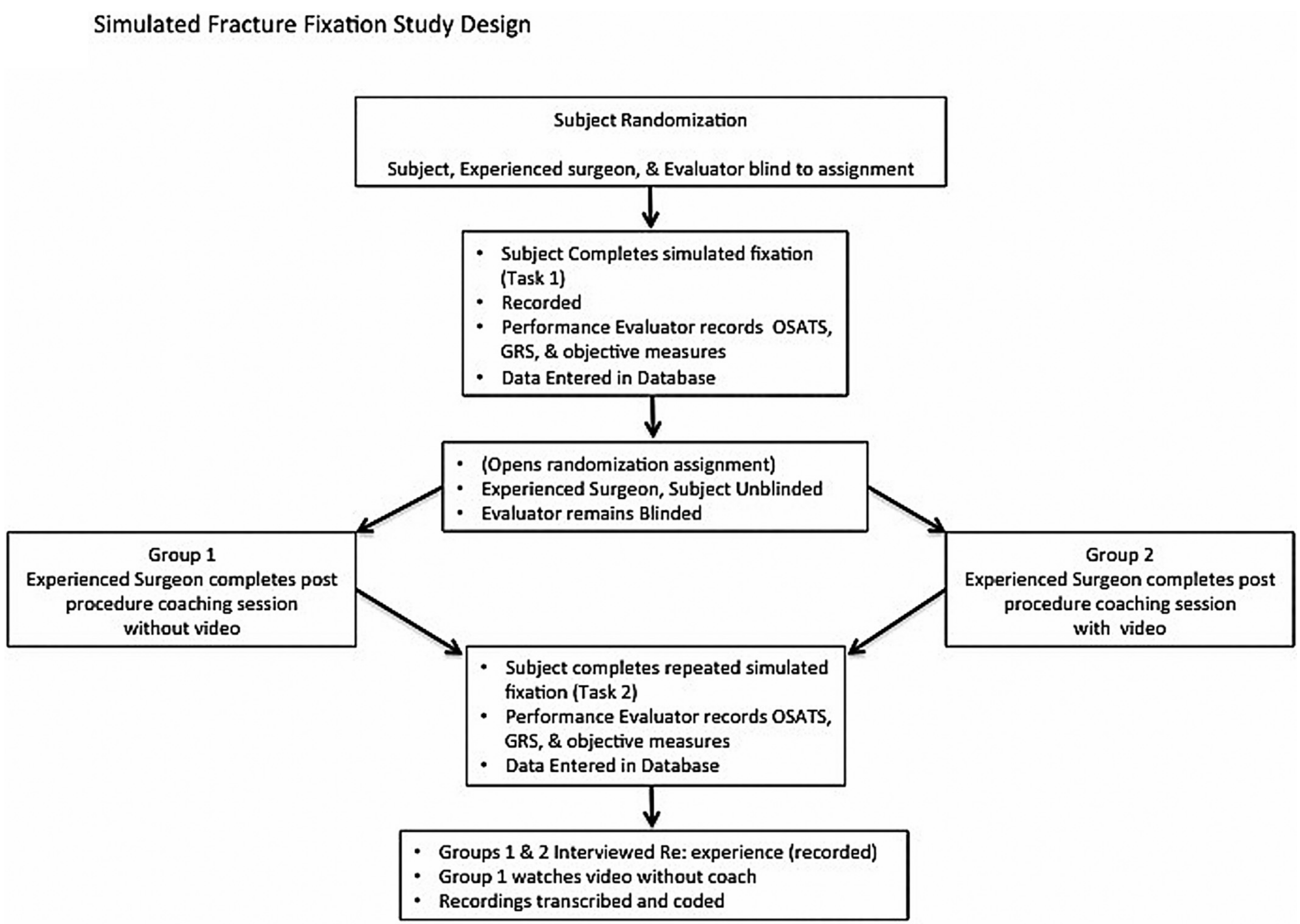

FIGURE 1. Flow chart that illustrates the organization of our study design.

The task was based on the American Board of Orthopaedic Surgery Surgical Skills Module #12: the fracture reduction module.[33] A Sawbones radioopaque 3-segment distal tibia fracture model with soft tissue coverage was used to represent a comminuted and displaced tibial pilon fracture. The task consisted of the participant incising anteriorly through the soft tissue envelope of the model, assessing fracture displacement, reducing the fracture, and provisionally fixing the fracture fragments with Kirschner wires. Participants were given a basic set of surgical tools (scalpel, self-retaining retractors, Freer, Senn retractors, and point-to-point clamps) and a mini C-arm in order to accomplish this task. Fifteen minutes was allotted for completion of the task. A qualitative interview was then conducted with participant following completion of the procedure. An example of the video obtained using the Google Glass and feedback given to the participant has been included, please access the video by clicking the link provided (Video).

Outcomes

Objective measurements of articular step off and fracture diastasis were measured after completion of each task at the point of maximal displacement. Subjective scores were calculated using Objective Structured Assessment of Technical Skills (OSATS) scoring methods.[34] Two scoring systems were used: an task specific checklist and a detailed global rating scale (GRS), which have been validated in previous studies as effective ways to assess surgically relevant skills within a resident population.[35-37] The task-specific checklist is a list of 8 discrete actions felt by a panel of surgeons to be necessary to perform the fracture reduction task effectively (Table 2).[35] Each action is scored as either "performed" or "not performed," and then summed and reported as a total numerical score ranging from 0 to 8 with 0 being the lowest and 8 being the highest. The GRS is a scale analyzing 9 discrete actions to be completed during the fracture reduction task (Table 3). Each individual action is scored on a scale from 1 to 5 with 1 being poor effort and 5 being best effort. The 9 actions are then summed together giving a possible score range from 9 to 45. Scoring for each attempt was performed by a single evaluator at each location (4 total). In order to promote consistency between each of the different sites, an exhaustive instruction manual was sent to each evaluator with video evaluations of performances illustrating how they were to be scored.

After completion of the trial, audio-recorded qualitative interviews were conducted with the participants to assess the impact of using the point-of-view video as a teaching intervention. A semistructured interview guide was used across sites to standardize interviews and target resident feedback in various areas (See Figs. A and B). These guides allowed for more consistency and limited bias across interviews.[38] The interview was designed to capture experiences of being coached, changes in perception of coaching with and without video, and potential areas of improvement.

Interviews were recorded and transcribed to capture verbatim responses of participants. Transcripts were assessed using the directed content analysis approach.[39] This approach is informed by the general "qualitative analytic method" and was used to assess face-to-face conversations and interactions.[40] We conducted a thematic analysis as described in detail by Attride-Striling[41] and by Braun and Clarke.[42] Any text that could not be coded by topic was included as an emergent code and aggregated into the final analysis. The grouped codes were then organized and assessed based on shared content, meaning, substance, and overall fit. Group codes were summarized into a narrative by comparing participant feedback and making interpretive linkages between the responses using salient examples from the text.

Data Analysis

Data gathering for the OSATS checklist, the GRS, and the objective measurements was performed on individualized forms that were then uploaded onto REDCAP. Statistical comparisons were performed using the 2 tailed *t* test, Welch's *t* test and analysis of variance (ANOVA) (STATA, College Station TX), with statistical significance

TABLE 2. OSATS Checklist

Procedural Step	Performed	Not Performed
Appropriate identification of landmarks and incision		
Appropriate selection of surgical instruments		
Appropriate handling of surgical instruments		
Appropriate preparation and manipulation of fracture fragments		
Appropriate placement of reduction devices and aids		
Appropriate reduction achieved		
Appropriate use of fluoroscopy		
Appropriate placement of fixation devices		

TABLE 3. Global Rating Scale (GRS)

	1	**2**	**3**	**4**	**5**
Preparation for procedure	Did not organize equipment well. Has to stop procedure frequently to prepare equipment.		Equipment generally organized. Occasionally has to stop and prepare items.		All equipment neatly prepared and ready for use.
	1	2	3	4	5
Respect for tissue	Frequently used unnecessary force on tissue or caused damage.		Careful handling of tissue but occasionally caused inadvertent damage.		Consistently handled tissue appropriately with minimal damage.
	1	2	3	4	5
Time and motion	Many unnecessary moves.		Efficient time and motion, but some unnecessary moves.		Clear economy of movement and maximum efficiency.
	1	2	3	4	5
Instrument handling	Repeatedly makes tentative or awkward moves with instruments.		Competent use of instruments, but occasionally appeared stiff or awkward.		Fluid moves with instruments and no awkwardness.
	1	2	3	4	5
Use of fluoroscopy	Frequently requested excess images. Requested images with repeated improper orientation.		Used images effectively, but occasionally had to ask for extra images because of error.		Successfully completed procedure with minimal images. Used proper orientations during image capture.
	1	2	3	4	5
Use of Kirschner wires	Consistently placed wires in poorly placed positions or used in excess.		Good use of wires with occasional repositioning.		Efficient use of wires with appropriate placement.
	1	2	3	4	5
Flow of procedure	Frequently stopped procedure and seemed unsure of next moves.		Demonstrated some forward planning with reasonable progression of procedure.		Obviously planned course of procedure with effortless flow from 1 move to the next.
	1	2	3	4	5
Knowledge of procedure	Deficient knowledge.		Knew all important steps.		Demonstrated familiarity with all aspects of the procedure.
	1	2	3	4	5
Overall performance	Very poor		Competent		Clearly superior

set at the $p < 0.05$ level. Video review was performed on a laptop computer.

A post hoc power analysis was performed using STATA v13 statistical software using the sampsi calculation for a 2-sided alpha of 0.05, and 80% power. Previous published data using OSATS and GRS scales specific to this fracture model[35] was used to set up 3 scenario's using articular step off as our outcome of interest. Scenario 1 was calculated with an expected difference of 1mm, scenario 2 was calculated with an expected difference of 1.5 mm and scenario 3 was calculated with an expected difference of 2 mm. After calculating sample sizes for our 3 scenarios: 36, 16, and 10 respectively; we were confident that our study size of 42 possessed enough power to detect a conservative articular step off at least 2 mm.

RESULTS

Quantitative Analysis

Both groups saw improvements in the Global Rating Scale (11.65 vs. 7.36, $p < 0.07$) and OSATS checklist scores (2.1 vs 1.64, $p < 0.50$) with a trend of greater improvement occurring in the video coached group, but the difference did not reach statistical significance for either (Fig. 2). Improvements in fracture diastasis (4.06 mm vs. 2.03 mm, $p < 0.47$) and fracture step off (4.4 mm vs. 3.28 mm, $p < 0.68$) were noted in both groups with a slightly greater improvement in the control group. A trend toward decrease in fluoroscopic usage time was seen in the video coached group compared to the control group (decrease of 14.97 seconds vs. increase of 1.95 seconds, $p < 0.11$; Table 4)

An analysis using 1-way ANOVA was conducted to determine if the amount of improvement seen between the first and second task was different for participants based on postgraduate year of training. While greater mean score improvement was seen in the earlier years of training when compared to later years, this difference did not reach statistical significance (Figs. 3 and 4).

Qualitative Analysis

Analysis of the interviews was organized into 3 main topics: (1) Coaching with video enhances tactical learning, (2) Changes in self-awareness based on video coaching, and (3) areas of improvement and future directions.

Coaching With Video Enhances Tactical Learning

Participants reported value in coaching both with and without video as a means to prepare for the second fracture reduction task and plan their approach, organize their work area, prioritize steps, and establish a goal for the procedure. A majority felt coaching was helpful but reflected that the contribution of video coaching added meaningfully to learning and understanding. One resident emphasized how the video enhanced learning based on "it was very useful to correlate actual images with the feedback he was trying to give me. (DH_008)" Many claimed the video offered a unique way to orient their "plan of attack" and guide improvement strategies.

Video coaching added valuable situational visual cues and provided a narrative explanation of success or failure. Observation of video by the control group after completion of the task was seen as less helpful than viewing the video with simultaneous coaching. Participants suggested that observing key teachable moments in the video with their coach increased their chance of learning and fixing issues when compared to dialogue alone.

Video coaching permitted the useful differentiation of behavior assumptions from actual behavior. Participants also acknowledged that use of video enhanced a process of self-reflection. The direct observation of personal behaviors, including hand movements and eye position, appeared to encourage learning beyond basic dialogue. This process seemed to help participants remember what they were thinking at the time, compare thoughts to behaviors, and identify the moment when a decision to act was made. Ultimately, the participants felt viewing themselves revealed an underlying thought process behind their hand movements, which permitted more efficient learning.

Changes in Self-Awareness Based on Video Coaching

The benefits of seeing the surgery from a first-person perspective alongside an expert teacher provided guidance and opportunities for improvement that all participants felt could not be achieved through a simple one-on-one discussion. It was felt that there could be little disagreement on what occurred during the procedure in the presence of a video. Participants agreed that this clarity allowed for more accurate and efficient learning of skills. In addition, use of video to recall moments of failure or confusion gave an added dimension to learning that may not be possible in the absence of video.

Several participants who were very clear about their hesitation and fears about performing the procedure expressed strong support for the use of video coaching. Other participants felt the coaching experience worked well as a collaborative learning format where subjects could recognize mistakes and possible alternatives and were therefore more comfortable performing the procedure on their second attempt. Further, coaching with the video allowed the participant and the coach to focus on adjusting behaviors and skills directly from the screen, relying on the immediacy of the video rather than relying on memory.

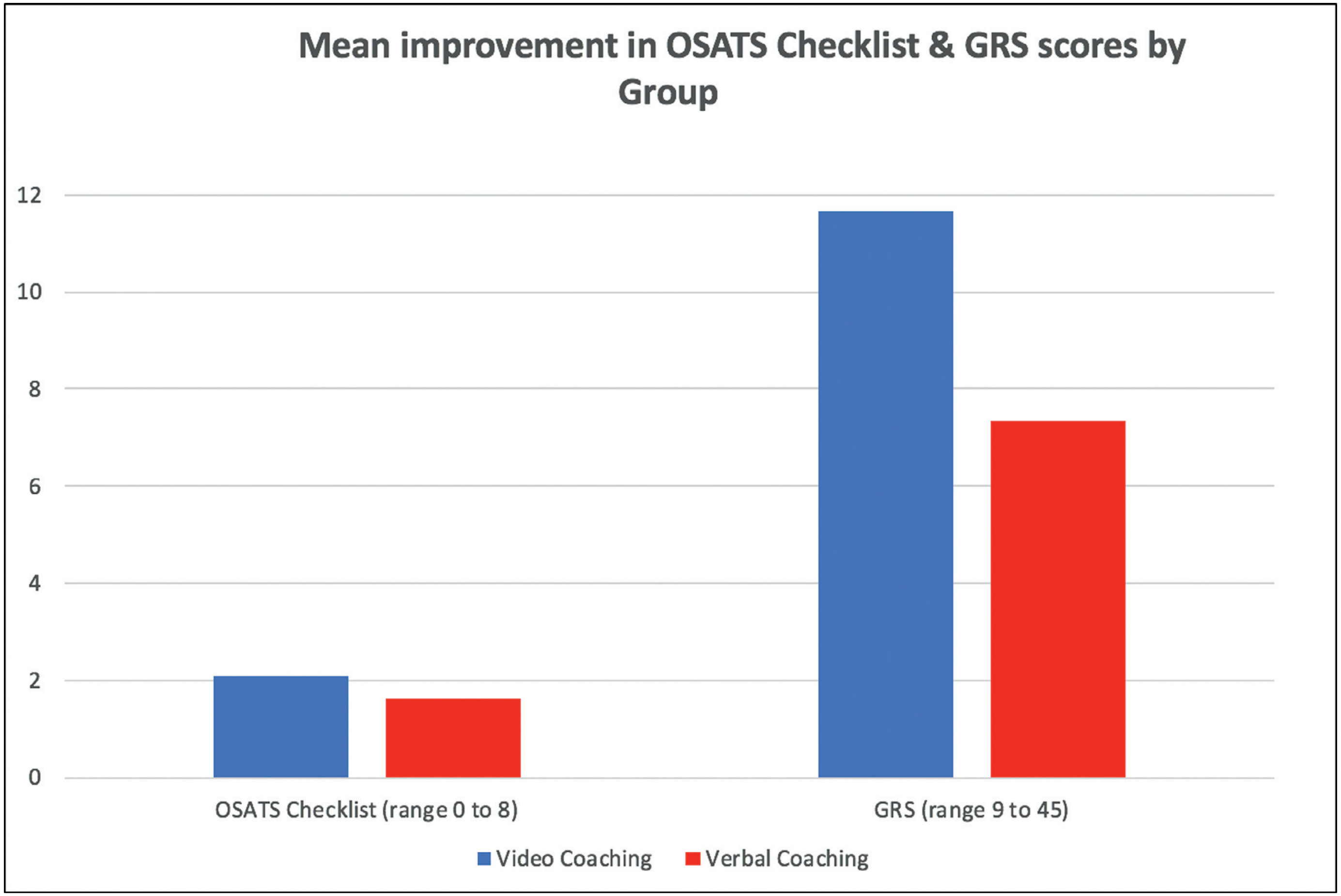

FIGURE 2. Graph showing differences in the mean improvement in both the OSATS checklist score and GRS, by group.

TABLE 4. Mean Improvement in Performance Scores Between First and Second Attempt of Fracture Reduction Task

Variable	No Google Glasses	Use Google Glasses	p Value*
OSATS checklist improvement	1.64	2.10	0.50
GRS improvement	7.36	11.65	0.07
Diastasis improvement (mm)	4.06	2.53	0.47
Step off improvement (mm)	4.40	3.28	0.68
Fluoroscopic usage improvement (s)	−1.95	14.97	0.11

*Statistical analysis done with *t* test.

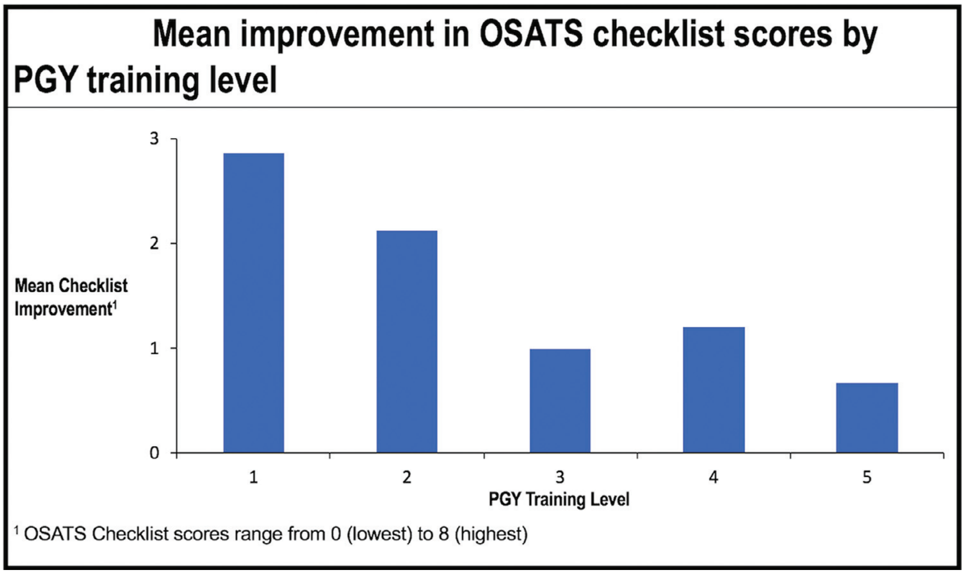

FIGURE 3. Graph showing mean improvement in OSATS checklist score by training level.

Areas of Improvement and Future Directions

While most participants felt there was little change needed, many noted that being unable to see the fluoroscopic images in the video review process was a barrier to more effective coaching. Participants felt that adding labels or prompts to specific parts of video prior to viewing would advance learning and efficiency.

One participant saw starting and stopping the video to discuss various points as disruptive and less conducive to learning. The benefits of coaching with the video were most observed when video review was focused, planned, and direct. Using the video to see inside the articular surface of the model was seen as very helpful for the participants, suggesting that the use of a zoom feature might add meaningfully to the coaching process.

Concerns about the Google Glasses were mainly technical in nature, focused primarily on field of view, camera position, and potential use of the in-camera screen. All participants thought the method could be very useful for assessing surgeries with live patients.

DISCUSSION

The goals of this study were to assess the feasibility and effectiveness of using point-of-view video to improve the surgical skills education of orthopaedic surgery residents. We had 2 hypotheses. While our results showed that there was not a statistically significant difference in objective measurements between the video and conventionally coached group refuting our first hypothesis, our qualitative analysis did show that participants found point-of-view video coaching beneficial and effective supporting our second hypothesis. This is in keeping with the results from a recent study from the University of Iowa in which Karam et al.,[22] using a model similar to ours, showed that residents who underwent a faculty coaching session using point-of-view video obtained with a head mounted camera had a significantly greater improvement in performance compared to those who did not undergo a coaching session.

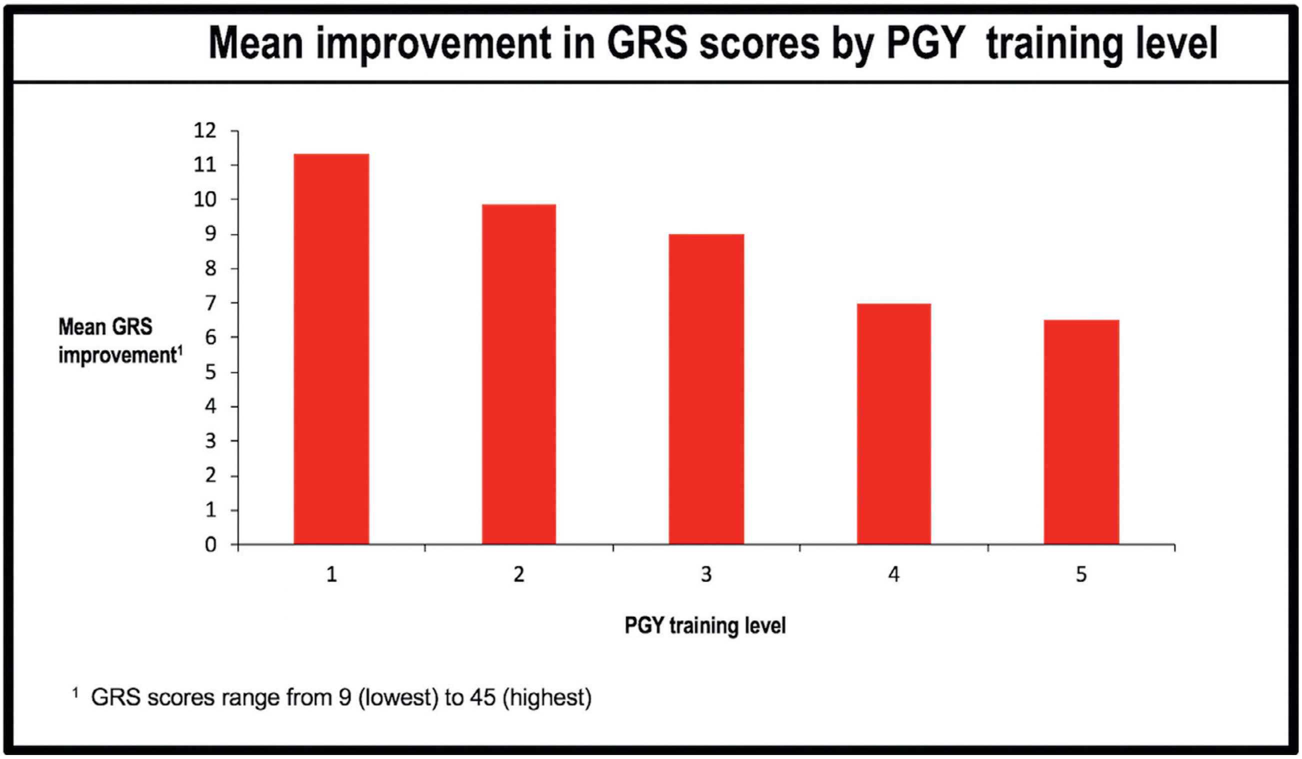

FIGURE 4. Graph showing mean improvement in GRS scores by training level.

One of the more interesting findings with our study is the decreased response to coaching seen in increased participant training level. A 1-way ANOVA showed statistically higher baseline scores in the more senior group, which could explain the decreased response seen to coaching due to a ceiling effect, leaving senior residents with less room for improvement when completing the second task. This is different than the findings reported by Yehyawi et al.[35], where in junior and senior residents performed comparably when using a similar pilon fracture model and OSATS scoring methods. Perhaps the decreased responsiveness seen in the more senior group in our study was due to the simulation task itself. Aggarwal et al.[43], showed that expert learners might benefit more from educational situations with high fidelity or realism, while novice learners do well with lower fidelity models and have diminishing returns with increased realism.

A novel aspect of our study is the inclusion of a qualitative interview to report participants' perceptions of using this educational technique. Almost universally participants felt that this was a useful tool that aids in learning and that it would help enhance their ability to develop proper surgical technique. Hu et al.[23] performed a similar qualitative analysis of recorded postparticipation interviews and showed similar results to ours, stating that the resident participants found the "postgame analysis invaluable." In that study participants identified similar reasons for the success of video coaching, such as the ability to use the video to view themselves in the third person and the ability to provide an avenue for targeted feedback. Perhaps this improved capability to focus the trainee's attention and efforts through video coaching may lead to an overall improvement in the learning experience and greater effectiveness in teaching.

Limitations of our study exist. First, for our trial we decided to use a single evaluator at each individual location to perform scoring. While logistically it made sense to proceed this way, there are some concerns about the validity in scoring among the different sites. In order to minimize this effect, we developed an exhaustive manual that was sent to each site with the aim of achieving consistency in the way performance was scored. A subgroup analysis showed no difference in scores at the various testing sites.

Another potential limitation of our study is that 5 participants out of 42 did not complete the first attempt within the allotted time frame. These participants were not included in the comparison analysis of fracture diastasis and fracture step off due to incomplete data, but were included in all other analyses. Three of these participants were allocated to the video coaching group and 2 in the control group. When these participants were removed from the analysis entirely, it did not change our results.

Another limitation of our study was model variability. While all models used for the study were 3-segment distal tibia fracture models manufactured by Sawbones, there was some uncontrollable variability in the amount of fracture displacement, fracture angulation, and fracture stability. Variability in fracture characteristics could not be appreciated until the initial incision through the soft tissue model was completed and the fracture was assessed directly. We were unable to control the differences seen between the individual models, which may have influenced performance on the task.

Like many new technologies there was a learning period with the equipment. While having a wearable recording device did bypass many of the expected issues of using a third person camera, some participants found that the screen was distracting. We also found that the glasses needed to be tilted down slightly for the best viewing angle due to fixed angle of the camera on the glasses. This altered the intended fit of the product, but was sustainable through the task.

CONCLUSIONS

In conclusion, while our study did not show a statistically significant difference in score improvement between the 2 groups, we believe video coaching with point-of-view video is still a potentially valuable educational tool. In regards to this specific product and this specific protocol, we cannot state that it was definitively valuable, but we believe there is still merit in considering other forms of video coaching in residency education.

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SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jsurg.2018.10.002.

APPENDIX A

Fig. A

APPENDIX B

Fig. B

Google Glass
Semi-Structured Interview

Control Group
COACHING WITHOUT VIDEO

Thank you for participating in this study. We would like to ask you a set of questions about your coaching experience and using Google Glasses. This should take 5-10 minutes.

1) Describe your experience of being coached
   a) In what ways did the coaching experience help you improve your performance on the procedure?
   b) How has the coaching experience helped you to understand performing this procedure?
   c) In your own words, how might the coaching experience be improved?
   (Allow Resident to View Video)
   d) Now that you've seen the video, how do you think the use of video might have helped and/or hindered your coaching experience?
   Probe: Please clarify how the video may have helped or hindered understanding the feedback from your coach. Helped or Hindered?
   e) How might the video have improved or worsened your learning the skill?

2) Please describe what it was like using Google Glasses?
   a) How did you find their ease of use, fit, comfort, etc?
   b) Were the Glasses noticeable, and if so, did they affect your concentration?
   c) Could you see these Glasses being used in actual surgeries with patients?
   d) Do you think you would be more or less likely to learn the surgical technique with video, and why?
   e) Would a stationary/fixed camera be better or worse?
   f) Would a hand held, third party camera-person, be better or worse?

Please rank each option for ideally capturing surgical video that could be used for coaching.

1 = Best
4 = Worst

USE VIEWING OPTION RANKING SURVEY

FIGURE A. Copy of the semistructured interview guide given to the control group (coaching without the video group).

Google Glass
Semi-Structured Interview

Intervention Group
COACHING WITH VIDEO

Thank you for participating in this study. We would like to ask you a set of questions about your coaching experience and using Google Glasses. This should take 5-10 minutes.

1) Describe your experience of being coached
   a) In what ways did the coaching experience help you improve your performance on the procedure?
   b) How has the coaching experience helped you to understand performing this procedure?
   c) In your own words, how might the coaching experience be improved?
   d) In what ways do you think the video helped and/or hindered your coaching experience?
      Probe: Please clarify how the video may have helped or hindered understanding the feedback from your coach. Helped or Hindered?

2) Describe what it was like reviewing a video of yourself with your coach?
   a) In what way did viewing the video help and/or hinder the coaching experience?
      Probe: In your opinion, how was the coaching reflective of an approach that was either collaborative (i.e., working in partnership) or individual (i.e., dependent on previous personal experience)?
      Probe: Coaching with video enhances or limits reflexive practice (the capacity to reflect on action so as to engage in a process of continuous learning)
   b) How might you change the way the video was used in your coaching experience?
   c) In what ways do you think the video added to the coaching experience?
   d) Do you think you would be more or less likely to improve your surgical technique on the model with video, and why?
   e) In what way does the video add an additional perspective to the coaching experience?

3) Please describe what it was like using Google Glasses?
   a) How did you find their ease of use, fit, comfort, etc?
   b) Were the Glasses noticeable, and if so, did they affect your concentration?
   c) Could you see these Glasses being used in actual surgeries with patients?
   d) Would a stationary/fixed camera be better or worse?
   e) Would a hand held, third party camera-person, be better or worse?

Please rank each option for ideally capturing surgical video that could be used for coaching.

1 = Best
4 = Worst

USE VIEWING OPTION RANKING SURVEY

FIGURE B. Copy of the semistructured interview guide given to the intervention group (coaching with the video group).