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Modernizing ED Care: Virtual Reality Enhances the Patient Experience during Minor Wide-awake Hand Procedures

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Background: Minor procedures in the emergency department (ED) can be distressing for patients. The emergence of virtual reality (VR) offers a promising new tool by immersing patients in an engaging three-dimensional world. Prior studies have shown VR's effectiveness during procedures in reducing pain, anxiety, and procedure duration but have not assessed its efficacy in the ED. This study aims to evaluate the efficacy of VR in managing pain and anxiety during ED minor hand procedures.

Methods: This was a prospective, interventional study at a level I trauma center examining adult patients requiring minor hand procedures. Patients were provided the Oculus Quest 2 VR headset, offering various immersive three-dimensional experiences. Pre- and postprocedure surveys assessed previous VR use, anxiety and pain levels, VR efficacy, and possible adverse effects. Responses were rated on a 10-point Likert scale with paired *t* tests used to compare scores.

Results: The study included sixteen patients, seven of whom were first-time VR users. Patients experienced a significant decrease in both anxiety and pain levels. Survey results indicated overall benefits from VR in several aspects, with no adverse effects reported, and unanimous patient recommendation of the VR experience to others.

Conclusions: VR is an effective tool to optimize the patient experience during ED hand procedures. The study observed a significant decrease in anxiety and a declining trend in pain levels. Patients believed VR helped manage their pain and would recommend it to others. Given the benefits and high safety profile, VR should become a standard offering in ED minor hand procedures. *(Plast Reconstr Surg Glob Open 2024; 12:e5790; doi: 10.1097/GOX.0000000000005790; Published online 3 May 2024.)*

INTRODUCTION

Emergency department (ED) minor procedures can be very distressing for patients. These procedures can last from 15 minutes to as much as 1 hour or more to complete, all while the patient is often fully conscious. Oftentimes, EDs are not equipped with comforting or distracting features to help divert a patient's attention away from the procedure. Thus, patients are left watching themselves being operated on, which further increases their anxiety and pain levels. The perception of pain requires that nociceptors are stimulated beyond a pain threshold, after which they fire an impulse which propagates along the afferent C-fiber and Aδ-fiber pathways.[1] These signals ultimately reach the brain and create the feeling of dull and sharp pain, respectively. Interestingly, distraction has the ability to increase pain modulatory activity in the cortex, while simultaneously inhibiting areas associated with pain perception.[2]

Various distraction techniques for pain relief have been used and previously described in the literature,

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involving both active and passive forms. Active forms include controlled breathing, guided meditations, and interactive toys/video games. Passive forms include activities such as listening to music or watching movies. Usually, active forms of distraction have fared better compared with passive forms, likely because active distraction requires multisensory engagement.[3] The emergence of a novel distraction tool has come in the form of virtual reality (VR), which combines both active and passive forms of distraction. VR is a unique tool because it immerses the subject into a three-dimensional world that engages key senses, including vision, audition, and proprioception.[4] This multisensorial approach allows us to transport the patient's consciousness out of the ED room and into a virtual world with surreal landscapes and guided meditations, which will enhance their ED experience.

Prior studies have demonstrated that VR can help reduce pain and anxiety during outpatient wide-awake hand and other small procedures.[5–7] Other studies have found that VR can also decrease the duration of procedures due to higher patient cooperativity and reduced muscle tension.[1,8] At our very own institution, the burn unit successfully utilizes VR to distract patients during wound dressing changes. However, there has been no study specifically evaluating the efficacy of VR for hand procedures performed in the ED specifically. The purpose of this study is to determine whether VR can help improve pain and anxiety related to ED hand procedures on adults and ultimately improve the patient experience. We hypothesize that VR will significantly improve patient pain, anxiety, and overall satisfaction, and that patients will perceive it as an overall positive experience.

Takeaways

Question: Is virtual reality (VR) an effective tool in managing anxiety and pain levels during wide-awake emergency department (ED) minor hand procedures?

Findings: VR effectively helped promote a state of relaxation and significantly reduced anxiety and pain levels. No adverse effects were reported, and all patients would strongly recommend the VR experience to others.

Meaning: VR is an effective and safe tool to help optimize the patient experience during ED hand procedures and should, therefore, become a standard adjunct in ED minor hand procedures.

MATERIALS AND METHODS

This was a prospective, interventional study at a level I trauma center evaluating patients presenting to the ED requiring minor hand procedures, including hand laceration repairs and distal radius fracture reductions. The study took place over a period of 12 months. Approval from the University of California, Irvine institutional review board was obtained before commencing the study. Patients were invited to participate, provided that they were 18 years old or older, and were undergoing a minor hand procedure in the ED. We defined a minor hand procedure as any less complex intervention for hand injuries or conditions performed in the ED under wide-awake local anesthesia no torniquet technique. After receiving consults that met our inclusion criteria in the ED, the plastic surgery hand team obtained informed patient consent for participation in this study.

The Oculus Quest 2 VR headset by Meta was provided by the lead investigator and is widely available to the general population at the cost of only $300 at the time of this study. The software used was Nature Treks VR and cost $9.99 as a one-time purchase. Notably, the software is fully functional without an internet connection after the installation. Enrolled patients had the Oculus headset applied before injection of local anesthetic, and they were given the ability to choose from a selection of immersive 3D experiences, including but not limited to beaches, underwater scenes, and forests. Once in the landscape, the VR was operated solely by the patients, who had the ability to navigate throughout the environment and manipulate objects via the use of a controller by the unaffected hand (Fig. 1). (**See Video [online],** which shows

Fig. 1. Patient wearing VR Oculus headset during hand laceration repair in the ED.

Preprocedural Survey		
1.	**Have you ever used a virtual reality headset?**	**(Yes/No)**
2.	**Do you have claustrophobia?**	**(Yes/No)**
3.	**How anxious are you currently?**	**(1–10)**
	(1 = not anxious, 5 = moderate, 10 very anxious)	
4.	**How much pain are you currently experiencing?**	**(1–10)**
	(1 = no pain, 5 = moderate, 10 severe pain)	
5.	**How relaxed are you currently?**	**(1–10)**
	(1 = relaxed, 5 = moderately relaxed, 10 anxious)	

Postprocedural Survey		
1.	**How much anxiety did you have during the procedure?**	**(1–10)**
	(1 = no anxiety; 5 = moderate anxiety, 10 = severe anxiety)	
2.	**How much pain did you have during the procedure?**	**(1–10)**
	(1 = no pain; 5 = moderate pain, 10 = severe pain)	
3.	**Virtual reality helped reduce my anxiety?**	**(1–10)**
	(1 = strongly disagree, 5 = neutral, 10 = strongly agree)	
4.	**Virtual reality helped reduce my pain?**	**(1–10)**
	(1 = strongly disagree, 5 = neutral, 10 = strongly agree)	
5.	**Virtual reality helped me relax?**	**(1–10)**
	(1 = strongly disagree, 5 = neutral, 10 = strongly agree)	
6.	**Did you enjoy the virtual reality experience?**	**(1–10)**
	(1 = strongly disagree, 5 = neutral, 10 = strongly agree)	
7.	**Did you experience cybersickness (nausea, dizziness, vomiting) during the procedure?**	**(Yes/No)**
8.	**Would you recommend the virtual reality experience to other patients?**	**(Yes/No/ Maybe)**
	If No or Maybe to previous question, please specify why?	
9.	**Do you have any additional comments?**	

Fig. 2. Pre- and postprocedure surveys.

a patient-centric view of the VR experience navigating a virtual landscape.)

Experimental data were collected at both preprocedural and postprocedural timepoints. before the application of the Oculus, a preprocedure survey was administered inquiring about prior VR headset use, history of claustrophobia, and levels of anxiety and pain before the procedure. After completion of the procedure and removal of the Oculus, patients were administered a postprocedure survey asking them to rate their levels of anxiety and pain during the procedure. Patients were also asked to provide a general rating on VR's efficacy in providing benefits related to anxiety, pain, relaxation, and overall enjoyment of the experience. All rating survey questions were on a 10-point Likert scale (Fig. 2). Additionally, patients were asked if they experienced any adverse effects, such as cybersickness, and if they would recommend the VR headset to other patients in similar circumstances. General comments were also collected. Injury descriptions, pain medications, and nerve blocks administered were recorded. However, no protected health information was collected. In all cases, dedicated research personnel set up the VR headset and administered the surveys while the surgeon gathered all the required supplies and during clean-up. Furthermore, the Oculus headset can be programed for most major languages to match the medical team's primary language. However, the VR content itself is not language-dependent, as it provides multisensorial stimulation without any spoken language and can be used by any patient without creating any language barriers. (**See figure, Supplemental Digital Content 1,** which shows a suggested protocol for implementing VR use in the ED. **http://links.lww.com/PRSGO/D188**).

The calculation for our sample size was based on a type II beta error rate of 20% to give us a power of 80% with an alpha error rate of 5%. Given prior studies which found significant statistical differences in our outcomes of interest between VR and non-VR, our power analysis indicated we would require at least ten patients to identify statistically significant benefits.[5] However, we conservatively opted to include a minimum of 15 patients, consistent with existing literature that highlights substantial benefits associated with approximately this sample size.[9,10] Survey data comparing levels of anxiety, pain, and relaxation were analyzed using paired *t* tests to compare responses between both timepoints. *P* values below 0.05 were considered statistically significant.

RESULTS

In total, 16 patients were included in this study. Only three patients had previously used a VR headset before, and three patients reported having a history of claustrophobia. All patients had unilateral lacerations of the hand or unilateral distal radius fractures. All patients received a local anesthetic, and four patients received pain medications during the procedure. Types of injuries, medications

Table 1. Case Mix Injuries, Medications, and Relevant History

ID	Injury	Local Anesthetic	Pain Medications	Previous VR Use	History of Claustrophobia
1	Nail bed injury	1% Lidocaine digital block	None	Yes	No
2	Glass in webspace	1% Lidocaine digital block	None	No	No
3	Nail gun injury to metacarpal area	1% Lidocaine dorsal/ulnar block	Fentanyl 100 mcg/2 ml	No	No
4	Partial finger amputation	1% Lidocaine digital block	Fentanyl 50 mcg/2 ml	No	No
5	Index finger laceration	1% Lidocaine digital block	None	No	No
6	Avulsion/ crush injury to index and middle fingers	1% Lidocaine digital block	Fentanyl 100 mcg/2 ml	No	No
7	Electric saw injury to thumb	2% Lidocaine digital block	Fentanyl 50 mcg/2 ml	No	Yes
8	Index finger laceration and partial amputation revision	1% Lidocaine digital block	None	No	Yes
9	Index and middle finger laceration	1% Lidocaine digital block	None	No	No
10	Index finger laceration	0.5% Bupivacaine digital block	None	Yes	Yes
11	Ring finger laceration	1% Lidocaine digital block	None	No	No
12	Nail bed injury	1% Lidocaine digital block	None	No	No
13	First metacarpal displaced fracture	1% Lidocaine dorsal/ulnar block	Oxycodone 5 mg	No	No
14	Index finger laceration	1% Lidocaine digital block	None	No	No
15	Middle finger laceration	2% Lidocaine digital block	Hydrocodone-acetaminophen 5–325 mg	No	No
16	Dorsal forearm near-circumferential laceration	1% Lidocaine radial/ulnar nerve block	Morphine 4 mg	Yes	No

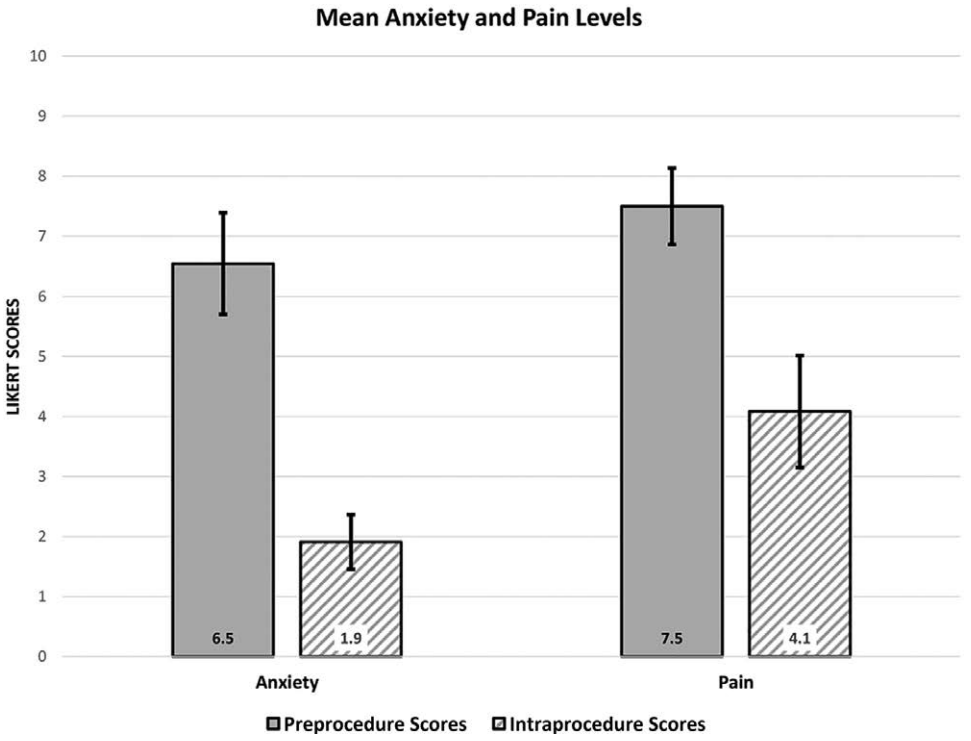

Fig. 3. Average anxiety and pain scores before and during the procedure, measured on a 0–10 Likert scale (0 = lowest, 10 = highest).

received, and relevant history are listed in Table 1. Setup and disassembly times for the headset were each less than 1 minute in every case, and there were no disruptions to the surgeons' workflows as it did not require any additional effort from them during the procedures.

Across all patients, average anxiety levels experienced a significant decline ($P < 0.05$) after application of the VR headset (Fig. 3). Similarly, pain levels showed a statistically significant reduction ($P < 0.05$). Scores to Likert scale questions inquiring about an overall rating demonstrated

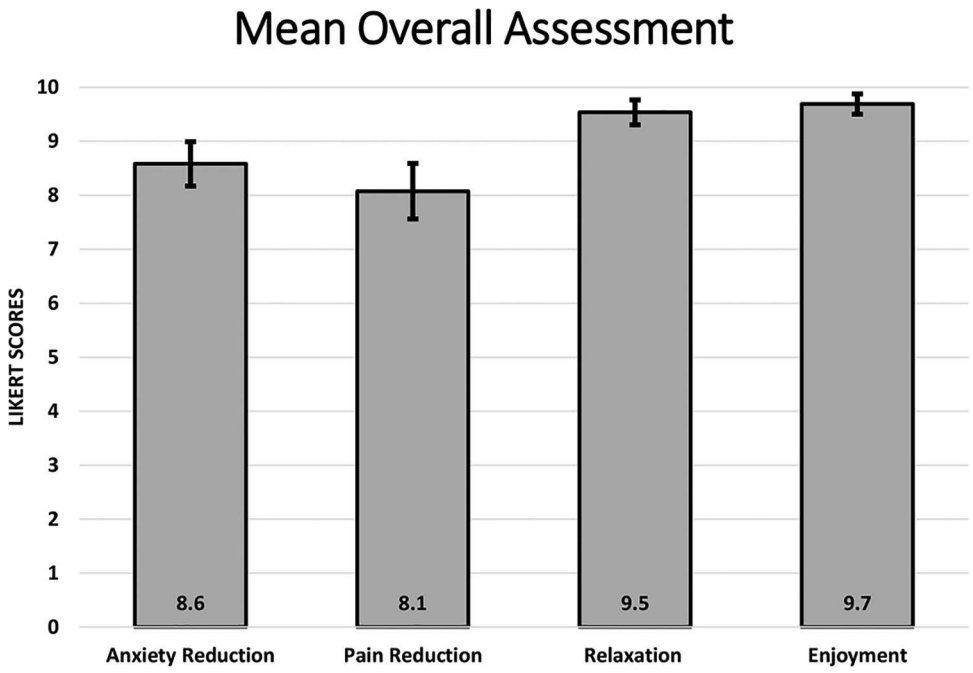

Fig. 4. Overall patient assessment scores of VR benefits, measured on a 0–10 Likert scale (0 = no perceived benefit, 10 = maximum perceived benefit).

Table 2. Patient Commentary on Overall Experience

"Good times, heck yeah!"
"It really helped distract me."
"This helped a lot thank you."
"This experience was awesome."
"I hope I can use this again if something like this ever happens again."
"Thank you, great idea, definitely helps."
"It was great for me, and I think it helps. Watching sporting or concert events would be great."

that VR was overall beneficial across anxiety and pain reduction, relaxation benefits, and overall enjoyment (Fig. 4). No instances of adverse effects, including motion sickness, were reported. All 16 patients stated they would recommend this experience to others. Patient comments related to the experience are shown in Table 2.

DISCUSSION

Currently, no studies exist that investigate the effectiveness of using VR to alleviate pain and anxiety in patients undergoing wide-awake minor hand procedures in the ED. In our study, we utilized the Oculus Quest 2 VR headset by Meta to create a multisensory experience for patients with traumatic hand injuries. Our findings demonstrate that patients who engaged in a VR experience reported feeling a significant decrease in their anxiety during their procedure compared with their preprocedure state. The immersive experience was highly effective in helping patients relax, with all 16 patients who used VR strongly agreeing to its positive impact. The findings supported our hypothesis that an immersive VR experience can effectively distract and relax patients. Additionally, mean pain ratings during the procedures were significantly lower than before the application of the VR headset, with all 20 patients reporting a reduction in pain levels. Altogether, the patients who used the VR headset expressed an overall greater sense of satisfaction and a willingness to recommend VR use to others, which may be attributed to their reduction in anxiety and discomfort during the procedures. Furthermore, the expeditious setup of the VR headset did not present any disruptions to the surgeons' workflows. Though not directly evaluated due to the heterogeneity of cases, the surgeons reported increased efficiency during the procedures due to eliminating the need to intermittently pause and reassure the patients, allowing for uninterrupted work.

Given the volume at our institution of patients requiring procedures in the ED, one or two headsets utilizing the same software would suffice. Maintenance costs are minimal, involving only disinfective wiping and battery charging. Given our results demonstrating VR's anxiolytic and pain reduction benefits, and anecdotal evidence of enhanced efficiency, we posit that the cost savings outweigh the minor VR implementation expenses. The headset and software together cost ~$310, and its offline usability makes it feasible for underdeveloped and developing countries through direct funding or donations, requiring only a power outlet for charging.

Overall, the findings of this study contribute to existing literature supporting the use of VR for reducing pain and anxiety in a clinical setting. Case studies of VR use for pain management have shown promising results of decreased pain ratings in burn care, postburn physical therapy, and dental procedures.[11–15] Of these studies, the study by Patterson et al also assessed anxiety levels and reported

a significant decrease in anxiety in patients who used VR hypnosis.[12] Similarly, randomized controlled trials have found that VR has the potential to decrease pain ratings and anxiety levels during clinical procedures ranging from IV blood draw, peripheral intravenous catheter placement, and minor outpatient surgical procedures.[16–19] Our results align with these previous findings that VR leads to lower anxiety levels, increased relaxation, and a reduction in pain. It is important to consider that perception of pain is inherently subjective, and assessments of VR's impact on pain reduction, including our own, depend on subjective pain ratings using numerical scales. Nevertheless, in our study, all patients concurred that their VR experience contributed to alleviating their pain. Therefore, though pain ratings are inherently subjective, there is compelling evidence suggesting that VR can indeed enhance patients' overall pain experience positively.

Although the exact mechanism by which VR modulates pain is not fully understood, it is thought to be related to the gate theory of pain, where descending signals from the brain modulate the pain perception, and the expansion of this theory, which postulates that attention is needed to perceive pain.[20,21] One way this occurs is by activation of the anterior cingulate cortex (ACC), which interconnects the descending pain modulating system and helps process pain-related emotion.[2,22] The ACC is also involved in modulating anxiety levels. One study used EEG to monitor brain waves in the ACC of patients engaging in VR meditation and reported decreased beta waves consistent with relaxation and decreased anxiety.[23] Therefore, it is likely that VR engages concentration, emotion, and multiple sensory systems to alter the body's pain modulating system and anxiety response.

One limitation of the present study is the absence of physiological measures of anxiety due to logistical constraints within our ED environment and personnel. However, we aimed to mitigate this by developing comprehensive, multifactorial pre- and postprocedure surveys that assess multiple aspects of the patient experience, including pain, anxiety, relaxation, and overall satisfaction. Although self-reported measures of anxiety and pain have been found to correlate with physiological measures lending credibility to our findings, adding physiological measures, such as heart rate and mean arterial pressure, to subsequent research protocols would yield more objective outcomes.[24,25] Future adaptations of the VR system for this setting can also entail collecting pulse oximetry data from the hand that holds the toggle. An additional limitation in our study is the absence of reports of preexisting motion sickness from any of the patients using the VR headset. Consequently, the potential negative effects of VR on patients who are predisposed to motion sickness remain unclear. This is a notable concern that requires further evaluation, particularly in patients who are unfamiliar with headsets and may be unaware of their susceptibility to cybersickness. However, another possible adaptation to the VR system can entail adjusting several graphics processing settings, such as frame rate, to mitigate the incidence of such adverse effects. Moreover, procedures conducted in the ED are variable and may sometimes require the patient to be in different positions, thus an important modification to the VR system involves ensuring 100% usability while patients are supine and with either one or two hands available. Another limitation is that our study did not encounter any patients requiring bilateral procedures in the ED. Nevertheless, the headset offers an immersive experience without the hand-held controller, limited only by advanced functions such as walking and throwing objects. Future advancements in eye-tracking technologies, however, hold promise for making VR headsets fully functional without the need for hand controllers in patients without a dispensable hand for control usage. Finally, our study omitted a control group due to the heterogenous nature of patients requiring a procedure in the ED, making it difficult to establish a comparable control without confounding variables, such as injury pattern and severity and comorbidities. Furthermore, withholding the early observed antianxiolytic and pain benefits of VR from any eligible patient was ethically questionable. Despite these factors, we recognize the significance of a control group in discerning the true benefits of VR from the confounding effects of anesthetics and the relief associated with the conclusion of the procedure. As such, future studies on VR usage should aim to include this critical component.

As we implement VR as a standard of care for minor awake procedures in the ED at our institution, we hope to include these adaptations, as well as assess how patients in different age groups and with different comorbidities respond to the experience. We advocate for universally offering VR to all patients, recognizing potential variations in individual preferences. Although younger patients with greater exposure to immersive technologies may be more inclined to opt in, we believe VR should be uniformly available to all patients, including the geriatric population. Although geriatric patients and those with preexisting anxiety may be more resistant to this novel technology, we believe they will also find the VR experience to be beneficial. Moreover, young children who may be more easily distracted can potentially see greater benefits from using VR during procedures. Notably, our findings confirm a high safety profile for VR with the ability to discontinue sessions if a patient becomes uncomfortable, so there is minimal risk.

CONCLUSIONS

Our findings demonstrated VR's efficacy in alleviating patient pain and anxiety during minor hand procedures in the ED setting. VR's visual, auditory, and proprioceptive stimulation allow for a unique combination of continuous active and passive distraction. No adverse events were reported, including cybersickness, highlighting its high safety profile. Moreover, the relatively insignificant purchase price and negligent maintenance costs make the VR headset a viable, cost-effective device to implement into clinical practice. Although additional research is warranted for a comprehensive quantification of VR's potential benefits in a controlled setting, we recommend considering VR as a standard

offering for patients requiring wide-awake minor hand procedures in the ED.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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