Virtual Reality for Pediatric Postoperative Pain Management: Exploring Methods and Efficacy – Narrative Review

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Submitted to: Journal of Medical Internet Research
on: November 04, 2024

Table of Contents

Original Manuscript..... 4

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Abstract

Ineffective postoperative pain management is associated with several negative consequences, including increased morbidity, impaired physical function and quality of life, delayed recovery, prolonged opioid use during and after hospitalization, and increased healthcare costs. Traditional pain management therapies, including pharmacological interventions, have several drawbacks, particularly in children, with growing concerns over long-term opioid abuse. Virtual reality (VR) has emerged as a promising non-pharmacological intervention for pain management in various clinical settings. VR technology immerses individuals in computer-generated environments, providing them with multisensory experiences that can distract and engage their attention, ultimately reducing their perception of pain. Evidence from various studies demonstrates beneficial effects of using VR for pediatric pain management, with improvements in pain outcomes, including decreased pain intensity and pain symptoms, as well as reduced need for rescue analgesia. Throughout this review, we address the major concepts related to VR, the use of VR in differing clinical situations, various VR-based therapy methods, and the practicality of VR to alleviate pain, as well as several key findings to date and future directions.

(JMIR Preprints 04/11/2024:68348)
DOI: https://doi.org/10.2196/preprints.68348

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Abstract

Ineffective postoperative pain management is associated with several negative consequences, including increased morbidity, impaired physical function and quality of life, delayed recovery, prolonged opioid use during and after hospitalization, and increased healthcare costs. Traditional pain management therapies, including pharmacological interventions, have several drawbacks, particularly in children, with growing concerns over long-term opioid abuse. Virtual reality (VR) has emerged as a promising non-pharmacological intervention for pain management in various clinical settings. VR technology immerses individuals in computer-generated environments, providing them with multisensory experiences that can distract and engage their attention, ultimately reducing their perception of pain. Evidence from various studies demonstrates beneficial effects of using VR for pediatric pain management, with improvements in pain outcomes, including decreased pain intensity and pain symptoms, as well as reduced need for rescue analgesia. Throughout this review, we address the major concepts related to VR, the use of VR in differing clinical situations, various VR-based therapy methods, and the practicality of VR to alleviate pain, as well as several key findings to date and future directions.

Keywords: *Virtual reality, pediatrics, pain management, analgesia, post-operative*

Abbreviations

Abbreviation	Meaning
BF	Biofeedback
CAM-S	Children's Anxiety Meter Scale
CAU	Care as usual
CBT	Cognitive Behavioral Therapy
CFS	Children's Fear Scale
FLACC	Face, Legs, Activity, Cry, Consolability
FPS-R	Faces Pain Scale-revised
HRV	Heart rate variability
MCDAS(f)	Faces version of Modified Child Dental Anxiety Scale
mYPAS	Modified Yale Preoperative Anxiety Scale
PACU	Postoperative anesthesia care unit
PAED	Pediatric Anesthesia Emergency Delirium Scale
PHBQ-AS	Post Hospitalization Behavior Questionnaire for Ambulatory Surgery
PPAS	Persistent pain after surgery
PPPM	Parents Postoperative Pain Measure
STAI	State Trait Anxiety 6-question short form
VAS	Visual Analog Scale
VR	Virtual Reality
VR-BF	Virtual Reality-Biofeedback
VR-CBT	Virtual Reality-Cognitive Behavioral Therapy
VR-D	Virtual Reality-Distraction Therapy
VR-E	Virtual Reality-Exposure Therapy
VR-GR	Virtual Reality-Guided Relaxation based Therapy
WBS	Wong Baker FACES Pain Rating Scale

Introduction

It has been estimated that more than 25% of hospitalized children have moderate to severe pain because of insufficient pain assessment and management techniques.[1–4] Ineffective postoperative pain management is associated with a number of negative

consequences, including increased morbidity, impaired physical function and quality of life, delayed recovery, prolonged opioid use during and after hospitalization, and increased healthcare costs.[4] A significant amount of effort has been placed on the use of multimodal analgesia to improve these outcomes. Despite these efforts, pediatric postoperative pain remains difficult to treat, increasing the risk of persistent postoperative and chronic pain in this population.[5,6] Various studies have reported persistent pain after surgery (PPAS) in many different pediatric surgical populations.[7–9] Pain following surgery can persist for days to weeks, and even months, leading to time away from school, decreased quality of life, and prolonged physical and emotional disability.[10,11] Furthermore, PPAS is a critical concern when discussing persistent opioid use after surgery.[6] This emphasizes the importance of proper pain management in pediatric patients with the optimization of postoperative analgesia and a decrease in the administration of opioid medications.

Traditional pain management therapies, including pharmacological interventions, may have limitations, particularly in children. Because of growing concerns over long-term opioid abuse among children and adolescents, alternative approaches to alleviate postoperative pain have garnered increasing interest.[6,10] In response to the opioid crisis and the need to address fear, anxiety, and the risks associated with narcotic overuse, there has been a push to identify novel and multimodal approaches to pain and anxiety control in pediatric patients undergoing surgery, aiming to reduce dependence on opioids and facilitating a rapid and effective recovery.[12,13]

Virtual reality (VR) has emerged as a promising non-pharmacological intervention for pain management in various clinical settings. VR technology immerses individuals in computer-generated environments, providing them with multisensory experiences that can distract and engage their attention, ultimately reducing their perception of pain.[14] Various types of VR technologies have been used to treat pain and anxiety, such as distraction-

based VR therapy (VR-D), exposure-based VR therapy (VR-E), guided relaxation-based VR therapy (VR-GR), and biofeedback-based VR therapy (VR-BF). Each of these VR modalities have been studied in various patient populations.[15–19] In recent years, VR has gained attention as a potential tool for pain relief in pediatric patients following surgery.

We conducted a comprehensive literature search to identify relevant studies on the use of VR interventions for postoperative pain management in the pediatric population. The findings of these studies are summarized in this narrative review to provide insights into the potential efficacy and benefits of VR as a non-pharmacological tool to assist in alleviating postoperative pain in children. We review the major concepts related to VR, the use of VR in various clinical situations, and the practicality of VR for pain management. Lastly, the potential future directions for VR are presented.

Methods

A systematic and comprehensive search was performed in the PubMed, EMBASE, PsycINFO, and CINAHL electronic databases from database inception through January 2023. Controlled vocabulary terms (e.g., "virtual reality", "video games", "pediatrics") and keywords (e.g., "VR", "postoperative pain") were used to capture all relevant articles. The search encompassed articles focusing on the use of VR in various pain therapy methods, the practicality of VR for pain alleviation, and key findings and future directions of VR use. The inclusion criteria for this review consisted of randomized clinical trials as well as observational, cohort, and case–control studies.

Studies and Outcomes

DISTRACTION THERAPY (VR-D): Distraction-based VR therapy (VR-D) focuses on using VR as a tool for distraction from painful stimuli. Although the literature is mixed regarding distraction alone, using augmented distraction with VR provides an immersive and engaging experience that may be more effective than distraction alone.[20–22] By focusing their attention on the virtual environment, the perception of pain by a patient can be reduced. VR experiences can range from interactive games to calming visual and auditory simulations.

In a pilot study, Olbrecht et al. provided a single virtual reality distraction (VR-D) session to 50 children after surgery, providing them the option to play one of several VR games.[15] The study included patients who had undergone several different types of procedures, all of whom required pain management by the Acute Postoperative Pain Service: 19 (38%) had abdominal surgery, 17 (34%) had Nuss repair of pectus excavatum or other chest surgery, and 14 (28%) had orthopedic procedures (such as posterior spinal fusion or major hip surgery). Pain and anxiety were assessed at baseline prior to the VR-D session and at 3 time points after VR-D (immediately and 15- and 30-minutes after the experience). Immediately after VR-D, pain intensity decreased (median change -1.0, $p<0.0001$), remaining significant at 15 minutes (median change 0, $p=0.02$), but not at 30 minutes. Pain unpleasantness (how much discomfort the pain was causing the patient) decreased immediately following VR-D (median -1.0, $p<0.0001$), remaining significant at both 15- and 30-minutes ($p=0.0008$ and $p=0.0001$). Finally, anxiety decreased immediately after VR-D (median 0, $p<0.0001$) and at 15 minutes (median 0, $p=0.0014$). Adjusted analyses showed significant decreases in pain intensity and unpleasantness after VR-D versus baseline. Reductions were also significant at later time points for pain unpleasantness but not intensity. No adjusted differences were seen for anxiety. Given that this study was not a randomized controlled trial, there were multiple limitations, particularly

in the lack of a control group. In addition, patients received only one VR-D session, there was variability in the timing of the session, and a heterogeneous patient population was included. Nevertheless, this pilot study showed the feasibility of using VR-D in children after surgery and provided preliminary evidence that a single VR-D session may be associated with a reduction in pain intensity and unpleasantness in children after surgery, laying the foundation for a larger randomized controlled trial to assess the efficacy and optimal timing/ duration of VR for pediatric postoperative pain management.

Buyuk et al. assessed the effectiveness of a VR intervention following circumcision in 5- to 10-year-old boys in a randomized controlled trial.[16] The study included 78 subjects who were divided into a control group (n=38) and an experimental group (n=40). The control group received standard care before surgery. The experimental group received a VR intervention in addition to standard care before surgery. Two VR programs were chosen for the study: one simulated walking through the Amazon rainforest, and the other simulated water skiing. Before surgery, the children in the experimental group were allowed to view one of the VR programs for an average of 4.5 minutes. Data was collected using the children's fear scale (CFS), the children's anxiety meter scale (CAM-S), and the Wong-Baker Faces Pain Rating Scale (WBS). Compared with the control group, children in the experimental group who received the VR intervention had significantly reduced CAM-S and CFS scores both before and after surgery. Furthermore, the experimental group's postoperative WBS scores were considerably lower. The study’s greatest limitation, however, was that analgesic consumption was not consistently tracked between the groups thereby adding significant risk for a confounding factor that would influence results. This study was notable because it was designed as a randomized controlled trial and demonstrated the potential benefits of adopting a VR intervention to reduce pre- and postoperative anxiety, fear, and pain in children undergoing circumcision. Nevertheless,

these limitations make it somewhat difficult to interpret the results.

Specht et al. conducted the first randomized study to examine the effects of VR as a non-pharmacologic intervention in the immediate postoperative period. Patients were randomized to using either VR (n=50) or an iPad tablet (control, n=56) for 30 minutes after surgery in the postoperative anesthesia care unit (PACU).[23] The Oculus Go devices were preloaded with the immersive Nature Treks VR application, while iPads were preloaded with educational games approved by Child Life Specialists. Assessments were done at multiple time points. Prior to surgery, patients self-reported pain using the WBS and anxiety using the Spilberger State Trait Anxiety 6-question Short Form (STAI) scale. Caregivers assessed their child for pain using the Visual Analog Scale (VAS). In the PACU, pain (VAS, WBS), anxiety (STAI) and Face, Legs, Activity, Cry, Consolability (FLACC) scores were repeated before the intervention; and FLACC assessments were done at baseline and 10-, 20-, and 30-minutes during the intervention. Follow-up was done with the Post Hospitalization Behavior Questionnaire for Ambulatory Surgery (PHBQ-AS) at 2-3 days and 7-10 days after discharge. After adjusting for age, gender, and pre-operative anxiety, patients using VR had significantly lower pain scores compared to the iPad group (p = 0.021). Younger patients (aged 7-12 years) were more likely to have decreased pain scores during VR use compared to older patients (aged 13-18 years), even after adjusting for treatment group, gender and STAI (p = 0.044). This was most significant after 20-30 minutes of VR use (p = 0.0003). Younger patients had higher odds of withdrawal or exclusion from the study compared to older patients, after adjusting for treatment group, gender and STAI (odds ratio 2.95, p=0.021). There was no significant difference in opioid consumption between the VR and iPad groups (p = 0.766). Pre-operative and post-operative self-reported pain scores were not significantly different between groups (p = 0.821 and p = 0.932 respectively), but at the 7-10 day follow-up, PHBQ-AS scores were significantly lower in the VR group

(p=0.006). Younger patients were also found to have higher odds of decreased FLACC scores over time regardless of intervention group ($p<0.05$). In summary, VR was more effective than iPad use in reducing observational pain scores (FLACC), especially in younger patients, but there was no difference in opioid consumption or patient-reported pain scores between the groups. Limitations of this study included premature study termination due to COVID-19, with only 106 of a planned 150 patients included in the study. There was also a self-selection bias as this study recruited voluntary participants. There was also variability in child self-reports and the use of multiple research assistants to assess patient outcomes. Nevertheless, this randomized controlled trial provides preliminary evidence that VR can reduce observational pain scores in children after surgery compared with a similar iPad distraction intervention. However, limitations like the smaller sample size preclude definitive conclusions.

Another randomized controlled trial conducted by Kumari et al. evaluated the effectiveness of VR as a distraction tool for children undergoing dental procedures.[24] The study included 200 subjects, with 100 allocated to the immersive VR group and 100 to the non-immersive VR group. During the immersive VR intervention, children played videogames using a hand-held controller, allowing them to explore and interact with the VR environment. For non-immersive VR, participants watched a cartoon movie. All participants were given a few minutes to familiarize themselves with the VR headset and controller prior to treatment initiation. Then a local anesthetic gel was placed followed by local anesthetic injection. Immediately after the local anesthetic injection, the VR equipment was retrieved from the patient, and the child's pain perception was assessed using VAS and WBS, and anxiety was evaluated via the Faces version of the Modified Child Dental Anxiety Scale (MCDAS(f)). Various dental procedures were then performed. Pre-operatively, mean MCDAS scores were similar between the immersive (29.20 ± 3.197) and non-immersive

(29.09 ± 3.803) (p=0.82) groups. Postoperatively the non-immersive group had higher MCDAS scores (20.72 ± 2.822) compared to the immersive group (10.99 ± 2.227, p=0.00). Post-operatively, the non-immersive VR group had higher VAS pain scores (2.72 ± 0.99) compared to the immersive group (0.75 ± 0.88, p=0.00). Similarly, postoperative WBS scores were higher in the non-immersive group (2.78 ± 1.097) versus the immersive group (0.82 ± 1.104, p=0.00). In summary, both the VAS and WBS pain scales indicated significantly higher postoperative pain levels in the non-immersive versus immersive VR groups. The immersive VR environment was more effective in reducing perceived pain during intraoral injections. This study had some limitations. While the study examined immersive and non-immersive VR effects on pain perception, it did not examine differences in the time to achieve immersion or variable effects between genders. Secondly, the authors did not compare pain perception based on patient education level or social status. Additionally, the bulkiness of the VR device may limit applicability for younger age groups and future research should explore different device sizes and collaborate with manufacturers to develop more user-friendly devices suitable for all age groups.

EXPOSURE THERAPY (VR-E): VR-based exposure therapy (VR-E) combines VR technology with exposure therapy to mimic any triggers, stressors, or fears a patient may have, exposing the patient to these triggers/stressors in a VR environment. Such triggers may include sights, sounds, smells, and vibrations that create realistic versions of the traumatic or stressful experience. This can be particularly useful for individuals with chronic pain or phobias. By gradually exposing them to their fears in a virtual setting, it helps desensitize their response to pain and anxiety.[25]

Eijlers et al. conducted a randomized controlled trial of VR-E (n=94) versus control/care as usual (CAU, n=97) in children undergoing elective day surgery to investigate if VR-E before surgery could reduce anxiety, pain, and delirium following surgery.[17] The VR

environment was designed to mimic the real operating room and medical staff, familiarizing children with the surgical environment and procedures via an interactive, developmentally-appropriate context using child-friendly, interactive computer-generated graphics presented via a head-mounted display for approximately 15 minutes. Two age-appropriate versions were created for children 4-7 and 8-12 years old. The study assessed child anxiety at multiple time points using the modified Yale Preoperative Anxiety Scale (mYPAS) including at hospital admission (VR-E median 26.7 vs CAU 26.7, p=0.697), in the holding area (VR-E 28.3 vs CAU 28.3, p=0.765), and during the induction of anesthesia (VR-E 40.0 vs CAU 38.3, p=0.862). Self-reported anxiety on VAS was also measured at admission (VR-E 3.0 vs CAU 1.5, p=0.407), in the holding area (VR-E 3.0 vs CAU 3.5, p=0.753), and postoperatively (p>0.05 at all postoperative time points). Pain was assessed in the recovery room through child self-report on the Faces Pain Scale - Revised (FPS-R) (VR-E 2.0 vs CAU 2.0, p=0.699), nurse observation with the FLACC scale (VR-E 0.0 vs CAU 0.0, p=0.669), and parent report on the Parents' Postoperative Pain Measure (PPPM) (VR-E 3.0 vs CAU 3.0, p=0.410). Emergence delirium was measured by the Paediatric Anaesthesia Emergency Delirium (PAED) scale and was not significantly different between groups (p=0.266). The only significant finding was that after tonsillectomy, the VR-E group required less postoperative rescue analgesia (55%) compared to controls (95.7%; p=0.002). In this study, VR-E did not significantly reduce postoperative anxiety, postoperative pain, or emergence delirium compared to standard care, but was associated with a reduction in postoperative rescue analgesia after tonsillectomy. The strengths of this study included a large sample size, limited missing data, standardized assessment tools, blinding of participating staff, and a narrow range of surgical procedures. However, the study also had limitations, including the use of only one postoperative assessment, the lack of measurement of satisfaction with VR-E, a large number of children discontinuing study

participation (n=21), and the exclusion of the most anxious children in the study population.

Yaz et.al. randomized 132 children undergoing surgery into 3 groups: educational animation VR (n=44), documentary VR (n=44), and control (n=44). A short, animated video was shown to the educational animation VR group (AG) to educate participants on preoperative and postoperative procedures. It covered the step-by-step process from the child's initial hospital visit for examination and vital sign checks, wearing a surgical gown, going to the operating room, and postoperative care including pain assessment. The documentary VR group (DG) saw a short documentary video with instrumental music that included forests, trees, and flowers. The documentary film was chosen by the researchers and consultant based on the cognitive levels of the children. The control group (CG) received routine care.[14] At baseline, there were no significant differences between the three groups in mean self-reported (AG 2.89 ± 0.72, DG 2.82 ± 0.58, CG 2.98 ± 0.66; p<0.001) and parent-reported fear scores (AG 2.77 ± 0.71, DG 2.52 ± 0.62, CG 2.68 ± 0.67; p<0.001). After watching the video, the animation group had significantly decreased self- and parent-reported mean fear scores (decrease from 2.89 ± 0.72 to 0.91 ± 0.85 and 2.77 ± 0.71 to 1.3 ± 0.76, respectively; p<0.001). The differences in the change in fear scores between pre- and post-video were significantly greater for the educational animation group compared to the documentary (p<0.001 for child and parent ratings) and control groups (p<0.001 for child and parent ratings). Intergroup comparison of mean pain scores showed an overall difference between groups (p<0.001). Based on children's self-reports, pain scores were lower in the animation group compared to control and documentary, with no difference between the documentary and control groups (p=0.097). However, both parent and nurse evaluations of children's pain found that scores were lower in the animation versus documentary and control groups. Additionally, parents and nurses reported a statistically significant difference in pain scores between documentary and control groups (p

= 0.035 for parents, p = 0.029 for nurses), unlike the children's self-reports. In this study, VR-E was effective in reducing preoperative fear and postoperative pain. While this intervention shows promise, larger studies are needed to better assess the value of this therapy.

GUIDED RELAXATION-BASED VR (VR-GR): Combining strategies of traditional mind–body therapies, such as relaxation, slow breathing, mindfulness, and biofeedback, with the immersive nature of VR opens new possibilities for multimodal analgesia and has the potential to simultaneously minimize acute postoperative pain and opioid consumption. VR-GR is a promising mechanism to deliver mind–body-based therapy (guided relaxation) and potentially enhance the effectiveness of these techniques to promote pain relief.[26]

Olbrecht et al. provided a single 10-minute VR-GR session to 51 children and adolescents after surgery using the Mindfulness Aurora application, an application that provides a guided relaxation session.[18] Pain intensity and unpleasantness and anxiety were assessed immediately before the session as well as immediately after and at 15- and 30-minutes after session conclusion. Pain intensity decreased immediately ($p<0.001$) and at 30-minutes ($p=0.04$) following the session, but not at 15-minutes ($p=0.16$) after VR-GR compared to baseline. Pain unpleasantness decreased at all evaluated time points ($p<0.001$). Anxiety decreased immediately ($p=0.02$) but not at 15- or 30-minutes after VR-GR. Patients with higher anxiety sensitivity scores had greater reductions in pain intensity ($p=0.04$) and unpleasantness ($p=0.01$). This study also assessed patient and parent satisfaction with VR. Overall, 96% of children would recommend VR and 88% believed they felt calmer and could better tolerate pain after VR-GR. Parents reported similarly positive experiences. While this is the first study to combine VR with mind-body therapy for pediatric postoperative pain, limitations of this study included the lack of a control group, potential interaction effects with the study team, no data on analgesic use, variable timing of the

postoperative visit, and potential bias in self-reported outcomes. In addition, given that this study was not a randomized clinical trial, no causative relationships between VR-GR and effects on pain and anxiety can be drawn. However, this pilot study provides initial evidence that a single VR-GR session is associated with a reduction in pain intensity and unpleasantness in children after surgery. These effects were immediate and sustained for up to 30-minutes after the experience. This study also lays the foundation for and highlights the need for a randomized controlled trial assessing the use of VR-GR to reduce pain, anxiety, and opioid consumption in children and adolescents having surgery.

Biofeedback-Based VR (VR-BF): More recently, biofeedback-based VR (VR-BF) has emerged as a potentially novel method to reduce pain, anxiety, and opioid consumption in children after surgery. Biofeedback (BF), a nonpharmacological, complementary therapy, teaches patients skills necessary for behavioral adjustments that affect involuntary systems. Slow breathing, for example, increases heart rate variability (HRV), which reduces pain by downregulation of the sympathetic nervous system.[19] VR-BF is a technique that uses VR to deliver BF, thereby increasing the immersion of this therapy. To date, no randomized clinical trial has been performed utilizing VR-BF for pain and anxiety management and, as such, it remains unclear how this therapy needs to be integrated in perioperative management.

Orgil et al. proposes a randomized pilot trial with 70 patients, aged 12-18 years, undergoing surgery expected to cause moderate-severe pain. Participants will be randomized to VR-BF (n=35) or Manage My Pain, a commercially available pain management application (control, n=35).[27] VR-BF will be used preoperatively for education and training, and postoperatively for pain management. The primary outcome is the feasibility of integrating perioperative VR-BF. Secondary outcomes include acceptability, pain, anxiety, and opioid use. Participants will document session usage and pain, and anxiety measures using the numerical rating scale. Some limitations of this planned study

include limits in generalizability, both based on the specific patient population used as well as the academic healthcare setting. Nevertheless, if feasibility of this intervention is demonstrated, a larger clinical efficacy trial will then be warranted.

VIRTUAL REALITY COGNITIVE BEHAVIORAL THERAPY (VR-CBT): VR can also be used as a tool in conjunction with cognitive behavioral techniques (CBT) to manage pain. By combining VR environments with cognitive strategies, individuals can learn to identify and challenge negative thoughts and emotions associated with pain. This approach modifies the perception and interpretation of pain, leading to reduced suffering.[28] VR-CBT combines many of the prior-mentioned principles of other VR strategies that help the patient focus on biofeedback (breathing pattern), while also providing distraction and immersive enjoyment. The FDA recently approved the use of a VR-CBT device for use in adult patients with diagnosed chronic back pain, however, the use of this technique in pediatric patients has not yet been explored.

Conclusion

In this narrative review, we analyzed 8 studies using VR as an intervention for perioperative pain and anxiety management in pediatric patients. Out of these, 6 were randomized controlled trials and 2 were prospective pilot studies. The studies investigated various VR modalities including VR distraction (VR-D), guided relaxation-based VR (VR-GR), and VR exposure (VR-E). Two prospective pilot studies from Olbrecht et al. demonstrated promising preliminary results. In their VR-D study, they found that there was immediate decrease in pain intensity that lasted up to 15 minutes post-intervention, as well as pain unpleasantness reduction persisting for 30 minutes. The VR-GR trial found similar transient reductions in pain intensity and anxiety but was not clinically significant (defined as a reduction of ≥2 points on the NRS or 30% reduction in pain). Among the randomized

controlled trials, Buyuk et al. found that patients who underwent circumcision and used VR had significant reduction in anxiety and fear scores both pre- and post-operatively, with reduced postoperative pain scores as measured by the Wong-Baker Scale. Specht et al. demonstrated VR's superiority for immediate postoperative pain management over iPad use, with notably better outcomes in younger patients despite a higher withdrawal rate. Kumari et al. specifically assessed immersive versus non-immersive VR during dental procedures, finding both methods effective for anxiety reduction but superior pain control with immersive VR during intraoral injections. Eijlers et al. conducted a larger trial to investigate the VR exposure before elective day care surgery. While they found no significant impact on anxiety or emergence delirium, they did observe a clinically important reduction in rescue analgesia following more painful surgeries. Yaz and Yilmaz found that educational animated VR movies effectively reduced both preoperative fear and postoperative pain scores compared to control groups. The ongoing trial by Orgil et al. is investigating the feasibility of perioperative biofeedback-based VR integration. Several important limitations were noted across these studies. Common limitations included the lack of standardization in VR session timing and duration, a potential self-reporting bias in pain assessments, and varying control group designs impacting the interpretation of the results. Studies by Olbrecht et al. did not evaluate changes in opioid consumption or control for pain medication usage, and their VR sessions were single sessions with irregular timing. In Buyuk et al.’s study, only parents and researchers evaluated pain score measurements and Specht et al.’s study was ended prematurely because of the COVID-19 pandemic, had not power estimates, and might have been biased by self-selection. Eijlers et al.'s study excluded the most anxious patients who received anxiolytic premedication, and they reported that 21 children stopped the intervention because of the big and heavy headset, which especially affected those between the ages of 4 and 5. According to Orgil et al.'s

study, certain patient demographics and academic hospital settings hindered the findings' generalizability.

While the current evidence suggests VR as a promising non-pharmacological intervention for perioperative pain management in pediatrics, future studies should prioritize focusing on conducting large-scale randomized controlled trials with standardized protocols while investigating the optimal timing and frequency of VR interventions. VR's benefits appear transient. While promising, these findings indicate the need to examine long-term outcomes and sustained benefits through repeated VR sessions integrated in perioperative management versus a single session. Additionally, future research should monitor analgesic consumption and integrate objective pain assessments while evaluating cost-effectiveness and implementation strategies in clinical settings. The collective findings from these studies provides a foundation for future research while highlighting the potential use of VR technology in pediatric pain management.

Conflicts of Interest

None declared.

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