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The effect of a 360º educational video in a virtual reality on preoperative fear and postoperative pain in children undergoing tonsillectomy/adenoidectomy: a blind, randomized, controlled study

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Abstract

Background Preoperative anxiety and postoperative discomfort are critical issues in pediatric surgical management, especially in children undergoing tonsillectomy/ adenoidectomy. Virtual Reality (VR) is an immersive, non-pharmacological approach that may alleviate anxiety and improve procedural tolerance.

Aim The aim of this study was to assess the efficacy of a 360-degree educational virtual reality movie in alleviating preoperative anxiety and postoperative discomfort in children aged 6 to 12 years undergoing tonsillectomy/ adenoidectomy.

Methods A single-blind, randomized controlled trial was performed with 92 pediatric patients allocated to either an experimental group ($n=46$), who viewed a 360° VR educational video, or a control group ($n=46$) that got conventional preoperative care. The Children's Fear Scale and Wong-Baker Faces Pain Rating Scale were employed to evaluate preoperative anxiety and postoperative discomfort, respectively. The Wilcoxon Signed Rank test and the Mann–Whitney U test were employed for data analysis.

Results Participants in the VR group demonstrated markedly reduced fear scores following the intervention (Median (Q3-Q1) = 2 (3–1)) in contrast to pre-intervention levels (Median (Q3-Q1) = 3 (4–2), $p<0.001$), as well as when compared to the control group (Median (Q3-Q1) = 3 (4–2), $p<0.001$). Postoperative pain levels were considerably reduced in the VR group (Median (Q3-Q1) = 6 (7–5)) compared to the control group (median = 7 (8–6), $p<0.001$).

Conclusion A 360° educational movie in virtual reality was associated with significantly lower preoperative fear and postoperative pain compared with standard care in children undergoing tonsillectomy/adenoidectomy. The findings suggest that VR may serve as a valuable adjunct in pediatric preoperative preparation; nevertheless, further large-scale and multi-center studies are necessary to corroborate these results.

Trial registration Retrospectively registered. approved by TCTR Committee on 13 May 2024. The TCTR identification number is TCTR20240513003.

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Keywords Pediatric surgery, Preoperative anxiety, Postoperative discomfort, Virtual reality, Tonsillectomy, Non-pharmacological intervention

What is already known

1. Preoperative anxiety and postoperative discomfort are critical issues in pediatric surgery patients.
2. Virtual reality and educational movies are non-pharmacological therapies that demonstrate efficacy in alleviating anxiety and pain in children undergoing medical procedures.

What this paper adds

1. A 360-degree educational virtual reality film markedly alleviates preoperative anxiety in pediatric patients undergoing tonsillectomy or adenoidectomy.
2. This intervention significantly reduces postoperative pain compared to usual care, Underscoring its importance as a supportive therapeutic tool in pediatric surgery.

Introduction

Unfavorable experiences in the medical field greatly increase patient anxiety, with particularly severe consequences for children and their parents. These encounters may seem burdensome and upsetting. A study by Li [1], have clarified that a variety of hospital environmental elements may contribute to elevated levels of anxiety, discomfort, and fear in pediatric patients. These variables include a wide range of stressors, such as strange environments, changes in daily schedules, interactions with strangers, uncomfortable medical procedures, being cut off from social and family support systems, symptoms like pain and vomiting, decreased autonomy, limited physical activity, communication barriers, dim lighting, and being around other young patients who are in distress [2]. Traumatic stress may occur in pediatric patients who struggle with the cognitive integration of medical procedures, especially surgical operations [2]. It has been suggested that proactive preoperative informational sharing is a useful tactic to enhance children patients' sense of control over medical and surgical procedures, hence considerably reducing their pain and anxiety experiences [3].

Children's physical and mental health are clearly impacted by excessive stress, anxiety, and suffering. Young patients who are having trouble managing medical interventions might present with a variety of behavioral changes, such as crying, obstinacy, loud complaints, denial, and hyperactivity. Thus, it is imperative that clinical researchers develop, carry out, and assess interventions like educational initiatives and therapeutic play that support young patients' capacity to control or lessen anxiety during hospital stays and medical procedures [4]. The effectiveness of preoperative education programs in preparing children for surgery has been acknowledged [5]. Children's preoperative sensations of worry, anxiety, fear, and discomfort can be considerably reduced by the use of games, toys, and video-based teaching resources [6]. According to Li et al. [1] when toys are used to explain preoperative procedures and the operating room atmosphere, children aged 7 to 12 experience less postoperative anxiety. He et al. study [7] found that exposing children aged 6 to 14 to video depictions of the surgical setting reduced their preoperative anxiety, fear, and postoperative pain. Buyuk & Bolisik [5] observed that preoperative education is effective in reducing fear and anxiety in children. Preoperative video distraction has been shown by Kim study [6] to be an effective strategy for lowering anxiety in young patients. Children between the ages of 6 and 12 showed cooperative behaviors and were open to instructional interventions, suggesting that they were inclined to stay calm and participate in educational activities. Children's preoperative anxiety and postoperative pain have been shown to be reduced by educational programs that use visual components [2, 8]. The aim of the current study is to thoroughly examine how a 360° educational virtual reality movie affects preoperative fear and postoperative pain in pediatric patients (6 to 12 years old) having tonsillectomy/adenoidectomy surgery.

The study's hypotheses

The hypothesis states that children who watch a 360-degree educational video in a Virtual Reality (VR) will have lower preoperative fear than children in the control group, as measured using children's fear scale. Moreover, it is expected that children who watch a 360-degree educational video in a VR will have lower postoperative pain, as determined by Wong-Baker Faces Pain Rating Scale, in comparison to children in the control group.

Methods

The aim: of the current study is to thoroughly examine how a 360° educational virtual reality movie affects preoperative fear and postoperative pain in pediatric

patients (6 to 12 years old) having tonsillectomy/adenoidectomy surgery.

Research design

A prospective, randomized, single-blind, controlled trial design. Ninety-two pediatric patients were divided into two groups using randomization: an experimental group ($n=46$) that watched a 360° educational video in VR, and a control group ($n=46$) that got regular medical care. Throughout the inquiry, rigorous adherence to the CONSORT checklist was maintained. Although the study was registered retrospectively in the Thai Clinical Trials Registry (TCTR20240513003), the protocol, including objectives, methodology, and outcome measures, had been approved by the Institutional Review Board before participant recruitment began, and no changes were made thereafter.

Site and setting

This study was conducted from June 2022 to April 2023 in a pediatric surgery unit in a university hospital located the northern West Bank of Palestine.

The characteristic of participant

Pediatric patients (6 to 12 years old) having tonsillectomy/adenoidectomy surgery. Those who fit the following criteria were included in the study: they had to be proficient in Arabic, having their first surgical procedure, scheduled for routine, everyday surgeries, and willing to participate in the study. These standards guarantee the homogeneity of the study population as well as the ability of participants to comprehend and interact with the study's materials and techniques.

Refusal to participate, hereditary or congenital problems, chronic illnesses, undergoing second or subsequent procedures, and lack of Arabic language proficiency were all grounds for exclusion from the study. In order to ensure that the data obtained is as accurate and trustworthy as possible, these exclusion criteria are designed to remove variables that may potentially confound the study results.

Sample size and sampling methods

Utilizing G*Power 3.1.9.4 and an 80% power threshold, 0.05 alpha level, and 0.3 effect size, the sample size was determined to guarantee excellent statistical power and significance. The effect size (0.3) used for the sample size estimation was derived from comparable studies evaluating virtual reality or educational video-based interventions in pediatric surgical settings, which reported moderate effects on anxiety and pain reduction [7, 9, 10]. Thus, a minimum of 42 patients were needed for each group. With a proportionate distribution of the sample and a 10% anticipated attrition rate (9 participants), each group contained 46 participants. The eligibility requirements included children between the ages of 6 and 12 years who were having their first surgery, restricted to outpatient procedures and a single intervention, and who could speak Arabic. Genetic or congenital abnormalities, chronic sickness, and prior surgical history were among the exclusion criteria.

Blinding

Blinding healthcare professionals, such as anesthesiologists and postoperative care providers, to the patient group assignment ensured objective clinical observation and management. Because the intervention involved an educational 360° virtual reality video, it was not possible to blind the children or their parents; however, standardized administration procedures and validated scales were employed to minimize performance and detection bias. The trained nursing staff who administered the Children's Fear Scale and Wong-Baker FACES Pain Rating Scale were unaware of each participant's group allocation to reduce observer bias.

Randomization

By using opaque, sealed envelopes with random assignments provided by an impartial healthcare expert unrelated to the study and sequential numbers generated by a Random Number Generator to generate the random allocation sequence, participants were randomly assigned into two cohorts. Group assignments were revealed after verifying patient consent and eligibility. Thirty-one of the 123 children who were first evaluated were eliminated for a variety of reasons, such as prior surgical procedures, pre-existing genetic or chronic diseases, or reluctance to participate. Ninety-two individuals were enrolled in total, with an equal number in the experimental and control groups.

Development of the 360° educational VR video

The educational video was developed in collaboration with the An-Najah Life Support and Simulation Center and guided by Bandura's Social Cognitive Theory [11] and the Cognitive–Behavioral framework for anxiety reduction [12]. The process followed five stages: conceptual design, script-writing, expert validation, production, and pilot evaluation.

1. Conceptual design

The goal was to create an immersive and interactive experience that models the perioperative journey in a calm and reassuring manner. The video was designed to reduce fear through observational learning, allowing children to become familiar with the hospital environment before surgery.

2. Script-writing and narrative approach

The narrative was child-centered and followed a first-person perspective through a peer model (a child actor aged 8 years) preparing for tonsillectomy. The storyline included greeting the nurse, changing into a surgical gown, meeting the anesthesiologist, brief explanations about the anesthesia mask, entering the operating room, and awakening in the recovery area. A friendly narrator used simple Arabic language and a supportive tone to guide the viewer. Soft background music and bright visuals were incorporated to sustain engagement without overstimulation.

3. Expert validation

The content and script were evaluated by a multidisciplinary panel of five experts: one pediatric anesthesiologist, two pediatric nurses, one clinical psychologist, and one child-life specialist. The panel reviewed the video for accuracy, emotional tone, developmental appropriateness, and cultural sensitivity. Revisions were made to simplify terminology, ensure positive framing, and include brief coping cues such as deep breathing and smiling interactions.

4. Production and testing

The video, lasting approximately four minutes, was filmed in the pediatric surgical unit using a 360° camera to create an immersive VR experience compatible with standard headsets. Before implementation, the video was tested with a small group of five children aged 6–12 to ensure comfort, clarity, and realism. Minor modifications were made to pacing and sound quality based on their feedback.

5. Technical specifications and pilot evaluation

The final video was recorded in 4K ultra-high definition (3840×2160 pixels) using an Insta360 ONE X2 camera and edited with Adobe Premiere Pro 2023, rendered in an equirectangular projection format suitable for VR playback. Each participant viewed the approximately four-minute video through a Meta Quest 2 headset featuring a 110° field of view, 3D spatial audio, and adjustable straps for comfort. Prior to study initiation, pilot testing was conducted with five children aged 6–12 who were not part of the main sample to evaluate clarity, acceptability, and emotional response. All participants reported that the content was understandable, engaging, and non-threatening. Minor adjustments were made to reduce background sound and improve scene transitions based on their feedback to ensure psychological safety and comfort.

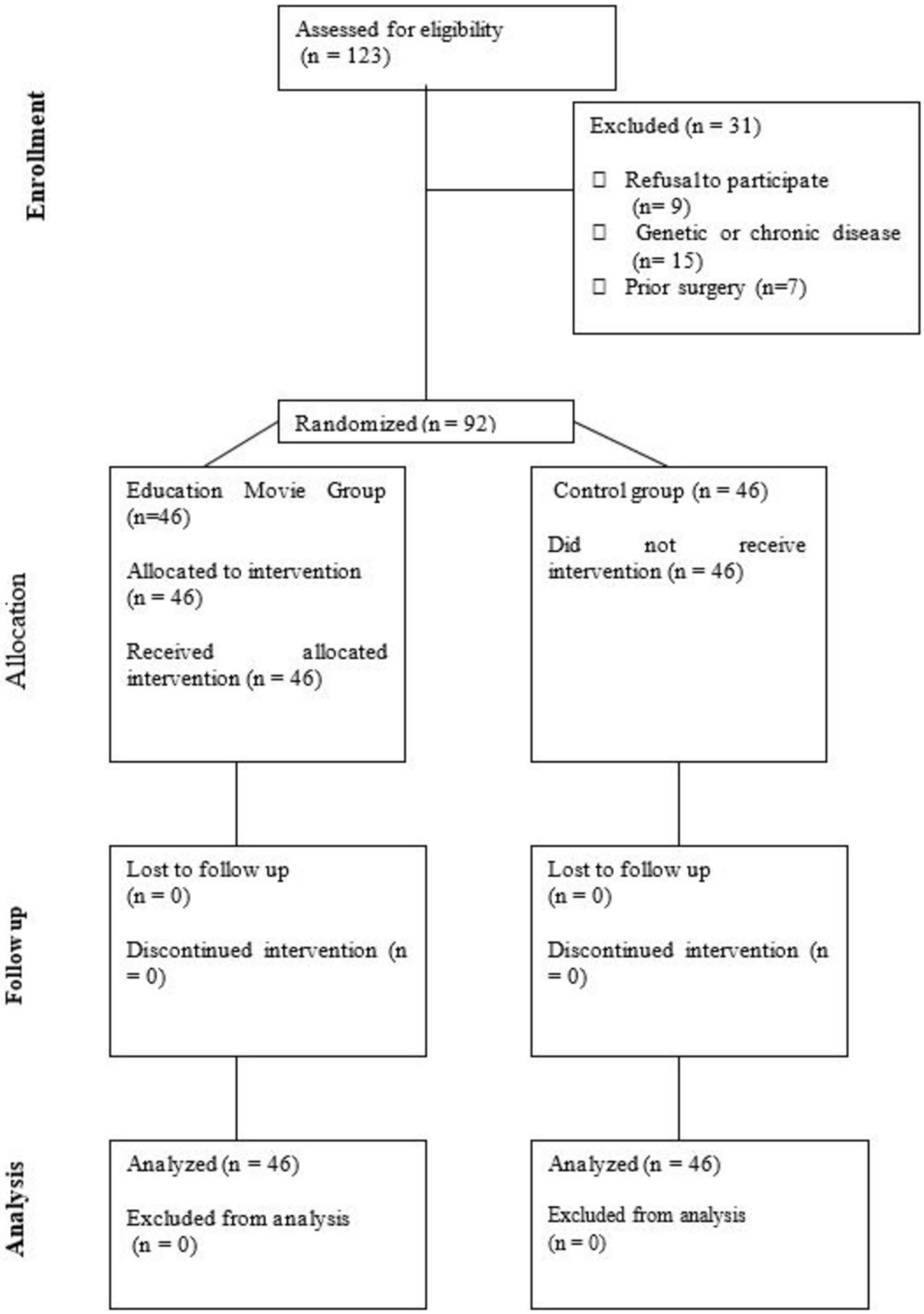
Intervention group procedure

Participants were guaranteed impartial treatment upon providing both verbal and written informed consents from parents and children. After gathering socio-demographic information, the Children's Fear Scale was initially administered preoperative. The experimental group watched a four-minute a 360° educational video in VR. Creating an interactive environment that comforts and realistically prepares children for surgery is the main goal of this intervention. The 360° educational VR video was developed using principles from Bandura's Social Cognitive Theory [11] and the Cognitive–Behavioral framework for anxiety reduction [12], emphasizing modeling, information provision, and guided exposure to decrease uncertainty and fear. The video's content and script were reviewed and validated by a multidisciplinary expert panel consisting of a pediatric anesthesiologist, two pediatric nurses, a clinical psychologist, and a child-life specialist to ensure developmental appropriateness, medical accuracy, cultural sensitivity, and emotional safety. The video depicted the pediatric surgery clinic's preoperative and postoperative procedures. The information covered the following topics: using surgical gowns, physical examination methods, entering the operating room, and postoperative procedures. The Children's Fear Scale was administered again after viewing the video. The Wong-Baker FACES Pain Rating Scale was used to measure pain following surgery for both groups, first in the recovery area and then one hour later. Throughout the intervention, participants were monitored for any signs of cybersickness or discomfort, including nausea, dizziness, eye strain, or disorientation. No sessions required termination, and the short four-minute duration with smooth scene transitions was intended to minimize motion sickness risk.

Control group procedure

This group's participants received conventional preoperative care. Every child who participated in the study received preoperative preparation from the surgery preparation nurse in compliance with standard operating procedures and clinic policy. Standard operating procedures involved explaining the surgery to the parent and child and answering any questions they might have had. A nurse then took their vital signs before putting them in a room that had been reserved for them. Scales were the only tools used to measure the participants' preoperative fear and postoperative pain; no further interventions were used during data collection, which was identical to that of the experimental group.

The Consolidated Standards of Reporting Trials (CONSORT) diagram showing the flow of participants through each stage of a randomized trial.


Enrollment
Assessed for eligibility (n = 123)
Excluded (n = 31)
Refusal to participate (n= 9)
Genetic or chronic disease (n= 15)
Prior surgery (n=7)
Randomized (n = 92)
Allocation
Education Movie Group (n=46)
Allocated to intervention (n = 46)
Received allocated intervention (n = 46)
Control group (n = 46)
Did not receive intervention (n = 46)
Follow up
Lost to follow up (n = 0)
Discontinued intervention (n = 0)
Lost to follow up (n = 0)
Discontinued intervention (n = 0)
Analysis
Analyzed (n = 46)
Excluded from analysis (n = 0)
Analyzed (n = 46)
Excluded from analysis (n = 0)

Measurement tools

Socio-demographic data form

The principal investigator of this study developed a sociodemographic data form based on existing literature. This tool was created to gather detailed data regarding the child's surgical experiences, history of hospitalizations, and sociodemographic background. Direct, face-to-face interviews with study participants were used to collect data.

The Children's Fear Scale

The Children's Fear Scale was created by McMurtry et al. and is a proven empirical tool for measuring fear in pediatric patients. It consists of five different face expressions that represent different levels of fear. The measure, which has been shown to be a valid and reliable tool for assessing fear in pediatric patients, ranges from 0 (maximum fear) to 4 (lack of fear) [13].

Wong-Baker Faces Pain Rating Scale

Children between the ages of six and twelve are assessed for pain using the Wong-Baker Faces Pain Rating Scale. Six facial expressions are included in this scale, and each one corresponds to a pain level between 0 (no pain) and 10 (the most severe pain). It is noteworthy that this instrument is effective in assessing acute pain without requiring verbal or numerical expression, and its accuracy and reliability have been verified [14].

Data collection procedure

The Institutional Review Board of An-Najah National University provided ethics approval, Ref: Nsg. August.2022. Once all participating parents and children gave their written and verbal informed consent. The preoperative sociodemographic information form was provided to a selected group of children and their parents to complete. The Children's Fear Scale was used for the both groups preoperatively. In line with the study procedure, children in the experimental group spent about four minutes watching a 360° educational virtual reality video. After viewing the video, both the experimental and control groups of children were asked to retake the Children's Fear Scale. The Wong-Baker Faces Pain Rating Scale was used to measure the children's pain after they were back in their rooms after surgery and once more an hour following surgery. The nursing staff did not know which particular intervention (video) the children had watched throughout the postoperative time.

Statistical analysis

The analysis of the collected data was executed using SPSS software, version 26. Descriptive statistical methods, including medians, quartiles, frequencies, and percentages, were utilized to delineate sample characteristics. Comparative analyses, both within and between groups, were conducted using the Wilcoxon Signed Rank test and the Mann–Whitney Test, applied independently for pre- and post-intervention comparisons.

Ethics approval and consent to participate

An-Najah National University's Institutional Review Board provided the required permissions and clearances for this study (Ref: Nsg.August.2022). The protocols followed the guidelines outlined in the Helsinki Declaration. Information on the study's goals, the confidentiality of the data they submitted, their ability to withdraw from the study, and access to the study's results were all given to the participants. Before sampling, the required permissions were obtained from the appropriate authorities, and all subjects provided written informed consent.

Results

Demographic data

In terms of the demographic makeup of the study's child sample, there is a discernible difference in the gender distribution between the experimental group (EMG) and the control group (CG) that watched the 360° educational virtual reality video. In particular, the EMG group is composed of (50%) female participants and (50%) male participants while the CG has a majority of male participants (60.9%) in its cohort. Every child participant in both groups had at least one parent with them, yielding a 100% accompaniment rate.

When comparing the two groups' past hospitalization experiences, a clear difference is seen. A small proportion of the children (56.5%) who had EMGs declared they had never been admitted to the hospital before. On the other hand, a far greater percentage in the CG—more than two-thirds, or 69.6%—said they had no prior hospital experience. Additionally, Table 1 shows that almost half of the children's families in both groups had history of hospital visits, with the EMG and CG reporting 50% and 47.8%, respectively, when looking at the familial context of hospitalization experience.

The Children's Fear Scale (within groups)

Different trends were seen in the Children's Fear Scale scores when comparing the educational movie group (EMG) which watched the 360-degree educational video and the control group (CG). After watching the video in virtual reality, there was a statistically significant decrease in the fear levels on the EMG. When comparing the EMG data before and after the intervention, there was a discernible drop in the median values of the fear scores. In particular, the EMG's pre-intervention fear scores showed a Median (Q3-Q1) = 3

Table 1 Demographic data of children ($n=92$)

Characteristics	EMG ($n=46$)		CG ($n=46$)		*P*-value
Age (year) $\bar{X} \pm SD$	8.91 ± 1.95		8.70 ± 1.83		0.632
	n	%	n	%	
Gender					
Girl	23	50.0	18	39.1	0.294
Boy	23	50.0	28	60.9	
Parent with child					
Yes	46	100.0	46	100.0	---
No	0	0	0	0	
Children Experience of hospitalization					
Yes	20	43.5	14	30.4	0.195
No	26	56.5	32	69.6	
Experience of family's hospitalization					
Yes	23	50	22	47.8	0.835
No	23	50	24	52.2	

The *P*-values are for the Mann–Whitney U Test for two independent samples

EMG Educational Movie Group, *CG* Control Group, *X* Mean, *SD* Standard Deviation

(4–2). These values significantly decreased to a 2 (3–1) in the post-intervention evaluation, with a p-value of less than 0.001 (Table 2).

On the other hand, the analysis in the CG showed that fear scores remained constant during the pre- and post-intervention periods. The very small difference between the median scores of fear served as evidence for this. A p-value of 0.432 was obtained from the CG's intervention scores, which had a Median (Q3-Q1) = 3 (3–2). These values were mostly maintained in the post-intervention scores, which had a Median (Q3-Q1) = 3 (4–2) Table 2.

The Children's Fear Scale (between groups)

When the pre-intervention and post-intervention scores on the Children's Fear Scale were compared between the groups, the analysis showed that the experimental group (EMG) had significantly lower fear scores after watching the 360-degree immersive educational film. The results indicate that during the same post-intervention period, the EMG post-intervention fear scores were significantly lower (Median (Q3-Q1) = 2 (3–1)) than those of the control group (CG) ((Median (Q3-Q1) = 3 (4–2))). The difference between the groups (EMG and CG) post-intervention reached statistical significance (p-value < 0.001).

The pre-intervention fear scores between the EMG and CG, however, did not show a statistically significant difference. The CG's pre-intervention scores, which had a Median (Q3-Q1) = 3 (3–2) closely matched the EMG's reported pre-intervention fear ratings, which had a Median (Q3-Q1) = 3 (4–2) (p-value = 0.200). These results, which include the medians and the inter-quartile ranges for fear levels in the EMG and CG before and after the intervention, are methodically presented in Table 3.

Wong and Baker Faces Pain Rating Scale (between groups)

A significant decrease in pain scores was seen in the experimental group (EMG) after the surgical operation when the post-surgical pain scores from the CG and EMG were compared. The statistical examination of median values of the two groups provides quantifiable evidence of this reduction. Following surgery, the Median (Q3-Q1) pain score on the EMG was 6 (7–5). This was significantly less than the Median (Q3-Q1) pain scores on the CG, that was 7 (8–6). In terms of pain scores after surgery, the statistical difference between the EMG and CG was determined to be significant, $p < 0.001$ (Table 4).

Table 2 Comparison between pre-test and post-test of fear scores in each study group (within groups)

Groups	Pre-test Median (Q3-Q1)	Post-test Median (Q3-Q1)	*P*-value
EMG ($n=46$)	3 (4–2)	2 (3–1)	< 0.001*
CG ($n=46$)	3 (3–2)	3 (4–2)	0.432

The *P*-values are for the Wilcoxon Signed Ranks Test for two related samples

EMG Educational Movie Group, *CG* Control Group, *Q3* Third quartile, *Q1* First Quartile, *Q3-Q1* the inter-quartile range

* The test is significant at the level 0.05

Table 3 Comparison between EMG and CG groups in each study interval (the pre-test and the post-test) of fear scores ((between groups))

Test	Groups		*P*-value
	EMG ($n=46$)	CG ($n=46$)	
	Median (Q3-Q1)	Median (Q3-Q1)	
Pre-test	3 (4–2)	3 (3–2)	0.200
Post-test	2 (3–1)	3 (4–2)	< 0.001*

The *P*-values are for the Mann–Whitney U Test for two independent samples

EMG Educational Movie Group, *CG* Control Group, *Q3* Third quartile, *Q1* First Quartile, *Q3-Q1* the inter-quartile range

* The test is significant at the level 0.05

Table 4 Comparison of pain scores between the two study groups (EMG and CG)

Groups	Median (Q3-Q1)	*P*- value
EMG ($n=46$)	6 (7–5)	< 0.001*
CG ($n=46$)	7 (8–6)	

The *P*-value is for the Mann–Whitney U Test for two independent samples

EMG Educational Movie Group, *CG* Control Group, *Q3* Third quartile, *Q1* First Quartile, *Q3-Q1* the inter-quartile range

* The test is significant at the level 0.05

Adverse events

No adverse effects such as nausea, dizziness, disorientation, or eye strain were reported by any child during or after the VR intervention. All participants completed the four-minute video comfortably without interruption, and no sessions were discontinued. The intervention was therefore considered safe, acceptable, and well-tolerated among the participating children.

Discussion

The primary objective of this study was the creation and application of a 360° educational film in VR to prepare children aged 6 to 12 years for tonsillectomy and adenoidectomy surgery and to evaluate its effectiveness in reducing preoperative fear and postoperative pain. The 360° educational film was designed to clarify the preoperative planning and recuperation stages, helping children understand what to expect before, during, and after surgery. Using VR headsets in conjunction with instructional content was a crucial component of this strategy for incorporating distraction and immersive learning tactics aimed at decreasing perioperative distress.

Although the present study demonstrated significant short-term benefits of the VR-based educational intervention in reducing preoperative fear and immediate postoperative pain, it did not include a post-discharge follow-up to assess long-term outcomes. Future research should evaluate whether these immediate improvements translate into sustained psychological benefits, such as reduced postoperative anxiety, improved behavioral recovery, or lower incidence of medical trauma. Longitudinal studies incorporating multi-timepoint assessments would provide valuable insight into the enduring impact of VR interventions on pediatric surgical experiences.

Many non-pharmacological techniques that effectively reduce postoperative pain have been identified by a systematic review [7]. Such interventions include distraction, play therapy, music therapy, and guided imagery, which have been proven to lessen children's perception of pain and anxiety during the perioperative period. Within this spectrum of approaches, VR emerges as a novel, technology-enhanced method that combines distraction with immersive patient education, offering both cognitive engagement and emotional relief.

Previous research, such those conducted by He et al. [7] and Özalp et al. [9], has demonstrated how successful VR headsets are as a non-pharmacological intervention for reducing pain and fear.

The theoretical foundation of this intervention is grounded in Bandura's Social Cognitive Theory [11] and the Cognitive–Behavioral framework for anxiety reduction [12]. According to these models, children's anxiety can be alleviated by enhancing their self-efficacy and sense of control through observational learning, guided exposure, and cognitive restructuring. In the present study, the 360° VR video allowed participants to observe a calm and cooperative child model during the surgical process, which likely helped to normalize the hospital environment, reduce uncertainty, and foster adaptive coping. This combination of cognitive preparation and behavioral modeling supports the observed reductions in preoperative fear and postoperative pain.

Children between the ages of 6 and 12 years in this study showed a strong interest in the VR technology and quickly adapted to the program. A comparative analysis showed that the educational video-exposed group scored lower on fear than the control group. This finding is consistent with previous research emphasizing the effectiveness of distraction-based interventions in alleviating preoperative anxiety among pediatric patients. Aytekin et al. [15] used animated cartoons and storytelling during the preoperative waiting period to divert children's attention, resulting in significantly reduced anxiety and tension. Similarly, El-Moazen et al. [16] implemented interactive tablet-based gaming, which effectively lowered surgical apprehension among children in a similar age group. These results collectively support the concept that engaging, age-appropriate distraction methods—such as our 360° VR educational film—can significantly decrease children's preoperative fear and enhance their perioperative experience.

In another study, children were divided into two groups, with one receiving educational training along with games, and the other receiving solely educational training. According to the results, individuals who engaged in both educational and gaming activities reported feeling less anxious about surgery [5]. Moreover, an abundance of research has validated the positive influence of pre-surgical education in mitigating children's preoperative fear [6]. A variety of distraction techniques, including computer games, cartoons, music, therapeutic play, and books with or without drawings, have also been shown to be successful in reducing anxiety [7, 17]. The present study's results align with previous research in the literature, emphasizing the dual benefits of preoperative education in VR video as a diversionary and informative tactic.

The results of this study are consistent with those of Yaz & Yilmaz [10] in their carefully planned randomized controlled trial assessing the impact of seeing an instructional animated film on children's pain and fear indices between the ages of 6 and 12. Their research demonstrated a significant decrease in pain and fear ratings in patients who watched virtual reality videos. In particular, the experimental group showed a statistically significant

decrease in fear levels (mean = 0.91) compared to the control group (mean = 2.98). Likewise, the postoperative pain scores were significantly lower in the experimental group (mean = 5.04) than in the control group (mean = 7.85) ($p < 0.001$ for both comparisons.

The results of this study are consistent with those of Yoo et al. [18], who conducted a quasi-experimental investigation to determine the impact of animation distraction on venipuncture pain responses among children aged 3–7 years. In their study, which included a cohort of 40 participants, the experimental group ($n = 20$) was provided with an animation distraction intervention using a laptop computer during their first venipuncture, while the control group received routine care. The findings demonstrated that the experimental group reported significantly lower pain scores (mean = 3.4) compared to the control group (mean = 8.2). Although Yoo et al.'s [18] intervention targeted venipuncture rather than surgical preparation and involved a slightly younger population, their results align with the present study's findings, supporting the effectiveness of audiovisual distraction techniques—such as the current study's 360° VR educational filming reducing children's fear, pain, and anxiety during medical procedures.

The findings of this interventional study also coincide also coincide with those of Özalp et al. [9]. from a controlled, randomized trial that split 136 patients into three groups: VR-Rollercoaster, VR-Ocean Rift, and a control group. The main outcome measures were pain scores after the operation and the patients' degrees of fear and anxiety before and after the blood draw. The VR-Ocean Rift and VR-Rollercoaster groups both reported reduced pain thresholds. After the blood draw, a substantial difference between groups was observed in the fear and anxiety levels reported by the researcher, the parents, and the children themselves, the VR-Rollercoaster and VR-Ocean Rift groups exhibited a reduction in children's fear and anxiety, whereas these parameters climbed by 20% and 34.1%, respectively, in the control group.

Animated films have been used to treat pediatric patients' pain and anxiety in lieu of pharmaceutical interventions in some subsequent empirical research [19]. The paucity of animated educational films made especially for children, however, is a noticeable gap in the literature. This deficiency highlights how innovative research, such as the one being done here, is when it comes to determining how well animation can prepare children for planned surgeries.

An innovative, entertaining, and useful strategy is the creation and use of an educational immersive video for pediatric patients awaiting surgery. It makes a substantial addition to pediatric healthcare techniques by acting as both an instructional tool and an efficient way to reduce preoperative fear and postoperative pain.

The implications of the findings in context of existing research

The results of the study have important ramifications for the care of pediatric patients having surgery, particularly those between the ages of six and twelve. According to the study, children in this age range are especially prone to experiencing worry and panic in relation to surgeries or other medical procedures. This is consistent with previous research highlighting the elevated affective reactions of young children undergoing surgery. For example, prior research has shown that in children, preoperative worry may result in higher levels of pain following surgery, a slower rate of recovery, and longer hospital stays.

In light of these results, the researchers advise that policies emphasize methods intended to lessen fear and anxiety in pediatric patients. Using virtual reality (VR) technology as part of standard preoperative preparation is one such method. Virtual reality (VR) has been demonstrated in numerous trials to be a useful technique for soothing and diverting young patients before to medical operations. Children's anxiety levels are lowered because of its immersive quality, which diverts their attention from the upcoming medical procedure and onto virtual experiences. Virtual reality (VR) technology could greatly improve the preoperative experience for pediatric patients, improving their overall outcomes.

Additionally, the research shows that pediatric patients benefit from the use of new breakthroughs and technologies in the medical area. This result adds credence to the increasing corpus of studies that promotes the use of cutting-edge technological interventions in healthcare to enhance patient outcomes and experiences.

Despite its promising results, the broader implementation of VR interventions in clinical practice may be limited by cost, equipment availability, and staff training requirements. Future investigations should explore cost-effectiveness, sustainability, and strategies for adapting VR-based interventions to low- and middle-income healthcare environments to ensure equitable access to this innovative approach.

Limitation

This study has several limitations that should be acknowledged. First, it was performed at a single tertiary care facility in Palestine, perhaps restricting the applicability of the results to other healthcare systems and cultural environments. This single-site design may

limit the generalizability of the findings, as clinical practices and patient experiences can vary across institutions and regions. Secondly, the sample size, while statistically adequate, was rather small ($n=92$) and may preclude subgroup analysis (e.g., by age or gender). Future research with larger sample sizes is warranted to enhance statistical power and external validity. The outcomes assessed were confined to the immediate perioperative period; we did not investigate long-term impacts on psychological adaptation or subsequent medical encounters. Future studies are encouraged to explore the long-term psychological and behavioral effects of VR interventions on children's adaptation to surgical experiences. In addition, post-discharge anxiety, behavioral changes, or possible medical trauma were not evaluated. Future studies should incorporate longitudinal follow-up to determine whether the beneficial effects of the VR intervention on fear and pain persist beyond the immediate postoperative phase. Fourth, although healthcare practitioners were blinded to group allocation, both children and parents were cognizant of the intervention, potentially introducing expectation bias. Fifth, the intervention was compared only with conventional preparation; it was not evaluated against alternative distraction techniques such as cartoons, music, or therapeutic play, which may similarly alleviate anxiety and pain. Finally, the implementation of VR headsets necessitates technical resources and staff training that may not be accessible in all pediatric surgical situations, especially in resource-constrained settings. Because participants and parents were aware of the intervention, the possibility of performance and detection bias cannot be entirely excluded; nevertheless, objective blinding of healthcare providers and the use of validated, standardized measurement tools mitigated this risk. To confirm and extend the current findings, future multicenter studies including more diverse pediatric populations are recommended.

Finally, the implementation of VR interventions requires access to appropriate equipment, maintenance, and trained personnel, which may not be feasible in all pediatric surgical settings, particularly in low-resource environments. Evaluating the cost-effectiveness and practical scalability of such interventions should therefore be a priority for future research.

Conclusion

Non-pharmacological approaches, including educational strategies, are recognized as effective in reducing pain and fear in pediatric patients. Among these methods, the use of a 360° educational movie in VR shows promise for engaging and supporting children aged 6–12. In this study, children who viewed the VR video experienced significantly lower preoperative fear and postoperative pain compared with those receiving standard care. These findings support further exploration of VR as an adjunct to standard preoperative preparation in pediatric surgery. While preliminary, this approach aligns with recent research supporting patient-centered and innovative solutions in pediatric perioperative care. Future studies should confirm these findings in larger, multi-center trials, with longer follow-up and diverse patient populations.

Abbreviations

VR	Virtual Reality
EMG	Educational Movie Group
CG	Control Group
CONSORT	Consolidated Standards of Reporting Trials

Authors' contributions

This manuscript was the results of the collaboration of all authors. Authors AA, NA, MT, MA and IW designed the study and wrote the study proposal. NR, MT, MA and IW conducted data collection. AA and NA analyzed the data. AA, NA, MT, MA, IW and NS wrote the final draft of the manuscript and prepared tables. AA submitted the manuscript to the journal. All authors have read and approved the final manuscript.

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Data availability

The corresponding author can provide the datasets used and/or analyzed for this study upon reasonable request.

Declarations

Ethics approval and consent to participate

An-Najah National University's Institutional Review Board provided the required permissions and clearances for this study (Ref: Nsg.August.2022). The protocols followed the guidelines outlined in the Helsinki Declaration. Information on the study's goals, the confidentiality of the data they submitted, their ability to withdraw from the study, and access to the study's results were all given to the participants. Before sampling, the required permissions were obtained from the appropriate authorities, and all subjects provided written informed consent.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form.

Competing interests

The authors declare no competing interests.

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