

**REDUCING ANXIETY IN CHILDREN WITH MOLAR
INCISOR HYPOMINERALIZATION USING VIRTUAL
REALITY – A RANDOMIZED CROSSOVER STUDY**

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Abstract

The aim of this study was to evaluate the effects of virtual reality (VR) video games on anxiety levels during dental treatments in children with molar incisor hypomineralization (MIH)-affected teeth. The incidence of MIH, characterized by hypomineralized enamel, observed in at least one permanent incisor and molar tooth, varies between 5% and 40%. Dental anxiety is a common condition in children affected by MIH, and this anxiety increases with the severity of hypomineralization.

A total of 23 children between the ages of 10 and 12 years played VR video games during their dental treatments. The Children's Perioperative Multidimensional Anxiety Scale questionnaire was administered before and during the treatments to measure the anxiety levels of the children.

Children undergoing treatment while playing VR games were found to be less worried and fearful during their appointments. They exhibited less nervousness, did not think about potential pain from the dental procedure and did not worry about future discomfort. A comparison of these results with those of children who underwent dental treatments without playing VR games revealed a statistically significant difference ($p < 0.05$).

Children with MIH-affected teeth who are distracted from dental procedures using three-dimensional VR games experienced less dental anxiety.

Key words: anxiety, Molar Incisor Hypomineralization, pediatric dentistry, virtual reality games

Introduction. Dental fear and anxiety may occur at any age. However, it is particularly common in children with molar incisor hypomineralization (MIH)-affected teeth. MIH, defined as a morphological enamel defect in occlusal and incisal thirds of molars and incisors, develops due to systemic causes [1]. It is clinically distinguished by limited opaque and yellow-brown lesions. Although the prevalence varies between 0.5% and 40%, severe tooth sensitivity and tooth loss are seen in many patients [2]. Fear and anxiety are frequently encountered during dental treatment in these children [3]. Some authors recommend general anesthesia and sedation due to behavioural management problems in these children [4,5]. Behaviours caused by this fear and anxiety may not only lead to difficulties in performing dental treatments, but may also affect the quality of the treatment [6]. Having a fear of dentists typically stems from the patient's fear that they will experience pain during their treatment [7].

The techniques used for reducing stress in pediatric patients during dental procedures are divided into two categories. The first category includes behaviour management methods such as tell-show-do, distraction, positive empowerment, and non-verbal communication. The second category comprises pharmacological methods [8].

Distraction is considered a safe and cost-effective means for managing anxiety during short-term dental treatments [9] and is the preferred technique for short-term invasive treatments [9,10]. Exposing children to music, allowing them to watch television, using different objects or decorations in the room, and talking with them about non-medical issues during treatment have all been used as distraction techniques during dental visits [11]. However, an ideal distraction should not only include auditory, visual, and tactile (kinesthetic) stimuli, but also divert attention away from harmful stimuli [11,12]. In one study, the presence of an active sensation was reported to be a highly advantageous distraction in addition to those already mentioned [13].

Human-computer interfaces created with virtual reality (VR) capabilities were first commercially introduced in the early 2000s, and users began to establish a dynamic relationship with computers in the virtual environment. VR distracts the user by disconnecting him/her from the outside world. The combination of auditory, visual and kinesthetic stimuli that is intrinsic to the VR experience presents a unique opportunity to the medical establishment in terms of patient treatment [11]. Head-mounted, 3-dimensional (3D) devices with a wide field-of-view that can be controlled by hand have been shown to be more successful in creating a virtual environment, reducing stress levels, and providing analgesia by increasing the pain threshold [11].

Therefore, the aim of this study was to evaluate the effects of playing 3D VR games during dental treatments on anxiety and fear in school-age children with mild, moderate and severe MIH.

Methods. A randomized, crossover study was carried out in a pediatric dentistry clinic at Medipol University, Faculty of Dentistry in Istanbul, Turkey. Ethical approval for the study was obtained from the Medipol University Medical Research Ethics Committee (granted on August 1, 2019, Ref. 589). This study is in accordance with the Consolidated Standards of Reporting Trials (CONSORT statement). The legal guardians signed a statement of informed consent and the children also signed an agreement to participate in the study.

The clinical study was conducted from 5 August 2019 to 5 March 2020. Twenty-eight children between the ages of 8–12 years were selected among children who came to our clinic for routine dental treatments. The following inclusion criteria were observed: being between the ages of 8 to 12 years and having MIH-affected teeth and having at least symmetric two dentin caries containing approximal. Exclusion criteria included children having systemic disease, an emotional, behavioural or learning disorder and teeth that require pulpotomy or pulpectomy treatment. Five children were excluded because they had systemic disease. The selected twenty-three children were randomly divided into two VR exposure groups (VR1 and VR2). Subjects were then divided into subgroups based on the severity of MIH: mild, moderate, or severe. White and cream to yellow-brown colourations on top of crown and chewing surface were grouped as mild MIH. Permanent first molar teeth were affected by all crowns, if there were hypomineralized yellow-brown colourations, moderate MIH was classified as severe MIH if there was a defect in crown morphology resulting in extensive loss of enamel.

VR glasses Preo VR Box (Preo, Beijing, China) and the VR game InCell VR Cardboard Android 1.4.3 (Nival Network, Moscow, Russia) were found to be appropriate for children between the age of 8–12. In-Cell VR is an action/racing genre, a roller coaster game with a story in a human cell. It was preferred because it could attract the attention of children and has educational features. As the VR glasses needed to be individually fitted, they were adjusted for each child using the tell-show-do technique, and information about the game was given before starting the dental treatment.

For the children in the VR1 group, a composite resin was administered to one of the teeth affected by decay while they played the VR game during their first session. In the second session, a composite resin was applied to the second decayed tooth without using the VR game. In the second group (VR2), the order of VR exposure was reversed. A composite resin was administered without the VR game in the first session, whereas the resin was applied while children played the VR game in their second session. Between the two sessions, the washout period was determined as one month. Flow diagram of the study is shown in Fig. 1.

In both groups, Class 2 cavity was opened according to the black classification without any local anesthesia during treatment. After applying the composite filling material, it was polymerized for 20 seconds and the treatment was completed after polishing.

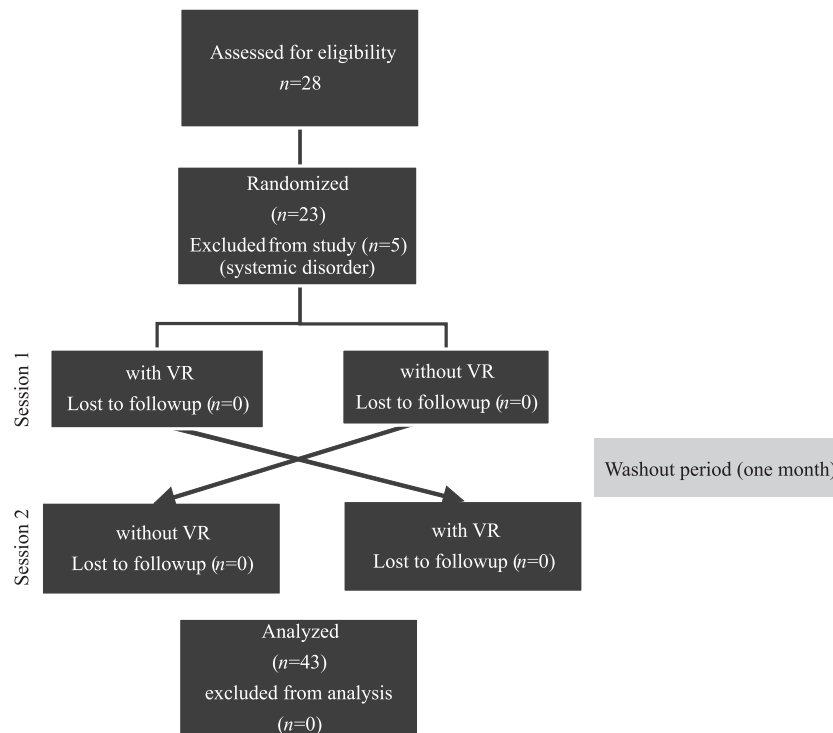


Fig. 1. CONSORT diagram showing the flow participants through each phase of the randomized crossover trial

Before and during cavity treatment, the fear and anxiety levels of the children were evaluated using the Children's Perioperative Multidimensional Anxiety Scale (CPMAS). This questionnaire is composed of five questions, each of which is scored from 0–100 (0 = not at all, 100 = very much). The CPMAS scale has a high fear level of 50 and above. During the evaluation, scores above 50 were considered high fear levels [12].

Before beginning a dental procedure using VR, each child was allowed to play the video game for 5 minutes before beginning treatment to ensure their engagement with the game. After the cavity was treated and prepared for composite filling, the game was stopped and the questionnaire was re-administered. The VR glasses were then re-fitted, and the game was restarted. During this period, the tooth was filled with a composite resin.

The data were analyzed using the Statistical Package for Social Sciences 21 for windows (SPSS Inc., Chicago, IL, USA). An ANOVA test was used to compare the means of multiple variables (relationship between the responses of the groups before and during the treatment). An Independent samples T test was used to compare the means of two variables (used to the mean scores of the CPMAS within VR subsections), while the Chi-Square test was used to compare

proportions (relationship between VR group and without VR group). The level of statistical significance was set at $p < 0.05$ for all analyses.

Results. Of the twenty-three children included in the study, 9 (39.13%), 8 (34.78%), and 6 (26.08%) presented with mild, moderate and severe MIH, respectively. An Anova test analysis of the CPMAS results showed that all of the children answering questions before the beginning of treatment (regardless of VR group or session), were frightened and worried about the possibility of experiencing pain during the procedure. However, results of the CPMAS administered to children while they played the VR game during treatment indicated that they were less worried, fearful, and nervous. Furthermore, the majority of these children did not believe they were going to experience pain, nor did they worry about the imminent possibility of something unpleasant occurring. A comparison of average CPMAS scores between children undergoing treatment with VR and those not using VR, regardless of VR group, revealed a statistically significant difference ($p < 0.05$).

When the results of the CPMAS from the second session of the VR1 group (no VR was used) were examined, the scores were lower than the scores in the first session. However, these decreases were not statistically significant ($p > 0.05$). Average score values for each of the questions in the CPMAS for the two VR groups according to session are presented in Table 1.

The relationship between the severity of MIH and the average scores from the CPMAS questions was also examined. We found that the average scores to the questions were lower when VR was used across all MIH severity levels, but

T a b l e 1

Average scores for each of the five Children's Perioperative Multidimensional Anxiety Scale questions given before and during dental treatments by group type and session

QUESTIONS	GROUP 1 (VR1)				GROUP 2 (VR2)			
	Session 1 (with VR ^a)		Session 2		Session 1		Session 2 (with VR)	
	Before	During	Before	During	Before	During	Before	During
How worried are you?	58.26	21.22 ^b	52.12	35.47	57.44	48.46	51.98	15.61 ^b
How scared are you?	61.63	18.05 ^b	49.59	52.43	63.02	58.23	58.03	14.22 ^b
How tense are you?	57.02	12.36 ^b	52.56	55.26	55.40	59.21	53.65	9.26 ^b
Are you afraid you may be hurt?	72.51	9.08 ^b	65.48	68.25	77.25	78.02	71.86	8.16 ^b
Are you worried the procedure might be a bad thing?	54.20	11.28 ^b	44.35	49.77	49.88	51.60	41.15	6.25 ^b

^a VR = virtual reality

^b Significant difference

T a b l e 2

Average scores for each of the five Children’s Perioperative Multidimensional Anxiety Scale questions according to the severity of molar incisor hypomineralization (MIH)

QUESTIONS	MIH SEVERITY	WITH VR		WITHOUT VR	
		Before	During	Before	During
How worried are you?	Mild	58.17	16.85	54.78	41.77
	Moderate	59.23	18.27	55.64	42.26
	Severe	60.89	19.29	58.62	42.24
How scared are you?	Mild	61.92	14.88	56.12	55.92
	Moderate	63.17	16.23	57.28	56.02
	Severe	65.23	17.04	59.56	56.23
How tense are you?	Mild	57.56	9.81	59.11	59.42
	Moderate	59.86	11.03	58.76	56.12
	Severe	60.19	12.05	58.95	59.58
Are you afraid you may be hurt?	Mild	75.52	8.75	73.16	71.25
	Moderate	77.42	8.82	72.83	73.04
	Severe	78.69	8.96	72.54	73.16
Are you worried the procedure might be a bad thing?	Mild	54.13	8.91	46.58	47.22
	Moderate	56.39	8.94	47.05	49.84
	Severe	58.01	8.98	47.63	51.82

no significant difference was found between MIH severity within the VR groups ($p>0.05$). The severity of MIH and the average scores to the CPMAS questions according to VR group are given in Table 2.

Discussion. During the treatment of pediatric patients, in many cases, dentists apply various behaviour management approaches according to the child’s degree of development and response to treatment. Tell-show-do, positive motivation, distraction in children whose basic behaviour management techniques are not successful, costly and with a high risk of complications such as sedation and general anesthesia are applied.

Health professionals take some approaches using clown doctors, wearing colourful and patterned clothes to encourage children to focus their mind in another direction, and to make the medical procedure fun [13]. In this case, it is tried to prevent negative behaviours or escape behaviours by reducing unpleasant perceptions. In this way, it is aimed to complete the treatments without the need for advanced behaviour techniques such as sedation and general anesthesia. Although it is known that these distracting systems work, there is no comprehensive study on how effective they are. These systems may not always be sufficiently effective in removing the child’s attention from pain. However, it seems that there is a need for a stronger and more comprehensive system that can occupy the child during the medical procedure due to the presence of some behavioural problems

due to MIH [2,3] and a relationship between MIH severity and dental fear [3].

Currently, the use of VR glasses with video games to create kinesthetic stimuli and active sensations are used with burn treatment patients, as they have been shown to reduce pain [14]. For instance, the VR game SnowWorld (www.vrpain.com), which was developed for use in the treatment of burns, is used by the United States Navy since the early 2000s [14]. Furthermore, a substantial number of 3D VR games are used not only in conjunction with burn treatments, but also with pain associated with cancer, chronic pain, blood collection, and intravenous catheter applications [15]. Virtual reality games have also been reported to reduce the frequency of contraction in patients with cerebral palsy and to have a positive effect on children with autism, attention deficit disorders, and fetal alcohol syndrome [16].

However, a literature review uncovered few studies investigating the use of VR in pediatric patients undergoing dental procedures; although some research has been conducted into the effects of VR in adult dental patients. In one study, dental patients who watched videos while using LCD glasses were compared to patients who were not exposed to VR and not given additional therapy for pain management. The researchers found that systolic blood pressure, anxiety, and pain were lower in those patients who were distracted with the VR videos [17]. A case report found that when a patient played SnowWorld with 3D glasses while another patient watched a video with 3D glasses, the patient actively playing the video game reported less pain and was observed to be more cooperative during burn treatment [18]. In another study where children between the ages of 4 and 6 years watched videos, better results were reported when the children's favourite programs were presented [19]. Another study, which compared distraction methods, reported that videos were more effective in reducing stress than audio techniques [20]. Still, research has shown that there is no kinesthetic stimulus in children who passively watch videos while wearing VR glasses [11]. In contrast, active participation in video games can provide a kinesthetic stimulus leading to adequate distraction. This idea is supported by the results of this study, where VR games were found to be highly effective in distracting children from their dental anxieties.

The CPMAS questionnaire used in this study is a validated measurement tool [14] that was originally developed for surgical applications. Its use in this study was chosen as it allowed patients to be evaluated both before and during their treatments.

The results of this study are similar to those of a previous one [3] that investigated the relationship between MIH and fear. We observed that all of the children expressed both fear and worry regarding the pain they might feel during treatment. However, those children exposed to VR expressed less worry and fear, were less nervous, believed nothing would hurt them, and did not feel that something unpleasant was going to happen. Furthermore, we found that the use of VR

reduced anxiety and fear in children with all MIH types. Therefore, the use of VR was highly distracting and may be an advantageous tool for use in pediatric dentistry. Specifically, its ease-of-use and the ability of patients to control VR devices during treatment make its application during dental treatments particularly inviting. Moreover, VR does not require additional personnel, and its positive effects can be seen in subsequent treatment sessions. Although success in children with behaviour management problems is achieved, advanced behaviour management techniques (sedation, general anesthesia) should be considered in young children and children with severe mental retardation.

In addition, its advantages include enabling the individual to interact with technology, adding a sense of dynamism and realism to objects, and embodying abstract concepts. While the game aims to attract attention at the beginning, it is possible to convey detailed information later. Thus, the continuation of the cooperation can be ensured in the following sessions. The disadvantages are that the number of games is insufficient (there are no dental games), and there are not enough hardware features.

Conclusions. The results of this research show that virtual reality (VR) video games provide a fun and comfortable environment with the help of virtual reality glasses supported video game application, to develop positive behaviours in children, to increase the success of dental treatments and to reduce the need for costly and complicated interventions such as sedation and general anesthesia.

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