Scientific Research Report

Distraction With Virtual Reality Goggles in Paediatric Dental Treatment: A Randomised Controlled Trial

Lior Zaidman, Gal Lusky, Aviv Shmueli, Elinor Halperson, Moti Moskovitz, Diana Ram, Avia Fux-Noy *

Faculty of Dental Medicine, Hebrew University of Jerusalem, Israel
Department of Pediatric Dentistry, Hadassah Medical Center, Jerusalem, Israel

ARTICLE INFO

Article history:
Received 28 March 2022
Received in revised form
1 June 2022
Accepted 6 June 2022
Available online 6 August 2022

Key words:
Virtual reality
Paediatric dental care
Local anaesthesia
Rubber dam
Pain

ABSTRACT

Aim: The aim of this study was to examine whether screening content through virtual reality (VR) goggles can diminish pain perception during local anaesthesia administered using the inferior alveolar nerve block technique and rubber dam placement in routine paediatric dental treatment.

Materials and methods: This is a crossover study of healthy 4- to 12-year-old children who were scheduled to receive local anaesthesia administered using the inferior alveolar nerve block technique and rubber dam placement in 2 visits. The participants were randomly assigned to undergo 1 treatment performed with Oculus GO VR goggles and the other treatment without. Pain was evaluated using the Wong-Baker FACES Pain Rating Scale and the Modified Behavioral Pain Scale (MBPS).

Results: The study group included 29 children with a mean age of 8.29 years (SD, 1.96). Whilst administering local anaesthesia, no significant difference was observed in the Wong-Baker FACES Pain Rating Scale and in MBPS movements between visits with and without the VR goggles. However, significantly lower pain perception was observed in the other parameters of MBPS when using the VR goggles: Face ($P = .007$) and Cry ($P = .046$). During placement of a rubber dam, significantly less pain was reported by the patients ($P = .005$) and observed by the assessor (Face [$P = .005$], Cry [$P = .029$], and Movement [$P = 0.028$]) when the VR goggles were used.

Conclusions: VR can decrease pain perception during rubber dam placement in children, but it has limited benefit during administration of local anaesthesia.

Introduction

Distraction is a behaviour management method used during procedures that may be painful or uncomfortable. The rationale is to reduce a patient's attention from cultivating pain signals and to thus diminish the pain experience.[1] An ideal distractor involves a number of senses and triggers emotional reactions that assure that the patient is focused on the distracting element.[2,3] Distraction techniques include playing music,[4] storytelling,[5,6] watching television,[7] and using audiovisual distraction.[8] Virtual reality (VR) is an interactive computer-generated experience using a head-mounted display, which creates an immersive experience through visual and sound effects and enables dynamic interaction of the user in a virtual environment. An advantage of the VR technique over traditional behaviour management distractors is that it blocks the patient's view of the possibly stressful environment and projects relaxing content that the patient can choose.[9] Distraction using VR has been shown to be an effective intervention for reducing pain in children undergoing needle-related medical procedures.[10] Amongst children and adolescents with kidney disease, significantly reduced pain intensity was reported during venipuncture amongst those who used VR compared to those who did not.[11,12]

Painful dental operations cause fear, and fear and anxiety can increase the amount of perceived pain.[13] Many patients fear the instruments needed for injection, which are usually long needles that are perceived as painful.[14] The rubber dam

* *Corresponding author*. Department of Pediatric Dentistry, Hadassah Medical Center, Faculty of Dental Medicine, Hebrew University of Jerusalem, P.O. Box 12272, Jerusalem 9112102, Israel.
E-mail address: fuxavia@gmail.com (A. Fux-Noy).

https://doi.org/10.1016/j.identj.2022.06.003

clamp causes pain and discomfort due to the clamp impinging on the gingival tissues.[15] A number of studies have demonstrated the use of VR to reduce pain and anxiety in certain dental procedures.[9,16-19] In those randomised clinical trials, the participants were allocated to 2 groups, 1 treated with VR and the other without. Anxiety and pain were measured at the end of the dental visit, which may have varied in length, local anaesthesia method, or type of restorative treatment.

The objective of the current study was to examine whether the use of VR goggles in routine paediatric dental treatment can reduce pain perception during local anaesthesia and rubber dam placement. In contrast to other randomised controlled trials on VR in paediatric dentistry, this was a randomised crossover trial in which the participants served as their own controls.

Methods

A randomised crossover clinical trial was designed to include children in need of 2 dental treatments. One treatment was conducted with the use of VR goggles and the other was conducted without. The toss of a coin by a single trained disinterested investigator determined the option that would be implemented first. In this study design, participants constitute their own controls. The random division into 2 groups was designed to ensure that the treatment order would have no effect on the results and that the effect examined would be due to the use of the goggles. Randomisation was performed after children were found to meet study inclusion criteria.

The study group comprised healthy children, aged 4 to 12 years, who needed 2 dental treatments that included inferior alveolar nerve block and rubber dam placement. The study inclusion criteria included being fully cooperative (Frankl[20] grade 4) during examination and suitability for dental treatment without the need for pharmacologic behaviour management methods, according to skilled specialist paediatric dentists. The children were treated by undergraduate students in their final year in the Department of Pediatric Dentistry, Faculty of Dental Medicine, Hebrew University of Jerusalem.

VR goggles

The hardware used was Oculus Go VR goggles from Facebook Technologies (Oculus Go virtual reality goggles, Meta Quest, Facebook Technologies, LLC). These glasses are made of glass lenses that project content from a Xiaomi screen. A sponge covers an area around the eyes, forehead, and nose and thus blocks the field of vision, separates the lenses from the face, and insulates so that only the desired content is visible to the participant. Straps enable adjusting the size of the glasses to a participant's head for optimal comfort (Figure). The glasses are equipped with speakers; thus, both the participant and the therapist can hear the projected content. Children and parents were offered 3 types of content suitable for children. Two of them were cartoon series and the third was a children's show. All the content had an average screening time of about 30 minutes.

Figure – Illustration of the virtual reality goggles in a clinical setting.

Pain indices

The Wong-Baker FACES Pain Rating Scale[21] was used to examine self-reported pain during local anaesthesia and rubber dam placement. This scale was designed to estimate pain as perceived in the participant's experience, by graphically representing pain levels through faces, from level 0 (no pain at all) to level 10 (greatest pain). Immediately after administration of the local anaesthesia and after placement of the rubber dam, the movie was stopped and the goggles were removed from the participants' eyes. The examiner then presented the participants with the graphic index on an A4-sized page and asked them to point to the face representing how they felt throughout the procedure. The goggles were then returned, and the participants continued to watch the selected content.

The Modified Behavioral Pain Scale (MBPS[22]) (Table 1) was used to examine the pain observed by a calibrated observer, who was a well-trained resident in paediatric dentistry. The observer examined 3 criteria during local anaesthesia and during rubber dam placement—facial expression, crying, and movement—and scored the children's behaviour accordingly.

After placing the rubber dam and before resuming the procedure, the patients were asked whether they wished to remove the VR goggles or to continue watching the rest of the content. At the end of the second meeting, the participants were asked which dental visit they preferred, that with or that without the VR goggles.

Sample size calculation

Power (sample size) calculators for continuous outcomes in parallel group superiority trials were used.[23] The mean outcome, the score on the Wong-Baker FACES Pain Rating Scale, was compared between visits that did and did not use VR

Table 1 – Modified Behavioral Pain Scale.

Facial expression		Cry		Movement	
Definite positive	0	Laughing/giggling	0	Usual movement/resting/relaxed	0
Neutral expression	1	Not crying	1	Partial movement or attempt to avoid pain	2
Slightly negative	2	Moaning	2	Complex movement involving head, torso, etc	3
Definite negative	3	Full-lunged cry or sobbing	3		

goggles. Fourteen patients were calculated as required for a 90% chance of detecting, as significant at the 5% level, a decrease in the primary outcome measure (Wong-Baker FACES Pain Rating Scale), from 5.44 in the control group to 2.56 in the experimental group.[15] Noncompliance/crossover was adjusted when a percentage crossover of 15% was expected in the control group, and the percentage crossover expected in the experimental group was 15%; accordingly, the adjusted total sample size required was 30.

Ethics

The study was approved by the Institutional Human Subjects Ethics Committee (HMO-0508-19) and conforms to the Declaration of Helsinki. The trial was registered at health.gov.il/CliniTrials (registration number: MOH_2020-07-02_009105). After receiving an explanation of the study, a parent or legal guardian of each participant signed an informed consent form.

Statistical analysis

The data were analysed by SPSS software (version 27.0.; SPSS, Inc.). Descriptive statistics of the demographic variables were presented as absolute numbers and percentages for the categorical variables and as means and standard deviations for the continuous variables.

The normality of the variables was tested using the Kolmogorov–Smirnov test; both the local anaesthesia variable ($P = .028$) and the rubber dam variable ($P = .024$) were abnormally distributed. Our null hypothesis was that there would be no difference in pain perception between children treated with VR glasses and those treated without the glasses. For testing the hypothesis of similar pain perception between the groups, Wilcoxon tests were performed and segmented according to the use of VR glasses vs not. Subsequently, a number of Mann–Whitney tests were conducted.

The results were considered statistically significant at a P value $< .05$ in a 1-tailed Wilcoxon test.

Results

During October 2020 through June 2021, 34 participants enrolled in the study. The children were aged 4 to 12 years, and the mean age was 8.29 years (SD, 1.96). Five participants were excluded from the study: 3 because of lack of cooperation that prevented treatment, 1 because of lack of attendance of the second visit, and 1 because they received an additional local anaesthesia injection, as the first one was not sufficient. The mean age of the 29 participants included was 8.34 years (SD, 2.1); 13 used the goggles in the first visit and 16 in the second one. Most of the participants were male (72%) and had prior experience with dental treatment (93%). They all preferred dental treatment with the use of the VR goggles (100%).

Pain during local anaesthesia

In visits with and without the VR glasses, the mean scores on the Wong-Baker FACES Pain Rating Scale were similar ($P = .234$) (Table 2). The movement component of the MBPS was also similar ($P = .083$). However, mean scores on the other 2 parameters of the MBPS were significantly lower in visits with than without the VR goggles: Face ($P = .007$) and Cry ($P = .046$) (Table 2).

Pain during placing a rubber dam

In visits that implemented the VR glasses compared to visits that did not, mean scores were lower on the Wong-Baker FACES Pain Rating Scale ($P = .005$) and for all 3 parameters of the MBPS: Face ($P = .005$), Cry ($P = .029$), and Movement ($P = .028$) (Table 3).

The order of the visits

Statistically significant differences were not found in either pain index between participants who used the VR goggles in the first compared to the second visit. In visits that did not implement the VR glasses, differences were not found in either pain index between participants who used the VR goggles in the first compared to the second visit (Table 4).

Discussion

The findings of this study suggest that the use of VR goggles can decrease some of the pain perceived by children during dental treatment. The crossover design is a strength, especially considering that tolerance to pain is individual for each

Table 2 – Pain index scores during local anaesthesia.

	With VR		Without VR				
	M	SD	M	SD	Z	P	η
Wong-Baker FACES Pain Rating Scale	3.66	3.12	4.28	2.91	−1.190	.234	0.22
MBPS–Face	0.93	0.79	1.34	0.81	−2.676	.007	0.50
MBPS–Cry	1.07	0.59	1.34	0.55	−2.000	.046	0.37
MBPS–Movement	0.86	1.06	1.24	1.09	−1.732	.083	0.32

VR, virtual reality; MBPS, Modified Behavioral Pain Scale.

Table 3 – Pain index scores during placement of the rubber dam.

	With VR		Without VR				
	M	SD	M	SD	Z	P	η
Wong-Baker FACES Pain Rating Scale	2.14	2.56	3.86	3.54	−2.824	.005	0.52
MBPS−Face	0.69	0.71	1.14	0.88	−2.837	.005	0.53
MBPS−Cry	0.90	0.77	1.21	0.67	−2.183	.029	0.41
MBPS−Movement	0.48	0.99	1.03	1.21	−2.196	.028	0.41

VR, virtual reality; MBPS, Modified Behavioral Pain Scale.

person. By comparing patients' pain levels during 2 visits, the effect of individual pain tolerance was negated.

The results of this study corroborate reports of the effectiveness of the use of VR goggles in decreasing pain and anxiety levels during dental procedures in children aged 4 to 12 years.[9,16-19,24-26] Shetty et al[9] found statistically significant decreases in anxiety and pain levels, and also in cortisol levels before, during, and after the procedure, amongst children who used compared to those who did not use VR goggles. Ran et al[26] found that the use of VR goggles decreased levels of anxiety and pain and also shortened the duration of the procedure.

The current study found VR to have a low ability to reduce pain during local anaesthesia administration. This is evident from the similar pain levels (according to the Wong-Baker FACES Pain Rating Scale) and MBPS movements between visits that used VR goggles and those that did not. As pain perception is individual and subjective, the self-reported pain perception and pain level could be more appropriately derived from participants themselves (self-report). We suspect that the difference in self-reported pain compared to pain observed by the assessor may stem from children's expectation of pain and discomfort whilst receiving local anaesthesia, as injections are perceived as painful.[14] According to Hedén et al,[27] even when the skin is numbed by topical anaesthesia, many children experience needle procedures as frightening and painful. However, the participants of our study expressed feeling less pain, as assessed by facial expression and crying, whilst using VR goggles than without the goggles. Notably, VR goggles are placed on the face and mask the eyes; thus, it is possible that they prevent the observer from noticing silent tearing or slightly negative facial expression. However, the goggles did not prevent the observer from evaluating more pronounced crying or facial expressions of the patients according to the MBPS. Hence, the differences found according to facial expression and crying can be interpreted as decreased pain perception when using VR.

During placement of a rubber dam, patients experienced less pain when using the VR goggles than when not using them. Furthermore, both with and without VR goggles, both observed and self-reported pain levels were lower during placement of a rubber dam than during administration of local anaesthesia. This might be due to the additional expected effect of the local anaesthesia in decreasing pain. We suspect that as children expect local anaesthesia to cause pain, they rated it high on the Wong-Baker FACES Pain Rating Scale. However, as they did not have expectations regarding the placement of a rubber dam, the Wong-Baker FACES Pain Rating Scale was able to demonstrate a decrease in pain perception with VR compared with no VR.

A number of studies have shown lower anxiety levels amongst children in the second compared to the first dental visit.[28,29] Therefore, decreased anxiety in the second visit can lead to reports of decreased pain levels.[30] Our demonstration

Table 4 – Examining the effect of the order of treatments on the level of pain.

			First with VR		First without VR				
	Method	With/without VR	M	SD	M	SD	Mann−Whitney U	P	η
Local anaesthesia	Wong-Baker FACES Pain Rating Scale	With VR	3.71	3.41	3.76	3.30	115.50	.557	0.07
	MBPS−Face	With VR	1.14	0.86	0.82	0.73	95.50	.313	0.21
	MBPS−Cry	With VR	1.07	0.48	1.12	0.70	113.00	.779	0.00
	MBPS−Movement	With VR	0.86	1.02	0.76	1.09	113.00	.780	0.05
Rubber dam	Wong-Baker FACES Pain Rating Scale	With VR	3.14	3.30	1.75	2.41	85.00	.236	0.15
	MBPS−Face	With VR	0.79	0.69	0.69	0.79	101.50	.636	0.03
	MBPS−Cry	With VR	0.93	0.91	0.94	0.68	106.00	.786	0.10
	MBPS−Movement	With VR	0.71	1.20	0.44	0.96	100.00	.500	0.05
Local anaesthesia	Wong-Baker FACES Pain Rating Scale	Without VR	4.31	3.25	5.00	3.07	115.00	.572	0.01
	MBPS−Face	Without VR	1.54	0.97	1.40	0.82	123.00	.779	0.15
	MBPS−Cry	Without VR	1.46	0.66	1.40	0.68	121.00	.690	0.15
	MBPS−Movement	Without VR	1.54	1.13	1.15	1.08	105.00	.304	0.24
Rubber dam	Wong-Baker FACES Pain Rating Scale	Without VR	4.15	3.31	4.20	3.83	128.00	.940	0.09
	MBPS−Face	Without VR	1.23	0.83	1.20	0.95	126.50	.891	0.09
	MBPS−Cry	Without VR	1.46	0.66	1.10	0.72	89.00	.054	0.38
	MBPS−Movement	Without VR	0.92	1.26	1.10	1.16	120.00	.680	0.08

VR, virtual reality; MBPS, Modified Behavioral Pain Scale.

of similar levels of pain between first and second visits supports the assumption that the decreased pain perceived during visits with VR goggles reflects an effect of this behaviour management technique rather than of the order of the visits. Table 4 demonstrates that pain perception was similar when VR was used in the first or the second visit. This indicates that the pain reduction with VR was related to the use of VR and not to the treatment, first or second, during which it was used.

Felemban et al[31] speculated that by blocking vision, VR goggles may make children feel isolated from the real world and more anxious regarding an unpleasant stimulus. However, although the goggles blocked our patients' view, they all preferred dental treatment with the use of the VR goggles.

As VR glasses cannot be worn with a nitrous oxide nasal hood, they cannot be used in conjunction with inhaled sedation. Whether the use of VR glasses can replace inhaled sedation in patients for whom it is contraindicated remains an open question, as conducting a crossover study to examine such would not be ethical.

A few limitations arise in the use of VR goggles. First, dentists must have basic knowledge of the hardware and software of the goggles. Second, the time required to place the VR goggles and explain their use to children should be considered. In addition, VR goggles do not isolate noise resulting from the treatment and the use of dental equipment, and these noises can cause fear and anxiety. In addition, side effects of nausea have been reported during the use of VR sets[32]; these stem from low screen resolution. None of our patients reported nausea whilst wearing VR glasses, and this may be due to the use of quality hardware and high-resolution screens for content. As VR goggles are noticeable, the intervention is clear to the patient and to the observer. In addition, as the goggles mask the eyes, rating the MBPS index is more difficult for the observer, and this raises the possibility of bias.

In conclusion, the use of VR goggles decreased the pain perceived during rubber dam placement amongst children but has limited benefit during administration of local anaesthesia.

Author contributions

AS, HE, MM, DR, and AFN conceived the ideas and designed the work. ZL supplied the technical knowledge and equipment. LG collected the data. ZL, MM, and AFN analysed the data. ZL, DR, MM, and AFN led the writing. All the authors contributed to the writing or critical revision of the manuscript, and all of them approved the submitted version.

Conflict of interest

None disclosed.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.identj.2022.06.003.

REFERENCES

1. Eccleston C, Crombez G. Pain demands attention: a cognitive–affective model of the interruptive function of pain. Psychol Bull 1999;125:356–66.
2. Slifer KJ, Tucker CL, Dahlquist LM. Helping children and caregivers cope with repeated invasive procedures: how are we doing? J Clin Psychol Med Settings 2002;9:131–52.
3. Leventhal H. I know distraction works even though it doesn't!. Health Psychol 1992;11:208–9.
4. Lahmann C, Schoen R, Henningsen P, et al. Brief relaxation versus music distraction in the treatment of dental anxiety: a randomized controlled clinical trial. J Am Dent Assoc 2008;139:317–24.
5. Stark LJ, Allen KD, Hurst M, et al. Distraction: its utilization and efficacy with children undergoing dental treatment. J Appl Behav Anal 1989;22:297–307.
6. Filcheck HA, Allen KD, Ogren H, et al. The use of choice-based distraction to decrease the distress of children at the dentist. Child Fam Behav Ther 2005;26:59–68.
7. Prabhakar AR, Marwah N, Raju OS. A comparison between audio and audiovisual distraction techniques in managing anxious pediatric dental patients. J Indian Soc Pedod Prev Dent 2007;25:177–82.
8. Ram D, Shapira J, Holan G, et al. Audiovisual video eyeglass distraction during dental treatment in children. Quintessence Int 2010;41:673–9.
9. Shetty V, Suresh LR, Hegde AM. Effect of virtual reality distraction on pain and anxiety during dental treatment in 5 to 8 year old children. J Clin Pediatr Dent 2019;43:97–102.
10. Czech O, Wrzeciono A, Rutkowska A, et al. Virtual reality interventions for needle-related procedural pain, fear and anxiety-a systematic review and meta-analysis. J Clin Med 2021;10:3248.
11. Atzori B, Vagnoli L, Graziani D, et al. An exploratory study on the effectiveness of virtual reality analgesia for children and adolescents with kidney diseases undergoing venipuncture. Int J Environ Res Public Health 2022;19:2291.
12. Piskorz J, Czub M. Effectiveness of a virtual reality intervention to minimize pediatric stress and pain intensity during venipuncture. J Spec Pediatr Nurs 2018;23.
13. Lin CS, Wu SY, Yi CA. Association between anxiety and pain in dental treatment: a systematic review and meta-analysis. J Dent Res 2017;96:153–62.
14. Kuscu OO, Akyuz S. Is it the injection device or the anxiety experienced that causes pain during dental local anaesthesia? Int J Paediatr Dent 2008;18:139–45.
15. Yoon RK, Chussid S. Topical anesthesia for rubber dam clamp placement in sealant placement: comparison of lidocaine/prilocaine gel and benzocaine. Pediatr Dent 2009;31:377–81.
16. Aminabadi NA, Erfanparast L, Sohrabi A, et al. The impact of virtual reality distraction on pain and anxiety during dental treatment in 4-6 year-old children: a randomized controlled clinical trial. J Dent Res Dent Clin Dent Prospects 2012;6:117–24.
17. Alshatrat SM, Sabarini JM, Hammouri HM, et al. Effect of immersive virtual reality on pain in different dental procedures in children: a pilot study. Int J Paediatr Dent 2022;32:264–72.
18. Niharika P, Reddy NV, Srujana P, et al. Effects of distraction using virtual reality technology on pain perception and anxiety levels in children during pulp therapy of primary molars. J Indian Soc Pedod Prev Dent 2018;36:364–9.
19. Gómez-Polo C, Vilches AA, Ribas D, et al. Behaviour and anxiety management of paediatric dental patients through virtual reality: a randomised clinical trial. J Clin Med 2021;10:3019.

20. American Academy of Pediatric Dentistry. Behavior guidance for the pediatric dental patient. The Reference Manual of Pediatric Dentistry. Chicago, IL: American Academy of Pediatric Dentistry; 2021. p. 306–24.
21. Wong DL, Baker CM. Pain in children: comparison of assessment scales. Pediatr Nurs 1988;14:9–17.
22. Taddio A, Nulman I, Koren BS, et al. A revised measure of acute pain in infants. J Pain Symptom Manage 1995;10:456–63.
23. Sealed Envelope Ltd. 2012. Power calculator for continuous outcome superiority trial. Available from: https://www.sealedenvelope.com/power/continuous-superiority/. Accessed 25 January 2022.
24. Atzori B, Lauro Grotto R, Giugni A, et al. Virtual reality analgesia for pediatric dental patients. Front Psychol 2018;9:2265.
25. Custódio NB, Costa FDS, Cademartori MG, et al. Effectiveness of virtual reality glasses as a distraction for children during dental care. Pediatr Dent 2020;42:93–102.
26. Ran L, Zhao N, Fan L, et al. Application of virtual reality on non-drug behavioral management of short-term dental procedure in children. Trials 2021;22:562.
27. Hedén L, von Essen L, Ljungman G. The relationship between fear and pain levels during needle procedures in children from the parents' perspective. Eur J Pain 2016;20:223–30.
28. Bagchi A, Lahiri B, Jalaluddin M, et al. Quantification and measurement of changes in anxiety level in preschool children and their mothers through multiple-visit dental treatment. J Int Soc Prev Community Dent 2017;7:125–30.
29. Rank R, Rank MS, Vilela JER, et al. Dental anxiety and behavior in young children undergoing different distraction techniques. Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2017;17:3651.
30. Michaelides A, Zis P. Depression, anxiety and acute pain: links and management challenges. Postgrad Med 2019;131:438–44.
31. Felemban OM, Alshamrani RM, Aljeddawi DH, et al. Effect of virtual reality distraction on pain and anxiety during infiltration anesthesia in pediatric patients: a randomized clinical trial. BMC Oral Health 2021;21:321.
32. Wismeijer AA, Vingerhoets AJ. The use of virtual reality and audiovisual eyeglass systems as adjunct analgesic techniques: a review of the literature. Ann Behav Med 2005;30:268–78.