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EVALUATION OF THE EFFECT OF PLAYING VIDEO GAMES ON CHILD BEHAVIOR DURING DENTAL TREATMENT

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KEYWORDS

Anxiety, Behaviour management, pain, video games, VAS, VCARS

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ABSTRACT

Introduction: One of the most difficult issues in paediatric dentistry is effectively managing children, ensuring that our treatment is delivered in a calm and comfortable atmosphere, while reducing any painful causes that may increase nervousness and fear. **Aim**: To compare the effects of video game playing and the Tell-Show-Do technique on anxiety and behavior in children during their first dental visit, using physiological (heart rate, oxygen saturation) and behavioral (VAS, Venham's scale) assessments. **Materials & Methods:** A randomized clinical trial was conducted on sixty children aged 6-8 years, who required vital pulpotomies for their primary molars. The children were randomized to two groups according to behavior management technique, where Group-I, the control group, comprised of 30 children who were received the tell show-do (TSD) approach and Group-II, referred to as the examined group, comprised of 30 children who were provided with hand-held Video Games (VGs). **Results:** There was no statistically significant difference regarding the mean heart rate and oxygen saturation readings among different time points in both groups. There were no significant differences in Visual Analogue Pain Rating Scale (VAS) between TSD and VGs distraction techniques after local anaesthesia administration, however, at end of procedure VGs group had statistically lower child pain scores compared with TSD group. Regarding Venham's clinical anxiety and behavioral rating scale (VCARS), results showed that VGs group had statistically very highly significant lower child anxiety levels than TSD group. **Conclusion:** The use of video games distraction significantly reduces pain and anxiety and has shown to be more effective compared with TSD distraction for redirecting a patient's attention away from pain, besides being more convenient because of its increased practicality and widespread availability. Considering our results, video games could be incorporated as an adjunct in routine dental practice during administration of local anesthesia.

INTRODUCTION

Children frequently experience dental anxiety and worry, which can result in difficult conduct during dental procedures and could have negative effects on their oral health results [(1)]. The prevalence of pain and anxiety during dental procedures is high, with approximately 40% of patients experiencing dental anxiety and 20% having a dental phobia. These issues are significant concerns in dentistry because they can hinder patients from pursuing or completing treatment [(2)].

Administering local anesthetics to children in a pain-free manner during dental treatments presents a definitive method to reduce the fear of the needle, which is often been more elusive. By mitigating the pain associated with injections, the child's anxiety and apprehension are reduced. This contributes to a positive and trust-filled rapport between the child and the pediatric dentist, which is important in developing a favorable dental attitude for the future[3].

Due to the complex nature of dental fear/anxiety, it is challenging to address it effectively with a single therapy, sometimes resulting in poor outcomes and a waste of time. As a result, several pharmacological and non-pharmacological approaches have been suggested to manage this issue. These include the use of sedatives, voice control, physical restraints, trust building, tell show-do, and distraction techniques to regulate children's behavior during dental visits[4,5]. Pediatric dentists frequently choose for the tell-show-do (TSD) method, which was developed by Addelston and is based on the principles of learning theory [6, 7].

There has been an increasing focus in recent years to explore novel methods for managing kid dental anxiety and enhancing patient compliance. An option that has garnered significant interest is the utilization of video games (VGs) as a diversionary tactic during dental operations[8]. Presently, youngsters across all age brackets engage with mobile phones to partake in gaming activities, explore the internet for educational purposes, and seek enjoyment.

Smartphones can be outfitted with suitable video games to serve as a novel, handy, and cost-effective method for alleviating dental anxiety in youngsters requiring dental procedures. Based on social learning theory, young individuals acquire knowledge by witnessing and replicating actions depicted on screens, especially when these actions are portrayed realistically[9,10,11]. Playing video games (VGs) has become a widespread hobby in today's culture. They have been extensively used in the field of healthcare, mostly for the purpose of diversion and behaviour modification treatment[12].

Engaging in an interactive VG has the potential to go beyond mere entertainment. Children can become completely absorbed in playing VGs to the point that they are unaware of their surroundings or ignore any verbal or physical cues. Research indicates that it can modulate attention, influence cognitive processes, and stimulate the release of endorphins. This can potentially enhance the dental experience for young patients in a positive way. [13]

This article seeks to assess the impact of VGs playing on child behavior during dental treatment by analyzing the existing data, probable mechanisms of influence, and the consequences for clinical practice. The swift progress of technology and the growing availability of mobile devices have made it easier to incorporate video games into healthcare settings. This provides a non-pharmacological approach that can enhance traditional behavior management methods in paediatric dentistry.[14]

According to our knowledge there have been limited research conducted on using handheld video games as a behavior guidance technique during invasive dental procedure using local anesthesia and vital pulp therapy. Therefore, the purpose of this study was to evaluate and compare the effect of playing video games (VGs) versus tell-show-do (TSD) technique on child behavior during dental treatment. This study tested a null hypothesis which stated that, there is no difference in management of pain and anxiety of the compared behavioral techniques.

MATERIALS AND METHODS

The research was conducted under the World Medical Association's Code of Ethics (Helsinki Declaration) for human research. The trial was registered on ClinicalTrials.gov under the identifier NCT06001710 on August 21, 2023. The Research Ethical Committee of faculty of Dentistry, Suez Canal University accepted the study proposal (311/2021). All clinical procedures were performed in accordance to its guidelines and regulations. Data reporting was in line with the Consolidated Standards of Reporting Trials Statement (CONSORT) checklist (**Fig.1**)[15,16]. The randomization sequence was created using computer-generated random numbers (CGRNs). Prior to the study, written informed consent was obtained from the parents and/or caregivers of the participating children, explaining the study procedures and the related possible complications and indicating their agreement to the treatment.

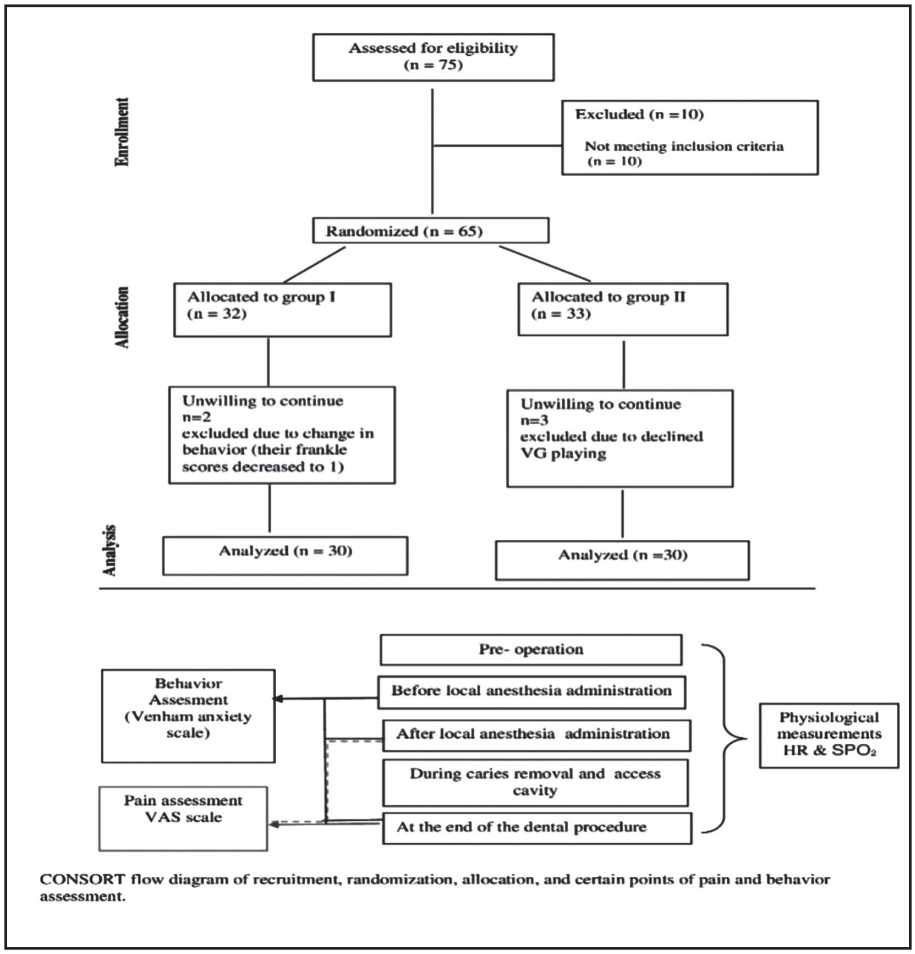

Fig. (1) Study's CONSORT flow diagram

Sample size calculations

Sample size calculation was carried out to compare between different treatments using G*power software, version 3.1.9.6.[17] The study determined that 60 patients were sufficient to identify an effect size of 0.30, ensuring a statistical power (1-β) of 95% and a significance threshold (p) of less than 0.05. Consequently, a total sample size of 60 children were included for this study with random allocation to either the control or study groups, to account for any loss within 10% during the follow-ups periods.

Sample selection

The study included a total of sixty children, aged between 6 and 8 years, of both genders, who were selected from the Outpatient Clinic of the Pediatric Dentistry Department at the Faculty of Dentistry, Suez Canal University. Eligible participants were apparently healthy children requiring local anesthesia for vital pulp therapy of primary molars[9]. Only children who had never received previous dental treatment and demonstrated cooperative behavior, specifically those rated as "positive (+2)" or "negative (–3)" according to the Frankl Behavior Scale (FBS)[10], were included. The need for treatment was confirmed through both clinical and radiographic examinations.

Children were excluded if they had developmental or systemic disorders, allergies to materials used in the study, spontaneous dental pain, intraoral facial swelling, or the presence of a fistula or sinus tract. Teeth showing signs of irreversible pulpitis—such as prolonged bleeding exceeding five minutes, dark or purplish blood—pulpal necrosis, internal or external root resorption, furcation radiolucency, or periapical pathology were also excluded. Prior to participation, verbal explanations of the study's aim, procedures, benefits, and potential risks were given to both the children and their parents or caregivers, and written informed consent was obtained from the parents or legal guardians.

Randomization and Sample Grouping

The study was conducted as a randomized clinical trial with 60 children who were assigned to two groups using a computer-generated random number into two groups, the coded papers were kept in an opaque envelope. Each youngster was instructed to select a paper from the envelope and was subsequently categorized and treated accordingly based on type of management technique as follow:

Group I (Control Group): the study involved a group of 30 children who received the tell-show-do (TSD) technique as a behavior management strategy. Firstly, patients were introduced to the dental clinic and received verbal explanations of the treatment procedure and what would be done precisely. Following this, the child received demonstrations of the visual, auditory, and tactile aspects of the procedure, meaning that the child was demonstrated all the equipment and materials needed for the treatment, as the dental chair, the instruments and the topical anesthetic gel as tooth sleeping drug in very simple words; informed about the noise produced by the airotor; and shown how the suction, three-way syringe, and airotor worked. Finally, the patient was treated.

Group II (Study group): Included 30 children who received handheld Video Games (VGs) as a behavior management technique. The child received a smartphone equipped with 10 different video games, among them a simulation dental game "Little Lovely Dentist" which is an application developed by Leaf cottage software and Shanghai Eday soft Co., Ltd. All video games were downloaded from android play store.

Clinical procedures

To ensure adherence to the eligibility criteria, each child participant underwent a comprehensive assessment that included extra-oral, intra-oral, and radiographic examinations. The child's ability to comply with the dentist's instructions during the clinical procedures, as well as their cooperation during the radiographic examination using periapical films without displaying distress (e.g., crying), was used to assess their behavioral response. Based on these observations, participants were categorized according to the Frankl Behavior Scale (FBS) as exhibiting either "positive" or "negative" dental behavior. Both the children and their parents or guardians were provided with a concise, age-appropriate explanation of the study procedures, including its purpose, steps, potential benefits and any associated risks.

Pulse Oximeter device was introduced to all children and attached to their index finger for recording physiological measurements: the heart rate (HR) and oxygen saturation (SPO_2). Where (HR1) and ($SPO_2$1) were recorded in the waiting area before the child entered the dental clinic as a baseline. According to random allocation, once the children were seated in the dental chair, they received the assigned behavior management technique. In the Tell-Show-Do (TSD) group, the behavior modification method was implemented prior to the administration of local anesthesia. In the video games (VGs) group, children were provided with a mobile phone containing ten different games and were instructed to choose and play a game of their preference throughout the dental procedure.

Before the administration of LA, and while the child was seated comfortably in the dental chair, (HR2) and (SPO_2) levels were recorded.[9] Additionally, dental anxiety was assessed using Venham's Anxiety and Behavioural Rating Scale (Venham 1), by observing the child's behavior according to the 6-point Venham index Table (1)[18,19].

For all patients, the LA administration process was explained in terminology that can be easily understood for both groups [20]**.** Flavored topical anesthetic gel (Benzocaine 20% (Opahl-S, Dharma, USA) was applied after drying the injection area for 30 seconds, then followed by anesthetic injection (Infiltration/nerve block) of mepivacaine 2% with 1/100,000 epinephrine (Scandicaine 2% speciale, Septodont, UK) [21]**.** Where the syringe was kept out of the children's line of sight either from behind their head or below their chin. At the time of anesthetic injection (T2), physiological measurements—including heart rate (HR3) and oxygen saturation ($SpO_2$3)—were recorded by a research assistant using a pulse oximeter. Immediately after the administration of local anesthesia, the Visual Analog Scale (VAS1) was used to assess the child's self-reported pain during the injection. Additionally, the Venham's Clinical Anxiety and Behavioral Rating Scale (VCARS) was used to evaluate the child's behavior at the time of anesthetic administration (Venham 2).

Following a 5-minute waiting period, vital pulpotomy was performed under rubber dam isolation by a single practitioner. During cavity preparation using a high-speed handpiece , heart rate (HR4, HR5) and oxygen saturation ($SpO_2$4, $SpO_2$5) were recorded at two time points[9]. At the end of treatment, with the dental chair returned to its upright position, final physiological (HR6, $SpO_2$6) and behavioural (VAS2), and (Venham3) assessments were recorded.

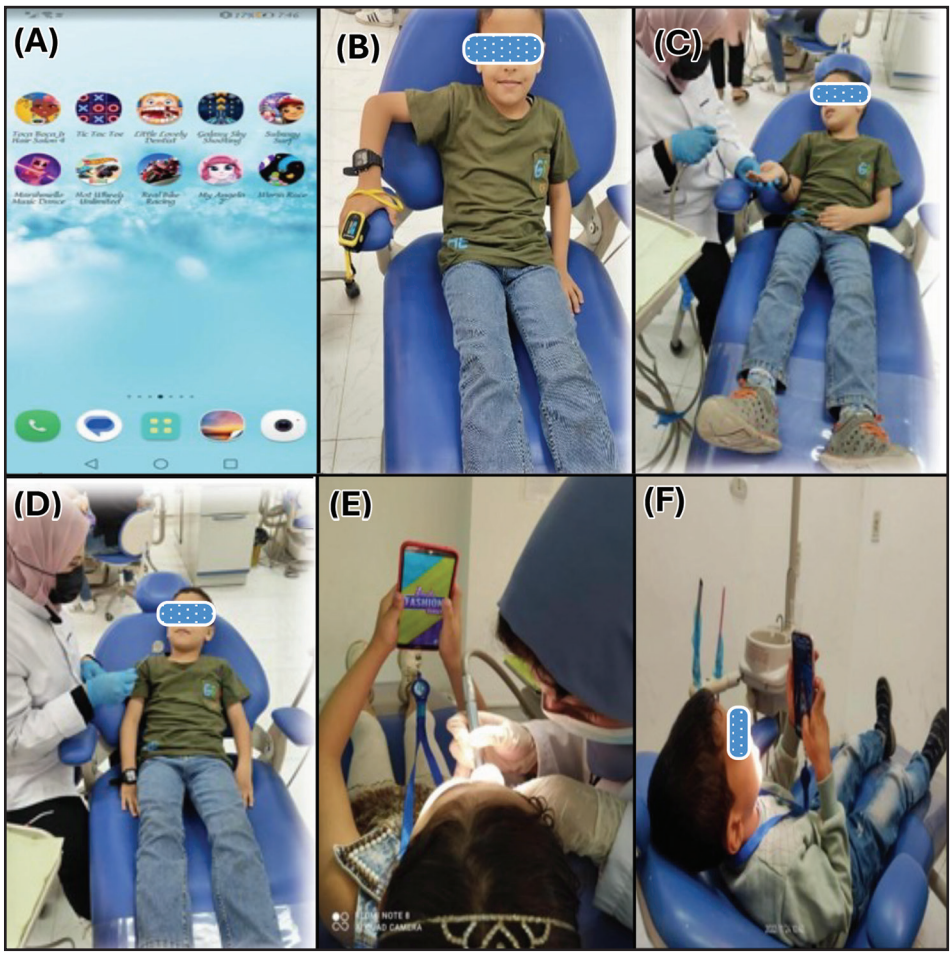

Fig. (2) (A) 10 different video games downloaded from play store. (B) Pulse oximeter attached to a child's finger for monitoring heart rate and oxygen saturation. (C, D) Conditioning a child using Tell-Show-Do technique. (E, F) Patients played their chosen video games throughout dental procedure

Assessment Methods

Physiological Measurements: Anxiety levels were objectively assessed by measuring heart rate (HR) and oxygen saturation (SpO_2) using a finger pulse oximeter (Pulsox-304, Granzia, Italy), which provides continuous real-time readings. Measurements were taken at six time points: in the waiting area (baseline), upon seating on the dental chair, during local anesthesia administration, during caries removal, during pulp amputation, and at the end of treatment [9].

Psychological Measurements: The study utilized two distinct assessment methods: a subjective assessment represented by the Visual analog scale (VAS) to record self-reporting pain and an objective assessment represented by Venham's Anxiety and Behavioral Rating Scale. Subjective pain was assessed using the Visual Analog Scale (VAS), a 10 cm line anchored by neutral (0) and frowning (10) faces representing no to maximum pain. The child selected the face corresponding to their perceived pain level at two time points:

after local anesthesia (VAS1) and at the end of the procedure (VAS2). Behavioral anxiety was assessed using the Venham's Clinical Anxiety and Behavioral Rating Scale (VCARS), which categorizes behavior into six levels (scores 0–5), with higher scores indicating increased anxiety or reduced cooperation. Observations were recorded at three time points: before local anesthesia (Venham1), after anesthesia (Venham2), and at the end of treatment (Venham3). Assessments were conducted by both the operator and the main supervisor.

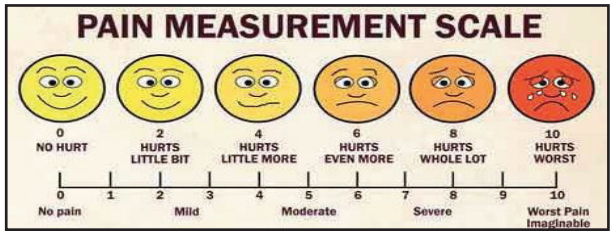

Fig. (3) Visual Analog Scale

Table 1. *Venham Anxiety and Behavior Rating Scale*

Score	Criteria
0	Relaxed: smiling, willing, able to converse, displays behavior desired by the dentist.
1	1 | Uneasy: concerned, may protest briefly to indicate discomfort, hands remain down or partially raised. Tense facial expression, high chest. Capable to cooperating.
2	Tense: tone of voice, question and answers reflect anxiety. During stressful procedure, verbal protest, crying, hands tensed and raised, but not interfering very much. Protest more distracting and troublesome. Child still complies with the request to cooperate.
3	Reluctant: pronounced verbal protest, crying. Using hands to stop procedure. Treatment proceeds with difficulty.
4	Interference: general crying, body movements sometimes needing physical restraint. Protest disrupts procedure.
5	Out of contact: hard loud crying, swearing, screaming. Unable to listen, trying to escape. Physical restraint required.

Statistical analyses

The data were entered into a Microsoft Excel Spreadsheet 2016. Data analyses were carried out using computer software Statistical Package for Social Science SPSS (IBM-SPSS ver. 29.0 for Mac OS)[22]. Difference between groups I and II were assessed by independent samples t-test at 0.05 level. The difference between scores was assessed using Chi-square test. The Mann-Whitney U test was used to examine the differences in anxiety scores between the two groups.

RESULTS

A consort flow diagram representing the random allocation of children who met all inclusion criteria (n=65) is shown in Fig. 1. All cases were analyzed in each group post-intervention (n = 65), except for two participants in Group I (TSD group) who were excluded due to changes in their Frankl behavior scores during follow-up (final n = 30), and three participants in Group II (VG group) who were excluded due to refusal to continue video game interaction (final n = 30).

1. Demographic parameters (age and gender):

Table 2 showed that no significant difference was detected between the mean age values neither between gender values, in both groups.

2. Physiological measurements (objective measures):

2.a. Heart rate (HR)

Table 3 presents the heart rate values recorded at six different time points (HR1–HR6) for both groups (Group I: TSD and Group II: VGs). Intragroup analysis using repeated measures ANOVA, showed a statistically significant change in heart rate over time in both groups

(p<0.001). The Duncan multiple range test indicated that HR3 was significantly higher than other time points in both groups (p<0.05). However, intergroup comparison using independent t-tests showed no statistically significant differences between the two groups at any time point (p=0.259). These findings suggest that while heart rate varied significantly within each group over time, the pattern of change was similar between the two groups.

Table 2. *Age and gender distribution of children among study:*

Variable		Group-I TSD (n=30)	Group-II VGs (n=30)	Sign.
Age (mean ±SD)	**Male**	6.89±0.81	7.04±0.91	
	Female	6.84±0.78	6.67±0.68	t>0.239 ns
	Total	6.87±0.79	6.82±0.79	
Gender (n, %)	**Male**	14.0 (46.6%)	12.0 (40.0%)	C 0.795 ns
	Female	16.0 (53.3%)	18.0 (60%)	

Mean, standard deviation (SD), frequencies (n), percentages, significant at p<0.05; ns, non-significant at p>0.05, C= Chi-square test; t= t-test

Table 3. *Heart rate in both groups (I, II):*

Heart rate timing	Heart rate				Independ. t-test
	Group I TSD		Group-II VGs		
	Mean±SD	DMRTs	**Mean±SD**	DMRTs	
HR1	98.4±8.6	d	98.2±9.2	d	0.934 ns
HR2	100.3±8.8	cd	97.7±19.1	d	0.459 ns
HR3	109.4±7.4	a	106.6±10.9	ab	0.149 ns
HR4	106.6±9.3	ab	103.6±10.9	ab	0.876 ns
HR5	102.5±8.9	bcd	101.7±9.7	bcd	0.730 ns
HR6	96.6±8.4	d	96.5±7.8	d	0.949 ns
ANOVA RM	<0.001***		<0.001***		
Two-way repeated measure ANOVA					
Between groups	0.259 ns				
Among time points	<0.001***				
Group x time	0.241 ns				

*SD: Standard Deviation, *significant difference<0.05, **highly significant p<0.01, ***Very highly significant p<0.001, $DMRT_S$: Duncan multiple range test, where means in the same row with different letter were significantly different.*

2.b. Oxygen saturation

Table 4 presents the oxygen saturation (SpO_2) values measured at six different time points in both groups. Repeated measures ANOVA revealed a statistically significant change in oxygen saturation over time within each groups ($p < 0.001$). The Duncan multiple range test showed fluctuations across different time points, with the lowest mean oxygen saturation values were observed at $SPO_2$and SPO_2 in both groups, possibly reflecting transient physiological stress response during the procedure.

Independent t-tests indicated statistically significant differences between the two groups at SPO_2 ($p = 0.012$) and SPO_2 ($p = 0.044$), while no significant differences were found at other time points ($p>0.05$). Two-way repeated measures ANOVA showed a significant effect of treatment ($p= 0.044$) and time ($p < 0.001$), with no significant interaction between them ($p = 0.967$). These findings suggest that while both groups exhibited significant result within-group, changes in oxygen saturation over time occurs, with Group II tended to maintain higher SpO_2 levels at specific time points.

Table 4. *Oxygen saturation in both groups.*

SPO_2 timing	Oxygen saturation				Independent t-test
	Group-I		Group-II		
	Mean ±SD	DMRTs	Mean ±SD	DMRTs	
$SPO_2$1	98.1±1.5	Ab	98.5±1.0	a	0.312 ns
$SPO_2$2	97.5±1.5	De	98.4±0.9	bc	0.012 *
$SPO_2$3	96.3±2.1	Ef	97.1±1.6	e	0.471 ns
$SPO_2$4	97.2±1.2	E	97.8±1.4	de	0.118 ns
$SPO_2$5	98.5±1.1	Bc	98.9±0.3	a	0.044*
$SPO_2$6	98.9±0.4	a	98.9±0.3	a	0.435 ns
ANOVA RM	<0.001***		<0.001***		
Two-way repeated measure ANOVA					
Groups	0.044*				
Time	<0.001***				
Group x time					

**Significant difference at p<0.05, **highly significant p<0.01, ***Very highly significant p<0.001, $DMRT_S$: Duncan multiple range test, where means in the same row with same letter were insignificantly different, while means in the same row with different letter were significantly different.*

3. Psychological measurements:

3.a. VAS (subjective measure):

Table 5 illustrates the distribution of Visual Analogue Scale (VAS) scores in both groups at two different time points (VAS 1 & VAS 2). Group I (TSD) showed a slight reduction in mean pain score from 2.93 to 2.60, while Group II (VGs) showed a more pronounced decrease from 2.50 to 1.93. The change was statistically significant in both groups over time ($p = 0.039$) and ($p < 0.001$), respectively. While intergroup comparison of VAS1 was not statistically significant ($p = 0.150$), a significant difference was observed at VAS2 ($p = 0.026$). Repeated measures ANOVA indicated a significant effect of time ($p < 0.001$), but no significant difference between groups ($p = 0.134$) or group-by-time interaction ($p = 0.293$), suggesting both methods were effective in reducing perceived pain over time.

Table 5. *VAS in group-I and II during different time points VAS 1 & VAS 2 recorded as average (±SD).*

VAS	Group-I	Group-II	Independent t-test sig.
	Mean±SD	Mean±SD	
After local anaesthesia (VAS1)	2.93±1.82 a	2.50 ±1.36 ab	0.150 ns
The end of dental procedure (VAS2)	2.60 ± 1.48 b	1.93±1.11 c	0.026*
Paired t-test	0.039 *	<0.001***	
Repeated measure ANOVA			
Between Groups	0.134 ns		
Time	<0.001***		
Group x Time	0.293 ns		

, **, *, significant at p<0.05, <0.01, <0.001; ns, non-significant at p>0.05. The difference between groups I and II was evaluated by independent t-test. Overall difference was assessed using repeated measure ANOVA.*

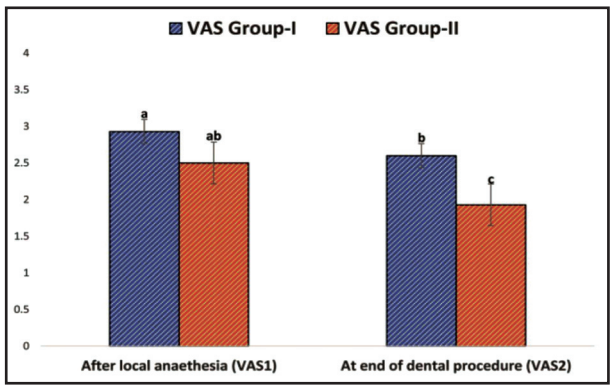

Fig. (4) Bar chart showing Visual Analogue Scale in both groups

3.b. Venham's clinical anxiety and behavioral rating scale (VCARS) (Objective measurement):

Table 6 presents the VCARS scores at the three time points (VCARS1, VCARS 2 and VCARS 3) in both groups. The decrease in VCARS was very highly significant in group I (TSD) and group II (VGs), ($p=0.001$) and ($p = 0.007$), respectively. Also, the intergroup comparison of VCARS was statistically significant among time intervals. Repeated measures ANOVA indicated a significant effect of time ($p < 0.001$), and a significant difference between groups ($p = 0.001$), but a non-significant in group-by-time interaction ($p = 0.390$).

Table 6. *The VCARS in group-I and group-II presented as mean, standard deviation (SD) and Dun's Bonferroni*

VCARS	Group-I		Group-II		Sig.
	Mean±SD	Dun's	Mean±SD	Dun's	
Before L.A (Venham1)	**1.03±0.67**	**ab**	**0.57±0.57**	**C**	0.005**
After L.A (Venham2)	**1.37±0.56**	**a**	**0.90±0.40**	**B**	<0.001***
At the end of procedure (Venham3)	**0.57±0.63**	**c**	**0.27±0.45**	**D**	0.037*
ANOVA	0.001***		0.007**		
Repeated measure ANOVA					
Group	0.001***				
Time	<0.001***				
Group x Time	0.390ns				

, **, *, significant at p<0.05, <0.01, <0.001; ns, non-significant at p>0.05*

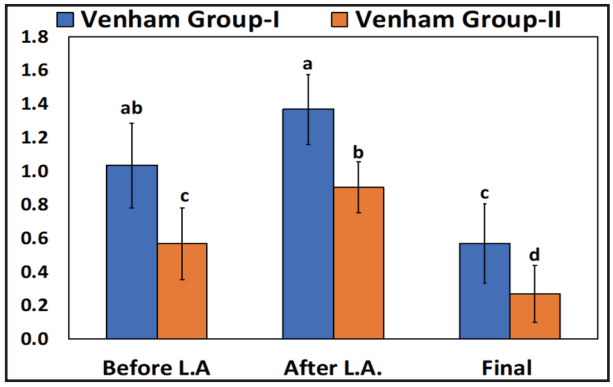

Fig. (5) The Venham Behaviour Rating Scale in group I and II presented as mean and standard deviation. Bars followed by different letters are significantly different according to Dun's Bonferroni.

DISCUSSION

Pain and anxiety are the two main determinants for disruption of any dental treatment, they are two sides of the same coin. They can manifest through behaviors such as crying, sudden or jerky movements, kicking, tantrums, or resisting dental equipment—all of which increase the risk of injury. These behavioral responses not only compromise the safety and efficiency of dental procedures but also contribute to poor oral health due to the avoidance of dental treatment and uncontrolled behavior during various procedures. To address this issue, various pharmacologic and non-pharmacologic behavior management techniques have been proposed[23].

Primary molar pulpotomy is the most common dental treatment among pediatric patients, and it consists of several irritating steps that can induce pain and anxiety[24,25].

TSD is the most employed approaches in behavior management technique for the effective management of children's anxiety at their pretreatment visit. It familiarizes them with new procedures, thus reducing their anticipatory anxiety[6]. Meanwhile, in the era of digitization, dentists also have to adapt to the current technologies. With the advent of mobile phones, children have been exposed to a myriad of newer technologies since their infancy[26]. VGs is one of the newly developed tools, also peer-filmed videotaped presentation have been tried as

a mean of behaviour management preceding dental treatment. The interactive mobile game consists of active participation of the child which simulates the dental procedure he is to undergo. The child treats the virtual patients thereby instilling in him a positive behaviour[23]

Therefore, this study aimed to evaluate and compare between the effect of VGs in reducing pain and anxiety compared with the TSD technique during primary molars pulpotomy in pediatric patients aged 6–8. All participants were undergoing their first dental treatment session and were selected from the Outpatient Clinic of the Pediatric Dentistry Department, Faculty of Dentistry, Suez Canal University.

The present study was performed on 60 children according to study sample calculation, aged from 6 to 8 years old, as dental treatment is more likely to be tolerated by children over the age of five than it is by younger ones, since their cognitions, emotions, and even mental understanding become more evolved as they grow older, this is in agreement with **Derbala et al.**[20] . Furthermore, they can accurately express their pain and anxiety according to different scales[27], and follow the instructions while playing virtual games[28,29]. In addition, primary molar pulpotomies are frequent among this age group[30]. In this study, there was no distinction between boys and girls, as it was hypothesized that gender was of less important for behavioral changes in this younger age group, this agrees with **Mohebbi et al.**[31]

Only apparently healthy children without systemic diseases were included to avoid confounding effects on physiological measures and minimize potential complications such as chronic bacteremia in vulnerable cases.[32] Behavior was assessed using the Frankl Behavior Rating Scale (FBRS), and only children with scores of 2 or 3 were selected, those expected to comply with dentist instructions cooperatively or those with some evidence of negative attitude but still can cooperate.[18,23] Children with score 1 were excluded due to the limited effectiveness of distraction techniques, which in turn affects the judgment on the effectiveness of outcomes. To eliminate the influence of prior dental experiences, only first-time dental patients were included, in line with **Derbala et al.,**[20] as previous traumatic experiences may reduce the effectiveness of distraction methods.[26]

The study focused on children undergoing vital pulp therapy in primary molars, as the procedure type and duration are known to significantly influence behavior in pediatric patients[33]**.** Children requiring emergency treatment or with allergies to any used materials were excluded to ensure uniform pain stimuli and safe treatment conditions**.**[34]

Dental procedures involving local anesthesia often trigger stress-related physiological changes, leading to anxiety and behavioral issues**.**[35]. Elevated heart rate and respiratory rate are common clinical signs of anxiety, linked to hormonal responses such as adrenaline release, as noted in several studies**.**[33,37-39] Pulse rate is an objective and physiological measurement of dental anxiety. In this study, heart rate (HR) and oxygen saturation (SpO_2) were monitored using a pulse oximeter at multiple time points to objectively assess anxiety levels and if the management protocol was doing any good or harm for the anxiety level. Also, by the end of the visit the last record gave a general idea if the child enjoyed the visit and can accept to attend future dental visit or not, in accordance with **Harrison et al.**[40] Pulse oximetry is a non-invasive, reliable method for monitoring vital signs, with normal SpO_2 values ranging from 95–100% where hypoxemia defined as values below 90%.[41]

Pain perception was evaluated using the Visual Analogue Scale (VAS), a simple and widely accepted tool in dental research, particularly effective due to its intuitive facial expressions that can be used with all patients aged 3 and above.[18,42,43] Anxiety and uncooperative behavior were also assessed using the Venham scale, a validated five-point behavioral scale with high inter-rater reliability to assess the anxiety and uncooperative behaviour of children in the dental setting.[18,19] TSD technique was selected as the control group because it is the gold standard behavior guidance technique, widely accepted, and most dentists are familiar with it [44].

In accordance to demographic parameters (age, gender) in our study, the difference between groups in age and genders was non-significant. Our study revealed that the effectiveness of VG playing in reducing anxiety was not influenced by the gender of the child. Although, the general impression seems to be that boys are more interested in VGs, we found that girls were interested in playing as the boys. We ensured availability of games that boys and girls would find interesting, in agreement with **Derbala et al**.[20]

In this study, baseline heart rate (HR) recorded in the waiting area showed no significant difference between groups, indicating similar preoperative anxiety levels, consistent with **Shah et al.**[30]. HR increased notably during injection and cavity preparation in both groups, marking these stages as the most anxiety-inducing. However, children in the VG group showed a lower HR rise during these steps compared to those in TSD group, suggesting that video distraction helped reduce anxiety, in line with several studies.[9,45,46]

By the end of treatment, HR levels decreased below baseline in both groups, reflecting the effectiveness of both techniques. No significant difference in HR was found between groups overall, supporting findings by **Nivedita et al.**[23] and **Derbala et al.**[20]. In contrast, **Elicherla et al.**[10] reported a significant HR reduction only for the children in the dental app group than TSD group.

With respect to oxygen saturation in our study, preoperative oxygen saturation (SpO_2) levels were recorded in the waiting area and showed no significant difference between groups, indicating comparable baseline anxiety. Throughout the procedure, SpO_2 remained within normal limits, and no cases of hypoxemia were reported. A slight decrease in SpO_2 -below preoperative baseline- was observed during anesthetic delivery and cavity preparation, suggesting increased anxiety during these stages. Although the TSD group showed a greater decline in SpO_2 than the VG group, however, the difference between groups was not statistically significant. Stress and anxiety can alter the respiratory rate which in time may alter oxygen saturation levels in the blood. These findings align with **Khandelwal et al.**[38], who observed higher SpO_2 levels with audiovisual distraction compared to TSD, reflecting reduced anxiety, despite no significant differences between groups. Conversely, **Rayen et al.**[47] reported no clear correlation between oxygen saturation and anxiety in dental settings.

Regarding psychological outcomes, VAS scores showed no significant overall difference between groups, aligning with **Meshki et al.**[9] and **Matthyssens et al.**[48].However, by the end of the procedure, pain scores were significantly lower in the VG group, indicating improved pain distraction over time—similar to findings by **Maru et al.**[45] and **Kumprasert et al.**[46]

For anxiety, the Venham Clinical Anxiety Rating Scale revealed a highly significant reduction in the VG group, possibly due to endogenous dopamine release associated with video game play, as suggested by **Kühn et al.**[49]. These findings

are supported by several studies [10,20,30,50], who all reported greater anxiety reduction with video or digital distraction compared to TSD. Conversely, **Kumprasert et al.**[46] and **Nivedita & Amar**[23] found no significant behavioral differences between VG and TSD techniques.

The study has limitations, is that incorporating video games (VGs) into pediatric dental practice comes with challenges including ethical concerns, technical constraints, individual variability, and cost. Some children may show reluctance, and content must be age-appropriate to ensure effectiveness. Thus, it is recommended that standardized protocols be developed to integrate video games (VGs) into pediatric dental settings for anxiety management. Their use should complement traditional behavioral techniques to enhance effectiveness. Efforts must focus on ensuring accessibility and affordability. Further research is needed to assess the long-term efficacy of video games (VGs) interventions and their influence on children's oral health outcomes. Thus, the null hypothesis was rejected, supporting the use of VGs as an effective behavioural management tool in paediatric dentistry.

CONCLUSION

Based on our findings, both TSD and video game (VG) distraction reduced anxiety and pain effectively during dental treatment of children aged 6-8 years, but the smartphone VGs was superior to the TSD technique in diverting attention from the stressful dental environment. Smartphones are practical, accessible, user-friendly, and cost-effective tools for managing paediatric dental anxiety.

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