Original Article

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# Video games, audiovisual, and conventional distractions for pediatric dental patients: A crossover randomized controlled clinical trial

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**Objectives:** To compare the effectiveness of Audiovisual (AV), Video games (VG), and Conventional (Co) distractions in pediatric dental patients.

**Materials and Methods:** Sixty healthy children, 6–9-years-old, with carious molars in three quadrants were treated with a local anesthetic, rubber dam, and caries removal over three visits. On the first visit, Co distraction was used, and the patients were then randomly divided into two groups, where Group A received VG, followed by AV, on their second and third visits, respectively, and Group B received the distractions in the reverse order. The Wong-baker FACES pain rating scale and a modified FLACC behavioral scale were used, and heart rate was measured.

**Results:** The patient's behaviors were less disruptive when using VG than AV ($p$ = 0.006) during the local anesthetic injection, during which VG alleviated pain ($p$ = 0.036), promoted cooperative behavior ($p$ = 0.007), and reduced heart rates ($p$ = 0.0004).

**Conclusion:** VG was the most effective distraction to reduce disruptive behavior during local anesthetic injection.

**Keywords:** audiovisual, behavior management, distraction technique, video games

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## Introduction

Dental anxiety is prevalent among young children, which deleteriously affects their attitude towards behavior during dental treatment performed by dental care providers. The prevalence of dental anxiety in children varies from 6–42% in different populations [1, 2]. Children with dental anxiety tend to have more severe dental caries and often avoid dental visits, which possibly aggravates the child's level of anxiety [1, 3-5].

Distraction is a behavior management technique to help pediatric dental patients divert their attention from unpleasant stimuli and reduce disruptive behavior [6]. Distraction has positive effects on pain and distress during medical procedures [7]. Likewise, Conventional (Co) distractions, including conversing with the dentist, breath counting, listening to music or a story, watching videos, and playing video games, are widely used in pediatric dentistry [3-6, 8-12, 14].

Audiovisual (AV) distraction, such as watching cartoons, is a passive technique composed of two sensations, visual and auditory. However, the evidence of AV distraction effectiveness is not conclusive [2]. Numerous studies demonstrated that AV distraction alleviated unpleasantness during dental restorative procedures [9], enabled patients to be less aware of the pain associated with injecting a local anesthetic [5, 10], thereby reducing their heart rates, relieved physical distress [3], and minimized disruptive behavior [4].

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However, other studies found little to no medical effect of AV distraction on stress, disruptive behavior, or anxiety in dental patients [11-13].

It has been hypothesized that an ideal distraction should be an active distraction that involves multiple sensory modalities, including visual, auditory, and physical movements, to provide anxiolysis and analgesia [4, 5, 11, 12, 14]. A study confirmed that the active distraction technique of playing video games on an iPad was more effective in managing dental patients compared with the passive distraction of having patients watch a video through AV eyeglasses [14].

However, there is little investigation into the efficacy of active distractions, such as playing a VG. Many studies compared only two distraction techniques, AV, and Co distraction, such as using specialized AV eyeglasses or a ceiling mount television, mostly conducted in a sophisticated clinical setting. Electronic devices such as smartphones and tablets, which are common and easy to implement, have been less studied. Therefore, the aim of this study was to compare the effectiveness of VG, AV, and Co distraction techniques using smartphones and tablets in a small district hospital setting.

## Materials and Methods

This study was a randomized controlled trial with a split-mouth crossover design and a balanced allocation ratio of 1:1. The design did not include the collection of any information on harm, and the protocol was approved by the Institutional Review Board at the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University (Registration number MU-DT/PY-IRB 2018/024.2004) and the Thai Clinical Trials Registry (TCTR20181012001). The dental treatments were performed and finished during June–December 2018 at the Bo-phoi District Hospital, Kanchanaburi, Thailand. Informed consent was obtained from the patients' parents or legal guardians.

### 1. Sample Size

The sample size was calculated using the Two dependent means formula, assuming a standard deviation ($\sigma$) of 0.83 and a difference mean ($\Delta$) of 0.33 (based on observed behavior scores during local anesthesia injection) [14]. With alpha ($\alpha$) and beta ($\beta$) set at 0.05 and 0.2, respectively, the sample size had an 80% confidence level. Although a minimum sample size of 50 subjects was recommended, the sample size was increased to 62 subjects to allow for dropouts.

### 2. Subject Selection

The subjects were selected from 74 children (6–9-years-old), who needed dental treatment that involved using a local anesthetic and rubber dam in the posterior region in at least 3 quadrants, e.g. a filling, pulpotomy, pulpectomy, or stainless-steel crown. The inclusion criteria comprised children with a Frankl behavior rating scale, used to measure dental anxiety, score of 3 or 4 (Score 3: Acceptance of treatment; cautious behavior at times; willingness to comply with the dentist, at times with reservation, but still follows the dentist's instructions cooperatively; and Score 4: Good rapport with the dentist, interested in the dental procedures, laughter, and enjoyment), subjects who had not received local anesthesia for the past two years [15], were willing to play VG or watch cartoons during the procedure, and healthy (ASA I) with no physical or medical disability.

### 3. Procedures

This study investigated the effects of the three distraction techniques on disruptive behavior in pediatric patients. All dental visits were conducted by the same pediatric dentist, with

different distractions and parental separation. The treatments were performed at three visits, 1–4 weeks apart [4, 5, 16]. At the first visit, the standard behavior management techniques consisted of Conventional distraction (breath counting, making conversation about other things during the dental procedure), tell-show-do, and positive reinforcement. The subjects were then randomly divided into two groups. Group A (n=31) received AV and then VG distraction in the second and third visits, respectively. Group B (n=31) received the same distractions, but in reverse order, to prevent a possible carry-over effect from the split-mouth design [16]. AV distraction was performed by letting the subjects watch their preferred YouTube cartoons on a tablet, and VG distraction was implemented by having the subjects play their chosen video games on a provided smartphone. The tablet and smartphone were used with in-ear headphones. The subjects' pain perception, behavior, and heart rate were measured at certain points in time (Figure 1).

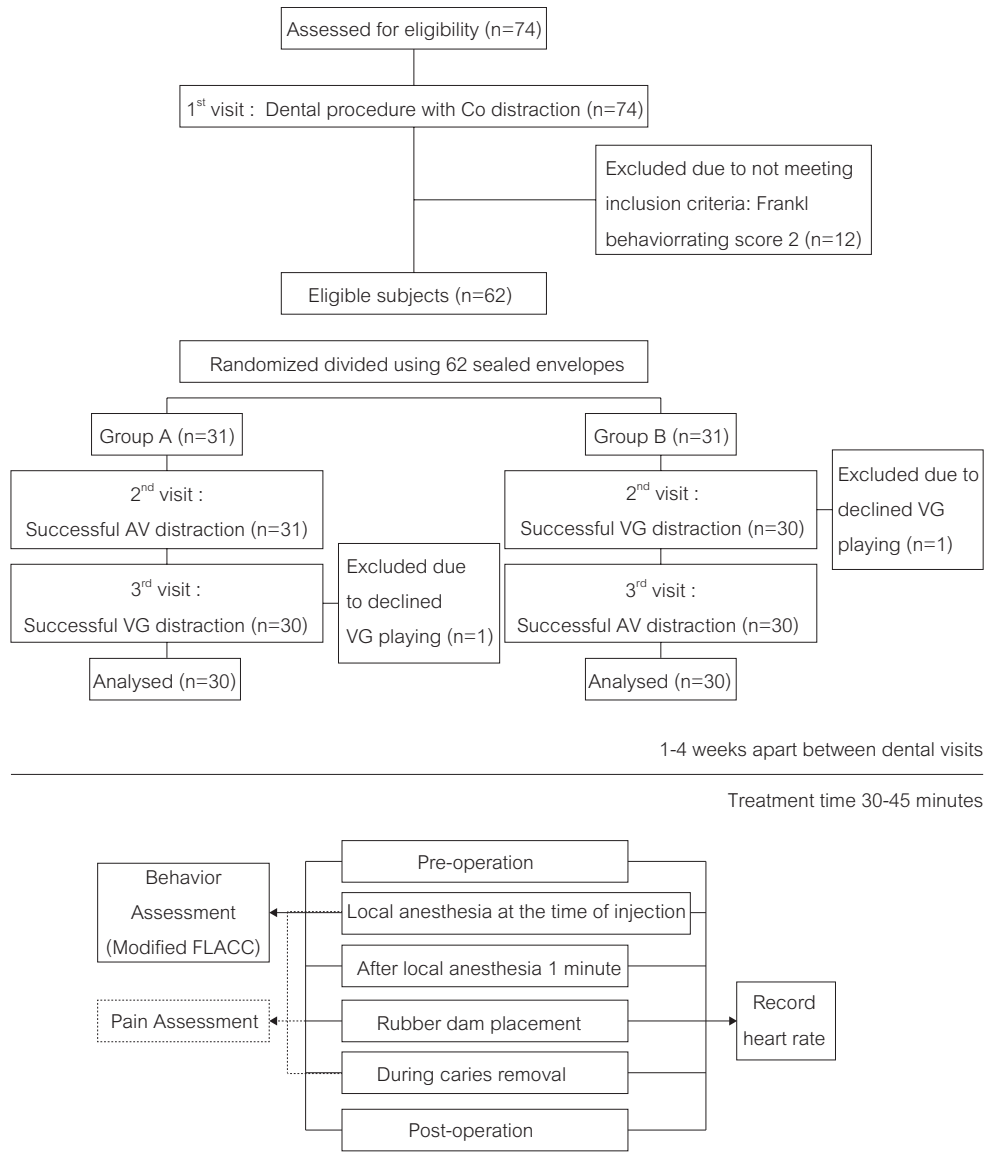


**Figure 1** CONSORT flow diagram of recruitment, randomization, allocation, completion of distraction techniques and certain points of pain and behavior assessment.

## 4. Randomization and Allocation Concealment

A dentist who was not involved in the intervention or assessment performed the randomization method. Sixty-two sealed opaque envelopes were created, 31 of which were Group A and 31 of which were Group B. The envelopes were mixed together, randomly selected before treatment began, and the subject received the selected distraction sequence.

## 5. Outcomes Measures

The primary outcome measures were pain and behavior associated with dental anxiety measured by the Wong-Baker FACES (WBS) Pain Rating Scale and the Modified FLACC Behavioral Scale. The secondary outcome measure was heart rate.

## 6. Pain and Anxiety level assessment

### 6.1 Pain Assessment

The WBS Pain Rating Scale [17] was employed for self-reported pain assessment and was performed by asking the subjects to make a face that described their current level of pain. The WBS has been demonstrated to be an excellent measurement tool for its treatment effect on school-aged children and adolescents [18] (Figure 2).

### 6.2 Behavior Assessment

The FLACC Behavioral Scale [19] was used as an observational pain-related behavioral scale, consisting of 5 behavioral categories, facial expression, leg movement, bodily activity, crying, and consolability. The FLACC has been reported to give excellent reliability and validity and is particularly suitable for young children [20, 21]. In the present clinical study, the facial expression measure was excluded from the behavior scale because using rubber dams did not meet the criteria for face assessment. The modified behavior assessment was performed by two calibrated pediatric dentists who independently watched video records and were blinded for the intervention from pre-operation to post-operation. The video camera was hidden from the subject's sight, and the subject's entire body was visible during recording. Calibration reliability checks were done, with intra- and inter-rating for every six videos recorded to evaluate the consistency of the evaluations. The significance level was 0.8. The Kappa coefficient was used to analyze the intra-variable and inter-variable and was calculated as 0.831 for Legs, 0.831 for Activity, 0.843 for Crying, and 0.843 for Consolability. The total score was 0.88 at $p < 0.002$.

### 6.3 Heart Rate Measurement

Heart rate was used as a direct physiological measurement of anxiety during the dental procedure [22, 23]. The heart rate was recorded using a finger pulse oximeter (Beurer® PO 30 pulse oximeter) placed on the child's toe.

## 7. Statistical Analysis

The normality of the data was assessed by the Shapiro-Wilk test. The pain and behavior scores were compared using the Friedman test. The heart rates were compared using two-way analysis of variance. The statistical tests had a 95% confidence level and a 0.05 significance level.


Figure 2 The Wong-Baker Face pain rating scale

## Results

The recruitment, randomization, allocation, and distraction intervention to the children belonging to Group A and Group B are represented in the CONSORT flow diagram (Figure 1). Two patients were excluded from the study in the VG distraction visit. Therefore, 60 subjects, 30 boys and 30 girls, participated in the study. The mean age was 85.40±10.54 months-old. There was no significant difference in sex ($p$ = 0.439) or age ($p$ = 0.604) between groups (Table 1). Furthermore, there was no significant difference in treatment time ($p$ = 0.435), treatment area ($p$ = 0.395), or treatment performed ($p$ = 0.668) for all distraction techniques (Table 2).

**Table 1** Participants characteristic

| Characteristic | | Group A | Group B | Total | Intergroup p-value |
|---|---|---|---|---|---|
| Sex | Male | 13 | 17 | 30 | 0.439[C] |
| | Female | 17 | 13 | 30 | |
| Age (Month) | Male | 84.62±10.96 | 83.35±11.10 | 83.9±10.87 | 0.604[M] |
| | Female | 86.00±7.95 | 88.08±12.75 | 86.9±10.16 | |
| | Total | 85.40±9.22 | 85.40±11.87 | 85.40±10.54 | |

C: Chi-square test, M: Mann-Whitney U test, Significant difference at p<0.05

**Table 2** Treatment time, treatment area, and treatment performed

| Characteristic | | Co | AV | VG | Total | Intergroup p-value |
|---|---|---|---|---|---|---|
| Treatment time (min) | | 29.75±5.95 | 28.50±5.33 | 28.85±5.21 | 29.31±5.28 | 0.435[T] |
| Treatment area | Maxilla | 33<br>55% | 27<br>45% | 25<br>41.67% | 85<br>47.22% | 0.395[Q] |
| | Mandible | 27<br>45% | 33<br>55% | 35<br>58.33% | 95<br>52.78% | |
| Treatment performed | Filling | 48<br>26.67% | 51<br>28.33% | 51<br>28.33% | 150<br>83.33% | 0.668[F] |
| | Pulp | 7<br>3.89% | 6<br>3.33% | 8<br>4.44% | 21<br>11.67% | |
| | SSC | 5<br>2.78% | 3<br>1.67% | 1<br>0.56% | 9<br>5% | |

T: Two way ANOVA analysis of variance, Q: Cochran's Q test, F: Friedman test, Significant difference at p<0.05, SSC: Stainless steel crown

### Pain Assessment Result

The local anesthetic injection resulted in the highest self-reported pain scores compared with other dental procedures for each distraction technique (Figure 3). The average self-reported pain scores demonstrated that VG distraction resulted in significantly lower pain scores compared with Co distraction ($p = 0.036$), however, the pain scores with Co or AV distraction were not significantly different ($p = 1.000$). (Table 3) There was no significant difference in pain score during rubber dam application and caries removal between the distraction techniques and between Group A and Group B, therefore no carry-over effects were found.

### Behavior Assessment Result

During the local anesthetic injection, VG distraction resulted in a significantly lower score on the behavioral scale compared with Co distraction ($p = 0.007$) and AV distraction ($p = 0.006$). However, there was no significant difference between the Co and AV distraction behavioral scale scores ($p = 1.000$). In addition, there were no significant differences in behavioral scale scores between the distraction techniques in other dental procedures and between groups, confirming that there were no carry-over effects. The local anesthetic injection resulted in the highest score on the behavioral scale among the other dental procedures (Table 4).

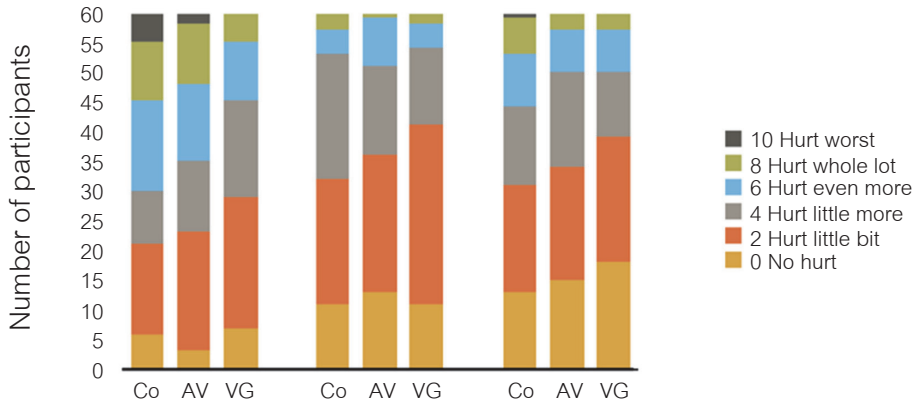


**Figure 3** Distribution of self-reported pain score during each treatment procedure.
Co: Convention distraction, AV: Audiovisual distraction, VG: Videogame distraction, LA: Local anesthesia, RD: Rubber dam application, CR: Caries removal.

**Table 3** Median and mean of self-reported pain scores.

| Procedure | Median (IQR) | | | Mean ± SD | | | p-value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Co | AV | VG | Co | AV | VG | Co-AV | Co-VG | AV-VG | Gr. A | Gr. B |
| LA | 5 (6) | 4 (4) | 4 (4) | 4.77±2.97 | 4.43±2.61 | 3.47±2.27 | 1.000 | 0.036* | 0.067 | 0.038* | 0.038* |
| RD | 2 (2) | 2 (2) | 2 (2) | 2.90±2.06 | 2.70±2.04 | 2.53±1.91 | | 0.423 | | 0.506 | 0.905 |
| CR | 2 (4) | 2 (4) | 2 (4) | 3.33±2.67 | 2.80±2.28 | 2.53±2.32 | | 0.068 | | 0.298 | 0.298 |

Interquartile range (IQR), Standard deviation (SD), *Indicates a significant difference ($p<0.05$) by Friedman test

Table 4 Median and mean of the modified FLACC behavior scale

| Procedure | Median (IQR) | | | Mean ± SD | | | p-value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Co | AV | VG | Co | AV | VG | Co-AV | Co-VG | AV-VG | Gr. A | Gr. B |
| Pre-op | 0 (0) | 0 (0) | 0 (0) | 0.13±0.47 | 0.02±0.13 | 0.00±0.00 | 1.000 | 1.000 | 1.000 | 1.000 | 0.317 |
| LA | 1 (4) | 1 (3) | 1 (1) | 1.90±1.92 | 1.87±1.88 | 1.10±1.62 | 1.000 | 0.007* | 0.006* | 0.003* | 0.034* |
| RD | 0 (0) | 0 (0) | 0 (0) | 0.28±0.56 | 0.23±0.85 | 0.12±0.45 | 1.000 | 0.653 | 1.000 | 0.157 | 1.000 |
| CR | 0 (0) | 0 (0) | 0 (0) | 0.50±1.37 | 0.42±1.18 | 0.17±0.59 | | 0.516 | | 0.102 | 0.480 |
| Post-op | 0 (0) | 0 (0) | 0 (0) | 0.00±0.00 | 0.02±0.13 | 0.00±0.00 | | 0.368 | | 1.000 | 0.317 |

Pre-operation (Pre-op), Local anesthetic (LA), Rubber dam application (RD), Caries removal (CR), Post-operation (Post-op).

*Significant difference at p<0.05 using the Friedman test

## Heart Rate Result

During the local anesthesia injection, VG distraction lowered the heart rates significantly more than Co distraction ($p$ = 0.0004). Throughout caries removal, the subjects' heart rates also increased significantly higher when Co distraction was used compared with AV distraction ($p$ = 0.010) or VG distraction ($p$ = 0.004) (Table 5).

Table 5 Mean and standard deviation of the heart rate in beats per minute

| Procedure | Mean ± SD | | | p-value | | |
|---|---|---|---|---|---|---|
| | Co | AV | VG | Co-AV | Co-VG | AV-VG |
| Pre-op | 94.83±12.34 | 92.23±10.17 | 93.35±10.19 | 0.078 | 0.312 | 0.446 |
| LA | 107.35±16.14 | 104.15±15.55 | 100.70±13.59 | 0.82 | 0.0004* | 0.61 |
| After LA | 97.25±12.83 | 95.62±12.82 | 97.03±12.42 | 0.259 | 0.881 | 0.328 |
| RD | 99.25±16.06 | 99.30±14.13 | 98.08±13.88 | 0.997 | 0.507 | 0.489 |
| CR | 101.03±14.18 | 97.08±11.77 | 96.60±12.94 | 0.010* | 0.004* | 0.750 |
| Post-op | 92.58±12.23 | 92.67±11.58 | 93.47±11.68 | 0.956 | 0.562 | 0.599 |

Pre-operation (Pre-op), Local anesthesia (LA), After LA 1 minute (After LA), Rubber dam application (RD), Caries removal (CR), Post-operation (Post-op). *Significant difference at $p$<0.05 by two-way ANOVA

## Discussion

The advantage of using a crossover study was that we could compare each subject's results across three experiment distractions. Although a carry-over effect from each previous treatment could influence the subjects and enhance or diminish the effect of the intervention, in this study specifications, e.g. washout period and statistical methods, were made following crossover research design, to prevent this effect [16].

The results of the current study demonstrated that VG distraction was more effective compared with AV distraction from the behavioral aspect, which corresponds with a previous study that reported that playing games on an iPad was superior [14]. Additionally, the present study found that VG distraction was more effective compared with Co distraction for redirecting a patient's attention away from pain, preventing disruptive behavior, and keeping their heart rate under control during local anesthetic injection and caries removal. Similarly, the results of a systematic review indicated that video games have physical and psychological benefits to pediatric patients undergoing fear-inducing procedures, such as venipuncture or neurological and traumatic injuries [24]. These findings correspond with the cognitive-affective model of the interruptive function of pain by Eccleston and Crombez, which focuses on diverting attention away from pain [25]. Furthermore, there is a study reporting that the endogenous dopamine, which is the neurotransmitter involved in behavior reinforcement, was released in the human striatum while playing VG [26].

In the current study, the effectiveness of VG distraction might have been influenced by the age of the subjects. The subjects' ages in this study were 6–9 years-old, which is the age that children are more likely to play video games, as found in a previous study where children older than 6 years benefited more from active play with VGs compared with younger children [14].

Although playing VG was accepted by most of the subjects, there were two subjects that were excluded from the study because their behavior was worse than on the first visit (their Frankl scores decreased from 3 to 2). They cried after the injection and refused to play the VG. Positive reinforcement, voice control techniques, and light physical active restraint were used to complete the dental procedure instead. Therefore, this kind of distraction might be effective for very anxious patients or particularly negative behavior, which aligns with the AV eyeglasses distraction results in other studies [4, 5, 11].

The heart rate assessment results during caries removal were also interesting. These results indicated that VG and AV distraction were more effective compared with Co distraction in reducing an increased heart rate, agreeing with a previous study that found that AV eyeglasses were effective in reducing the heart rate at the first time a patient experienced the use of a high-speed handpiece [3]. However, there are no studies comparing heart rate between VG and Co distractions. Heart rate is a reliable physiological measurement of anxiety [27, 28], because there are direct correlations between blood pressure and heart rate during anxious dental situations [23]. The dental drill is one of the main causes of dental anxiety in young children [29, 30]. The sound of the drill made the children feel uncomfortable, and they preferred watching television to cope with the noise. Therefore, the noise was anxiety provoking, and AV distraction was the best method to overcome that anxiety [30].

The present study compared VG and AV distractions with Co distraction. Our results indicated that VG distraction was more effective

than Co distraction in the aspects of pain, behavior, and heart rate. AV distraction was more effective than Co distraction only in the aspect of heart rate during caries removal; however, in the aspects of pain and behavior AV distraction and Co distraction were comparable. Although these finding are similar to those of the previous study that found that watching TV was ineffective in reducing stress in young children during dental treatment [11], they differ from those of other studies that found that AV was more effective than Co distraction [8, 10], which might be because these studies used AV eyeglasses as the AV distraction. However, in our study, we had the patients watch cartoons on a tablet with earphones, which did not completely block their vision during the dental procedure.

Over the years, there has been an increase in research in the efficacy of using new technology, such as AV eyeglasses Virtual Reality glasses, in distraction techniques. However, these new devices were not generally available and are often difficult to use in young pediatric patients [4, 5, 10]. The use of tablets and smartphones as a means of distraction has proven to be more convenient than AV eyeglasses because they are more practical, readily available, user-friendly, and easy to maintain. These devices provide effective distraction and are also cost effective for behavior management in pediatric dental patients.

## Conclusion

This study found that playing a video game could better elicit a child's cooperation with the dentist, compared with watching cartoons and other conventional distractions during local anesthesia injection. Furthermore, during caries removal, playing a video game and watching cartoons reduced the increased heart rate more, compared with conventional distraction techniques. Therefore, active distractions, such as playing video games on a tablet or smartphone, could be effective distraction devices for behavior management in pediatric dental patients.

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