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Effects of audiovisual distraction on children's behaviour during dental treatment: a randomized controlled clinical trial

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ABSTRACT

Aim: Dental anxiety leads to undesirable distresses such as avoidance of dental treatment and increase stress among caregivers that consequently affect the treatment quality. The aim of this study was therefore to evaluate the effectiveness of viewing videotaped cartoons using an eyeglass system (*i*-theatre™) as an audiovisual (AV) distraction technique on behaviour and anxiety in children receiving dental restorative treatment.

Methods: Fifty-six consecutive children patients who presented for treatment and met inclusion criteria were included and randomly divided into two groups; a control group without distraction (CTR-group) and a distraction-group (AV-group). Three dental treatment visits were provided for each patient. Anxiety and cooperative behaviour were assessed with the Facial Image Scale (FIS) and the Modified Venham's clinical ratings of anxiety and cooperative behaviour scale (MVARS). The vital signs, blood pressure and pulse were also taken.

Results: The AV-group showed significantly lower MVARS scores than the CTR-group ($p = 0.029$), and the scores decreased significantly during treatment in the AV-group ($p = 0.04$). Further, the pulse rate was significantly increased in the CTR-group during injection with local anaesthesia ($p = 0.02$), but not in the AV-group.

Conclusion: AV distraction seems to be an effective method in reducing fear and anxiety in children during dental treatment. Further, children who used eyeglass goggle display as a distraction tool during dental treatment reported not only less anxiety than control groups but also showed more positive responses after injection with local anaesthesia. Hence, AV-distraction seems to be a useful tool to decrease the distress and dental anxiety during dental treatment.

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Introduction

One of the primary desires for dental professionals is to treat their patients in an anxiety-free environment along with a high quality of the dental care. To achieve this, dentists have to implement their learned skills and experience. Previous studies have shown that the level of fear that children perceive before or during dental treatment is not only associated with the degree of disruptive behaviour,[1] but also with an increase of pain perception, which consequently may result in nervousness, anxiety and sensitization for future appointments.[2] Based on the theory by McCaul and Mallot, a patient's perception of pain is decreased when the patient is distracted from an unpleasant stimulus.[3] One can understand that the perception of pain is directly associated with the amount of attention a patient pays to an unpleasant stimulus. Several neurophysiological studies have confirmed this theory pointing out the importance of distraction concerning lower levels of pain and anxiety.[4,5]. Previous research indicates that dental fear seems to rise from past adverse dental experiences,[6,7] while a continuing behaviour of avoidance may aggravate dental anxiety. Hence, anxiety and fear are closely related. Dental anxiety is therefore defined as the distressed expectation of a visit to a dentist to the extent where a child might avoid treatment,[6,8] while dental fear/phobia is defined as when the distressed expectation interferes with normal functioning.[9]

Distraction, one of the psycho-behavioural approaches used in medical and dental treatment situations, is defined as a non-aversive approach used to modify a child's discomfort by disrupting his/her attention away from the main task to accomplish successful treatment with high quality.[10] Previous studies have suggested that the use of distraction during dental treatment is beneficial to patients by reducing their distress and in turn decrease their perception of pain sensation, especially during injections with local anaesthesia.[11] It has been stated, however, that the ideal distractor ought to possess various abilities such as visual, auditory and kinaesthetic modalities (i.e. physical movements) to provide the full capacity to harness the child's concentration and

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attention and in turn minimizing the child's anxiety.[12] Furthermore, it has also been shown that the use of audiovisual (AV) distraction not only leads to full involvement of scenes (visual and auditory), but it also induces a positive emotional reaction resulting in a relaxed experience.[13,14] Several studies have shown that AV distraction in medical practice is commonly used in short invasive procedures to reduce the patients' pain and anxiety.[15,16] Nevertheless, there is still a controversy regarding the effectiveness of distraction during dental treatment procedures. Some studies concluded that the use of AV distraction is successful in decreasing not only anxiety,[11,17,18] but also pain perception.[19] However, other studies found that distraction by displaying a videotaped cartoon did not reduce uncooperative behaviour during dental treatment.[20] On the other hand, Sullivan et al. (2000) showed that AV distraction significantly reduced the pulse but did not have an effect on anxiety or behaviour.[21]

With this in mind, the aim of this study was to evaluate the effectiveness of viewing videotaped cartoons using an eyeglass system (*i*-theatre^{TM}) as an AV distraction technique on behaviour and anxiety in children receiving restorative dental treatment.

Materials and methods

The local ethics committee at the College of Dentistry Research Center at King Saud University, Riyadh, Saudi Arabia, approved the current study. The study was carried out in compliance with the Declaration of Helsinki as well as the International Conference on Harmonization Guideline for Good Clinical Practice. All participants and their parents received both written, and verbal information about the procedure before inclusion. Both the children and their parents gave their verbal and written consent.

Participating patients

The participants were selected from consecutive patients that presented for treatment at the paediatric dentistry clinic at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia. These were uncooperative patients referred from undergraduate clinic to the postgraduate clinic for behaviour management. The children were aged between 7 and 9 years, with a mean (SD) age of 8.2 (0.8) years, (Table 1). The sample size was calculated on a two-sample comparison of proportions of behaviours; one group with AV distraction (AV-group) and one control group (CTR-group). The inclusion of 26 patients in each group would be sufficient to detect a statistically significant difference between interventions at a significance level of 5% with a power of 80.[22] To compensate for dropouts two additional patients were included in each group leading to a total of 56 included boys and girls.

Table 1. Participant characteristics, sub-grouped by type of distraction.

	CTR-group	AV-group	Total
Individuals	28 (50%)	28 (50%)	56 (100%)
Sex			
Female	17 (60.7%)	17 (60.7%)	34 (60.7%)
Male	11 (39.3%)	11 (39.3%)	22 (39.3%)
Age			
Mean (SD)	8.1 (0.9)	8.3 (0.8)	8.2 (0.8)
Min–max	7–9.8	7–9.6	7–9.6
7 years	12 (43%)	10 (35.7%)	22 (39.3%)
8 years	9 (32%)	12 (43%)	21 (37.5%)
9 years	7 (25%)	6 (21.4%)	13 (23.2%)

SD: standard deviation; AV-group, with audiovisual distraction; CTR-group, without distraction.

The inclusion criteria for the patients were: (1) general good health, (2) no previous dental experience involving local anaesthetic administration for the last 2 years and (3) restorative treatment required under local anaesthesia.

The exclusion criteria were: (1) previous unpleasant experience in medical setting or known dental phobia as reported in the medical records, (2) need for pharmacological management to cooperate or (3) medical disability such as the history of seizures or convulsion disorders, nystagmus, vertigo or equilibrium disorders, eye problems and autism. Further, the participating children were excluded if their parents did not give consent.

Study design

This prospective randomized controlled parallel arm trial was carried out during September 2007 to May 2008. The patients were divided randomly into two groups that received either AV distraction or no distraction. The randomization was performed by a dental assistant not participating in the study by assigning the first patient to either group by the toss of a coin, after that the next patient went to the other group.

The study comprised three visits: V1) dental examination and inclusion, V2), acclimatization (including oral hygiene information and prophylaxis) and V3) restorative visit. The patients were treated by the same dentist (AA-K), specialist in paediatric dentistry, and the same dental assistant, at all three visits. If further appointments were necessary for dental treatment of their restorative needs, the patients booked with the same dentist and dental assistant after the end of the study.

A pilot study was conducted consisting of six participants meeting the inclusion criteria to get acquainted with the measurement technique and the AV distraction (i-theatre^{TM}). These participants were, however, not included in the main study. Findings from the pilot study suggested the protocol worked well, and subsequently, no changes were made.

Audio-visual distraction

The Merlin *i*-theatre^{TM} (*i*-theatre$_{pro}$, Merlin, Soft Magic Systems LLC, Al Ain Center, Dubai, UAE) was used for the AV distraction (Figure 1). It is an eyeglass system (16.9 cm wide) placed in front of the eyes and can be connected to several devices such as DVD Players, gaming systems like Sony Play Station Pro, Microsoft X-BOX, Nintendo WII, etc., or a satellite box. According to the manufacturer, it is equivalent to watching a 60 inches (1.53 m) LCD-screen from a distance of 2.0 m.

Dental operatory procedures

The dental clinic used for this study was fully equipped with a dental unit, pulse oximeter and blood pressure (BP) monitor. A video camera was attached to an adjustable tripod and

placed in a position that allowed complete viewing of the child during the entire dental procedures, i.e. before, during and after the prophylaxis process in visit 2 and the restorative procedure in visit 3. The accompanying parent/guardian was allowed to attend during the entire procedure, however, only as a passive observer and was seated on a chair that placed behind the child and the operator (the child was aware of the parent/guardian presence). The amount of time for each visit was 30 min or less. Three visits for each patient were as follows.

Visit 1: dental examination and inclusion visit

Before the clinical dental examination, including radiographs when necessary, the parent/guardian was asked about the child's medical and dental history. After the examination, a treatment plan was done and discussed with the parent/guardian. In order to introduce the child to the dental procedures, the psychological behaviour management technique tell-show-do was used during this visit. This method includes; a verbal description by 'tell', demonstration by 'show' and completion of the show by 'do' to introduce the child with dental settings.

Visit 2: acclimatization visit including oral hygiene information and prophylaxis

This visit started by using the tell-show-do technique to explain the procedure. After that the Facial Image Scale (FIS), validated to assess dental anxiety,[23] was explained to the child, and the dentist asked the child to choose one of the five faces that best represented his/her current emotional state. A BP cuff (DURA-CUF, Critikon, Tampa, FL) and a pulse oximeter sensor were then placed on the left biceps muscle and the big toe of the right foot respectively; baseline values for BP, and pulse rate (PR) were obtained.

The acclimatization started with the instruction of oral hygiene by explaining the technique to brush the teeth (toothpaste and toothbrush were used). After that, dental prophylaxis was performed using a slow-speed hand piece with a rubber cup and prophylaxis paste, followed by application of topical fluoride using disposable trays. Information regarding the topical fluoride was then given to both the child and parent/guardian. At the end of the acclimatization visit the child rated his/her anxiety on the FIS.

Figure 1. Illustration of the AV distraction eyeglass goggle Merlin *i*-theatre™ in a clinical setting.

Visit 3: restorative visit

Before the visit, the participating patients were randomly divided into two groups: (a) the distraction group (AV-group) or (b) the control/non-distraction group (CTR-group).

In both groups, the following procedures were carried out: (1) preoperative and postoperative anxiety was rated with FIS at the beginning and the end of treatment respectively, (2) the Modified Venham's clinical ratings of anxiety and cooperative behaviour scale (MVARS).[24,25] BP and PR have registered preoperatively and also for the following period: (a) intraoral examination, (b) injection with local anaesthesia, (c) application of rubber dam, (d) cavity preparation and (e) tooth restoration. During all the procedures the same behaviour management techniques were used including verbal communication and positive reinforcement.

However, in the AV-group, before the start of the restorative procedure, the child was introduced to the AV-system (*i*-theatre™) and allowed to choose his/her favourite cartoon, appropriate for the age-group, out of four funny movies with similar characteristics. The cartoon film was in the Arabic language to involve full auditory and visual engagement.

Patient assessment

The child's response to dental stress was assessed using a combination of five measures: (1) the FIS for dental anxiety. This scale consists of five faces ranging from 'very happy' (1) to 'very unhappy' (5). The first two faces; response number 1 and 2 are positive, i.e. without signs of anxiety.[23] Each patient was asked to choose one of these faces that best represent his/her feeling at the beginning, and at the end of each visit. However, the response number (1) accounts for the most positive affect face (approval and no discomfort) and the response number (5) represents the most negative affect face (disapproval and extreme discomfort); (2) MVARS.[25] This scale consists of six categories, (range from 0 to 5), where; 0 = Relaxed, 1 = Uneasy, 2 = Tense, 3 = Reluctant, 4 = Interference, 5 = Out of contact. Each category describes the patient status in the dental chair when a particular dental procedure is performed; (3) the systolic BP (s-BP); (4) the diastolic BP (d-BP); (5) the PR. The values obtained for FIS, MVARS, BP and PR were averaged to produce mean value for the visit.

Observer training

Two observers (NCh and LB) who did not have any contact with the patients, were trained as observers through using video recordings from the pilot study. Scores were assigned using MVARS to determine the clinical ratings of anxiety and cooperative behaviour at intervals when a specific dental procedure is performed. The videotapes were scored and repeated until a sufficient reliability level was reached (Cohen's Kappa = 0.85). Inter-observer agreement was also

achieved by scoring the videotapes individually; where there was disagreement; joint decision made the final score. The two observers were blinded, and the tapes were coded during the main study.

Statistical analysis

The statistical analyses were performed using IBM SPSS Statistics 22 (IBM Corp., Armonk, NY). Normality of the data was tested with the Shapiro–Wilk test. Descriptive data are reported as frequencies, means and standard deviation (SD). For analyses of group differences in frequencies, χ^2-test was used. For analyses of group differences in variables on a nominal scale *t*-test was used, while the Mann–Whitney U-test was used for variables on an ordinal scale. The two-way repeated measures ANOVA with Holm–Sidak as *post hoc* test (ANOVA) for analyses of changes between data at baseline and during the restorative procedure for each group (AV-group and CTR-group). The significance level was set at $p < 0.05$.

Results

There were no differences between the AV-group and CTR-group regarding background data such as age and sex, as shown in Table 1. Further, there were no drop-outs or missing data from the participants. According to the FIS scale, none of the included patients reported any anxiety at baseline; 57% said they were 'very happy' and 43% said they were 'happy' in the CTR-group. While 43% said they were 'very happy', and 57% stated that they were 'happy' in the AV-group.

Behavioural and anxiety measurements

When the cooperative behaviour was analyzed (MVARS), there was a significant difference between groups with lower mean (SD) MVARS scores in the AV-group (0.14 ± 0.36) compared to the CTR-group (0.75 ± 0.52) ($p = 0.03$). When the clinical anxiety was analyzed with MVARS there was a significant reduction in clinical anxiety throughout the restorative procedure, including injection with local anaesthesia, in the AV-group ($p = 0.04$), where it was 0.71 before the restorative procedure and 0.25 at the end of the procedure. This significant reduction was not found in the CTR-group ($p > 0.05$), where it was 0.64 before and 0.75 at the end of the restorative procedure, as shown in Figure 2. Although girls tended to show more anxiety than boys in MVARS in the AV-group, there were no significant differences in any aspect between sexes.

However, as illustrated in Figure 3, there were no significant differences in mean (SD) FIS scores between the AV-group; 1.93 (1.15) and CTR-group (1.68 ± 0.86) ($p = 0.570$). Although the mean (SD) value of the AV-group tended to be lower after restoration (1.32 ± 0.67) ($p = 0.057$). Further, there

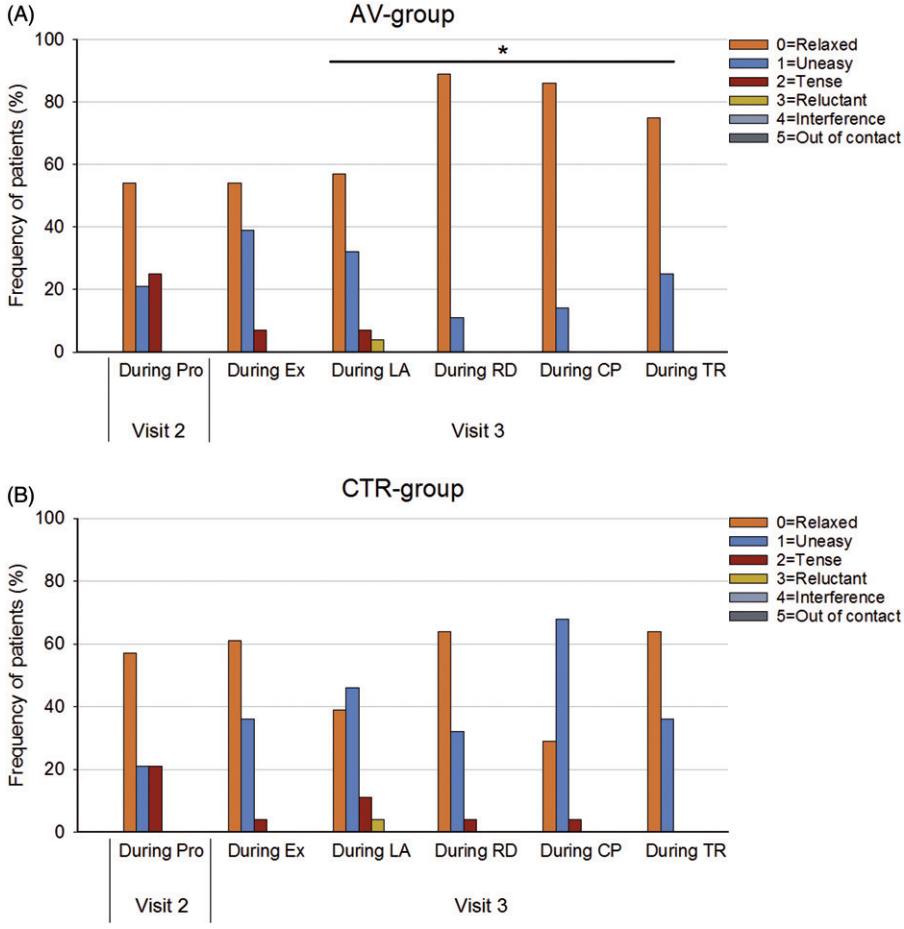

Figure 2. The proportions of clinical anxiety and cooperative behaviour (MVARS) with either audiovisual distraction (AV-group; A) or no distraction (CTR-group; B). *Significant decrease in clinical anxiety throughout the restorative procedure in visit 3.

were no significant differences regarding situational anxiety according to the FIS scores between the visits in any of the groups ($p = 0.34$).

Vital signs

Table 2 presents the vital signs, including PRs, s-BP and d-BP. Within the CTR-group, there was a significant elevation of the PR during injection with local anaesthesia ($p = 0.04$) during the restorative procedure, but this elevation was not found after the procedure. The PR did not increase in the AV-group ($p = 0.27$) either during or after the restorative procedure. However, there were no significant differences in the overall mean PRs between the CTR-group and the AV-group ($p = 0.564$).

Further, there were no significant changes in s-BP throughout the restorative procedure in any of the groups ($p = 0.131$). Although s-BP seemed to be higher during injections with local anaesthesia in both groups, there were neither any differences in s-BP between the groups ($p = 0.854$). As for s-BP, there were no significant changes in d-BP throughout the restorative procedure in any of the groups ($p = 0.21$), and there were no significant differences between the groups ($p = 0.147$).

Discussion

The present study showed that AV distraction using the eyeglass system *i*-theatre™ seems to be effective in reducing observer-rated dental anxiety and keeping good cooperative behaviour in children during restorative dental treatment. On the other hand, this study could not show any effect on the patient/child-rated anxiety using the FIS scale. However, there was a difference in the overall disruptive behaviour between the CTR-group and the AV-group where children in the AV-group showed improved behaviour with a positive response. This improved behaviour was significantly evident after injection with local anaesthesia in the AV-group, and this was not

Table 2. Vital signs (mean, SD) for each sub-group at different sections of the dental restoration process, from the 56 children undergoing restorative dental treatment.

	CTR-group Mean (SD)	AV-group Mean (SD)
Prophylaxis visit		
Systolic blood pressure	111.7 (10.8)	113.6 (9)
Diastolic blood pressure	67.9 (9)	69.0 (7.0)
Pulse rate	94.3 (17.6)	95.5 (13.3)
Restorative visit		
Examination		
Systolic blood pressure	112 (10)	111.7 (10.7)
Diastolic blood pressure	67.8 (9)	65.2 (7.5)
Pulse rate	94.3 (14.4)	95.9 (10.3)
After LA		
Systolic blood pressure	110.9 (9.6)	115 (6.3)
Diastolic blood pressure	64.5 (5.8)	66.8 (6.3)
Pulse rate	99.4 (14.5)[a]	98.6 (12.2)
After RD		
Systolic blood pressure	112 (10.2)	114.6 (7.5)
Diastolic blood pressure	64.9 (6.7)	67 (6.8)
Pulse rate	95.2 (12.3)	98.5 (11.6)
During cavity preparation		
Systolic blood pressure	111 (11.6)	114.9 (5.6)
Diastolic blood pressure	65.4 (6)	66 (7.1)
Pulse rate	97.1 (14.1)	98.2 (12.7)
After tooth restoration		
Systolic blood pressure	111.6 (7.6)	110.6 (5.5)
Diastolic blood pressure	67.6 (5.6)	63.7 (5.1)
Pulse rate	93.4 (14.7)	95.3 (11.1)

SD: standard deviation; LA: injection of local anaesthesia; RD: rubber dam application; AV-group, with audiovisual distraction; CTR-group, without distraction.
[a]Significant increase in pulse rate after injection of LA ($p = 0.04$).

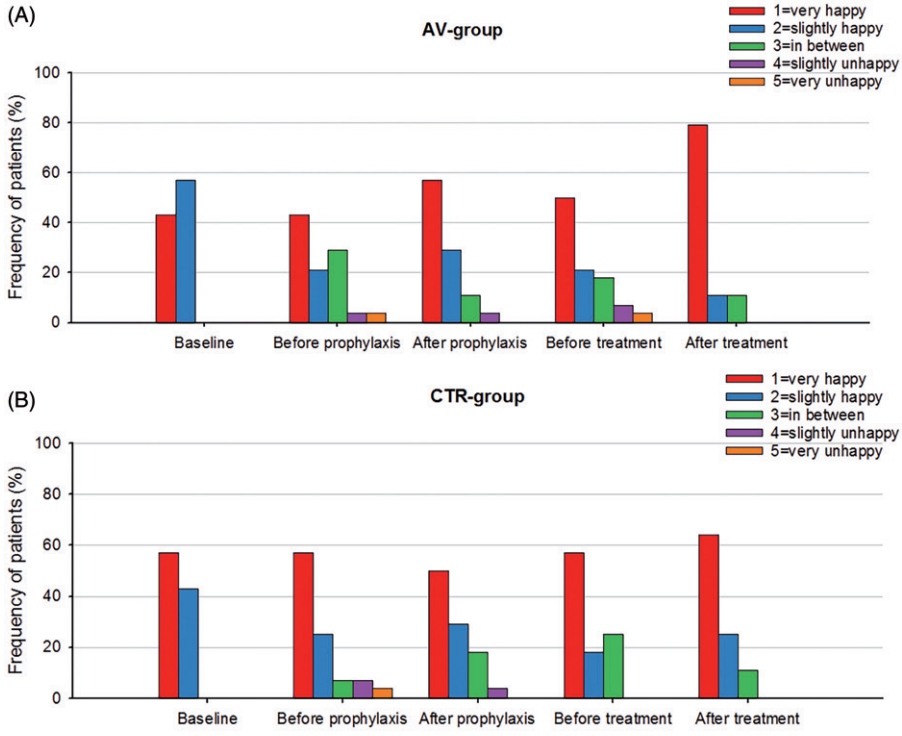

Figure 3. The proportions of self-reported measures of anxiety (FIS), ranging from 'very happy' (1) to 'very unhappy' (5), before and after each visit with either audiovisual distraction (AV-group; A) or no distraction (CTR-group; B).

the case in the CTR-group. Further, there was a marginal difference in the observed mean cooperative behaviour and anxiety between those who used AV distraction and those who did not. However, the AV-group showed more positive responses after injection with local anaesthesia. As observed in this present study, Filcheck et al. (2004) reported that the display of attention-grabbing videotaped material had an effect in distracting the children from the feared stimuli and that it was considered as one of the most attractive methods for modifying children's behaviour during dental treatment.[26] Also, a study by Prabhakar et al. (2007) reported results coinciding with the present study. They found that the use of AV distraction during dental treatment was more effective in managing the children than using audio distraction solely.[14]

In a study by Ram et al. (2010), the use of AV eyeglass system was shown to be more efficient than a regular television screen and that it also could be used instead of nitrous oxide gas.[27] When compared to similar behaviour management techniques, such as music relaxation, storytelling, listening to the audio by headphones, playing video games and watching television. The AV eyeglass system has been shown to minimize not only the children's anxiety towards dental treatment, but in turn also, enhance the children's cooperative behaviour,[14,18] which is consistent with the results of this study. Previous studies have also reported that parents/guardians and the practicing paediatric dentists were relaxed and satisfied about the treatment situation.[27]

Patel et al. (2006) showed that children who enjoyed playing hand-held video games had less anxiety during anaesthesia induction compared with the children who had only their parental presence.[28] Also, another study showed that the use of an iPad, where a kinaesthetic component is involved, is more effective than an AV eyeglass system in reducing not only fear and disruptive behaviour but also in decreasing the treatment duration.[29] The AV distraction used in the present study had no kinaesthetic components and did therefore not involve any participation of the patient except viewing the cartoon movies. Nevertheless, the individual choice of distraction can provide the sense of a familiar situation during dental treatment in order to increase the child's control over the unpleasant stimulus and in turn reduce the chance of uncooperative behaviour.[26,29] Thus, since the children in the present study had the opportunity of choosing their preferred movie cartoon (one out of four movies), one can believe that this can compensate for the lack of kinaesthetic components in the used AV eyeglass system.

Further, it has been shown that children showed more distress and uncooperative behaviour when the dental procedure went beyond 30 min.[29] However, to prevent these behaviour changes of the children during dental procedures, the length of the visits in the present study were no longer than 30 min. For further control of unexpected influence on the study outcomes, the dental appointments were scheduled in the afternoon. This arrangement was made not only to standardize the visit time for all children but also to eliminate the chance of misbehaviour due to missing the school time if the appointments were given in the morning since the school is crucial for this age group.[30]

Dental anxiety is a multi-dimensional concept that consists of behavioural, cognitive and physiological components. The strength of this study can be the use of a combination of more than one measurement technique, which is crucial to successfully assess children who have limited cognitive/linguistic skills and little ability to remember.[31] For instance, FIS was used as a self-report measure that, appropriately used with children, provides an immediate state of emotional feeling towards dental treatment. It has been reported as a valid indicator of a child's pain experience.[23] MVARS precisely determine the children's behaviour during the dental treatment procedure. This system has been used in previous studies and found to have good validity.[32] On the other hand, s-BP and d-BP, as well as PRs are commonly used as indirect measures of dental anxiety in children.[33] The present study showed that s-BP and d-BP were increased during injections with local anaesthesia in both in the CTR-group and the AV-group. However, this change was not significant between these groups. In agreement with previous studies that reported a small increase in arterial BP, but not significant, in children undergoing dental treatment following administration of local anaesthesia.[33] Furthermore, the PR within the CTR-group in this study was significantly elevated during injection with local anaesthesia when compared to the preoperative baseline value during the restorative treatment procedure. However, this was not observed in the AV-group. This result complements other studies that reported less increase in PR in a group of children undergoing dental treatment with AV distraction methods.[14,26,28]

Pre-school age groups have shown to have a higher level of fear and anxiety than school age children.[14] For that reason, school age children were chosen for the current study, since the use of distraction requires a low level of dental fear and anxiety.[14] Further, different age groups possess different cognitive and behavioural actions towards AV distraction. Therefore, it has been suggested that distraction is more effective in an older age group.[34] Another reason for choosing school age children is that younger age groups exhibit more uncooperative and disruptive behaviour that's hard to control.[35]

One limitation of the current study might be that the design of the eyeglass system (*i*-theatre^{TM}). This design does not eliminate visual access to the surrounding environment. Hence, the patients might not have been completely distracted from the procedures performed in the oral cavity. Although previous research has shown that distraction in children as being a highly acceptable technique in helping divert their attention, anxiety and helping them relax,[36] this study did not take these qualitative aspects regarding the child patients' opinions into consideration, which is another limitation of the study. Also, the sample size could be considered as a limitation. A larger sample size and in a general clinical setting might have elucidated the differences in the use of AV distraction as indicated by anxiety and behaviour measures. This study excluded children with previous bad experience which might have affected the results and could hence be considered a limitation. However, this was chosen in order to achieve as a homogeneous group as possible to be able to draw any conclusions.

In conclusion, children using AV distraction with the eyeglass-goggle display during restorative dental treatment do not only report less distress during the procedure than those without, but they also show a more positive response after injection with local anaesthesia. Hence, AV-distraction seems to be a useful tool to decrease the distress and anxiety during dental treatment.

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Disclosure statement

The authors declare no conflicts of interest. The authors alone are responsible for the content and writing of the paper. All authors have read and approved the final version of the manuscript.

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