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Cartoon-assisted visual/auditory distraction usage in paediatric dental care, assessment of effects on patient anxiety, pain, and behaviour: a randomised crossover clinical trial

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Abstract

Objectives This randomized crossover clinical trial designed to evaluate the impact of visual and auditory distraction techniques on pediatric patients' anxiety, pain perception, and behavior during dental treatment. The study specifically focuses on children, aiming to determine whether distraction methods can effectively reduce anxiety levels, alleviate pain experiences, and improve cooperative behavior in a clinical setting.

Method and materials Children aged 4 to 9 years receiving routine dental care at the Pediatric Dentistry Clinic, Istanbul Medipol University, were randomly assigned to Group 1 (distraction first, then tell-show-do) or Group 2 (tell-show-do first, then distraction), with a two-week washout period before switching interventions. Anxiety was assessed using the Venham Picture Test and pulse rate, pain perception with the Sounds, Eyes, and Motor Scale during local anesthesia and the Wong-Baker FACES Pain Rating Scale during treatment, while cooperation and behavior were evaluated using the Houpt Scale. Statistical analysis was conducted using Mann-Whitney U, Student's t-test, Paired t-test, and Wilcoxon test, with the significance level set at 0.025 using the Bonferroni correction.

Results Sixty-eight patients (37 female, 31 male) with a mean age of 6.69 ± 1.08 years completed the study (Group 1: $n = 32$, Group 2: $n = 36$). The cartoon-assisted distraction technique did not significantly reduce anxiety compared to the tell-show-do method. A non-significant reduction in pain perception was observed during local anesthesia with distraction. However, this technique significantly reduced self-reported pain during treatment ($p < 0.025$) and improved child cooperation and behavior.

Conclusion Cartoon-assisted visual and auditory distraction can alleviate pain perception and improve behavior during pediatric dental procedures. However, it does not appear to reduce dental anxiety or pain perception during local anesthesia. Integrating this technique with the traditional tell-show-do approach may enhance the pediatric dental experience.

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Keywords Behaviour guidance, Crossover clinical trial, Dental anxiety, Distraction, Paediatric patients, Pain

Introduction

Providing positive attitudes in the clinical setting is a challenge for dental professionals, especially for paediatric patients. Dentists play a critical role in using behaviour guidance techniques to achieve success and maintain high-quality oral healthcare. A critical factor in managing patient behaviour is reducing pain, fear and anxiety during dental care [1, 2]. Procedures performed in a dental setting that causes fear and anxiety in children may be listed as local anaesthesia injections, drilling with a high-speed rotary instrument, and tooth extraction. The level of fear that children perceive before or during these corresponding procedures is associated with disruptive behaviour and increased pain perception, resulting in nervousness and anxiety [3–5].

Several methods, including tell-show-do, ask-tell-ask, voice control, nonverbal communication, positive reinforcement, and distraction, have been used as basic behaviour guidance techniques to reduce anxiety, pain and behavioural distress in children [6]. The parents and dental professionals prefer the use of less aggressive behaviour guidance techniques such as tell-show-do and/or distraction nowadays [5]. The descriptions tell-show-do and distraction techniques are described as follows according to the American Academy of Paediatric Dentistry [6]:

> *"Tell-show-do- technique involves verbal explanations of procedures in phrases appropriate to the developmental level of the patient (tell); demonstrations for the patient of the visual, auditory, olfactory, and tactile aspects of the procedure in a carefully defined, nonthreatening setting (show); and then, without deviating from the explanation and demonstration, completion of the procedure (do).*
> *Distraction- is the technique of diverting the patient's attention from what may be perceived as an unpleasant procedure. Distraction may be achieved by imagination (e.g., stories), clinic design, and audio (e.g., music) and/or visual (e.g., television, virtual reality eye- glasses) effects."*

Following the use of distraction technique in the medical setting for adults, and effectiveness has been proven [7, 8], its usage to contribute to children's dental treatment process positively has become increasingly common [5, 9, 10]. Distraction technique during dental treatment was found useful previously by reducing children's distress and pain perception, especially during local anaesthesia application [11]. Many studies have been conducted in this field using audio-visual materials for achieving the cooperation of paediatric patients, and concluded with controversial results [12–17]. Limited data was observed covering the effects of visual/auditory distraction usage on anxiety, pain, and behavioural control in paediatric patients in a previous study [18]. To our knowledge, this is the first study that focuses on both objective and subjective measures for each variable. Therefore, the objective of this study was to assess the effect of the cartoon-assisted audio/visual distraction technique usage on paediatric patient's anxiety, pain and behaviour during dental care.

Materials and methods

Experimental design and study population

This study was conducted at Istanbul Medipol University, School of Dentistry, Department of Pedodontics, in Istanbul, Turkey, between June 2022 and October 2022. The study was registered on ClinicalTrials.gov (Registration No: NCT04927754) and was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines (http://www.consort-statement.org). A prospective, randomized, crossover trial design was employed, involving volunteers who sought routine dental care at the pediatric dentistry clinic of Istanbul Medipol University School of Dentistry.

The study population comprised children aged 4–9 years who presented for routine dental care at the pediatric dentistry clinic. Participants were recruited based on predefined inclusion and exclusion criteria as follows:

The inclusion criteria

1. Systemically healthy children with no prior history of dental treatment.
2. Children requiring restorative procedures in the lower primary molars (including pulpotomy, pulp capping, or composite fillings) under local anesthesia.
3. Children who, after receiving oral prophylaxis at the initial appointment, exhibited a behavior rating of 2 (negative) or 3 (positive) according to the Frankl Behavior Rating Scale (Categories as 1: definitely negative; 2: negative; 3: positive; 4: definitely positive).

The exclusion criteria

1. Presence of systemic diseases requiring continuous medication.

2. Mental or cognitive disorders, as well as visual or auditory impairments.
3. Children exhibiting either "definitely negative" (Frankl 1) or "definitely positive" (Frankl 4) behavior following oral prophylaxis at the initial appointment.

Following the initial dental examination, eligible patients were selected ($n = 95$) after 3 months of recruitment (June 2022 and August 2022). Each eligible patient was evaluated with the inclusion and exclusion criteria. Of these patients, 7 children demonstrated definitely negative behaviour at the first visit (V1), and 16 children did not show up to their scheduled V1; thus, 23 patients were excluded (Fig. 1), and a total of 72 patients were included in the study.

Sample size calculation

A sample size calculation based on a pilot study consisting of six patients was performed. Among all variable calculations, the larger sample size was employed according to 'self-reported anxiety measures using Venham Picture Test' [19], estimating a standard deviation of 2.51, minimum 30 patients in each group would be sufficient to detect a significant difference of 0.5 in self-reported anxiety levels between interventions at a significance level of 0.05 with statistical power of 80%. To compensate for dropouts (20%) six additional patients were included in each group enrolling to a total of 72 patients.

Randomisation

Participants were assigned randomly into two groups according to the treatment sequence: Group1, AB (*distraction - tell-show-do*) and Group2, BA (*Tell-show-do - distraction*). Randomisation was performed using online software (http://www.graphpad.com/quickcalcs/index.cfm), where patients enrolled on the study were rando mised into 2 groups with an allocation ratio of 1:1. The random allocation sequence was generated by an independent researcher (MB) who was not involved in data collection to ensure allocation concealment; thus, the operator (NU) and observer (BBA) were blinded to the assignment of the study participants to the groups. The operator and observer did not have a blinded condition due to the nature of the study. The observer (BBA), who had no involvement in the treatment of patients, was trained as an observer during the pilot study. This training involved conducting six observations of children (not included in the main study) in the clinic over one month, achieving an inter-rater reliability score with a Kappa statistic of 0.83. No methodological changes were performed after trial commencement occurred. The study participants switched treatments (distraction and tell-show-do technique) after a washout period. The study groups as follows:

Group 1: Dental treatment was carried out by showing a cartoon movie as a visual/auditory distraction (sequence A) during the treatment in the second visit (V2). The third visit (V3) did not consist of any distractions, the tell-show-do (sequence B) technique was used as a behavioural guidance technique.
Group 2: Dental treatment was carried out using the tell-show-do (sequence B) technique without any visual/auditory distraction in the V2. The V3 consisted cartoon movie as a distraction (sequence A).

Ethical considerations

Ethical approval for this study was obtained from the Ethics Committee of Istanbul Medipol University (Ref: E-10840098-604.01.01-E.60990). The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Prior to participation, the parents of all participants were fully informed about the study's objectives, potential benefits, and possible risks. The research team provided a written informed consent form detailing the study's purpose, duration, required procedures, potential advantages, and key contact information.

Experimental phase

At the V1 following the initial dental examination, dental prophylaxis was performed using a slow-speed handpiece with a prophylaxis paste to children. A Frankl Behaviour Rating Score was assigned following dental prophylaxis. Children who demonstrated a score of 2 or 3 according to the Frankl Behaviour Rating Scale were selected. Subsequently, the patients were randomly assigned to G1 (AB) or G2 (BA).

Paediatric patients were able to choose any of the 12 cartoon movies that had been approved by two paediatric dentists who carried out the study, checked for violence, slang language, and appeal to the 4–9 age range. The screen was attached to the dental unit; hence, the child could watch the cartoon movie clearly. While the same paediatric dentist (NU) performed all dental procedures in each session to remove the inter-operator variability, an independent, non-blinded observer (BBA) recorded the data (all objective and subjective measures). Before each treatment session, the treatment stages were explained to the child using the tell-show-do technique; the patient was requested to interrupt the treatment as little as possible. Parents were kindly requested to leave the operating room. Same treatment procedures were carried out in both groups during each visit in the following consecutive order. After the same topical anaesthesia application, mandibular block anaesthesia was performed and followed by restoration treatment in the lower primary molar tooth. Each visit period did not last longer than 30 min. The period between V2 and V3 was

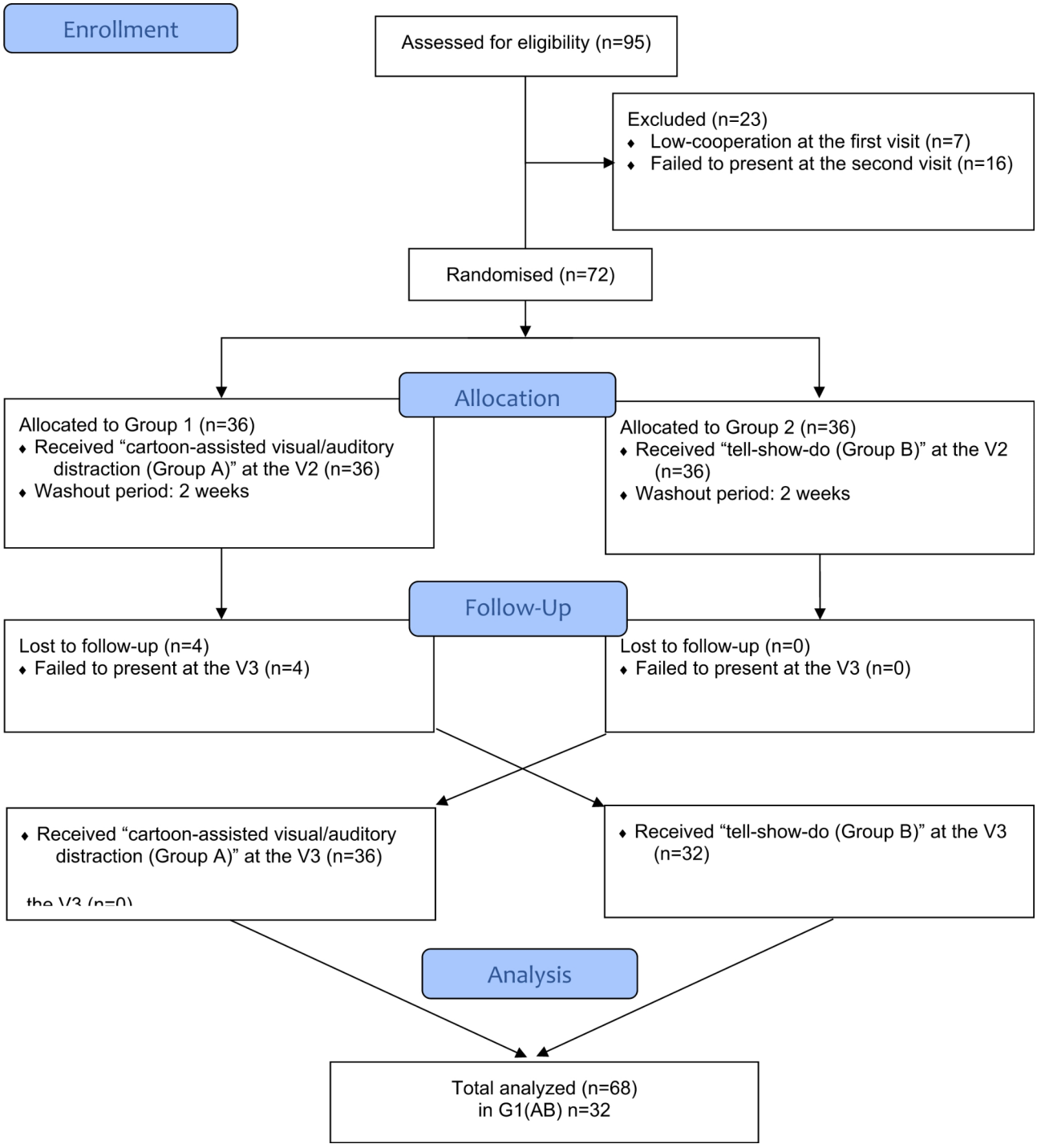

Fig. 1 CONSORT Flow-chart (Word) of the progress up to 5 months

two weeks and standardized for all subjects. This time interval between V2 and V3 was established as washout period to let the effects of the previous intervention diminish and promote children's cooperation. Besides, washout period was not kept long to avoid negative effect of severe carious lesions.

Variables, data sources, and measurement

The following variables and their interactions were considered for analysis:

Demographic variables

Age and gender.

Pre-operative variables

(i) ***Pulse rate (PR)***: The physiologic response to dental anxiety is characterised by an initial brief acceleration of heart rate and elevation in blood pressure followed by a deceleration of heart rate and a drop in blood pressure [20]. PR is a reliable and safe indicator of stress which increases simultaneously with anxiety in the dental setting [5]. Therefore, PR was chosen as a physiological measurement of anxiety in this study. Pre-operative PR was retrieved by a pulse oximeter to evaluate the child's anxiety objectively. From the moment the patient was ready and waiting for the beginning of the treatment, the highest value in the measurements was recorded.

(ii) ***Venham Picture Test (VPT)***: The ideal anxiety measurement method should be valid, allow for limited cognitive and linguistic skills, and be easy to administer and score in a clinical context. A picture scale is obviously able to cover all of these criteria. VPT is a valid scale which is relatively easy to administer and is readily understood and accepted by children [19]. VPT was applied before the beginning and at the end of each visit to evaluate the child's subjective anxiety. Eight cards, with two figures on each, represented anxious and non-anxious moods in the VPT. Cards were shown to the child in their numerical order, and he/she was asked to choose the figure that felt closest to him/her at that moment. The choice of "anxious" figure was recorded as one, and the "non-anxious" figure was recorded as zero, which totalled a final score. According to the VPT, the score ranges from 0 (not anxious) to 8 (extremely anxious).

Both PR (objective measure) and VPT (subjective measure) was used preoperatively for the anxiety assessment.

Intraoperative variables

i. ***PR***: During the treatment, PR was retrieved with the pulse oximeter at five-minute intervals starting from the local anaesthesia application.

Table 1 Houpt scale for general behaviour

Behaviour		Score
Aborted	No treatment rendered	1
Poor	Treatment interrupted; only partial treatment completed	2
Fair	Treatment interrupted but eventually all completed	3
Good	Difficult, but all treatment performed	4
Very good	Some limited crying or movement	5
Excellent	No crying or movement	6

1. Local anaesthesia application,
2. The intraoral procedure with a high-speed rotary instrument,
3. Matrix application,
4. Restorative treatment (etch/adhesive application/polymerase/composite application with light-curing),
5. Finishing.

ii. ***Houpt Scale***: The Houpt scale is a reliable tool for the assessment of childs' cooperation and behaviour, and it has a significant correlation with the validated scales such as the Global Rating Scale, the Visual Analogue and Frankl scales. Moreover, it has been emphasised that using this scale is beneficial in different treatment stages [21]. Therefore, the Houpt Scale was chosen to measure childs' behaviour in this study. Cooperation and general behaviour during treatment were evaluated by the examiner (BBA) using the Houpt Scale (Table 1) [22] taking into consideration the patient's reactions and interruption of treatment. The following treatment phases were evaluated, and an average was calculated to determine the patient's general behaviour score.

iii. ***Sounds, Eyes and Motor Scale (SEM)***: The SEM scale is an objective method that observes sounds, eye and motor reactions and has been used in previous studies to measure comfort or pain in children [23, 24]. The local anesthetic injection is one of the most anxiety-provoking and painful procedures for both children and adult patients in dentistry [24]. In order to evaluate pain perception during local anaesthesia, SEM scoring (Table 2), which is a non-subjective method based on the

Table 2 SEM scale for the assessment of pain/comfort

Parameter	Comfort	Mild discomfort	Moderate discomfort	Severe discomfort
	Grade 1	**Grade 2**	**Grade 3**	**Grade 4**
Sound	No sound	Nonspecific sound (probable pain)	Verbal complaint, louder sound	Verbal complaint, shouting, crying
Eye	No sign	Dilated eyes without tears (anxiety sign)	Tears, sudden eye movements	Crying, tears covering the face
Motor	Relaxed body and hand status	Muscular contraction, contraction of hand	Sudden body and hand movements	Hands movements for defense, turning the head to the opposite side

observation of the physician, was used by the same examiner (BBA) [23]. This method consists of two categories as comfortable (grade 1), and uncomfortable according to the patient's reactions. Uncomfortable responses were evaluated in three sub-categories: mild discomfort (grade 2), moderate discomfort (grade 3), and severe discomfort (grade 4).

Post-operative variables

Following the treatment, post-operative PR (i) and VPT (ii) were repeated.

iii. ***Wong-Baker FACES Pain Rating Scale (WBF)***: The use of the WBF was found appropriate as a self-reported pain assessment tool among children [25]. It shows high sensitivity and validity, is simple to use and is preferred by paediatric patients in comparison with other pain scales [26]. In this study, WBF was chosen as a subjective measurement for pain. At the end of the dental treatment, WBF was applied to the child to measure the self-reported pain during treatment [27]. A detailed explanation regarding the figures of the scale was provided to the child. Six faces ranging from happy to crying were shown to the child, and the question "How much did you hurt during the treatment?" was asked. Based on the self-reported answer, the score was noted on the patient form.

Statistics

Data was recorded to spreadsheets using Microsoft Excel (Microsoft Corporation. Redmond. WA. USA) for further analysis. NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) software was used for statistical analysis. While evaluating the study data, descriptive statistical methods (Mean, Standard Deviation, Median, Frequency, Ratio, Minimum, Maximum), as well as the distribution of the data, were evaluated with the Kolmogorov-Smirnov Test. Mann-Whitney U test was used to compare the quantitative data between two groups that did not show normal distribution, and Student's t-test was used in case of normal distribution. Paired test in comparisons of two periods with normal distribution; Wilcoxon test was used for comparisons between two periods (V2, V3) that did not show normal distribution. The level of significance (0.05/2) was adjusted to 0.025, using the Bonferroni method. No subgroup analysis was carried out in this study.

Table 3 Characteristics of the study population

	G1 (AB)	G2 (BA)	Total
Study group	32 (47.06%)	36 (52.94%)	68 (100%)
Gender			
Female	18 (56.25%)	19 (52.78%)	37 (54.41%)
Male	14 (43.75%)	17 (47.22%)	31 (45.59%)
Age			
Mean ∓ SD	6.67 ∓ 1.08	6.70 ∓ 1.13	6.69 ∓ 1.08
Min - Max	4.59–8.85	4.70–8.90	4.59–8.90

Results

Participants' enrollment, randomisation, allocation, completion of the interventions, and analysis were presented in the CONSORT flow chart (Fig. 1).

This randomised crossover clinical study lasted for five months, with three months of recruitment and two months to allocate treatment arms, including a two-week washout period between interventions. Four patients from G1(AB) were lost to follow-up and thus were excluded; the final sample analysed consisted of 68 patients (G1(AB) $n = 32$ / G2(BA) $n = 36$), with a mean age of 6.69 ± 1.08 years (Table 3).

There were no local anaesthesia reactions observed in either group. No serious adverse events potentially related to the treatment procedures were expected. Confidence intervals, mean and standard deviation (SD), min-max (median), and p values of anxiety, pain and behaviour outcomes of both groups are laid out in Table 4.

Anxiety outcomes

The differences in the mean PRs for both visits during the whole procedure (pre-op, during treatment, post-op) are laid out in Fig. 2.

Although mean PRs were lower in most of the sessions during which cartoon assisted distraction technique was used, no statistically significant differences were found between the two methods in G1(AB) ($p > 0.025$, Table 5). There was a statistically significant difference in pulse rate between the two visits during treatment in G2 (BA) ($p < 0.01$, Table 5). Cartoon assisted distraction technique did not significantly reduce the child's self-reported anxiety compared to the tell-show-do technique.

Pain outcomes

There were no statistically significant differences between groups with regard to the SEM values ($p > 0.025$, Table 4). The child self-reported pain (WBF) values of the G1(AB) were found statistically significantly lower than G2 (BA) ($p < 0.025$, Table 4). Distraction significantly decreased pain perception (SEM score) in both groups during local anaesthesia ($p < 0.01$, Table 5) and child self-reported pain (WBF) during treatment compared to the tell-show-do technique ($p < 0.01$ for G1(AB), $p < 0.025$ for G2 (BA), Table 5).

Table 4 Comparison of anxiety, pain and behaviour measurements by groups in two visits

			V2			V3			
	Group	***n***	**CI (%95)**	**Mean ± SD**	**Min-Max (Median)**	***p* value**	**CI (%95)**	**Mean ± SD**	**Min-Max (Median)**	***p* value**
Pre-op PR	***AB***	32	97.02-110.16	103.59 ± 18.24	68–146 (104)	0.897[a]	94.46-107.91	102.19 ± 15.88	63–138 (101)	0.313
	BA	36	96.03-109.46	102.75 ± 19.85	57–148 (103)		93.49-103.17	98.33 ± 14.31	70–123 (96.5)	
Intraoperative PR	***AB***	32	97.54-108.72	103.13 ± 15.5	73.33–140.5 (103.35)	0.975[a]	99.63-111.05	105.34 ± 15.85	80.67-150.17 (103.67)	0.105
	BA	36	97.68-108.88	103.28 ± 16.56	68.67-138.33 (102.59)		93.69-104.54	99.12 ± 16.03	69.5-144.67 (98.67)	
Post-op PR	***AB***	32	94.46-105.54	100 ± 15.37	68–137 (99.5)	0.708[a]	96.63-107.06	101.84 ± 14.46	72–142 (103.5)	0.054
	BA	36	93.78-103.88	98.83 ± 14.93	71–133 (98.5)		90.37–99.74	95.06 ± 13.85	66–120 (94.5)	
Pre-op VPT	***AB***	32	0.78–2.28	1.53 ± 2.08	0–8 (0)	0.361[b]	0.8–2.51	1.66 ± 2.36	0–8 (0)	0.979
	BA	36	1.16–2.56	1.86 ± 2.07	0–7 (1)		0.78–2.15	1.47 ± 2.02	0–8 (0.5)	
Post-op VPT	***AB***	32	0.22–1.09	0.66 ± 1.21	0–5 (0)	0.100[b]	0.55–2.01	1.28 ± 2.02	0–7 (0)	0.686
	BA	36	0.63–1.81	1.22 ± 1.74	0–8 (1)		0.38–1.61	1 ± 1.8	0–8 (0)	
SEM scale	***AB***	32	4.25–5.93	5.09 ± 2.32	3–12 (4)	***0.035[b]***	5.12–7.12	6.13 ± 2.78	3–12 (5)	0.135
	BA	36	5.60–7.62	6.61 ± 2.98	3–12 (6)		4.35–5.81	5.08 ± 2.16	3–12 (5)	
WBF	***AB***	32	0.87–2.51	1.69 ± 2.28	0–8 (0)	***0.019**[b]***	2.15–4.34	3.25 ± 3.04	0–10 (2)	0.03
	BA	36	2.30–4.64	3.47 ± 3.46	0–10 (2)		0.94–2.72	1.83 ± 2.63	0–10 (0)	
Houpt scale	***AB***	32	5.19–5.68	5.44 ± 0.67	3.2-6 (5.6)	0.053[b]	4.95–5.54	5.24 ± 0.82	2–6 (5.4)	0.252
	BA	36	4.87–5.37	5.13 ± 0.74	3.4-6 (5)		5.21–5.65	5.43 ± 0.65	3–6 (5.6)	

[a]*Student's t-test* [b]*Mann-Whitney U test* *$p < 0.025$ **$p < 0.01$

Behaviour outcomes

There were no statistically significant differences between groups with regard to the child's cooperation and general behaviour of the patient as determined by the Houpt scale ($p > 0.025$, Table 4). The distraction technique improved the child's cooperation and general behaviour significantly during treatment in G2 (BA) ($p < 0.01$, Table 5).

The results of anxiety, pain, and behavior scales for the G1(AB) group are presented in Fig. 3

Discussion

This study was conducted to assess the efficacy of visual/auditory distraction on children's anxiety, pain, and general behaviour during restorative dental treatment. Dental anxiety can be managed using pharmacological and non-pharmacological interventions to achieve a comfortable dental treatment experience. The visual/auditory distraction technique is one of the non-pharmacological interventions and is better than traditional distraction methods because of the capability to block out real-world stimuli using music, cartoon, movies, games, etc [9, 28–31]. The current study revealed that cartoon-assisted visual/auditory distraction is relatively ineffective in reducing patient self-reported anxiety, which is in line with previous studies [9, 10, 18, 32]. VPT was applied as a self-reported anxiety scale in this study to measure the state anxiety of child patients, which is an effective and reliable measure [33] and several studies have demonstrated the validity [19, 34, 35].

PR is generally used as a direct, physiological measurement of anxiety in children and is considered an objective measure. The PR obtained in this study showed increased mean values in both groups during the treatment compared to pre-operative baseline values. During the treatment, PR decreased gradually; however, a reduction to the baseline levels was reached earlier in sessions with cartoon movie (Fig. 2). Regarding objective measures of anxiety, no statistically significant difference was found in PR among the groups during visits, which is in line with previous researches [18, 32, 36].

In this study, the patient's pain perception during local anaesthesia was assessed using the SEM scale, while the patient's self-reported pain during treatment was evaluated using the WBF. The components of the SEM scale allow for the assessment of the relationship between pain and the reactions it elicits in the patient, including eye movements, bodily responses, and verbal expressions of discomfort. The scale enables the recording of the pain sensation's degree of intensity [37]. Distraction diverts the patient's attention from the unpleasant and invasive procedures. This method is most helpful in diverting the patient's focus from the needle tip; thus, it helps minimise the pain perception [38]. The current study's

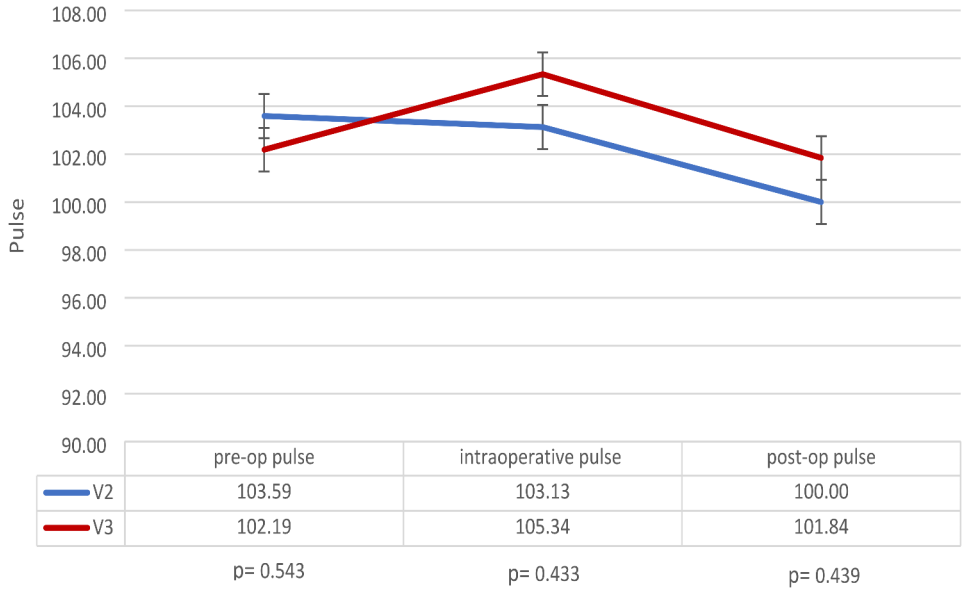

Fig. 2 Pulse rate comparison between visits in G1 (AB). The error bars represent standard deviations

Table 5 Comparison of anxiety, pain and behaviour measurements by period in groups

		G1(AB)			G2(BA)		
		V2 (n = 32)	***V3 (n = 32)***	***p* value**	***V2 (n = 36)***	***V3 (n = 36)***	***p* value**
Pre-op PR	***Meant ± SD***	103.59 ± 18.24	102.19 ± 15.88	0.543[a]	102.75 ± 19.85	98.33 ± 14.31	0.201[a]
	Min-Max (Median)	68–146 (104)	63–138 (101)		57–148 (103)	70–123 (96.5)	
Intraoperative PR	***Meant ± SD***	103.13 ± 15.5	105.34 ± 15.85	0.433[a]	103.28 ± 16.56	99.12 ± 16.03	***0.004**[a]***
	Min-Max (Median)	73.33–140.5 (103.35)	80.67-150.17 (103.67)		68.67-138.33 (102.59)	69.5-144.67 (98.67)	
Post-op PR	***Meant ± SD***	100 ± 15.37	101.84 ± 14.46	0.439[a]	98.83 ± 14.93	95.06 ± 13.85	0.108[a]
	Min-Max (Median)	68–137 (99.5)	72–142 (103.5)		71–133 (98.5)	66–120 (94.5)	
Pre-op VPT	***Meant ± SD***	1.53 ± 2.08	1.66 ± 2.36	0.943[b]	1.86 ± 2.07	1.47 ± 2.02	0.312[b]
	Min-Max (Median)	0–8 (0)	0–8 (0)		0–7 (1)	0–8 (0.5)	
Post-op VPT	***Meant ± SD***	0.66 ± 1.21	1.28 ± 2.02	0.074[b]	1.22 ± 1.74	1 ± 1.8	0.210[b]
	Min-Max (Median)	0–5 (0)	0–7 (0)		0–8 (1)	0–8 (0)	
SEM scale	***Meant ± SD***	5.09 ± 2.32	6.13 ± 2.78	***0.002**[b]***	6.61 ± 2.98	5.08 ± 2.16	***0.001**[b]***
	Min-Max (Median)	3–12 (4)	3–12 (5)		3–12 (6)	3–12 (5)	
WBF	***Meant ± SD***	1.69 ± 2.28	3.25 ± 3.04	***0.002**[b]***	3.47 ± 3.46	1.83 ± 2.63	***0.021**[b]***
	Min-Max (Median)	0–8 (0)	0–10 (2)		0–10 (2)	0–10 (0)	
Houpt scale	***Meant ± SD***	5.44 ± 0.67	5.24 ± 0.82	0.154[b]	5.13 ± 0.74	5.43 ± 0.65	***0.002**[b]***
	Min-Max (Median)	3.2-6 (5.6)	2–6 (5.4)		3.4-6 (5)	3–6 (5.6)	

*[a]Paired t-Test[b]Wilcoxon test *p < 0.025 **p < 0.01*

findings regarding pain alleviation during dental treatment are consistent with previous research, which also found pain reduction during treatment but not during local anaesthesia administration [9, 18, 29, 39]. The studies recommended that audio-visual devices may be used in paediatric dentistry clinics routinely, especially when dealing with young children.

A previous study by Baghdadi [16] evaluating audio analgesia for dental restoration in children reported a statistically significant difference in self-reported pain measures during the treatment. Apart from the present study method, Baghdadi applied the self-reported pain scale immediately upon penetration of the dentin-enamel junction during cavity preparation associated with the highest pain feeling. In another study [40], using audio-visual glasses as a distraction method on pain perception revealed statistically significant differences in self-reported pain just after the local anaesthetic injection. Aside from the current study findings regarding self-reported pain measures employing WBF, another study [18] conducted in Spain, using the audio-visual distraction method by cartoon films obtained no significant differences in self-reported pain measures applying WBF at the end of visits. The study concluded that the main problem was forgetting about the pain sensation during the treatment due to the time period between applying the scale and pain perception. They suggested applying self-reported pain scales following the specific

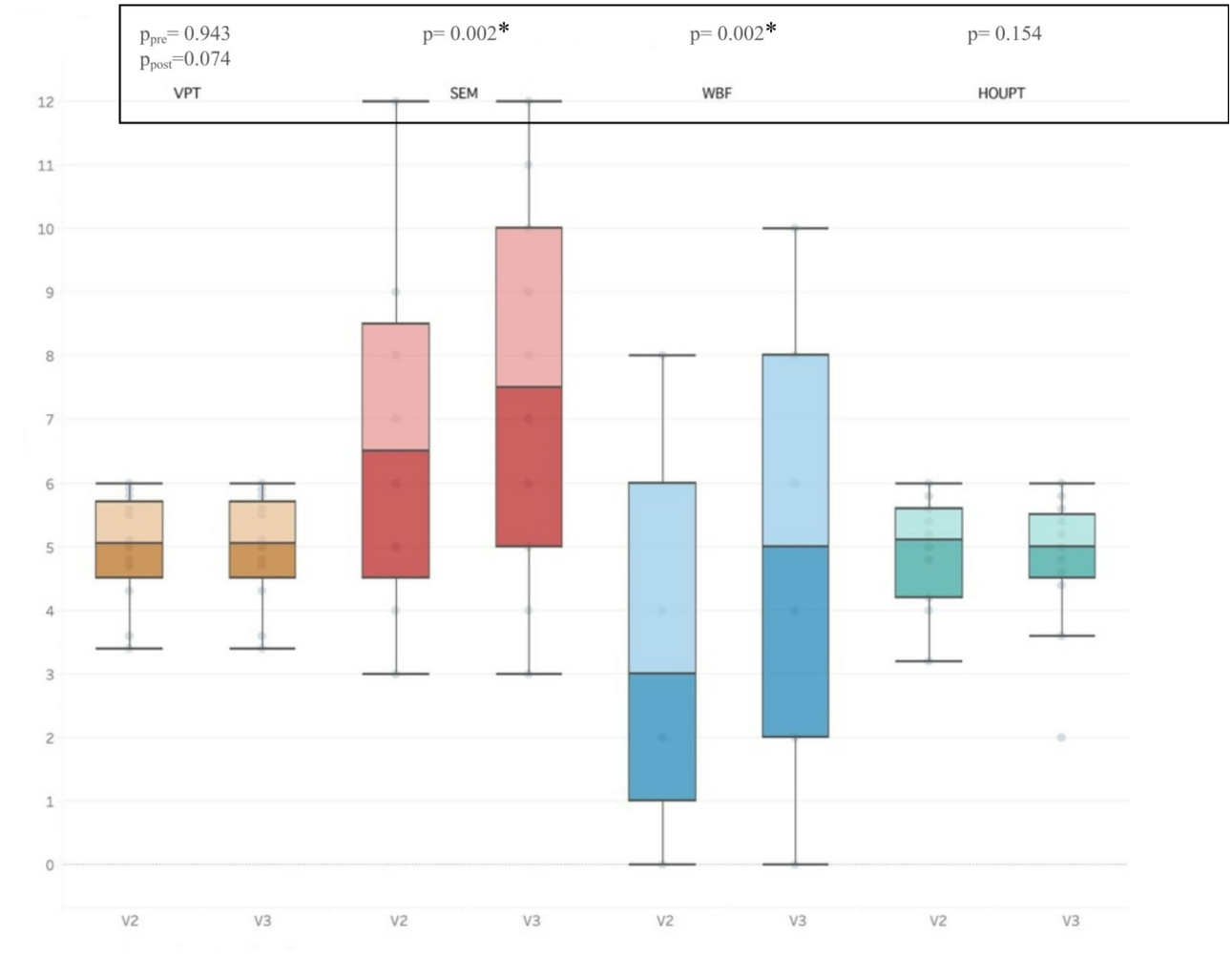

Fig. 3 Anxiety, pain, behaviour scales between visits in G1 (AB)

interventions, such as right after local anaesthetic injection or rubber dam application.

The present study showed that the visual/auditory distraction technique significantly affects children's cooperation and general behaviour during treatment. Similar to the present study findings, a previous study [18] concluded that when cartoon movies were shown to the child patients, global behaviour improved significantly. In contrast, Sullivan et al. [17] found no significant effect of virtual reality use for distraction on children's behaviour. The reason was argued to be linked by the design of the virtual reality system, which eliminates visual access to the surrounding environment. Researchers concluded that anticipation and negative emotions increase in children when they cannot see or hear what is happening around them. In the present study, the angle of the attached screen, displaying a cartoon movie, was arranged close enough for the patient, and the child had visual access to the surrounding environment. Moreover, the volume was adjusted to a level so that the child could hear the instructions and noise of the high-speed handpiece and the suction.

Another essential factor for effectively distracting the child is letting the displayed movie be self-chosen. It was suggested that if the child is allowed to choose the audio-visual material, the stress level reduces, which affects general behaviour and feeling of control over the dentist's behaviour [13, 18]. In the current study, the children could select their preferred cartoon movie, which may explain contradiction to the previous studies further [12, 17, 41] which did not allow patients to choose audio-visual materials.

In medical studies [42, 43], audio-visual distraction was reported to reduce patients' pain and anxiety levels during short invasive procedures. More children showed distress and uncooperative behaviour in a previous study [44] when dental procedures exceeded 30 min compared to shorter procedures. Therefore, to prevent children's negative behaviour during dental procedures, visit time in the present study was arranged to be no longer than

30 min. Moreover, all treatments were scheduled as the first appointment in the morning to standardise visit time and eliminate fatigue factors for both the operator and the child.

The strengths of this study may be listed as follows: The same examiner recorded all objective and subjective measurements, and data analysis was performed blindly by an independent examiner to improve the reliability of the study. Using various objective and subjective measurement techniques such as dental anxiety via self-report and physiologic measures, pain perception via SEM and WBF scale, and cooperation level and general behaviour via Houpt scale to achieve a comprehensive assessment of the child patient condition. Furthermore, the crossover study design allows each participant to serve as his/her own matched control, hence, eliminating the interpatient variability, and lowering estimation bias between treatments [45].

This study has several limitations that warrant consideration. First, the absence of a recording and videotaping system prevented blinded conditions for examiners, potentially introducing observer bias, although scoring outside the treatment session was recommended to minimize this issue [46]. Additionally, subgroups such as age and gender were not included in the analysis, as the study focused on the overall efficiency of the methods rather than subgroup-specific findings.

Another limitation is the lack of standardization in the cartoon movies selected by participants. Pediatric patients were allowed to choose from 12 options, but no data were analyzed on which movies were most frequently selected or on differences in patient responses based on the selected movie. This omission may have influenced the results and overlooked variations in the effectiveness of individual movies in alleviating anxiety, pain, or behavioural issues.

Furthermore, the study focused solely on cartoon-assisted audio/visual distraction as a singular method. While the findings provide valuable insights, this narrow focus may limit real-world applicability, as pediatric care often employs a combination of strategies tailored to individual preferences. The exclusive focus on cartoons reduces the generalizability of the findings and highlights the need for future research to explore integrated distraction methods.

Lastly, the study did not account for differences in procedure duration or pain levels associated with various dental treatments, such as composite fillings, pulp capping, and pulpotomy. These procedural variations could have influenced the outcomes and reduced the robustness of the findings. Future studies should consider controlling for or stratifying data based on procedural differences to improve the accuracy and applicability of results.

Previous researchers [5, 9, 18, 31, 47–50] evaluated the effects of visual distraction use on several parameters, i.e., pain, anxiety and general behaviours during dental treatment of pediatric patients. Although the general conclusion drawn by these studies may be interpreted as the use of visual distractions having improving effects on these parameters, when further investigated, it is noteworthy to state that different results are obtained by using objective or subjective methods for obtaining pain and anxiety data. There is no previous study in which pain and anxiety parameters have been evaluated using both methods and associated with patient compliance. Therefore, in this study, both the physician's observation and the child's expression were taken into account when evaluating the effect of visual-distraction-use on pain and anxiety during dental treatment.

Meta-analysis and systemic studies [28, 51–54] reveal that the use of visual distractions reduced the dental anxiety of children during dental treatment [52, 54] and pain [51]. However, Prado et al. [53] and Liu et al. [28] reported very low certainty that visual distraction use reduces children's dental anxiety. This dilemma is thought to occur due to the heterogeneity of methodologies and findings in researches. Therefore, further well-conducted randomised controlled studies using improved methodologies are required.

Conclusion

In conclusion, this study has demonstrated the effectiveness of audio-visual distraction in alleviating children's pain perception and enhancing their cooperation and general behaviour during dental treatment. The utilization of cartoon-assisted audio/visual distraction presents a promising approach, offering the potential for a relatively painless and comfortable dental experience in pediatric settings. Furthermore, this method may contribute to the reduction of dental anxiety among pediatric patients. These findings underscore the importance of incorporating innovative distraction techniques into pediatric dental care to enhance patient comfort and overall treatment outcomes. Further research and implementation of such strategies are warranted to optimize pediatric dental care practices and improve patient experiences.

Abbreviations

PR	Pulse rate
VPT	Venham picture test
SEM	Eyes and motor
WBF	Wong-Baker FACES pain rating scale
SD	Standard deviation
V	Visit

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions
NU conceptualized the manuscript. BBA and NU carried out methodology; MB carried out data analysis, drafted and edited the manuscript. All authors subsequently revised the drafts. All authors read and approved the final manuscript.

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Data availability
All data generated or analysed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate
Ethics committee approval was received for this study from the Ethics Committee of Istanbul Medipol University (REF: E-10840098-604.01.01-E.60990). The research was carried out in compliance with the policy set out in the Declaration of Helsinki, and informed consent inwritten form was obtained from the parents of participants included in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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