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Are technological contributions in behavior guidance techniques superior to conventional methods?: Effects on dental anxiety and pain perception

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Abstract

Background To evaluate the effects of three different behavior guidance methods on children's dental anxiety levels and pain perception.

Methods This study included 63 children aged 6–8 years who required pulpotomy and were divided into three groups: tell–show–do (TSD; Group 1), TSD with video modeling (Group 2), and TSD with mobile phone application (Group 3). Systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and hemoglobin oxygen saturation (SPO_2) of the participants were recorded before the procedure, after local anesthesia, after pulpotomy, and after the end of the procedure. Faces Version of the Modified Child Dental Anxiety ($MCDAS_f$), Wong-Baker Faces Pain Rating Scale (WBFPRS), and Face, Legs, Activity, Cry, Consolability (FLACC) pain scales were applied. Chi-squared test, one-way ANOVA, Kruskal–Wallis test, Friedman's test, and repeated measurement analysis statistical tests were used.

Results No significant difference was found between the steps in terms of BP, HR, and SPO_2 within the groups ($p > 0.05$). When comparing the groups, there were significant differences in SBP ($p = 0.040$) and DBP ($p = 0.027$) measured at the beginning and end of the procedure, and between $MCDAS_f$ ($p = 0.041$) and WBFPRS ($p = 0.013$) scores. These values were lower in Group 3.

Conclusion Dental anxiety and pain perception scores were lowest when using TSD with mobile phone application (Group 3). In line with developing technology, the use of mobile phone applications in pediatric dentistry can contribute to more harmonious treatment management in children.

Trial registration The trial protocol was retrospectively registered ID NCT06912789 (https://clinicaltrials.gov/); 2025-03-26.

Keywords Behavior, Child, Dental anxiety, Mobile applications, Pain, Vital signs

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Background

Anxiety is a feeling related to apprehension that allows a person to respond to events and changes in their environment and can occur with or without a stimulus [1]. Dental anxiety is defined as the apprehension a person feels towards dental treatments [2]. Dental anxiety, which can occur in childhood and adolescence, can develop into dental phobia in later life. This situation is of great importance as it can cause dental treatments to be delayed and oral health to be neglected [3, 4]. Although pain is essentially a physiological condition, psychological factors, such as anxiety and fear, also play an important role in pain perception. The thought that pain might occur during treatment is considered among the main causes of dental anxiety. Therefore, pain and dental anxiety are linked and can be among each other's etiological factors [5].

Observational, psychometric, projective, and physiological scales can be used to assess anxiety [6]. The Faces Version of the Modified Child Dental Anxiety ($MCDAS_f$) is a psychometric scale developed by Howard et al. for younger age groups and patient groups with low perception levels [7]. Dental anxiety can cause changes in a child's blood pressure (BP), heart rate (HR), and oxygen saturation (SPO_2) [8]. For this reason, vital signs are commonly used as physiological criteria to assess dental anxiety in children [9]. The Face, Legs, Activity, Cry, Consolability (FLACC) pain scale that was developed by Merkel et al., is used by observers to assess pain perception, which contributes to the development of dental anxiety [10]. Another pain assessment scale, the Wong–Baker Faces Pain Rating Scale (WBFPRS), allows for the subjective assessment of pain in children, older people, and individuals who do not have adequate communication skills [11].

Behavior guidance is a continuous process of interaction between the child, parent, and dentist. By establishing effective communication in this way, this process could alleviate the child's anxiety and fear, establish trust (i.e., between the dentist, the child, and the parent), and increase the awareness of both the child and the parent about the importance of oral health, ultimately improving dental treatments. According to the American Academy of Pediatric Dentistry (AAPD) guide, behavior guidance techniques are classified as either basic or advanced behavior guidance techniques [12]. Basic behavioral guidance techniques incorporate methods based on the physician's communication skills and include procedures, such as positive pre-visit imagery, direct observation (modeling), tell–show–do (TSD), distraction, and desensitization. Advanced behavior guidance techniques include protective stabilization, sedation, and general anesthesia [12].

Among the basic behavior guidance techniques, the TSD method is the most used in dentistry. This technique, which has maintained its reliability and validity for decades, is the most accepted method by parents [13]. In the behavior guidance technique with modeling, the patient is either shown a video recording of another child cooperating during dental treatment or is allowed to observe the child directly [12]. Given the prevalence of phone and screen use among preschool and school-aged children, mobile phone applications can serve as an educational tool for dental procedures. Mobile phone applications developed for behavior guidance in dentistry can be beneficial for reducing dental anxiety [14].

This study aimed to evaluate the effects of three different behavior guidance techniques—TSD, TSD with video modeling, and TSD with mobile phone application—on pulpotomy treatment in pediatric patients with anxiety by using physiological and projective methods, and for pain perception, using FLACC and WBFPRS scales.

Methods

Ethics approval

This study was approved by the Recep Tayyip Erdoğan University Non-Interventional Clinical Research Ethics Committee (decision no: 2023/244). Since the participants were under 16 years of age, detailed information about the research was provided to their parents or legal guardians before the study, and an informed consent form was obtained. According to the principles described in the Declaration of Helsinki, the study protocol included all amendments and revisions.

Sample size

For the power analysis, the a priori hypotheses considered a medium effect size (f: 0.20) for four different stages (repeated measurements) across three groups, with a type I error rate set at $\alpha = 0.05$ and a target test power of $1\text{-}\beta = 0.90$. The minimum required sample size for the study was 45. Considering the potential for missing data, we decided to include 63 patients in the study with 21 per group.

Study group criteria

Inclusion criteria

The inclusion criteria for the study were that the patients had no previous dental treatment, were between ages 6 and 8 years, scored 3 (positive) or 4 (definitely positive) on the Frankl Behavior Scale, had no systemic disease, did not need emergency dental treatment, required Class II composite restorations after pulpotomy on one of the maxillary molars, had no mental or physical disabilities, understood the commands, and whose parents agreed to participate in the study and signed the consent form.

Exclusion criteria

Patients who did not meet the inclusion criteria included those who needed other asymptomatic root canal treatment other than pulpotomy indication, needed restorative treatment due to a history of dental trauma, those who did not want to be included voluntarily, who cried during the procedure or left the treatment unfinished, and who were determined to be negative (2) or definitely negative (1) according to the Frankl Behavior Scale.

Study procedure

In the randomized controlled clinical trial, while the pediatric dentist (MY), who performed various behavioral guidance techniques, dental treatment and applied $MCDAS_f$ and WBFPRS scale, was aware of the study groups and participant distribution, the other pediatric dentist (SA), who completed the initial examinations, Frankl and FLACC Scale assessments, was blinded to the study groups and distribution among the participants.

Participants were randomly assigned to the three study groups with 21 per group using the Randomizer (www.randomizer.org) software, accessed January 15, 2024. Participant demographic information, such as sex and age, was recorded in the waiting room. After the parents were informed about the research and the procedures, their written consent was obtained. All children were treated by the same pediatric dentist (MY) in the same clinical setting.

The patient met with their pediatric dentist and their information was recorded before they were taken to the treatment unit. Children's vital signs (BP, HR, and SPO_2) were recorded 15 min before the treatment while the child was seated in the dental unit (first measurement). In Group 1 (TSD), the treatment procedure and the exact steps were explained to the child verbally after which all the tools and equipment required for the treatment were shown to the child before the pulpotomy was performed. In Group 2 (TSD with video modeling), with TSD a 4 min 33 s behavioral guidance video was presented to the child (https://youtu.be/ir1cyjqsWq4?si=pn7jPwzcDfuMHcq; Fig. 1). In Group 3 (TSD with mobile phone application), TSD and the Roogies application were presented to the children together. Roogies is a freely available application (https://apps.apple.com/tr/app/roogies/id1542220556?l=tr; Fig. 2) and can be used to lightheartedly educate chil dren about all dental procedures (e.g., oral prophylaxis, various restorations, etc.). Each child was allocated 5 min to use the app. All behavioral guidance techniques were administered before the patient started the treatment while seated in the dental unit. As such, 15 min were allocated for behavioral guidance for all patients. The treatment process was conducted identically for all groups. After topical anesthetic (Vemcaine Pump Sprey 10%, VEM Medicine) was applied to the buccal mucosa of the tooth to be treated with pulpotomy using a cotton pellet, local infiltration anesthesia (Ultracain DS forte Ampoule 2 mL Sanofi Aventis, France, Articaine HCl: 40 mg/mL Epinefrin HCl: 0.012 mg/mL) was used. Patient vital signs were measured again after local anesthesia was applied (second measurement). After local anesthesia control, the pulpotomy procedure was performed and after coronal pulp amputation, vital signs were measured and recorded again (third measurement). The pulpotomy procedure was completed and the teeth were restored with composite filling material, then the patient was placed in a sitting position. The vital signs of the patients who rested for 15 min were measured (fourth measurement). The same pediatric dentist (MY) measured and recorded vital signs (BP, HR, and SPO_2) at all stages.

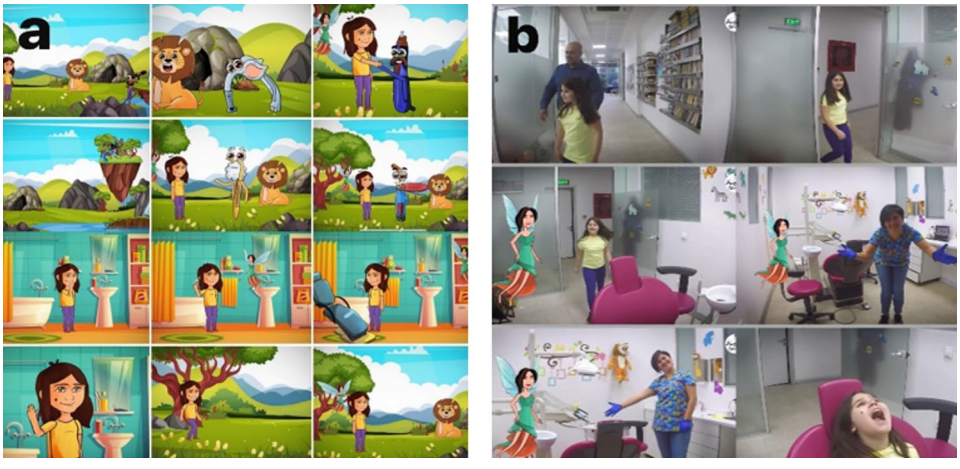

Fig. 1 Sample sections from the video used in the 'video modeling' behavior guidance techniques used in patients in Group 2 (**a**) Explanation of the dental treatment process in the form of a video animation (**b**) Demonstration of the dental clinic and dental treatment process steps in the continuation of the video animation

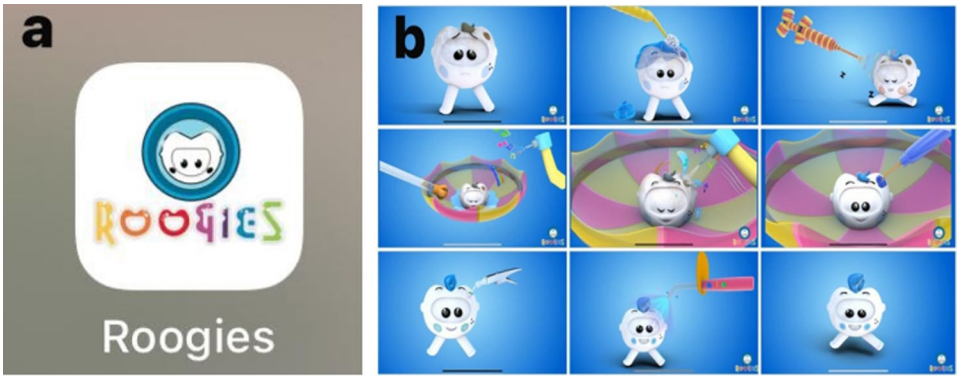

Fig. 2 The mobile phone application used as a behavior guidance technique in Group 3 patients (**a**) and sample visual sections of dental treatment steps in the application (**b**)

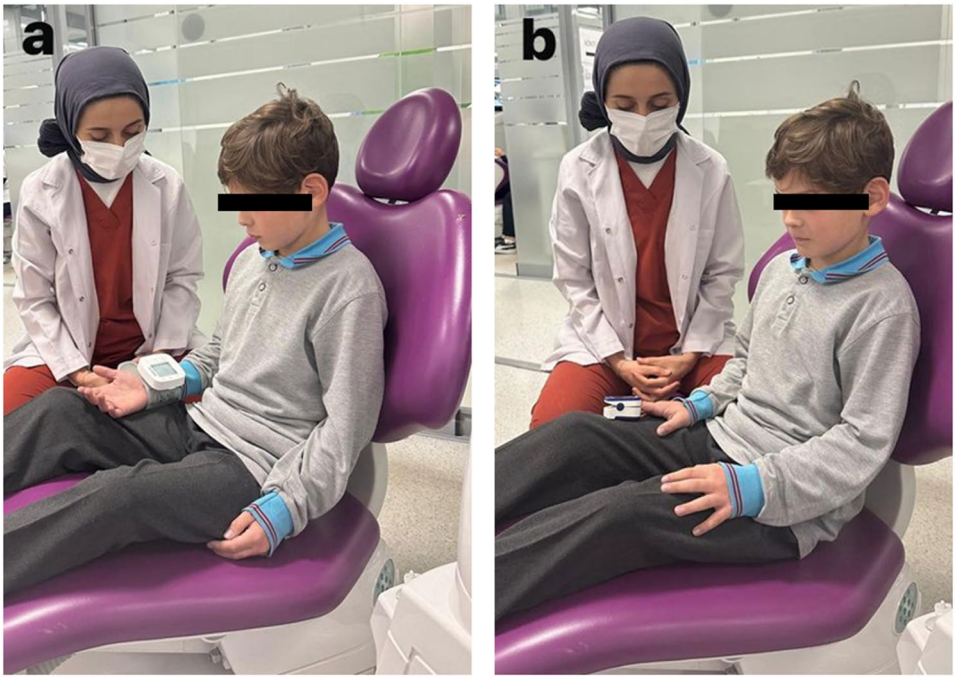

Fig. 3 Demonstration of vital signs used in anxiety assessment (**a**) Blood pressure and heart rate measurements (**b**) Haemoglobin Oxygen Saturation measurement

At the end of the treatment, the $MCDAS_f$ scale was used by the treating pediatric dentist (MY) to assess the children's dental anxiety levels whereas the WBFPRS scale was used to assess pain perception. The child's movements during treatment were scored with the FLACC scale by the pediatric dentist (SA) who was masked from the subject and content of the study. As such, evaluator bias was excluded when scoring with the FLACC scale.

Outcome measures

Evaluation of dental anxiety

Physiological evaluation

BP, HR, and SPO_2 were measured in the study. These measurements were repeated four times during the dental procedure: 15 min before the beginning (T0), after local anesthesia (T1), after pulpotomy (T2), and 15 min after the end of treatment (T3; Fig. 3).

Blood pressure (BP) Each patient rested for 15 min before BP measurement. Measurements were taken from the right wrist with the child in an upright position using an automatic wrist blood pressure device (Wohler, Türkiye). Systolic (SBP) and diastolic blood pressure (DBP) values in cm of mercury (cmHg) were recorded.

Heart rate (HR) and hemoglobin oxygen saturation (SPO_2) After blood pressure measurement, HR and SPO_2 were measured while the child was in a seated position

using a finger-type portable pulse oximeter (Oncomed, USA) attached to the child's right finger. HR values on the digital monitor were measured as beats per minute whereas SPO_2 was recorded as a percentage.

Psychometric evaluation

$MCDAS_f$ $MCDAS_f$ is a psychometric scale consisting of eight questions and was developed by Humpris et al. [15] to measure dental anxiety level and was adapted for children by Howard et al. [7] For this scale, there are five possible responses consisting of smiling or sad faces, appropriate for each answer given by the child. A happy face corresponds to 1 point whereas a very sad face corresponds to 5 points. After dental treatment, the children in all three groups were asked the questions after which the scores corresponding to the facial expressions were chosen by the children were recorded by the pediatric dentist (MY). The total score was calculated as a minimum of 8 and a maximum of 40, with high anxiety associated with increasing score [16].

Evaluation of dental pain perception

Wong–Baker faces pain rating scale (WBFPRS)

The WBFPRS includes six facial expressions ranging from a smiling face to a crying face. These expressions were explained to the children who were asked to choose the face that best reflected the level of pain they felt during treatment. A smiling face was 0 points (no pain) whereas a crying face was 10 points (very severe pain).

After physiological and psychometric measurements were recorded, the pediatric dentist (MY) used the WBFPRS score to evaluate the children's pain perception. The scoring was recorded by the same pediatric dentist (MY).

Face, legs, activity, cry, consolability (FLACC) scale

The measurement was made by evaluating five behavioral categories (i.e., face, legs, activity, crying, and consolability). Each parameter was scored between 0 and 2 and the total score ranged between 0 and 10 where 0 is calm and comfortable, 1–3 is mild discomfort, 4–6 is moderate pain, and 7–10 is severe discomfort or pain, or both. A score closer to 10 indicates severe pain whereas 0 meant no pain.

To accurately, consistently, and objectively compare the effects of behavior guidance techniques on pain perception (and to allow for the assessment of intra-observer agreement by re-evaluation after a specific time interval), patients were video recorded throughout the pulpotomy procedure. The pediatric dentist (SA), who had no prior knowledge of the study's subject or content, later reviewed the videos and evaluated them using the FLACC pain scale.

Statistical analysis

The data obtained from the study were analyzed using SPSS statistical software (SPSS V23.0, SPSS, Chicago, IL, USA). The normality distribution of the data were evaluated with the Shapiro–Wilk test. In the analysis of time-dependent data within the group, repeated measures analysis was applied to data that conformed to a normal distribution, and the Friedman test was applied to data that did not conform. For the inter-group evaluation, data from study groups that were normally distributed were analyzed using one-way ANOVA whereas data from non-normally distributed groups were analyzed using the Kruskal–Wallis test. The categorical data were analyzed with the Chi-squared test. The statistical significance level was set as $p < 0.05$. Cohen's kappa test was applied to evaluate intra-observer agreement with the FLACC scale. Accordingly, FLACC scores were evaluated at two different times, 10 days apart, and these scores were recorded.

Results

63 children were randomly assigned to three groups of 21 participants. The distribution of participants by sex was 55.6% ($n = 35$) girls and 44.4% ($n = 28$) boys. The boy to girl distribution was 42.9–57.1% in Group 1; 38.1–61.9% in Group 2; and 52.4–47.6% in Group 3. There was no significant difference between sex and the three groups ($p = 0.638$). The mean age of the children participating in the study was 7 ± 0.86 years.

The value of the intra-observer agreement of FLACC scale scores, expressed as Cohen's Kappa, was 0.840 [17]. According to McHugh, there was an almost perfect agreement between assessments with regards to the FLACC scale score.

The mean $MCDAS_f$ scores for all groups are given in Table 1. When the groups were compared, $MCDAS_f$ scores in Group 3 were significantly lower than in Groups 1 and 2 ($p = 0.045$).

Physiological data obtained at different timepoints of pulpotomy treatment are given in Table 2. Accordingly,

Table 1 Comparison of psychometric ($MCDAS_f$) results of children who underwent pulpotomy using TSD (Group 1), TSD-Video modeling (Group 2), and TSD-Mobile phone application (Group 3) behavioral guidance techniques

	Mean ± SD	M (Min-Max)	*P*
Group 1	19.38 ± 4.86	21 (10–26)	**0.041**[1*]
Group 2	21.57 ± 5.75	21 (13–31)	
Group 3	17.29 ± 5.18	17 (10–32)	

*There was a significant difference between groups with the [1]Kruskal-Wallis Test (significance set at *P*-values < 0.05); SD: Standard Deviation; M: Median; Min: Minimum; Max: Maximum; $MCDAS_f$: Modified Child Dental Anxiety Scale Faces Version; TSD: Tell-Show-Do behavioral guidance technique; Group 1: The group that received dental treatment using only the TSD behavioral guidance technique; Group 2: The group that received dental treatment using TSD and Video Modelling behavioral guidance techniques; Group 3: The group that received dental treatment using TSD and Mobil Application behavioral guidance technique; [1]Kruskal-Wallis Test

Table 2 Physiological outcomes (systolic blood pressure, diastolic blood pressure, heart rate, and haemoglobin oxygen saturation) obtained at different periods during pulpotomy treatment of children who were using TSD (Group 1), TSD-Video modeling (Group 2), and TSD-Mobile phone application (Group 3) behavioral guidance techniques

		T_0		T_1		T_2		T_3		
		Mean ± SD	**M (Min-Max)**	**Ort ± SD**	**M (Min-Max)**	**Ort ± SD**	**M (Min-Max)**	**Ort ± SD**	**M (Min-Max)**	***P***
SBP (cmHg)	**Group 1**	106.95 ± 10.01	111(92–123)	104.62 ± 9.14	106(84–118)	103.29 ± 8.71	101(90–121)	103.48 ± 8.81	105(81–124)	0.839[1]
	Group 2	96.29 ± 8.38	95(84–114)	97.71 ± 7.77	97(85–115)	98.71 ± 8.32	95(83–117)	95.81 ± 8.68	95(85–115)	0.238[2]
	Group 3	100.76 ± 8.72	105(85–114)	97.90 ± 8.37	99(81–111)	98.86 ± 10.10	97(85–121)	95.70 ± 7.66	97(80–107)	0.050[1]
DBP (cmHg)	**Group 1**	65.81 ± 7.02	67(53–82)	68.14 ± 9.56	61(44–87)	65.14 ± 7.50	67(51–77)	62.81 ± 15.28	61(40–102)	0.207[2]
	Group 2	64.10 ± 6.80	63(50–74)	62.29 ± 10.92	62(40–85)	63.14 ± 7.40	64(47–73)	63.77 ± 7.37	65(50–75)	0.757[2]
	Group 3	65.52 ± 11.80	63(42–88)	61.95 ± 9.35	61(44–87)	61.90 ± 9.24	61(47–77)	60.48 ± 8.87	60(40–73)	0.189[2]
HR (BPM)	**Group 1**	96.10 ± 8.84	94(86–119)	96.38 ± 7.82	95(85–110)	95.43 ± 8.14	95(84–110)	95.14 ± 8.12	96(78–113)	0.467[1]
	Group 2	99.95 ± 13.56	102(69–127)	100.62 ± 13.20	105(69–128)	100.62 ± 13.20	105(69–128)	99.10 ± 16.02	98(73–141)	0.915[1]
	Group 3	94.76 ± 12.34	94(73–117)	94.90 ± 14.65	93(69–120)	94.24 ± 10.40	93(69–120)	93.67 ± 8.87	95(74–107)	0.915[2]
SPO_2 (%)	**Group 1**	95.33 ± 3.67	96(85–99)	94.62 ± 4.28	96(81–99)	95.81 ± 3.31	96(86–100)	96.10 ± 2.80	96(87–100)	0.050[1]
	Group 2	97.24 ± 2.77	98(90–100)	97.29 ± 3.00	98(90–100)	97.29 ± 2.41	98(92–100)	97.00 ± 2.81	98(90–100)	0.379[1]
	Group 3	95.19 ± 3.06	96(86–99)	95.52 ± 2.65	96(88–99)	94.14 ± 4.48	96(84–99)	95.05 ± 3.02	96(87–99)	0.680[2]

*: There was a significant difference between groups with the Friedman Test (significance set at *P*-values < 0.05); SD: Standard Deviation; M: Median; Min: Minimum, Max: Maximum; cmHg: Centimeter of Mercury, BPM: Beats Per Minute, %: Percentage; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate; $12O_2$: Haemoglobin Oxygen Saturation; TSD: Tell-Show-Do behavioral guidance technique; Group 1: The group that received dental treatment using only the TSD behavioral guidance technique; Group 2: The group that received dental treatment using TSD and Video Modelling behavioral guidance techniques; Group 3: The group that received dental treatment using TSD and Mobil Application behavioral guidance technique; T_0: Measurement before treatment; T_1: Measurement after local anesthesia; T_2: Measurement after coronal pulpotomy; T_3: Measurement after treatment; [1]Friedman Test; [2] Repeated Measures ANOVA

Table 3 Comparison of physiological findings in different times of children treated with 3 different behavioral guidance techniques (TSD (Group 1), TSD-Video modeling (Group 2), and TSD-Mobile phone application (Group 3))

		Group 1		Group 2		Group 3		
		Mean ± SD	M (Min-Max)	Mean ± SD	M (Min-Max)	Mean ± SD	M (Min-Max)	*P*
SBP (cmHg)	SBT_1-SBT_0	-2.33 ± 6.99	-2[(-14)-12]	1.42 ± 6.75	2[(-10)-12]	-2.85 ± 7.28	-2[(-18)-11]	0.104[1]
	SBT_2-SBT_0	-3.66 ± 7.62	-3,66 ± 7,62	2.42 ± 9.05	1[(-15)-18]	-1.90 ± 9.32	-1[(-20)-14]	0.073[2]
	SBT_3-SBT_0	-3.47 ± 8.07	-4[(-17)-10]	-0.47 ± 5.05	0[(-14)-13]	-5.0 ± 5.96	-5[(-14)-7]	**0.040**[1*]
DBP (cmHg)	DBT_1-DBT_0	-0.33 ± 4.60	0[(-9)-6]	0.42 ± 8.16	0[(-14)-20]	-3.37 ± 11.94	-5[(-23)-16]	0.086[1]
	DBT_2-DBT_0	-0.66 ± 5.71	-1[(-10)-7]	-0.95 ± 7.94	1[(-15)-10]	-3.61 ± 11.41	-5[(-23)-16]	0.574[2]
	DBT_3-DBT_0	-3.00 ± 13.04	-2[(-27)-35]	-0.42 ± 5.14	0[(-10)-13]	-5.04 ± 10.27	-10[(-2)-21]	**0.027**[1*]
HR (BPM)	NT_1-NT_0	0.28 ± 5.60	1[(-10)-12]	0.66 ± 5.13	0[(-8)-13]	0.14 ± 8.81	-2[(-18)-28]	0.814[1]
	NT_2-NT_0	-0.66 ± 6.65	-2[(-12)-13]	-0.52 ± 10.26	-1[(-24)-19]	-0.52 ± 7.28	2[(-16)-14]	0.998[2]
	NT_3-NT_0	-0.95 ± 8.61	-1[-18)-14]	-0.85 ± 10.57	0[(-29)-14]	-1.09 ± 8.07	0[(-20)-14]	0.996[2]
SPO_2 (%)	ST_1-ST_0	-0.71 ± 1.84	-1[(-4)-3]	-0.04 ± 3.15	0[(-8)-10]	0.33 ± 2.22	0[(-3)-5]	0.339[1]
	ST_2-ST_0	0.47 ± 4.36	0[(-9)-12]	0.04 ± 3.05	0[(-5)-9]	-1.04 ± 4.46	0[(-13)-7]	0.546[1]
	ST_3-ST_0	0.76 ± 4.62	0[(-9)-14]	0.23 ± 2.99	0[(-7)-9]	-0.14 ± 4.40	0[(-9)-11]	0.522[1]

*:There was a significant difference between groups with the Kruskal Wallis Test (significance set at *P*-values < 0.05); SD: Standard Deviation; M: Median; Min: Minimum, Max: Maximum; cmHg: Centimeter of Mercury, BPM: Beats Per Minute, %: Percentage; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate; SPO_2: Haemoglobin Oxygen Saturation; TSD: Tell-Show-Do behavioral guidance technique; Group 1: The group that received dental treatment using only the TSD behavioral guidance technique; Group 2: The group that received dental treatment using TSD and Video Modelling behavioral guidance techniques; Group 3: The group that received dental treatment using TSD and Mobil Application behavioral guidance technique;; SBT_1-SBT_0: Difference between systolic blood pressure values measured after local anesthesia and before dental treatment procedure; SBT_2-SBT_0: Difference between systolic pressure values measured after coronal pulpotomy and before dental treatment procedure; SBT_3-SBT_0: Difference between systolic blood pressure values measured at the end of dental treatment procedure and before dental treatment procedure; DBT_1-DBT_0: Difference between diastolic blood pressure values measured after local anesthesia and before dental treatment procedure; DBT_2-SDT_0: Difference between diastolic pressure values measured after coronal pulpotomy and before dental treatment procedure; DBT_3-DBT_0: Difference between diastolic blood pressure values measured at the end of dental treatment procedure and before dental treatment procedure; NT_1-NT_0: Difference between heart rate values measured after local anesthesia and before dental treatment procedure; NT_2-NT_0: Difference between heart rate values measured after coronal pulpotomy and before dental treatment procedure; NT_3-NT_0: Difference between heart rate values measured at the end of dental treatment procedure and before dental treatment procedure;; ST_1-ST_0: Difference between Haemoglobin Oxygen Saturation values measured after local anesthesia and before dental treatment procedure; ST_2-ST_0: Difference between haemoglobin oxygen saturation values measured after coronal pulpotomy and before dental treatment procedure; NT_3-NT_0: Difference between haemoglobin oxygen saturation values measured at the end of dental treatment procedure and before dental treatment procedure; [1]Kruskal Wallis Test; [2]Two Way Anova Test

Table 4 Results of children's pain perception who underwent pulpotomy of TSD, TSD-Video modeling, and TSD-Mobile phone application groups with Wong-Baker faces pain rating scale

	Mean ± SD	M (Min-Max)	*P*
Group 1	1.90 ± 1.17	2(0–4)	**0.013**[1*]
Group 2	3.14 ± 2.24	2(0–10)	
Group 3	1.52 ± 1.66	2(0–6)	

*: There was a significant difference between groups with the Kruskal Wallis Test (significance set at *P*-values < 0.05); SD: Standard Deviation; M: Median; Min: Minimum, Max: Maximum; TSD: Tell-Show-Do behavioral guidance technique; Group 1: The group that received dental treatment using only the TSD behavioral guidance technique; Group 2: The group that received dental treatment using TSD and Video Modelling behavioral guidance techniques; Group 3: The group that received dental treatment using TSD and Mobil Application behavioral guidance technique; [1]Kruskal Wallis Test

Table 5 Comparison of pain perception with face, legs, activity, crying, consolability (FLACC) in groups that received behavioral guidance techniques of TSD (Group 1), TSD-Video modeling (Group 2) and TSD-Mobile phone application (Group 3)

	Mean ± SD	M (Min-Max)	*P*
Group 1	0.86 ± 1.38	0 (0–5)	0.089[1]
Group 2	1.00 ± 1.48	0 (0–4)	
Group 3	0.95 ± 1.64	0 (0–4)	

SD: Standard Deviation; M: Median; Min: Minimum, Max: Maximum; FLACC: Face, Legs, Activity, Crying, Consolability Behavioral Pain Assessment Tool; TSD: Tell-Show-Do behavioral guidance technique; Group 1: The group that received dental treatment using only the TSD behavioral guidance technique; Group 2: The group that received dental treatment using TSD and Video Modelling behavioral guidance techniques; Group 3: The group that received dental treatment using TSD and Mobil Application behavioral guidance technique; [1]Kruskal Wallis Test

no statistically significant difference was seen in terms of physiological data values between the timepoints ($p = 0.050$). Comparison of the changes in physiological findings measured at different timepoints in children who underwent pulpotomy treatment are given in Table 3. Accordingly, when the differences between the SBP and DBP values measured at the end of treatment (T3) and at the beginning of treatment (T0) were compared, SBP ($p = 0.040$) and DBP ($p = 0.027$) values decreased significantly more in Group 3 at T3.

A comparison of data regarding the evaluation of pain perception with WBFPRS in children who underwent pulpotomy is given in Table 4. The WBFPRS scores of patients in Group 3 were significantly lower compared to the other groups ($p = 0.013$). Data regarding the comparison of pain perception via FLACC scale are presented in Table 5 with no significant difference observed between the groups ($p = 0.089$).

Discussion

Dental anxiety is a common issue that can affect children's oral health [2, 18]. Early identification and management are crucial for successful treatment [12]. The

TSD technique, widely used and accepted by parents, has been a standard approach in dentistry for decades [12]. Another method, modeling, based on social learning theory, involves observing behavior either live or through video [19]. Studies show that techniques like video modeling and mobile apps effectively reduce children's dental anxiety [20, 21]. Given the widespread use of phones and screens among children [14], video modeling and mobile app digital approaches were considered suitable for this study.

In dental anxiety studies, selecting the appropriate age group is crucial for reliable results. Children aged 6 and above can express emotions more clearly and respond more accurately to anxiety scales [22, 23]. Therefore, this study included cooperative children aged 6–8 to better assess the impact of behavior guidance techniques.

Studies have shown that combining maternal presence with mobile dental games can significantly reduce dental anxiety in children [24]. Likewise, techniques such as tell–show–play-doh and smartphone dentist games have proven more effective than traditional TSD, resulting in better cooperation and lower anxiety scores [25]. Del Carmen et al. reported that children found a dental anxiety mobile app enjoyable and suggested it would be helpful in waiting rooms [26]. The Hello Dentist! app also significantly reduced anxiety in children aged 6–10 compared to a control group [27]. Similarly, Campbell et al. showed that children primed with images related to general anesthesia had lower anxiety and improved coping compared to those who received only verbal preparation [28]. Based on such evidence, TSD, video modeling, and mobile application-based guidance techniques were selected for this study.

Since dental anxiety cannot be fully assessed with a single method, multiple approaches are recommended [29]. Therefore, this study used both psychometric ($MCDAS_f$) and physiological (BP, HR, SPO_2) measures. $MCDAS_f$ is widely used in the literature due to its simplicity, speed, and clarity [30–32]. In this study, the $MCDAS_f$ scores of the children in the group where TSD and mobile phone application (Roogies) were used together were lower than those in the groups where TSD and TSD with video modeling was used. This difference might be because children are now growing up more involved with technology and are more familiar with mobile phone applications. Also, children might feel more comfortable during their own treatments after seeing the steps of the treatment being implemented on a more friendly looking dental model.

Physiological reactions that occur in the child due to anxiety can lead to fluctuations in SBP, DBP, HR, and SPO_2 levels. Research has shown that audiovisual distraction techniques can significantly reduce SBP and increase SPO_2 levels more effectively than TSD alone [33]. Radhakrishna et al. and others found that methods like tell–show–play-doh, smartphone games and applications (Little Lovely Dentist, Tell-Play-Do etc.), and audiovisual tools led to lower HR levels compared to traditional TSD, highlighting their effectiveness in reducing pediatric dental anxiety [25, 34–36]. In this study, although no significant difference was found between SPO_2 and HR levels, SBP and DBP measured at the end of the treatment were significantly lower compared with the beginning in the group where TSD and mobile phone application (Roogies) were used together. This difference might be due to the mobile phone application's use of multiple behavior guidance methods, such as systematic desensitization, modeling, distraction, and memory restructuring, and it being a more entertaining behavior guidance approach compared with other methods.

Pain has long been considered primarily a subjective and internal experience [37, 38]; therefore, self-reported pain is the gold standard for pain assessment [39, 40]. However, self-report measures should not be treated as an unquestioned gold standard and should be supplemented by alternative approaches [41]. For this purpose, in the current study, the FLACC scale (an observational pain scale) was used to assess pain during pulpotomy in children and WBFPRS (a self-assessment scale) was used to assess pain after the procedure.

A study by Maru et al. found that preschool children who regularly played interactive computer games before pulp therapy experienced significantly reduced dental anxiety and pain, as measured by the WBFPRS [42]. However, another study reported no significant impact of a smartphone game on dental pain [43]. Verma et al. showed that using a mobile phone application alongside maternal presence significantly lowered FLACC scores in children aged 4–6 years [24]. Similarly, Karkoutly et al. and others observed lower pain scores in groups using mobile applications compared to traditional TSD methods [39, 44]. In the current study, pain assessed by WBFPRS was also lower in the TSD with mobile app group, although FLACC scores did not differ significantly. This discrepancy may stem from pain's subjective nature and factors such as the child's communication skills, clinical setting, and the evaluator. Methodological differences in previous studies—like population size, study duration, and behavior classifications—could also explain the variations in FLACC outcomes.

Limitations of this study include that the sample group consisted of patients coming to only one university hospital, patients coming from similar socioeconomic backgrounds, and that the study was conducted over a limited time rather than a longer period. Additionally, the long-term effects of mobile phone applications on dental anxiety are not fully known. However, the strengths of the study include the combined use of psychometric and physiological methods in the evaluation of anxiety levels

of children who underwent an interventional procedure such as pulpotomy, the fact that physiological evaluation was evaluated at four different time points during the treatment, and the combined application of both objective and subjective pain assessment scales for pain perception.

Conclusion

The behavior guidance technique using the mobile phone application together with TSD is effective in reducing children's dental anxiety and pain perception. Therefore, we show that this method makes a significant contribution to easier management of children's dental anxiety levels with more comfortable and positive results from their treatments. By incorporating current technological advancements into behavioral guidance techniques, pediatric dentists can help children aged 6–8 feel more comfortable during treatment, thereby reducing anxiety levels in dental practices. To achieve this, pediatric dentists can use mobile phone applications before treatment to ease dental anxiety or introduce interactive technological applications in patient waiting areas to explain the steps of dental procedures.

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Author contributions
M.Y.: Design, Data Collection, Literature Review, Writing; S.A.: Design, Analysis, Literature Review; D.N.G.: Design, Literature Review, Analysis; All authors read, review, editing, and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Human ethics and consent to participate
Ethical approval was obtained from the Non-Invasive Clinical Research Ethics Committee of Recep Tayyip Erdoğan University (Decision no: 2023/244). The study was conducted in accordance with the Declaration of Helsinki of 1975, as revised in 2013. Since the participants were under 16 years of age, detailed information about the research was given to the children's parents or legal guardians before the study, and an informed consent form was obtained.

Consent for publication
The informed consent forms obtained from the patients included explanatory text for personal or clinical details and identifying images to be published in this study, and written informed consent was obtained for their use.

Competing interests
The authors declare no competing interests.

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