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# Effectiveness of a dental simulation game on reducing pain and anxiety during primary molars pulpotomy compared with tell-show-do technique in pediatric patients: a randomized clinical trial

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## Abstract

**Background** Dental simulation games are virtual educational games that help children get familiar with different dental procedures. This study aimed to evaluate the pretreatment exposure to the “Baby Panda Dental Care” game in reducing pain and anxiety in comparison with the tell-show-do (TSD) technique during primary molars pulpotomy for patients aged 6–10 years.

**Materials and methods** It was a triple-blinded, two-arm, parallel-group, randomized, active-controlled trial. It was done on 60 patients, who were randomly divided into two groups: the control group, TSD technique ( $n = 30$ ), and the experimental group, “Baby Panda Dental” Care ( $n = 30$ ). For the TSD technique, children were provided with a verbal explanation followed by a demonstration of the dental treatment in a non-threatening way. The “do” phase is then initiated during performing treatment. For the “Baby Panda dental care” game, children were asked to play for 5 min before treatment, selecting root canal therapy procedures. Pulse rate and RMS pictorial scale were recorded at four time points: (1) at the baseline ( $t_0$ ). (2) After conditioning the child ( $t_1$ ). (3) During treatment ( $t_2$ ). (4) After finishing the treatment ( $t_3$ ). Face, Legs, Activity, Cry, Consolability (FLACC) behavioral pain scale was recorded during treatment ( $t_2$ ).

**Results** The pulse rate is higher in the control group at  $t_1$  ( $p = 0.012$ ) and  $t_2$  ( $p = 0.015$ ). There was a statistically significant difference in the mean RMS pictorial scale score at  $t_1$  ( $p < 0.001$ ),  $t_2$  ( $p = 0.006$ ), and  $t_3$  ( $p < 0.001$ ), a statistically significant difference was noticed in FLACC behavioral pain assessment between the two groups ( $p = 0.033$ ).

**Conclusions** The mobile dental game showed better results than the TSD technique, but neither technique did not reduce anxiety and pain effectively during dental treatment.

**Trial registration** The trial was registered at the ISRCTN registry (ISRCTN30470866) on 19/04/2024.

**Keywords** Pain, Anxiety, Mobile game, Behavior guidance

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## Background

Dental anxiety is considered a vicious cycle, where avoidance of attending the clinic and lack of cooperation during treatment are common consequences. Thus, dental anxiety leads to poor oral health and painful dental experiences, which escalate over time. In addition, uncontrolled behavior during dental sessions leads to subsequent dental failure [1]. Otherwise, dental pain and anxiety are two sides of the same coin since painful dental experiences lead to dental anxiety, and dental anxiety exaggerates dental pain [2]. According to Grisolia et al. [3], the global prevalence of dental anxiety is 25.8%.

Primary molars pulpotomy is the most common dental procedure among pediatric patients, which consists of several distressing steps. Receiving multiple injections, the sight of sharp metallic instruments, unfamiliar smells, and applying bulky apparatus such as rubber dam can induce anxiety. The sound of the high-pitched drill and the suctioning sound can even trigger anxiety in the waiting room before dental treatment [4, 5]. Therefore, according to the American Academy of Pediatric Dentistry (AAPD), the pediatric dentist must master various behavior guidance techniques to meet the intellectual, physical, and emotional needs of the pediatric patient. Tell-show-do (TSD) is a basic guidance technique that includes a verbal explanation of the dental procedure, followed by a demonstration of different sensory aspects of the treatment, and then completion of the treatment in correspondence with explanation and demonstration. TSD technique aims to address the fear evoked by the unknown and is considered the gold standard of the non-pharmacological behavior guidance technique [6].

Dental simulation games are virtual educational games that help children get familiar with different dental procedures and tools and increase acceptance towards treatment [7]. Baby Panda Dental Care is a mobile app that lets children enjoy the experience of being a dentist and perform different dental procedures such as extraction, scaling, drilling, filling, aligning brackets, and much more. This study aimed to evaluate the pre-treatment exposure to the Baby Panda Dental Care game in reducing pain and anxiety in comparison with the TSD technique during primary molars pulpotomy in pediatric patients aged 6–10 years.

## Materials and methods

### Study setting and ethical considerations

This study was designed as a triple-blinded, two-arm, parallel-group randomized active-controlled trial and conducted at the Department of Pediatric Dentistry, Faculty of Dentistry, Damascus University, Syria, between February 2024 and March 2024. The study was performed in full accordance with the CONSORT checklist [8] and the World Medical Association Declaration of Helsinki on

experimentation involving human subjects, as revised in 2013 [9]. The legal guardians provided written informed consent before the participants' inclusion in the study, and the participants' anonymity was preserved. The dental procedure was explained in detail. No child was excluded based on their gender, race, and socioeconomic status, and excluded children still received complete treatment. Ethical approval was obtained from the Ethical Committee of Damascus University (N1325/2024), and the trial was approved and registered at the ISRCTN registry (ISRCTN30470866) on 19/04/2024.

### Sample size

Sample size calculation was done using G\*Power version 3.1.9.4 (G\*Power 3.1.9, Heinrich Heine Universität Düsseldorf, Düsseldorf, Germany). A sample size of 60 patients achieved a small effect size  $f$  (0.36), 80% Power ( $1 - \beta$  err prob) [10], and a significance level of 0.05 [11]. The effect size was estimated based on a pilot study on 10 subjects [12].

### Participant recruitment and grouping

67 patients who were referred to the Department of Pediatric Dentistry were screened according to the following recruitment criteria:

#### Inclusion criteria

1. Children aged 6–10 years.
2. Children are categorized as definitely positive or positive ratings, according to Frankel's behavior rating scale.
3. Children requiring pulpotomy for a primary molar.
4. Children who are familiar with smartphone games.

#### Exclusion criteria

1. Children with oral, mental, and/or systemic conditions.
2. Children are categorized as definitely negative or negative ratings, according to Frankel's behavior rating scale.
3. Children with previous exposure to local anesthesia.

Based on inclusion criteria, 60 patients were recruited and randomly divided into two groups:

Group 1: control group, TSD technique ( $n = 30$ ).

Group 2: experimental group, Baby Panda Dental Care game (Baby Panda Dental Care, BabyBus Co., Fuzhou, China) ( $n = 30$ ).

### Randomization and blinding

Participants were randomly assigned into two groups in a ratio of 1:1 according to the randomization online software: <https://www.randomizer.org>. The number of sets was 2, with 30 patients per set, and the number range was from 1 to 60. It was a triple-blinded trial where the pediatric dentist and the outcome assessors were masked to the group allocation. In addition, participants were not aware of the grouping and the aim of the study.

### Primary outcome measures

The following primary outcome measures were considered:

1. Pulse rate.

The pulse rate was measured using a finger pulse oximeter (Alpha, Prolix GmbH, Düsseldorf, Germany) at four time points: (1) at the baseline in the waiting room ( $t_0$ ). (2) After conditioning the child before initiating the treatment ( $t_1$ ). (3) Mean pulse rate during treatment ( $t_2$ ). The pulse rate was recorded after injection and immediately after amputation of the pulp. (4) After finishing the treatment ( $t_3$ ) [13]. Pulse rate is an objective measurement of dental anxiety [14].

2. RMS Pictorial Scale.

RMS pictorial scale was recorded at four time points: (1) at the baseline in the waiting room ( $t_0$ ). (2) After

conditioning the child before initiating the treatment ( $t_1$ ). (3) Immediately after amputating of the pulp ( $t_2$ ). (4) After finishing the treatment ( $t_3$ ). RMS pictorial scale is a subjective measurement of dental anxiety [15].

3. Face, Legs, Activity, Cry, Consolability (FLACC) behavioral pain scale.

FLACC behavioral pain scale was recorded during treatment ( $t_2$ ). FLACC behavioral pain assessment scale is a non-verbal pain scale (Table 1) [16].

### Procedure

The baseline anxiety level in the waiting room was assessed by recording the pulse rate and using the RMS pictorial scale. Children were presented with two sets of five faces based on their gender and were asked to select the most suitable face that matched their current level of anxiety. For the TSD technique group, children were provided with a verbal explanation followed by a demonstration of the dental treatment in a friendly, non-threatening way. The “do” phase was performed after initiating the dental treatment without deviating from the verbal explanation and demonstration. For the Baby Panda dental care game, Arabic was installed, and children were asked to play for 5 min. It includes five dental procedures: restoring chipped teeth, filling cavities, performing root canal therapy, extracting decayed teeth, and performing orthodontic treatment for five little animals: a cat, hippo, mouse, bunny, and monkey. The different stages of the selected procedure are presented in Fig. 1. Children were presented with two animals in the waiting room, and then a root canal therapy virtual procedure was selected. Children were instructed to remove the dental calculus using an ultrasonic scaler, clean teeth using a water gun, and then suction dirty water. Children were instructed to perform an intraoral radiograph of the decayed tooth, drill the decayed cavity, anesthetize the nerve cells using an electric gun, fill the tooth, polish the teeth to fit well with the dental crown, and then put the dental crown. Pulse rate and RMS pictorial scale were recorded after conditioning the child when sitting on a dental chair before initiating the dental treatment. The conventional pulpotomy method was performed according to AAPD guidelines. During treatment, the FLACC behavioral pain scale and pulse rate were recorded by two blinded investigators. After finishing the cavity preparation and amputation of the pulp RMS pictorial scale was recorded. It was recorded during controlling hemorrhage using a wet cotton pellet. After removing the rubber dam and cementing the stainless steel crown, the pulse rate and RMS pictorial scale were recorded [13, 15]. Cohen’s Kappa coefficient values of intra-examiner and inter-examiner reliability were  $>0.8$  [17].

**Table 1** FLACC behavioral pain scale

Categories	0	1	2
<b>Face</b>	No particular expression or smile	Occasional grimace or frown; withdrawn, disinterested	Frequent to constant frown, clenched jaw, quivering chin
<b>Legs</b>	Normal position or relaxed	Uneasy, restless, tense	Kicking or legs drawn up
<b>Activity</b>	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Crying steadily, screams or sobs; frequent complaint
<b>Cry</b>	No cry (awake or asleep)	Moans or whimpers, occasional complaint	Arched, rigid, or jerking
<b>Consolability</b>	Content, relaxed	Reassured by occasional touching, hugging or being talked to; distractible	Difficult to console or comfort

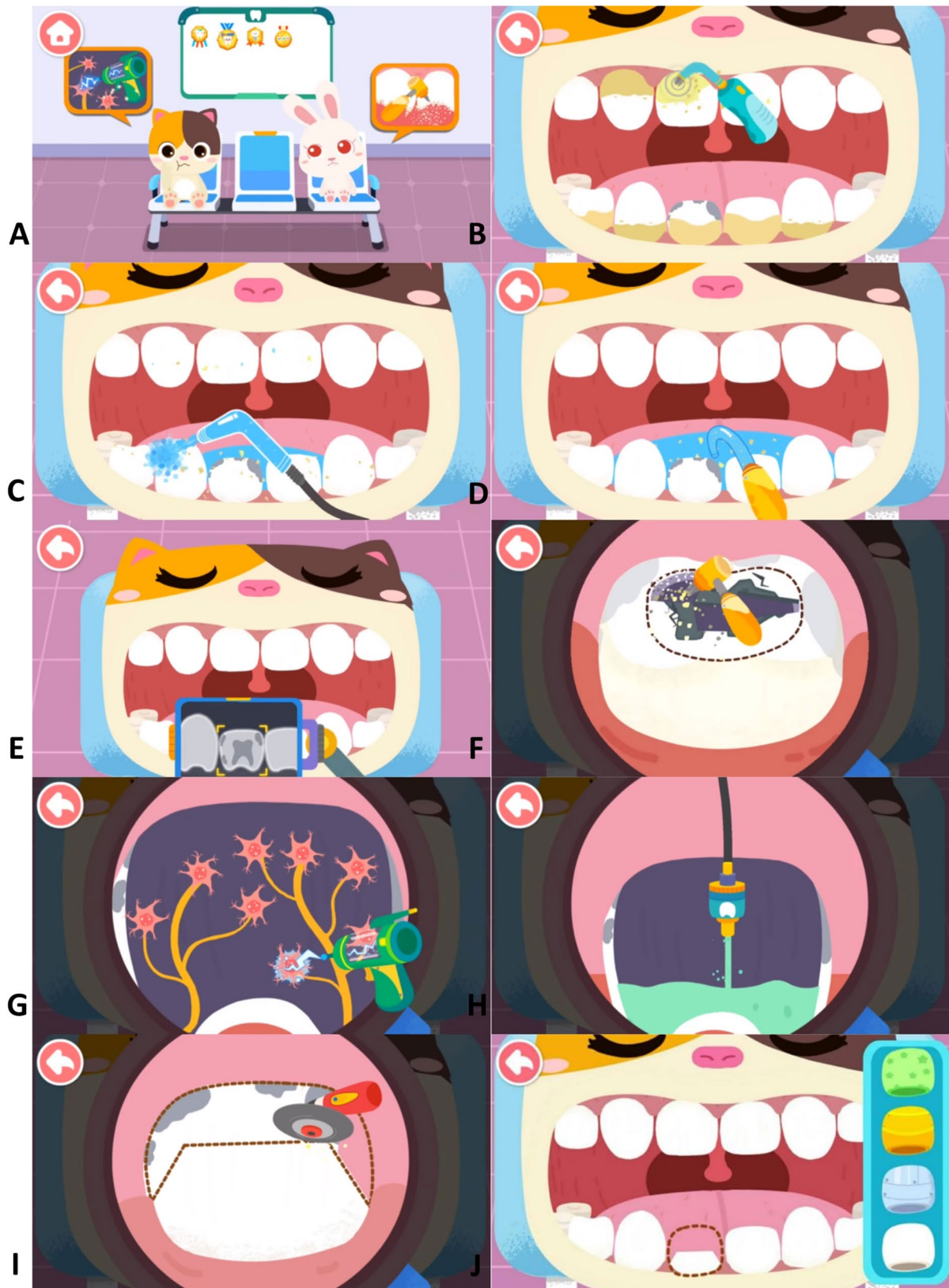
Each category is scored on the 0–2 scale, which results in a total score of 0–10.

0: Relaxed and comfortable

1–3: Mild discomfort

4–6: Moderate pain

7–10: Sever discomfort or pain or both



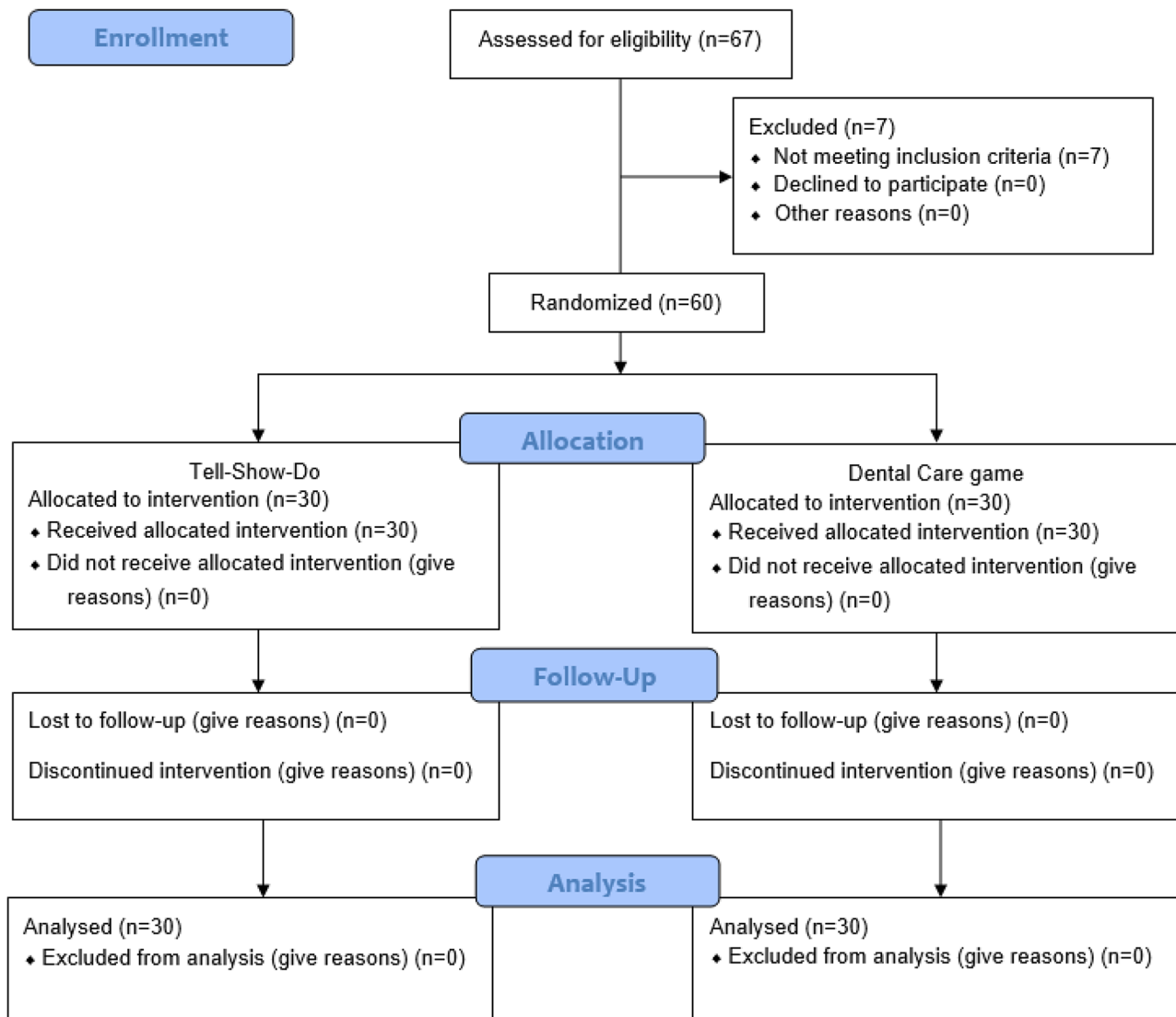
**Fig. 1** The different stages of the virtual root canal therapy procedure. (A) The little animal with root canal therapy was selected. (B) The removal of the dental calculus using an ultrasonic scaler. (C) Rinsing teeth using a water gun (D) suctioning dirty water. (E) Performing a dental X-ray. (F) Drilling the decayed cavity. (G) Anesthetizing the nerve cells using an electric gun. (H) Filling the tooth. (I) Polishing the teeth to fit well with the dental crown. (J) Putting the dental crown [30]

### Statistical analysis

Statistical analysis was performed using IBM SPSS software version 24 (IBM SPSS Statistics® version 24, IBM Corp., New York, USA). Descriptive statistics were presented as mean and standard deviation (SD). The normality of data was checked by performing the Kolmogorov–Smirnov test. Fisher’s exact test and Mann-Whitney U test were performed to compare baseline demographic and clinical characteristics between groups. Mann-Whitney U test was used for comparing pulse rate, RMS pictorial scale, and FLACC behavioral pain assessment scale scores between control and experimental groups. The statistical significance level was adjusted at 0.5 ( $p < 0.5$ ).

### Results

The CONSORT flow diagram is presented in Fig. 2. A total of 60 patients completed the full treatment. Table 2 shows the baseline demographic and clinical characteristics of participants. Of the participants, 71.67% were male, and 28.33% were female. The mean age was 7.47 (SD 1.08; range 6–10 years). Most participants (93.33%) had a previous dental experience, and among those who had a previous dental experience, 42.86% were definitely positive, and 57.14% were positive, according to Frankel’s behavior rating scale. 48.33% of dental procedures were located in the maxilla, and 51.67% were located in the mandible. No statistically significant difference was found between the baseline characteristics of the study participants with  $p = 1.000$ ,  $p = 0.429$ ,  $p = 0.612$ ,  $p = 0.787$ , and  $p = 1.000$ , respectively, suggesting that the baseline demographic clinical characteristics were homogenous.



**Fig. 2** CONSORT flow diagram

**Table 2** Baseline demographic and clinical characteristics

Variables	Total	Control	Experimental	P-value
Sex	17 (28.33)	9 (30.00)	8 (26.67)	1.000
Female n (%)	43 (71.67)	21 (70.00)	22 (73.33)	
Male n (%)				
Age (years)	7.47 ± 1.08	7.77 ± 1.07	7.17 ± 1.01	0.429
Mean ± SD	6–10	6–9	6–10	
Min-max				
Previous dental experience	56 (93.33)	27 (90)	29 (96.67)	0.612
Yes n (%)	4 (6.67)	3 (10)	1 (3.33)	
No n (%)				
Frankel's behavior rating scale of those who had previous dental experience (n = 56)	24 (42.86)	11 (39.29)	13 (46.43)	0.787
Definitely positive n (%)	32 (57.14)	17 (60.71)	15 (53.57)	
Positive n (%)				
Location of procedure	29 (48.33)	14 (46.67)	15 (50.00)	1.000
Maxilla n (%)	31 (51.67)	16 (53.33)	15 (50.00)	
Mandible n (%)				

**Table 3** Results of the Mann-Whitney U test for comparison of the anxiety and pain level of the participants

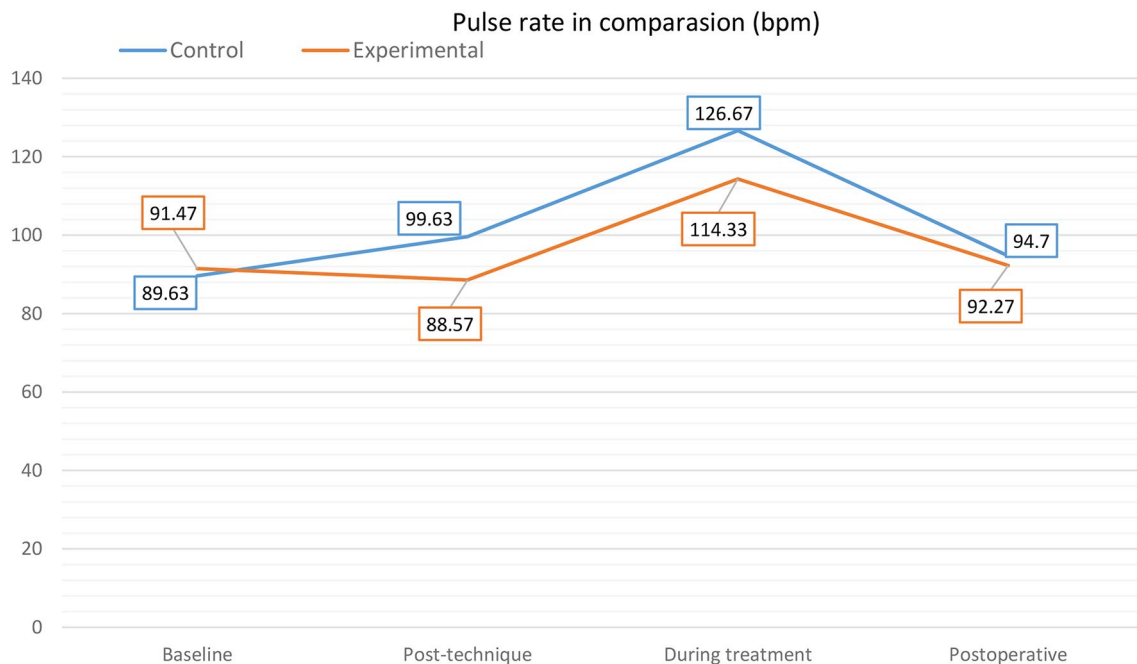
Variable	N	Control Mean ± SD	Experimental Mean ± SD	Mann-Whitney U	P-value
t <sub>0</sub> pulse rate	20	89.63 ± 12.32	91.47 ± 9.50	450.50	0.994
t <sub>1</sub> pulse rate	20	99.63 ± 13.50	88.57 ± 13.36	281.00	0.012*
t <sub>2</sub> pulse rate	20	126.67 ± 20.61	114.33 ± 15.12	285.00	0.015*
t <sub>3</sub> pulse rate	20	94.70 ± 12.11	92.27 ± 7.65	354.50	0.158
Pule rate difference (t <sub>1</sub> – t <sub>0</sub> )	20	10 ± 17.65	-2.9 ± 17.10	281.50	0.013*
Pule rate difference (t <sub>2</sub> – t <sub>0</sub> )	20	37.33 ± 17.82	22.87 ± 15.60	221.00	0.001*
Pule rate difference (t <sub>3</sub> – t <sub>0</sub> )	20	5.07 ± 13.12	0.80 ± 10.12	345.50	0.122
t <sub>0</sub> RMS pictorial scale	20	1.17 ± 0.38	1.23 ± 0.43	480.00	0.522
t <sub>1</sub> RMS pictorial scale	20	1.70 ± 0.60	1.07 ± 0.25	193.00	< 0.001*
t <sub>2</sub> RMS pictorial scale	20	3.30 ± 1.20	2.53 ± 1.00	271.50	0.006*
t <sub>3</sub> RMS pictorial scale	20	2.00 ± 0.74	1.33 ± 0.66	230.00	< 0.001*
t <sub>2</sub> FLACC behavioral pain scale	20	3.14 ± 1.78	2.17 ± 1.53	308.50	0.033*

\*Significant difference at  $p < 0.05$ 

Table 3 shows the pain and anxiety scores of the study participants at different time points. There was no statistically significant difference in the mean pulse rate between the experimental and the control group at t<sub>0</sub> ( $p=0.994$ ). In addition, there was no statistically significant difference between the control and the experimental group in the mean RMS pictorial scale score at t<sub>0</sub> ( $p=0.522$ ), indicating that the baseline level of anxiety was homogenous among participants. There was a statistically significant difference in the mean pulse rate between the control and the experimental group at t<sub>1</sub> ( $p=0.012$ ) and t<sub>2</sub> ( $p=0.015$ ). Similarly, the mean change in the pulse rate from the baseline to these time points was a statistically significant difference between the experimental and the control group, with  $p=0.013$  and  $p=0.001$ , respectively. In the control group, the mean pulse rate was higher at t<sub>1</sub> ( $99.63 \pm 13.50$ ) compared to t<sub>0</sub> ( $89.63 \pm 12.32$ ). On the contrary, the mean pulse rate was higher at t<sub>0</sub> ( $91.47 \pm 9.50$ ) compared to t<sub>1</sub> ( $88.57 \pm 13.36$ ) in the experimental group. These results indicate that the physiological response to dental anxiety is higher in the control group compared to the experimental group after conditioning the child and performing the dental treatment (Fig. 3). However, the mean pulse rate of both groups at t<sub>2</sub> was higher than the pulse rate at t<sub>0</sub>, indicating that both techniques did not reduce anxiety effectively during dental treatment. There was no statistically significant difference in the mean pulse rate between the experimental and the control group at t<sub>3</sub> ( $p=0.158$ ) and in the mean change in the pulse rate from the baseline to t<sub>3</sub> ( $p=0.122$ ), suggesting that the level of anxiety after finishing the treatment was similar to that at the baseline (Fig. 3). However, there was a statistically significant difference in the mean RMS pictorial scale score between the control and the experimental group at t<sub>1</sub> ( $p < 0.001$ ), t<sub>2</sub> ( $p=0.006$ ), and t<sub>3</sub> ( $p < 0.001$ ), indicating that children's subjective report of anxiety was higher in the control group compared to the experimental group after conditioning the child, during the dental procedure, and after completion the treatment. Regarding pain level during dental treatment, there was a statistically significant difference between the control and the experimental group in FLACC behavioral pain assessment at t<sub>2</sub> ( $p=0.033$ ), indicating that the pain reported was higher in the control group compared to the experimental group.

## Discussion

Dental pain and anxiety are two sides of the same coin, and they often lead to poor oral health due to the avoidance of dental treatment and uncontrolled behavior during various procedures [1, 2]. Primary molar pulpotomy is the most common dental treatment among pediatric patients, and it consists of several irritating steps that can induce pain and anxiety [4, 5]. Dental stimulation



**Fig. 3** The changes of pulse rate during different time points

games help children get familiar with different dental procedures and instruments that address the fear of the unknown [7]. Therefore, this study aimed to evaluate the pretreatment exposure to the Baby Panda Dental Care game in reducing pain and anxiety compared with the TSD technique during primary molars pulpotomy in pediatric patients aged 6–10.

Children belonging to the 6–10 years category group were included in the current study because they are expected to cooperate during dental treatment, accurately express their pain and anxiety according to different scales [18, 19], and follow the instructions while playing virtual games [4]. In addition, primary molar pulpotomies are frequent among this age group [20].

Pulse rate is an objective and physiological measurement of dental anxiety [14], while the RMS pictorial scale is a subjective measurement where children themselves report their current level of anxiety. RMS pictorial scale is a validated anxiety assessment scale, which is quick, simple, and efficient as it is colorful, attractive, and consists of original photographs for males and females [21]. FLACC behavioral pain assessment scale is a non-verbal pain scale that is reliable and accurate [16].

Baby Panda Dental Care Game is a virtual educational game that provides dental care for little animals, and children help them solve their dental problems by applying various procedures and using different tools and instruments. It includes five dental procedures: restoring chipped teeth, filling cavities, performing root canal therapy, extracting decayed teeth, and performing orthodontic treatment for five little animals: a cat, hippo, mouse,

bunny, and monkey. The root canal therapy virtual game was chosen because it is similar to pulpotomy treatment since it requires local anesthesia, caries removal, access cavity preparation, stamping the pulp with appropriate dental materials, and putting a dental crown. TSD technique was selected as the control group because it is the gold standard behavior guidance technique, widely accepted, and most dentists are familiar with it [22].

The results of the current study indicated that the physiological response to dental anxiety and children's subjective reports of anxiety are higher in the control group compared to the experimental group after conditioning the child. In addition, the level of anxiety after applying the TSD technique was higher than the baseline level. The result can be attributed to the fact that mobile games present the dental procedure in an attractive, interactive, and playful manner, and children can imagine themselves in a friendly, joyful environment [11, 15]. According to Derbala et al. [23], 55% of communication is based on visual elements, and 7% is based on words, which makes the TSD technique a less attractive manner for presenting dental procedures. The result is consistent with Meshki et al. [13] findings, which concluded that the TSD technique exaggerates anxiety. A dental simulation game reduces the physiological response to dental anxiety immediately after conditioning the child. According to Tahersoltani et al. [24], the pulse rate is not affected after applying the TSD technique, while the tiny dentist game significantly reduces the pulse rate. However, Radhakrishna et al. [25] suggested that both the TSD technique and the smartphone dental game significantly

reduce dental anxiety. The controversial results can be attributed to the differences in the study designs and age range. Similarly, the results of the current study showed that the physiological response to dental anxiety and children's subjective reports of anxiety are higher in the control group compared to the experimental group during dental treatment. This result is in agreement with Radhakrishna et al. [25] findings, which suggested that mobile App is superior to TSD techniques in reducing anxiety during dental treatment. However, the objective and subjective levels of anxiety of both groups during treatment were higher than the anxiety level at the baseline, indicating that both techniques did not reduce anxiety effectively during dental treatment. The increase in the pulse rate can be attributed to vasoconstrictors added to local anesthetics [26]. The result is consistent with Tahersoltani et al. [24] and Meshki et al. [13] findings. However, the current result is in contrast with Sedky et al. [27], Aziz et al. [28], Abbasi et al. [29], and Elicherla et al. [15], which suggested that the pulse rate during treatment in the mobile dental game group was lower than the baseline. However, these disagreements can be attributed to the differences in dental treatment, clinical settings, and methodologies. The current results suggested that the pain reported was higher in the control group compared to the experimental group, and this can be attributed to the fact that anxious children experience pain more intensely. The result is in contrast with Meshki et al. [13] findings, which suggested that playing mobile games does not affect the pain level. The pulse rate after finishing the treatment was similar to that at the baseline in both groups. However, children's subjective report of anxiety was higher in the control group compared to the experimental group after completion of the treatment. The lack of consistency between objective and subjective expression of postoperative anxiety can be explained by the existence of an unpleasant memory of a painful experience in the TSD technique group.

This study has limitations. First, this study only evaluated the short-term effect of playing the game in the waiting room of the dental clinic. Second, the unequal distribution of gender across the study groups. Third, the application of a rubber dam is one of the steps in the pulpotomy procedure which is not there in the game.

## Conclusions

Based on our findings, the mobile dental game was superior to the TSD technique in controlling subjective and objective anxiety levels and pain during primary molars pulpotomy. However, both the mobile dental game and the TSD technique did not reduce anxiety and pain effectively during dental treatment.

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Not applicable.

## Author contributions

M.K. data curation, performed the statistical analysis, wrote the manuscript. M.N.A. & M.L. performed critical revision of the manuscript. N.B. research concept and design, performed critical revision of the manuscript. All authors have approved the manuscript.

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## Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

Ethical approval was obtained from the ethical committee at Damascus University (N1325/2024). The study was performed in accordance with the Declaration of Helsinki, and written informed consent was obtained from participants' legal guardians.

### Consent for publication

Consent for publication was obtained from participants' legal guardians.

### Competing interests

The authors declare no competing interests.

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