

ORIGINAL RESEARCH

Effectiveness of oral simulation games and "tell-show-do" behavioral management in alleviating dental fear in children: a randomized controlled study

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Abstract

Background: This study aimed to evaluate the efficacy of Oral Simulation Games and the "Tell-Show-Do" (TSD) behavioral management technique in reducing dental fear among children aged 4 to 6 years. **Methods:** Two hundred fifty-five children aged between 4 and 6 years, experiencing initial dental fear and scheduled for a single deep caries tooth treatment under local anesthesia, were randomly assigned to either the "Tell-Show-Do" group or the Oral Simulation Games group, and their physiological stress, fear intensity, pain and anxiety levels, and compliance were compared between the two groups. Physiological stress was assessed through heart rate, respiration, and blood oxygen saturation. Fear intensity was evaluated using the Child Fear Survey Schedule-Dental Subscale (CFSS-DS), while pain and anxiety levels were measured using the Wong-Baker FACES Pain Rating Scale and Venham's Scale, respectively. Compliance was assessed using the Frankl Behavior Rating Scale. Between-group comparisons were conducted using the Wilcoxon signed-rank test. **Results:** Significant improvements were observed in pain reduction, fear alleviation, and enhanced compliance among children utilizing oral simulation games for behavior management. In addition, the oral simulation game group exhibited a lower Q value compared to the TSD (Tell-show-do) group ($p < 0.01$), with no significant differences observed in respiration and blood oxygen saturation. **Conclusions:** Both approaches were found to effectively alleviate children's anxiety. Compared to the TSD method, oral simulation games were more effective in reducing dental fear in children undergoing treatment for deep caries under local anesthesia. **Clinical Trial Registration:** The trial was registered on Chinese Clinical Trial Registry, the identification number is ChiCTR2400089734.

Keywords

Children dental fear; Pain; Oral simulation puzzle game; Tell-show-do

1. Introduction

Children's dental fear is a psychological state closely related to dental diagnosis and treatment, characterized by patients experiencing nervousness, anxiety, and fear both before and during dental procedures. This fear can directly influence behavior during dental treatment, posing a challenge for dentists and potentially impeding successful treatment outcomes [1]. Studies have indicated a prevalence of dental fear in children as high as 30%–40% [2]. Hence, it is imperative to explore methods to alleviate children's dental fear [2–5].

Treatment options for children with dental fear include pharmacotherapy and non-pharmacological approaches [1]. Parents sometimes decline pharmacotherapy due to contraindications associated with certain anesthetics and potential post-

operative side effects [6, 7]. Non-pharmacological methods comprise behavioral management techniques, restraint therapy, and cognitive behavioral therapy, among others, and can be used either independently or in conjunction with pharmacotherapy. Among these strategies, behavior management represents the safest and least invasive technique, often readily accepted by parents [8].

Behavior management methods include techniques such as tell-show-do (TSD), distraction, and oral simulation games. TSD remains the most widely utilized behavior management technique in pediatric dentistry [5] and is routinely employed by all dental team members working with children [9]. This method involves the dentist explaining the upcoming treatment to the child, demonstrating the treatment process, and then executing the treatment as demonstrated. However, the efficacy

of TSD can be limited at times due to children's immature mental development and limited understanding, especially in early childhood [9]. Oral simulation games, a relatively novel approach, can complement or partially replace TSD. Typically, these games inform children about their condition using language tailored to their age, followed by a recreation of the treatment steps in a gaming format. These games incorporate the tools and equipment used in the procedure, allowing children to simulate the dental treatment experience. Among various behavior management strategies reported to reduce children's dental fear during treatment, oral simulation games emerge as a relatively safe and cost-effective method, providing an effective and relaxed experience during dental procedures. Some researchers have noted that utilizing oral simulation games during ultrasound dental cleaning for children aged 4 to 6 can decrease anxiety levels [10]. Additionally, studies have shown that oral simulation games can enhance compliance among preschool children undergoing treatment for dental caries during their initial dental visit [11, 12]. Several studies have evaluated the efficiency of oral simulation games in reducing a child's dental anxiety, suggesting that they may be more effective than traditional TSD methods. However, these studies have primarily focused on treatments with short duration or relatively low levels of pain, such as ultrasound dental cleaning and moderate dental caries [10–12]. For deep caries requiring local anesthesia, research on the effectiveness of oral simulation games in reducing children's dental fear is lacking.

In this study, we conducted a randomized clinical trial (RCT) to compare the effectiveness of two behavioral management techniques, TSD and oral simulation games, in alleviating dental fear during the treatment of deep caries under local anesthesia.

2. Patients and methods

2.1 Study design

The trial was registered on Chinese Clinical Trial Registry, the identification number is ChiCTR2400089734. The study comprised children aged 4–6 years who were visiting the Dental Department of the Fifth Affiliated Hospital of Xinjiang Medical University from December 2022 to November 2023 for their initial visit and required local anesthesia for treatment of a single deep cavity. Their data were collected and assessed.

2.2 Clinical sample size

The sample size in previous research investigating the effectiveness of behavioral management in reducing dental fear typically ranged from 50 to 120 individuals [2, 4, 5]. To ensure the robustness of our current study, we aimed for a sample size of 250 individuals.

The study inclusion criteria were as follows: (1) children undergoing their initial dental visit with no prior experience of dental treatment; (2) children presenting with at least one deep carious lesion in the mandibular deciduous molars requiring local anesthesia for pain control, with radiographically healthy tooth pulp and absence of pathologic root or internal resorption; (3) children scoring above 38 on the Child Fear Survey

Schedule-Dental Subscale (CFSS-DS), indicating dental fear [13]; (4) generally healthy with no systemic diseases or history of allergies; and (5) parents or guardians capable of reading, understanding, and completing questionnaires.

The following cases were excluded: (1) children with physical or mental disabilities; (2) those unwilling to participate in the study or unable to complete the survey for other reasons; and (3) children with prior tooth treatment experience.

All participants received treatment from the same attending oral physician, and data collection was conducted by one researcher. Ultimately, 255 children were involved in our clinical trial.

2.3 Intervention procedure

Every child underwent a dental examination, which included a radiographic evaluation, followed by an oral prophylaxis. Each patient meeting the inclusion and exclusion criteria was randomized using a random number table. Before the formal treatment, a researcher who was not involved in the dental treatment conducted a behavioral management intervention. This researcher had been trained to administer both behavior management techniques according to a standardized procedure, ensuring the concealment of the children's allocation to the dental treatment operator. The two behavior management interventions were then implemented in the waiting room under medical supervision. Lastly, the same dentist completed the treatment, and the researcher collected the patients' data.

In the TSD group, the researcher first explained the process of injecting local anesthesia, removing the deep caries, and filling the cavity using the dental treatment cartoon brochure provided by the department. Then, the researcher showed the children the tools that would be used for dental treatment, such as the single tooth anesthesia injector, the three-way syringe, the high-speed airtor (without a needle installed), and the saliva suction. The children were then guided to touch the tools and understand their functioning, followed by imitation of the treatment process. Once the children were familiar with the tools, they were allowed to try using some of the safe tools under medical supervision. This standardized procedure lasted for 10 minutes.

In the oral simulation game group, we utilized the "Baby Dentist Simulator" software (v1.0.0, Hainan Liancheng Wireless Network Technology Company, Hainan, China), which was installed on tablets. This software incorporates the entire process of injecting local anesthesia, removing caries, and filling the cavity within the game. The children were allowed to engage with the game, selecting relevant tools to experience the treatment as instructed. The game contained sound effects mimicking the therapy process, was conducted under medical supervision, and the game time was limited to approximately 10 minutes.

After the behavioral management intervention conducted by a trained researcher, the treatment was started under the supervision of the same dentist for consistency. Each treatment session focused exclusively on addressing a single deep carious mandibular deciduous molar using standardized procedures. The treatment protocol encompassed disinfection, local infiltration anesthesia administered using computer-controlled

single-tooth anesthesia delivery system technology with 4% articaine injected at a speed of 35 seconds/mL for 3 minutes, installation of a rubber barrier, removal of caries, and filling of the cavity. The entire treatment process lasted approximately 25–30 minutes. Throughout this process, a designated researcher recorded the results pre-, during, and post-treatment.

2.4 Outcomes measured

2.4.1 Comparison of physiological stress levels before and during treatment in both groups

We recorded the highest levels of heart rate, respiration, and blood oxygen saturation for children in both groups before and during treatment using an Oximeter (Hangzhou, China). To compare individual baseline differences in these physiological parameters before surgery for each child, standardized indices were utilized to evaluate the impact of the two interventions. These standardized indices include Q value = (intra-operative heart rate – preoperative heart rate)/preoperative heart rate, M value = (intra-operative respiration – preoperative respiration)/preoperative respiration, and N value = (intra-operative blood oxygen saturation – preoperative blood oxygen saturation)/preoperative blood oxygen saturation.

2.4.2 Pain assessment during the treatment

The Wong-Baker FACES Pain Rating Scale was used to evaluate the pain level during dental treatment [14]. It assessed pain intensity using six distinct facial expressions, representing “no hurt”, “hurts a little bit”, “hurts a little more”, “hurts even more”, “hurts a whole lot” and “hurts worst”, respectively. The dentist recorded the child’s pain level based on their facial expressions during treatment.

2.4.3 Comparison of fear levels before and after the treatment in both groups

The level of fear in children from both groups was assessed pre- and post-operation using the CFSS-DS [15], administered by the same attending physician. This scale comprises 15 items, with scoring levels ranging from “not afraid at all” (1 point) to “very afraid” (5 points). The total scores range from 15 to 75 points, with higher scores indicating greater dental anxiety and fear.

2.4.4 Compliance assessment before and during the procedure in both groups

Compliance was assessed utilizing the Frankl Behavior Rating Scale, in which the assessed scores range from 1 to 4, with lower scores indicating poorer compliance.

2.4.5 Venham's clinical anxiety scale

The scale was utilized to evaluate the anxiety levels of children in both groups [16] based on the child’s cooperative behavior during treatment, categorizing children as either cooperative (levels 0 to II) or uncooperative (levels III to V), with higher levels indicating poorer cooperation. The incidence of anxiety was determined as the ratio of children at levels II to V to the total number of children in the group, expressed as a percentage. The detailed description can be found in Table 1.

2.5 Statistical analysis

The data underwent coding, double-entry for verification, and compilation into Microsoft Office Excel spreadsheets. Statistical analysis was conducted using SPSS 23.0 software (Armonk, IBM Corp, NY, USA). The children’s general information, heart rate, respiration, blood oxygen saturation, Frankl Compliance Assessment, and CFSS-DS scores were treated as quantitative data, while pain levels and clinical anxiety and cooperation grades (Venham scale) were considered ordinal data. Descriptive statistics described quantitative data using median and interquartile range, and ordinal data using frequency and percentage (%), with chi-square tests applied. Given the skewed distribution of data, the Wilcoxon signed-rank test was utilized for statistical analysis, with a significance level set at $\alpha = 0.05$ (two-sided).

3. Results

3.1 Patients' general characteristics

The 255 patients meeting the inclusion criteria were divided into the TSD group and the Game group, with the TSD group comprising 122 cases and the Game group including 133 cases. In the TSD group, the female-to-male ratio was 1:1.10, with females comprising 47.54% and males accounting for 52.46%. The average age in the TSD group was 4.35 ± 1.13 years, with an average weight of 18.85 ± 2.41 kg. In the Game group, the female-to-male ratio was 1.38:1, with females accounting for 57.89% and males accounting for 42.11%. The average age in the Game group was 4.51 ± 1.03 years, with an average weight of 18.86 ± 2.38 kg. Data analysis revealed no significant differences in gender, age, and weight between the two groups ($p = 0.098$, $p = 0.242$, and $p = 0.964$, respectively) (Table 2).

3.2 Physiological stress levels

Regarding heart rate, statistically significant differences were observed between preoperative and intra-operative phases within each group ($p1 < 0.001$). Additionally, (intra-operative heart rate – preoperative heart rate)/preoperative heart rate (Q value) exhibited significant differences between groups ($p2 < 0.001$).

Similarly, significant differences were found in respiration and blood oxygen saturation between preoperative and intra-operative periods in all groups ($p1 < 0.001$). However, the ratios of preoperative to intraoperative respiration and blood oxygen saturation (M and N values) did not differ significantly between groups. Further details can be found in Table 3.

3.3 Pain perception

Under the two behavioral management methods, differences in pain levels among children in each group were observed. In the TSD group, most children experienced more severe pain (41%), while 13.1% reported severe pain. Conversely, in the Game group, most children experienced slight pain (43.6%), with significantly fewer reporting severe pain compared to the TSD group. This difference was statistically significant ($p < 0.001$), as demonstrated in Table 4.

TABLE 1. Venham clinical anxiety and cooperation behavior scale.

Classification	Specific Characteristic
Cooperative Level 0 (Relaxed)	Cooperates well with the doctor, appears relaxed, and can quickly and accurately answer the doctor's questions.
Cooperative Level 1 (Uncomfortable)	Displays unnatural expressions and hand placement, can accurately answer questions but appears tense.
Cooperative Level 2 (Tense)	Voice changes when answering questions but remains accurate, frequently raises hands but does not hinder the doctor's operation.
Uncooperative Level 3 (Reluctant)	Crying, frequently raising hands, attempts to obstruct the procedure, making treatment difficult.
Uncooperative Level 4 (Fearful)	Continuous crying, minimal verbal communication, constant body movement, challenging operation, occasional need for restraint.
Uncooperative Level 5 (Out of Control)	Loud shouting, ineffective communication, require forced measures to proceed with treatment.

TABLE 2. Sex, age and weight of children in each group.

Features	TSD	Game	<i>p</i>
Sex			
Female	58 (47.54%)	77 (57.89%)	0.098
male	64 (52.46%)	56 (42.11%)	
Female-to-male rate	1:1.10	1.38:1	
Age	4.35 ± 1.13	4.51 ± 1.03	0.242
Weight	18.85 ± 2.41	18.86 ± 2.38	0.964

TSD: tell-show-do.

TABLE 3. Comparison of heart rate, respiration and oxygen saturation level before and after intervention in two groups of children, M (P25, P75).

Group	Before surgery	During surgery	<i>p</i> 1	Ratio	<i>p</i> 2
Heart rate					
TSD	95 (90, 98)	106 (102, 113)	<0.001	<i>Q</i> value 0.13 (0.10, 0.17)	<0.001
Game	94 (90, 97)	100 (98, 103)	<0.001		
Respiration					
TSD	25 (24, 27)	24 (23, 25)	<0.001	<i>M</i> value -0.08 (-0.12, -0.04)	0.696
Game	25 (24, 26)	23 (23, 25)	<0.001		
Oxygen saturation					
TSD	98 (97, 98)	96 (96, 97)	<0.001	<i>N</i> value -0.01 (-0.02, -0.01)	0.400
Game	98 (97, 98)	97 (96, 97)	<0.001		

Note: *p*1 represents the comparison between postoperative and preoperative, and *p*2 indicates the comparison of each ratio between the TSD group and the game group. TSD: tell-show-do.

TABLE 4. Assessment of pain levels during treatment, (n (%)).

Group	Case	No pain 0	A little pain 1	Slight pain 2	More obvious pain 3	More severe pain 4	Severe pain 5	Rank mean	<i>p</i>
TSD	122	1 (0.8)	5 (4.1)	13 (10.7)	37 (30.3)	50 (41.0)	16 (13.1)	60.11	<0.001
Game	133	0 (0.0)	22 (16.5)	58 (43.6)	36 (27.1)	15 (11.3)	2 (1.5)	51.21	

TSD: tell-show-do.

3.4 CFSS-DS score

Regarding the degree of fear (measured using the CFSS-DS score), statistically significant differences were observed both pre-operatively and post-operatively within each group ($p < 0.001$). Postoperative scores in the TSD group and the Game group were 54 (49, 58) and 49 (42, 56), respectively, and the differences were statistically significant between the groups ($p < 0.001$). Furthermore, the difference in scores pre-operatively and post-operatively also showed statistically significant differences between the groups ($p < 0.001$), with the Game group exhibiting a notably lower mean than the TSD group (Table 5).

3.5 Frankl scale score

In the Game group, the difference in behavioral management outcomes pre-operatively and post-operatively was statistically significant ($p < 0.001$), whereas no statistically significant difference was observed in the TSD group. Additionally, in the postoperative Frankl Behavior Rating Scale, a significant difference was observed between the two behavioral management methods ($p < 0.05$), as demonstrated in Table 5.

3.6 Venham clinical anxiety and cooperation behavior rating assessment

The changes in cooperation behavior ratings of children under both behavioral management methods were analyzed for inter-group differences, revealing no statistically significant findings ($p = 0.270$), as shown in Table 6.

4. Discussion

In this study, we made four main findings. Firstly, oral simulation games were found to be more effective in alleviating certain physiological stress levels compared to the TSD method. Secondly, the effectiveness of oral simulation games was greater in reducing pain levels compared to TSD. Thirdly, the fear levels of children in the oral simulation game groups showed a more pronounced reduction compared to the TSD method. Lastly, children in the game group demonstrated better compliance. These findings indicate that oral simulation games can effectively alleviate dental fear in children undergoing treatment for deep caries under local anesthesia compared to the TSD method.

The experience of pain and fear plays a crucial role in determining children's compliance during dental treatment, especially during lengthy procedures [17]. In our current study, we observed that 13.1% of children in the TSD group experienced severe pain, whereas only 1.5% of children in the oral simulation game group reported similarly severe pain (Table 4). Additionally, we observed a significantly lower mean fear level in the Game group compared to the TSD group (Table 5). Similar findings have been reported by Meshki *et al.* [18], who found that dental simulation games reduced patients' perceptions of anxiety and pain. Similarly, Radhakrishna *et al.* [11] reported that the smartphone game method was more effective in reducing dental pain than the TSD method by observing that most children in the smartphone dentist game groups were relaxed, indicating better behavior during cavity preparation and restoration, whereas most of those in the TSD group experienced moderate pain. Consistent with the measurements of pain and fear levels, our compliance

TABLE 5. Comparison of preoperative and postoperative behavioral performance between the two groups, M (P25, P75).

Group	Before surgery	After surgery	p_1	Difference	p_2
CFSS-DS scores					
TSD	58 (56, 67)	54 (49, 58)	<0.001	5.00 (3.00, 8.25)	<0.001
Game	57 (53, 65)	49 (42, 56)	<0.001	8.00 (5.00, 12.50)	
p_3	0.172	<0.001			
Frankl behavioral scale scores					
TSD	2 (2, 3)	3 (1, 3)	0.108	-	-
Game	2 (2, 3)	3 (2, 3)	<0.001	-	-
p_3	0.331	0.013			

Note: p_1 : Comparison between postoperative and preoperative; p_2 : Comparison of the difference between the TSD group and the game group; and p_3 : Comparison between the TSD group and the game group before or after surgery. TSD: tell-show-do; CFSS-DS: Child Fear Survey Schedule-Dental Subscale.

TABLE 6. Clinical anxiety and cooperative behavior rating assessment of children in both groups (%).

Group	Venham clinical anxiety and cooperative behavior level rating scale						Incidence of anxiety (II-V)/N	Rank mean	p
	0	I	II	III	IV	V			
TSD	10 (8.2)	22 (18.0)	50 (41.0)	33 (27.0)	4 (3.3)	3 (2.5)	73.77%	133.07	0.27
Game	15 (11.3)	27 (20.3)	54 (40.6)	30 (22.6)	7 (5.3)	0 (0.0)	68.42%	123.35	

Note: N denotes the number of researchers in each group. TSD: tell-show-do.

measurements also revealed that children in the game group demonstrated better compliance than those in the TSD group. These findings suggest that oral simulation games can effectively reduce pain and fear levels during dental treatment compared to the TSD method, consequently enhancing compliance with dental procedures.

We observed that respiration and blood oxygen saturation were not significantly different between the TSD and oral simulation groups, unlike heart rate (Table 3). Alkanan *et al.* [19] reported similar findings, indicating that in the lavender group, while there was a distinct difference in heart rate compared to the control group, no similar difference was observed in respiration and blood oxygen saturation. This suggests that heart rate may be a more sensitive measurement than respiration and blood oxygen saturation. However, it is important to consider other variables that may contribute to this lack of difference in respiration and blood oxygen saturation, such as inclusion criteria and clinical settings.

Various strategies for behavior management during dental treatment have been explored, including reading books, clown therapy, TSD, simulation games, and more. Among these strategies, games hold particular appeal to young children compared to reading books or educational methods [20]. Moreover, the interactive nature of games allows children to engage in role-playing scenarios, such as assuming the role of a dentist treating animals' oral health issues. The animations played during treatment, featuring tools used in the game, likely contribute to reduced fear and a heightened pain threshold due to this familiarity [21].

The oral simulation game utilized in this study is simple and user-friendly, utilizing free mobile applications on mobile phones or tablets and requiring no specific gaming equipment. This characteristic makes it easily adaptable for widespread implementation in other dental clinics or treatment centers, particularly in developing countries or districts. Future efforts to develop more engaging oral simulation games tailored to different age groups could hold promise as potential avenues for further research and development.

Several limitations should be mentioned. First, the study was conducted in a single medical center. Later, research focuses on deep series, which is one type of disease. Further investigation is needed to determine whether similar manifestations are present in other diseases.

5. Conclusions

This study highlights that oral simulation games are effective in reducing dental fear in children undergoing treatment for deep caries under local anesthesia, compared to the TSD method, and could hold significant potential for widespread promotion in future clinical treatment settings.

AVAILABILITY OF DATA AND MATERIALS

The data are contained within this article.

AUTHOR CONTRIBUTIONS

YuZ and TG—conceptualization; writing-original draft. YuZ, CXL, YaZ, YFJ, YY, DYI and LC—methodology; investigation. YuZ and LC—writing-review & editing. LC—supervision.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Parents and/or guardians were informed about the study and told to sign a consent form. The ethics council of the Fifth Affiliated Hospital of Xinjiang Medical University (Urumqi, China) gave its consent for the study to be carried out (XYDWFYLSk-2024-115).

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Yue Zhang, Chen-xi Li, Yang Zhou, Yin-fu Jia, Ying Yu, Dan-yang Li, *et al*. Effectiveness of oral simulation games and “tell-show-do” behavioral management in alleviating dental fear in children: a randomized controlled study. *Journal of Clinical Pediatric Dentistry*. 2025; 49(2): 154-160. doi: 10.22514/jocpd.2025.035.