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ORIGINAL RESEARCH

Reducing dental anxiety in children through tell-show-do technique *vs.* additional instructions with an artificial intelligence-based animated video: randomized clinical trial

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Abstract

Background: Dental anxiety has always been a problem for practitioners, particularly among children. This research aimed to use artificial intelligence (AI) to create personalised cartoons that would positively engage and desensitise paediatric patients. **Methods**: The use of AI was evaluated as an adjunct to the traditional tell-show-do (TSD) method and compared versus TSD technique alone. A total of 42 paediatric patients, aged 5–10 years, classified as with high dental anxiety based on the Modified Dental Anxiety Scale (MDAS) and the Face, Legs, Activity, Cry, Consolability scale (FLACC), were randomly assigned to the Trial group (AI animated video plus TSD) or the Control group (TSD only). Dental anxiety levels were measured at baseline (T0) and after 14 days (T1) using the MDAS and FLACC. Oral hygiene was assessed using the Oral Hygiene Index-Simplified (OHI-S) and Bleeding on Probing (BoP). The International Caries Detection and Assessment System (ICDAS) was recorded at T0. Data normality was assessed using the D'Agostino-Pearson test, and the data were analysed with Analysis of Variance (ANOVA) test followed by a Tukey's multiple comparisons test. Linear regressions were also performed (significance threshold: $p < 0.05$). **Results**: At T1, both groups exhibited significantly lower anxiety scores and non-verbal responses, as well as lower oral hygiene scores ($p < 0.05$). In the intergroup comparison, significantly lower MDAS scores were found in the Trial group ($p > 0.05$). Linear regression analysis revealed a significant effect of group on MDAS, with lower values observed in the Trial group ($p < 0.05$). **Conclusions**: These results confirm the positive role of AI-based instructions in addition to the standard TSD technique. Further studies should evaluate the implementation of AI interventions in dental settings as a complementary approach. **Clinical Trial Registration**: NCT06276478.

Keywords

Dental anxiety; Artificial intelligence (AI); Patient compliance; Oral hygiene; Dental care for children

1. Introduction

Dental anxiety represents a significant problem in the field of paediatric dentistry. Current estimates have revealed an overall prevalence of 23.9% of dental anxiety in paediatric patients, with this prevalence being higher for preschoolers (36.5%) and schoolchildren (25.8%) [1]. In particular, it is estimated that over 50% of paediatric patients may experience varying degrees of anxiety during dental treatment [2].

A significant corpus of scientific research has focused specifically on identifying the most anxious paediatric patients. It has been found that those who experience the most anxiety are the youngest children [3], those with previous traumatic dental injury [4], and those influenced by anxious parents about dental manoeuvres [5]. Furthermore, children who have previously endured distressing or adverse experiences in the context of hospital, medical or dental visits may also exhibit heightened levels of anxiety when it comes to undergoing dental treatment [6–8]. It is imperative to address dental anxiety in children, as they have a greater capacity to process negative experiences when a trusting relationship is established with the dentist. The development of their memory, personality and nervous system is ongoing; consequently, there is a greater dynamic in overcoming an experience that is perceived as unpleasant [9]. A plethora of techniques and instruments have been developed for the purpose of reducing dental anxiety in children [10–14]. The tell-show-do (TSD) technique is among the earliest, and was

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first discussed by Addleston in 1959 [13]. This technique *involves* the introduction of children to new instruments through verbal discussion, practical demonstration of the instrument's functionality, and the provision of opportunities for children to safely handle and explore the instrument with their own hands [13].

In the contemporary context, alongside the utilisation of the conventional TSD technique, the advent of innovative technologies has paved the way for the incorporation of virtual instruments. This promising method has been shown to reduce the discomfort often associated with dental procedures, thereby providing a relaxed state for children [14]. Studies have demonstrated that the presence of distraction can serve to reduce both pain and anxiety during dental procedures. This technique is defined as a state of mind that diverts attention away from unpleasant stimuli [15]. In recent years, there has been a notable shift in children's media preferences, with a growing inclination towards mobile applications and games [16–18]. This trend has given rise to the development of specialized dentistry-related applications that utilise verbal instructions from clinicians. The influence of cartoons on the development of children has been a subject of considerable research. It has been demonstrated that exposure to cartoons can influence a child's cognitive development during early childhood [19]. A potential function of cartoons in this context is as a form of informal education, providing children with knowledge about life experiences. Consequently, this instrument has the potential to be employed in a favourable manner within the domain of paediatric dentistry. Another tool that is gaining popularity in dentistry and paediatric dentistry is artificial intelligence (AI), which holds a considerable potential for dentists to enhance patient care [20].

In the present study, the utilisation of AI to create a cartoon was employed as a tool to facilitate positive conditioning in paediatric patients towards the dental environment, functioning as an adjunct to the TSD technique. This was achieved in order to reduce dental anxiety and enhance oral health indices subsequent to hygiene motivation.

The null hypothesis of the study was that there is no difference between the two groups (AI + TSD technique *vs.* TSD technique) in the two time frames of the study in terms of Face, Legs, Activity, Cry and Consolability (FLACC) scale, Modified Dental Anxiety Scale (MDAS), Oral Hygiene Index-Simplified (OHI-S), and Bleeding on Probing (BoP).

2. Materials and methods

2.1 Trial design

This was a single-center, parallel group, randomized controlled trial with a 1:1 allocation ratio. CONSORT guidelines were adopted for structuring the study. The study was approved by the Unit Internal Review Board (2024-0117), and the protocol was registered on clinicaltrials.gov platform (NCT06276478). The study started in March 2024 and ended in July 2024.

2.2 Patients

Pediatric patients aged between 5 and 10 years who have sought treatment at the Unit of Orthodontics and Pediatric Dentistry, Section of Dentistry, Department of Clinical, Surgical, Diagnostic, and Pediatric Sciences at the University of Pavia, Pavia, Italy were recruited for the study.

Inclusion criteria are:

- Written informed consent to participate in the study signed by parents/legal guardians.
- Patients presenting for the first dental visit ever.
- MDAS [21] score ≥19.
- FLACC [22] score ≥4.
- OHI-S [23] ≥1.3.
- Patients able to sit in the dental chair.

Exclusion criteria were:

- Previous traumatic dental/orthodontic treatments.
- Previous hospitalizations.
- Intellectual disabilities and psychiatric disorders.
- Long term medications and chronic diseases or conditions.

2.3 Interventions and outcomes

At the first dental visit (T0), parents or legal guardians were invited to sign the informed consent for the participation in the study of the patients. Patients were visited by one instructed and calibrated operator. 5 patients not included in the study and which needed two close visits underwent the collection of the indices to guarantee test-retest reliability. The indices in question should have been calculated anyway. To assess dental anxiety, the Modified Dental Anxiety Scale [21] was, in which five questions are asked to patients regarding their confidence at the dental chair, with a score of 0–5 for each question and a total of 30 points; a score higher than 19 classifies a patient with high dental anxiety. MDAS is validated for use in adults, however it has been used with children aged 5–8 [24], 4–12 [25] and 6–12 years old [26]. Additionally, the Face, Legs, Activity, Cry and Consolability score [22] was recorded to, in which the operator assigns a score from 0 to 2 for each of the five categories analysed, with a total score from 0 to 10. Oral assessment was conducted recording the following indices: the Simplified Oral Hygiene Index (OHI-S) [23], which measures the cleanliness of teeth by scoring the presence of dental plaque (from 0 to 3) and calculus (from 0 to 3); the average score for both plaque and calculus across all surfaces is combined for an overall OHI-S score, typically ranging from 0 to 6; the Bleeding on Probing (BoP) [27], in which the total of bleeding sites was divided for the total examined sites and multiplied by 100; and the International Caries Detection and Assessment System (ICDAS) [28], based on visual examination, it uses a range of scores from 0 to 6 for each tooth according to the extent of caries. The examination was carried out in the dental chair. After the oral examination, an operator not *involved* in clinical procedures randomly allocated patients using sequentially numbered, opaque sealed envelopes (SNOSE) in the following two groups according to the instructions to be delivered:

- In the Control group, patients received verbal instruction on home oral hygiene with TSD technique;

- In the Trial group, patients received verbal instruction on home oral hygiene with TSD technique as in the Control group, but after that patients were shown an AI-based cartoon on a tablet, a small "talking molar" which summarized and explained how dental procedures are carried out, what happens in the dental practice, explaining how dental fillings and professional hygiene are conducted. The molar was drawn using Paint software (version 11.2404.1020.0, Microsoft Corporation, Redmond, WA, USA). The drawing was animated using the AI program Animated Drawings (Meta Platforms Inc., Menlo Park, CA, USA, https://sketch.metademolab.com/canvas). A text was created with ChatGPT (version 3.5, OpenAI, San Francisco, CA, USA, https://chat.openai.com) to be integrated into the video, utilizing terminology deemed most suitable for a patient classified as with high dental anxiety. The complete text is available as **Supplementary material**. The text was transformed from written to spoken dialogue using an AI-based online program FlexClip (PearlMountain Limited, Hong Kong, China, https://www.flexclip.com/) and then incorporated into the video. The rationale behind the use of these tools and programs is that they are simple to use also for non-professionals and they do not require charges for basic use.

Children were scheduled for a second appointment after 14 days (T1) to evaluate changes in their oral hygiene maneuvers after the instructions and allow the schedule of the nonsurgical periodontal debridement with a piezoelectric instrument (Satelect Acteon Newton p5 xs, KaVo Dental, Biberach an der Riss, Germany) and manual scaler (Scaler LM 23, Hu-Friedy, Chicago, IL, USA). Patients were aware of this second dental appointment as they were informed by the clinician at the end of the first visit and one week before the second appointment by their parents. The procedure was replicated and standardised for all patients in order to avoid any alteration in their anxiety levels. All the outcomes were re-evaluated, with the exception for ICDAS, which was only recorded at T0. The video is available as **Supplementary Video 1**, while Fig. 1 summarizes the study protocol.

2.4 Sample size

Sample size was calculated considering the Modified Dental Anxiety Scale as the primary outcome of the study. The results of Shetty *et al*. [29] was used for the calculation, considering the power to detect a clinically relevant difference of 41% in the percentage of MDAS scoring $\geq$19 based on an expected value of 19%. Setting an alpha error = 0.05 and power = 80%, 21 patients per group were required for the study. The drop-out rate was not considered due to the study's simple and rapid nature and taking into account that the T1 procedure was nonsurgical periodontal debridement.

2.5 Randomization and blinding

The data analyst generated a randomization sequence, and a block randomization table was used considering a permuted block of 42 total patients. Sequentially numbered, opaque, sealed envelopes (SNOSE) were used to assign patients into the two study groups. Patients and operator were not be blinded. The data analyst, instead, was blinded.

2.6 Statistical analysis

Statistical analysis was performed with R Software (R version 3.1.3, R Development Core Team, R Foundation for Statistical Computing, Wien, Austria). Descriptive statistics (mean and standard deviation) were calculated for each variable. The D'Agostino-Pearson test was adopted to assess data normality of distributions. Subsequently, Students' *t* test was performed to analyze ICDAS between the 2 groups. ANOVA test was performed to analyse MDAS, FLACC; OHI-S and BoP. In case of significant results from ANOVA test, Tukey's *post hoc* test was performed to analyze intergroup and intragroup multiple comparisons. Subgroup analysis was performed dividing patients into two clusters: 5–7 and 8–10 age ranges. Finally, linear regressions were performed to assess the influence of sex, time, group, BoP and ICDAS (independent variables) on MDAS, FLACC and OHI-S (dependent variables). Significance was predetermined for $p < 0.05$.

3. Results

42 patients were recruited for the study. They all fulfilled the inclusion criteria and accepted to participate in the study, they all received the allocated interventions, and none of them was excluded from the analysis. Fig. 2 shows the participant's flow. The mean age of the participants at the beginning of the study was 7.76 $\pm$ 1.35, the baseline characteristics of the study sample are shown in Table 1.

TABLE 1. Baseline demographic data of the study sample.

Sex	Mean Age $\pm$ Standard Deviation	Range
Male (15)	7.80 $\pm$ 1.54	5–10
Female (27)	7.74 $\pm$ 1.25	5–10

Descriptive and inferential statistics are given below in Table 2 (Ref. [30]). In order to better show significant differences between and within groups, a letter-based comparison was used, so that groups with the same letter did not show statistically significantly different means [30].

Regarding dental anxiety scores, MDAS significantly decreased from T0 to T1 in both the groups ($p < 0.05$), but the Trial group showed significantly lower scores at T1 ($p < 0.05$). FLACC scores also significantly decreased from T0 to T1 in both groups ($p < 0.05$); however, no significant differences were found in the intergroup comparisons ($p > 0.05$). For an in-depth analysis, Table 3 presents the precise number of patients in which MDAS and FLACC increased, did not change or decreased at T1 evaluation. In general, a higher percentage of decrease in all the groups were observed, both for MDAS and FLACC scores (from 71.43% to 90.48%). However, it should be noted that in some children the scores increased.

Regarding oral health indices, ICDAS did not show significant differences between groups, and the same was observed for OHI-S ($p > 0.05$), although lower scores were recorded for the Trial group. Finally, the BoP index decreased in both groups after treatment, but with no significant intergroup and

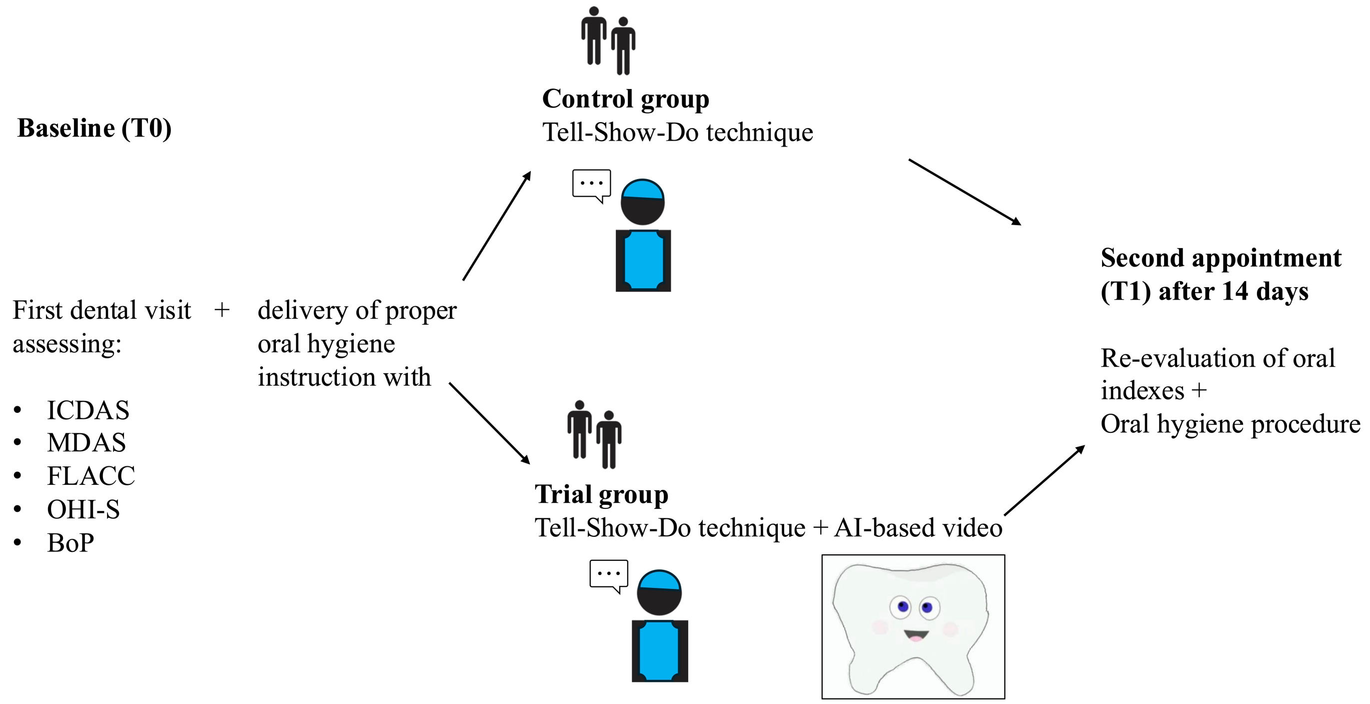

FIGURE 1. Schematic representation of the study protocol. AI: artificial intelligence; ICDAS: International Caries Detection and Assessment System; MDAS: Modified Dental Anxiety Scale; FLACC: Face, Legs, Activity, Cry, Consolability scale; OHI-S: Oral Hygiene Index-Simplified; BoP: Bleeding on Probing.

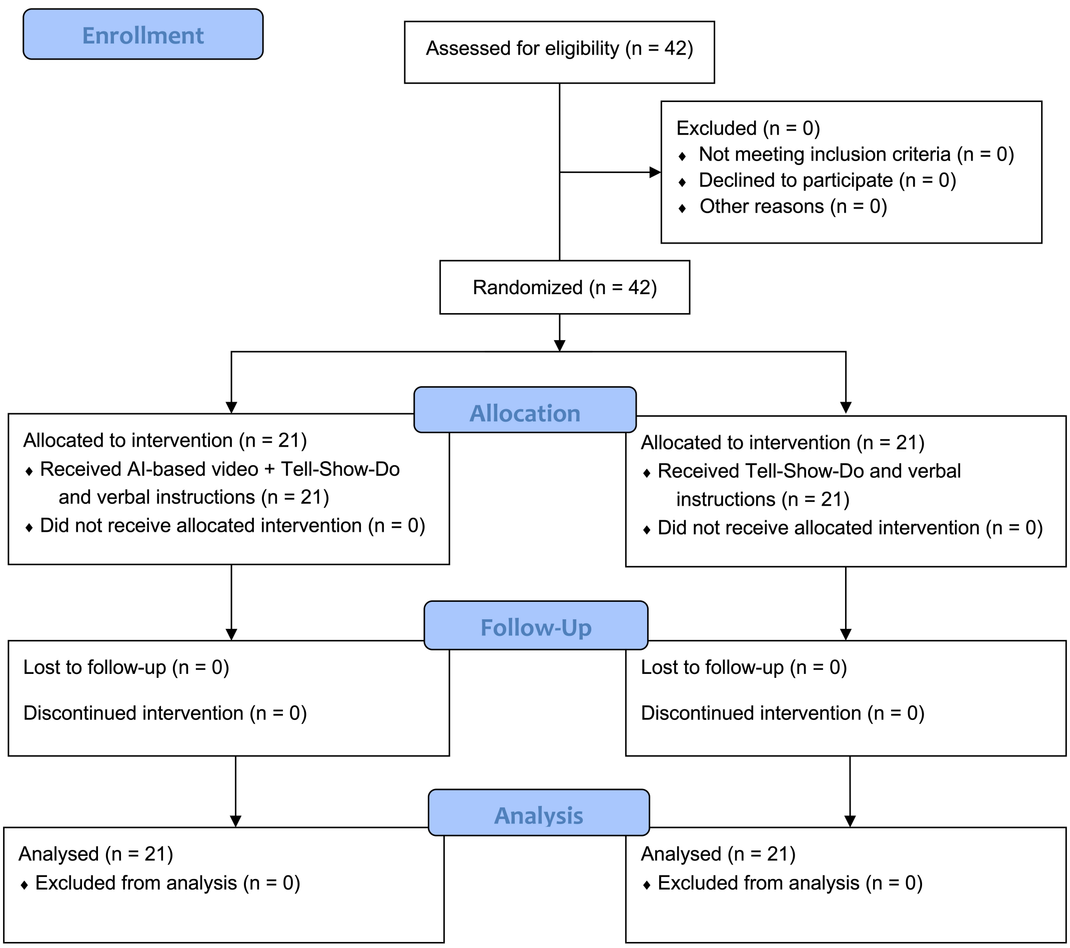

FIGURE 2. CONSORT flowchart of the study showing all the phases of the study. AI: artificial intelligence.

TABLE 2. Descriptive and inferential statistics (Tukey's multiple comparisons test) for each study variable.

	ICDAS	MDAS	FLACC	OHI-S	BoP
Control T0	2.62 ± 2.13^{A}	21.05 ± 1.60^{A}	5.33 ± 1.20^{A}	1.34 ± 0.60^{A}	$2.05 \pm 1.94^{A,C}$
Control T1	-	17.95 ± 3.01^{B}	3.43 ± 1.99^{B}	1.07 ± 0.60^{A}	0.71 ± 1.15^{B}
Trial T0	2.57 ± 2.06^{A}	20.52 ± 1.50^{A}	4.90 ± 1.73^{A}	1.35 ± 0.59^{A}	2.33 ± 1.74^{A}
Trial T1	-	12.86 ± 5.01^{C}	3.14 ± 2.13^{B}	0.92 ± 0.60^{A}	$0.86 \pm 1.31^{B,C}$

For each variable, means with same capital letter/s are not significantly different ($p < 0.05$) [30].
Legend: MDAS: Modified Dental Anxiety Scale; FLACC: Face, Legs, Activity, Cry and Consolability scale; OHI-S: Oral Hygiene Index-Simplified; BoP: Bleeding on Probing; ICDAS: International Caries Detection and Assessment System.

TABLE 3. Number of patients (and percentages) on total patients in brackets in which MDAS and FLACC indices increased, did not change and increased at T1 evaluation.

	n (%)		
	Increase	No change	Decrease
MDAS			
Control	3/21 (14.29)	2/21 (9.52)	16/21 (76.19)
Trial	2/21 (9.52)	0/21 (0.0)	19/21 (90.48)
FLACC			
Control	4/21 (19.05)	2/21 (9.52)	15/21 (71.43)
Trial	1/21 (4.76)	3/21 (14.29)	17/21 (80.95)

Legend: n: number of patients; MDAS: Modified Dental Anxiety Scale; FLACC: Face, Legs, Activity, Cry and Consolability scale.

intragroup differences ($p > 0.05$). Subgroup analyses were conducted for the 5–7 and 8–10 age ranges (Table 4, Ref. [30]) to assess the potential bias related to children's maturity. Due to the fact that the sample size was not calculated with regard to age and sex, the subgroups were found to be imbalanced. For MDAS, a significant intragroup difference was found from T0 to T1 in the Trial subgroups ($p < 0.05$), whereas no significant intragroup differences were observed in the Control subgroups ($p > 0.05$). The only significant intergroup difference was found at T1 ($p < 0.05$). For FLACC, a significant difference was observed between the Trial T0 5–7 and the Trial T1 8–10 subgroups ($p < 0.05$), with lower scores in the latter. No other noteworthy differences were found for the remaining variables.

A linear regressions analysis (Table 5) was conducted in order to assess the influence of sex, time, group, ICDAS and BoP on MDAS, FLACC and OHI-S. All R^2 coefficients were positive. Low R^2 values were found, with the exception of OHI-S~ICDAS, OHI-S~BoP. The impact of time on all recorded indices was found to be significant ($p < 0.05$), and the Trial group's influence on MDAS was also found to be significant, resulting in lower scores ($p < 0.05$). Higher ICDAS scores were found to be associated with higher OHI-S values ($p < 0.05$). In a similar manner, elevated BoP scores were associated with elevated MDAS and FLACC values ($p < 0.05$).

4. Discussion

Dental anxiety has been demonstrated to be associated with avoidance behaviours, which can negatively impact oral hygiene and increase the likelihood of caries and other dental problems. It has been observed that a reduction in dental anxiety has resulted in an improvement in adherence to proper oral hygiene practices [31]. Consequently, contemporary literature has investigated endeavours to mitigate dental anxiety in paediatric patients, with a particular focus on the utilisation of innovative technologies [16–19].

A reduction in the degree of dental anxiety may be achieved in patients who are granted controlled access to technological devices in addition to conventional TSD in respect to patients instructed with the traditional TSD method only [32]. An Iranian study [33] was conducted to evaluate the impact of an animated film simulating a real dental office on children's behaviour, in comparison with the conventional TSD technique. It was determined that the utilisation of cartoon modelling constitutes a viable method for the administration of effective conditioning in children within the 4–6 age range. The efficacy of this technique may be further enhanced through its combination with the conventional TSD technique, thereby yielding a positive synergistic effect. This approach was adopted in the present study, as contemporary techniques should serve as an enhancement to existing clinical practices rather than a substitute for established methods. Another study published in 2022 [34] compared TSD technique with audio-visual storytelling method. In this study, each instrument, person and procedure of the dental office was fictionalised and assimilated into positive situations in the children's imagination. The study demonstrated that audio-visual storytelling is a highly effective and applicable method of reducing dental anxiety in children. Nevertheless, in this particular context, it is imperative to select

TABLE 4. Descriptive and inferential statistics (Tukey's multiple comparisons test) of age subgroup analysis for each study variable. Number of patients per subgroup (in brackets): Control 5–7 (10), Control 8–10 (11), Trial 5–7 (8), and Trial 8–10 (13).

	Age	ICDAS	MDAS	FLACC	OHI-S	BoP (%)
Control T0	5–7	2.70 ± 2.50^{A}	20.40 ± 1.58^{A}	5.30 ± 1.25^{A}	127 ± 0.61^{A}	$1.40 \pm 1.71^{A,B}$
Control T0	8–10	2.55 ± 1.86^{A}	21.64 ± 1.43^{A}	5.36 ± 1.21^{A}	1.41 ± 0.60^{A}	2.64 ± 2.01^{A}
Control T1	5–7	-	$17.40 \pm 2.59^{A,B}$	$3.20 \pm 2.35^{A,B}$	1.07 ± 0.61^{A}	$0.60 \pm 1.07^{A,B}$
Control T1	8–10	-	18.45 ± 3.39^{A}	$3.64 \pm 1.69^{A,B}$	1.06 ± 0.62^{A}	$0.82 \pm 1.25^{A,B}$
Trial T0	5–7	2.63 ± 2.50^{A}	21.38 ± 1.85^{A}	5.63 ± 1.41^{A}	1.51 ± 0.67^{A}	$2.50 \pm 2.00^{A,B}$
Trial T0	8–10	2.54 ± 1.85^{A}	20.00 ± 1.00^{A}	$4.46 \pm 1.81^{A,B}$	1.25 ± 0.53^{A}	$2.23 \pm 1.64^{A,B}$
Trial T1	5–7	-	13.63 ± 5.04^{B}	$3.63 \pm 1.77^{A,B}$	1.18 ± 0.77^{A}	$1.50 \pm 1.77^{A,B}$
Trial T1	8–10	-	12.38 ± 5.14^{B}	2.85 ± 2.34^{B}	0.77 ± 0.42^{A}	0.46 ± 0.78^{B}

For each variable, means with same capital letter/s are not significantly different ($p < 0.05$) [30].
Legend: MDAS: Modified Dental Anxiety Scale; FLACC: Face, Legs, Activity, Cry and Consolability scale; OHI-S: Oral Hygiene Index-Simplified; BoP: Bleeding on Probing; ICDAS: International Caries Detection and Assessment System.

TABLE 5. R^2 and p values (in brackets) of linear regressions for the variables considered in the study.

Independent variables	Dependent variables		
	MDAS	FLACC	OHI-S
Sex	0.05 (0.036*)	ns	ns
Time	0.37 (<0.001*)	0.21 (<0.001*)	0.18 (0.008*)
Group	0.10 (0.003*)	ns	ns
ICDAS	ns	ns	0.62 (<0.001*)
BoP (%)	0.10 (0.004*)	0.11 (0.003*)	0.64 (<0.001*)

*: $p < 0.05$; ns: not significant.
MDAS: Modified Dental Anxiety Scale; FLACC: Face, Legs, Activity, Cry and Consolability scale; OHI-S: Oral Hygiene Index-Simplified; BoP: Bleeding on Probing; ICDAS: International Caries Detection and Assessment System.

an appropriate narrative for each patient, whilst also giving due consideration to the dentist-patient relationship.

Additionally, another research group tested tablet and headphones so that patients could watch their favourite shows and demonstrated a significant reduction of dental anxiety in respect to the control group with no auxiliary device [35]. Finally, a number of studies were conducted in order to compare the efficacy of smartphone applications with that of the TSD technique. The results of these studies were positive and significant [16, 18, 36–38].

In contrast with these findings, however, the null hypothesis of the study was partially rejected. In fact, no significant differences between the two groups in the assessed variables after the administered interventions were found, with the exception of the MDAS variable. In this case, significantly lower scores were found for the Trial group in respect to the Control group at T1 evaluation. This result is in line with previous works that revealed no significant differences between the TSD approach and the use of a film [31] or virtual reality distraction [29, 39, 40]. It is important to acknowledge that, in the present study, objective evaluations were not conducted, in contrast to previous literature that has recorded heart rate [31, 36] and salivary cortisol levels [29]. The incorporation of objective parameters could enhance the comprehension of the interventions implemented, as this research domain encompasses psychological aspects that are challenging to evaluate.

A recent study [25] confirmed an association between salivary cortisol level and dental caries, highlighting that it could be considered a "biomarker" for stress in pediatric patients, with all the implications on their oral hygiene levels; therefore, these aspects should be expanded in future research. With regard to the oral indices, all parameters improved in both groups, with the exception of the OHI-S; this is likely due to the oral hygiene instructions given to the patient of both the study groups in the baseline session. However, it should be noted that the baseline BoP for both groups was already low, with initial values of 2.05 ± 1.94 for the Control group and 2.33 ± 1.74 for the Trial group. Preliminary regression analysis suggests a significant influence of the Trial Group on the MDAS score, thus sustaining the hypothesis that artificial intelligence can play a pivotal role in delivering additional instructions to patients. This finding is in line with the conclusions of previous studies [31, 32]. Furthermore, the findings of the present study corroborate earlier research, in that linear regressions confirmed that higher levels of anxiety, as measured by the

FLACC and MDAS, significantly influenced oral hygiene levels. This supports the hypothesis that patients with poorer BoP are associated with dental anxiety [32]. However, it should be noted that the models explain approximately 10% of the variability in the dependent variables considered, according to R^2 values. In summary, non-significant differences can be interpreted as indicative of the importance of the clinician's role in delivering verbal instructions to patients, as outlined in Good Clinical Practice guidelines. Conversely, the MDAS significant T1 difference underscores the potential of AI-based intervention in routine dental practice. Indeed, as demonstrated in the present study, even non-experts are capable of producing content of a certain complexity using artificial intelligence (AI), in this case for the creation of an animated film to assist patients in acclimatising to the dental office.

It is important to note that children's awareness of the upcoming second examination may have contributed to a further reduction in MDAS and FLACC indices. Moreover, the presence of high MDAS scores—reflecting cognitive fear—alongside low FLACC scores—indicating minimal behavioural signs of distress—may suggest a certain degree of compliance by children. Additionally, the fact that a minority of the patients experienced an increase of MDAS and FLACC could be explained with the anticipation of the dental hygiene appointment that might have increased anxiety, as the video seemed not to have negatively influenced the patients.

The utilisation of artificial intelligence (AI) in dentistry has witnessed a considerable surge in recent times. A prominent example of this trend is the noteworthy efficacy of AI in the domain of endodontics [41]. Moreover, AI has demonstrated its potential in restorative dentistry by attaining a diagnostic accuracy of 97.1% for dental caries in digital radiographs, an improvement that surpasses the performance of earlier models documented in the extant literature [42]. However, it is imperative to note that the system employed for the classification of the depth of caries remains a subject for improvement. In the domain of paediatric dentistry, artificial intelligence (AI) has the potential to be utilised for a range of sophisticated applications, including personalised learning, gamification, virtual assistants, emotional support and monitoring [43]. The field of Artificial Intelligence (AI) has attracted considerable interest, as evidenced by the mounting prevalence of research publications and related academic activities. This growing interest is reflected in a recent bibliometric analysis [20]. Emotional support represents a particularly challenging area of analysis within the broader field of applications, due to the psychological intricacies *involved* and the considerable variability observed among subjects. Consequently, further research is required in this domain to enhance the level of evidence available. In contrast, the majority of previous studies have focused exclusively on dental fear, while oral health parameters have been largely overlooked. It can be hypothesised that an analysis of oral conditions in relation to social and economic factors could provide more insights into patients' perspectives and approach to oral hygiene following AI-based interventions. In the contemporary era, the implementation of artificial intelligence (AI) in the field of dentistry is predominantly associated with diagnostic procedures. A gradual and prudent integration of AI into clinical practice is also recommended, particularly in the context of ensuring compliance with regulatory frameworks. In light of the findings of this study, which demonstrate the efficacy of adopting AI to facilitate the creation of AI-based videos, it can be concluded that the utilisation of AI in interventions designed to enhance patient education is a viable proposal. Undoubtedly, future advancements in AI have the potential to generate bespoke content for each patient, thereby facilitating the management of their specific dental concerns. The utilisation of artificial intelligence (AI) in a dental practice has the potential to enhance the effectiveness with which clinicians manage patient care and reduce anxiety levels. Nevertheless, it should not supplant the dentist's pivotal function in making clinical decisions and cultivating trust with patients. It is evident that conventional modes of communication, including verbal interaction and the TSD method, continue to be of significant pertinence. These techniques are imperative for the establishment of positive relationships, the alleviation of fear, and the assurance of favourable treatment outcomes. The present study was innovative in its application of artificial intelligence (AI) to generate AI-based cartoons. This novel approach aimed to enhance the TSD technique and improve patients' experience in the dental setting. The utilisation of freely available and user-friendly tools is a significant advantage, as it ensures accessibility for the average user.

The present study is subject to certain limitations. Firstly, the recruitment of paediatric patients may have introduced a degree of subjectivity, particularly when compared to the outcomes that might have been observed in a study *involving* only adult participants. Secondly, the lack of objective outcomes, such as heart rate measurements and salivary cortisol levels, is another limitation of the study. It is acknowledged that children may exhibit divergent levels of understanding and maturity. However, the present study *involved* conducting additional analysis to assess the influence of older age on the assessed outcomes. The Trial subgroups obtained a significantly decreased result in comparison to the Control subgroups ($p < 0.05$), with the lowest compliance scale values being obtained by the Trial 8–10 subgroup. This finding suggests that the AI intervention was more effective in this subgroup, possibly due to its higher level of maturity. However, the subgroups were found to be numerically imbalanced, thereby rendering the statistical analysis inadequate for drawing definitive conclusions. Evidence for this can also be seen in the other results of the study. Moreover, another limitation of the study was the absence of patient feedback on the video, which could have provided valuable insights into their perceptions and engagement. It is recommended that future studies be designed to compare balanced age group subgroups, and that objective outcomes be recorded. It should be noted that previous studies found significant differences in this regard [28, 29, 31]. It is also recommended that artificial intelligence be tested in other clinical procedures that require compliance, such as the use of nitrous oxide.

The objective of this research is to advance the utilisation of AI in the domain of complex issues, such as dental anxiety in paediatric patients. In the future, the potential of AI in the more specific and fine-tuned psychological framing of paediatric patients could be further explored to create videos with the most targeted language and content based on each child's characteristics. The utilisation of AI has the potential to enhance communication with paediatric patients, thereby ensuring the dissemination of information is more accessible, comprehensible, and engaging. It can also facilitate the comprehension of dental procedures through the utilisation of simplified, reassuring language, accompanied by visual aids and animations. Further studies should evaluate the effects of similar interventions in paediatric patients with health-related anxiety, for example the fear of dental anaesthesia. In the design of future studies, the incorporation of objective evaluations, such as galvanic skin tests or heart rate measurements, in conjunction with operator-based scales, is recommended [29, 31].

5. Conclusions

TSD technique and TSD + additional chairside AI-based instructions resulted both effective in reducing dental anxiety in pediatric patients, but the additional AI-based instructions determined significantly lower anxiety levels evaluated through MDAS scores in respect to TSD technique alone. Consequently, the implementation of AI in the delivery of instructions to patients warrants further exploration. A study of the impact of TSD technique on oral hygiene scores revealed no significant effects. Nevertheless, the results of linear regression analysis suggested a potential influence of AI-based instruction on reducing dental anxiety, although it was observed that the model only accounted for 10% of the analysed dependent variable.

AVAILABILITY OF DATA AND MATERIALS

Data are available upon request to the corresponding author.

AUTHOR CONTRIBUTIONS

MCV—designed the research study. AB—performed the research. AB and MP—wrote the manuscript. AS—analyzed the data. AS and PZ—revised the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All procedures performed in this study were in accordance with the Declaration of Helsinki (1964) and its later amendments, and it was approved by the Internal Review Board of the Unit of Orthodontics and Pediatric Dentistry (2024-0117). The study was registered on clinicaltrials.gov (NCT06276478). Informed consent for the participation in the study of the minors was signed by parents/legal guardians.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Andrea Scribante is serving as the Editor-in-Chief. Maurizio Pascadopoli and Paolo Zampetti are serving as Editorial Board member of this Journal. We declare that Andrea Scribante, Maurizio Pascadopoli and Paolo Zampetti had no involvement in the peer review of this article and have no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to BB.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.jocpd.com/files/article/1963123534254227456/attachment/Supplementary%20material.zip.

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