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# CONTEMPORARY METHODS FOR REDUCING ANXIETY IN PEDIATRIC DENTISTRY

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## ABSTRACT

Dental anxiety in children represents a significant clinical challenge, adversely affecting patient cooperation, treatment outcomes, and long-term attitudes toward dental care. In recent years, increasing attention has been directed toward modern technologies designed to alleviate anxiety and pain during dental procedures. The aim of this review was to present contemporary technologies used to reduce dental anxiety in pediatric patients and to evaluate their effectiveness based on current scientific evidence.

A literature search was conducted using the PubMed and Google Scholar databases. Publications investigating the application of virtual reality (VR), audio and audiovisual distraction techniques, and mobile applications in pediatric dentistry were analyzed. Most studies demonstrated that these technologies effectively reduce anxiety levels, pain perception, and physiological parameters associated with stress. The strongest evidence supports the use of virtual reality and audiovisual distraction techniques, which, through immersive experiences and cognitive distraction, effectively divert children's attention from unpleasant dental stimuli. Mobile applications appear particularly useful in preparing children for dental visits by providing education and familiarization with dental procedures.

Despite promising findings, further high-quality clinical studies are required to standardize these interventions and to evaluate their long-term effectiveness and safety.

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## KEYWORDS

Dental Anxiety; Pediatric Dentistry; Virtual Reality; Audiovisual Distraction; Mobile Applications; Behavior Management; Children

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## Introduction

Dental anxiety among pediatric patients represents a significant clinical challenge and remains a major concern for pediatric dentists. Previous studies have shown that at least 10% of children experience excessive anxiety related to dental treatment [1,2]. In children, fear of pain, unfamiliar clinical settings, and previous negative experiences may result in avoidance of dental visits, poor cooperation during treatment, and deterioration of oral health. This often leads to the need for emergency interventions due to pain and may further exacerbate dental anxiety [3]. Elevated stress level also negatively affects the clinician's work by increasing the difficulty of performing procedures, prolonging treatment time, and, in severe cases, rendering treatment impossible. Moreover, dental anxiety may persist into adulthood and may even be transmitted across generations. Uziel et al. demonstrated that parental behavior during a child's dental treatment, as well as parents' own dental fears, significantly influence the level of stress and anxiety experienced by pediatric patients [4,5]. Therefore, early interventions aimed at reducing anxiety from the very first dental visits are of paramount importance.

Contemporary pediatric dentistry increasingly seeks methods that can reduce patient anxiety while simultaneously improving treatment comfort and clinical outcomes. Conventional approaches to anxiety management include behavioral techniques, effective communication with the patient, and pharmacological sedation. However, the effectiveness of these methods may be limited by the clinician's interpersonal skills, individual patient characteristics, and the degree of parental involvement in the therapeutic process [6]. Consequently, modern technologies have gained increasing attention in recent years, providing more effective means of diverting children's attention from stressful stimuli and improving their overall dental experience.

According to McCaul et al., pain perception and the amount of attention devoted to painful stimuli play a crucial role in the experience of pain [7]. Consequently, distraction techniques are considered an effective strategy for redirecting patients' attention away from unpleasant procedures [8]. The development of immersive technologies, such as virtual reality (VR), together with mobile applications and audio or audiovisual distraction techniques, has created new opportunities for supporting pediatric patients during medical and dental procedures. These technologies have the potential to reduce stress, improve patient cooperation, and decrease the need for pharmacological anxiety-management strategies.

The aim of this review was to present contemporary technologies used to reduce anxiety in children, with particular emphasis on pediatric dentistry, and to evaluate their effectiveness based on the currently available scientific evidence.

## Materials and Methods

A literature review was conducted using the PubMed and Google Scholar databases. The search was performed between January and April 2026 using the following keywords and their combinations: *dental anxiety*, *dental fear*, *paediatric dentistry*, *children*, *virtual reality*, *VR*, *augmented reality*, *mobile applications*, *smartphone applications*, *audio distraction*, *audiovisual distraction*, *behaviour management*, *pain management*, and *new technologies in dentistry*. In addition, the reference lists of the retrieved articles were screened to identify further relevant studies.

Studies published in English involving pediatric patients undergoing dental treatment were included in the review. Exclusion criteria comprised studies involving exclusively adult populations, articles unrelated to dental treatment, case reports, and studies that did not evaluate the effects of technological interventions on anxiety levels, patient behavior, or pain perception.

## Results

### *Virtual Reality (VR)*

One of the most rapidly evolving approaches for anxiety management in pediatric patients is the use of virtual reality (VR). This technology involves the application of head-mounted displays (HMDs) or specialized goggles that allow patients to become immersed in a computer-generated three-dimensional audiovisual environment. Visual, auditory, and, in some cases, haptic stimuli are employed to enhance the sense of presence and immersion, thereby diverting the child's attention and reducing the perception of stress-inducing stimuli associated with dental treatment. This distraction effect constitutes the principal mechanism underlying VR, which primarily relies on cognitive distraction, redirecting the patient's attention away from pain, the sounds of dental instruments, and the procedure itself [9,10]. Another mechanism contributing to the effectiveness of VR is the induction of relaxation and emotional calmness. The immersive experience facilitates emotional regulation and attenuates the physiological stress response [11].

Shetty et al. investigated the effects of virtual reality on anxiety and pain perception during dental treatment in children aged 5–8 years. The study included 120 children undergoing short invasive dental procedures. The authors demonstrated a statistically significant reduction in anxiety levels and pain perception in patients using VR compared with controls who did not receive immersive distraction. Moreover, children exposed to VR exhibited lower salivary cortisol concentrations, indicating a reduced stress response. The authors concluded that VR may serve as an effective behavior modification strategy during pediatric dental treatment [12]. These findings are consistent with those reported by Aminabadi et al., who observed that VR significantly reduced both anxiety and pain perception compared with conventional treatment. In addition, improved patient cooperation and lower stress-related physiological parameters, including heart rate, were reported [13].

Similar conclusions were reached by Rosa et al., who identified VR as an effective distraction technique for reducing dental anxiety. According to the authors, the immersive environment enables children to become partially detached from the reality of the dental setting, thereby improving cooperation and alleviating emotional distress [14].

Cunningham et al. further suggested that modern technologies may not only reduce stress during dental procedures but also serve as preparatory tools before treatment. Interactive simulations may familiarize children with the dental environment and decrease anxiety associated with unfamiliar situations [15].

Overall, the majority of studies included in this review demonstrated statistically significant benefits of VR in reducing anxiety and pain compared with control groups, although several exceptions have been reported. In a study conducted by Sullivan et al., virtual reality did not significantly affect patient behavior or self-reported anxiety levels in children undergoing dental treatment. Nevertheless, the authors observed a significant reduction in heart rate among children exposed to VR, suggesting attenuation of the physiological stress response [16]. Furthermore, two additional studies reported that conventional audiovisual distraction techniques, such as watching cartoons or videos on tablet screens, provided superior distraction effects compared with VR [17,18]. These findings may be attributed to limitations associated with the comfort and usability of VR headsets in younger children, difficulties in adapting to immersive environments, or excessive sensory stimulation induced by the technology [12,15].

Despite the promising findings, several authors have emphasized that the currently available evidence regarding the use of VR in pediatric dentistry is characterized by considerable methodological limitations. Consequently, further investigations are required to establish standardized protocols and evaluate the long-term effectiveness of this approach. Frequently reported limitations include relatively small sample sizes, heterogeneity of intervention protocols, and the lack of standardized instruments for assessing anxiety and pain [15,19]. In addition, the implementation of VR in routine clinical practice may be hampered by the high cost of equipment, the need for appropriate staff training, and the potential occurrence of adverse effects, including dizziness, nausea, and sensory discomfort in susceptible patients [12,19,20].

#### ***Audio and Audiovisual Distraction Techniques***

Distraction techniques represent one of the most widely used non-invasive approaches for reducing anxiety and pain perception in pediatric patients undergoing dental treatment. Audio distraction involves providing children with auditory stimuli, such as music, stories, or other sounds delivered through headphones or speakers during dental procedures. In contrast, audiovisual (AV) distraction combines auditory and visual stimuli simultaneously, most commonly through cartoons, movies, or animated content accompanied by sound presented on screens or multimedia glasses. The primary aim of both approaches is to redirect the child's attention away from treatment-related stimuli, including needle insertion, the sound of rotary instruments, or vibrations generated during dental procedures, toward more engaging and pleasant sensory experiences.

Available evidence suggests that audiovisual distraction techniques are generally more effective than auditory distraction alone in reducing anxiety and subjective pain perception in children undergoing dental treatment [21,22].

Kaur et al. conducted a randomized study involving children aged 4–6 and 6–8 years, comparing a control group with audio and audiovisual distraction during consecutive dental visits. The authors demonstrated that audiovisual distraction resulted in significantly greater reductions in anxiety levels compared with both audio distraction and no intervention [23].

These findings are consistent with those reported by Prabhakar et al., who showed that various forms of audiovisual distraction, including movies accompanied by sound, significantly reduced heart rate and anxiety scores compared with interventions based exclusively on auditory stimuli [24].

The superior efficacy of audiovisual distraction in reducing anxiety and pain perception may be explained by the simultaneous engagement of visual and auditory pathways. The combination of visual stimuli, such as animated cartoons, videos, or interactive games, with appropriately selected auditory stimuli increases cognitive engagement and reduces the attentional resources available for processing nociceptive and stress-related stimuli.

This hypothesis is supported by the findings of Jafarimofrad et al., who evaluated the effectiveness of audiovisual distraction (combined image and sound) compared with visual stimulation alone in children aged 4–7 years [25]. Anxiety and pain levels were assessed using both physiological parameters, namely heart rate measurements, and behavioral assessment tools, including the objective Sound, Eyes, and Motor (SEM) scale and the subjective Faces Pain Rating (FPR) scale. The results demonstrated that complete audiovisual distraction significantly reduced both physiological and behavioral indicators of anxiety and pain compared with visual stimulation alone and with the control group. These findings indicate that the auditory component plays a crucial role in enhancing the distraction effect and that simultaneous stimulation of multiple sensory modalities may more effectively modulate stress perception and improve children's tolerance of dental procedures. Consequently, audiovisual stimulation may represent a more effective adjunctive strategy for behavior management in pediatric dental patients than interventions targeting a single sensory modality.

Nevertheless, auditory distraction alone has also demonstrated beneficial effects in several studies [23,24]. Singh et al. reported that listening to self-selected music significantly reduced intraoperative anxiety compared with a control group without music in a cohort of 60 children aged 6–12 years undergoing tooth extractions. The study showed significantly lower systolic blood pressure, pulse rate, and Venham Picture Test (VPT) scores among children exposed to music [26].

The anxiolytic effects of auditory distraction may be attributed to relaxation induction, mood modulation, and alterations in pain perception through competitive processing of auditory stimuli. Although audiovisual techniques appear to provide superior outcomes, authors have emphasized that when audiovisual equipment is unavailable, auditory distraction alone, such as listening to music through headphones, remains an effective and practical option for reducing anxiety and pain [25]. In clinical practice, auditory distraction constitutes a simple, inexpensive, and readily accessible intervention. It may be particularly useful in situations where the use of screens or multimedia devices is impractical, such as during procedures requiring restricted head movement.

### ***Mobile Applications***

Recent years have witnessed a rapid increase in the use of mobile devices among children for both educational and recreational purposes. Early exposure to digital technologies has made smartphones and tablets an integral part of children's daily lives. In response to this trend, novel strategies employing mobile applications have emerged as promising tools for reducing anxiety in pediatric patients.

The mobile applications evaluated in the available studies incorporated a variety of features, including animated presentations of dental visits, educational games, procedural simulations, gamification elements such as rewards and achievements, and interactive storytelling designed to actively engage children. These interventions aim to familiarize patients with the dental environment and increase their understanding of dental procedures, thereby alleviating fear associated with unfamiliar experiences.

One of the most frequently investigated application is *Little Lovely Dentist*. This interactive educational game allows children to assume the role of a dentist and perform basic dental procedures on virtual patients. By providing a safe and child-friendly environment, the application enables users to become acquainted with dental instruments, clinical settings, and treatment procedures, potentially reducing anxiety related to unfamiliar situations.

The effectiveness of this application was evaluated in a randomized clinical trial conducted by Elicherla et al., who compared the *Little Lovely Dentist* application with the conventional tell-show-do (TSD) behavioral technique. The authors demonstrated that children using the mobile application exhibited better cooperation during treatment and lower anxiety scores, as assessed by standardized behavioral scales, compared with patients prepared using the traditional TSD approach [27].

Comparable findings were reported by Aziz and Jafar in a study involving Iraqi children. The authors compared the effectiveness of the *Little Lovely Dentist* application with that of the tell-show-do technique in preparing children for dental treatment. They emphasized that active participation in a virtual dental environment allows children to gain a better understanding of clinical procedures and enhances their sense of control over the situation, which constitutes one of the key mechanisms underlying anxiety reduction [28].



These findings are consistent with observations reported in other studies and literature reviews [29,30]. Nevertheless, the body of evidence regarding the use of mobile applications for managing dental anxiety remains limited. Furthermore, considerable heterogeneity exists among studies in terms of the applications employed, study designs, and sample sizes. Consequently, additional well-designed clinical trials are required to establish the effectiveness of these digital interventions more conclusively.

Despite these limitations, currently available evidence suggests that mobile applications may represent a valuable adjunct in preparing children for dental treatment. Their beneficial effects appear to arise primarily from gradual familiarization with the dental environment, educational play, and increased predictability of clinical procedures. Unlike distraction techniques employed directly during treatment, such as virtual reality and audiovisual interventions, mobile applications exert their effects predominantly during the pre-appointment phase, facilitating adaptation to the dental setting and promoting positive attitudes toward dental care.

### **Discussion**

Dental anxiety remains one of the most important barriers to successful dental treatment in pediatric patients. Elevated levels of stress adversely affect not only the child's comfort but also treatment delivery, patient cooperation, and long-term attitudes toward oral healthcare. Consequently, considerable efforts have been directed toward the development of adjunctive strategies capable of enhancing conventional behavior management techniques and improving children's dental experiences.

The findings of the present review indicate that modern technologies may represent valuable additions to traditional behavior guidance approaches in pediatric dentistry. Among the interventions evaluated, virtual reality has received the greatest scientific attention. Most studies included in this review reported significant reductions in anxiety levels, pain perception, and stress-related physiological parameters following the use of VR [13–16]. The effectiveness of this technology is primarily attributed to immersion and cognitive distraction, which divert children's attention away from unpleasant dental stimuli and facilitate emotional regulation.

Despite these promising findings, not all studies demonstrated a clear advantage of VR over alternative distraction techniques. Several investigations reported comparable or even superior outcomes with conventional audiovisual interventions involving tablets or multimedia screens [17,18]. These findings suggest that the effectiveness of VR may depend on multiple factors, including the child's age, the type of VR equipment employed, duration of exposure, and individual patient preferences. Furthermore, the implementation of VR in routine clinical practice is associated with several challenges, including the cost of specialized equipment and the possibility of adverse effects, such as dizziness, nausea, or sensory discomfort [12,19,20].

Another issue warranting further consideration concerns the age at which children are exposed to immersive digital technologies. Although a growing body of evidence supports the effectiveness of VR in reducing dental anxiety, data regarding its long-term effects on child development remain limited. For this reason, many VR device manufacturers recommend restricting the use of their products in younger children, with age limits typically ranging from 12 to 13 years and, in some cases, even 15 years [31]. Notably, the majority of studies included in this review involved children younger than those recommended by manufacturers. Although no serious adverse events associated with short-term clinical use have been reported to date, further studies are needed to evaluate the long-term safety of VR and its potential effects on visual development, cognitive functions, and psychosocial maturation.

Audio and audiovisual distraction techniques also occupy an important place among the technologies analyzed. The majority of available studies suggest that both auditory and audiovisual interventions effectively reduce anxiety and pain perception during dental treatment [21–24]. However, current evidence indicates that audiovisual methods generally provide greater benefits, likely owing to the simultaneous engagement of visual and auditory sensory pathways and a stronger distraction effect [23,24]. Nevertheless, auditory distraction alone remains an attractive option because of its simplicity, low cost, and widespread availability, making it suitable for routine clinical practice.

The use of mobile applications as tools for preparing children for dental treatment represents a relatively new area of research. In contrast to interventions applied during treatment, mobile applications primarily exert their effects before the dental appointment. Their mechanisms of action rely mainly on education, familiarization with the clinical environment, and enhancement of procedural predictability. Available

evidence suggests that such applications may reduce anxiety and improve patient cooperation during treatment [27–30].

Compared with VR and audiovisual distraction techniques, mobile applications offer several practical advantages, including low implementation costs and the possibility of gradual familiarization with dental procedures over an extended period. However, currently available evidence suggests that technologies directly engaging children's attention during treatment, such as VR and audiovisual distraction, may be more effective in reducing anxiety during the procedure itself. Therefore, mobile applications appear to be particularly valuable as preparatory tools aimed at promoting positive attitudes toward dental care rather than as primary intraoperative anxiety-management strategies.

Several limitations should be considered when interpreting the findings of the present review. The included studies exhibited substantial heterogeneity regarding participant age, types of dental procedures performed, technologies employed, and methods used to assess anxiety and pain. Such variability limits direct comparisons between studies and hampers the formulation of definitive clinical recommendations. Moreover, most investigations focused on short-term outcomes, whereas evidence concerning the long-term impact of these technologies on children's attitudes toward dental care remains scarce.

Based on the currently available evidence, modern technologies should be regarded as valuable adjuncts rather than substitutes for conventional behavior management strategies in pediatric dentistry. They should complement, rather than replace, effective communication and established behavioral techniques within a comprehensive patient-centered approach aimed at reducing anxiety and improving the quality of dental care. Future well-designed clinical trials involving larger populations and standardized outcome measures are required to determine the optimal application of these technologies in everyday clinical practice.

### **Summary of findings**

Dental anxiety in children represents a major clinical concern that negatively influences patient cooperation, treatment outcomes, and long-term attitudes toward dental care. Contemporary technological advances have provided novel opportunities to complement traditional behavior management strategies and reduce stress associated with dental treatment.

The available evidence indicates that virtual reality, audiovisual distraction techniques, and mobile applications can effectively support anxiety management in pediatric dentistry. Virtual reality and audiovisual interventions appear to provide the greatest benefits during dental procedures by diverting children's attention away from unpleasant stimuli and reducing pain perception. In contrast, mobile applications are particularly useful during the preparatory phase, promoting familiarization with the dental environment and improving children's understanding of dental procedures.

Although these technologies show considerable promise, substantial heterogeneity among studies and the lack of standardized protocols limit the formulation of definitive clinical recommendations. Therefore, further well-designed clinical trials are necessary to determine the optimal use of these interventions and to evaluate their long-term effectiveness and safety.

### **Conclusions**

- Modern technologies may effectively complement conventional behavior management techniques in pediatric dentistry, contributing to reductions in anxiety, pain, and stress associated with dental procedures.
- Virtual reality and audiovisual distraction techniques are among the most effective methods for reducing anxiety during treatment; however, the choice of intervention should be individualized according to the child's age, the type of procedure, and the resources available in the dental practice.
- Mobile applications may represent valuable tools for preparing children for dental visits by enhancing procedural familiarity, providing education, and increasing patients' sense of control.

The use of modern technologies should be integrated into a comprehensive patient-centered approach and should complement effective communication and established behavioral techniques, thereby improving treatment experiences and promoting positive attitudes toward oral healthcare.

**Authors' contribution:****Research concept and design** – Martyna Smogór**Data collection and/or compilation** – Maria Torchalska, Monika Szerszeń**Data analysis and interpretation** – Maria Torchalska, Monika Szerszeń**Writing** – Martyna Smogór, Krzysztof Kowalik**Supervision, project administration** - Martyna Smogór, Krzysztof Kowalik**Funding statement:** This research received no external funding.**Conflict of interest statement:** The authors declare no conflict of interest.**REFERENCES**

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