Review Article

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Immersive Distraction: The Role of Virtual Reality in Managing Pain and Anxiety Among Pediatric Dental Patients - A Comprehensive Review
Running head: Virtual Realityin Pediatric Dentistry

Abstract: Pain and anxiety remain major behavioral barriers to successful dental treatment in children. Virtual Reality (VR)—an immersive digital environment that redirects attention away from unpleasant stimuli—has emerged as a promising non-pharmacological tool for managing dental fear and pain in pediatric patients. This review aims to critically evaluate and synthesize the current evidence regarding the effectiveness, underlying mechanisms, benefits, and limitations of VR in reducing pain and anxiety during pediatric dental procedures. An integrative literature review was conducted across databases until August, 2025. It was found that VR distraction has been shown to significantly lower self-reported pain and anxiety compared with conventional behavioral management techniques. Physiological markers, including heart rate and salivary cortisol, were also reduced in children exposed to VR. Most participants experienced positive emotions, greater comfort, and improved cooperation during dental procedures. However, variability in VR hardware, software content, and study methodologies limits the ability to directly compare results across studies. Additional considerations such as cost, hygiene protocols, and practical implementation pose challenges for routine clinical integration. In conclusion, VR provides a safe, child-friendly, and engaging approach to managing pain and anxiety during pediatric dental procedures. While existing evidence is encouraging, further large-scale, standardized, and long-term studies are needed to confirm its clinical efficacy and feasibility.

Key-words : Virtual reality, pediatric dentistry, pain management, dental anxiety, behavioral management, immersive distraction

Introduction:

Pain and anxiety continue to be major obstacles to effective dental care in children. Dental fear often emerges early, influenced by previous painful experiences, parental anxiety, or sensory triggers such as the sight or sound of dental instruments. If left unaddressed, this fear can result in treatment avoidance, disruptive behavior, and long-term neglect of oral health.[1]

Traditional behaviour management strategies in pediatric dentistry (PD) include psychological techniques such as Tell-Show-Do, modelling, positive reinforcement, and distraction.[2] While these approaches are effective for many children, they may be insufficient for those with high anxiety or behavioural challenges. Pharmacological methods, including sedation or general anaesthesia, can facilitate cooperation but carry safety, ethical, and cost concerns.[3] This has led to increased interest in non-invasive, technology-assisted interventions that reduce distress while promoting compliance.

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Virtual Reality (VR) has emerged as a promising tool, providing a computer-generated, three-dimensional environment that delivers immersive sensory experiences via head-mounted displays, allowing users to perceive themselves within a simulated world. By redirecting attention away from painful or anxiety-provoking stimuli, VR engages sensory and cognitive pathways to modulate both emotional and physiological responses. Unlike conventional distractions such as cartoons, VR fully isolates children from external stimuli, offering deeper psychological immersion and enhanced therapeutic potential.[4]

The theoretical basis for VR's anxiolytic and analgesic effects is grounded in the Gate Control Theory of Pain, which suggests that cognitive and emotional processes can modulate pain transmission at both spinal and cortical levels.[5] Engagement with a virtual environment diverts attention, thereby suppressing pain signalling. Additionally, immersive VR experiences can evoke positive emotions such as curiosity, enjoyment, and a sense of control, which help counteract fear and distress. Neuroimaging studies further demonstrate that VR reduces activation in pain-related brain regions, including the anterior cingulate cortex and somatosensory areas.[6]

Multiple studies in PD have reported significant reductions in anxiety and pain when VR is used during procedures such as local anesthesia, restorative treatments, and prophylaxis.[7,8] However, differences in study design, VR equipment, and assessment tools limit the generalizability of these findings.

Methodology:

The purpose of the study was to synthesize and consolidate existing evidence regarding the effectiveness of VR in reducing pain and anxiety during pediatric dental procedures. Literature searches were performed across PubMed, Scopus, Web of Science, and Google Scholar. Search terms included virtual reality, immersive technology, pediatric dentistry, pain, anxiety, and behaviour management. Studies on children and adolescents aged ≤ 18 years undergoing dental treatment with the use of immersive or semi-immersive VR were extracted. The literature search included studies until August, 2025.

The key findings from recently published relevant studies have been summarized and presented descriptively, organized under appropriate thematic headings to highlight important insights.

Neuropsychological and Behavioural Basis of VR Analgesia:

Pain and anxiety are multidimensional experiences shaped by sensory, cognitive, and emotional interactions. Virtual Reality modulates these processes simultaneously by redirecting attention, regulating emotions, and influencing neural pain pathways.[9]

1. Cognitive Distraction and Attention Modulation: The primary mechanism of VR lies in attentional diversion, where engaging visual and auditory stimuli compete with pain signals for cognitive processing.[10] As per the Gate Control Theory of Pain, focused attention can dampen nociceptive transmission.[5] Neuroimaging studies using fMRI reveal that VR reduces activity in the anterior cingulate cortex and somatosensory regions, both linked to pain perception.[11] Given their strong imaginative capacity, children respond more effectively to VR than to conventional distraction methods.[12]

2. Emotional Regulation and Fear Reduction:

VR environments—ranging from interactive games to tranquil landscapes—evoke positive emotions, curiosity, and relaxation, counteracting fear and anticipatory stress.[13] Immersion in such settings stimulates dopaminergic and serotonergic pathways, normalizing the stress response and lowering cortisol secretion.[14] These neurochemical effects reduce physiological arousal and foster cooperative behaviour during dental care.[15]

3. Perceptual Immersion and Presence:

The sense of "presence" within a virtual environment intensifies emotional engagement and pain inhibition.[16] Fully immersive systems using head-mounted displays (HMDs) offer superior distraction compared to semi- or non-immersive formats. Higher perceived presence correlates strongly with lower self-reported pain and anxiety levels.[17]

4. Neurobiological Mechanisms:

VR influences several pain- and anxiety-related neural networks:

- Reduced thalamic and insular activation, corresponding with decreased pain signaling.[18]
- Enhanced prefrontal cortex activity, facilitating top-down control over pain.[14]

- Suppressed amygdala response, diminishing emotional fear processing.[6]
- Activation of the periaqueductal gray (PAG), promoting endogenous opioid-mediated pain relief.[11]

5. Pediatric-Specific Behavioral Mechanisms: Children's neurocognitive plasticity and rich imaginative tendencies amplify VR's effectiveness. Immersive experiences shift attention from threat to exploration, improving compliance and trust. Moreover, repeated exposure to VR prior to dental visits can foster positive conditioning, reducing long-term dental fear and anxiety.[19]

Virtual Reality Systems in Pediatric Dentistry:

Virtual Reality systems utilized in PD differ considerably in their design, degree of immersion, and operational requirements. A clear understanding of their structural components and practical implementation factors is crucial for their successful integration into clinical practice.

They systems can be broadly categorized into[18]:

1. Fully Immersive Systems:

Fully immersive VR setups utilize HMDs or goggles that completely enclose the user's visual field, presenting stereoscopic images with synchronized audio. These systems provide the greatest sense of presence and engagement, making them particularly effective for distraction during dental procedures. These systems remain the most widely used in PD, as they provide maximum sensory isolation and engagement, effectively minimizing the child's awareness of clinical stimuli.

2. Semi-Immersive Systems:

Semi-immersive VR systems utilize large projection screens or CAVE (Cave Automatic Virtual Environment) setups, enabling partial engagement with the virtual environment. While they allow children to remain somewhat aware of their surroundings, their use in dental clinics is often limited by space constraints.

3. Non-Immersive Systems:

Non-immersive systems deliver interactive VR content via desktop monitors or tablets, offering a less immersive but more accessible and cost-effective option. These are particularly useful for pre-treatment familiarization or educational purposes.

Core Components of a Dental VR Setup:

A typical VR system used in PD consists of three core components—hardware, software, and interface control—each tailored to enhance comfort, safety, and usability in the clinical setting[6]:

1. Hardware:

Modern systems incorporate lightweight HMDs such as *Oculus Quest, Pico G2,* or *HTC Vive Focus*, paired with headphones for immersive binaural sound and optional handheld controllers. Pediatric models are specifically scaled down and ergonomically designed to ensure a secure and comfortable fit for children.

2. Software:

Applications include interactive games, soothing animations (like underwater or space environments), and educational simulations about dental visits. These programs are customized to match the child's age, cognitive level, and emotional needs, optimizing engagement and distraction.

3. Interface and Control:

Most systems offer wireless control through smartphones or by dental assistants, allowing real-time content adjustment without disrupting the ongoing procedure.

4. Recent Advancements:

Newer developments include wireless, standalone headsets that eliminate cable clutter and sanitizable silicone covers to meet infection control standards, enhancing both safety and practicality in dental environments.

Content Design and Customization:

Content quality is a crucial determinant of patient engagement, emotional regulation, and therapeutic effectiveness in VR-assisted dental care. For optimal outcomes, VR applications designed for PD should adhere to the following principles[20]:

1. Encourage relaxation through calm, nature-inspired environments or guided breathing and mindfulness scenes.
2. Incorporate interactive game elements that sustain attention and transform passive distraction into active participation.
3. Minimize rapid visual transitions or excessive motion to prevent cybersickness and discomfort.
4. Ensure age-appropriateness and cultural neutrality, fostering inclusivity and comfort for diverse pediatric populations.

Evidence indicates that interactive VR experiences outperform passive visualizations in reducing both anxiety and perceived pain. Additionally, children report greater enjoyment and satisfaction when VR scenarios allow autonomy, such as controlling avatars or completing engaging in-game tasks, enhancing their sense of control and cooperation during treatment.[21]

Integration into the Dental Workflow:

Incorporating VR into pediatric dental practice can be achieved with minimal disruption when systematically organized. A structured workflow enhances both clinical efficiency and patient comfort, typically following these steps:[22]

1. Pre-procedure familiarization: Allow the child to handle and briefly explore the headset (1–2 minutes) to reduce novelty-related anxiety and ensure a comfortable fit.
2. Application during anxiety-triggering stages: Deploy VR during local anesthesia administration, drilling, or other potentially distressing phases to maximize its distraction effect.
3. Monitoring and communication: Maintain verbal reassurance or use gentle shoulder taps for communication, as children wearing HMDs cannot maintain eye contact.
4. Post-procedure debrief: Collect brief feedback from the child to evaluate comfort, enjoyment, and engagement, helping refine future sessions.

Team training is essential to ensure smooth implementation—staff should be proficient in device setup, hygiene maintenance, content selection, and basic troubleshooting.[23] Proper preparation minimizes workflow interruptions and enhances both child cooperation and clinical productivity.

Infection Control and Safety:

Due to the direct facial contact involved, maintaining rigorous infection control standards is crucial when using VR in pediatric dental settings. Headsets should be thoroughly disinfected with alcohol-free medical-grade wipes between patients to prevent skin irritation and microbial contamination. The use of disposable sanitary covers, silicone protectors, or single-use mask interfaces further enhances hygiene. In response to clinical needs, several manufacturers now produce healthcare-adapted VR headsets featuring antimicrobial coatings, detachable washable parts, and fluid-resistant materials.[24]

Safety measures should include:

- Ensuring the child can easily communicate discomfort or nausea (e.g., via a hand signal).
- Confirming the headset fits securely without impeding access to the oral cavity or dental instruments.
- Maintaining continuous visual monitoring of the child's posture, breathing, and overall responsiveness.

Cost and Feasibility Considerations:

Historically, high equipment costs limited the adoption of VR in dental clinics; however, the advent of affordable, wireless standalone headsets has significantly improved accessibility. Devices priced between USD 250–400 now offer high-quality visuals, built-in tracking, and minimal maintenance requirements, making them practical for pediatric practices of varying scales.[25]

From an economic standpoint, the initial investment is often offset by the benefits of enhanced patient cooperation, reduced reliance on sedation, and shorter chairside durations, collectively improving clinic efficiency and throughput.[14] Additionally, because these systems can serve dual purposes—behavioral management and preventive education—they provide sustained value over time.[26] Feasibility assessments further demonstrate strong stakeholder acceptance, with more than 90% of parents and dental professionals expressing willingness to incorporate VR in future appointments.[15] This high acceptance underscores the practicality, cost-effectiveness, and scalability of VR integration in pediatric dental care.

Evidence from Literature:

Over the past decade, a growing body of randomized and observational studies has examined VR as a non-pharmacological approach for managing pain and anxiety in pediatric dentistry. Initial research primarily explored feasibility and acceptability, but recent systematic reviews and meta-analyses offer strong evidence supporting its clinical effectiveness.[27]

1. Evidence from Systematic Reviews and Meta-Analyses:

Table 1 presents pooled evidence from high-level reviews confirming VR's analgesic and anxiolytic effects in children.

Table 1- Summary of Systematic Reviews and Meta-Analyses on Virtual reality in Pediatric Dentistry

Author	Studies	Age Range	Measured Outcomes	Main Conclusions
Cunningham et al. 2021[28]	4 studies	<? 18 years	Anxiety	Promising tool to reduce anxiety
Eren & Dursun, 2023[29]	15 studies	5–10 years	Pain, anxiety	Strong evidence for VR superiority; moderate heterogeneity
Barros Padilha et al., 2023[30]	22 studies	<? 18 years	Pain, anxiety	Effective method of behaviour management, alleviating pain, and anxiety

(VR: Virtual reality)

1. Evidence from Randomized Controlled Trials (RCTs): Multiple RCTs have demonstrated the effectiveness of VR distraction in reducing pain and anxiety during pediatric dental procedures.

Across these RCTs, consistent patterns are observed: children show increased relaxation, better compliance, and reduced procedure durations. Importantly, no study reported adverse effects severe enough to warrant discontinuation of treatment.

Table 2 consolidates high-quality RCTs establishing VR's efficacy in pediatric dental behavior management.

Table 2- Summary of Major Randomized Controlled Trials on Virtual reality in Pediatric Dentistry

Author	Sample Size /Age	Dental Procedure	Outcome Measures	Main Findings
Shetty et al., 2019[23]	120; 4–6 years	Local anesthesia	MCDAS, WBFP	Significant ? anxiety and pain in VR vs control
Al-Halabi et al., 2020[8]	80; 5–8 years	Restorative procedures	FLACC, FIS	Improved cooperation; ? anxiety and pain
Niharika et al., 2021[31]	90; 6–10 years	Cavity preparation	MCDAS, WBFP	35% ? anxiety and 30% ? pain compared to control
Shetty & Hegde, 2022[32]	50; 4–8 years	Split-mouth restorative treatment	FIS, FLACC	Consistent anxiety reduction in VR-assisted visits

(MCDAS: Modified Child Dental Anxiety Scale, WBFP: Wong-Baker FACES Pain Scale; FLACC: Face, Legs, Activity, Cry, Consolability scale; FIS: Facial Image Scale; HR: heart rate; VR: Virtual reality)

1. Comparative Studies:

When compared with other distraction or behavior management strategies, VR consistently shows superior outcomes:

a) VR vs. Audiovisual distraction (TV/cartoons): VR produced significantly greater reductions in both anxiety and pain levels.[8]

b) VR vs. Music distraction: VR resulted in higher engagement and longer sustained calmness during treatment.[23]

c) VR vs. Tell-show-do: VR yielded better behavioural ratings (Frankl scale) and required fewer verbal reinforcements from clinicians.[31]

d) VR + Tell-show-do combination: Some trials indicate synergistic benefits, suggesting that VR can complement traditional techniques rather than replace them.[15]

However, comparisons with pharmacological methods (e.g., nitrous oxide) remain limited. Preliminary results show that VR may reduce the need for mild sedation in moderately anxious children.[29]

4. Quantitative Summary of Outcomes:

Table 3 quantitatively summarizes VR's impact across behavioral and physiological domains in pediatric dental settings.

Table 3- Reported Clinical and Psychological Benefits of Virtual reality in Pediatric Dentistry

Outcome Measure	Effect of VR vs. Control	Evidence Strength	Author
Anxiety (MCDAS, FIS)	? 35–60% reduction	High (Meta-analyses)	Eren & Dursun, 2023[29]; Pakkar et al., 2024[15]
Pain (WBFP, FLACC)	? 30–50% reduction	High	Shetty et al., 2019[7]; Al-Halabi et al., 2020[8]
Heart Rate / Cortisol	? 10–20% decrease	Moderate	Garrett et al., 2014[6]; Li et al., 2011[14]
Cooperation (Frankl scale)	? 20–40% improvement	Moderate	Shetty & Hegde, 2022[32]; Niharika et al., 2021[31]
Adverse Effects	Rare (<2% mild discomfort)	High	Eren & Dursun, 2023[29]

(MCDAS: Modified Child Dental Anxiety Scale, WBFP: Wong-Baker FACES Pain Scale; FLACC: Face, Legs, Activity, Cry, Consolability scale; FIS: Facial Image Scale; VR: Virtual reality)

Benefits and Clinical Strengths:

1. Effective Reduction of Pain and Anxiety: A key benefit of VR is its consistent ability to alleviate both subjective and physiological measures of pain and anxiety. By engaging attentional and emotional resources, VR diverts focus from unpleasant dental stimuli, providing a psychological buffer that reduces distress.[4]

Meta-analytic evidence indicates that children exposed to VR during dental procedures experience 35–60% reductions in anxiety and 30–50% reductions in pain intensity, with effect sizes similar to those achieved with mild pharmacological interventions.[29]Physiological markers, including heart rate, galvanic skin response, and salivary cortisol, also show significant decreases during VR use.[6]

2. Improved Cooperation and Behavioral Control: Dental anxiety in children often manifests as avoidance, crying, or physical resistance, which can complicate treatment.[1] The immersive, game-like experience of VR fosters calmness and curiosity, enhancing patient cooperation.

Research using the Frankl Behavior Rating Scale shows that children using VR are two to three times more likely to display positive behavior during procedures compared to those receiving standard Tell-Show-Do or audiovisual distraction.[23]

For children with developmental or behavioral disorders, VR's structured sensory engagement can help reduce hyperactivity and improve attention, facilitating smootherdental treatment.[22]

3. Enhancement of Positive Dental Experiences: Qualitative research shows that over 90% of children describe VR as "fun," "exciting," or "relaxing" and are willing to use it in future dental visits.[20] Parents also report reduced pre-treatment anxiety and greater overall satisfaction with care.[12] Such experiences contribute to positive conditioning, helping to reduce dental fear over successive visits.[29]

4. Safe and Non-Invasive Alternative to Sedation:

Unlike pharmacological methods such as nitrous oxideo or oral sedation, VR is entirely non-invasive and carries minimal medical risk.[25]Pediatric dental trials report no serious adverse events, with only occasional mild dizziness or discomfort (<2%) that resolves spontaneously.[15]

By promoting relaxation without pharmacological side effects, VR serves as a viable alternative for children whoare medically unsuitable for sedation or in settings lacking anesthesia facilities.[14]

5. Efficiency and Time Optimization:

Dental professionals have observed notable improvements in clinical efficiency when VR is incorporated into treatment protocols.[32] Calm and cooperative children allow for faster administration of local anesthesia, smoother restorative procedures, and reduced reliance on behavioral management techniques.

Some studies report an average 10–20% reduction in total chairside time, due to fewer behavioral interruptions and shorter acclimation periods.[21] This enhanced efficiency can increase patient throughput, reduce practitioner fatigue, and indirectly improve the overall quality of care.

6. Accessibility and Cost-Effectiveness:

The advent of affordable standalone VR devices has significantly lowered the cost barrier for clinical use.[25] Modern wireless headsets, priced between USD 250–400, are reusable and require minimal maintenance.

By potentially decreasing the reliance on sedation and shortening chairside time, VR offers a long-term economic advantage, particularly in busy pediatric practices. Additionally, because children often view VR as entertainment, its use can enhance patient engagement and satisfaction without imposing substantial financial burden.[19]

7. Parental and Dentist Acceptance:

The support of parents and clinicians is essential for the successful adoption of new behavioral tools. Surveys indicate that over 90% of parents are satisfied with VR-assisted dental visits and are willing to let their children use it again.[29]

Dentists also report improved workflow, reduced stress, and enhanced engagement during procedures.[23] With minimal initial training, most clinicians can become proficient in a few sessions. These results underscore VR's practicality and high acceptability among both families and dental care providers.

8. Psychological Empowerment and Autonomy:

Virtual reality offers children a sense of control during dental treatment, which is crucial for reducing fear and fostering resilience.[20] Interactive or gamified VR environments provide tasks or goals, turning passive anxiety into active engagement. This enhanced autonomy aligns with self-determination theory, reinforcing motivation, confidence, and trust in the dental setting.[33]

Limitations and Challenges:

Despite notable advances in using VR for managing pediatric dental anxiety and pain, several limitations and practical challenges continue to hinder its broader clinical implementation.

1. Methodological Limitations in Current Evidence: Most existing studies are short-term, single-center trials with a limited sample, which restrict their statistical power and generalizability.[15] Additionally, many investigations are conducted in controlled academic settings rather than busy, real-world clinics, limiting the assessment of practical feasibility.[29]

A key methodological issue is the lack of blinding, as both children and clinicians are aware of VR exposure, potentially introducing performance bias.[22] Furthermore, some studies do not adequately account for confounding variables, such as previous dental experiences, parental anxiety, or the novelty effect of VR, which can influence outcomes.[19]

2. Technical and Operational Barriers:

While VR technology is becoming more cost-effective, its clinical implementation still faces logistical and technical challenges. Proper sanitation between patients is essential, especially in pediatric settings with strict infection control requirements.

Another limitation is the scarcity of pediatric-specific VR content; many applications are adapted from general entertainment or gaming platforms rather than being designed for dental care. Additionally, some devices may cause mild cybersickness, eye strain, or motion-related discomfort, particularly in younger children.[25]

Integrating VR into routine clinical workflows can also temporarily disrupt standard procedures, as dental teams must divide attention between the treatment and monitoring the child's VR experience.[23] However, with adequate training and preparation, these operational challenges are generally manageable and short-term.

3. Lack of Standardization and Protocol Uniformity:

At present, there is no universally accepted clinical protocol for VR use in PD.[34] Existing studies vary considerably in timing (pre-procedure, during the procedure, or for the entire session), duration (ranging from 3 to 15 minutes), and immersion level (semi-immersive versus fully immersive).[6]

Establishing standardized protocols is essential to ensure reproducibility and comparability of research findings. Developing consensus-based guidelines for VR interventions would help define optimal exposure times, headset specifications, and validated outcome measures for assessing anxiety, cooperation, and overall effectiveness.

4. Ethical and Safety Considerations:

Before widespread adoption, ethical concerns related to screen time, data privacy, and informed consent must be addressed. Although serious adverse events are rare, some children may experience dizziness, mild nausea, or discomfort, highlighting the need for pre-procedure screening.[4]

Special precautions are warranted for children with photosensitive epilepsy, severe motion sensitivity, or certain neurodevelopmental disorders.[12] Institutional review boards should ensure proper informed consent, emphasizing voluntary participation and parental awareness to safeguard child welfare.

Research Gaps and Future Directions:

Future studies should progress beyond initial proof-of-concept work toward longitudinal, multicenter, and interdisciplinary research designs. Over the next decade, several priority areas should be addressed[9,22]:

1. Standardized Evaluation Metrics:

Create and validate consistent tools for assessing anxiety and pain specific to VR-based interventions.

2. Technological Innovation:

Develop biofeedback-integrated VR systems that dynamically adjust content intensity based on physiological signals, such as heart rate or pupil dilation.

3. Personalized VR Content:

Design adaptive virtual environments that account for age, cognitive ability, and cultural background, maximizing engagement and emotional impact.

4. Integration with Artificial Intelligence (AI):

Leverage AI to monitor child responses in real time and modify VR scenarios accordingly, enhancing personalization and therapeutic precision.

5. Long-Term Psychological Impact:

Evaluate the sustained effects of VR across multiple dental visits, including its role in fear desensitization and promotion of preventive dental behaviors.

6. Cost-Effectiveness Analyses:

Conduct thorough cost-benefit evaluations comparing VR to sedation and traditional behavioral management approaches, accounting for setup, maintenance, and operational expenses.

The Future Landscape of VR :

The advent of lightweight, wireless, and easily sterilizable headsets is making VR technology increasingly accessible and suitable for infection-controlled clinical settings. The integration of Augmented Reality (AR) holds potential to enhance clinician–patient interaction, allowing children to remain aware of their surroundings while benefiting from immersive distraction.[35]

Moving forward, collaborative efforts among dental professionals, psychologists, engineers, and software developers will be crucial to develop VR systems that are both clinically effective and tailored to pediatric needs. As VR converges with artificial intelligence and sensor-based feedback, PD is poised to evolve into an era of interactive, engaging, and fear-free dental care experiences.

Clinical Recommendations:

1. Pre-procedure Familiarization: Allow children to interact with the VR setup for 1–2 minutes before beginning treatment to minimize anxiety associated with novelty.

2. Procedure Selection:

Implement VR distraction during high-stress phases of treatment (such as administration of local anesthesia or tooth preparation) to achieve optimal anxiety and pain reduction.

3. Content Customization:

Choose age-appropriate, low-motion, and interactive VR content to maintain engagement without causing discomfort or motion sickness.

4. Infection Control:

Employ disposable face shields or silicone protective covers for each patient to ensure hygienic use of VR headsets.

5. Documentation:

Note the use of VR as a behavioral management strategy in the patient's clinical record.

6. Training:

Offer basic training to dental staff on VR headset operation, maintenance, and child monitoring during its use.

Conclusion:

The incorporation of VR into PD marks a major advancement toward child-centered and anxiety-free dental care. Scientific evidence consistently indicates that VR effectively reduces pain, anxiety, and physiological stress, while improving patient cooperation and treatment experience.

By immersing children in interactive, multisensory environments, VR diverts their focus away from unpleasant dental stimuli, activating cognitive, emotional, and neurobiological pathways associated with relaxation and analgesia. This approach is especially beneficial for children, who are naturally more imaginative and responsive to visual and interactive engagement.

Clinically, VR functions as a non-invasive, affordable, and well-accepted behavioral aid, complementing established techniques like Tell-Show-Do and positive reinforcement. Its capacity to reduce reliance on sedation or pharmacological management enhances safety, efficiency, and parental reassurance. Furthermore, the versatility of VR enables its application across across a wide spectrum of dental procedures, including prophylaxis, local anesthesia, restorative care, and extractions.

Although substantial short-term evidence supports the use of VR in PD, the existing literature remains limited by the absence of standardized protocols, long-term follow-up data, and multicenter validation. Future investigations should aim at formulating standardized clinical protocols, integrating AI-driven adaptive VR systems, and designing culturally sensitive and child-specific virtual environments to enhance the generalizability and sustainability of outcomes across diverse pediatric populations.

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