

REVIEW



Sedation alternatives, behavioral therapy, and patient experience design in modern dentistry: A comprehensive review

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ABSTRACT

Dental anxiety is a significant barrier to optimal oral healthcare, affecting millions worldwide. Traditional pharmacologic sedation methods such as nitrous oxide, oral benzodiazepines, and intravenous sedation are effective but carry potential risks, high costs, and accessibility issues. In this comprehensive review, literature was selected through systematic searches in PubMed, Scopus, and Web of Science databases, covering publications from January 2000 to June 2025, using keywords such as dental anxiety, sedation alternatives, behavioral therapy, and patient experience. The review includes randomized controlled trials, meta-analyses, and clinical reports in English. The research gap lies in the limited integration of multidisciplinary, technology-driven, and behavior-based approaches as mainstream dental anxiety management strategies, despite growing evidence of their effectiveness. This article explores non-pharmacologic interventions including cognitive behavioral therapy (CBT), exposure therapy, virtual reality (VR), music therapy, aromatherapy, biofeedback, and patient experience are designed to address anxiety, enhance comfort, and improve treatment adherence. The paper also discusses implementation challenges, comparative outcomes, and limitations, concluding with future directions for integrating these methods into modern dentistry. By bridging psychology, technology, and environmental design, this review aims to guide practitioners toward safe, cost-effective, and patient-centered care models.

KEY WORDS

Dental anxiety; Sedation alternatives; Cognitive behavioral therapy; Virtual reality; Patient experience design

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Introduction

Dental phobia affects approximately 15–20% of the global population [1], leading to avoidance of routine care, increased emergency visits, and poorer oral health outcomes. Traditional management relies heavily on pharmacologic sedation methods, ranging from nitrous oxide to general anesthesia. While effective, these methods present risks such as respiratory depression, prolonged recovery, high operational costs, and the need for specialized infrastructure [2,3]. They are also less suitable for certain patient populations, such as medically compromised, pediatric, or geriatric patients [4].

Over the past decade, dentistry has seen a marked shift toward non-pharmacologic anxiety management strategies. These include behavioral therapies, sensory distraction techniques, patient-centered clinic design, and bioadaptive technologies [5]. These approaches aim not only to reduce procedural fear but also to foster long-term trust and enhance the entire patient journey [6]. Evidence from psychology, neuroscience, and design research supports their capacity to positively influence patient perception and physiological responses.

Although multiple non-pharmacologic strategies have been individually validated, there is a lack of integrated, evidence-based frameworks that combine behavioral science, technology, and environmental design in dental care. Adoption remains inconsistent due to fragmented research, limited clinician training, and absence of standardized protocols.

Objectives

1. To review the evidence base for both established and emerging alternatives.

2. To categorize these methods into behavioral, technological, and design-based domains.
3. Comparing their effectiveness, feasibility, and patient satisfaction outcomes.
4. To identify barriers to implementation and propose strategies for integration into dental practice.

By presenting a structured synthesis of behavioral, sensory, and environmental strategies, this review provides clinicians, researchers, and policymakers with an evidence-based guide to sedation alternatives that are safer, more accessible, and more aligned with holistic patient care principles.

Methodology

This review was conducted using a structured literature search strategy. Electronic databases like PubMed, Scopus, and Web of Science were searched for publications between January 2000 and June 2025. Search terms included combinations of “dental anxiety”, “sedation alternatives”, “behavioral therapy”, “virtual reality dentistry”, and “patient experience design”.

Inclusion criteria

- Randomized controlled trials, systematic reviews, meta-analyses, and observational studies in English.
- Studies involving both pediatric and adult populations.
- Interventions focusing on non-pharmacologic methods or direct comparisons with pharmacologic sedation.

Exclusion criteria

- Studies solely examine pharmacologic sedation without alternative interventions.
- Non-peer-reviewed reports and conference abstracts.

Data extraction focused on intervention type, study design, sample size, anxiety measurement tools, primary outcomes, and limitations. The findings were synthesized into three domains: behavioral therapies, technological/sensory interventions, and patient experience design.

Types of Sedation

Inhalational sedation (Nitrous Oxide): Delivered by a nasal hood, nitrous oxide provides rapid onset, adjustable sedation levels, and quick recovery. It is widely used for anxious pediatric and adult patients but requires monitoring for diffusion hypoxia [7].

Oral sedation (Benzodiazepines): Agents such as diazepam or midazolam are administered orally to reduce anxiety. They are easy to give but have variable absorption rates, unpredictable peak effects, and longer recovery periods [8].

Intravenous (IV) sedation: Delivers agents like midazolam directly into the bloodstream, allowing rapid titration and deeper sedation levels. Requires venous access, continuous monitoring, and trained personnel [9].

General anesthesia: Induces complete unconsciousness, indicated for extensive dental procedures or patients unable to tolerate care otherwise. Carries the highest risk and requires specialized facilities, anesthesiologists, and extended recovery monitoring [10].

Need for Alternatives

While pharmacologic sedation is effective, its limitations necessitate the development and use of alternatives [11]:

- **Safety:** Risks include respiratory depression, allergic reactions, and drug interactions.
- **Patient Suitability:** High-risk populations such as the elderly, children, pregnant women, and medically compromised patients require safer options.
- **Cost and Accessibility:** Sedation involves specialized equipment, trained personnel, and recovery spaces, raising costs.
- **Ethical & Legal Concerns:** Informed consent complexity, potential over-sedation, and medico-legal risks.
- **Patient Preference:** Growing demand for minimally invasive, drug-free care.

Evidence indicates that non-pharmacologic strategies can achieve comparable anxiety reduction while avoiding these drawbacks.

Table 1. Sedation alternatives comparison.

Alternative	Mechanism	Advantages	Limitations
Cognitive Behavioral Therapy (CBT)	Modifies maladaptive	Long-term benefit; no drugs	Requires multiple sessions; trained therapist
Virtual Reality (VR)	Immersive distraction from dental stimuli	Immediate effect; high engagement	Equipment cost; unsuitable for some patients

Music Therapy	Auditory relaxation	Low-cost; customizable	Effectiveness varies; passive engagement
Aromatherapy	Calming olfactory stimulation	Simple; non-invasive	Subjective response; possible allergies
Biofeedback	Real-time monitoring & control of stress	Personalized; improves self-regulation	Device cost; training needed
Patient Experience Design	Optimized clinic environment & workflow	Universal benefit; enhances comfort	May require infrastructure modifications

Limitations and Future Directions

Non-pharmacologic sedation alternatives have been shown to reduce physiological anxiety indicators like heart rate, salivary cortisol and improve patient-reported comfort. RCTs demonstrate significant anxiety reduction with VR, CBT, and patient experience design interventions [12].

Limitations include

- Variability in patient response.
- Need for specialized training.
- Initial setup and equipment costs.
- Multiple sessions required for some methods (e.g., CBT).
- Sensory interventions may be ineffective for certain individuals.

A multimodal approach combining behavioral, sensory, and environmental strategies appears to yield the best results in most clinical scenarios [13].

Future directions include AI-powered anxiety detection, gamified therapy platforms for children, and adaptive clinical environments that adjust in real time to patient physiology. Collaboration between dental professionals, psychologists, engineers, and designers will be essential for creating these innovations and ensuring accessibility across practice settings [14].

Ultimately, integrating these approaches has the potential not only to reduce procedural anxiety and improve compliance but also to redefine the dental experience as a positive, trust-building encounter.

Conclusion

The global burden of dental anxiety creates significant challenges for dental clinical care, affecting millions of individuals and driving avoidance, treatment delay, and poor oral health outcomes. Traditional pharmacologic sedation remains a mainstay, especially for severe anxiety and phobic cases. However, its limitations including risk, cost, accessibility, and inability to address deep-seated psychological causes underscore the urgent need for effective, patient-centered alternatives.

Contemporary research has firmly established the effectiveness of non-pharmacologic interventions such as cognitive behavioral therapy (CBT), technological strategies like virtual reality (VR), and holistic patient experience design. CBT stands out for its ability to deliver sustainable, long-term reductions in dental fear, improved treatment compliance, and decreased avoidance, especially when

combined with supportive communication and environmental adjustments. VR is rapidly gaining ground, especially in pediatric settings, for its capacity to distract and comfort, while biofeedback, music, and aromatherapy offer accessible adjuncts to standard care. Despite robust evidence for these alternatives, prominent barriers including lack of training, inconsistent standardization, and gaps in long-term outcome data contribute to underuse in routine dental practice. The most pressing research gaps involve the need for standardized intervention protocols, cost-effectiveness analyses, and pragmatic clinical trials that reflect real-world patient demographics and dental care environments. The role of interdisciplinary teamwork integrating dental professionals, psychologists, and patient experience designers should also be emphasized for best practice adoption.

Looking forward, the future of dental anxiety management will likely involve a tailored, integrative approach that harnesses pharmacologic and non-pharmacologic methods, is sensitive to individual patient needs (including children, elderly, and special populations), and is adaptable to diverse dental practice settings. Adoption of these patient-centered methods not only promise enhanced comfort and satisfaction but holds the potential to transform public oral health by increasing access, trust, and preventive care utilization. Dental practitioners are strongly encouraged to invest in evidence-based training, environmental improvements, and collaborative care models to ensure optimal outcomes for all patients. The transition from pharmacologic sedation to behavioral, sensory, and environmental approaches reflects a broader shift toward patient-centered, holistic dental care. These methods grounded in psychology, neuroscience, and design offer safe, cost-effective, and sustainable solutions for managing dental anxiety.

Behavioral strategies like CBT and exposure therapy address the root cognitive and emotional factors contributing to fear. Technological innovations such as VR and biofeedback provide real-time anxiety modulation, while sensory enhancements music therapy, aromatherapy, and optimized lighting further transform the clinical atmosphere into one of comfort and reassurance. Patients increasingly express preference for non-pharmacologic options, citing a desire for greater control, reduced recovery time, and avoidance of drugs. However, adoption is hindered by training gaps, equipment costs, and the absence of integrated guidelines in dental education.

Disclosure Statement

The author does not have conflict of interest in this research.

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