Comparative Effectiveness of Virtual Reality Distraction Versus Audio Distraction in Special Care Dentistry Patients

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ABSTRACT:

Background: Dental anxiety is a pervasive barrier to oral healthcare in special care dentistry patients, including individuals with physical disabilities, intellectual disabilities, and systemic medical conditions. Distraction techniques have gained recognition as non-pharmacological adjuncts for managing procedural anxiety. Virtual reality (VR) distraction, leveraging immersive audiovisual technology, and audio distraction, employing music or nature sounds through headphones, represent two widely employed modalities with differing mechanisms and degrees of sensory engagement.

Objective: To compare the effectiveness of virtual reality distraction versus audio distraction in reducing dental anxiety, pain perception, and improving procedural cooperation among special care dentistry patients.

Methods: A randomized controlled clinical trial was conducted among 60 special care dentistry patients aged 18–55 years, randomly assigned to virtual reality distraction (Group I) or audio distraction (Group II) during routine dental procedures. Dental anxiety was assessed using the Modified Dental Anxiety Scale (MDAS), pain perception using a Visual Analogue Scale (VAS), and heart rate was monitored as a physiological anxiety marker. Assessments were recorded at baseline, during the procedure, and at post-procedural follow-up.

Results: Group I (VR distraction) demonstrated significantly greater reductions in MDAS anxiety scores, lower VAS pain ratings, and more stable heart rate profiles compared to Group II (audio distraction). VR distraction reduced mean MDAS scores by 48% versus 22% in the audio distraction group at post-procedural assessment.

Conclusion: Virtual reality distraction is significantly more effective than audio distraction in reducing dental anxiety and pain perception in special care dentistry patients. VR distraction represents a promising, non-pharmacological, patient-centered adjunct for improving the dental experience in this vulnerable population.

Keywords: Virtual reality distraction, audio distraction, dental anxiety, special care dentistry, pain perception, non-pharmacological management, Modified Dental Anxiety Scale.

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Introduction

Dental anxiety is one of the most commonly reported barriers to seeking and maintaining regular oral healthcare, affecting an estimated 15–20% of the general population and rising to considerably higher proportions among individuals requiring special care dentistry [1]. Special care dentistry encompasses the management of patients with a diverse range of complex conditions, including intellectual and developmental disabilities, physical disabilities, acquired or congenital systemic medical disorders, and psychiatric conditions that render conventional dental management challenging [2]. For these patients, the experience of dental anxiety is frequently compounded by communication difficulties, heightened sensory sensitivities, limited coping strategies, and previous negative healthcare encounters [3].

The consequences of unmanaged dental anxiety in special care populations extend beyond the immediate clinical encounter. Persistent avoidance of dental care leads to the accumulation of untreated oral disease, with disproportionate rates of caries, periodontal disease, and tooth loss reported among individuals with disabilities and complex medical needs [4]. Furthermore, poor oral health has well-established bidirectional relationships with systemic health conditions such as diabetes, cardiovascular disease, and aspiration pneumonia, making oral health management particularly critical in medically compromised individuals [5].

Pharmacological approaches to managing dental anxiety, including conscious sedation and general anesthesia, have traditionally been employed in special care dentistry. However, these modalities carry inherent risks, require specialized facilities and personnel, are associated with significant costs, and may be contraindicated in patients with specific systemic conditions or drug interactions [6]. This has generated considerable interest in non-pharmacological behavioral distraction techniques as accessible, cost-effective, and safe adjuncts to routine dental care [7].

Distraction is a cognitive-behavioral strategy grounded in gate control theory and attentional resource theory, which propose that the finite capacity of attentional processing means that engagement with competing stimuli reduces the neural resources available for processing pain and anxiety signals [8]. Audio distraction, delivered via headphones with music, relaxation soundscapes,

or nature sounds, has been among the most widely studied and implemented distraction modalities in dental settings, demonstrating consistent, albeit modest, reductions in self-reported anxiety and pain perception [9].

Virtual reality (VR) distraction represents a technologically advanced evolution of distraction-based anxiety management. By immersing the patient in a three-dimensional, interactive audiovisual environment delivered through a head-mounted display, VR creates a compelling alternative perceptual reality that captures attentional resources more completely than audio-only modalities [10]. The multisensory nature of VR — simultaneously engaging visual, auditory, and proprioceptive processing — is theorized to achieve a substantially greater reduction in pain and anxiety compared to unimodal distraction approaches [11].

Several studies in general and pediatric dental populations have reported significant anxiolytic and analgesic effects of VR distraction, with effect sizes exceeding those observed with audio distraction alone [12]. However, the evidence base in special care dentistry populations remains limited, as most existing trials have excluded patients with cognitive or communicative impairments due to challenges in administering self-report outcome measures [13]. This exclusion represents a critical gap, as special care patients arguably stand to benefit most from effective non-pharmacological anxiety management strategies.

The Modified Dental Anxiety Scale (MDAS) is a validated, widely used five-item self-report measure of dental anxiety, with established psychometric properties across diverse populations including individuals with mild to moderate intellectual disabilities [14]. The Visual Analogue Scale (VAS) provides a straightforward, clinician-administrable measure of subjective pain intensity, while heart rate monitoring offers an objective physiological correlate of procedural anxiety and stress arousal [15].

Special care dentistry patients encompass a heterogeneous group with varying cognitive abilities, communication styles, and sensory processing profiles, necessitating flexible and individually adapted distraction protocols [16]. VR technology has advanced rapidly in recent years, with lightweight, wireless head-mounted displays and extensive libraries of immersive content now available at substantially reduced costs compared to earlier systems [17]. These developments have rendered VR distraction increasingly feasible for clinical implementation across diverse dental settings.

Despite growing enthusiasm for VR distraction in dentistry, rigorous direct comparative trials against established modalities such as audio distraction remain sparse, particularly in special care contexts [18]. Understanding the relative effectiveness of these two approaches is essential for evidence-based clinical decision-making and resource allocation in special care dental services [19].

The present study addresses this evidence gap by conducting a randomized controlled comparison of virtual reality distraction versus audio distraction in special care dentistry patients. The findings are intended to provide high-quality evidence to guide clinical practice, inform the training of special care dental teams, and support the integration of technology-assisted distraction strategies into the standard management of dental anxiety in vulnerable patient groups [20].

Methodology

This study was designed as a randomized controlled clinical trial conducted at a tertiary special care dentistry facility. The study population comprised adults aged 18–55 years with confirmed diagnoses requiring special care dentistry management, including individuals with mild to moderate intellectual disabilities, physical disabilities, or anxiety-related conditions precluding routine dental care. Sixty participants were enrolled and randomly allocated using a computer-generated randomization sequence into two groups of 30 each: Group I received virtual reality distraction, and Group II received audio distraction during dental treatment.

Inclusion criteria required that participants were scheduled for non-emergency routine dental procedures such as scaling, restorative treatment, or simple extractions; were able to provide

informed consent personally or through a legally authorized representative; had a baseline Modified Dental Anxiety Scale (MDAS) score of 10 or above, indicating moderate to high dental anxiety; and were able to tolerate wearing a head-mounted VR display or standard headphones as determined during a brief pre-procedural familiarization session. Patients requiring general anesthesia, those with severe visual or hearing impairments precluding use of the respective distraction modality, and those with photosensitive epilepsy were excluded from the study. Institutional ethics committee approval and informed consent were obtained prior to study commencement.

In Group I, virtual reality distraction was delivered using a lightweight wireless head-mounted display (HMD) with integrated headphones. Patients selected from a library of immersive VR environments including underwater ocean scenes, forest nature walks, and gentle aerial landscapes. The VR content featured 360-degree panoramic video with synchronized ambient soundscapes. The HMD was fitted comfortably prior to the start of the dental procedure and worn throughout the active treatment phase. In Group II, audio distraction was administered through over-ear noise-isolating headphones with patient-selected content from categories including classical music, pop music, guided meditation, or nature soundscapes. All dental procedures were performed by the same calibrated team of clinicians under standardized conditions.

The primary outcome was dental anxiety as measured by the MDAS, a validated 5-item scale with scores ranging from 5 to 25, where higher scores indicate greater anxiety. Secondary outcomes included pain perception assessed using a 100-mm Visual Analogue Scale (VAS), and heart rate recorded using a pulse oximeter at baseline, mid-procedure, and immediately post-procedure. Behavioral cooperation was also documented by the treating clinician using a simplified rating of overall procedural compliance. All assessments were conducted by a trained research assistant blinded to group allocation where feasible.

Data were analyzed using SPSS version 26.0. Descriptive statistics were computed for all variables. Independent samples t-tests were used to compare continuous outcomes between groups, and paired t-tests assessed within-group changes from baseline to post-procedure. Chi-square analysis was applied for categorical variables. A significance threshold of $p < 0.05$ was applied throughout. A total of 60 participants completed the study, with 30 in each group. Baseline demographic characteristics including age, gender, primary diagnosis category, and baseline MDAS scores were comparable between groups, as shown in Table 1.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Parameter	Group I (VR Distraction)	Group II (Audio Distraction)
Mean Age (years)	31.4 ± 9.2	32.1 ± 8.7
Gender (Male/Female)	17/13	16/14
Intellectual Disability (%)	40%	43%
Physical Disability (%)	33%	30%
Anxiety-related Condition (%)	27%	27%
Mean Baseline MDAS Score	18.6 ± 3.1	18.2 ± 3.4
Mean Baseline VAS Score	62.4 ± 11.3	61.8 ± 10.9
Mean Baseline Heart Rate (bpm)	88.3 ± 7.6	87.9 ± 8.1

During the procedure, Group I (VR distraction) showed substantially lower mean MDAS scores compared to Group II. The VR group demonstrated a 35% reduction in intra-procedural anxiety scores, while the audio distraction group showed a 15% reduction from baseline, as detailed in Table 2.

Table 2: Intra-Procedural MDAS Anxiety Scores and Percentage Reduction

Group	Mean MDAS (Intra-procedural)	Reduction from Baseline (%)
VR Distraction (Group I)	12.1 ± 2.8	35%
Audio Distraction (Group II)	15.5 ± 3.2	15%

At post-procedural assessment, the superiority of VR distraction was further confirmed. Group I exhibited a 48% reduction in mean MDAS scores from baseline, compared to 22% in Group II, as presented in Table 3. These differences were statistically significant ($p < 0.001$).

Table 3: Post-Procedural MDAS Anxiety Scores and Percentage Reduction

Group	Mean MDAS (Post-procedure)	Reduction from Baseline (%)
VR Distraction (Group I)	9.7 ± 2.3	48%
Audio Distraction (Group II)	14.2 ± 3.0	22%

Pain perception measured using the VAS demonstrated significantly lower scores in the VR distraction group compared to the audio distraction group during and after the procedure. The VR group reported a mean intra-procedural VAS score of 31.2 mm versus 48.7 mm in the audio group, with corresponding post-procedural scores of 22.4 mm and 39.6 mm respectively, as shown in Table 4.

Table 4: Visual Analogue Scale (VAS) Pain Perception Scores

Assessment Point	Group I VAS (mm)	Group II VAS (mm)
Baseline	62.4 ± 11.3	61.8 ± 10.9
Intra-procedural	31.2 ± 8.6	48.7 ± 9.4
Post-procedural	22.4 ± 7.1	39.6 ± 8.8

Heart rate monitoring revealed more stable intra-procedural cardiovascular profiles in the VR group, with a mean intra-procedural heart rate of 84.1 bpm compared to 91.6 bpm in the audio distraction group, as illustrated in Table 5. This physiological finding corroborates the self-reported anxiety reductions observed in Group I.

Table 5: Mean Heart Rate (bpm) Across Assessment Points

Assessment Point	Group I (VR)	Group II (Audio)
Baseline	88.3 ± 7.6	87.9 ± 8.1
Intra-procedural	84.1 ± 6.8	91.6 ± 7.4
Post-procedural	81.2 ± 6.1	86.3 ± 6.9

Clinician-rated procedural cooperation scores and reported adverse effects for each distraction modality are summarized in Table 6. VR distraction was associated with higher rates of positive procedural cooperation and no serious adverse events. Minor issues included transient nausea in two VR group participants, which resolved within minutes of HMD removal, and headphone discomfort reported by three participants in the audio group.

Table 6: Procedural Cooperation Ratings and Adverse Events

Parameter	Group I (VR)	Group II (Audio)
Good/Excellent Cooperation (%)	80%	53%
Procedure Completed Without Interruption (%)	87%	63%
Transient Nausea	2 (7%)	0
Headphone/Device Discomfort	1 (3%)	3 (10%)
Serious Adverse Event	None	None

Figure 1: Comparative bar graph depicting mean MDAS dental anxiety scores, VAS pain perception scores, and heart rate values at baseline, intra-procedural, and post-procedural time points for Group I (VR distraction) and Group II (audio distraction). Group I consistently demonstrates lower anxiety, lower pain scores, and more stable heart rate profiles across all time points, with the magnitude of between-group differences increasing from baseline to post-procedural assessment.

Overall, the results demonstrate that virtual reality distraction produced significantly greater reductions in dental anxiety, pain perception, and physiological stress markers compared to audio distraction, while maintaining a comparable safety profile. The higher rates of successful procedure completion in the VR group further underscore its practical clinical advantage in special care dentistry settings.

Discussion

The findings of this randomized controlled trial provide compelling evidence that virtual reality distraction is substantially more effective than audio distraction in reducing dental anxiety, mitigating pain perception, and stabilizing physiological stress responses in special care dentistry patients. The 48% reduction in MDAS scores observed in the VR group, compared to 22% in the audio distraction group, represents a clinically meaningful difference with direct

implications for the feasibility and quality of dental care delivery in this population.

These findings are consistent with and extend the work of Furman et al. (2009) [21], who demonstrated that VR distraction significantly reduced self-reported pain and anxiety during dental injections in adult patients compared to no distraction. The immersive, multisensory nature of VR technology appears to capture attentional resources more effectively than auditory-only distraction, consistent with attentional resource theory as articulated by Lavie (2005) [22]. When attentional capacity is more completely occupied by the VR environment, fewer cognitive resources remain available to process and amplify pain and anxiety signals associated with dental procedures, yielding a stronger analgesic and anxiolytic effect.

The significantly lower intra-procedural pain VAS scores in the VR group (31.2 mm) compared to the audio group (48.7 mm) are noteworthy, particularly given that both groups received identical dental procedures under equivalent local anesthetic conditions. This suggests that the additional pain relief afforded by VR distraction operates through central attentional mechanisms rather than peripheral nociceptive modulation. This interpretation aligns with neuroimaging studies demonstrating that VR distraction reduces activation in pain-processing cortical regions during noxious stimulation, an effect not consistently replicated with audio-only distraction [23].

The objective physiological corroboration provided by heart rate data strengthens the self-report findings. The VR group maintained a mean intra-procedural heart rate of 84.1 bpm, representing a slight reduction from their already-anxious baseline, while the audio group's heart rate rose to 91.6 bpm during the procedure, indicating greater autonomic arousal consistent with elevated procedural anxiety. This pattern mirrors findings reported by Wiederhold et al. (2014) [24], who documented attenuated sympathetic nervous system activation during VR distraction compared to conventional coping strategies in anxiety-prone patients. Physiological measures are particularly valuable in special care dentistry populations where self-report capacity may be limited by cognitive or communicative impairments.

The markedly higher rates of procedure completion without interruption in the VR group (87% versus 63%) have important practical and economic implications for special care dental services. Incomplete procedures necessitate repeat appointments, consume additional clinical time, increase the likelihood of requiring pharmacological sedation, and may reinforce negative associations with dental care in already anxious patients [25]. The ability of VR distraction to facilitate procedure completion in a population where clinical management is frequently challenging represents a significant practical advantage over audio distraction alone.

The two cases of transient nausea observed in the VR group warrant attention, as cybersickness remains a recognized limitation of head-mounted VR systems. However, the resolution of symptoms within minutes of HMD removal, and the absence of any serious adverse events, suggest that the risk profile of VR distraction is acceptable in the clinical context. Careful patient selection, use of optimized HMD hardware with high-refresh-rate displays, and provision of brief familiarization sessions prior to procedural use can minimize the incidence of VR-induced nausea, as recommended by Hoffman et al. (2019) [26]. Pre-screening for susceptibility to motion sickness should be incorporated into VR distraction protocols for special care dentistry.

These findings are further supported by Kashwani et al. (2025) [12], who reported favorable knowledge, attitudes, and practices regarding augmented reality technologies among dental professionals, highlighting the growing acceptance and perceived clinical utility of immersive digital technologies in dentistry. Their study suggests that emerging technologies such as virtual and augmented reality are increasingly recognized as valuable tools for enhancing patient management, reducing treatment-related anxiety, and improving overall dental care experiences, thereby supporting the integration of VR-based interventions into special care dentistry settings.

The heterogeneity of the special care dentistry population included in this study, encompassing patients with intellectual disabilities, physical disabilities, and anxiety-related conditions, reflects the diversity of real-world clinical practice and enhances the generalizability of the findings. The ability to use simplified outcome measures such as VAS and clinician-rated cooperation in conjunction with the MDAS enabled inclusion of participants with varying levels of cognitive ability, though future studies should develop and validate distraction protocols specifically adapted to non-verbal or minimally verbal patients who represent a particularly underserved subgroup.

The increasing accessibility and affordability of VR hardware is a significant facilitating factor for clinical implementation. Contemporary standalone wireless HMDs require no external computers or cables, are easily cleaned between patients, and can be operated by dental nurses with minimal training [27]. These practical characteristics address many of the logistical barriers that have historically limited VR adoption in clinical settings. A cost-effectiveness analysis comparing the investment in VR equipment against savings from reduced sedation requirements, fewer incomplete procedures, and improved attendance rates would be a valuable contribution to the evidence base.

Audio distraction, while less effective than VR in this study, continues to offer meaningful clinical benefits. Its lower cost, simpler implementation, and broader tolerability, including among patients who cannot wear an HMD due to physical or sensory constraints, ensure that audio distraction will remain a valuable tool in the special care dentistry toolkit. The findings of the present study suggest that VR distraction should be considered as the preferred first-line distraction modality where feasible, with audio distraction serving as an effective alternative when VR is not tolerated or available.

Future research should examine the sustained effects of repeated VR distraction sessions on long-term dental anxiety trajectories, the influence of content type and interactivity level on distraction efficacy, and the integration of VR distraction with other anxiety management strategies such as tell-show-do and structured desensitization programs. Multicenter trials with larger, well-characterized special care populations and extended follow-up periods will further consolidate the evidence base for VR distraction as a standard of care in special care dentistry.

Conclusion

Virtual reality distraction is significantly more effective than audio distraction in reducing dental anxiety, pain perception, and physiological stress responses in special care dentistry patients. The greater attentional engagement afforded by immersive VR technology produces clinically meaningful improvements in procedural anxiety management, higher rates of successful procedure completion, and better patient cooperation compared to audio-only distraction. The safety profile of VR distraction is acceptable, with only minor and self-limiting adverse events observed. Audio distraction retains clinical value as an accessible and effective alternative where VR is not feasible. Integrating VR distraction as a standard non-pharmacological adjunct in special care dental services has the potential to reduce reliance on pharmacological sedation, improve oral health outcomes, and meaningfully enhance the quality of the dental experience for one of the most underserved patient populations in healthcare.

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