RESEARCH PAPER

Virtual reality (VR) for Anxiety and Pain Management during Periodontal procedures: A Systematic Review and Meta-analysis.

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Received: 23 September 2026; Accepted: 15 October 2026 ; Available Online: 02 November 2026

ABSTRACT:
Background: Dental anxiety (DA) is a major barrier to oral healthcare, often causing treatment avoidance and worsening oral health. DA is associated with increased pain perception, and although opioid-based analgesia is commonly used, non-pharmacological strategies such as virtual reality (VR) have emerged as promising adjuncts for reducing anxiety and discomfort during dental and periodontal procedures. **Objectives:** To evaluate the effectiveness of VR in reducing anxiety and pain during periodontal treatment. **Materials and Methods:** A systematic literature search across five databases was conducted. Eligible studies were selected using the PICOS framework. Data extraction was performed independently by two reviewers, and risk of bias was assessed using the Cochrane Risk of Bias 2 tool. A meta-analysis was carried out with Review Manager (RevMan) 5.1 to examine the impact of VR on systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and pain measured via Visual Analogue Scale (VAS). The certainty of evidence was evaluated using the GRADE approach. **Results:** Nine studies met the inclusion criteria. Pooled analysis showed a modest but statistically significant reduction in DBP with VR (SMD -0.51; 95% CI: -0.88 to -0.14; P = 0.006). No significant differences were found for SBP (SMD 0.26; P = 0.16), HR (SMD 0.13; P = 0.49), or VAS pain scores (SMD -0.34; P = 0.12). **Conclusion:** VR represents a safe, non-invasive adjunct for managing dental anxiety during periodontal therapy, with modest benefits for DBP. Its impact on pain and other physiological outcomes appears limited, warranting further refinement of VR protocols and larger clinical trials.

Keywords: Virtual reality, Pain management, Periodontal procedure, Anxiety

How to cite this article: Pooja V, Sidharthan S, Bafna RR, Shah RU, Hegde R, Aaron N, Ghaytidak RR., Virtual Reality (VR) for Anxiety and Pain Management during Periodontal Procedures: A Systematic Review and Meta-Analysis. Int J Drug Deliv Technol. 2026;16(89s): 853-868; DOI: 10.25258/ijddt.16.89s.91

INTRODUCTION:

Dental anxiety (DA) is a significant barrier to oral healthcare, often leading to treatment avoidance and deteriorating oral health. Unlike state anxiety (SA), which is situation-specific and fluctuates during treatment, DA is persistent and closely linked to heightened pain perception. Research indicates that highly anxious patients report greater pain intensity during dental procedures due to the interplay of emotional states, cognitive factors, and past negative experiences.[1]

Modern pain management strategies integrate pharmacological innovations to enhance patient comfort. Transdermal fentanyl patches and patient-controlled analgesia (PCA) are widely used in medical settings, with fentanyl iontophoretic transdermal systems offering precise opioid dosing while minimizing central sensitization and adverse effects.[2] Although effective, opioid-based approaches require careful monitoring due to potential side effects and dependency risks.

The shift toward non-pharmacological approaches has gained traction, especially in managing dental anxiety. The ADVANCE protocol, designed for pediatric patients, utilizes parental involvement, video modeling, and exposure therapy to reduce preoperative anxiety.[3] Similarly, psychological interventions such as relaxation techniques and patient education help mitigate anxiety and pain perception. Music therapy has demonstrated efficacy in reducing stress biomarkers like cortisol, while guided imagery fosters relaxation through mental visualization techniques.[2]

Pain perception during periodontal procedures, including scaling and root planing (SRP), varies based on patient characteristics such as gender, smoking status, and prior dental experiences. Studies suggest that pre-procedural anxiety significantly influences pain perception, with highly anxious patients reporting greater discomfort.[4] Identifying high-risk individuals through validated anxiety assessment tools allows clinicians to implement targeted interventions, improving both patient compliance and treatment outcomes.

A study by Fardal et al. found that 12.1% of self-reported highly anxious periodontal patients experienced extreme anticipatory anxiety, primarily due to fear of pain and prior negative encounters.[5] While overall anxiety levels declined as treatment progressed, individual responses varied, underscoring the challenge of predictability. Music therapy has been shown to significantly reduce dental anxiety in periodontal surgery, with notable decreases in Modified Dental Anxiety Scale (MDAS), State-Trait Anxiety Inventory-State (STAI-S), and Dental Fear Survey (DFS).[6]

Virtual reality (VR) has emerged as a promising, non-invasive technique for managing pain and anxiety in periodontal therapy. By immersing patients in a simulated three-dimensional (3D) environment, VR engages multiple senses—including visual, auditory, and proprioceptive—effectively diverting cognitive attention from noxious stimuli.[7] Research suggests that VR distraction significantly reduces pain perception and distress, surpassing conventional methods such as watching movies or listening to music.[8] Patients undergoing SRP with VR consistently report lower pain levels and reduced anxiety, leading to a more comfortable treatment experience.[9]

Beyond psychological benefits, VR influences physiological responses associated with pain and stress. Studies have documented lower heart rates and blood pressure in patients using VR during periodontal procedures, supporting its role in anxiety reduction.[7] Additionally, VR distraction reduces the need for local anesthesia and sedatives, making it a valuable non-pharmacological alternative, particularly for individuals who might otherwise avoid necessary dental treatments due to anxiety.[7]

Managing DA and pain requires a multifaceted approach that integrates both pharmacological and non-pharmacological strategies. While opioid-based analgesia remains an effective option, behavioral and technological interventions, including music therapy and VR, offer compelling alternatives that enhance patient comfort, improve compliance, and minimize reliance on pharmacological agents. As VR technology continues to evolve, its role in modern periodontal care is expected to expand, further transforming the patient experience and promoting better oral health outcomes. This review focuses on the use of VR for anxiety and pain management during periodontal procedures.

MATERIALS AND METHODS:

This systematic review was conducted in accordance with a pre-registered protocol in the International Prospective Register of Systematic Reviews (PROSPERO; CRD42025637029). The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [10], ensuring transparency and methodological rigor.

The review question for this study is *'Are there differences in the effectiveness of Virtual Reality (VR) in reducing anxiety and pain during periodontal procedures compared to no distraction methods?"*.

The detailed eligibility criteria was categorised under PICOS criteria and is summarized in Table 1.

Table 1. Eligibility Criteria

Review Question: Are there differences in the effectiveness of Virtual Reality (VR) in reducing anxiety and pain during periodontal procedures compared to no distraction methods?		
	Inclusion criteria	**Exclusion criteria**
Population	Patients above 18 years of age and any gender with periodontal disease without visual or hearing impairments	Patients below 18 years of age and patients with visual, hearing or other impairments
Intervention	Use of VR to reduce anxiety and/or pain during periodontal procedures	Use of VR solely for education or training without addressing anxiety or pain
Comparator	No behavioural intervention for pain and anxiety management during periodontal procedures	Studies lacking a comparator group
Outcome	Primary outcomes: Anxiety and pain reduction (measured by VAS, Pulse Rate, Blood Pressure) Secondary outcomes: DAS-R (Dental Anxiety Scale-Revised), MDAS (Modified Dental Anxiety Scale)	Studies that do not report on anxiety and pain reduction
Study Design	Randomized controlled trials (RCTs)	Cohort studies, Non-randomised trials, Case reports, narrative reviews, expert opinions, conference abstracts, Animal studies or in vitro experiments

Literature Search Strategy

A comprehensive search was conducted across multiple electronic databases including PubMed/MEDLINE, ScienceDirect, Cochrane Library, Scopus, grey literature sources such as Google Scholar. The search strategy combined controlled vocabulary (MeSH/Emtree terms) and free-text keywords, linked with Boolean operators ("AND," "OR"). Core terms were structured around population ("Dental Anxiety," "Dental Fear," "Dental Phobia," "Dental Pain," "Tooth Pain," "Tooth Ache"), intervention ("Virtual Reality," "Augmented Reality"), and context ("Periodontal Procedures," "Periodontal Treatment," "Dental Scaling," "Dental Prophylaxis," "Oral Scaling," "Oral Prophylaxis"). Database-specific syntax and record yields are detailed in Table 2.

Table 2. Search strategy for the study

Database	Search String	N
PubMed	**#1** (((virtual reality OR augmented reality) AND (dental anxiety OR dental fear OR dental phobia)) AND (dental pain OR tooth pain OR tooth ache)) AND (periodontal procedures)	5
	#2 ((virtual reality) AND (dental anxiety OR dental pain)) AND (periodontal procedures)	8
	#3 (((virtual reality OR augmented reality) AND (Dental anxiety OR dental fear OR dental phobia)) AND (dental pain OR tooth pain OR tooth ache)) AND (dental scaling OR dental prophylaxis OR oral scaling OR oral prophylaxis)	27
Science direct	(((virtual reality OR augmented reality) AND (dental anxiety OR dental fear OR dental phobia)) AND (dental pain OR tooth pain OR tooth ache)) AND (periodontal procedures)	165
Cochrane library	(((virtual reality OR augmented reality) AND (dental anxiety OR dental fear OR dental phobia)) AND (dental pain OR tooth pain OR tooth ache)) AND (periodontal procedures):ti,ab,kw	8
Scopus	(TITLE-ABS-KEY(virtual reality) AND TITLE-ABS-KEY(dental anxiety) AND TITLE-ABS-KEY(periodontal treatment))	128
Google Scholar	#1 ("virtual reality" OR "augmented reality") AND ("dental anxiety" OR "dental fear" OR "dental phobia")) AND ("dental pain" OR "tooth pain" OR "tooth ache")) AND ("periodontal procedures")	8
	#2 ((("virtual reality" OR "augmented reality") AND ("Dental anxiety" OR "dental fear" OR "dental phobia")) AND ("dental pain" OR "tooth pain" OR "tooth ache")) AND ("dental scaling" OR "dental prophylaxis" OR "oral scaling" OR "oral prophylaxis")	54

Study Selection

Two reviewers (PV and SS) independently screened all retrieved records according to predefined eligibility criteria. Duplicates were detected and excluded using Rayyan platform (https://rayyan.ai/). After duplicate removal, titles and abstracts were assessed, followed by full-text evaluation of potentially relevant studies. Disagreements were resolved through discussion with a third reviewer (RRB). Inter-reviewer agreement was quantified using Cohen's kappa statistic ($\kappa = 0.83$), indicating almost perfect concordance.

Data Extraction

Data extraction was performed independently by both reviewers using a customized Excel spreadsheet. Extracted information included: author, year of publication, study design, setting, sample size, intervention, comparator, outcomes, and conclusions. This standardized approach ensured consistency and minimized bias.

Risk of Bias Assessment

Each included study was assessed for methodological quality using the Cochrane Collaboration's Risk of Bias (RoB 2) tool [11]. Assessments were conducted independently by two reviewers (PV and SS), with discrepancies resolved through consultation with the third reviewer (RRB). Studies were categorized according to whether Virtual Reality (VR) was employed versus no VR during periodontal treatment.

Data Synthesis and Meta-Analysis

A meta-analysis was performed on studies comparing VR with no VR during periodontal treatment. A random-effects model was applied to account for between-study variability. Standardized mean differences (SMD) with 95% confidence intervals (CI) were calculated for outcomes including blood pressure, heart rate, and pain. Forest plots were generated to visualize pooled effects. Statistical analyses were conducted using RevMan Version 5.1, with significance set at $p < 0.05$. Heterogeneity was evaluated using the I^2 statistic. The certainty of evidence was appraised using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework [12], considering domains of risk of bias, inconsistency, indirectness, imprecision, and publication bias.

RESULTS:

Study selection:

A total of 401 records were identified from various electronic databases. Following the removal of 89 duplicates, 312 records were screened for eligibility. Of these, 286 were excluded—254 for irrelevance to the study objectives, 14 due to incompatible study designs, and 18 based on abstract review. Twenty-six

full-text articles were retrieved and assessed for eligibility. Seventeen studies were excluded at this stage, primarily because they evaluated VR as a learning tool (n = 6), applied VR in non-periodontal contexts (n = 8), or involved pediatric populations (n = 3). The excluded studies of 17 articles are listed in Table 3 [13-29]. Ultimately, nine studies met the inclusion criteria and were incorporated into the qualitative synthesis [8,30-37], of which two provided sufficient data for quantitative meta-analysis. The study selection process is summarized in the PRISMA flow diagram (Figure 1).

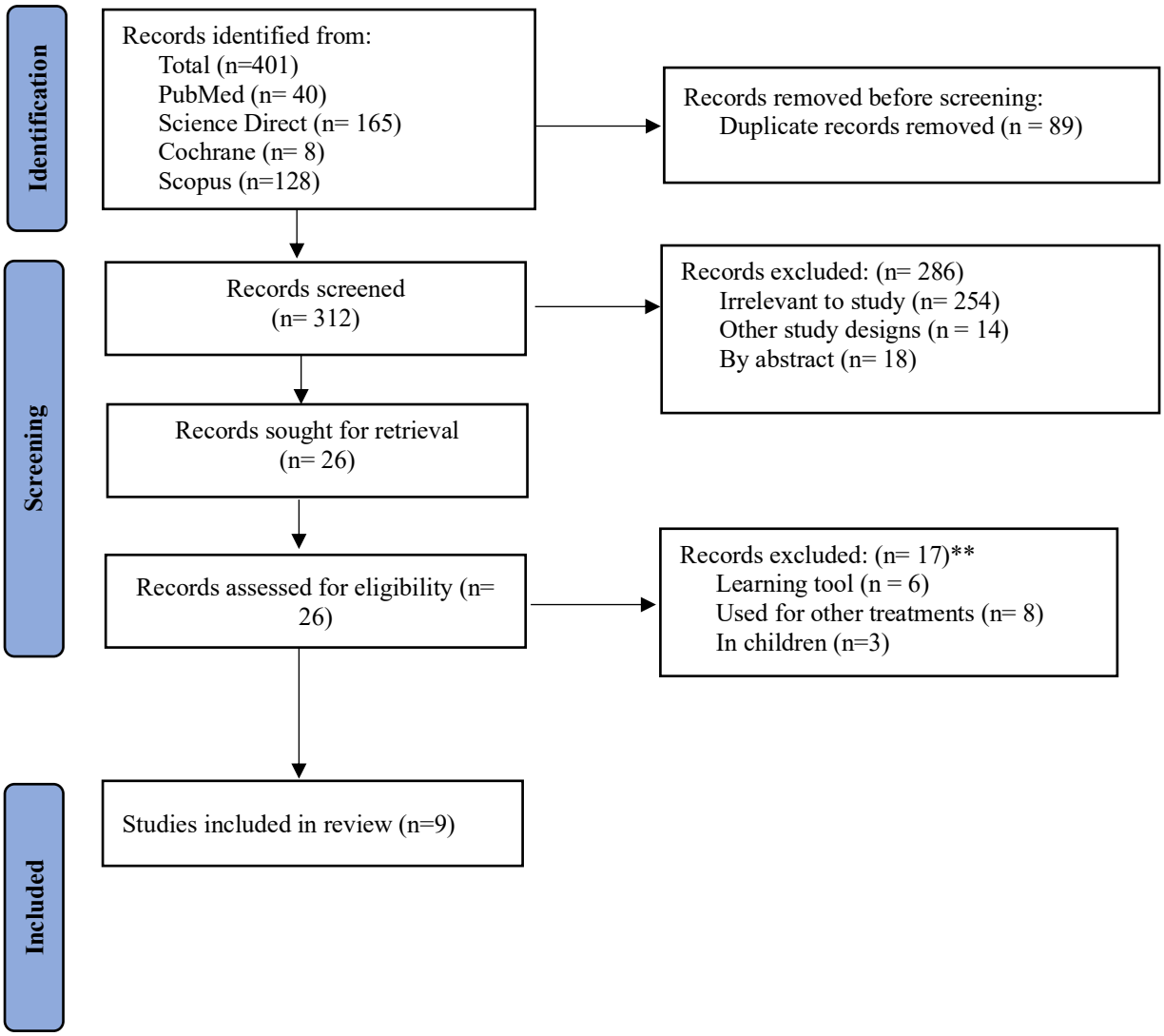


Figure 1. PRISMA Flow chart

Table 3. Reasons for excluding studies

Reasons for Exclusion	Authors
Used as learning tool	Zhang J et al. [13], Tak NY et al. [14], Preshaw PM et al. [15], Yamaguchi S et al. [16], Wu S et al. [17], Huang Y et al. [18],
Used during other treatments	Sorribes De Ramón LA et al. [19], Yamashita Y et al. [20], Valls-Ontañón A et al. [21], Aslan K et al. [22], Maples-Keller JL et al. [23], McCune M et al. [24], Gujjar KR et al. [25], Ledwoń A et al. [26],
Pediatric	Mediani HS et al. [27], Nuvvula S et al. [28], Gomez-Polo G et al. [29],

Study characteristics:

The nine studies included in this review were conducted across diverse settings in the USA, Jordan, Iran, Turkey, India, and Denmark between 2001 and 2024. Study designs varied, with most employing randomized controlled trials or within-subject split-mouth designs, and sample sizes ranging from 14 to 60 participants. Mean ages of participants spanned from late twenties to mid-fifties, with balanced male-to-female ratios reported in several trials. Interventions consistently involved the use of immersive or audiovisual virtual reality (VR) devices such as head-mounted displays, video eyeglasses, or smartphone-based visualization eyewear during periodontal procedures including scaling and root planing (SRP), gingivectomy, gingivoplasty, and dental prophylaxis. Comparators included conventional treatment without distraction, movie viewing, or nitrous oxide analgesia.

Across studies, outcomes were assessed using validated measures of pain (VAS), anxiety (DAS, MDAS, DFS), physiological parameters (systolic and diastolic blood pressure, heart rate, respiratory rate), and patient-reported experience (immersion, realism, nausea, satisfaction). The majority of trials reported reductions in pain perception and anxiety levels with VR compared to controls, alongside improvements in patient comfort and preference. Some studies also noted reductions in blood pressure and heart rate, while others highlighted enhanced satisfaction for both patients and clinicians. However, findings were not universally consistent: one trial reported no significant impact of VR on pain or anxiety during periodontal surgery, and another found video glasses comparable to nitrous oxide in pain control. The detailed study characteristics are presented in Table 4,5.

Table 4. Summary of included studies on Virtual reality in patients undergoing periodontal treatments

Author, years of study	**Study setting**	**Study design**	**Sample size**	**Mean age**	**M:F ratio**	**Intervention**	**Control**	**Outcome**
Furman E et al.,2009 [8]	USA	Within-subject split-mouth design	38	45.9±12.6	17:21	SRP with VR	No distraction and Movie	Pain by VAS SBP, DBP Patient preference Anxiety by DAS
Padrino-Barrios C et al., 2015 [30]	USA	Split mouth (random)	30	29.96 ± 7.8	23:7	IV eyewear used during oral debridement.	Oral debridement without IV eyewear	Anxiety by DASR-R Calmness scores before and after treatment Post-IV opinion survey

Author, years of study	Study setting	Study design	Sample size	Mean age	M:F ratio	Intervention	Control	Outcome
Alshatrat S et al., 2019 [31]	Jordan	Within-subject Split Mouth design (Random)	50	36 ± 11.843	22:28	SRP with VR	SRP without VR	Pain level using VAS, SBP, DBP, HR Participant's responses to the VR experience (presence, realism, nausea)
Birang E et al., 2019 [32]	Iran	Within-subject Split mouth design (Random)	14	31 ± 7.4	NR	SRP with VR	SRP without VR	SBP DBP HR Anxiety by DAS-R Pain levels using VAS Relaxation status using DSTG index Patient and Dentist satisfaction
Gurbuz E and Gurbuz AA, 2024 [33]	Turkey	RCT	58 Test: 28 Control: 30	Test: 30.04 ± 11.87 Control: 29.37 ± 12.92	Test: 8:20 Control: 9:21	Gingivectomy and gingivoplasty with VR	Gingivectomy and gingivoplasty without VR glasses	Anxiety by MDAS Pain by VAS SBP, DBP, HR Procedure time Time perception Patient Satisfaction

Author, years of study	Study setting	Study design	Sample size	Mean age	M:F ratio	Intervention	Control	Outcome
Ceylan E and Gurbuz E, 2024 [34]	Turkey	RCT	60, 30:30	40.83 ± 10.34	31:29	SRP with VR	SRP without VR	Anxiety by DAS SBP, DBP, HR Procedure time Pain and discomfort levels by VASP Sensation of immersion (VASI) Realism (VASR) Nausea (VASN)
Menon S N et al., 2024 [35]	India	Split mouth RCT	29	39.62 ± 14.14	20:9	Dental scaling with VR	Dental scaling without VR	Pain scores VR experience scores SBP, DBP HR
Bentsen B et al., 2003 [36]	Denmark	RCT	26	55	14:12	Video glasses during scaling	Nitrous oxide (N2O) analgesia and	Pain by VAS Pain intensity of Von Frey filament
Frere CL et al.,2001 [37]	USA	Randomized, mixed factorial design	27 patients Final analysed 25	44.3 ± 20.2		Audiovisual eyeglass during dental prophylaxis.	No Audiovisual eyeglass	Fear by DFS Pain related fear by FPQ-III PR SBP DBP RR

VR: Virtual Reality; SRP: Scaling and Root planning; DAS: Dental anxiety scale; HR: Heart Rate; SBP: Systolic Blood pressure; DBP: Diastolic Blood pressure; IV: Immersive Visualization

Table 5. Summary of outcomes and conclusion of the included studies

Authors	Intervention	Control	Conclusion
Furman E et al.,2009 [8]	SBP:125.6±12.6 DBP:81.0 ±9.0 HR:67.5±7.4/68.3±7.7	SBP: Control: 133.7±15.7 Movie: 130.4±14.8 DBP: Control:86.0±8.9 Movie:83.3±10.8 HR: Control: 76.7±9.5/69.0±9.0 Movie:79.0±10.8/70.2±9.0	Immersive virtual reality (VR) distraction was found to be an effective pain control method during scaling and root planing procedures, significantly reducing pain and discomfort compared to control and movie conditions. VR also led to lower blood pressure and pulse rate, with most patients preferring the VR treatment.
Padrino-Barrios C et al., 2015 [30]	Calmness score: Group A: Left:2.93±1.22/3.13±1.96 Group B: Right: 4.8±0.68/4.33±1.54	Calmness score: Group A: Right: 4.66±1.04/2.93±1.22 Group B: Left:4.33±1.54/2.13±0.99	Visualization eyewear effectively reduces short-term dental anxiety during routine oral debridement. The portable and affordable system, combining a smartphone with a head-mounted display, offers a non-pharmacological solution that is well-received by patients, leading to significant anxiety reduction.
Alshatrat S et al., 2019 [31]	SBP:113.72±15.3 DBP:71.3 ± 12.2 HR:75 ±9.3	SBP: 116±16.6 DBP:71.3±13 HR:74.4±13.18	VR effectively reduces pain perception during SRP procedures, with most participants preferring VR over other methods. It shows promise as a non-pharmacological pain management tool in dental settings.
Birang E et al., 2019 [32]	SBP:71.13±60.13/25.13±88.12 DBP:77±31.12/64.77±71.12 HR:28.85±29.11/43.89±43.12	SBP:35.13±19.13/25.13±69.13 DBP:81.76±84.11/89.77±82.9 HR:53.84±55.15/71.81±60.12	The use of video eyeglasses during SRP significantly reduces patient anxiety, pain, and improves both patient and dentist satisfaction.

Authors	Intervention	Control	Conclusion
Gurbuz E and Gurbuz AA, 2024 [33]	SBP:118.71±17.01/112.14±10.67 DBP:75.71± 9.79/70.25±10.55 HR:87.05±12.17/83.61±12.52 MDAS:11.68 ± 3.56/-1.43 ± 2.82 AP:4.29 ± 2.40 VASP:1.60 ± 1.92	SBP:113.47±12.11/108.42±15.06 DBP: 73.17 ± 8.66/73.57 ± 7.05 HR: 84.57±15.27/81.53±10.21 MDAS:11.37±3.41/-1.73 ± 2.55 AP:4.20 ± 2.12 VASP:1.83 ± 1.84	VR did not impact anxiety or pain levels during mandibular periodontal surgery, but patients using VR reported high satisfaction and reduced anxiety.
Ceylan E and Gurbuz E, 2024 [34]	SBP:114.92 ± 14.33/119.17 ± 16.21 DBP:78.00 ± 8.24/80.50 ± 11.67 HR:82.42 ± 12.94/81.27 ± 12.25 VASP:3.30 ± 2.08 DAS:8.82 ± 3.37/7.72 ± 3.20	SBP:117.25 ± 14.56/115.50 ± 14.07 DBP:78.00 ± 11.13/87.73 ± 9.97 HR:81.67 ± 12.35/80.33 ± 12.32 VASP:4.54 ± 2.25 DAS:10.13 ± 3.44/7.87 ± 3.44	The use of virtual reality glasses during scaling and root planing procedures significantly reduced pain and discomfort levels in anxious periodontitis patients. Starting the procedure with VR glasses also impacted anxiety, immersion, and realism.
Menon S N et al., 2024 [35]	SBP:121.31±13.95/121.24±16.38 DBP:77.62±9.53/76.14±10.68 HR:74.90±10.46/72.69±10.70 Pain score:2.00±1.13	SBP:121.31±13.95/116.00±23.95 DBP:77.62±9.53/76.28±10.99 HR:74.90±10.46/72.31±16.70 Pain score:3.38±1..66	VR reduced pain perception during dental scaling in healthy adults. Individuals with a more positive VR experience reported a greater reduction in pain, emphasizing the potential of VR as a beneficial tool for enhancing patient comfort during dental procedures.
Bentsen B et al., 2003 [36]	VAS score: 16.9±18.4	Control: VAS score:15.2±15.2 N_2O: VAS score: 14.1±20.0	Video glasses and nitrous oxide (N2O) did not significantly reduce the perceived intensity of pain or unpleasantness during dental scaling.
Frere CL et al.,2001 [37]	SBP: 112.6±19.4/116.2±18.0 HR:71.1±11.9/67.0±9.3	SBP:112.6±19.4 /118.4±20.5 HR: 71.1±11.9/67.2±10.6	The use of audiovisual (A/V) eyeglasses during dental prophylaxis effectively reduces anxiety and discomfort in most patients, while also decreasing procedure time.

MDAS: Modified dental anxiety scale , VASP: Visual Analog Scale, AP: Anticipated pain

Risk of bias assessment:
The methodological assessment determined low risk of bias for 3 studies, some concerns for 5 studies and high risk for 1 study mainly associated with randomization and measurement of outcome. (Figure 2 and 3)

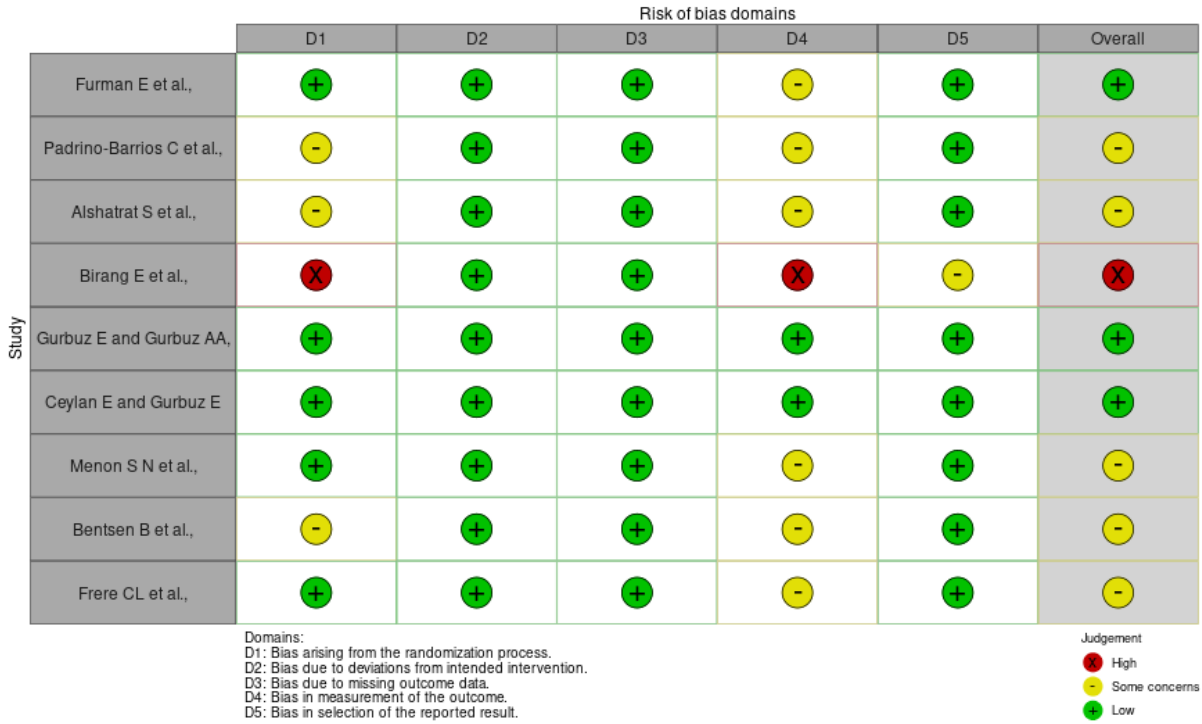


Figure 2. Risk of bias assessment of included Studies

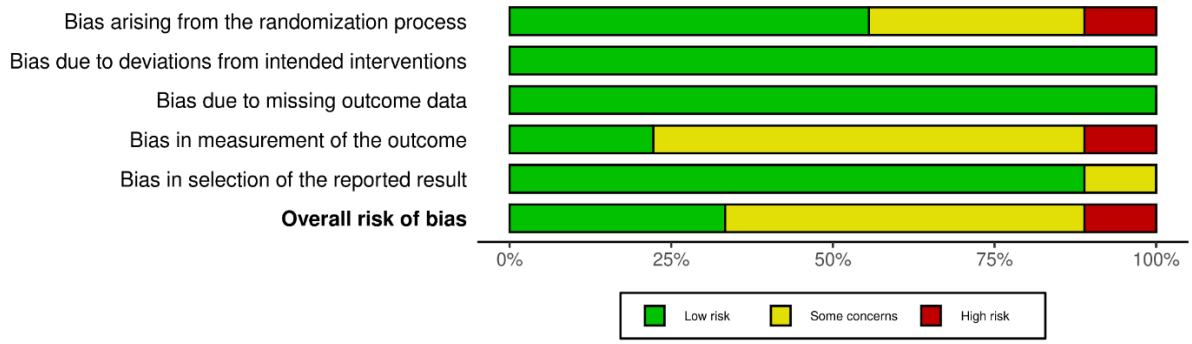


Figure 3. Overall Risk of bias graph of included studies

Quantitative analysis:
Meta-analysis revealed varying effects of Virtual Reality (VR) on systolic blood pressure (SBP) and diastolic blood pressure (DBP) during periodontal treatments. For SBP, two studies [33,34] showed a small increase with VR, though the effect was not statistically significant (SMD 0.26, 95% CI: -0.10 to 0.62, P = 0.16). No significant heterogeneity was observed (I^2 = 0%, P = 0.91), indicating consistency across studies. In contrast, DBP showed a modest reduction with VR, which was statistically significant (SMD -0.51, 95% CI: -0.88 to -0.14, P = 0.006). Low heterogeneity was observed for DBP (I^2 = 0%, P = 0.79), suggesting that VR may effectively manage DBP during periodontal treatments. When combining SBP and DBP, the overall effect size was -0.12 (95% CI: -0.58 to 0.33), indicating no significant change in blood pressure (P = 0.59). The overall heterogeneity was moderate (I^2 = 67%, P = 0.03), suggesting variability in the results. (Figure 4)

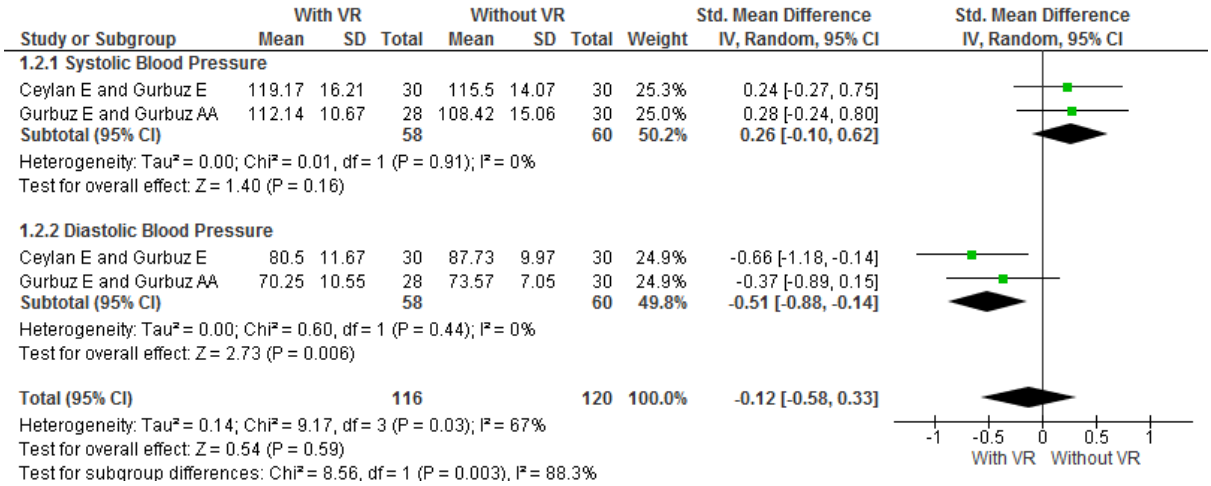


Figure 4. Forest plot comparing Blood pressure between Virtual reality and no distraction group

For heart rate (HR), two studies [33,34] showed a small increase with VR, but the effect was not statistically significant (Standard mean difference 0.13, 95% CI: -0.23 to 0.49, P = 0.49). No substantial heterogeneity was observed (I^2 = 0%, P = 0.78).(Figure 5) In terms of pain, two studies [33,34] that used the Visual Analogue Scale (VAS) indicated a slight reduction in anxiety with VR compared to no VR, but the effect was not statistically significant (SMD -0.34, 95% CI: -0.78 to 0.09, P = 0.12). Moderate heterogeneity was noted across studies (I^2 = 30%, P = 0.23), suggesting variability in the outcomes. (Figure 6) The overall certainty evidence was graded as very low. (Table 6)

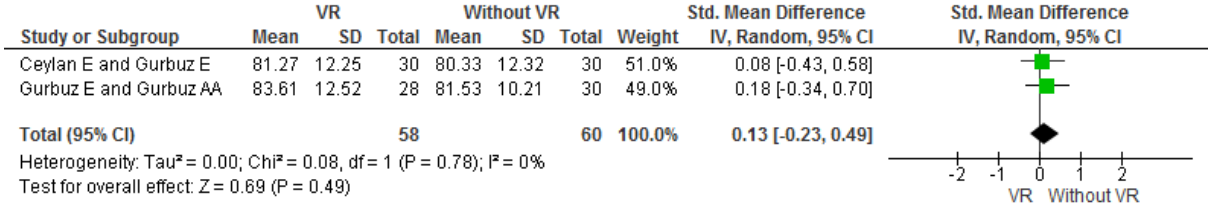


Figure 5. Forest plot comparing Heart Rate between Virtual reality and no distraction group

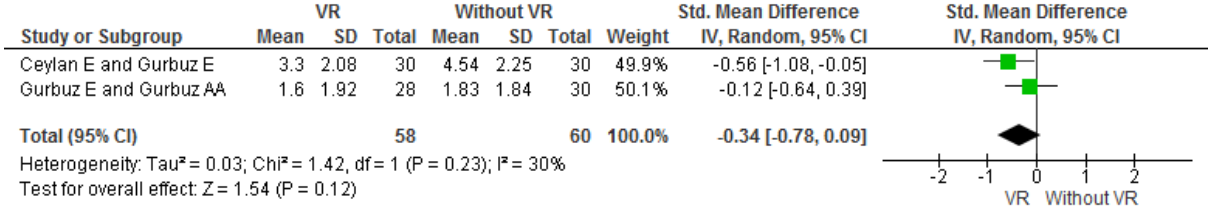


Figure 6. Forest plot comparing Pain perception between Virtual reality and no distraction group

Table 6. Grading of recommendations assessment, development, and evaluation (GRADE) evidence profile

Outcome	Certainty Assessment							No. of patients		Effect	Certainty
	No. of studies	Study design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other consideration	VR	Without VR		
Heart Rate	2	RCT	No limitation	Not Serious	Not serious	Not serious	None	58	60	SMD 0.13 (CI 95% -0.23,0.49)	High ⊕⊕⊕⊕
Blood Pressure	2	RCT	No limitation	Not Serious	Not serious	Not serious	None	58	60	**SBP:** SMD 0.26 (CI 95% -0.10,0.62) **DBP:** SMD -0.51 (CI 95% -0.88,-0.14)	High ⊕⊕⊕⊕
Pain	2	RCT	No limitation	Not Serious	Not serious	Not serious	None	58	60	SMD -0.34 (CI 95% -0.78,0.09)	High ⊕⊕⊕⊕

SBP: Systolic Blood pressure; DBP: Diastolic Blood pressure; RCT: Randomised Controlled trials; CI: Confidence interval

The following studies were not assessed in the meta-analysis due to variations in their outcome assessment timelines. Furman E et al. [8] assessed outcomes during treatment, while Menon SN and George BB recorded outcomes throughout the treatment session. Birang's study [32] had excessively high standard deviation values, compromising result reliability. Alsharat's study [31] lacks clarity on both the treatment used and the assessment timeline, preventing comparison.

DISCUSSION:

This systematic review and meta-analysis aimed to assess the effects of Virtual Reality (VR) on anxiety and pain management in adults undergoing periodontal treatments. The findings suggest that VR offer some benefits, particularly in reducing diastolic blood pressure (DBP), but its effects on systolic blood pressure (SBP), heart rate (HR), and pain reduction were less pronounced.

A meta-analysis of the two included studies, Gurbuz E et al. [33] and Ceylan E et al. [34] revealed that VR resulted in a modest but statistically significant reduction in DBP (SMD -0.51), suggesting that VR can help reduce physiological signs of anxiety, such as DBP, during periodontal procedures. However, its effect on SBP was minimal and non-significant (SMD 0.26). Similarly, VR had a small and non-significant impact on HR (SMD 0.13). The lack of a statistically significant effect on HR and the minimal impact on SBP suggest that VR's influence on these physiological markers may be limited in adults undergoing periodontal treatments.

In terms of pain, VR showed a slight reduction in perceived pain (SMD -0.34), but the effect was not statistically significant. This result aligns with the mechanism of VR in pain management, which relies on attention diversion as explained by the Gate Control Theory of Pain.[38] According to this theory, pain perception requires attention, and VR's immersive environment diverts attention away from the painful stimulus to a more engaging virtual world. This redirection of attention may decrease the intensity of pain perception. Additionally, multisensory VR, involving sight, sound, and touch,

further enhances this distraction, providing a comprehensive approach to pain management during medical procedures. [39-41] The attenuation of pain by virtual reality is often referred to as VR analgesia. Neurobiological studies, including fMRI, support this mechanism by showing that VR reduces activity in key pain-related brain areas like the insula and thalamus by more than 50%, aligning with patients' subjective reports of decreased pain. VR not only helps with pain perception but also addresses the emotional aspects of pain, such as fear and anxiety, which can further reduce overall discomfort during periodontal treatments. [41]

While acknowledging the significant effectiveness of VR technology in reducing dental anxiety (DA), it is essential to consider potential risks, which were not extensively highlighted in the included studies. The use of extended reality (VR) devices may induce adverse reactions, such as vertigo, headaches, mild nausea, and eye irritation, often attributed to "virtual environment sickness." This condition results from sensory conflicts between the visual and vestibular systems. To mitigate these effects, research suggests optimizing sensory inputs, such as improving image quality, adjusting the field of view, and refining interface design. Additionally, user adaptation training, including gradual exposure and adaptive training, can help reduce discomfort and enhance user satisfaction. However, certain patient populations, such as those with cognitive impairments or vertigo, may still experience discomfort despite these adjustments. [42-44] Consequently, oral healthcare providers should carefully assess patients' medical histories and tailor VR regimens accordingly to ensure safety and comfort. These potential risks in the included studies is a limitation that should be addressed in future research.

CONCLUSION:

The use of virtual reality (VR) during periodontal procedures shows a modest effect on physiological measures of anxiety, such as diastolic blood pressure, but has minimal impact on systolic blood pressure and heart rate. VR leads to a small reduction in DBP, suggesting a potential benefit in managing physiological signs of anxiety. However, its effects on SBP and HR are minimal and not considered clinically meaningful. Furthermore, VR demonstrates a slight reduction in pain, but the effect is not substantial enough to be considered significant. Due to very low certainty of evidence, further research with larger sample sizes and extended follow-up is needed to fully evaluate the effectiveness of VR in reducing dental anxiety and pain.

DECLARATIONS

1.Patient's/ Guardian's consent: Not Applicable
2. Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
3. Acknowledgements: None
4. Ethical clearance: Not Required
5. Conflict of interest : Nil
6. Data Availability: All data generated or analyzed during this systematic review are included in the manuscript, tables and figures.

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