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Original Article

Effect of Virtual Reality on managing dental anxiety and vital signs during surgical wisdom tooth extraction: A Randomized Controlled Trial

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Abstract

Fear of dental visits is often perceived as an unpleasant experience, leading patients to postpone or cancel appointments until emergencies arise. Virtual reality (VR) intervention has been proposed as a support to overcoming anxiety for dental treatment. This randomized controlled trial evaluated the effectiveness of VR in reducing dental anxiety and stabilizing physiological responses. Thirty-two participants aged 19–51 years with moderate to severe dental anxiety (DAS-R ≥9) were randomly assigned to a VR group or a control group via a basic lottery, i.e., group assignment on arrival at the dentist's office. The experimental group received VR intervention during treatment, while the control group underwent standard care. Dental Anxiety Scale-Revised (DAS-R) scores and physiological parameters (oxygen saturation, blood pressure, pulse rate) were recorded before and after treatment. Paired-samples t-tests examined within-group changes, while independent-samples t-tests were used to compare groups. Of the 32 participants (59.4% female, 40.6% male), psychological outcomes indicated that VR significantly reduced dental anxiety compared with the control group ($p < 0.001$). Mean DAS-R scores decreased from 3.38 ± 0.71 to 1.69 ± 0.47 in the VR group, compared with 3.56 ± 0.96 to 2.81 ± 0.83 in controls. Clinically, post-treatment, all VR participants reported only mild anxiety, versus 87.5% of controls remaining moderately anxious. Physiological outcomes showed that VR also significantly reduced systolic blood pressure ($p = 0.02$) but had no significant effect on diastolic pressure, oxygen saturation, or pulse rate. These findings suggest that VR is a cost-effective, non-pharmacological tool for alleviating dental anxiety and enhancing patient comfort during treatment, warranting further investigation of its broader clinical applications through larger, long-term studies.

Keywords: Dental Anxiety, Virtual Reality, Vital Signs, Dental Care, Randomized Controlled Trial.

1. Introduction

Dental anxiety is a nonspecific generalized state characterized by cognitive and emotional components. It affects up to 20% of patients and is triggered by the dental clinic environment [1, 2]. Mainly, it increases pain perception and occurs throughout treatment stages, from waiting periods before appointments to procedures [3]. Physiologically, it impairs functions, including increased cortisol, tachycardia, respiratory changes, and circulatory stress [4, 5]. These changes are a risk to patients as well as clinicians, especially with high-anxiety invasive procedures such as third molar surgery, which is common among young adults [6]. In such procedures, monitoring of vital signs (heart rate, oxygen saturation, blood pressure) is essential for patient safety [7]. Although pharmacological treatment of anxiety is linked to side effects [8] psychological treatments, such as Virtual Reality (VR), are in trial phases to help minimize acute procedural pain and anxiety [9–12]. Furthermore, advanced VR systems now incorporate biofeedback and real-time control to modulate physiological responses (e.g., heart rate) and improve relaxation [13–15].

Despite VR's well-known efficacy, gaps still exist in its utility. Previous studies on VR use have focused on non-surgical dental procedures such as restorative treatments, while evidence on its use in high-anxiety surgical procedures, particularly third molar surgery, remains limited [16]. Furthermore, there is a lack of evidence from Pakistan evaluating the effectiveness of biofeedback-based VR interventions on both dental anxiety and physiological responses during dental treatment. Additionally, prior research has inadequately tracked dynamic changes in vital signs during surgery, relying instead on pre- and post-comparisons.

To address this, we measured dental anxiety and vital signs (heart rate, blood pressure, oxygen saturation) pre- and post-third-molar surgery in patients using VR immersion. The main aim of the VR interface was to induce relaxation and provide real-time biofeedback based on patients' physiological status. This approach is innovative on three broad fronts: it is the first study from Pakistan, on VR use during surgical removal of wisdom teeth; secondly, it uses dynamic vital-sign monitoring during surgery to identify fleeting anxiety responses that were missed in previous studies; and thirdly, the study aims to utilize biofeedback-augmented VR for the personalized management of anxiety. By supporting the use of a non-pharmacological intervention for high-anxiety procedures in resource-limited settings, this study aims to provide evidence-based support for VR's utility in dentistry.

Therefore, the objective of this study was to evaluate the effectiveness of biofeedback-based VR intervention in reducing dental anxiety and stabilizing vital signs during third molar surgery. We hypothesized that patients receiving VR intervention would demonstrate lower anxiety levels and improved physiological stability compared with patients receiving standard care.

2. Materials and methods

2.1. Study setting and subject recruitment

This study was conducted at the Maxillofacial Surgery Department of Sharif Medical and Dental Hospital, Lahore. The duration of this study was nine months. The sample size was determined based on the effect size reported by Ghobadi et al. (2024). To compare two independent means with 95% power and a 5% significance level (α = 0.05), anticipated population means of 12.88 and 17.42 are used as reference points. Based on these parameters and a 1:1 allocation ratio, the minimum required sample size was 32 participants, with 16 participants per group. This sample size is considered sufficient to detect the hypothesized differences between the intervention and control conditions while maintaining high statistical rigor.

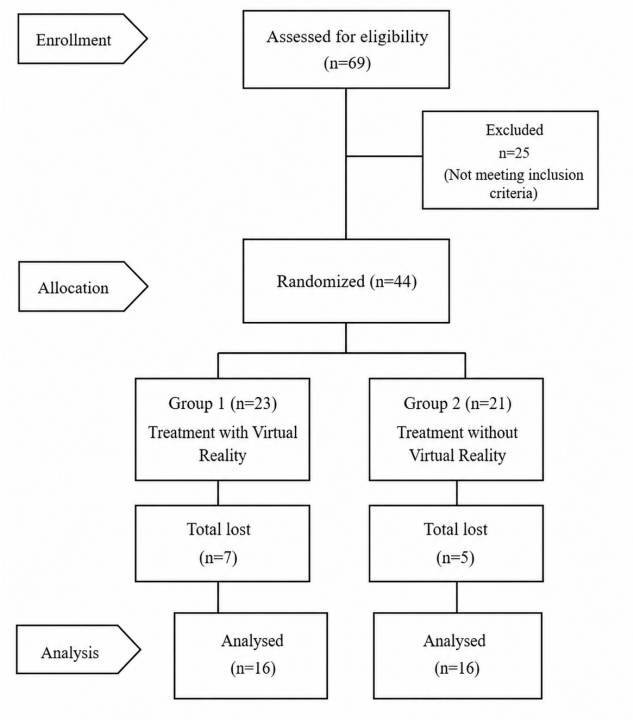

Figure 1: *CONSORT diagram showing trial enrolment, allocation, and analysis. This flowchart illustrates the recruitment and retention process for the study. Enrollment Phase: A total of 69 individuals is assessed for eligibility, of whom 25 are excluded for failing to meet specific inclusion criteria. In the Allocation Phase, the remaining 44 participants are randomized into two parallel groups: Group 1 (n=23) receiving Virtual Reality treatment and Group 2 (n=21) receiving no Virtual Reality treatment. Follow-up and Attrition: During the study period, 7 participants from Group 1 and 5 participants from Group 2 were lost to follow-up or discontinued. Analysis Phase: A final sample of 32 participants (n=16 per group) is included in the statistical analysis to ensure a balanced comparison between the intervention and control conditions.*

2.2. Participant recruitment and randomization

Experimental design is provided in Figure 1. Participants were informed about the study, and written consent was obtained from patients. Patients who agreed to participate in the study were asked to complete a demographic form and DAS-R questionnaire. The DAS-R questionnaire was used to assess dental anxiety before and after dental treatment. Participants were randomized using a lottery method with equal allocation to the intervention and control groups. Allocation concealment was maintained using sealed opaque slips prepared before participant recruitment. During participant induction, five participants within the control group declined to participate in the study. Seven participants in the experimental group declined to participate in the research during surgery due to discomfort with the VR device.

2.2.1. Inclusion and exclusion criteria

Patients aged 18 to 65 years, who required surgical wisdom tooth extraction and had dental anxiety scores of ≥9 (measured by DAS-R) were included. Participants who were taking anxiolytic (anti-anxiety) drugs, had visual or auditory impairments, mandibular joint defects, preexisting depression, or were pregnant women were excluded.

2.3. Virtual reality intervention

The experimental group received a VR intervention during dental treatment (Figure 2). The device, named VRPARK (manufactured by VRPARK Technology Co., Ltd., China), weighed 0.615 kg and featured a dual-screen display, high comfort, high breathability, and a simulated video screen. Lens material was PMMA, with 95% transparency and a size of 42mm. The device had a viewing angle of 120 degrees. The control group received only dental treatment. The experimental group participants underwent a 15-minute virtual reality session during treatment, featuring relaxing nature scenes and audio designed to promote distraction and relaxation during the surgical procedure. Standard dental surgical instruments were used for dental procedures.

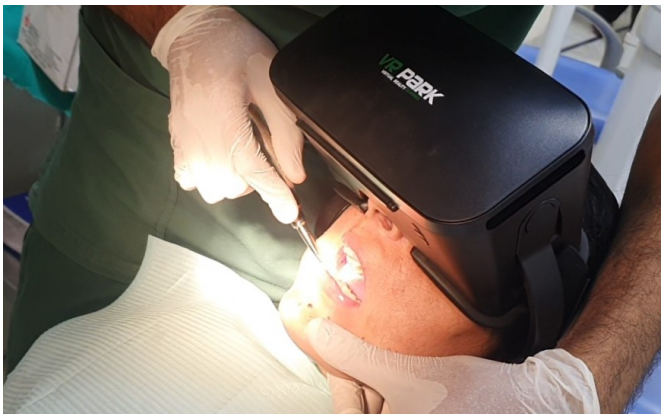

Figure 2: *Virtual reality–assisted setup for wisdom tooth (third molar) surgical extraction, illustrating the immersive simulation environment, VR headset interface, and procedural guidance used for intervention.*

2.4. Outcome measures and data collection

Vital signs were monitored before and after surgery. A pulse oximeter was used to measure oxygen saturation and pulse rate before and after surgery. The blood pressure of participants in both groups was measured with a sphygmomanometer. Vital signs included oxygen saturation, pulse rate, systolic blood pressure, and diastolic blood pressure. Dental anxiety of both group participants was measured by the Corah dental anxiety scale, which consists of 4 questions, making it easy to use. Dental anxiety was assessed before and after treatment using the DAS-R questionnaire to evaluate changes associated with the VR intervention.

2.5. Statistical Analysis

Data from the study were analyzed using descriptive and inferential statistics in R (significance level $p < 0.05$). Descriptive statistics summarized group demographics and baseline data. Normality was assessed using the Shapiro–Wilk test. DAS-R scores were normally distributed, but several variables deviated from normality. T-tests were used because they are robust to moderate violations of normality, given the absence of extreme values, particularly in samples of this size ($n = 32$). An independent t-test compared post-treatment dental anxiety (DAS-R scores) and vital signs between VR and non-VR groups, as these comparisons involved two independent groups. Paired t-tests compared within-group differences (pre- vs. post-treatment) in DAS-R scores and vital signs within each group. Effect sizes were calculated using Hedges' g to assess the magnitude of differences between groups and within-group changes. Additionally, non-parametric tests (Wilcoxon signed-rank test and Mann–Whitney U test) were conducted as sensitivity analyses to confirm the consistency of the results.

3. Results

3.1. Demographic and Clinical Characteristics of Participants

The study enrolled 32 participants, with females comprising 59.4% (n=19) (Table 1). Participants had a mean age of 32.6 ± 7.6 years (range: 19–51 years), with a median age of 32 years (IQR: 27–37 years). Most female participants were housewives (43.8%), while 34.4% were employed and 12.5% were unemployed. Socioeconomic analysis revealed that most participants (68.8%) were from the lower-middle class. Regarding dental history, 56.3% (n=18) reported prior satisfactory dental experiences, while 21.9% were visiting a dentist for the first time. Relatives were the most common source of information about tooth surgery (43.8%), followed by friends (18.8%) and internet resources (9.4%).

Table 1: Demographic characteristics of study participants (n=32)

Demographics	Frequency	%
Gender		
Male	13	40.6
Female	19	59.4
Occupation		
Housewives	14	43.8
Employed	11	34.4
Business	3	9.4
Unemployed	4	12.5
Socioeconomic background		
Upper middle	7	21.9
Lower middle	22	68.8
Upper lower	3	9.4
Participants' satisfaction levels with the previous dental visit		
Satisfactory	18	56.3
Un-Satisfactory	7	21.9
Not applicable	7	21.9
Sources of information		
Relatives	14	43.8
Friends	6	18.8
Internet	3	9.4
Others	9	28.1

3.2. Psychological Outcomes

The DAS-R score ranged from 5 to 20 in all participants, with a mean of 11.27±3.87. Severe anxiety was observed in 56.25% of the patients in the non-VR group, which reduced to 6.25% after treatment. On the contrary, the VR group reflected the complete change towards mild levels of anxiety, with no participants remaining in the moderate, high, or severe anxiety categories.

However, post-treatment scores were lower in the VR group across all DAS-R domains and total score (Figure 3), indicating a greater reduction in anxiety levels with the VR intervention. Between-group comparisons showed that baseline scores were comparable between the VR and non-VR groups (p-value < 0.05) (Table 2). Within-group analysis demonstrated a reduction in dental anxiety scores following treatment across all domains (Q1–Q4) and total DAS-R score (p-value < 0.001) (Table 3). These findings were consistent across both parametric and non-parametric analyses. Effect size analysis using Hedges' g demonstrated a substantial reduction in dental anxiety following treatment. Within-group comparisons showed large effect sizes for all psychological variables, including the total anxiety score ($g = -1.91$) and individual domains (g ranging from -1.22 to -1.92).

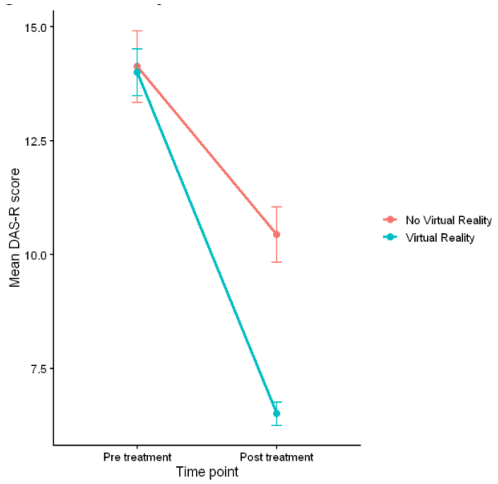

Figure 3: *Change in mean DAS-R scores before and after treatment in the virtual reality (VR) and non-virtual reality (non-VR) groups. Mean scores (± standard error) were 14.12 ± 0.79 and 10.44 ± 0.61 in the non-VR group, and 14.00 ± 0.52 and 6.50 ± 0.26 in the VR group at pre- and post-treatment, respectively. Error bars represent standard errors. The y-axis was scaled to reflect the observed range of scores.*

Table 2: Between-group comparison of psychological variables using independent t-tests (n=32)

Anticipation Variable	**Pre-treatment**				**Post-treatment**			
	No VR Mean ± SD	**VR** Mean ± SD	**Mean diff.** (95% CI)	***p-value***	**No VR** Mean ± SD	**VR** Mean ± SD	**Mean diff.** (95% CI)	***p-value***
General anticipation	3.56 ± 0.96	3.38 ± 0.72	0.18 (−0.43-0.79)	*0.5379*	2.81 ± 0.83	1.69 ± 0.48	1.12 (0.63-1.61)	*0.0001*
Waiting period	3.69 ± 0.95	3.44 ± 0.51	0.25 (−0.31-0.81)	*0.3624*	2.44 ± 0.63	1.56 ± 0.63	0.88 (0.43-1.33)	*0.0005*
Drill usage by a dentist	3.69 ± 0.87	3.62 ± 0.50	0.07 (−0.45-0.59)	*0.8059*	2.69 ± 0.70	1.62 ± 0.50	1.07 (0.63-1.51)	*<0.001*
Routine dental procedures	3.44 ± 0.89	3.31 ± 0.70	0.13 (−0.45-0.71)	*0.6633*	2.50 ± 0.89	1.62 ± 0.62	0.88 (0.32-1.44)	*0.0034*
DAS-R Score	14.12 ± 3.16	14.00 ± 2.07	0.12 (−1.82-2.06)	*0.8957*	10.44 ± 2.42	6.50 ± 1.03	3.94 (2.57-5.31)	*<0.001*

Significant at p-value <0.05

Table 3: Mean scores and within-group comparison of psychological variables using paired t-tests (n=32)

Anticipation Variable	**Pre-treatment** Mean ± SD	**Post-treatment** Mean ± SD	**Mean diff.** (95% CI)	***p-value***
General anticipation	3.47 ± 0.84	2.25 ± 0.88	−1.22 (−1.57 to −0.87)	*<0.001*
Waiting period	3.56 ± 0.76	2.00 ± 0.76	−1.56 (−1.88 to −1.25)	*<0.001*
Drill usage by a dentist	3.66 ± 0.70	2.16 ± 0.81	−1.50 (−1.77 to −1.23)	*<0.001*
Routine dental procedures	3.38 ± 0.79	2.06 ± 0.88	−1.31 (−1.61 to −1.02)	*<0.001*
DAS-R Score	14.06 ± 2.63	8.47 ± 2.71	−5.59 (−6.63 to −4.56)	*<0.001*

Significant at p-value <0.05

3.3. Physiological outcomes

Between-group comparisons indicated similar baseline values (p-value > 0.05). Post-treatment differences between VR and non-VR groups were small for all physiological parameters (Table 4).

Within-group comparisons showed changes in physiological parameters following treatment. A reduction in systolic blood pressure was observed (p-value = 0.0185) (Figure 4), whereas changes in pulse rate, oxygen saturation, and diastolic blood pressure were minimal (Table 5). Physiological parameters showed small effect sizes (g ranging from −0.43 to 0.30), indicating limited clinical impact.

Table 4: Between-group comparison of physiological parameters using independent t-tests (n=32)

Variable	Pre-treatment				Post-treatment			
	No VR Mean ± SD	**VR** Mean ± SD	**Mean diff.** (95% CI)	***p-value***	**No VR** Mean ± SD	**VR** Mean ± SD	**Mean diff.** (95% CI)	***p-value***
Pulse	86.94 ± 12.47	85.81 ± 8.80	1.13 (−6.70-8.96)	0.7703	89.00 ± 13.05	88.25 ± 9.28	0.75 (−7.46-8.96)	*0.8528*
Oxygenation	97.69 ± 1.14	97.62 ± 0.96	0.07 (−0.69-0.83)	0.8677	97.88 ± 1.41	97.94 ± 0.57	−0.06 (−0.85-0.73)	*0.8711*
Systolic	118.75 ± 10.72	118.12 ± 8.73	0.63 (−6.44-7.70)	0.8578	115.56 ± 15.80	113.00 ± 10.23	2.56 (−7.12-12.24)	*0.5908*
Diastolic	79.38 ± 7.04	78.75 ± 6.19	0.63 (−4.16-5.42)	0.7916	77.19 ± 10.48	75.75 ± 6.49	1.44 (−4.91-7.79)	*0.6449*

Significant at p-value <0.05

Table 5: Within-group comparison of physiological parameters using paired t-tests

Variable	**Pre-treatment** Mean ± SD	**Post-treatment** Mean ± SD	**Mean diff.** (95% CI)	***p-value***
Pulse	86.38 ± 10.63	88.62 ± 11.15	2.25 (−0.42 to 4.92)	*0.0951*
Oxygenation	97.66 ± 1.04	97.91 ± 1.06	0.25 (−0.16 to 0.66)	*0.2225*
Systolic	118.44 ± 9.63	114.28 ± 13.16	−4.16 (−7.57 to −0.75)	*0.0185*
Diastolic	79.06 ± 6.53	76.47 ± 8.61	−2.59 −5.42 to 0.23	*0.0703*

Significant at p-value <0.05

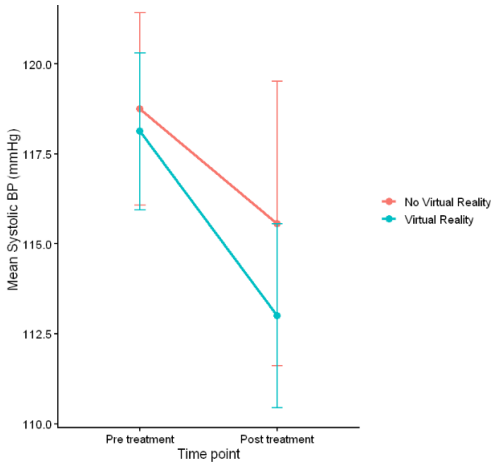

Figure 4: *Change in mean systolic blood pressure before and after treatment in the virtual reality (VR) and non-virtual reality (non-VR) groups. Mean systolic blood pressure (± standard error) was 118.75 ± 2.68 and 115.56 ± 3.95 mmHg in the non-VR group, and 118.12 ± 2.18 and 113.00 ± 2.56 mmHg in the VR group at pre- and post-treatment, respectively. Error bars represent standard errors.*

4. Discussion

We found that virtual reality (VR) intervention during dental surgery significantly reduces dental anxiety across all measured domains ($p < 0.001$), with VR users transitioning from severe to mild anxiety states. This indicates that VR can meaningfully shift patients from clinically significant to more manageable anxiety levels during invasive procedures. Additionally, VR had a significant positive effect on systolic blood pressure (p = 0.02), though it did not significantly affect diastolic blood pressure, oxygen saturation, or pulse rate. These findings establish VR as an effective non-pharmacological intervention for managing dental anxiety while maintaining physiological stability during invasive procedures.

Our results align with and extend previous research demonstrating VR's efficacy in reducing dental anxiety. Significant anxiety reduction with VR, confirming its potential as an alternative to pharmacological interventions [17, 18]. The consistency of these findings across diverse populations strengthens the evidence for VR's anxiolytic effects in dental settings. Several trials in both children and adults undergoing dental procedures have also reported reductions in dental anxiety and procedural pain with VR distraction or VR relaxation, further supporting our findings [21–24]. Notably, our work adds to existing literature by focusing specifically on a surgical context, where anxiety and physiological arousal are typically higher than in routine dental procedures.

Regarding physiological parameters, our oxygen saturation results corroborate the findings reported by *Alabduljabbar R. et al.* [19], who found no significant differences in SpO2 between VR and non-VR groups. This suggests VR distraction does not compromise respiratory function, addressing a common safety concern. However, our systolic blood pressure findings align with a Chinese randomized controlled trial [20], which reported a significant reduction in mean arterial pressure with VR. Similar reductions in systolic blood pressure and heart rate following VR exposure have been reported in perioperative and medical settings, supporting a potential hemodynamic benefit of VR-based relaxation [26–28]. This discrepancy may stem from procedural differences or measurement timing, highlighting the need for standardized protocols in future studies. In particular, the use of intraoperative VR and biofeedback in our study may have enhanced autonomic regulation compared with purely preoperative or waiting-room VR applications reported elsewhere. Future studies should therefore consider unified timing of physiological measurements and more detailed reporting of VR content, duration, and level of interactivity to enable meta-analytic synthesis across studies.

The mechanism underlying VR's effectiveness likely involves modulation of the sympathetic nervous system. By providing immersive distraction, VR may reduce stress-induced catecholamine release, thereby stabilizing cardiovascular parameters. This is supported by the researchers' reports, who observed improved heart rate variability and decreased heart rate with VR, indicating reduced sympathetic activation [17, 20]. Immersive VR environments also engage multiple sensory channels and alter patients' perception of time and threat, thereby diverting attentional resources away from nociceptive and anxiety-provoking stimuli. In our study, the integration of biofeedback-based VR may further promote self-regulation by allowing patients to observe and adjust their breathing and relaxation responses in real time, consistent with emerging evidence on VR biofeedback for stress reduction and autonomic control. Collectively, these mechanisms provide a plausible psychophysiological explanation for the concurrent reductions in anxiety scores and systolic blood pressure observed in our study.

Our study's strengths include its rigorous design, with both psychological and physiological outcome measures, which provide a comprehensive evaluation of VR's effects. The use of standardized DAS-R questionnaires enhances comparability with existing literature. Furthermore, conducting the intervention in a real-world surgical setting and combining VR with biofeedback represent important novel aspects, as most previous dental VR studies have focused on non-surgical treatments or preoperative waiting-room interventions [21–24]. VR therapy is a groundbreaking way of pain and anxiety management, which enables the use of distractions for dental treatment patients immersed in a virtual world. [25] These features increase the ecological validity of our findings and suggest that VR can be integrated into routine surgical workflows without compromising patient safety. In addition, VR was well tolerated and did not interfere with the operative field, consistent with reports from dental teams in other clinical settings. The current study results were consistent with those of a study conducted in Iran, in which pulse rate did not differ significantly between groups [26]. Another study conducted in Kenya [27] showed that participants who received VR treatment exhibited lower levels of anxiety compared to those in the standard of care (SOC) group.

Clinically, our findings support incorporating VR as a practical, non-pharmacological tool for managing dental anxiety. Because VR hardware is becoming more affordable and portable, it may offer a scalable option for busy public clinics and resource-limited settings, helping reduce chairside distress, improve patient cooperation, and potentially reduce the need for pharmacological sedation or general anesthesia. By improving patient experience during dental surgery, VR-based interventions could also reduce appointment cancellations and avoidance, thereby facilitating earlier treatment and better oral health outcomes over time. This may be especially relevant in low- and middle-income or resource-limited settings, where inexpensive VR headsets have already shown promise in reducing perioperative anxiety and are feasible to integrate into existing care pathways.

However, several limitations warrant consideration. The headsets used in the study were mainly intended for use in either a seated or standing position. Therefore, patients lying supine in a dental chair can find it uncomfortable to wear the headsets while treating their upper teeth. It is important to note this when planning to apply the headsets in dentistry. Another limitation of this research was that all subjects received identical audiovisual material. The single-center design restricts generalizability to other clinical contexts and populations. The relatively small sample size (n=32) may have limited power to detect smaller physiological changes, particularly in diastolic blood pressure and pulse rate. Attrition was relatively high, with 7 participants in the VR group and 5 in the control group discontinuing participation. This attrition may have introduced potential bias and was likely influenced by limited acceptance and familiarity with VR devices in a low- and middle-income country (LMIC) setting. Additionally, we cannot rule out placebo effects, as participants were aware of the intervention. Blinding was not feasible due to the VR device's visibility and the intervention procedures. The short-term follow-up also prevents conclusions about VR's long-term efficacy. Outcomes were assessed only during a single treatment sitting; therefore, the long-term impact of VR on dental anxiety reduction, treatment adherence, and repeated dental visits remains unknown. Furthermore, although

the VR intervention included relaxing nature scenes and calming audio, limited details regarding immersive features and content standardization may affect reproducibility in other clinical settings. Future multicenter studies with larger sample sizes, longer follow-up periods, and standardized VR protocols are recommended to strengthen the evidence base for VR-assisted anxiety management in dental practice.

Future research should confirm these findings in larger, multi-center trials with diverse patient populations. Studies should explore optimal VR content types, exposure durations, and potential synergistic effects in relation to minimal sedation. Unanswered questions include VR's impact on procedural pain perception and its efficacy in pediatric and geriatric populations. Longitudinal studies should assess whether reduced anxiety translates to improved treatment adherence and oral health outcomes.

These findings have significant implications for clinical practice, particularly in resource-limited settings like Pakistan. By providing a cost-effective, non-pharmacological anxiety management tool, VR could increase treatment uptake among anxious patients, potentially reducing oral health disparities. The ability to maintain physiological stability during procedures also enhances patient safety, especially for those with cardiovascular co-morbidities. For healthcare systems, VR represents a scalable intervention that could reduce the need for anxiolytic medications and their associated risks.

5. Conclusion

Our study demonstrates that VR significantly reduces dental anxiety while maintaining physiological stability during dental surgery. This non-pharmacological approach offers promise to improve the accessibility and experience of dental care in lower-middle-income countries. As dental anxiety remains a major barrier to treatment, VR represents an evidence-based solution that addresses both psychological and physiological aspects of patient care. The integration of VR into dental practice may enhance patient comfort and safety during surgical procedures while potentially improving treatment acceptance and adherence among anxious patients. Furthermore, VR-based interventions may have broader applicability across different dental procedures and patient populations, supporting their role as a practical adjunctive tool in contemporary dental care.

6. Declarations

Funding

This work received no funding.

Author Contributions

A.M. designed the study, collected and analyzed samples and data, and drafted the manuscript. S.S. collected data and drafted the manuscript. W.A. supervised the study, supported the statistical analysis, and carefully reviewed the manuscript. All the authors approve the final draft of the manuscript.

Ethics Approval and Consent to Participate

This study obtained ethics approval from the Research Ethics Committee of Sharif Medical and Dental College, Ref. No.SMDC/SMRC/339-24 and The University of Lahore's Research Ethics Committee Ref No.REC-UOL-/423/08/24. The trial was registered in a WHO-approved trial registry with registration number ChiCTR2500095660 (Chinese Clinical Trial Registry, ChiCTR (www.chitr.org.cn). Participation in the study was voluntary, and written informed consent was obtained from all individual participants before data collection.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data is available from the corresponding author upon request. Supplementary Tables for the data are available upon request.

Acknowledgments

The authors are thankful to the patients for their cooperation during the study.

AI Declaration

The authors confirm that no content in this manuscript was generated using artificial intelligence (AI) tools, and the authors take full responsibility for the accuracy and integrity of the work.

7. Abbreviations

The following abbreviations are used in this manuscript:

ChiCTR	Chinese Clinical Trial Registry
CONSORT	Consolidated Standards of Reporting Trials
DAS-R	Dental Anxiety Scale-Revised
LMIC	Low-and middle-income countries
PMMA	Polymethyl Methacrylate
SOC	Standard of care
VR	Virtual Reality
WHO	World Health Organization

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