Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Virtual Reality Versus Nitrous Oxide for Anxiety Reduction and Behavior Management During Pediatric Dental Treatment: A Randomized Crossover Study

Rupini Shukla

rshukla@geisinger.edu

Department of Dental Medicine and Oral Surgery, Geisinger Medical Center

Jason Salvato

Geisinger Commonwealth School of Medicine

Esnel Diaz

Geisinger Commonwealth School of Medicine

Lacey Williams

Department of Dental Medicine and Oral Surgery, Geisinger Medical Center

Natalie Stinton

Department of Dental Medicine and Oral Surgery, Geisinger Medical Center

Shengxuan Wang

Department of Population Health Sciences, Geisinger Medical Center

Gayatri Malik

Department of Dental Medicine and Oral Surgery, Geisinger Medical Center

Article

Keywords: Virtual Reality, Nitrous Oxide, Pediatric Dentistry, Dental Anxiety, Behavior Management, Pain Management, Crossover Study, Distraction Techniques, Child Behavior, FLACC Scale, Houpt Scale, Wong-Baker FACES Scale

Posted Date: September 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10697358/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: There is no conflict of interest

Abstract

Aim: To compare virtual reality (VR) and nitrous oxide (N_2O) as distraction modalities to alleviate anxiety and dental pain in children undergoing dental procedures.

Materials and Methods: Sixty-two participants, aged 5 to 12 years, were included in this crossover study. Participants randomly received either N_2O or VR, followed by the alternative subsequently. All participants received restorative treatments (e.g., dental restorations, crowns, extractions) using local anesthesia. Participants rated their pain using the Wong-Baker FACES scale before and after the procedure. After local anesthesia administration, the provider rated the child's reaction using the FLACC scale, followed by the Houpt Crying and Movement Scale to assess the child's overall behavior.

Results: Statistically significant differences favoring N_2O were observed for the Houpt ($P < .001$), FLACC ($P < .001$), and Wong-Baker FACES scores ($P = .021$). "Definitely positive" behaviors (Houpt score 15-16) were observed more frequently in the N_2O group (54.9%) than the VR group (40.3%). The VR group exhibited a higher incidence of negative behaviors (Houpt score ≤ 10: 11.3% vs. 1.6%).

Conclusions: N_2O demonstrated superior effectiveness in reducing dental pain and anxiety. VR may be a viable non-pharmacologic alternative or adjunct to nitrous oxide, but requires careful case selection.

INTRODUCTION

Dental anxiety remains a significant barrier to care among pediatric patients and may negatively influence treatment acceptance, procedural efficiency, and long-term attitudes toward oral healthcare. Recent evidence suggests that approximately one-third of children experience dental fear and anxiety, often triggered by sensory stimuli inherent to the dental environment, including visual, auditory, tactile, and olfactory cues.[1,2] Effective management of procedural anxiety is therefore essential to facilitate treatment completion while promoting positive healthcare experiences and improving future treatment acceptance.[3]

Multiple approaches have been developed to reduce anxiety and improve cooperation during pediatric dental treatment. Conventional behavior guidance techniques including tell-show-do (TSD), distraction, positive reinforcement, and communication-based approaches remain foundational components of pediatric dental practice.[3,4] Pharmacologic interventions such as nitrous oxide (N_2O) inhalation sedation are also widely utilized because of their established safety profile and demonstrated effectiveness in reducing procedural distress and facilitating treatment completion.[4,5,6] More recently, virtual reality (VR) has emerged as a novel non-pharmacologic behavioral modality intended to increase engagement and redirect attention away from unpleasant procedural stimuli.[7,8,9]

VR has been investigated across numerous medical and dental settings as a distraction technique for painful and anxiety-provoking procedures. Prior studies have demonstrated reductions in perceived pain,

anxiety, and procedural distress among pediatric patients receiving VR interventions.[8,9,10,11] Additional comparative investigations have suggested that immersive VR may outperform traditional audiovisual distraction methods because of greater attentional engagement and environmental immersion.[12,13,14] Systematic reviews and meta-analyses have generally supported VR as a promising adjunctive tool for pediatric dental care, reporting improvements in behavior and reductions in pain perception, although findings remain heterogeneous depending on procedural stage and study design.[15,16,17,18,19]

Patient behavior during dental procedures directly influences procedural quality, efficiency, and safety. Pain perception and procedural anxiety are major determinants of cooperation and treatment success. Standardized behavioral assessment tools including the Face, Legs, Activity, Cry, Consolability (FLACC) scale, Wong-Baker FACES Pain Rating Scale, and Houpt Behavior Rating Scale have demonstrated reliability and validity for evaluating pain and behavioral responses in pediatric populations and dental settings.[20,21,22,23,24]

Despite increasing investigation into VR based distraction, most studies have compared VR with routine care or alternative distraction modalities rather than established pharmacologic anxiolysis.[15,16,17,19] Direct comparisons between VR and N_2O remain limited despite N_2O serving as one of the most widely accepted modalities for pediatric behavior guidance.[4,5,6] Therefore, the purpose of this study was to compare VR and N_2O as anxiety-reduction and behavior management modalities during pediatric dental procedures requiring local anesthesia. We hypothesized that VR would demonstrate non-inferior performance compared with N_2O in reducing pain perception and improving procedural behavior.

MATERIALS and METHODS

Study Design and Population

This study (IRB# 2023 – 1000; NCT04886141) was an IRB-approved, cross-sectional, crossover, randomized controlled, interventional therapy utilizing VR goggles (Oculus Quest 2) as a method of distraction. Data was collected during and after the procedure on the behavior displayed during local anesthesia administration and the child's responses to standardized questions.

Sixty-two ASA 1 and 2 patients aged 5–12 years undergoing painful dental treatment necessitating the use of local anesthesia (restorations, crowns, pulpotomy, extractions) were recruited from one of two pediatric dental clinics at a tertiary medical center. Participation was voluntary, and the parents of participants consented. Participants age 7–12 also gave assent prior to beginning the study. Exclusion criteria included participants with motion sickness, hypersensitivity to light and/or sound that could lead to seizures, and those who could not tolerate the use of the VR headset, local anesthesia, or N_2O.

In this crossover study, all participants served as their own control and attended two separate appointments, one with N_2O and one with VR goggles. Treatment modality order was randomly assigned by a coin toss at the first visit, and all procedures were performed by a single provider (R.S.). We used a

Porter silhouette low-profile nasal mask, with N_2O delivered at a flow rate of 2 to 4 liters per minute through a disposable nasal hood. N_2O usage averaged 50%.

Virtual Reality Apparatus

The Oculus Quest 2 (Fig. 1) is a VR headset designed to give users an immersive experience while watching media or playing games. The headset is strapped to the user's head so that a Liquid-crystal display (LCD) screen dominates the user's field of vision, blocking all other visual distractions, while also projecting built-in audio. Participants were shown an 85-minute movie (A Turtle's Tale: Sammy's Adventures) during treatment.[25]

Comparative Scoring for Pain

Participants in both groups scored their pain before beginning the procedure using the Wong-Baker FACES scale (WBFS) to establish a baseline level.[22] WBFS is conducted using 6 cartoon faces with emotions ranging from “No Hurt” to “Hurts Worst”, with the intention of quantifying emotions on a scale of 0–10, 10 being the worst (Fig. 2). After administration of local anesthesia, the provider gave the participant a FLACC score.[23] FLACC scale assesses the child’s behavioral distress through five categories; each scored on a scale of 0–2, yielding a total score of 0–10, 10 being the highest level of distress. The five categories scored are the following: face, legs, activity, cry, and consolability (Fig. 3). At the end of the procedure, the participants rated their experience using the Wong-Baker FACES scale, and a survey was given to the participants to be completed. The investigator completed the Houpt Crying and Movement Scale after the procedure was completed.[24] This scale assesses how well the procedure was tolerated through the severity of the patient’s interruptions, like crying or movement, and how it affected the provider’s ability to finish the procedure. A score is calculated from 1–6, 6 being “excellent: no crying or movement” (Fig. 4).

Statistical Analysis

All demographics and outcomes are fully described. Continuous variables are summarized using mean with standard deviation, and median with interquartile range. Categorical variables are summarized using frequency and percentages. Comparisons between the VR group and the N_2O group were performed using McNemar's test for binary data and Cochran-Mantel-Haenszel test for multi-level categorical data, and Wilcoxon signed-rank test for continuous data. Statistical analysis was conducted using SAS® Enterprise Guide 8.2 (SAS Institute Inc., Cary, NC, USA). All tests were 2-sided and p values < 0.05 were considered statistically significant.

Sample Size Power Analysis

From the previous power analysis, a sample size of 62 patients was recommended. According to the study hypothesis, a non-inferiority paired t-test was used to perform a sample size calculation, and the overall FLACC pain scale score was used as an outcome. The non-inferiority margin was set as '1', which is the largest difference that is clinically acceptable. Based on a similar study, the actual mean of paired difference of FLACC pain scale score is 0.3, and the estimated standard deviation is 2. To achieve 80% power to detect non-inferiority using a one-sided paired t-test when the non-inferiority margin is 1, a minimum of 52 subjects was needed. The significance level of the test is 0.05. Assuming a dropout rate of approximately 20%, we recruited 62 patients.

RESULTS

There was a total of 62 participants analyzed, male patients making up 63% and female patients 37% (Table 1). The average age was 9 with a standard deviation of 3 (Table 1).

Comparing FACES, Houpt, and FLACC results, we found a statistically significant difference between the N_2O and VR groups in every measure. Differences in Houpt and FLACC scores demonstrated a low p-value of < 0.001, while the FACES score demonstrated a p-value of 0.021 (Table 2).

Most patients who received N_2O had a total FLACC score of zero (61.3%), compared to only 43.6% of patients in the VR group with a total FLACC score of zero (Table 3). More patients who received N_2O treatment reported no pain in all categories of face, legs, activity, cry, and consolability compared to their visits when they received treatment with a VR headset. The median FLACC total score was compared between the two visits. A higher median FLACC total score was observed in the VR headset group (median = 1, IQR = 0–5) compared to the N_2O group (median = 0, IQR = 0–2, $p < 0.001$) (Table 3).

Also, higher Houpt total scores were more frequently observed in the N_2O group, with 35.5% of patients having a total score of 15 and 19.4% of patients having a total score of 16, compared to only 27.4% and 12.9% of patients in the VR group, respectively (Table 3). Significantly, better behavior in crying and movement was observed among the patients when they received the N_2O treatment compared to the visits when they wore a VR headset. Also, a higher Houpt total score was noticed in the N_2O group (median = 15, IQR = 13–15) compared to the VR group (median = 13, IQR = 12–15, $p = 0.001$) (Table 3).

DISCUSSION

Our results demonstrate that N_2O is a more effective anxiolytic and behavior management tool than VR during pediatric dental procedures requiring local anesthesia. Statistically significant differences favoring N_2O were observed across all three outcome measures: the Houpt Behavior Scale, the FLACC scale, and the Wong-Baker FACES Pain Rating Scale. These findings are corroborated by substantial evidence supporting N_2O as a time-tested and effective pharmacologic intervention for managing pediatric dental anxiety.[4,5,6]

While VR may not yet match N_2O in reliability or effectiveness, this does not render it ineffective. Rather, providers must carefully weigh the risks and benefits of VR, with particular attention to case selection. Several benefits of VR were observed. Children using VR required less verbal guidance, as they would be immersed in the headset, diverting their attention away from the procedure. The headset effectively obscured visual access to anxiety-inducing instruments such as needles and drills. Its design encouraged optimal head positioning, facilitating provider access. Notably, VR was highly appealing to children; many perceived their appointment as more fun and expressed desire to use VR again.

Despite these advantages, significant drawbacks emerged. Some children missed auditory instructions due to immersion, and ambient dental noise sometimes obscured the headset audio. The physical weight and bulk of the headset rendered it uncomfortable for some children, particularly younger patients, diminishing its distracting effect. Children with reactive gag reflexes tolerated the IsoDry system poorly without N_2O. Passive video content did not engage all children equally, and VR became completely ineffective once a child began to cry or shut their eyes. Furthermore, VR proved less effective for children who preferred preparatory information and responded favorably to tell-show-do a finding that contradicts some previous research suggesting VR benefits all pediatric populations equally.[12,13] Additional practical challenges included parental concerns regarding movie content and a provider learning curve for working around the headset.

In contrast, N_2O demonstrated well-established benefits. Decades of evidence support its anxiolytic and gag reflex suppression properties.[4,5,6] N_2O can be complemented by nonpharmacologic techniques such as tell-show-do, distraction, and voice control. Unlike VR, which offers a fixed stimulus, N_2O can be titrated in real time according to patient distress, representing a significant advantage. However, N_2O is not without drawbacks. Successful use still requires adjunctive behavioral techniques. A well-fitting nasal mask is essential but not always achievable for younger children. Some children dislike the nasal sensation or affective changes of N_2O, and medical contraindications such as active ear infections preclude its use in select patients.

When directly comparing the two modalities, N_2O may be more effective for patients with higher baseline dental fear. This enhanced anxiolysis is likely attributable to N_2O's pharmacologic action on the central nervous system via GABA receptor modulation, inducing mild to moderate sedation that a purely behavioral distraction technique cannot replicate.[3,5]

An interesting and potentially important finding is that, despite exhibiting poorer behavioral scores on the Houpt and FLACC scales during VR treatment, many participants consistently reported greater subjective enjoyment of VR compared to N_2O. This dissociation between objective behavioral ratings and subjective patient enjoyment suggests that VR may offer unique advantages in terms of patient satisfaction, even if it does not achieve the same level of behavioral compliance as N_2O. These observations warrant further investigation into the potential synergistic anxiolytic effects of combined N_2O and VR, which could produce additive benefits while potentially reducing the required dose of N_2O.

Limitations and Future Directions

Several limitations must be acknowledged. Although a prior power analysis was conducted, the sample size of 62 remains modest. Due to physical differences between the VR headset and N_2O delivery systems, the provider could not be blinded, representing a potential source of observer bias.

Case selection appears critically important for VR. Children who are naturally inquisitive and respond favorably to tell-show-do may find the VR headset more distressing than reassuring. In this study, some participants were receiving their first dental treatment, making it difficult to control baseline anxiety, and behavior on VR may have been poorer when VR was administered as the first intervention.

While the crossover design allowed each participant to serve as their own control, we did not standardize several procedural variables. We did not account for consistency in the quadrant treated or the specific types of procedures completed at each visit. Certain procedures, such as extractions, may be inherently more anxiety provoking than simple restorations, representing a potential source of bias.

Data were collected through participant surveys and operator-assigned behavior scores, both of which introduce subjectivity. Future research should incorporate objective physiologic measures such as heart rate variability or salivary cortisol levels.

This pilot study included only ASA 1 and 2 patients. While N_2O is well-documented in children with special health care needs, evidence for VR in these populations remains limited and mixed.[26,27] Further research is needed to evaluate VR in children with special needs, who often experience disproportionate barriers to dental care.

This study should be revisited in the future when VR technology becomes less bulky and obstructive to the provider's visibility. With slimmer design, it could be easier to justify the use of VR headsets in more dental procedures. Additionally, future studies could be made to assess the possible compounding effects that nitrous oxide and VR can have together during a procedure, once technology allows.

Finally, the choice of VR content may influence outcomes. All participants viewed the same stimulating animated movie. Some research suggests that calmer VR content may be more appropriate for invasive procedures, while other evidence indicates that active distraction may be superior to passive modalities.[27,28] The optimal characteristics of VR content for pediatric dental anxiety reduction warrant systematic investigation.

CONCLUSION

N_2O demonstrated superior effectiveness to VR for behavior management and pain reduction during pediatric dental procedures requiring local anesthesia, with statistically significant differences favoring N_2O across all outcome measures. VR remains a viable non-pharmacologic modality for anxiety reduction, but its successful application requires careful case selection. N_2O continues to be the more

reliable tool for managing pediatric dental anxiety, while VR may serve as a promising adjunct in appropriately selected patients.

Abbreviations

Abbreviation	Definition
ASA	American Society of Anesthesiologists
FLACC	Face, Legs, Activity, Cry, Consolability
IRB	Institutional Review Board
IQR	Interquartile Range
LCD	Liquid-Crystal Display
NO	Nitrous Oxide
SD	Standard Deviation
TSD	Tell-Show-Do
VR	Virtual Reality
WBFS	Wong-Baker FACES Scale

Declarations

Ethics Approval and Guidelines

This study was approved by the Geisinger Institutional Review Board (IRB No. 2023-1000). The trial was registered at ClinicalTrials.gov (N NCT04886141). All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to institutional data privacy policies but are available from the corresponding author on reasonable request.

Author Contributions

RS contributed to study conceptualization, study design, participant recruitment, data collection, project supervision, and manuscript revision. JS and ED contributed to data interpretation, literature review, manuscript drafting, and manuscript revision. NS contributed to methodology refinement, data interpretation, project supervision, and critical review of the manuscript. SW contributed to statistical

analysis, data interpretation, and critical revision of the manuscript for important intellectual content. GM and LW contributed to study design, methodology refinement, data interpretation, project supervision, and critical review of the manuscript. All authors participated in drafting or revising the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgments

The authors thank the staff and patients of the Geisinger pediatric dental clinics for their participation and support of this study.

References

1. Sun IG, Chu CH, Lo ECM, Duangthip D. Global prevalence of early childhood dental fear and anxiety: a systematic review and meta-analysis. J Dent. 2024;142:104841.
2. Shindova MP, Belcheva AB. Dental fear and anxiety in children: a review of the environmental factors. Folia Med (Plovdiv). 2021;63(2):177–182.
3. Armfield JM, Heaton LJ. Management of fear and anxiety in the dental clinic: a review. Aust Dent J. 2013;58(4):390–407.
4. American Academy of Pediatric Dentistry. Behavior guidance for the pediatric dental patient. Pediatr Dent. 2017;39(6):246–259.
5. Kunta S, Arora RV, Jain R, Rawat P. The effect of anxiety and stress on acceptance of dental procedure before and after inhalation sedation in pediatric patients: an in vivo study. J Int Clin Pediatr Dent. 2023;16(2):302–307.
6. Garret-Bernardin A, Festa P, Matarazzo G, et al. Behavioral modifications in children after repeated sedation with nitrous oxide for dental treatment: a retrospective study. Int J Environ Res Public Health. 2023;20(5):4037.
7. Zaidman L, Lusky G, Shmueli A, et al. Distraction with virtual reality goggles in paediatric dental treatment: a randomised controlled trial. Int Dent J. 2023;73(1):108–113.
8. Wiederhold MD, Gao K, Wiederhold BK. Clinical use of virtual reality distraction system to reduce anxiety and pain in dental procedures. Cyberpsychol Behav Soc Netw. 2014;17(6):359–365.
9. Shetty V, Suresh LR, Hegde AM. Effect of virtual reality distraction on pain and anxiety during dental treatment in 5 to 8 year old children. J Clin Pediatr Dent. 2019;43(2):97–102.
10. Asl Aminabadi N, Erfanparast L, Sohrabi A, Ghertasi Oskouei S, Naghili A. The impact of virtual reality distraction on pain and anxiety during dental treatment in 4–6 year-old children: a randomized controlled clinical trial. J Dent Res Dent Clin Dent Prospects. 2012;6(4):117–124.

11. Felemban OM, Alshamrani RM, Aljeddawi DH, Bagher SM. Effect of virtual reality distraction on pain and anxiety during infiltration anesthesia in pediatric patients: a randomized clinical trial. BMC Oral Health. 2021;21(1):321.
12. Rao DG, Havale R, Nagaraj M, et al. Assessment of efficacy of virtual reality distraction in reducing pain perception and anxiety in children aged 6–10 years: a behavioral interventional study. Int J Clin Pediatr Dent. 2019;12(6):510–513.
13. Shams SA, Reddy A, Vaghela LL, Jain M, Naik H, Krishnan P. Comparison of effectiveness of audio and VR distraction techniques in managing pediatric dental patients. J Pharm Bioallied Sci. 2024;16(Suppl 1):S504-S506.
14. Anchala K, Tirumala V, Saikiran KV, Elicherla NR, Rahul S, Nuvvula S. Efficacy of kaleidoscope, virtual reality, and video games to alleviate dental anxiety during local anesthesia in children: a randomized clinical trial. J Dent Anesth Pain Med. 2024;24(3):195–204.
15. López-Valverde N, Muriel-Fernández J, López-Valverde A, et al. Use of virtual reality for the management of anxiety and pain in dental treatments: systematic review and meta-analysis. J Clin Med. 2020;9(10):3086.
16. López-Valverde N, Muriel Fernández J, López-Valverde A, et al. Use of virtual reality for the management of anxiety and pain in dental treatments: systematic review and meta-analysis. J Clin Med. 2020;9(4):1025.
17. Dahlan M, Alsaywed R, Alamoudi R, et al. Assessment of different distraction behavioral methods in pediatric dental clinic: a systematic review. Cureus. 2023;15(7):e42366.
18. Hao T, Pang J, Liu Q, Xin P. A systematic review and network meta-analysis of virtual reality, audiovisuals and music interventions for reducing dental anxiety related to tooth extraction. BMC Oral Health. 2023;23(1):684.
19. Rosa A, Pujia AM, Docimo R, Arcuri C. Managing dental phobia in children with the use of virtual reality: a systematic review of the current literature. Children (Basel). 2023;10(11):1763.
20. Howard KE, Freeman R. Reliability and validity of a faces version of the modified child dental anxiety scale. Int J Paediatr Dent. 2007;17(4):281–288.
21. Wong HM, Humphris GM, Lee GT. Preliminary validation and reliability of the modified child dental anxiety scale. Psychol Rep. 1998;83(3 Pt 2):1179–1186.
22. Wong-Baker FACES Foundation. Wong-Baker FACES® Pain Rating Scale. Available from: https://www.WongBakerFACES.org.Accessed7/8/26.
23. Merkel SI, Voepel-Lewis T, Shayevitz JR, Malviya S. The FLACC: a behavioral scale for scoring postoperative pain in young children. Pediatr Nurs. 1997;23(3):293–297.
24. Houpt MI, Weiss NJ, Koenigsberg SR, Desjardins PJ. Comparison of chloral hydrate with and without promethazine in the sedation of young children. Pediatr Dent. 1985;7(1):41–46.
25. Van den Braak B, director. A Turtle's Tale: Sammy's Adventures [motion picture]. United States: Vivendi Entertainment; 2011.

26. Alyahyawi A, Barry M, Helal NM. Dental conscious sedation for the treatment of children with autism spectrum disorder: a narrative review. Cureus. 2024;16(7):e64834.
27. Mehrotra D, Shetty AA, Rai K, Kumara. Effect of audio and virtual reality distraction on the dental anxiety of children with mild intellectual disability. Spec Care Dentist. 2024;44(3):868–877.
28. Yamashita Y, Aijima R, Danjo A. Clinical effects of different virtual reality presentation content on anxiety and pain: a randomized controlled trial. Sci Rep. 2023;13(1):20487.

Tables

Table 1. Demographic Characteristics of the Study Cohort

Characteristic	Value
Male, n (%)	39 (63%)
Female, n (%)	23 (37%)
Age (yr), mean (SD)	9 (3)

* Notes: *n* = number of participants; yr = years; SD = standard deviation.

Table 2. Comparison of Baseline and Post-Treatment Wong-Baker FACES Pain Scores Between the VR and N2O Groups

Variable	VR (n=62)	N_2O (n=62)	p-value*
Baseline Faces, n (%)			0.739
Score 0	55 (88.7%)	54 (87.1%)	
Score 2, 4, 6	7 (11.3%)	8 (12.9%)	
End of Treatment Faces, n (%)			0.052
Score 0	46 (74.2%)	53 (85.5%)	
Score 2, 4, 6, 8	16 (25.8%)	9 (14.5%)	
Face Score Change, n (%)			**0.021**
No change in pain	47 (75.8%)	55 (88.7%)	
Worsening pain	15 (24.2%)	7 (11.3%)	

Notes: VR = virtual reality; N_2O = nitrous oxide; *n* = number of participants.

*Calculated using McNemar's test; statistically significant values ($p < 0.05$) are indicated in bold.

Table 3. Distribution of FLACC and Houpt Behavioral Scores by Treatment Group. (a) FLACC total scores ($p < 0.001$). (b) Houpt total scores ($p = 0.001$).

Variable	VR (n=62)	N_2O (n=62)
FLACC Total Score, n (%)		
0	27 (43.6%)	38 (61.3%)
1	5 (8.1%)	6 (9.7%)
2	5 (8.1%)	8 (12.9%)
3	7 (11.3%)	4 (6.5%)
4	2 (3.2%)	1 (1.6%)
5	7 (11.3%)	3 (4.8%)
6	5 (8.1%)	1 (1.6%)
7	1 (1.6%)	0
8	2 (3.2%)	1 (1.6%)
9	1 (1.6%)	0
Houpt Total Score, n (%)		
6	1 (1.6%)	0
9	2 (3.2%)	0
10	4 (6.5%)	1 (1.6%)
11	8 (12.9%)	7 (11.3%)
12	9 (14.5%)	7 (11.3%)
13	12 (19.4%)	9 (14.5%)
14	1 (1.6%)	4 (6.5%)
15	17 (27.4%)	22 (35.5%)
16	8 (12.9%)	12 (19.4%)

Notes: FLACC = Face, Legs, Activity, Cry, Consolability scale; VR = virtual reality; N_2O = nitrous oxide; *n* = number of participants.

Figures



Figure 1

Oculus Quest 2 VR headset, featuring a head-mounted display with built-in audio that occludes peripheral visual stimuli to provide an immersive audiovisual distraction experience during dental treatment.



©1983 Wong-Baker FACES Foundation. www.WongBakerFACES.org
Used with permission. Originally published in *Whaley & Wong's Nursing Care of Infants and Children.* ©Elsevier Inc.

Figure 2

The Wong-Baker FACES® Pain Rating Scale, featuring six cartoon faces ranging from a happy face at 0 ("No Hurt") to a crying face at 10 ("Hurts Worst"), utilized to assess self-reported pain intensity. Wong-Baker FACES Pain Rating Scale Wong-Baker FACES Foundation (2022). Wong-Baker FACES® Pain Rating Scale. Retrieved 7/8/26 with permission from http://www.WongBakerFACES.org. Originally published in Whaley & Wong's Nursing Care of Infants and Children. © Elsevier Inc.[22]

Category	Scoring		
	0	1	2
Face	No particular expression or smile	Occasional grimace or frown, withdrawn, disinterested	Frequent to constant quivering chin, clenched jaw
Legs	Normal position or relaxed	Uneasy, restless, tense	Kicking or legs drawn up
Activity	Lying quietly, normal position moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking
Cry	No cry (awake or asleep)	Moans or whimpers; occasional complaint	Crying steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging or being talked to, distractible	Difficult to console or comfort

Figure 3

The Face, Legs, Activity, Cry, Consolability (FLACC) behavioral pain assessment scale, utilized to evaluate pain intensity in non-verbal or pre-verbal patients based on five clinical categories scored from 0 to 2. Merkel SI, Voepel-Lewis T, Shayevitz JR, Malviya S. The FLACC: a behavioral scale for scoring postoperative pain in young children. **Pediatr Nurs.** 1997;23(3):293-297.[23]

Rating scale	Definition	Score
Rating scale for sleep	Fully awake, alert	1
	Drowsy, disoriented	2
	Asleep	3
Rating scale for movement	Violent movement that interrupts treatment	1
	Continuous movement that makes treatment difficult	2
	Controllable movement that does not interfere with treatment	3
	No movement	4
Rating scale for crying	Hysterical crying that interrupts treatment	1
	Continuous, persistent crying that makes treatment difficult	2
	Intermittent, mild crying that does not interfere with treatment	3
	No crying	4
Rating scale for overall behavior	Aborted: No treatment	1
	Poor: Treatment interrupted, only partial treatment completed	2
	Fair: Treatment interrupted but eventually all completed	3
	Good: Difficult, but all treatment performed	4
	Very good: Some limited crying or movement, e.g. during anesthesia or mouth prop	5
	Excellent: No crying or movement	6

Figure 4

The Houpt Crying and Movement Sale assesses how well the procedure was tolerated through the severity of the patient's interruptions and how it affected the provider's ability to finish the procedure. Houpt MI, Weiss NJ, Koenigsberg SR, Desjardins PJ. Comparison of chloral hydrate with and without promethazine in the sedation of young children. Pediatr Dent. 1985;7(1):41-46.[24]