

Immersive virtual reality familiarisation with the operating theatre versus verbal flip-chart education for preoperative anxiety before third molar surgery under general anesthesia: a randomized controlled trial

Saptiadi Oktora

saptiadi.oktora@unpad.ac.id

Doctoral Programme, Faculty of Dentistry, Universitas Padjadjaran

Harmas Yazid Yusuf

Universitas Padjadjaran

Eriska Riyanti

Universitas Padjadjaran

Firdaus Hariri

Universiti Malaya

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Abstract

Background

Unfamiliarity with the operating theatre contributes to preoperative anxiety before general anesthesia. This trial evaluated whether a 360-degree virtual reality familiarisation with the operating theatre reduces preoperative anxiety compared with conventional verbal education in adults undergoing third molar surgery under general anesthesia.

Methods

In this single-centre, parallel-group randomized controlled trial, 32 adults aged 18–40 years (American Society of Anesthesiologists physical status I–II, no previous general anesthesia) scheduled for removal of at least two impacted third molars were allocated by coin toss to virtual reality (n = 16; 360-degree video of the pathway from theatre entry to induction) or verbal education supported by a flip chart (n = 16) on the day before surgery. The Amsterdam Preoperative Anxiety and Information Scale, salivary alpha-amylase and cortisol (enzyme-linked immunosorbent assay), blood pressure, pulse rate and respiratory rate were measured before, immediately after and 15 minutes after the intervention. Between-group comparisons used the independent t-test or Mann–Whitney U test; within-group changes used repeated-measures analysis of variance or the Friedman test.

Results

In the virtual reality group, anxiety scores decreased from 18.88 ± 5.15 to 16.75 ± 4.95 and 16.38 ± 5.04 ($p = 0.043$); in the control group they decreased from 20.00 ± 4.60 to 18.13 ± 4.47 and 16.81 ± 5.37 ($p = 0.067$). Scores did not differ between groups at any time point (15 minutes after the intervention: mean difference – 0.43, 95% confidence interval – 4.19 to 3.33; $p = 0.814$). Salivary alpha-amylase, cortisol, systolic and diastolic blood pressure, pulse rate and respiratory rate did not differ between groups at any time point and did not change significantly within either group (all $p > 0.05$).

Conclusions

A brief virtual reality familiarisation with the operating theatre was followed by a significant within-group reduction in self-reported preoperative anxiety but was not superior to verbal flip-chart education, and neither approach changed salivary stress biomarkers or vital signs. Virtual reality may serve as an adjunct to, rather than a replacement for, conventional preoperative education; larger trials are warranted.

Trial registration:

Background

Preoperative anxiety is an unpleasant state of tension and apprehension that affects a large proportion of patients awaiting surgery [1–3]. Beyond its effect on patient experience, high preoperative anxiety has been associated with greater anesthetic and analgesic requirements, haemodynamic instability at induction, more intense postoperative pain, slower recovery and, after major surgery, higher morbidity [4–6]. Reducing preoperative anxiety is therefore a legitimate goal of perioperative care rather than a matter of comfort alone.

Surgical removal of impacted third molars (odontectomy) is one of the most frequently performed procedures in oral and maxillofacial surgery and is typically undertaken in young adults [7, 8]. When several teeth must be removed or the impactions are complex, the procedure is often performed under general anesthesia with nasotracheal intubation [9, 10]. For many of these otherwise healthy patients this is their first contact with an operating theatre. Fear of the unknown, of losing control and of not waking up are among the most frequently reported concerns related to anesthesia [11], and lack of familiarity with the theatre environment and the sequence of events before induction is a modifiable source of this anxiety.

Anxiolytic premedication is effective but may delay discharge and cause residual sedation, which is undesirable in day-case oral surgery. Non-pharmacological interventions, including information provision, music, relaxation techniques and digital technologies, are therefore increasingly used [12, 13]. Immersive virtual reality (VR) isolates the user visually and acoustically from the surroundings and can act through two complementary mechanisms: attentional distraction and graded exposure to, and rehearsal of, a feared situation [14]. Meta-analyses of randomized trials suggest that VR-based interventions reduce preoperative anxiety in adults [15–18], and informative 360-degree videos that let patients "walk through" the hospital or operating theatre have been evaluated in several surgical populations [19–23]. In dentistry, VR has mainly been studied as a distraction during treatment under local anesthesia [24].

Most VR trials have relied exclusively on self-reported anxiety scales [25]. Anxiety, however, is a multidimensional response. Activation of the sympathetic–adrenal–medullary system can be captured non-invasively through salivary alpha-amylase, whereas activation of the hypothalamic–pituitary–adrenal axis is reflected by salivary cortisol [26–28]. Both markers have been used to evaluate preoperative and dental anxiety [29, 30], and vital signs are routinely used as simple physiological correlates [31, 32]. Whether a reduction in perceived anxiety produced by VR is accompanied by a corresponding physiological change remains unclear, and, to our knowledge, no randomized trial has examined VR operating-theatre familiarisation in patients scheduled for third molar surgery under general anesthesia using combined subjective, biochemical and haemodynamic outcomes.

We therefore conducted a randomized controlled trial to compare an immersive 360-degree VR familiarisation with the operating theatre against conventional verbal education supported by a flip chart.

We hypothesised that VR would produce a greater reduction in preoperative anxiety, as measured by the Amsterdam Preoperative Anxiety and Information Scale (APAIS), salivary alpha-amylase, salivary cortisol, blood pressure, pulse rate and respiratory rate.

Methods

Study design and setting

This was a single-centre, two-arm, parallel-group randomized controlled trial conducted at the Central Operating Theatre of Universitas Padjadjaran Dental and Oral Hospital (RSGM Unpad), Bandung, Indonesia, between June and August 2026. Salivary analyses were performed at the Clinical Pathology Laboratory of Dr. Hasan Sadikin General Hospital, Bandung. The study was approved by the Research Ethics Committee of Universitas Padjadjaran (No. 344/UN6.KEP/EC/2026) and is reported in accordance with the CONSORT 2025 statement [33]; the completed CONSORT 2025 checklist is provided as Additional file 1. The trial followed a superiority framework, with each participant having an equal probability of allocation to either arm (1:1). It was retrospectively registered at Thai Clinical Trials Registry TCTR20261003001; <https://www.thaiclinicaltrials.org/show/TCTR20261003001> on Registered 3rd October 2026, after enrolment had been completed. The study protocol was also registered with the Research Ethics Committee of Universitas Padjadjaran (registration no. 2602050245) on 28 April 2026. The approved protocol is available from the corresponding author on request; no separate statistical analysis plan was prepared beyond the analyses specified in the protocol. No changes were made to the eligibility criteria, interventions, outcomes or analyses after the trial commenced.

Participants

Patients scheduled for elective odontectomy under general anesthesia and listed in the Central Operating Theatre register were screened consecutively. Inclusion criteria were: (1) planned surgical removal of at least two impacted third molars of any Pell and Gregory classification under general anesthesia; (2) American Society of Anesthesiologists (ASA) physical status I or II; (3) age 18–40 years; (4) no previous surgery under general anesthesia; (5) no previous participation in a similar study; (6) normal or adequately corrected vision (visual acuity of at least 6/12); and (7) normal hearing, defined as the ability to respond to verbal instructions at normal conversational intensity without a hearing aid. Exclusion criteria were: refusal to participate; visual or hearing disorders that would impair perception of audiovisual VR content (e.g., total colour blindness, diplopia, severe strabismus or sensorineural deafness); systemic disease beyond ASA II; severe psychiatric disorders (e.g., schizophrenia, bipolar disorder or severe post-traumatic stress disorder); claustrophobia; a history of epilepsy or seizures; and a history of severe motion sickness, vertigo or cybersickness. All participants gave written informed consent.

Sample size

The sample size was calculated with the formula for comparing two independent means, $n = 2[(Z_{\alpha} + Z_{\beta})S/(X_1 - X_2)]^2$, with a two-sided α of 0.05 ($Z_{\alpha} = 1.96$), power of 80% ($Z_{\beta} = 0.84$), a standard deviation (S) of 1.08 and expected group means of 3.59 and 4.65. This yielded 16.3 participants per group; 16 participants were enrolled in each group.

Randomization, allocation and blinding

Eligible participants were allocated to the VR group or the control group by simple randomization using a coin toss performed for each participant. The coin was tossed by the first author (SO) immediately after the participant had given written informed consent and completed the baseline (T0) assessments. Because no allocation sequence was generated in advance, the allocation could not be known or predicted at enrolment; no other concealment mechanism was used. Because of the nature of the interventions, neither participants nor the investigator delivering the intervention could be blinded. The laboratory staff who performed the salivary assays were unaware of group allocation; the investigator who recorded vital signs and performed the statistical analysis was not blinded.

Interventions

Both interventions were delivered once, on the day before surgery, in the inpatient ward between 08:00 and 10:00, by the first author (SO).

Virtual reality group. Participants watched a fully immersive, non-interactive 360-degree video through a standalone head-mounted display (Oculus Quest 2; Meta Platforms, Menlo Park, CA, USA). The video was recorded in the Central Operating Theatre of RSGM Unpad from the patient's first-person perspective and depicted the complete perioperative pathway from entering the theatre suite, through the preparation room and transfer to the operating table, to monitoring and induction of general anaesthesia until loss of consciousness, accompanied by narration in Bahasa Indonesia in 15 minutes. Before use, the content was evaluated by five experts (two oral and maxillofacial surgeons and three anesthesiologists) using a structured evaluation instrument developed for this study (English version provided as Additional file 2). All experts rated all four content-validity items (logical sequence of the procedure, accuracy of the anesthetic technique, clinical information, and adequacy of the 360-degree perspective) at 4 or 5 on a 5-point scale, giving an item-level and scale-level content validity index of 1.00. All four technical-quality items (visual quality, clarity of narration and sound, adequacy of duration, and immersion without dizziness or nausea) were likewise rated 4 or 5 by all experts. Three experts judged the video suitable without revision and two suggested minor revisions (balance between narration and background sound, and lighting from the operator's viewpoint), which were incorporated before the trial. To prevent cross-infection, each participant wore a disposable non-woven hygiene mask under the headset; all contact surfaces were wiped with 70% alcohol before and after each use, lenses were cleaned with a dry microfibre cloth, and hand hygiene was performed before fitting and after removing the device.

Control group. Participants received verbal education from the first author supported by a flip chart containing photographs of the preparation room, operating theatre and recovery room, covering the same sequence of events as the VR video in 15 minutes.

All participants otherwise received standard preoperative care.

Outcomes

Outcomes were assessed at three time points: before the intervention (T0), immediately after the intervention (T1) and 15 minutes after the intervention (T2). Six outcomes were prespecified with equal priority: APAIS score, salivary alpha-amylase, salivary cortisol, blood pressure (systolic and diastolic), pulse rate and respiratory rate.

Subjective anxiety. The validated Indonesian version of the APAIS was used [34–36]. The instrument comprises six items rated on a 5-point Likert scale (1 = not at all to 5 = extremely), covering anxiety about anesthesia and surgery and the desire for information. In the Indonesian validation study of 102 adult elective surgical patients, the scale showed a content validity coefficient of 1.0, a two-factor structure (anxiety and information need) explaining 70.79% of the variance, and Cronbach's α values of 0.825 and 0.863 for the anxiety and information components, respectively [36]. The total score of the six items (range 6–30; higher scores indicating greater anxiety) was analysed. Participants completed the questionnaire themselves. The APAIS was not developed for this study: the original instrument was published by Moerman et al. [34], and the Indonesian version used here was validated by Firdaus [36]. No other questionnaire was administered to participants.

Salivary biomarkers. Participants refrained from eating, drinking and smoking for at least 1 hour before sampling and rinsed their mouths with water. Unstimulated whole saliva (4–5 mL) was collected by passive drooling into sterile tubes, placed immediately on ice, and stored at 4°C if analysed within 24 hours or frozen at –10°C or below. Blood-contaminated samples were discarded and recollected. All samples were collected between 08:00 and 10:00 to limit diurnal variation in cortisol [28]. Before analysis, samples were thawed and centrifuged, and the supernatant was assayed in duplicate using commercial enzyme-linked immunosorbent assay (ELISA) kits for alpha-amylase and cortisol according to the manufacturers' instructions. Absorbance was read at 450 nm (Biobase microplate reader; Biobase, Jinan, China) and concentrations were derived from a four-parameter logistic standard curve. Alpha-amylase is reported in U/L and cortisol in ng/mL.

Vital signs. After the participant had rested in a seated position for at least 5–10 minutes, systolic and diastolic blood pressure were measured with a calibrated sphygmomanometer and stethoscope (Korotkoff phases I and V) on the upper arm at heart level. Pulse rate was counted by palpation of the radial artery over 60 seconds, and respiratory rate was counted by observing chest movement over 60 seconds. Each measurement was performed three times and the mean value was recorded.

Adverse events. Adverse effects of the interventions, including symptoms of cybersickness (dizziness, nausea, headache or eye strain) and distress, were assessed by direct observation during the intervention and by asking participants about such symptoms after the intervention.

Statistical analysis

Categorical variables are presented as numbers (percentages) and continuous variables as mean $\pm$ standard deviation (SD) and median (minimum–maximum). Normality was assessed with the Shapiro–Wilk test. Baseline characteristics were compared with the chi-square test with continuity correction, the Mann–Whitney U test or Fisher’s exact test, as appropriate. At each time point, between-group differences were tested with the independent t-test for normally distributed data and the Mann–Whitney U test otherwise. Changes over the three time points within each group were tested with one-way repeated-measures analysis of variance (ANOVA) for normally distributed data and the Friedman test otherwise. To indicate the precision of the estimates, between-group mean differences (VR minus control) with 95% confidence intervals (CIs) were calculated from the group means and pooled SDs. All randomized participants were analysed in the group to which they were allocated. No adjustment was made for multiple comparisons, and the results should be interpreted accordingly. Two-sided $p < 0.05$ was considered statistically significant. Analyses were performed with IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). All participants completed all assessments, so there were no missing data and no imputation was required. No interim analyses were planned or performed, no stopping rules were specified, and no subgroup or sensitivity analyses were performed. The between-group mean differences with 95% CIs were calculated post hoc for this report; all other analyses were prespecified.

Patient and public involvement

Patients and members of the public were not involved in the design, conduct or reporting of this trial.

Use of large language models

A large language model (Claude, Anthropic) was used to assist in translating the Indonesian-language dissertation on which this report is based and in drafting and editing the English manuscript. It was not used for study design, data collection or statistical analysis. The authors reviewed and verified all content and take full responsibility for the manuscript.

Results

Participant flow and baseline characteristics

Of 32 patients assessed for eligibility, 32 were randomized: 16 to the VR group and 16 to the control group. All participants received the allocated intervention, completed all measurements and were included in the analysis (Fig. 1). Recruitment and data collection took place between June and August 2026.

Baseline characteristics are shown in Table 1. Women predominated in both groups (68.8% in the VR group and 81.3% in the control group; $p = 0.683$). The median age was 25.5 years (range 21–39) in the VR group and 24.5 years (range 18–39) in the control group ($p = 0.508$). Most participants in both groups (68.8%) had four third molars removed and had impacted teeth in all four quadrants. No characteristic differed significantly between groups. Baseline values of all outcome measures were also comparable (Tables 2 and 3), although the mean baseline pulse rate was higher in the VR group (81.1 vs 73.9 beats/min; $p = 0.076$).

Table 1
Baseline characteristics of participants

Characteristic	VR (n = 16)	Control (n = 16)	p value
Sex, n (%)			0.683 ^a
Male	5 (31.3)	3 (18.8)	
Female	11 (68.8)	13 (81.3)	
Age, years, median (min–max)	25.5 (21–39)	24.5 (18–39)	0.508 ^b
Age 18–20 years, n (%)	0 (0)	4 (25.0)	
Number of third molars removed, n (%)			0.907 ^b
2	1 (6.3)	0 (0)	
3	4 (25.0)	5 (31.3)	
4	11 (68.8)	11 (68.8)	
Location of impacted teeth, n (%)			0.689 ^c
All four quadrants	11 (68.8)	11 (68.8)	
Three quadrants	4 (25.0)	5 (31.3)	
Two quadrants (both mandibular)	1 (6.3)	0 (0)	
VR, virtual reality. ^a Chi-square test with continuity correction ($\chi^2 = 0.167$); ^b Mann–Whitney U test; ^c Fisher’s exact test (computed on the detailed distribution of quadrant combinations).			

Table 2

Amsterdam Preoperative Anxiety and Information Scale (APAIS) scores by group and time point

Time point	VR (n = 16)	Control (n = 16)	Mean difference (95% CI) ^e	p value
T0 – before intervention				
Mean ± SD	18.88 ± 5.15	20.00 ± 4.60	-1.12 (- 4.65 to 2.41)	0.520 ^a
Median (min–max)	17.50 (12–28)	19.00 (14–30)		
T1 – immediately after				
Mean ± SD	16.75 ± 4.95	18.13 ± 4.47	-1.38 (- 4.79 to 2.03)	0.557 ^b
Median (min–max)	16.50 (9–26)	16.50 (12–30)		
T2–15 min after				
Mean ± SD	16.38 ± 5.04	16.81 ± 5.37	-0.43 (- 4.19 to 3.33)	0.814 ^a
Median (min–max)	17.00 (7–26)	16.00 (9–30)		
Change over time, p value	0.043 ^c	0.067 ^d		
CI, confidence interval; SD, standard deviation; VR, virtual reality. Total APAIS score range 6–30; higher scores indicate greater anxiety. ^a Independent t-test; ^b Mann–Whitney U test; ^c one-way repeated-measures ANOVA; ^d Friedman test; ^e VR minus control, calculated from summary statistics using the pooled SD.				

Table 3
Salivary biomarkers and vital signs by group and time point

Outcome / time point	VR (n = 16)	Control (n = 16)	Mean difference (95% CI) ^e	p value
Salivary alpha-amylase (U/L)				
T0	59.55 ± 26.56	64.23 ± 23.60	-4.68 (- 22.82 to 13.46)	0.602 ^a
T1	60.70 ± 23.79	57.96 ± 27.26	2.74 (- 15.73 to 21.21)	0.762 ^a
T2	57.56 ± 39.58	64.61 ± 24.23	-7.05 (- 30.74 to 16.64)	0.475 ^a
Change over time, p value	0.938 ^c	0.640 ^c		
Salivary cortisol [unit]^f				
T0	41.30 (12.49–715.98)	120.23 (19.00–497.01)	–	0.113 ^b
T1	69.83 (4.16–275.87)	103.54 (24.52–692.10)	–	0.258 ^b
T2	74.11 (11.09–579.57)	90.64 (12.37–853.50)	–	0.327 ^b
Change over time, p value	0.939 ^d	0.570 ^d		
Systolic blood pressure (mmHg)				
T0	116.19 ± 13.23	116.36 ± 10.33	-0.17 (- 8.74 to 8.40)	0.969 ^a
T1	113.98 ± 12.92	115.96 ± 8.48	-1.98 (- 9.87 to 5.91)	0.598 ^b
T2	113.08 ± 11.63	116.54 ± 11.14	-3.46 (- 11.68 to 4.76)	0.397 ^a
CI, confidence interval; SD, standard deviation; VR, virtual reality. Values are mean ± SD unless indicated otherwise. T0, before the intervention; T1, immediately after; T2, 15 minutes after. ^aIndependent t-test; ^bMann–Whitney U test; ^cone-way repeated-measures ANOVA; ^dFriedman test; ^eVR minus control, calculated from summary statistics using the pooled SD (not shown for cortisol because of marked skewness); ^fvalues are median (min–max) because data were not normally distributed. Mean ± SD for cortisol: VR 130.59 ± 199.57, 99.46 ± 87.55 and 105.17 ± 138.05; control 152.75 ± 128.76, 169.62 ± 178.91 and 152.47 ± 203.99. Mean ± SD for pulse rate: VR 81.12 ± 12.41, 80.65 ± 12.25 and 79.10 ± 11.87; control 73.88 ± 8.67, 75.92 ± 9.73 and 75.10 ± 10.38.				

Outcome / time point	VR (n = 16)	Control (n = 16)	Mean difference (95% CI) ^e	p value
Salivary alpha-amylase (U/L)				
Change over time, p value	0.248 ^c	0.890 ^d		
Diastolic blood pressure (mmHg)				
T0	76.02 ± 11.94	77.77 ± 8.94	-1.75 (- 9.37 to 5.87)	0.643 ^a
T1	77.02 ± 11.28	78.65 ± 8.09	-1.63 (- 8.72 to 5.46)	0.643 ^a
T2	77.10 ± 10.84	78.21 ± 9.15	-1.11 (- 8.35 to 6.13)	0.758 ^a
Change over time, p value	0.839 ^c	0.778 ^c		
Pulse rate (beats/min)^f				
T0	79.00 (66.67–120.33)	75.00 (54.67–88.00)	7.24 (- 0.49 to 14.97)	0.076 ^b
T1	79.67 (64.00–119.33)	76.34 (58.67–90.00)	4.73 (- 3.26 to 12.72)	0.258 ^b
T2	78.33 (64.67–117.67)	74.00 (55.00–90.67)	4.00 (- 4.05 to 12.05)	0.584 ^b
Change over time, p value	0.147 ^d	0.423 ^c		
Respiratory rate (breaths/min)				
T0	18.48 ± 2.91	18.94 ± 1.55	-0.46 (- 2.14 to 1.22)	0.582 ^a
T1	19.56 ± 3.47	19.27 ± 1.16	0.29 (- 1.58 to 2.16)	0.753 ^a
CI, confidence interval; SD, standard deviation; VR, virtual reality. Values are mean ± SD unless indicated otherwise. T0, before the intervention; T1, immediately after; T2, 15 minutes after. ^aIndependent t-test; ^bMann–Whitney U test; ^cone-way repeated-measures ANOVA; ^dFriedman test; ^eVR minus control, calculated from summary statistics using the pooled SD (not shown for cortisol because of marked skewness); ^fvalues are median (min–max) because data were not normally distributed. Mean ± SD for cortisol: VR 130.59 ± 199.57, 99.46 ± 87.55 and 105.17 ± 138.05; control 152.75 ± 128.76, 169.62 ± 178.91 and 152.47 ± 203.99. Mean ± SD for pulse rate: VR 81.12 ± 12.41, 80.65 ± 12.25 and 79.10 ± 11.87; control 73.88 ± 8.67, 75.92 ± 9.73 and 75.10 ± 10.38.				

Outcome / time point	VR (n = 16)	Control (n = 16)	Mean difference (95% CI) ^e	p value
Salivary alpha-amylase (U/L)				
T2	18.54 ± 3.41	19.04 ± 1.35	-0.50 (- 2.37 to 1.37)	0.589 ^a
Change over time, p value	0.053 ^c	0.502 ^c		
CI, confidence interval; SD, standard deviation; VR, virtual reality. Values are mean ± SD unless indicated otherwise. T0, before the intervention; T1, immediately after; T2, 15 minutes after. ^a Independent t-test; ^b Mann–Whitney U test; ^c one-way repeated-measures ANOVA; ^d Friedman test; ^e VR minus control, calculated from summary statistics using the pooled SD (not shown for cortisol because of marked skewness); ^f values are median (min–max) because data were not normally distributed. Mean ± SD for cortisol: VR 130.59 ± 199.57, 99.46 ± 87.55 and 105.17 ± 138.05; control 152.75 ± 128.76, 169.62 ± 178.91 and 152.47 ± 203.99. Mean ± SD for pulse rate: VR 81.12 ± 12.41, 80.65 ± 12.25 and 79.10 ± 11.87; control 73.88 ± 8.67, 75.92 ± 9.73 and 75.10 ± 10.38.				

Subjective anxiety

APAIS scores are presented in Table 2 and Fig. 2. At baseline, mean scores indicated moderate-to-high anxiety in both groups (VR 18.88 ± 5.15; control 20.00 ± 4.60; p = 0.520). In the VR group, scores decreased to 16.75 ± 4.95 at T1 and 16.38 ± 5.04 at T2, a statistically significant change over time (repeated-measures ANOVA, p = 0.043). In the control group, scores decreased to 18.13 ± 4.47 at T1 and 16.81 ± 5.37 at T2 (Friedman test, p = 0.067). The absolute reduction from T0 to T2 was 2.50 points in the VR group and 3.19 points in the control group. There was no significant between-group difference at T1 (p = 0.557) or T2 (mean difference - 0.43, 95% CI - 4.19 to 3.33; p = 0.814).

Salivary biomarkers

Salivary alpha-amylase activity did not differ between groups at any time point (T2 mean difference - 7.05 U/L, 95% CI - 30.74 to 16.64; p = 0.475) and did not change significantly over time in either group (VR p = 0.938; control p = 0.640) (Table 3). Salivary cortisol concentrations were not normally distributed and showed wide inter-individual variation. Median cortisol in the VR group was 41.30, 69.83 and 74.11 at T0, T1 and T2, compared with 120.23, 103.54 and 90.64 in the control group; neither between-group comparisons (p = 0.113, 0.258 and 0.327) nor within-group changes (VR p = 0.939; control p = 0.570) were statistically significant.

Vital signs

Systolic and diastolic blood pressure, pulse rate and respiratory rate remained within normal ranges throughout and did not differ between groups at any time point (all p > 0.05; Table 3). Within-group changes were not significant for systolic blood pressure (VR p = 0.248; control p = 0.890), diastolic blood pressure (VR p = 0.839; control p = 0.778), pulse rate (VR p = 0.147; control p = 0.423) or respiratory rate

(VR $p = 0.053$; control $p = 0.502$). In the VR group, respiratory rate increased transiently from 18.48 ± 2.91 to 19.56 ± 3.47 breaths/min immediately after the intervention and returned to 18.54 ± 3.41 breaths/min at 15 minutes.

Adverse events

No adverse events were observed in either group.

Discussion

In this randomized trial of young adults awaiting third molar surgery under general anesthesia, a single immersive VR familiarisation with the operating theatre was followed by a statistically significant reduction in self-reported anxiety over time. However, the reduction was not greater than that achieved with verbal flip-chart education, and neither intervention produced measurable changes in salivary alpha-amylase, salivary cortisol, blood pressure, pulse rate or respiratory rate. VR was therefore not superior to an active educational comparator on any subjective or objective outcome.

The within-group reduction in APAIS scores after VR is consistent with meta-analyses reporting that VR-based interventions lower preoperative anxiety in adults undergoing elective surgery [15–18] and with trials using informative 360-degree videos of the hospital or operating theatre [19, 21, 22]. Several features of our design explain why a between-group difference was not detected. First, the comparator was an active intervention delivering the same information, not usual care. Information provision itself reduces anxiety, and part of the APAIS captures the desire for information; a well-delivered verbal explanation may therefore narrow the gap between arms. Pooled estimates of VR effects are generally larger when the comparator is usual care than when it is an active educational intervention [17, 18], and the control group in our study showed a numerically larger reduction (3.19 vs 2.50 points) that narrowly missed statistical significance. Second, the observed between-group differences corresponded to small standardised effects (Cohen's $d \approx 0.1$ – 0.3), whereas the trial, with 16 participants per group, had adequate power only for large effects. The wide confidence intervals are compatible both with no effect and with a clinically relevant benefit of either intervention.

The absence of biochemical and haemodynamic change, despite a reduction in perceived anxiety, is the most notable finding. Several explanations are plausible. Salivary cortisol typically peaks 20–30 minutes after the onset of an acute psychological stressor and requires a stressor that is uncontrollable and socially evaluative to produce a robust response [37]; a sampling window ending 15 minutes after an intervention delivered the day before surgery may have been too early and the stimulus too mild to reveal a difference. Cortisol also has a steep diurnal slope and large between-person variability [28, 38], reflected in the highly skewed distributions and the more than two-fold difference in baseline medians between our groups. Salivary alpha-amylase responds more rapidly to sympathetic activation, but it is sensitive to flow rate, oral stimulation and time of day [26, 27, 39]. Moreover, the threat that drives preoperative anxiety—surgery under general anesthesia—remained unchanged by either intervention and was still a day away, so a persistent autonomic readiness may coexist with an improved cognitive

appraisal. Finally, baseline vital signs were within normal limits, leaving little room for measurable reduction; trials that reported haemodynamic benefits of VR were typically conducted immediately before or during surgery, when sympathetic activation is greater [31, 32].

Discordance between self-reported stress and physiological measures is well documented outside the perioperative setting [40, 41] and has been described as a feature of the multidimensional nature of perioperative anxiety [6]. Our findings suggest that subjective and objective indices should not be treated as interchangeable measures of the same construct. Studies that aim to demonstrate a physiological benefit of VR should align sampling times with the known kinetics of each biomarker, deliver the intervention closer to the stressful event, and consider continuous measures such as heart rate variability.

From a clinical perspective, VR familiarisation was feasible in a hospital ward with a single, shared headset and simple infection-control measures, and it was not inferior to verbal education in its effect on perceived anxiety. It may therefore be useful where staff time for individual education is limited, for patients who prefer a visual format, or as an adjunct to conventional information. Whether combining VR with verbal education, repeating exposure, or delivering it on the day of surgery confers additional benefit—and whether any benefit translates into reduced anesthetic requirements, better haemodynamic stability at induction or improved recovery—remains to be established [13, 42].

Limitations

This study has several limitations. First, the sample was small and the sample size calculation was based on assumed means that were not derived from the outcomes analysed here; the study was therefore underpowered to detect small-to-moderate differences, and the null between-group findings should not be interpreted as evidence of equivalence. Second, allocation was by coin toss, participants and the intervention provider could not be blinded, which may have influenced self-reported outcomes. Third, no single primary outcome was designated, multiple outcomes and time points were tested without adjustment, and the one statistically significant within-group result ($p = 0.043$) should be regarded as exploratory. Fourth, the interventions were delivered on the day before surgery, and anxiety was not measured on the day of surgery, at induction or postoperatively, so effects on perioperative outcomes could not be assessed. Fifth, salivary biomarker sampling ended 15 minutes after the intervention, which may be too early for peak cortisol responses, and baseline cortisol and pulse rate differed numerically between groups. Sixth, the sample consisted of young, predominantly female, ASA I–II patients undergoing their first general anesthetic at a single centre, limiting generalisability. Finally, the trial was registered retrospectively.

Conclusions

In adults awaiting third molar surgery under general anesthesia, a single immersive VR familiarisation with the operating theatre was followed by a significant within-group reduction in self-reported

preoperative anxiety, but it was not superior to verbal education with a flip chart, and neither intervention altered salivary alpha-amylase, salivary cortisol or vital signs within 15 minutes. The dissociation between perceived anxiety and autonomic and neuroendocrine markers indicates that subjective and objective outcomes capture different dimensions of preoperative anxiety. VR is a feasible adjunct for preoperative preparation; larger, adequately powered trials with a designated primary outcome, day-of-surgery assessment and perioperative clinical endpoints are needed to determine its added value.

Abbreviations

ANOVA

Analysis of variance

APAIS

Amsterdam Preoperative Anxiety and Information Scale

ASA

American Society of Anesthesiologists

CI

Confidence interval

CONSORT

Consolidated Standards of Reporting Trials

ELISA

Enzyme-linked immunosorbent assay

RSGM Unpad

Universitas Padjadjaran Dental and Oral Hospital

SD

Standard deviation

VR

Virtual reality

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of Universitas Padjadjaran, Bandung, Indonesia (No. 344/UN6.KEP/EC/2026). Written informed consent was obtained from all participants before enrolment.

Consent for publication

Not applicable.

Availability of data and materials

The de-identified datasets generated and/or analysed during the current study, together with a data dictionary, are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests. The authors have no relationship with any manufacturer or distributor of virtual reality devices.

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Authors' contributions

SO conceived and designed the study, developed the virtual reality content, recruited participants, collected the data, performed the statistical analysis and drafted the manuscript. HYY supervised the study and contributed to its conception, design and interpretation of the data. ER contributed to the study design and methodology and critically revised the manuscript. FH contributed to the interpretation of the data and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Figures

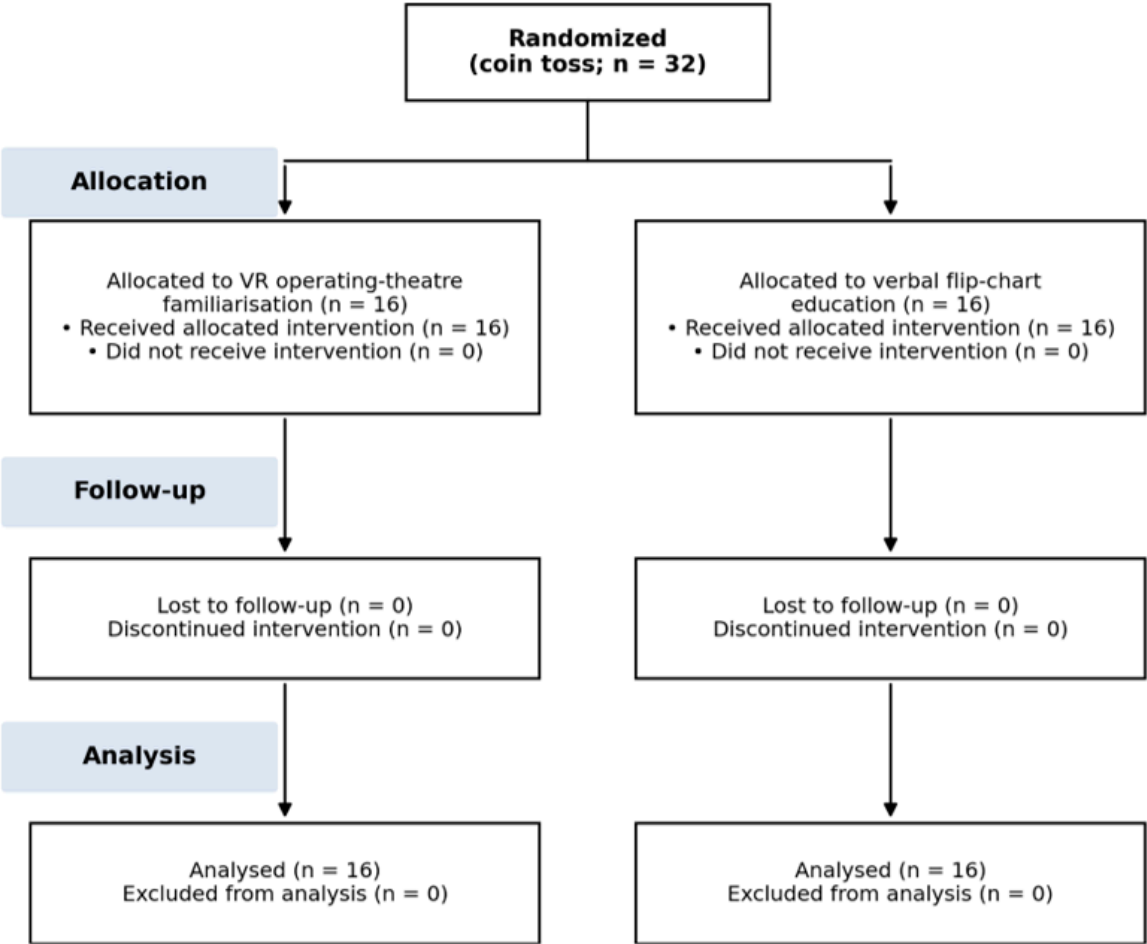


Figure 1

CONSORT flow diagram of participant enrolment, allocation, follow-up and analysis. VR, virtual reality.

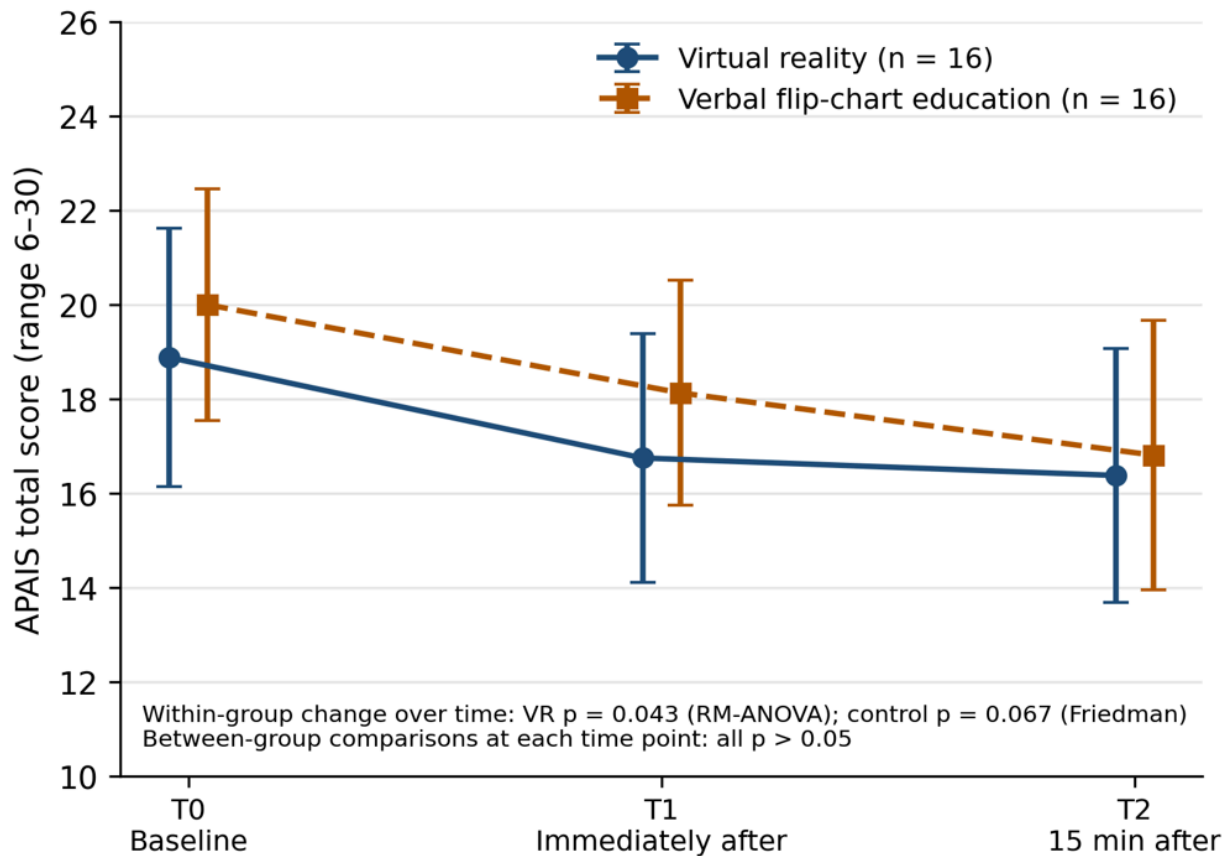


Figure 2

Mean Amsterdam Preoperative Anxiety and Information Scale (APAIS) scores in the virtual reality and verbal flip-chart education groups before (T0), immediately after (T1) and 15 minutes after (T2) the intervention. Error bars indicate 95% confidence intervals. Within-group change: repeated-measures ANOVA (virtual reality) and Friedman test (control). Between-group comparisons at each time point: independent t-test or Mann–Whitney U test.

Supplementary Files

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- [Additionalfile1CONSORT2025checklist.docx](#)
- [Additionalfile2Expertevaluationinstrument.docx](#)