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Effectiveness of virtual reality in relieving anxiety and controlling hemodynamics during oral surgery under local anesthesia: A prospective randomized comparative study

Adaia Valls-Ontañón^{a,b,*}, Sarah Sophie Vandeputte^a, Carlos de la Fuente^b,
Maria Giralt-Hernando^{a,b}, Gloria Molins-Ballabriga^b, Mireia Cigarrán-Mensa^c, Ali Sabbagh^a,
Federico Hernández-Alfaro^{a,b}

^a Department of Oral and Maxillofacial Surgery, Universitat Internacional de Catalunya (UIC), Barcelona, Spain

^b Institute of Maxillofacial Surgery, Teknon Medical Center, Barcelona, Spain

^c VRPharma Immersive Technologies SL, Barcelona, Spain

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ABSTRACT

It was the aim of the study to evaluate the contribution of a relaxing immersive experience with virtual reality (VR) goggles in reducing patient anxiety related to wisdom tooth extraction under local anesthesia.

A prospective randomized comparative study in consecutive patients scheduled for bilateral wisdom tooth extraction under local anesthesia was carried out between March and December 2022. Both sides were operated upon in the same surgery, but on one side VR goggles were applied (VR), while on the other they were not (noVR). Anxiety was evaluated both subjectively (State-Trait Anxiety Inventory [STAI] and visual analogue scale [VAS]) and objectively (measuring heart rate, blood pressure [BP] and blood oxygen saturation) before (T1) and after each surgical step (T2VR and T2noVR).

The study sample consisted of 27 patients: 9 men and 18 women, with an average age of 25.8 ± 6.5 years (range: 18–43). Anxiety as assessed by the STAI and VAS decreased from T1 to T2 ($p < 0.001$ and $p < 0.001$, respectively), although to a similar degree regardless of whether VR was used or not. Heart rate showed significant differences influenced by VR exposure ($p = 0.013$): it increased $+2.5 \pm 8.8$ bpm in the control group and decreased -2.22 ± 7.55 bpm with VR ($p = 0.013$). Both minimum and maximum BP after surgery were significantly higher in the noVR group ($p = 0.002$ and $p = 0.040$, respectively). Regarding minimum BP, VR proved more effective among male patients ($p = 0.057$) and on starting the procedure using VR ($p = 0.055$).

The results provided evidence of meaningful control of the hemodynamic variables, but less predictable performance in the subjective evaluation of anxiety.

1. Introduction

Virtual reality (VR) has been successfully used in a number of areas in healthcare, such as simulation-based medical teaching. There is currently a great deal of interest in VR, particularly for addressing anxiety disorders related to surgical and oncological procedures (Rutkowski et al., 2021).

Although many oral surgery procedures such as wisdom tooth (WT) extraction can be performed under local anesthesia, oral cavity treatments are very much associated with patient fear (Fabián et al., 2003; de Jongh and Broers 2009); indeed, dental anxiety is the fifth most common

cause of anxiety (Appukuttan 2016). It may be produced by a variety of concerns, including pain, aversion to certain stimuli such as handpieces or needles, the sight of blood, or the idea of foreign objects piercing the body. Moreover, oral surgeons themselves experience heightened discomfort when treating anxious patients. The availability of fast and easy tools for preventing preoperative anxiety in such patients therefore would be very useful.

Patient anxiety is an undesirable side effect of dental procedures that affects the willingness of the patient to undergo treatment, tending to cause delays in consultation, and finally worsening the initial prognosis. On the other hand, the waiting period before the procedure, the

* Corresponding author. Maxillofacial Institute, Teknon Medical Center, Carrer de Vilana, 12 (desp. 185), 08022, Barcelona, Spain.

E-mail address: avalls@institutomaxilofacial.com (A. Valls-Ontañón).

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administration of local anesthesia, and the surgical operation often give rise to undesirable psychological reactions in the form of anxiety, anguish, stress, fear, distress and phobias. Furthermore, patients with high levels of preoperative anxiety experience a slower, more complicated and more painful postoperative recovery period (Kain et al., 2000).

Thus, for patients with high levels of anxiety when facing invasive operations such as wisdom tooth removal, several tools have been proposed in order to alleviate both pain and anxiety, such as hypnosis, the administration of drugs (analgesics, anxiolytics, antihistamines and benzodiazepines) and the application of topical anesthesia, although such measures are not always completely effective. As a result, general anesthesia or conscious sedation, involving intravenous medication or inhaled nitrous oxide, have been used in such scenarios. However, for patients with lower levels of anxiety, noninvasive and non-pharmacological distraction interventions based on VR are being used, with promising results (Falguière et al., 2021). Virtual reality goggles do not only provide potentially appealing visual stimuli; they also restrict any other nearby visual stimuli that can be threatening to the patient.

Therefore, the aim of the present study was to evaluate the contribution of a relaxing immersive experience with VR goggles in reducing patient anxiety related to WT extraction under local anesthesia.

2. Material and methods

2.1. Study design and sample selection

To address the research purpose, the investigators designed and implemented a prospective comparative study in consecutive patients scheduled for bilateral WT extraction under local anesthesia between March and December 2022 at our Department. Both sides were operated upon in the same surgery, but on one side VR goggles were applied, while on the other they were not; all patients therefore went through the two study conditions on the same day. A statistician not participating in any other way in the study generated a randomization table for patients receiving VR per side and during the first or second surgical procedure.

Patients of either sex and over 18 years of age requiring bilateral lower WT extraction presenting similar difficulty according to the Winter and Pell and Gregory classifications (Pell and Gregory 1933) were included in the study. Those requiring concomitant bilateral upper WT extraction presenting similar difficulty were also included. Pregnant or breastfeeding women, patients with impaired cognitive function, individuals with blindness, deafness or epilepsy, or patients not willing to sign the informed consent document were excluded.

The study was approved by the Ethics Committee of our Medical Center (Ref. 2021/112-MAX-CMT), and was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki (1964 and later amendments). After receiving information about how the study would be conducted, all participants signed an informed consent document prior to study enrollment. This paper has been presented according to the Consolidated Standards of Reporting Trials Statement (CONSORT) guidelines.

2.2. Study variables and data collection

Subjective evaluation of the presence and severity of fear and anxiety before and after surgical treatment was carried out using the Spanish version of the State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1971). This questionnaire was delivered to the patients at two time-points: in the operating room before local anesthesia injection and VR immersion (T1), and after surgery with (test: T2VR) and without the VR goggles (control: T2noVR). A final score was obtained from the individual items of the STAI form, which constitutes the primary response variable of the STAI analysis: (STAI = 30+STAI.3+ STAI.4+ STAI.6 + STAI.7+ STAI.9+ STAI.12+ STAI.13+ STAI.14+ STAI.17+ STAI.18 - STAI.1- STAI.2- STAI.5- STAI.8- STAI.10- STAI.11- STAI.15- STAI.16-

STAI.19- STAI.20).

On the other hand, anxiety experienced during treatment was also measured using a color visual analogue scale (VAS), with 0 indicating no anxiety and 10 the worst anxiety imaginable.

Concomitantly, for the objective assessment of anxiety, measurements were made of heart rate, blood pressure (BP) and blood oxygen saturation before and after surgery at T2VR and T2noVR.

The following demographic variables were recorded: sex, age, smoking and alcohol consumption habits, and type of WT impaction according to the Winter and Pell and Gregory classification [7]. The order of surgeries and the surgery time were also recorded, as well as the degree of satisfaction/comfort with the VR system from the surgeon's point of view, scored from 0 (very bad) to 10 (very good).

2.3. Surgical procedure

The patients were invited to sit in a lounge dental chair in an isolated, bright and calm room. The staff offered a blanket and made sure the patients were comfortable. Then, a BP monitor and pulseoxymeter were placed. And the patients were invited to answer the T1 STAI questionnaire.

Surgery was performed by the same surgeon (AVO) 5 min after local anesthesia injection in the form of 4% articaine with 1:100,000 epinephrine. At T2VR, the VR goggles were worn by the patient during the entire surgical procedure. The system consisted of a head-mounted display (Pico Interactive) and an external Android AOYODKG tablet that controlled the VR experience, where the software of VR Pharma Immersive Technologies SL was installed, allowing external control of the experience in the VR goggles (Fig. 1). The content was designed and produced by VRPharma: "Ocean Breeze" and "Crystal Serenity."

Following the extraction procedure of each side at T2VR and T2noVR, the patients were asked to again complete the STAI questionnaire and the anxiety VAS.

Conventional postoperative antibiotic and anti-inflammatory medication was prescribed, and the follow-up visit took place after 1 week.

2.4. Statistical analysis

Demographic characteristics and other parameters were presented in terms of descriptive statistics. Continuous variables were reported as number (n), mean, standard deviation (SD), minimum, maximum and median, while relative frequencies (percentages) were used for



Fig. 1. The virtual reality (VR) system consisted of a head-mounted display (Pico Interactive) and an external tablet that controlled the VR experience. The software from VR Pharma Immersive Technologies allowed external control of the experience in the VR goggles.

qualitative variables.

The inferential analysis comprised an analysis of variance (ANOVA) model of repeated measures with intra-subject factors, the time of measurement and exposure to VR for the comparison of the different indicators of anxiety. Main effects and interaction between the two factors were evaluated. For multiple comparisons, the Bonferroni test was applied. In turn, a mixed ANOVA model was used for the study of the anxiety indicator at the end of extraction according to exposure to VR and other independent factors of the patient or clinical profile of the WT. As in the previous case, estimation was made of the variability inherent to each term and to the interaction, with Bonferroni correction of the pairwise comparisons.

It was also contrasted if both conditions (exposure or no exposure to VR) were applied homogeneously to similar anatomical conditions of the WT: a) the McNemar test for two related samples was used to determine whether the distribution of a categorical variable (degree of extraction difficulty) was symmetric in the same patient; b) binomial testing was used to determine whether VR exposure was applied in a similar proportion in first and second order in the sequence of two surgeries; and c) the Wilcoxon test was used to determine whether the surgery time with and without VR was similar.

For all purposes, two-sided p-values <0.05 were considered statistically significant. For sample calculation, the paired t-test afforded a statistical power of 80% in identifying differences in STAI score of 20–25 as clinically relevant, assuming a confidence level of 95% in a one-tailed test and a standard deviation of ± 10 . Data analysis was performed using the SPSS version 25.0.0 statistical package (SPSS Inc., Chicago, IL, USA).

3. Results

The study sample consisted of 27 patients subjected to bilateral WT extraction under local anesthesia on the same day, applying VR goggles upon operating on one side but not on the other side. There were 9 men (33.3%) and 18 women (66.7%), with an average age of 25.8 ± 6.5 years (range: 18–43 years). Two patients who experienced claustrophobia when wearing the VR goggles were excluded from the analysis. Table 1 summarizes the relevant demographic and clinical data.

The homogeneity analysis demonstrated general study homogeneity; the anatomical and intraoperative conditions of the VR exposure and non-exposure phases were thus taken to be similar (Table 2). Surgery time was longer when two WT per side (upper and lower) were removed, with a difference of approximately 3 min between medians ($p = 0.036$), although the exposed and non-exposed groups remained homogeneous.

The mean preoperative (T1) STAI score was 19.1 ± 11.1 . Given that the maximum possible score is 60, patients were experiencing 31.8% of maximum anxiety. Following T2noVR, the mean score was 12.3 ± 8.5 points, corresponding to 20.5% of the maximum possible score. Thus, the STAI score decreased an average of -6.9 ± 7.4 points (-35.6%). On the other hand, after the VR intervention (T2VR) the mean score was 13.9 ± 9.3 points, corresponding to 23.2% of the maximum possible

Table 2

Homogeneity analysis of interventions with and without virtual reality (VR) according to patient profile and clinical difficulty: McNemar test, binomial test and Wilcoxon test results.

	p-value
Side (right vs left)	1.000 (MN)
Winter classification	0.513 (MN)
Pell & Gregory classification	0.317 (MN)
Order of surgery	1.000 (Bin)
Operative time	0.930 (Wil)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

score. Thus, the score decreased an average of -5.3 ± 7.2 points (-27.2%). The STAI anxiety score was therefore seen to decrease from T1 to T2 ($p < 0.001$), although to a similar degree regardless of whether VR was used or not used ($p = 0.265$), since the decrease in STAI score proved statistically significant in both phases (control $p < 0.001$; test $p = 0.001$) (Fig. 2). Regarding the association with secondary variables such as age, sex, WT impaction classification or surgery time, the duration of the operation was seen to affect the final STAI score ($p = 0.002$), although to a similar extent regardless of whether VR was used or not used ($p = 0.512$).

Regarding the self-assessment of anxiety based on the VAS scale (0–10), the mean score at T1 was 5.9 ± 2.8 versus 3.7 ± 2.9 after surgery in T2noVR and 3.6 ± 2.5 in T2VR. It therefore can be concluded that anxiety based on the VAS decreased from T1 to T2 ($p < 0.001$), although

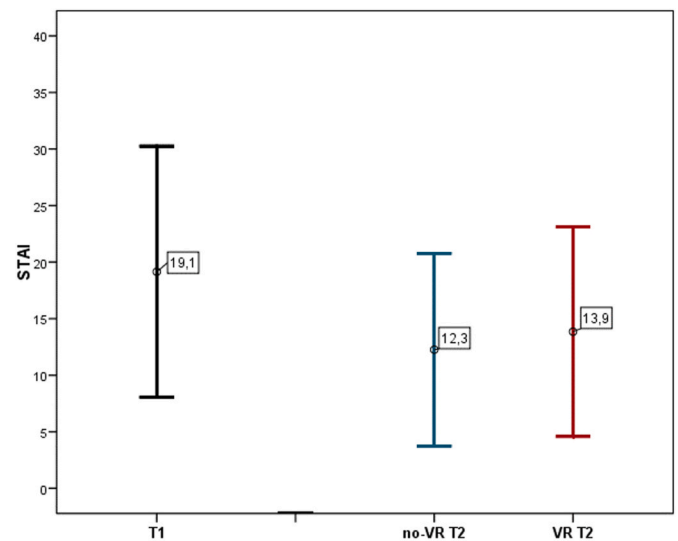


Fig. 2. Evolution of the State-Trait Anxiety Inventory (STAI) scores before (T1) and after surgery in the test (T2VR) and control groups (T2noVR).

Table 1

Demographic and clinical data of the sample.

GROUP	WINTER	PELL & GREGORY	NUMBER OF WT (per side)	SIDE		OPERATIVE TIME	ORDER OF INTERVENTION	
				Right	Left		1st	2nd
Control (no VR)	Vertical: 13	1A: 4	1 (lower): 6	13	14	9.5 $\pm$ 6.8	13	14
	Horizontal: 4	2A: 7	2 (upper & lower): 21					
	Mesio-angular: 10	2B: 8						
		2C: 1						
		3A: 1						
Test (VR)	Vertical: 13	1A: 4	1 (lower): 6	14	13	8.6 $\pm$ 5.4	14	13
	Horizontal: 5	2A: 6	2 (upper & lower): 21					
	Mesio-angular: 9	2B: 9						
		2C: 2						
		3C: 6						

to a similar degree regardless of whether VR was used or not used ($p = 0.548$). The final self-assessment of anxiety was not substantially influenced by any secondary variables.

All patients (27/27) answered that the procedure was more comfortable when VR goggles were used and agreed they would like to use it again in future dental procedures (Fig. 3).

Heart rate showed significant differences influenced by RV exposure ($p = 0.013$): it increased $+2.5 \pm 8.8$ bpm (from 80.3 ± 82.8 to 82.8 ± 7.9) in the control group and decreased -2.22 ± 7.55 bpm (from 79.1 ± 11.1 to 76.9 ± 9.5) with VR ($p = 0.013$) (Fig. 4). The Bonferroni test showed the mean heart rate to be similar in both groups preoperatively ($p = 0.479$), although postoperatively the difference proved statistically significant ($p < 0.001$). The F test of the mixed ANOVA model for each independent factor agreed that the heart rate at the end of the extraction procedure was significantly different depending on whether or not there had been exposure to VR (being lower with VR) (Table 3). It is interesting to highlight the strong interaction of the order of application of the VR goggles ($p = 0.005$): when VR was applied first, heart rate control with VR was much more evident than without VR. In other words, when the patient started without VR, the difference in heart rate between groups was subtle, so starting the procedure with VR increased the effectiveness of heart rate control.

Similar results were obtained for minimum and maximum blood pressure (BP). The minimum BP increased an average of 3.3 ± 8.6 mm Hg in the noVR group (from 71.6 ± 9.5 to 74.9 ± 7.5) versus 0.7 ± 7.9 mm Hg in the VR group (from 70.3 ± 7.4 to 71.1 ± 7.3); thus the minimum BP was significantly lower with VR than without VR ($p = 0.012$) both before and after surgery ($p = 0.164$). The Bonferroni test showed that minimum BP was not different between the groups at the start, although after surgery it was significantly higher in the noVR group ($p = 0.002$). Moreover, when VR was applied, BP remained constant ($p = 0.641$). The F test of the mixed ANOVA model for each independent factor suggested the following: VR was much more effective when applied in the first WT extraction ($p = 0.055$) (Fig. 5); VR was much more effective among male patients ($p = 0.057$); the final minimum BP was significantly influenced by patient age, being higher in older individuals ($p = 0.020$); and the final minimum BP tended to be higher in short operations ($p = 0.069$).

The maximum BP in turn increased an average of 5.2 ± 8.0 mm Hg in the noVR group (from 122.4 ± 17.6 to 127.6 ± 17.6) versus 1.5 ± 10.3

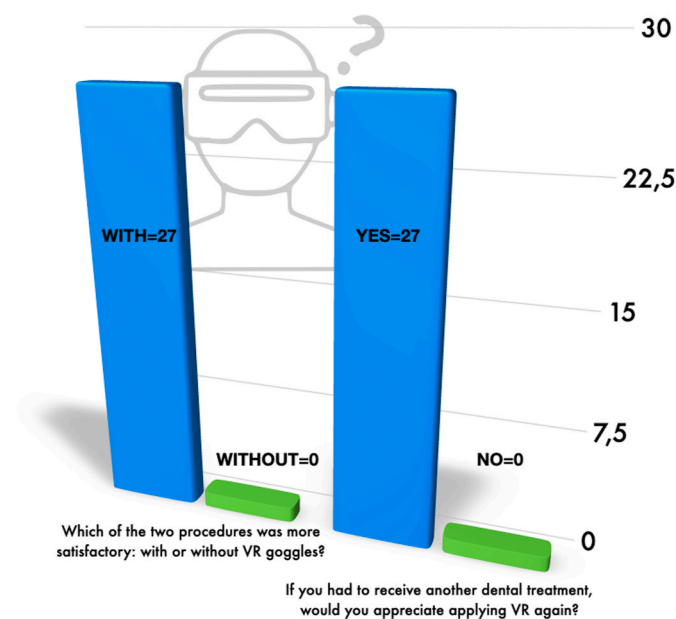


Fig. 3. Heart rate increased in the patients not exposed to virtual reality (VR) and decreased in those exposed to VR.

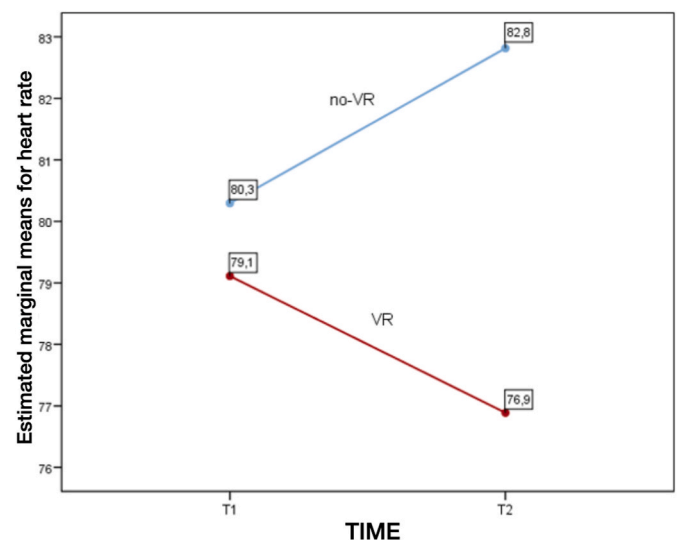


Fig. 4. Interaction between the order of surgery and minimum blood pressure (F test of the mixed analysis of variance model for independent factors, $p = 0.055$).

Table 3

Final heart rate according to independent factors: F test of the mixed ANOVA model for each factor.

	Phase	Factor	Interaction
Model 1. Order of exposure to VR	0,001**	0,243	0,050**
Model 2. Sex	0,001**	0,835	0,428
Model 3. Age ($\leq$ / $>$ 25 years old)	<0,001***	0,757	0,837
Model 4. Degree of difficulty	<0,001***	0,714	0,886
Model 5. Operative time ($\leq$ / $>$ 7,5 min)	<0,001***	0,212	0,715

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$.

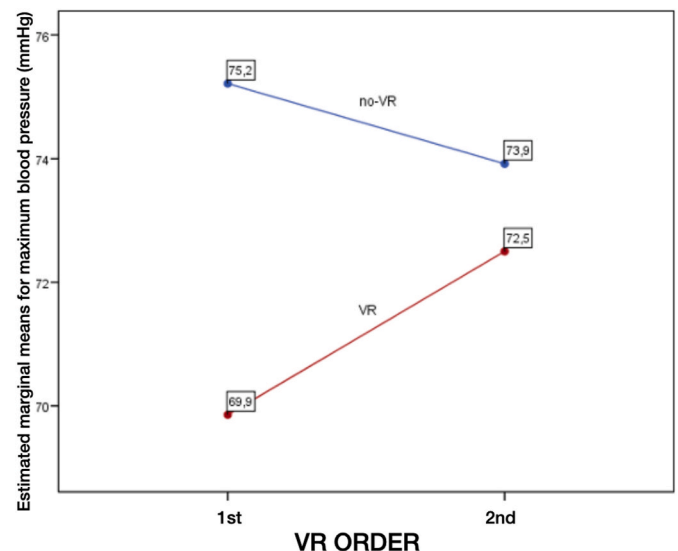


Fig. 5. Interaction between the order of surgery and minimum blood pressure (F test of the mixed ANOVA model for independent factors, $p = 0.055$).

mm Hg in the VR group (from 121.6 ± 18.3 to 124.4 ± 15.0); the maximum BP therefore was significantly lower with VR than without VR ($p = 0.027$), and this was particularly manifest at the end of surgery ($p = 0.084$). The Bonferroni test showed that the maximum BP was not different between the groups at the start, although after surgery it was significantly higher in noVR group ($p = 0.040$). Moreover, in the noVR

group the maximum BP increased significantly ($p = 0.002$), but remained constant in VR group ($p = 0.454$). The F test of the mixed ANOVA model for each independent factor highlighted the efficacy of VR when used during the first surgical procedure ($p = 0.048$), and showed that the maximum BP tended to be higher in male patients ($p = 0.058$).

Blood oxygen saturation was maintained at 100%, with mean variations of 0–0.1; no statistical analysis was therefore indicated in relation to this parameter.

Finally, surgeon rating of comfort improved as the study progressed or on gaining greater experience with the VR system. The Spearman correlation coefficient ($r = 0.37$) suggested a weak-to-moderate magnitude of the association, close to statistical significance ($p = 0.059$) (see Fig. 6).

4. Discussion

By inducing a patient to concentrate on other ideas, less attention centers on discomfort (Wiederhold et al., 2014). Thus, when patients are immersed in a virtual environment, they can focus on visual and audible stimuli rather than on the procedure being carried out (Maples-Keller et al., 2017; Veling et al., 2021). In this regard, the present study focuses on the effectiveness of VR technology, a straightforward and noninvasive strategy for reducing anxiety and pain perception, and for providing a more comfortable patient experience, which a surgery department can finance and reproduce with ease. The results obtained show an interesting control of the hemodynamic parameters, although the outcomes in terms of the subjective evaluation of pain and anxiety appear to be less predictable.

The existence and intensity of fear and anxiety was assessed both before and after treatment using the STAI questionnaire, which is sensitive to the anxiety generated by various anxiety-related scenarios. The pre-treatment STAI results in this study indicated that most patients felt somewhat stressed prior to surgery (31.8% of maximum anxiety). The lack of knowledge regarding the surgical technique and potential postoperative consequences is one of the most powerful anxiety-inducing factors before an operation (Choi et al., 2015). A previous explanation of the experience and postoperative period is therefore helpful for reducing preoperative anxiety, and constitutes a usual element in the clinical practice of our Department. On the other hand, preoperative anxiety has been demonstrated to be significantly higher in young patients, female patients, individuals without prior anesthesia experience or with unfavorable anesthesia-related experiences, as well as in patients

who use tranquilizers (Kindler et al., 2000). Besides, some studies specifically focused on reducing preoperative anxiety using VR technology have concluded that the latter appears to be more effective in pediatric patients than in adults, and also more effective in young adults than in older individuals (Eijlers et al., 2017). Likewise, women have been found to rate their VR experience less favorably than men (Ougradar and Ahmed 2019).

The results obtained show that most patients experienced a decrease in anxiety from the first surgical step to the second (from T1 to T2), regardless of the use of VR goggles. In this regard, anxiety may have decreased due to the experience gained from the first surgical extraction, and fear of the unknown may have disappeared. Furthermore, longer operations had an impact on the final anxiety STAI score, but this impact was the same in both groups (VR versus noVR). Surprisingly, however, no differences in anxiety were found between patients exposed and not exposed to VR, and no associations to other variables such as sex, age or degree of difficulty were observed. Thus, other factors such as fluid communication between the patient and surgeon during surgery are also important in reducing anxiety levels.

Due to the inherent characteristics of the STAI questionnaire, we decided to additionally use a VAS, which enables patients to quickly and easily express their level of pre- and postoperative apprehension by simply drawing a point on a horizontal line to afford more accurate results. Nevertheless, similar results were obtained when anxiety was evaluated with the VAS; that is, it decreased from T1 to T2, although to a similar degree regardless of whether VR was used or not used.

On the other hand, changes in physiological markers such as heart rate and BP reflect the degree of anxiety and pain (Ding et al., 2020). Virtual reality exposure had a significant impact upon the preoperative versus postoperative heart rate values, increasing in the control group and decreasing with VR ($p = 0.013$) (Fig. 3). Moreover, when VR was applied first, heart rate control with VR was stronger than without VR, and hence the effectiveness of VR was increased. Mladenovic and Djordjevic (2021) concluded that when VR eyewear was used, the heart rate values before and during the surgical procedure were noticeably lower.

Similar results were obtained for both minimum and maximum BP, with values that increased in the control group and decreased with VR ($p = 0.012$ and $p = 0.027$, respectively). Likewise, when VR was applied first, BP control with VR was stronger than without VR. The evaluation of minimum BP showed VR to be significantly more effective in male patients and in young patients (<25 years of age), which is consistent with the data found in the literature (Ougradar and Ahmed 2019).

Although VR has a well-established track record of success in treating anxiety disorders and phobias (Mayer et al., 2022), two of our patients dropped out of the study because they were unable to wear the VR goggles due to claustrophobia. After removing the VR goggles, these patients asked to keep their eyes uncovered. Similarly, VR goggles have a small field of view and prevent users from seeing their own bodies while in a virtual setting. Thus, it could be useful before putting on the VR goggles to ask the patients whether they feel overwhelmed by being blindfolded. Immersive rooms could be an alternative for these patients, but this strategy is more expensive and difficult to perform in an operating room.

Problems with VR use include the thickness of the current head-mounted displays, which impose restrictions on surgeon positioning and placement of the surgical instruments, such as retractors on the upper jaw (Yamashita et al., 2019). Other, less bulky VR devices have been developed, but are unable to offer the same level of realism. The results referred to surgeon comfort showed improved comfort during the course of the operation, so finally the surgeon did find a comfortable working position.

Finally, although the study was randomized, well designed and involved homogenous groups regarding related variables (using the same patient for VR and noVR, degree of surgical difficulty, surgery time, side and order of surgery), it has some limitations attributable to

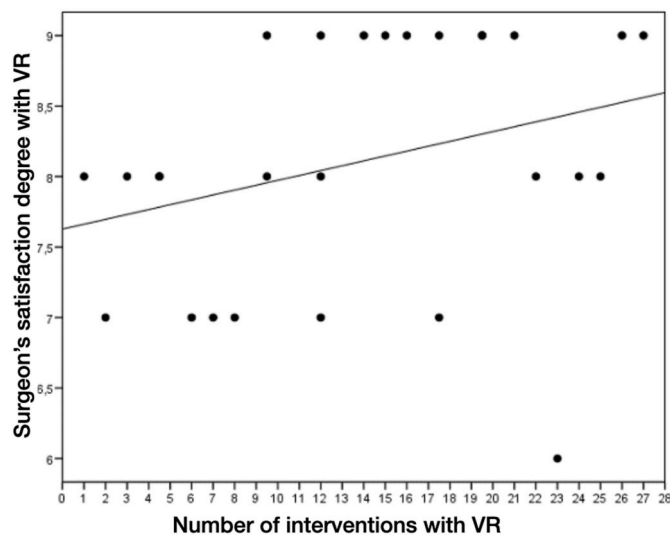


Fig. 6. Improvement of surgeon comfort rating during the course of the operation on gaining experience with the VR system ($r=0.37$, $p=0.059$).

its single-center and single-surgeon design, with the inherent biases that this implies. On the other hand, although the study was focused on WT extraction, the use of VR could be broadened to other surgical and dental fields carried out under local anesthesia, since it is a simple, effective and noninvasive technique that appears to be promising for improving patient experiences and anxiety.

5. Conclusion

In conclusion, although more research is needed to fully assess the effectiveness and usefulness of this approach in daily clinical practice, this study shows that VR goggles proved useful in controlling patient anxiety during surgery. Nevertheless, while significant differences between the groups were found for heart rate and BP, the subjective evaluation of anxiety remained the same in both groups.

References

- Appukuttan, D.P., 2016. Strategies to manage patients with dental anxiety and dental phobia: literature review. *Clin. Cosmet. Invest. Dent.* 10 (8), 35–50. <https://doi.org/10.2147/CCIDE.S63626>.
- Choi, S.H., Won, J.H., Cha, J.Y., Hwang, C.J., 2015. Effect of audiovisual treatment information on relieving anxiety in patients undergoing impacted mandibular third molar removal. *J. Oral Maxillofac. Surg.* 73 (11), 2087–2092. <https://doi.org/10.1016/j.joms.2015.06.175>.
- Ding, L., Hua, H., Zhu, H., Zhu, S., Lu, J., Zhao, K., Xu, Q., 2020. Effects of virtual reality on relieving postoperative pain in surgical patients: a systematic review and meta-analysis. *Int. J. Surg.* 82, 87–94. <https://doi.org/10.1016/j.ijssu.2020.08.033>.
- Eijlers, R., Legerstee, J.S., Dierckx, B., Staals, L.M., Berghmans, J., van der Schroeff, M.P., et al., 2017. Development of a virtual reality exposure tool as psychological preparation for elective pediatric day care surgery: methodological approach for a randomized controlled trial. *JMIR Res. Protocols* 6 (9), e174, 11. <https://doi.org/10.2196/resprot.7617>.
- Fábián, G., Fejérdy, L., Fábián, C., Kaán, B., Gáspár, J., Fábián, T.K., 2003. Epidemiologic study of dental fear in school children 8–15 years of age. *Fogorv. Sz.* 96 (3), 129–133.
- Falguière, A., LeGruiec, C., Herry, H., Genest-Beucher, S., Dessus, J., Boisramé, S., 2021. Contribution of virtual reality in oral surgery: a literature review. *J. Stomatol. Oral Maxillofac. Surg.* 122 (4), 405–410. <https://doi.org/10.1016/j.jormas.2021.02.004>.
- de Jongh, A., Broers, D.L.M., 2009. Risks of dental fear reduction treatments. *Ned. Tijdschr. Tandheelkd.* 116 (6), 324–329.
- Kain, Z.N., Sevarino, F., Pincus, S., Alexander, G.M., Wang, S.M., Ayoub, C., Kosarussavadi, B., 2000. Attenuation of the preoperative stress response with midazolam: effects on postoperative outcomes. *Anesthesiology* 93 (1), 141–147. <https://doi.org/10.1097/00000542-200007000-00024>.
- Kindler, C.H., Harms, C., Amsler, F., Ihde-Scholl, T., Scheidegger, D., 2000. The visual analog scale allows effective measurement of preoperative anxiety and detection of patients' anesthetic concerns. *Anesth. Analg.* 90 (3), 706–712. <https://doi.org/10.1097/00000539-200003000-00036>.
- Maples-Keller, J.L., Yasinski, C., Manjin, N., Rothbaum, B.O., 2017. Virtual reality-enhanced extinction of phobias and post-traumatic stress. *Neurotherapeutics* 14 (3), 554–563. <https://doi.org/10.1007/s13311-017-0534-y>.
- Mayer, G., Gronewold, N., Polte, K., Hummel, S., Barniske, J., Korbel, J.J., Zarnekow, R., Schultz, J.H., 2022. Experiences of patients and therapists testing a virtual reality exposure app for symptoms of claustrophobia: mixed methods study. *JMIR Ment Health* 9 (12), e40056, 5. <https://doi.org/10.2196/40056>.
- Mladenovic, R., Djordjevic, F., 2021. Effectiveness of virtual reality as a distraction on anxiety and pain during impacted mandibular third molar surgery under local anesthesia. *J. Stomatol. Oral Maxillofac. Surg.* 122 (4), e15–e20. <https://doi.org/10.1016/j.jormas.2021.03.009>.
- Ougradar, A., Ahmed, B., 2019. Patients' perceptions of the benefits of virtual reality during dental extractions. *Br. Dent. J.* 227 (9), 813–816. <https://doi.org/10.1038/s41415-019-0939-6>.
- Pell, G.J., Gregory, G.T., 1933. Impacted mandibular third molars: classification and modified technique for removal. *Dent. Digest* 39, 330–338.
- Rutkowski, S., Czech, O., Wrzeciono, A., Kiper, P., Szczepańska-Gieracha, J., Malicka, I., 2021. Virtual reality as a chemotherapy support in treatment of anxiety and fatigue in patients with cancer: a systematic review and meta-analysis and future research directions. *Compl. Ther. Med.* 61, 102767. <https://doi.org/10.1016/j.ctim.2021.102767>.
- Spielberger, C.D., González-Reigosa, F., Martínez-Urrutia, A., 1971. Development of the Spanish edition of the state-trait anxiety inventory. *Rev. Interam. Psicolog.* 5 (3–4), 145–158.
- Veling, W., Lestestuiver, B., Jongma, M., Hoenders, H.J.R., van Driel, C., 2021. Virtual reality relaxation for patients with a psychiatric disorder: crossover randomized controlled trial. *J. Med. Internet Res.* 23 (1), e17233, 15. <https://doi.org/10.2196/17233>.
- Wiederhold, M.D., Gao, K., Wiederhold, B.K., 2014. Clinical use of virtual reality distraction system to reduce anxiety and pain in dental procedures. *Cyberpsychol., Behav. Soc. Netw.* 17 (6), 359–365. <https://doi.org/10.1089/cyber.2014.0203>.
- Yamashita, Y., Shimohira, D., Aijima, R., Mori, K., Danjo, A., 2019. Clinical effect of virtual reality to relieve anxiety during impacted mandibular third molar extraction under local anesthesia. *J. Oral Maxillofac. Surg.* 78 (4), 545.e1–545.e6. <https://doi.org/10.1016/j.joms.2019.11.016>.