Original Research Article

Effectiveness of Virtual Reality Glasses in Reducing Anxiety in Children and Dentists' Operative Time for Pediatric Dental Procedures: A Randomized Clinical Trial

Abstract:

This randomized clinical trial aimed to evaluate the effects of audiovisual distraction using virtual reality glasses during inferior alveolar nerve block in pediatric dental patients. This clinical trial randomly included 20 participants aged 4 to 11 years from a pediatric dentistry clinic to receive anesthesia with or without VR glasses. Behavioral assessments were conducted using the Frankl scale, FLACC (Face, Legs, Activity, Cry, Consolability) scale, and Wong-Baker FACES Pain Rating Scale (PRS). Anesthesia administration time was recorded. The results were compared by Wilcoxon test, and Cohen's $d_{Repeated\ Measures,\ pooled}$ (Cd_{RMp}) estimated the effect size. Three children were excluded due to device rejection. In the Frankl scale assessment, children achieved better behavior scores in the session with VR glasses ($Cd_{RMp} = 0.20$; $p = 0.031$). Children reported significantly less pain when using VR glasses according to the PRS scale ($Cd_{RMp} = -0.73$; $p = 0.016$).
. Additionally, the time required for anesthesia administration was significantly shorter with VR glasses ($Cd_{RMp} = -1.20$; $p < 0.001$). The results suggest that virtual reality glasses are a valuable tool for audiovisual distraction in pediatric dentistry, effectively reducing anxiety, fear, and the time required for anesthesia administration during dental treatment.

Keywords: anxiety**,** Children, dental, anesthesia

Introduction

Pediatric pain management is essential for treatment success and fostering a positive relationship between the dentist and the young patient (ASSED, 2005). The anesthetic injection is considered the most painful factor of invasive procedures. Needle puncture evokes a sharper pain, while the pain from anesthetic inflation tends to be more intense and prolonged due to chemical irritants and rapid tissue distension (STRAZAR et al., 2013). Improper administration of anesthesia can lead to excessive pain during injection, iatrogenesis, and anesthesia failure, which are common complications that provoke fear and anxiety reactions during pediatric dentistry treatment (ELBAY et al., 2014). Fear and anxiety reactions can lead to procedure limitation and increase the risk of patient injury. Such situations may traumatize the children besides fueling their fear of dental visits (HOGE et al., 2012).

Managing a child's behavior to keep them comfortable and ensure proper access to the oral cavity is always a professional challenge, and conventional behavior management techniques are not always effective. Some alternative measures may

helppatient management, such as acupuncture (AVISA et al., 2018), hypnosis (OBEROI et al., 2017), nitrous oxide administration (GALEOTTI et al., 2016), and others. However, these techniques require specialized training from the professional, and some children may react poorly to them, especially when needles and equipment causing fear are involved (MITRAKUL et al., 2015). Distraction through audiovisual resources has emerged in dentistry as an option for behavior management that does not require additional training or substantial investment in equipment. It is common to find televisions displaying animations to distract children from the dental environment (BARREIROS et al., 2018). However, this technique has shown limitations because children often struggle to maintain focus on the TV while receiving information about the treatment in their field of vision (MITRAKUL et al., 2015). To address this limitation, researchers have enhanced audiovisual distraction resources to offer greater comfort and reduce patient anxiety during dental treatment by introducing virtual reality glasses. Widely used in gaming, virtual reality glasses display videos on their lenses and provide audio through headphones. This device conceals the child's view and sound of the dental environment, making it a cost-effective and easy-to-administer tool (RAM, 2010).

Several studies have already been conducted to assess the effects of audiovisual distraction using virtual reality glasses during pediatric dental care (RAM, 2010; EL-SHARKAWI et al., 2012; MITRAKUL et al., 2015; ZHANG et al., 2018; BAGATTONI et al., 2018; FAKHRUDDIN et al., 2018). However, some factors prevent a robust conclusion about the technique, such as different operators conducting the research, different types of treatments, and, primarily, costly and complex devices. Therefore, the objective of this study was to evaluate the effects of audiovisual distraction on fear and anxiety reactions in children during dental care using affordable and easy-to-use virtual reality glasses during inferior alveolar nerve block.

Methods

Sample

Each new patient who started treatment at the pediatric dentistry clinic of **********during the years 2018 and 2019 participated in andrawn to random inclusion to the clinical trial. Through a simple coin toss (head our tails), the legal guardians of drawn patients' were invited for a selection interview to assess whether the patient met all the inclusion criteria. Children treated of both genders, aged 4 to 11 years, with normal vision and no psychological disorders, and requiring at least two dental treatment sessions that involved inferior alveolar nerve block were included. Children who refused to use the virtual reality glasses during the session were excluded.

The patient who was not drawn started the pediatric dental treatment normally but was not invited to participate in this clinical trial.

Procedure

A single dentist was previously calibrated using Cohen's kappa index to measure the accuracy of the inferior alveolar nerve block technique. Five children

who did not participate in the study underwent the anesthetic technique, and two judges evaluated the operator. The inter-examiner reliability was 95%.

All children underwent two sessions of inferior alveolar nerve block before treatment: in one session, the audiovisual device (VR BOX MINI - PMTec – FredericoWestphalen – RS – Brazil) (Figure 1) attached to a smartphone (A72 - Samsung Electronics - Seoul - South Korea) was used; in the other session, conventional management techniques were employed. The order of the sessions was chosen randomly (coin toss). In the session with the device, the child was presented with a gallery of 3D animations in side-by-side format, such as Cars 3®, Moana®, and Big Hero 6®, from which they could choose their preferred animation. The device and headphones (JBL Tune 510BT - JBL - Los Angeles - USA) were adjusted, and once the child confirmed everything was correct, the dentist accommodated the child in the dental chair and asked them to open their mouth to begin the inferior alveolar nerve block. For both sessions, the timing started when the child was properly accommodated in the dental chair, with or without the device. Initially, the area was disinfected with 0.12% chlorhexidine, and the injection site was dried. Next, topical anesthesia was administered using 200mg/g Benzocaine gel (Benzotop - DFL - Rio de Janeiro - Brazil) with a flexible cotton swab for one minute. The chosen site for injection was the occlusal level of the mandibular ramus using the indirect technique. A short needle (21mm) 30G (All prime - São José - Santa Catarina - Brazil) and 2% lidocaine with 1:100,000 epinephrine (Alphacaine - DFL - Rio de Janeiro - Brazil) were used as an anesthetic. The timing ended after administering 1 cartridge (1.8 ml) of the anesthetic.

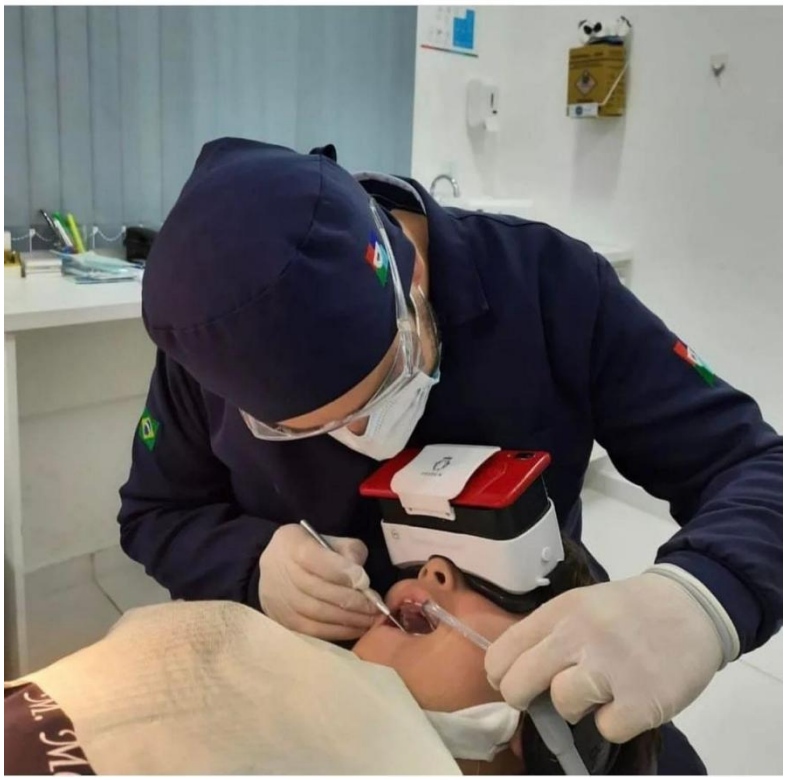

Figure 1: Children using the virtual reality glasses during the session.

Behavior assessment

A second operator, previously trained, evaluated the children's reactions. Three scales were used: the Frankl scale (1962), which measures the child's anxiety during the preoperative period; FLACC (Face, Legs, Activity, Cry, Consolability) (Merkel et al., 1997), during the anesthetic injection to investigate the level of pain; immediately after the anesthetic injection, the patient was subjected to the last assessment, the Wong-Baker FACES Pain Rating Scale (PRS) (International Association For The Study Of Pain. 2001). In this evaluation, the child marked their impression of pain on a scale of 0 to 10, where facial expressions ranged from "no pain" to "worst possible pain."

Statistical analysis

The scores from the scales and the minutes spent on the technique were subjected to the Shapiro-Wilk data distribution test, which diagnosed that the data had an unknown distribution ($p < 0.05$). Mean and standard deviation (SD) were calculated, and the Wilcoxon test was used to compare the values obtained in the two sessions. The effect size of Cohen's $d_{\text{Repeated Measures, pooled}}$ (Cd_{RMp}) was also calculated. The data were analyzed using the statistical program Sigma Plot 12.0® (Systat Software Inc., San Jose, USA), at a significance level of 5%.

Results

Of the 20 included children, 3 were excluded from the research due to device rejection (hysterical behavior). The sample consisted of 6 girls and 7 boys, with an average age of 7.16 years (SD = 2.13).

In the Frankl scale assessment (1962), there was a statistically significant difference between the sessions ($Cd_{RMp} = 0.20$; $p = 0.031$). The children achieved better scores in the session with the audiovisual device (Mean = 3.83; SD = 0.64) compared to the session without the device (Mean = 3.64; SD = 1.05). Eleven children achieved the maximum behavior score in the session with the device.

In the assessment during the anesthetic technique with the FLACC tool, there was no statistically significant difference between the sessions without the device (Mean = 2.00; SD = 3.85) and with the device (Mean = 0.53; SD = 1.85) ($p = 0.063$).

When the child was asked to rate their pain on the PRS scale after the anesthesia, the results were significantly better when the child underwent the session with the device (Mean = 0.92; SD = 1.25) compared to the session without the device (Mean = 2.76; SD = 2.89) ($Cd_{RMp} = -0.73$; $p = 0.016$).

The time required for the inferior alveolar nerve block was statistically shorter in the session with the device (Mean = 2.66; SD = 0.72) compared to the session without the device (Mean = 4.35; SD = 1.62) ($Cd_{RMp} = -1.20$; $p < 0.001$).

Discussion

The results of this study allow us to reject the null hypothesis, suggesting that not are differences in behavior, pain sensitivity, and administration time of anesthesia in children using audiovisual distraction compared to children undergoing

conventional management techniques. Virtual reality glasses were chosen as the distraction resource due to their novelty in dentistry, as they completely block the child's vision and hearing of the dental environment. Additionally, they are easy to handle and adapt to, are well-accepted by patients, and are affordable (LIU et al., 2018).While the insights gained from this study are valuable, it is important to acknowledge that the relatively small sample size may limit the generalizability of our findings to broader populations, and caution should be exercised when extrapolating these results beyond the scope of our specific cohort.

Dentists need to have knowledge and master techniques to alleviate fear and anxiety before and during procedures. Pain is a sensation that should be minimized to avoid disruptive reactions in patients and to allow the initiation and/or completion of treatment. Since anesthesia is the most painful part of dental procedures, our research was limited to evaluating the effects of virtual reality glasses only at this moment. We performed a single anesthetic technique to standardize the results and did not extend the evaluation to the dental procedure itself, due to the wide variability of pain sensation among different procedures and different patients (BARREIROS et al., 2018).

The Frankl scale is widely used by researchers to assess child behavior and their level of fear and anxiety. Despite being formulated over 50 years ago and being relatively simple, its reliability stands the test of time. GOMES (2013) correlated low Frankl behavior scores with high levels of cortisol, a hormone released in response to stress. The satisfactory result in our study indicates that children were more willing to undergo dental treatment when presented with virtual reality glasses (BAGATTONI et al., 2018). The available gallery of animations for children is crucial for their cooperation, as animations featuring well-known characters from the cinematic world capture children's attention (RAM, 2010).

Our perspective was also to obtain significant results regarding the sensation of pain, as pain is closely linked to fear and anxiety (HOGE et al., 2012). The FLACC scale was initially developed for use in hospital settings with non-communicative children. However, researchers understand that their patients' speech is also compromised due to instruments in the oral cavity, and absolute isolation, among other factors. For this reason, the FLACC scale is widely accepted in the literature to measure pain during dental procedures, as it provides a more detailed and comprehensive assessment (BUSSOTTI et al., 2015). On the other hand, the PRS scale is a pain measurement scale in which the patient indicates their pain level through drawings (OLIVEIRA et al., 2014). Although visual analog scales have proven reliability, physiological measures of fear and anxiety, such as blood oxygenation, pulse, cortisol levels, and respiratory rate, could have been used in our study, which could be considered a limitation of our study. Regarding the FLACC results, there were no significant differences between the two sessions. However, the session with the device showed a significant reduction in the sensation of pain according to the PRS scale. Although both scales measure pain, the FLACC scale provides a more accurate result because the score is assigned by an observer who witnesses the child's reactions in various categories and at the exact moment of the anesthetic injection (BUSSOTTI et al., 2015). As for the PRS scale, being a self-report scale applied after the anesthetic moment, it may yield results that do not truly reflect the child's actual sensation of pain (OLIVEIRA et al., 2014). The FLACC

results, however, do not undermine the results obtained by the PRS. If the same children responded more positively in the session with the glasses than without them, it is evident that, even if the sensation of pain did not decrease, they felt so satisfied and at ease that they responded positively to the pain scale when the anesthesia ended (OLIVEIRA et al., 2014).

We acknowledge that there exist other alternative validated tools of anxiety assessment, such as physiological measures like pulse rate and oxygen saturation. These instruments bring distinct nuances and perspectives to the evaluation of pediatric anxiety during dental procedures, and their omission from our research represents a potential avenue for further investigation. These physiologically grounded parameters serve as invaluable adjuncts to subjective scales, furnishing a more comprehensive psychophysiological profile of pediatric patients' emotional states during dental interventions. Thus, in forthcoming investigations, we commit to the deliberate integration of these objective indices to amplify the fidelity and depth of anxiety evaluation within this clinical context. (Koticha et al., 2019; Zaidman et al., 2023; Leopardi et al., 2023; Cunninghum et al., 2021; Buldur et al., 2021)

Saving time for dental procedures is of utmost importance for dentists, allowing for greater efficiency in patient care and increased patient satisfaction (SHOOK, 2015). Our study demonstrated that the use of distraction can halve the time spent on anesthesia. This is because, with the child's focus entirely directed to the animation, actions that delay the procedure, such as excessive talking during the procedure, placing hands in the mouth, crying, and head movement, were almost eliminated in the session with the virtual reality glasses (BAGATTONI et al., 2018). The reduced time for anesthesia is also a result of the facilitated administration of the anesthetic technique. In pediatric patients, the technique is often compromised, requiring the surgeon to interrupt the injection and/or inflation, losing the reference site and leading to additional punctures, increasing pain levels, and raising the chances of iatrogenesis (ASSED, 2005).

Conclusion

Our study demonstrates that virtual reality glasses serve as a highly effective tool for audiovisual distraction in pediatric dental care settings. The evidence presented herein underscores their remarkable potential in mitigating anxiety and fear among children undergoing dental procedures. Moreover, the integration of virtual reality technology not only enhances the overall dental experience for young patients but also contributes to a notable reduction in the dentist's working time. However, it is important to acknowledge that further research with larger and more diverse samples is warranted to strengthen the generalizability of our findings and to explore potential variations in the effectiveness of this intervention. Nevertheless, the positive outcomes observed in this study underscore the significance of integrating virtual reality as a valuable adjunctive tool in pediatric dental practice, promising a brighter and less anxiety-inducing future for young dental patients.

Ethical Approval and Consent :

This randomized clinical trial was previously approved by the Research Ethics Committee of ********** (protocol: 92598818.0.0000.5142). Eligible patients and their parents or legal guardians were invited to participate in the research and were included after reading and signing age-adapted consent forms.

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