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Distraction with AR Glasses During Dental Anesthesia: A Behavioral Assessment in Children

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Abstract:

Research background and aim: Managing distraction during local anesthesia injections in children is crucial for improving their behavior and minimizing negative dental experiences. This study aimed to assess the effectiveness of augmented reality (AR) glasses in children undergoing an inferior alveolar nerve block (IANB), by using animated cartoons with or without interactive gaming. Child behavior was evaluated using the Houpt Behavior Rating Scale.

Materials and methods: A randomized clinical study was conducted on 108 children aged 7 to 9 years who underwent a dental procedure requiring an inferior alveolar nerve block (IANB) injection. Participants were randomly assigned to four groups: Group A (control) received passive distraction by watching ani
mated cartoons on a mobile screen; Group B received passive distraction via cartoons displayed through a mobile device connected to augmented reality (AR) glasses; Group C experienced active distraction by playing video games on a mobile device connected to AR glasses; and Group D received a combination of active distraction through video games before the procedure, followed by passive distraction through cartoons via AR glasses during the injection. Children's behavior was assessed using the HOUPT Behavior Rating Scale. The Kruskal-Wallis test was employed to analyze differences in behavior scores among groups, with statistical significance set at $P < 0.05$.

Results: The results of this study revealed that the mean rank scores were 51.96 for Group A, 52.50 for Group B, 64.78 for Group C, and 66.76 for Group D. The Kruskal-Wallis test indicated statistically significant differences in overall behavior among the groups ($P < 0.05$). Further pairwise comparisons using the Mann-Whitney U test showed that Groups D and C performed significantly better than the other two groups.

Conclusions: The study concluded that the use of augmented reality (AR) glasses for active distraction through gaming prior to the procedure—either alone or combined with passive cartoon viewing during injection—significantly improved children's overall behavior during local anesthesia administration.

Key Words: Dental Anxiety, Inferior Alveolar Nerve Block, Distraction Techniques, Augmented Reality, Virtual Reality, Rokid Air Glasses.

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تشتيت الانتباه باستعمال نظارات الواقع المُعزَّز أثناء التخدير السني: تقييم سلوكي للأطفال

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الملخص:

خلفية البحث وهدفه: إنّ تشتيت انتباه الأطفال في أثناء إعطائهم حقن التخدير الموضعي من أهم تقنيات التدبير السلوكي عند الأطفال لما له من فوائد في تحسين سلوكهم وتخفيف مشاعرهم السلبية تجاه الإجراءات السنية. يهدف هذا البحث إلى تقييم فعالية نظارات الواقع المعزز عند استخدامها للأطفال قبل إعطائهم حقنة العصب السنخي السفلي أثناء مشاهدة أفلام الرسوم المتحركة أو اللعب. تم تقييم السلوك العام باستخدام مقياس هوبت.

مواد البحث وطرائقه: أُجريت دراسة سريرية معشاة على 108 طفلاً تراوحت أعمارهم بين 7–9 سنوات خضعوا لإجراء سني يتطلب حقنة العصب السنخي السفلي. تم تقسيمهم عشوائيًا إلى أربع مجموعات: المجموعة A (الشاهدة) طُبِّق تشتيت الانتباه بعرض أفلام الرسوم المتحركة عبر الموبايل، المجموعة B طُبِّق تشتيت الانتباه بعرض الأفلام عبر الموبايل المتصل بنظارات الواقع المعزز، المجموعة C طُبِّق تشتيت الانتباه من خلال ألعاب فيديو عبر الموبايل المتصل بالنظارات، والمجموعة D طُبِّق تشتيت الانتباه من خلال ألعاب الفيديو مع الأفلام عبر النظارات. تم تقييم سلوك الأطفال باستخدام مقياس هوبت.

النتائج: أظهرت نتائج هذه الدِّراسة أنّ متوسط الرتب في المجموعة A كان 51.96، وفي المجموعة B كان 52.50، وفي المجموعة C كان 64.78، وفي المجموعة D كان 66.76. بينت نتائج اختبار (Kruskal-Wallis) وجود فروق ذات دلالة إحصائيَّة بين المجموعات ($P > 0.05$)، كما بينت نتائج اختبار مان وتني تفوق المجموعة D والمجموعة C على المجموعتين الآخرتين.

الاستنتاجات :خلصت الدراسة إلى أن استخدام نظارات الواقع المعزز لإلهاء الطفل بشكل نشط من خلال الألعاب قبل الإجراء، سواء بمفردها أو بالاقتران مع مشاهدة الرسوم المتحركة أثناء الحقن، قد حسّن بشكل كبير من السلوك العام للأطفال أثناء إجراء التخدير الموضعي.

الكلمات المفتاحية: الخوف السني، حقنة إحصار العصب السنخي السفلي، تشتيت الانتباه، الواقع المُعزّز ، الواقع الافتراضي، نظارات (Rokid Air).

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Introduction:

Dental fear and anxiety are early indicators of dental phobia, a condition marked by an intense, irrational, and disproportionate fear of dental procedures that can lead to avoidance of treatment and significant impairment in daily life [1]. While the concept of a "disproportionate fear response" may not fully apply to children due to their limited ability to distinguish between real and perceived threats, the general definition of dental phobia remains suitable for pediatric populations [2]. In children, dental fear and anxiety often manifest as behavioral disturbances such as crying, refusal of treatment, or physical resistance. These reactions result from an interplay of genetic, behavioral, and cognitive factors that shape the child's perception of dental care. Dental professionals play a key role in breaking the fear–pain cycle and modifying these perceptions [3]. Efforts to manage pediatric behavior in dental settings have spanned over a century. While early approaches were often intuitive, systematic observation of children's behavior led to the development of behavioral management techniques aimed at enhancing cooperation and ensuring safe, trauma-free care. Behavioral management is defined as the use of effective, efficient methods that facilitate treatment while promoting a positive dental experience [4].

The American Academy of Pediatric Dentistry classifies behavioral techniques into basic (non-pharmacological) and advanced (pharmacological) categories [5]. Among the basic methods, distraction techniques are widely used to divert attention away from anxiety-inducing stimuli (e.g., injections or handpieces) toward more pleasant sensory inputs, thereby reducing fear and improving cooperation [6]. Distraction may be passive or active, depending on the level of child engagement [7].

Virtual reality (VR) and augmented reality (AR) are categorized as non-pharmacological distraction tools. Unlike traditional methods—which often have limited immersion, single-sensory focus, low cognitive engagement, reduced effectiveness in older children, and rapid habituation—AR/VR technologies offer immersive, multi-sensory environments that better capture the child's attention and reduce anxiety [8,9].

Given these advantages, the present study aims to evaluate the effectiveness of an advanced form of augmented reality glasses in distracting children during the administration of an inferior alveolar nerve block injection.

Materials and Methods:

Study design, Ethics, and Setting:

A randomized controlled trial (RCT) with a parallel-arm design was conducted on 108 children who required dental procedures involving an inferior alveolar nerve block (IANB), with the aim of evaluating the effectiveness of an augmented reality (AR)-based distraction device. The study was registered at ClinicalTrials.gov under the identifier NCT06724341, and received ethical approval from the Biomedical Research Ethics Committee of Damascus University (DN210125-392). All procedures performed in this study adhered to the principles of the Declaration of Helsinki (2000 revision). The parents of all participants were provided with detailed information about the study's purpose and procedures. Written informed consent was obtained from all participants prior to enrollment. The clinical trial was conducted at the Department of Pediatric Dentistry, Damascus University, between July 2024 and January 2025.

Sample Size Calculation, Group Allocation, Randomization, Blinding, and Patients Selection Criteria:

The sample size was estimated based on a recent clinical study [10] that evaluated the effectiveness of virtual reality in distracting pediatric dental patients. Using G*Power software and selecting the independent samples t-test, the mean pain score and standard deviations from the referenced study were entered to calculate the effect size, which was found to be 1.252. With a power of 95% and a significance level of $\alpha = 0.05$, the minimum required sample size was determined to be 36 participants (12 in each group). To ensure statistical robustness and account for potential dropout, the number was increased to 108 children, who were equally distributed into four groups as follows:

- Group A (Control): Children received passive distraction via direct viewing of animated cartoons on a mobile screen during the

administration of the inferior alveolar nerve block (IANB).

- Group B: Children received passive distraction through animated cartoons displayed on a mobile device connected to augmented reality (AR) glasses during the IANB procedure.
- Group C: Children received active distraction by playing video games on a mobile device connected to AR glasses *prior to* the dental procedure and IANB administration.
- Group D: Children who received active distraction by playing video games on an AR-connected mobile device before the procedure, followed by passive distraction through animated cartoons (via AR glasses) during the IANB injection.

Randomization was carried out using an online random number generator (www.random.org). While blinding of participants was not feasible due to the active use of the AR headset, steps were taken to minimize potential bias. Independent, trained assessors were responsible for evaluating the study outcomes, and the outcome data were recorded without disclosing the group assignments to the evaluators.

Participants were selected based on the following inclusion criteria:

- Children classified as positive or definitely positive according to the Frankl Behavior Rating Scale [11].
- Age between 7 and 9 years.
- No prior experience with virtual reality.
- No previous dental treatment experience.
- Requirement for unilateral dental treatment of a mandibular primary molar, with an estimated procedure time of less than 30 minutes.
- No administration of analgesics or sedatives within the three hours preceding the appointment.
- Children classified as ASA I or ASA II according to the American Society of Anesthesiologists (ASA) Physical Status Classification [12].

Children were excluded from participation based on the following criteria:

- Presence of neurological disorders (e.g., anxiety disorders or epilepsy).
- Presence of systemic diseases or significant health problems.
- Presence of visual or hearing impairments that could interfere with participation.
- Known allergy to local anesthetics.
- Parental refusal to participate or concerns regarding the use of AR glasses.

Study Intervention:

The study was conducted following the methodology outlined below:

1. A comprehensive clinical history was taken for children visiting the Pediatric Dentistry Department at Damascus University Dental School, presenting with a dental complaint in one side of the lower jaw. This included personal information, general medical history, dental history, and social history.
2. The site of treatment and the specific tooth to be treated were determined, and a radiographic image was taken to confirm the diagnosis. Additionally, the child's behavior was assessed according to the Frankl Scale.
3. Based on the aforementioned clinical diagnostic information, children who met the inclusion criteria were enrolled in the study. Informed consent was obtained from the parents (or guardians), who were provided with written and verbal information regarding the study, its procedures, and its objectives. Final written informed consent was obtained from the parents for participation in the research.
4. Distraction techniques were applied according to the group assignment before any dental procedure:
   - Group A: Children were shown animated cartoons on a mobile phone screen (e.g., Tom and Jerry, SpongeBob, Masha and the Bear).
   - Group B: Children wore the augmented reality headset (Rokid Air AR Glasses, China), as shown in **Figure 1 and 2**, connected to a mobile phone to watch preloaded animated cartoons during the injection.
   - Group C: Children wore the augmented reality headset connected to a mobile phone for playing video games before the injection (e.g., Galaxy on Fire, Grand Theft Auto, Clash of Clans, Mario). It was selected based on his/her preference.
   - Group D: Children wore the augmented reality headset connected to a mobile phone for playing video games before the injection and watching animated cartoons during the injection.

Figure (1): AR Glasses

Figure (2): Wearing augmented reality glasses by children.

Before each child entered the dental treatment chair (for Groups 3 and 4), they were placed in a separate room, and the appropriate distraction technique for each group was applied.

5. The child was then taken to the dental treatment chair, where topical anesthesia was applied using 8% lidocaine gel (Iolite Pharma, USA) for 20 seconds. Following this, a local anesthetic injection with 2% Lidocaine (Kwang, Colombia) was administered for inferior alveolar nerve block, and this phase was recorded on video by the researcher.

6. Finally, the appropriate dental treatment was carried out.

Assessment of General Behavior:

Child behavior during the inferior alveolar nerve block was evaluated using the Houpt Behavior Rating Scale, which comprises six levels ranging from 1 (most disruptive behavior) to 6 (full satisfaction with treatment). To ensure objectivity, a second, independent evaluator (not involved in the study) reviewed two-minute, slow-motion video recordings of the injection phase and assigned each child's overall behavior score. The scale is as follows:

Table (1): Houpt General Behavior Scale [13]:

Score	Description
1	Aborted: No treatment rendered.
2	Poor: Treatment interrupted, only partial treatment was completed.
3	Faire: Treatment interrupted but eventually completed.
4	Good: Difficult but all treatment was performed.
5	Very Good: Some limited crying or movement.
6	Excellent: No crying or movement.

Statistical Analysis:

Statistical analyses were performed using IBM SPSS Statistics software (Version 24, SPSS Inc., Chicago, IL, USA). The distribution of the data was assessed using the Kolmogorov-Smirnov test. Differences in the frequencies of general behavior scores on the Houpt Scale among the study groups were analyzed using the Kruskal-Wallis test. Behavior scores were expressed as percentages and mean ranks. A p-value of less than 0.05 was considered statistically significant.

Results:

The study sample consisted of 108 children of both sexes, aged between 7 and 9 years, who were randomly allocated into four equal groups (n = 27 per group, 25% each), according to the behavior management technique applied. In group D, there were 18 boys (67%) and 9 girls (33%). In the group C, 16 children were boys (59 %) and 11 were girls (51%). In both the group A and B, each contained 15 boys (56%) and 12 girls (44%). There were no statistically significant differences among the groups regarding gender distribution (P = 0.183).

The mean age of the participants was 7.8 ± 0.8 years, with comparable values across all groups: 7.7 ± 0.8 years in the group D, 7.9 ± 0.8 years in the group C, 7.9 ± 0.8 years in the group B, and 7.7 ± 0.8 years in the group A. No statistically significant differences were observed among groups in terms of age distribution (P = 0.371).

In the overall sample, 46 children were classified as "positive" on the Frankl Behavior Rating Scale, and 62 children as "definitely positive." All children in the AR distraction groups completed their planned treatment, whereas in the control group (no AR), only 16 children completed treatment—with the addition of other behavioral management techniques—and 11 children did not complete treatment.

The Kruskal-Wallis test was conducted to evaluate the significance of differences in the distribution of general behavior scores on the HOUPT Scale among the four behavior management groups. The test results are presented in the Table 2.

Table (2): Kruskal-Wallis Test Results

Distraction Method	Mean Rank	Chi-Square value	P-value
Group A	51.96	11.796	0.0102
Group B	52.50		
Group C	64.78		
Group D	66.76		

As shown in the table above, the P value is less than 0.05. This indicates that at the 95% confidence level, there were statistically significant differences in the HOUPT behavior scores among the four distraction method groups in the study sample, thus, Mann-Whitney U test was performed as it can be shown in the Table 3.

Table (3): Mann-Whitney U Test Results

Distraction Method (1)	Distraction Method (2)	U value	P-value
Group A	Group B	335.0	0.580
	Group C	206.5	0.006*
	Group D	204.2	0.006*
Group B	Group C	214.5	0.009*
	Group D	204.5	0.007*
Group C	Group D	305.2	0.307

***Statistically significant differences.**

The data presented in the previous table indicate that overall behavior was more favorable in the group exposed to behavioral management via AR glasses games and videos (Group A), as well as in the group exposed to AR glasses games alone (Group B), compared to the groups managed with AR video content alone (Group B) or mobile video content (Group A). As for the remaining pairwise comparisons, no statistically significant differences were observed in the frequency of overall behavior among the various behavioral management approaches employed in the study sample.

Discussion:

This study aimed to evaluate the effectiveness of augmented reality (AR) glasses in distracting children during the administration of the inferior alveolar nerve block and to assess their impact on children's overall behavior. Distraction is considered one of the commonly used non-pharmacological behavior management techniques in pediatric dentistry. These techniques work by engaging the child's available cognitive resources through visual, auditory, audiovisual, or sensory stimuli, which in turn block the processing of unpleasant stimuli such as pain or heat within the central nervous system [14].

Distraction techniques can be categorized into traditional methods—such as animated cartoons, music, or storytelling—and modern techniques, such as the use of virtual reality (VR) or augmented reality (AR) devices [15].

In the present study, the use of AR glasses as a distraction method during dental procedures was assessed. Compared to traditional methods, this technology offers a more immersive sensory experience, engaging a larger portion of the child's cognitive capacity while still allowing adequate communication

the surrounding environment. This enables the child to receive, comprehend, and follow the dentist's instructions. Moreover, compared to VR technology, AR has several advantages: It is relatively more affordable, easier to use, and features smaller, lighter glasses that are better suited to the size of a child's head—particularly in younger age groups—thus facilitating better access to the oral cavity during treatment [16–18]. In this study, the sample was selected to include children aged 7 to 9 years, as children within this age range have typically reached an adequate level of cognitive development. According to Piaget's stages of cognitive development, children between the ages of 7 and 10 are capable of understanding a wide range of mental concepts, such as cause-and-effect relationships, consequences of actions, and spatial relationships involving near and far elements within a three-dimensional environment. These cognitive abilities allow children in this age group to effectively engage with augmented reality (AR) glasses.

Additionally, children at this stage are generally able to distinguish between real objects and virtual elements, which reduces the risk of confusion or disorientation while using AR glasses. Their ability to comprehend instructions and understand assigned tasks further enhances their capacity to interact meaningfully with virtual elements displayed through the AR interface [19, 20].

Although the Houpt scale is traditionally employed to assess behavior throughout sedation procedures, its use here is justified because local anesthesia administration in children similarly requires sustained cooperation and minimal movement over a defined treatment interval. The scale's gradations effectively capture subtle differences in child responses to distraction techniques during the anesthetic injection.

The findings of this study demonstrated statistically significant differences in overall child behavior during the administration of local anesthesia across the four intervention groups, as measured by the HOUPT behavioral scale. Notably, children in Group D, who received a combination of active distraction via AR-based video games before the procedure and passive distraction through AR-delivered cartoons during the injection, exhibited the most favorable behavioral responses. Similarly, Group C, which received only active AR-based gaming prior to the injection, also showed significantly improved behavior compared to Groups A and B. These results suggest that active distraction, particularly when delivered through immersive augmented reality platforms, is more effective in reducing anxiety and promoting cooperative behavior in pediatric dental settings. The superiority of active over passive distraction may be attributed to the higher level of cognitive engagement and attentional focus required during interactive gameplay, which can effectively divert the child's attention away from the perceived threat of the procedure. The immersive nature of AR glasses likely enhances this effect by minimizing external stimuli and reinforcing the child's focus within the virtual environment.

There is a noticeable scarcity of studies in the dental literature evaluating the effectiveness of augmented reality (AR) technologies in managing dental fear and anxiety in children during dental

procedures. This highlights the importance of conducting further clinical research to assess the role of AR in pediatric behavioral management.

The findings of our study are consistent with those reported by *Muhammed & Noori (2022)*, who assessed the impact of audiovisual distraction using AR glasses on children's behavior during dental treatment. Their study included 40 children aged 6 to 10 years, divided into two groups: One managed with conventional behavior guidance techniques and the other using audiovisual distraction via AR glasses. Child behavior was evaluated using the Houpt behavior scale, and the results demonstrated a statistically significant improvement in the children's behavior in the AR group [21].

This discrepancy may be explained by differences in sample distribution and the comparison of distraction techniques with traditional methods. Similarly, the results corroborate the findings of *Nuvvula (2015)*, who also investigated the effect of audiovisual distraction with AR glasses on children's behavior during dental treatment. That study included 90 participants randomly divided into three equal groups. The first group received conventional behavioral management techniques, the second received auditory distraction only, and the third group received audiovisual distraction using AR glasses. The researchers used the Houpt Scale to assess general behavior and found that children in the AR group exhibited significantly better behavior than those managed with traditional techniques [22].

Conclusions:

This study highlights the potential of augmented reality (AR) technology as an effective behavioral management tool for pediatric dental procedures involving local anesthesia. The use of AR glasses, particularly when incorporating active distraction through interactive video games followed by passive visual stimuli, significantly improved children's overall behavior during the administration of inferior alveolar nerve block (IANB). The combination of immersive engagement and attentional redirection provided by AR-based interventions appears to be superior to traditional passive distraction methods. These findings support the integration of AR-driven strategies into clinical pediatric dentistry to enhance patient cooperation and reduce anxiety, ultimately contributing to more efficient and positive treatment experiences.

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