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ORIGINAL ARTICLE

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# Virtual reality in specialized dentistry: employing virtual reality for the alleviation of pain and anxiety in hereditary angioedema patients

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## ABSTRACT

**BACKGROUND:** Following an episode of hereditary angioedema (HAE), dental anxiety commonly arises, and many patients find it challenging to access proper care. While the use of virtual reality (VR) for pain and anxiety management in dentistry is on the rise, its application in individuals with angioedema remains largely unexplored. In a case series conducted at a specialized dental clinic, three patients with a history of acute angioedema attacks and dental anxiety engaged with 360° VR videos while seated in the dental chair, utilizing a virtual reality device.

**METHODS:** Three patients with hereditary angioedema were treated by subjecting them to virtual immersion using VR glasses. Intraoperative reactions were analyzed using VAS scales in order to report the patients' level of anxiety and pain.

**RESULTS:** The outcomes, evaluated through a standard observation tool, surveys, and interviews, encompass the assessment of patient anxiety and pain, responses to VR, and the evaluation of system usability along with its impact on the dental team's workflow. Three individuals underwent examination, from which three reliable questionnaires were obtained, demonstrating a success rate of 99.9%. The group included one male and two females, with their ages spanning from 6 to 58 years. The findings revealed an average anxiety score of 1.80 with a standard deviation of 0.6 points, and an average pain score of 1.98 with a standard deviation of 0.3, thus validating full immersion in distraction. Statistical analysis using independent-sample *t*-tests and ANOVA indicated no significant differences in anxiety levels among the patients based on gender. Both patients wore the VR device throughout the procedure, expressing that it was comfortable, diverting, and held the potential to alleviate anxiety and pain. The dentist noted a positive influence on patient anxiety levels and procedure completion times, expressing an intention to continue employing VR with other angioedema patients and across diverse clinical populations.

**CONCLUSIONS:** Virtual reality can be an excellent distraction tool in patients with hereditary angioedema who present at least one acute attack per year.

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**KEY WORDS:** Angioedema; Virtual reality; Dental anxiety.

Maintaining oral health in patients with angioedema poses a challenge for both patients and healthcare providers. For instance, angioedema is associated with acute attacks of localized or generalized swelling that can lead to patient mortality.<sup>1</sup> Anxiety disorders are a common psychological consequence of angioedema. Particularly for survivors of severe acute attacks during dental treatments, dental anxiety becomes a concern as it can affect participation in dental visits and is linked to an increased risk of poor oral health.<sup>2</sup> Additionally, commonly prescribed anesthetics during dental visits often cannot be administered as they may heighten the risk of adverse effects. Therefore, it is imperative to develop non-pharmacological interventions to manage dental pain and anxiety in patients with hereditary angioedema.<sup>3</sup> Hereditary angioedema (HAE) is a rare genetic disorder impacting 1:10,000-1:50,000 individuals. It follows a chronic and disabling course, posing challenges in diagnosis without specialized evaluation. The diagnostic process may be delayed by up to 15 years from the onset of symptoms. HAE is inherited in an autosomal dominant manner, resulting from a mutation in the C1-inhibitor gene located on chromosome 11.<sup>4</sup> This mutation causes a deficiency in C1 inhibitor, leading to uncontrolled activation of the complement system and the production of vasoactive mediators that induce edema. There are two HAE types: type I (affecting 85% of patients) characterized by a quantitative defect, and type II (affecting 15% of patients) characterized by a nonfunctional protein.<sup>5</sup> The most perilous symptom is glottis edema, which can lead to asphyxiation. Treatment objectives include preventing acute attacks, involving short-term prophylaxis before outpatient surgery, and long-term management for patients experiencing frequent attacks.<sup>6</sup> Ongoing efforts are directed toward developing experimental protocols and standardized guidelines for dental procedures. Psychophysical assessments and visual analog scales prove beneficial for patient management. In 78% of patients with skin edema, facial edema is also observed, and in most instances, this phenomenon can impact the larynx, manifesting as changes in voice (such as deep voice, hoarseness, aphonia), coupled with dyspnea and a sense of

suffocation.<sup>7</sup> The primary goal of treatment is to discourage behaviors and therapies that may trigger the onset of attacks.

Dental phobia, a prevalent concern among children, can significantly impact their oral health and overall well-being, often leading to avoidance of dental visits and delayed or inadequate care.<sup>8</sup> The literature extensively addresses the increasing occurrence of anxiety in patients undergoing dental treatment. While anesthetics provide painless treatments, they often neglect anxiety and fear. Virtual reality (VR) has emerged as an innovative therapy, utilizing a distractive approach by immersing patients in a three-dimensional computer-generated environment, detaching them from the anticipation of dental treatment.<sup>9</sup> Numerous scientific studies highlight the therapeutic benefits of VR in managing dental anxiety and pain, leading to improved pain control and reduced perception of therapy duration.<sup>10</sup>

Traditional management techniques, such as behavior guidance and pharmacological interventions, face limitations in addressing dental phobia in children. However, recent technological advancements introduce VR as a potential tool for managing dental phobia and enhancing the pediatric dental experience.<sup>11</sup> VR, characterized by a multisensory, immersive simulation, is increasingly utilized in healthcare, showing promise in pain management, mental health, and medical education.

Key benefits of VR in managing dental phobia include diverting attention from the procedure, providing a sense of control through interactive and customizable experiences, gradual exposure to dental scenarios, and incorporating gamification and rewards for positive behavior reinforcement.<sup>12</sup>

Operational through cognitive distraction, VR reduces the focus on negative thoughts and fears, alleviating anxiety during dental procedures. Additionally, its immersive nature induces relaxation, creating a calm environment during dental visits.<sup>13</sup>

Several studies have demonstrated that VR delivered through a Head-Mounted Display (HMD) is an effective tool for managing acute pain and associated anxiety, although its utility may vary depending on the population and clinical indication. In dentistry, the application of VR is an

emerging research area, with studies suggesting its potential in managing dental pain and/or anxiety in both adults and children. For individuals with angioedema, VR could be rapidly adopted as a rehabilitation tool. VR has been proven safe in healthy individuals, with no severe adverse events reported in various studies and generally mild side effects (such as dizziness and headaches).<sup>14</sup> In summary, VR could be an unexplored tool for managing dental pain and anxiety in patients with angioedema. Furthermore, anxiety can disrupt adherence to treatment plans and regular follow-up, negatively impacting overall disease management. It emerges as a significant contributor to perioperative stress, heightening pain perception and potentially compromising surgical outcomes.<sup>15</sup> The Visual Analog Scale (VAS) proves to be a reliable tool for assessing preoperative anxiety, exhibiting greater sensitivity compared to other measurement scales.<sup>16</sup> It can stand alone as an effective means to evaluate dental anxiety. Individuals with a VAS-A score exceeding 5.0 cm are considered anxious, while those with a VAS-A of  $\geq 7.0$  are categorized as phobic. Employing these scales may enhance sensitivity in controlling anxiety and managing acute attacks. Another study by Van Sickels revealed that the mean Diadidic Adjustment Scale (DAS) score is higher among dental clinic patients compared to those in community studies. Additionally, Zanette's study demonstrated that patients with systemic diseases exhibit higher anxiety levels than those without systemic compromise, posing a greater risk of experiencing acute attacks during the perioperative phase due to preexisting anxiety.<sup>17, 18</sup>

A case series was conducted to assess the potential of immersive virtual reality for pain and anxiety management in patients experiencing angioedema and dental anxiety in a clinical environment. The study aimed to evaluate the virtual reality system's acceptability, its effectiveness in

reducing patient pain and anxiety, and its influence on the dental team's workflow.

### Materials and methods

The researchers initially observed three dental patients at a specialized clinic in Rome, Italy. Potential environmental challenges were identified, and two patients with a history of acute angioedema attacks and dental anxiety were selected. The intervention was conducted by the research team, which assisted in placing a sanitized Head-Mounted Display (HMD) on the patients. The patients chose 360° virtual reality videos, including a cartoon, a music video, and a TV show.<sup>17</sup>

The first patient, a 6-year-old girl with angioedema and a history of 2 acute attacks per year, underwent the extraction of an odontoma with local anesthesia (3% articaine + 5% nitrous oxide). The second patient, a 43-year-old woman with an annual acute angioedema attack, received a simple filling with plexus and troncular anesthesia (mepivacaine). The third patient, a 58-year-old man with 3 annual acute attacks, underwent a simple extraction of residual root after infiltrative anesthesia (3% articaine). The respective patients were analyzed intra-operatively using a visual analog scale (VAS) to identify the level of virtual immersion and distraction. Both patients and the dental team provided written informed consent to participate in the case report and for the publication of photographs (Table I).

Both patients wore Meta Quest 2 - All-In-One VR headsets throughout the procedures. The clinician reported that the VR device was easy to use, did not hinder workflow, and did not affect the time required to complete the procedure. The dentist noted that patients required less reassurance due to the distraction provided by VR. Overall, virtual reality was well tolerated by all patients. Both patients and the dentist reported

TABLE I.—Patient data, type of intervention, type of VR and value expressed in mm on the VAS scale (1-10 mm) were collected. Values below 5 confirm a complete absence of pain or anxiety.

Patient, age, gender	Acute attacks HAE / years	Type of intervention	Type of VR	VAS anxiety evaluation (1-10 mm)	VAS pain evaluation (1-10 mm)
A., 6 y.o., female	2	Oral surgery	Meta Quest 2 - All-In-On	1.98	1.78
F., 43 y.o., female	1	Tooth Obturation	Meta Quest 2 - All-In-On	1.34	1.67
A., 58 y.o., male	3	Extractions	Meta Quest 2 - All-In-On	2.1	2.5

HAE: hereditary angioedema; VR: virtual reality; VAS: Visual Analogue Scale.

that the VR headset was helpful in providing distraction during procedures, and they expressed interest in using VR during future dental appointments. This interest stemmed from the perceived reduction in time, and it was observed that patients breathed more normally instead of frequently holding their breath. The dentist also noted that virtual reality proved to be a more effective tool compared to standard care strategies (such as calming voice or sedation) and did not interfere with communication with the patient.

Patients received an oral examination and underwent an oral pantomography 30 minutes prior to the initiation of treatment. The treatments were consistently administered by the same doctor, boasting more than 5 years of professional experience. Local anesthesia with 4% articaine plus epinephrine 1:100,000 was employed for the treatment process. Following the onset of anesthesia, the clinician executed the necessary procedures. In cases involving extractions, a 4-0 nonabsorbable suture (Johnson & Johnson, Shanghai, China) was applied to the suture wounds. Compression and hemostasis were facilitated using a recommended gauze pad. Written postoperative instructions were provided, and patients undergoing surgery were prescribed oral amoxicillin (1 g) for a duration of 5 days. Suture removal took place 5-7 days after the surgical procedure.

## Results

Three patients were examined and three valid questionnaires were retrieved, with an effectiveness rate of 99.9%. There were 1 male and 2 females, ranging in age from 6 to 58 years.

According to the results, the mean score of anxiety was  $1.80 \pm 0.6$  points; the mean score of pain was  $1.98 \pm 0.3$ . Thus confirming total distraction immersion.

The results of the independent-sample *t*-test and ANOVA showed that the anxiety level of the tested patients was not statistically significant for gender.

## Discussion

Dental procedures often induce pain and anxiety, particularly in children who are highly sensi-

tive to these experiences.<sup>19</sup> Historically, managing patient discomfort and anxiety focused on pharmacological treatments, but recent literature increasingly emphasizes non-pharmacological approaches.<sup>20</sup> One such strategy is distraction, a cognitive behavioral technique leveraging humans' limited attention spans. Distraction techniques vary from passive to active interventions, with the belief that more interactive distractions involving visual, auditory, and tactile stimuli offer greater potential for pain distraction.<sup>21</sup>

Managing dental phobia in children is challenging and necessitates innovative approaches to alleviate fear and anxiety associated with dental procedures. Although most studies in this meta-analysis focus on pediatric dental patients, it is crucial to note that dental fear and anxiety affect 15-20% of the global population, leading to avoidance of even basic dental treatments.<sup>22</sup>

VR has emerged as a promising therapeutic tool in pediatric dentistry, providing distraction, immersion, and desensitization. This reduces dental anxiety, improves cooperation, and facilitates behavior change. VR effectively redirects attention from the dental procedure, alleviating fear and negative thoughts associated with dental visits.<sup>23</sup>

While VR has demonstrated effectiveness in reducing dental anxiety and pain in children, challenges include ethical considerations, technical constraints, and varying responses based on age. VR's impact on pain and anxiety appears more pronounced in pediatric subjects, potentially due to higher anxiety levels during treatment and greater engagement with VR.<sup>17</sup>

Several studies indicate VR's superiority over traditional distraction methods, but challenges such as image resolution, motion sickness, and content limitations need continuous improvement. Tailoring VR experiences to individual preferences and needs, addressing ethical concerns, and considering cost and accessibility are crucial for widespread adoption in pediatric dental practices.<sup>24</sup>

Standardization and guidelines for VR use in managing dental phobia in children are necessary for establishing best practices. Long-term efficacy studies are needed to evaluate anxiety reduction persistence and oral health outcomes.<sup>25</sup>

Another intriguing study demonstrated that applying virtual reality (VR) during the extraction

of primary teeth in children, always performed under local anesthesia, can effectively diminish anxiety and perceived pain. However, it is noted that VR may not be entirely suitable for children with severe anxiety.<sup>26</sup> The utilization of VR helmets in conjunction with local anesthesia for primary teeth extraction significantly reduces dental anxiety and pain perception in children, without inducing simulator sickness. Nonetheless, it may not be sufficient for aiding children with severe anxiety in completing their treatment.<sup>6</sup>

Numerous studies indicate that virtual reality is more effective in alleviating pain and anxiety compared to conventional treatment (CAU). However, it remains challenging to isolate the unique contribution of virtual reality when compared to other forms of distraction, such as watching television cartoons, as CAU is often not clearly defined in its distractive form.<sup>27</sup> The findings suggest that VR distraction may be more potent than CAU distraction during medical procedures. For instance, a Cochrane review revealed an effect size of 0.21 for the impact of mechanical distraction (toys, colors) on self-reported pain during dental procedures. Similarly, a meta-analysis of studies on music therapy as a distraction during various medical procedures found a significant reduction in pain and anxiety, with an effect size of 0.22 for VR compared to other distractive techniques. However, additional dimensions of effects need exploration to advance VR as a preparatory tool for medical procedures compared to other forms of preparatory interventions aimed at reducing pain and anxiety.<sup>28</sup> Despite limitations, VR's potential to transform dental visits into positive experiences for children is significant. Ongoing research, technological advancements, and collaborative efforts can further enhance VR's role in improving oral health outcomes and ensuring positive dental experiences for children with dental phobia.<sup>29</sup> Subsequent research endeavors could explore the utilization of eye-tracking systems and assess their efficacy in minimizing pain and discomfort in contrast to conventional VR applications during dental procedures. It has been observed that virtual reality devices with enhanced resolutions and broader fields of view effectively decreased thermal pain on the skin and the duration of contemplating the pain, in com-

parison to lower resolution and narrower field VR systems. Other prospective areas for investigation in this domain encompass examining patient satisfaction and enjoyment levels with the virtual reality encounter during dental appointments.<sup>30</sup> Applying mathematical models, within virtual simulations, where individuals behave as in real life, can represent an excellent method both for developing further mathematical models and for predicting the course of certain epidemics.<sup>31</sup>

## Conclusions

This study emphasizes the importance of a comprehensive approach, combining detailed assessments and anxiety management, to improve angioedema care. It suggests the diversity of strategies for handling dental care challenges and underscores the clinical relevance of its findings for further research on anxiety's impact on hereditary angioedema (HAE). Future research could focus on comparing eye-tracking and traditional VR systems in dental pain reduction, and explore patient satisfaction with VR experiences in dental settings. Personalizing VR to individual preferences may enhance its effectiveness. With artificial intelligence's growing role, refining VR techniques and establishing standardized protocols for first-time dental visits could be beneficial.<sup>32</sup> It is clear that there are different methods and equally different ways to manage our patients in the event of non-cooperation in the case of dental care.<sup>33, 34</sup>

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#### Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

#### Authors' contributions

Alessio Rosa and Alberto M. Pujia have given substantial contributions to the conception or the design of the manuscript, Claudio Arcuri to acquisition, analysis and interpretation of the data. All authors have participated to drafting the manuscript, Alessio Rosa revised it critically. All authors read and approved the final version of the manuscript.

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