



## Exploring the Potential of Augmented Reality and Virtual Reality for Dental Education: A Scoping Review

<sup>1</sup>Bhagyashri Mune, <sup>2</sup>Dr. Rahul Hegde, <sup>3</sup>Dr. Anand Shigli, <sup>4</sup>Dr Pritesh Gawali, <sup>5</sup>Dr Geetanjali Jadhav, <sup>6</sup>Dr. Vijayalaxmi Mohite

*Post graduate student D Y Patil Dental School, Lohegaon Pune.*

*Director D Y Patil Dental School, Lohegaon Pune.*

*Dean and H.O.D D Y Patil Dental School, Lohegaon Pune.*

*Associate Professor D Y Patil Dental School, Lohegaon Pune.*

*Associate Professor D Y Patil Dental School, Lohegaon Pune.*

*Post graduate student, D Y Patil Dental School, Lohegaon Pune.*

Date of Submission: 01-06-2024

Date of Acceptance: 10-06-2024

**ABSTRACT:Background:** The digital transformation in dentistry has introduced advancements like 3D technology, computer-aided design/manufacturing (CAD/CAM), and digital image manipulation. While these methods streamline workflows, emerging technologies like Augmented Reality (AR) and Virtual Reality (VR) offer exciting possibilities for further improvement.

**Objectives:** This scoping review investigates the current applications of AR-VR systems in dental education for training students and practitioners at various levels.

**Methods:** We conducted a comprehensive review of existing literature on the use of AR and VR in dental education.

**Results:** Our findings suggest that AR-VR technology offers significant advantages in dental training. These include the ability to present ideal teeth morphology and simulate specific dental conditions, fostering a more immersive learning experience. Additionally, integration with haptic feedback shows promise for further enhancing skill development. However, a potential challenge identified is the need to address the gap in practical experience with real-world dental emergencies that AR-VR simulations may not fully capture.

**Conclusions:** This review highlights the immense potential of AR-VR for dental education, emphasizing the need for further research to bridge the gap in practical experience. Future research efforts should prioritize advancements in AR, VR, Artificial Intelligence (AI), and Robotics to ensure the delivery of high-quality dental care.

**KEYWORDS:** Dental Education, Augmented Reality, Virtual Reality, Haptic Feedback

dimensional (3D) technology, computer-aided design (CAD), and computer-aided manufacturing (CAM) have become standard practices (1). Beyond these advancements, innovative technologies like Augmented Reality (AR) and Virtual Reality (VR) are poised to revolutionize both dental education and clinical workflows (2).

This paper explores the current applications of AR-VR systems in dentistry, specifically focusing on their role in training students and practitioners across various skill levels (6).

Traditional digital workflows in dentistry often involve a three-step process: acquiring a digital image, digitally modifying specific aspects (e.g., tooth position), and transferring the information for physical model creation or digital storage. AR and VR offer a more streamlined and intuitive approach, simplifying these steps (2).

AR-VR systems function by integrating real-world data with virtual elements, employing tracking mechanisms, processing capabilities, and feedback systems (3). The potential benefits of this technology, particularly when combined with advancements in haptic feedback, necessitate its inclusion in standard dental education curriculums.

While AR and VR offer valuable tools for teaching standardized procedures with ideal scenarios, they may limit exposure to the diverse clinical situations and emergencies encountered by practicing dentists (4). This potential gap in practical experience with real-world scenarios could leave students unprepared for certain clinical situations.

The integration of digital technologies presents a significant opportunity to reshape both dental education and clinical practice. Students can benefit from improved knowledge acquisition and practical skill development. Similarly, dental professionals can leverage these tools to enhance patient care delivery (5).

### I. INTRODUCTION

The dental landscape is rapidly transforming due to the integration of digital technologies. Three-



Although advancements in Artificial Intelligence (AI) and Robotics hold promise for the future of dentistry, their current applications remain primarily experimental (5). Future research efforts should prioritize advancements in AR, VR, AI, and Robotics to ensure high-quality and efficient dental care delivery.

## II. APPLICATIONS OF AR AND VR IN DENTISTRY

Augmented Reality (AR) and Virtual Reality (VR) are emerging technologies poised to transform various dental specialties. Their potential applications in oral health offer exciting possibilities for both dental professionals and patients.

- **Revolutionizing Dental Education:** AR and VR can create immersive learning environments unlike traditional methods. Students can visualize ideal teeth morphology in 3D, practice procedures on virtual patients, and experience diverse clinical scenarios in a safe, controlled setting. This fosters deeper understanding, improves skill development, and allows for experimentation without risk to real patients (2, 4).
- **Enhancing Treatment Planning:** VR simulations can empower dentists to virtually plan complex procedures like implant placement or orthognathic surgery. This visualization capability can enhance surgical precision, minimize risks associated with real-world procedures, and improve communication with patients regarding treatment expectations (3).
- **Empowering Patients and Reducing Anxiety:** AR can be a valuable tool for patient education. By visually explaining dental procedures, AR can alleviate anxiety and promote informed consent. VR simulations can also be used to help patients with dental phobias confront their fears in a safe virtual environment, potentially improving treatment acceptance (5).
- **Optimizing Dental Procedures:** AR can overlay real-time patient data onto the dentist's field of view, providing critical information like nerve locations or anatomical landmarks in real-time. This can improve surgical accuracy, potentially reduce procedure times, and enhance overall treatment outcomes (3).
- **Facilitating Post-Operative Care:** VR can be used for post-operative rehabilitation exercises. By guiding patients through jaw movements or muscle strengthening techniques in a virtual environment, VR can

promote faster healing and improve patient recovery (6).

These are just a few of the ways AR and VR are transforming dentistry. As the technology matures and integrates with advancements like haptics, the impact on dental education and clinical practice is expected to be even more profound. Future research can explore how AR and VR can be further optimized to address specific dental needs and unlock their full potential in delivering exceptional patient care.

## III. AUGMENTED REALITY AND VIRTUAL REALITY: TRANSFORMING PAEDIATRIC DENTAL ANXIETY MANAGEMENT

Dental anxiety and phobias are a significant barrier to oral healthcare, affecting an estimated 50-60% of individuals (7). This often leads to delayed or avoided dental care, potentially compromising oral health. Traditional exposure therapy (In Vivo Exposure Therapy - IVET) has proven effective in managing dental phobias, but Virtual Reality Exposure Therapy (VRET) offers a promising alternative. VRET allows patients to confront their fears in a safe, controlled virtual environment, potentially leading to reduced anxiety and improved treatment outcomes (8).

- **VR for Non-Pharmacological Behavioural Management:** Effective paediatric dental care requires addressing both psychological anxiety and sensory/emotional pain (8). VR emerges as a valuable tool for non-pharmacological behavioural management. Studies have shown that VR can significantly reduce anxiety, pain, and procedure duration in children undergoing dental procedures (9). This can lead to improved patient cooperation and a more positive dental experience, potentially reducing the need for pharmacological interventions.
- **Immersive Distraction with Virtual Reality:** VR technology offers a unique approach to distraction. Unlike traditional methods, VR is immersive and engaging, encompassing multiple sensory experiences and capturing a patient's full attention. This immersive distraction has been shown to be clinically effective in reducing pain and anxiety during dental procedures (10). It's a safe, non-invasive technique with lasting positive effects, potentially leading to better memories of treatment and increased willingness for future dental visits.
- **The Impact of Distraction on Pain and Anxiety:** Distraction is a recognized and



endorsed behaviour guidance technique within paediatric dentistry (11). VR distraction builds upon traditional audio-visual distraction methods by offering an immersive virtual environment that blocks out potentially anxiety-provoking external stimuli (11). Studies have shown VR distraction to have similar effects on heart rate and pain levels as screen distraction during local anaesthesia administration in children (12).

- **Audio-visual Distraction for Children with Special Needs:** While VR offers promising possibilities, audio-visual distraction with video glasses can be a valuable tool for managing anxiety in children with special healthcare needs (SHCN) during dental procedures (13). This method complements conventional behaviour management techniques, potentially reducing self-reported pain, operator stress, and improving patient cooperation during subsequent treatments (13). Video glasses provide a combination of visual and auditory distraction close to the patient without interfering with the treatment. This allows for partial communication and monitoring of facial expressions, particularly beneficial during injections and caries removal, the most stressful steps for both patient and dentist.

#### IV. VR AND AUDIO-VISUAL DISTRACTION: REDUCING ANXIETY IN PAEDIATRIC DENTISTRY

- This review summarizes research on VR and audio-visual distraction for managing anxiety and pain in children undergoing dental procedures.
- **VR for Anxiety and Pain Reduction:** Studies by Longkuan et al. (2021) and Osama et al. (2021) suggest VR is effective in reducing anxiety and pain in children during dental procedures.
- **Audio-visual Distraction for Children with Special Needs:** Simone et al. (2017) found audio-visual distraction may be beneficial for managing anxiety in children with special healthcare needs (SHCN) without intellectual disability, but it cannot replace traditional behaviour management techniques.

These findings highlight the promise of VR and audio-visual distraction in paediatric dentistry, potentially improving children's dental experiences.

#### V. EMBRACE AR/VR IN DENTISTRY, BUT ADDRESS POTENTIAL CONCERNS

Augmented Reality (AR) and Virtual Reality (VR) offer tremendous potential for dentistry. VR simulations can realistically replicate procedures like root canals, allowing dentists to experience bleeding or other natural occurrences in a safe, virtual environment. This immersive training can lead to improved skills and patient outcomes.

However, potential drawbacks exist. Stereoscopic vision used in AR/VR can cause visual fatigue in both children and adults (15). Repeated exposure to these environments in paediatric and geriatric patients' needs further investigation through randomized controlled trials (RCTs) to assess the impact on different age groups.

#### CONCLUSION:

The future of dentistry is bright with technological advancements like AR/VR. These technologies hold promise for improved visualization, reduced procedure times, better patient communication, and ultimately, improved treatment outcomes. While limited studies have explored their use in dentistry, further research is crucial. Future efforts should focus on developing high-quality data standards and scientifically validated AR/VR tools specifically designed for dental practice.

In essence, the benefits of AR/VR outweigh the concerns, but addressing potential visual fatigue through further research is crucial for successful integration across all age groups in dentistry.

#### REFERENCES

- [1]. Orsini, G.; Tosco, V.; Monterubbianesi, R.; Orilisi, G.; Putignano, A. A New Era in Restorative Dentistry. In *The First Outstanding 50 Years of "Università Politecnica delle Marche": Research Achievements in Life Sciences*; Longhi, S., Monteriù, A., Freddi, A., Aquilanti, L., Ceravolo, M.G., Carnevali, O., Giordano, M., Moroncini, G., Eds.; Springer International Publishing: Cham, Switzerland, 2020; pp. 319–334. ISBN 978-3-030-33832-9.
- [2]. Flavián, C.; Ibáñez-Sánchez, S.; Orús, C. The Impact of Virtual, Augmented and Mixed Reality Technologies on the Customer Experience. *J. Bus. Res.* 2019, 100, 547–560.
- [3]. Huang, T.-K.; Yang, C.-H.; Hsieh, Y.-H.; Wang, J.-C.; Hung, C.-C. Augmented



- Reality (AR) and Virtual Reality (VR) Applied in Dentistry. *Kaohsiung J. Med. Sci.* 2018, 34, 243–248.
- [4]. Mallikarjun, S.A.; Tiwari, S.; Sathyanarayana, S. & Devi, P.R. Haptics in periodontics. *J. Indian Soc. Periodontol.* 2014, 18(1), 112–3.
- [5]. Cipresso, P.; Giglioli, IAC.; Raya, MA. & Riva, G. The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. *Front. Psychol.*, 2018, 9(NOV), 1–20.
- [6]. Monterubbianesi, R.; Tosco, V.; Vitiello, F.; Orilisi, G.; Fraccastoro, F.; Putignano, A.; Orsini, G. Augmented, Virtual and Mixed Reality in Dentistry: A Narrative Review on the Existing Platforms and Future Challenges. *Appl. Sci.* 2022, 12, 877
- [7]. Getka, E.J.; Glass, C.R. Behavioral and Cognitive-Behavioral Approaches to the Reduction of Dental Anxiety. *Behav. Ther.* 1992, 23, 433–448.
- [8]. Raghav, K.; Van Wijk, A.J.; Abdullah, F.; Islam, M.N.; Bernatchez, M.; De Jongh, A. Efficacy of Virtual Reality Exposure Therapy for Treatment of Dental Phobia: A Randomized Control Trial. *BMC Oral Health* 2016, 16, 25.
- [9]. Ran, L., Zhao, N., Fan, L. et al. Application of virtual reality on non-drug behavioral management of short-term dental procedure in children. *Trials* **22**, 562 (2021).
- [10]. American Academy of Pediatric Dentistry. Guideline on behavior guidance for the pediatric dental patient. *Ref Man Pediatr Dent.* 2015;36(6):180–90.
- [11]. Felemban, O.M.; Alshamrani, R.M.; Aljeddawi, D.H.; Bagher, S.M. Effect of virtual reality distraction on pain and anxiety during infiltration anesthesia in pediatric patients: A randomized clinical trial. *BMC Oral Health* 2021, 21, 321.
- [12]. S. Bagattoni, Department of Biomedical and NeuroMotor Sciences (DiBiNeM), Unit of Dental Care for Special Needs Patients and Paediatric Dentistry, University of Bologna, Via San Vitale 59, 40125 Bologna, Italy.
- [13]. Ran, L., Zhao, N., Fan, L. et al. Application of virtual reality on non-drug behavioral management of short-term dental procedure in children. *Trials* **22**, 562 (2021).
- [14]. :Fahim, S.; Maqsood, A.; Das, G.; Ahmed, N.; Saquib, S.; Lal, A.; Khan, A.A.G.; Alam, M.K. Augmented Reality and Virtual Reality in Dentistry: Highlights from the Current Research. *Appl. Sci.* 2022, 12, 3719.