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ADVANCING THROUGH INNOVATION

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Rapid development of a novel and open-access mixed reality resource for dental education

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1 | PROBLEM

High-quality physical models of teeth are inherently rare due to the low probability that an unrestored tooth would be extracted. Furthermore, physical collections rarely capture uncommon dental variation due to their finite storage capacity and limited lifespan. The biggest limitation of physical models in dental education is the inability to nondestructively view endodontic morphology. Since the inception of the COVID-19 pandemic, students are faced with even greater difficulty gaining exposure to a broad range of dental anatomy. Therefore, the value of virtual teaching aids has become increasingly relevant, and especially so for resources that are representative of the anatomical variation seen clinically. Although the practical, ethical, and economic benefits of virtual models are extensive,[1–4] models developed for traditional digital atlases are usually sculpted by digital artists and idealized, therefore lacking clinical fidelity. In other words, most 3D models found in traditional atlases fail to portray the large variability of clinical anatomy, especially dental anatomy. These limitations impress upon students a very narrowed view on the broad range of normative dental anatomy, which can lead to iatrogenic damage during their clinical training and future practice.

2 | SOLUTION

The 3D Database of Clinical Oral and Maxillofacial Anatomy (OMFA3D; https://3dmodels.trevorthang.com) was developed as a response to the relative lack of open-access anatomical resources for dental education and the limitations of traditional atlases. This curated database consists of over 100 unique models of both normative and uncommon anatomical features. Each 3D mesh was created from cone-beam computed tomography (CBCT) scans via an in-house digitization workflow. The database consists of three model categories: Crown & Root Anatomy, Endodontic Anatomy, and Maxillofacial Anatomy (Figure 1). Users can navigate the models online via keywords, tags, and a modified odontogram based on Fédération Dentaire Internationale notation. Each model page features an interactive 3D viewer with anatomic labels, a model description, links to anatomical variations, and quick response codes for an augmented reality and stereoscopic virtual reality (VR) environment (Figure 2). A 3D quiz functionality for pedagogic evaluations is also currently being developed (Figure 3).

3 | RESULTS

Compared to other 3D modeling methods, our in-house digitization workflow has several advantages. First, the acquisition of CBCT scans is nondestructive and does not require exodontia or cadaveric dissection, unlike photogrammetry or 3D scanning. Second, our protocol minimizes the amount of artistic discretion involved in model creation by using clinical CBCT scans as a data source and an algorithmic approach to segmentation. Third, the bespoke web-based user interface for digitized models allows for ease of access and the possibility of crowdsourcing data. Finally, the implementation of a VR environment allows the viewer to achieve stereoscopic vision, a feature of physical models that was recently identified to be critical for learning anatomy.[5] This work will have immediate applications in didactic and clinical dental

FIGURE 1 The online database page containing various color-coded 3D models (A). An example of a crown and root anatomy model of the left mandibular first molar (B). An example of an endodontic anatomy model of the right maxillary second molar (C). An example of a maxillofacial anatomy model of the maxillary bone and associated dentition (D). Figure first published in the *Ontario Dentist*

education, improving student understanding of anatomical variations, and promoting caution during operative procedures. Furthermore, OMFA3D can be used freely by practicing dentists for patient education, allowing clinicians to easily demonstrate concepts such as pulp capping, dilacerations, and accessory canals.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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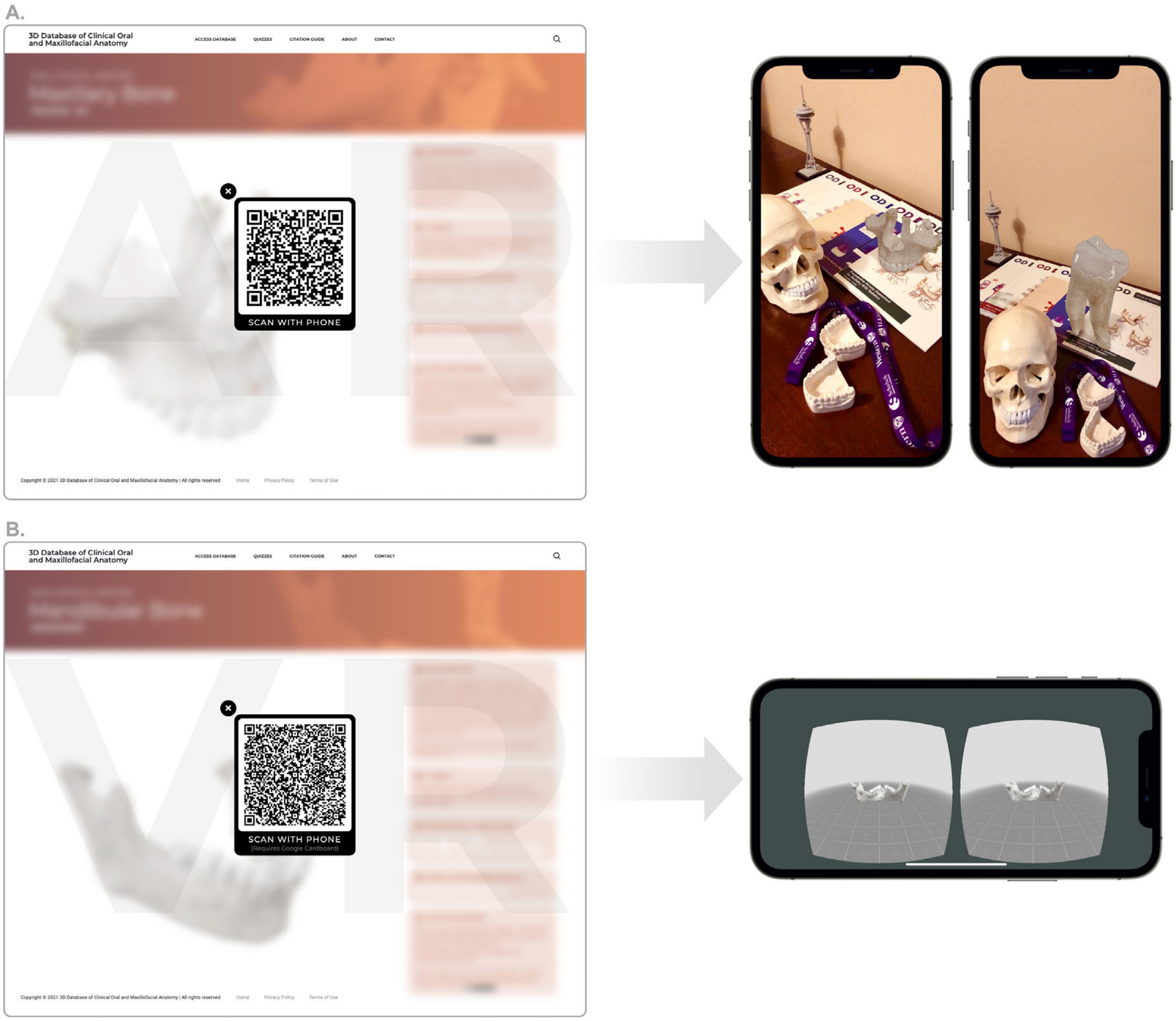

FIGURE 2 Top: A quick response code interface for activating the augmented reality (AR) functionality. Example AR environments displaying a maxilla and mandibular first molar can be seen on the right. Bottom: The equivalent interface for activating the VR functionality. A low-cost and open-source cardboard VR headset is required. Figure first published in the *Ontario Dentist*

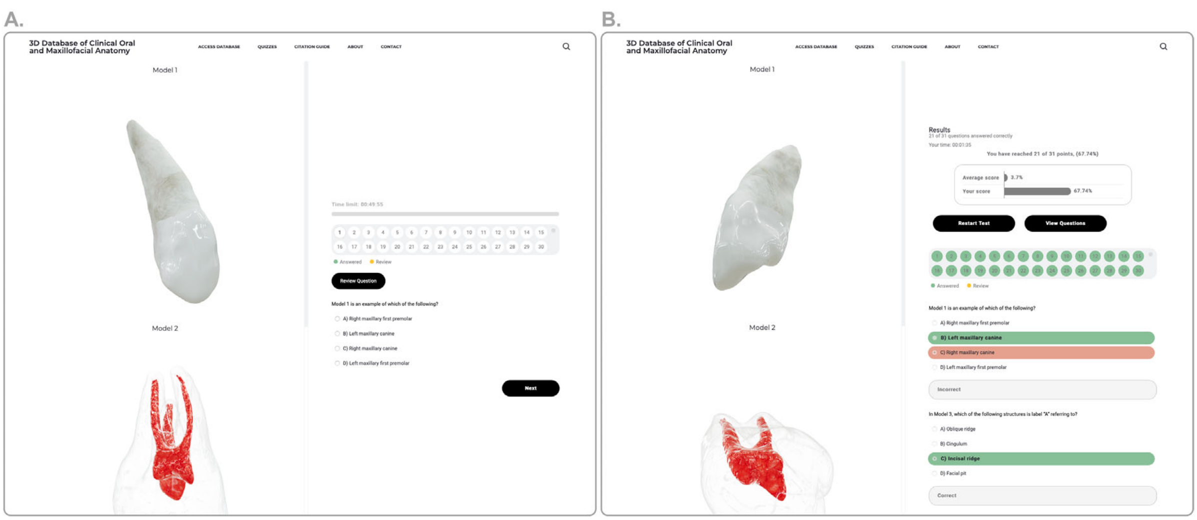

FIGURE 3 Interactive 3D anatomy quizzes with automatic score calculation and feedback. Figure first published in the *Ontario Dentist*

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