

## Application of 3D Models for Educational Purposes in Oral Pathology

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**Abstract:** This review explores the application of 3D models in the education of oral pathology, highlighting their potential to enhance learning outcomes. 3D models provide a tactile, visual, and interactive experience, allowing students to better understand complex anatomical structures and pathological conditions. By simulating real-life scenarios, these models bridge the gap between theoretical knowledge and clinical practice, improving diagnostic skills and spatial awareness. The review discusses various types of 3D models, including digital and printed versions, and their effectiveness in dental education. Ultimately, 3D modeling represents a promising tool for advancing oral pathology education.

**Keywords:** Diseases; Histopathology; Oral Pathology; 3D.

### Introduction:

Oral pathology, a critical branch of dental science, involves studying and diagnosing diseases affecting the oral and maxillofacial regions. Traditionally, education in this field has relied heavily on two-dimensional (2D) histological slides, photographs, and descriptive texts. However, the advent of three-dimensional (3D) modeling and printing technology has revolutionized educational methods, offering an enhanced, interactive learning experience. This short communication discusses the application of 3D models in oral pathology education, highlighting their benefits, current uses, and potential future developments.

### The Need for Advanced Educational Tools in Oral Pathology:

Oral pathology is a visually intensive discipline, requiring a deep understanding of complex anatomical structures and pathological processes. Traditional 2D learning resources, while effective, have limitations in conveying the full spatial relationships and structural details of these entities. The shift towards competency-based education and the need for more engaging, interactive teaching methods have driven the exploration of 3D models as an educational tool. These models can offer a more immersive learning experience, helping students and professionals better visualize and understand the intricate anatomy and pathology of the oral cavity<sup>(1)</sup>.

### Overview of 3D Modeling and Printing:

3D modeling involves creating a three-dimensional representation of an object using specialized software. These models can be viewed on screens or, through 3D printing, transformed into physical objects. 3D printing, also known as additive manufacturing, builds objects layer by layer from

materials such as plastic, resin, or metal, based on a digital model. In the context of oral pathology, 3D models can be created from various sources, including digital imaging data (e.g., CT scans, MRI scans) and manual or automated reconstructions of histopathological sections. These models can depict normal and pathological tissues in great detail, providing a tangible and manipulable representation of oral structures and diseases<sup>(2)</sup>.

### Benefits of 3D Models in Oral Pathology Education:

The use of 3D models in oral pathology education offers several significant advantages. Firstly, they enhance spatial understanding by allowing learners to visualize the complex spatial relationships between anatomical structures, which is crucial in oral pathology where the interactions between different tissues often influence disease progression. Unlike 2D images, 3D models provide a more comprehensive view, enabling better comprehension of these relationships. Additionally, the interactive nature of physical 3D models promotes hands-on learning, as students can examine structures from various angles and magnifications, leading to improved retention and understanding of complex concepts. Another key benefit is the ability to simulate pathological conditions with high accuracy. 3D models can replicate diseases such as tumors or cysts, providing a realistic platform for studying their morphology and progression. This not only aids in understanding the diseases but also enhances problem-solving skills and clinical decision-making by simulating clinical scenarios. Moreover, 3D printing technology enables the creation of customized models based on individual cases, facilitating personalized education. This is particularly useful in case-based learning, where models of specific patient cases can be used to bridge the gap between theoretical knowledge and clinical practice. Overall, 3D

models serve as a valuable tool in helping students and professionals transition from theory to practical application by providing a more accurate representation of the conditions they will encounter in clinical settings<sup>(2,3)</sup>.

#### Current Applications of 3D Models in Oral Pathology:

3D models play a crucial role in oral pathology education by providing detailed representations for both anatomical and pathological studies. These models allow students to explore intricate structures such as teeth, bones, soft tissues, and blood vessels, enhancing their understanding of oral and maxillofacial anatomy. Additionally, 3D models of pathological specimens, like oral squamous cell carcinoma or ameloblastoma, offer a comprehensive way to study disease morphology, making complex conditions more tangible for learners. The advent of digital technology has further advanced this field through the development of virtual 3D models and simulations, which can be manipulated on-screen and integrated into e-learning platforms. These virtual tools provide a flexible and accessible method for studying oral pathology without the need for physical models. Furthermore, 3D models are increasingly used in case-based learning scenarios, where students engage with clinical cases using 3D-printed models. This approach fosters critical thinking and diagnostic skills by placing students in a more realistic context for learning. For postgraduate students and professionals, 3D models are invaluable for training and skill development, particularly in surgical procedures. These models allow for the practice of complex techniques on accurate anatomical replicas, leading to better preparation and increased confidence before performing surgeries in real-life situations<sup>(4)</sup>.

#### Challenges and Future Directions:

While the use of 3D models in oral pathology education offers significant benefits, there are challenges to their widespread adoption. The cost of 3D printing technology and materials can be prohibitive, particularly for institutions with limited budgets. Additionally, there is a need for standardized protocols for the creation and use of 3D models to ensure consistency and accuracy across educational settings.

However, the future of 3D modeling in oral pathology is promising. Continued advancements in 3D printing technology, such as the development of more affordable and accessible printers, are likely to overcome current barriers.

Moreover, the integration of 3D models with other emerging technologies, such as augmented reality (AR) and virtual reality (VR), could further enhance the educational experience by providing even more immersive and interactive learning environments<sup>(4,5)</sup>.

#### Conclusion

The application of 3D models in oral pathology education represents a significant advancement in teaching and learning methodologies. By offering enhanced spatial understanding, interactive learning opportunities, and realistic simulations of pathological conditions, 3D models can bridge the gap between traditional education methods and the demands of modern, competency-based training. As technology continues to evolve, the role of 3D models in oral pathology education is set to expand, providing even greater opportunities for innovation in teaching and learning.

**Conflict of Interest:** Nil

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