

# Sustainable Advances in Oral Pathology: The Impact of Artificial Intelligence

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## Abstract

*Oral cavity cancers constitute about 4% of all malignant neoplasms. More than 9,900 new cases are reported from the developed countries yearly, and the 5-year mortality rate is higher than 39%. In Europe, the highest rates occur in Hungary, Croatia, and other Central and Eastern European countries; high levels are also seen in India, Pakistan, and Bangladesh. The management of endosseous pathologies presents considerable challenges because they often exhibit no or few symptoms, and early diagnosis involves several difficulties. In recent years, three-dimensional radiological imaging and artificial intelligence have revolutionized the way the diagnostics and therapeutic methods used in oral pathology are performed. Artificial intelligence helps to increase the accuracy of diagnostics by clinicians so that early treatment can be planned, and the chances of complications and recurrence can be lowered. However, the importance of artificial intelligence goes far beyond improving the quality of health care, since it also ensures the sustainability of medical practices. In the medical field, this translates into accuracy, precision, and predictability of treatments. By analyzing big data in a much shorter time, artificial intelligence would optimize diagnostic and therapeutic resources, besides lowering costs associated with diagnostic errors and ineffective treatments. This, therefore, reduces the need for invasive procedures, fostering a more conservative and biologically respectful approach for patients. These characteristics make artificial intelligence one of the key components of more sustainable healthcare practices, combining technological innovations with the wise management of resources, while simultaneously enhancing clinical outcomes and the effectiveness of healthcare systems.*

**Keywords:** Oral cavity cancers, Artificial Intelligence in diagnostics, radiological imaging, sustainable healthcare

## INTRODUCTION

Artificial intelligence is a technology that uses a complex algorithm to allow computers and machines to simulate human intelligence to perform problem-solving tasks based on vast labeled dataset. The integration between artificial intelligence and oral pathology has gained significant popularity in recent decades and offered extensive valuable applications that have contributed to various aspects of the specialty, such as diagnosis of cysts and tumor from digital radiographs. Hence, by fostering more sustainable practices, artificial intelligence can help minimize biomedical waste, lower environmental impact, and improve resource management as sustainability and healthcare are intrinsically connected.

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Received Date: January 18, 2025

Accepted Date: January 22, 2025

Published Date: February 01, 2025

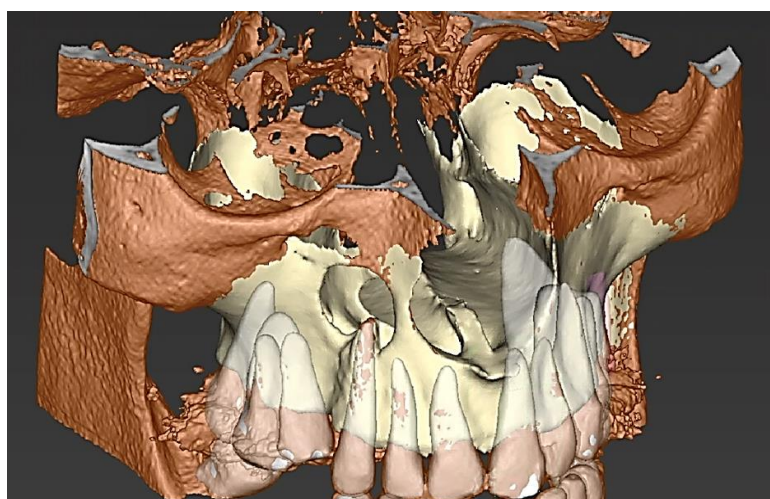
**Citation:** Giuseppe D'Albis, Abdulrahman Omar Alrashadah, Marta Forte, Luisa Limongelli, Saverio Capodiferro. Sustainable Advances in Oral Pathology: The Impact of Artificial Intelligence: A Journal of Dentistry. 2025; 16(1): 24–27p.

## ENHANCED DIAGNOSTIC ACCURACY

The significant impact that systemic diseases can have on the oral cavity highlights the importance of

early detection and accurate diagnosis. The profound effects that systemic diseases can have on the oral cavity, including infectious, endocrine, and autoimmune disorders and other conditions. Tuberculosis, for example, is primarily a pulmonary disease but may have oral manifestations, such as periodontal or periapical lesions, abscesses, or extensive mucosal ulcerations and sometimes may be associated with cervical lymphadenopathy [1]. Moreover, cancers of the oral cavity and oropharynx represent a rapidly growing public health problem. Thus, in 2018, the death rate was estimated at 177,400 persons worldwide – 119,700 males and 7,700 females – and 51,000 persons, respectively 42,100 males and 8,900 females. Traditionally, the major non-genetic risk factors for both cancers have been represented by smoking, human papillomavirus infection, and alcohol consumption. However, according to Infante Cossio et al. [2], there is still high potential for future prevention by means of public health campaigns on the decrease of smoking and consumption of alcohol and close follow-up of oral cavity cancer and oropharyngeal cancer mortality rates.

These are many promising application areas where an artificial intelligence model can offer support to pathologists for early diagnosis. A recent systematic review underlined diagnostic performance across the type of disease, with larger numbers of studies being conducted in gastrointestinal, urological, and breast pathology [3]. Many disease areas are, however, underrepresented and must also be pursued in further studies. These findings highlight the necessity for early detection, where could be instrumental in improving diagnostic precision and promoting prompt treatment in oral pathology. Artificial intelligence markedly helps in improving diagnostic accuracy through automated segmentation of osseous structures. The examination of medical imaging data through artificial intelligence algorithms precisely identifies and delineates both normal and abnormal bone characteristics, thereby facilitating the development of comprehensive three-dimensional reconstructions (Figure 1). Moreover, this technological advance represents an improvement in depicting intricate anatomical formations, hence aiding in the identification of subtle irregularities that could otherwise go unnoticed. Further, artificial intelligence -driven segmentation reduces the workload associated with manual procedures, improving efficacy and consistency of diagnosis. This kind of innovation contributes to improved treatment planning through more accurate, minimally invasive approaches and therefore better clinical results in oral pathology.



**Figure 1.** Automated segmentation of a Keratocyst in the Maxilla using Advanced Artificial Intelligence Algorithms.

## DIGITAL PATHOLOGY AND REMOTE DIAGNOSTICS

The gold standard for pathological examination is the examination of specimens on stained glass slides. Recently, the introduction of digital pathology has been proposed, and this mainly focuses on examining digital slides using a computer workstation [4]. The inherent importance of digital pathology lies in its ability to overcome the limitations associated with conventional practices. It represents a

significant advancement in the field of pathology by transitioning from the use of glass slides to digital formats, specifically whole slide imaging (WSI), which is the cornerstone of digital pathology. Digital pathology offers exceptional advantages, including high-resolution images, superior long-term data storage, advanced analysis capabilities, and effortless sharing with other pathologists [5]. While artificial intelligence is taking over many other fields in pathology, traditional pathological diagnosis had mainly been done by pathologists using the traditional microscope with a view of a stained-glass slide [6]. Hence, in digital pathology it enhances the accuracy and speed of diagnosis with no transfer of specimens, therefore leading to timely and informed decisions in pathology.

### **EDUCATION AND TRAINING**

Artificial intelligence technology has significant potential to revolutionize educational approaches. The emergence of big data, artificial neural networks, and cloud computing will inevitably change daily workstations. Similarly, the inclusion of the integration of television once revolutionized information accessibility information much like the inclusion of artificial intelligence it has been touted to be shown to enhance the receiving of information to students and educators. Nonetheless, educators and students are obliged to review the current application of Artificial intelligence to maximize the learning process without fundamentally altering the core principles of traditional educational practices [7]. Moreover, the use of artificial intelligence to generate a specific and targeted question in pathology from different sources, such as lectures notes, research articles and internet uploaded content to different artificial intelligence platforms can make questions in any format. This includes multiple choice questions, short answers and extended match thus enhancing learning efficiency of students. It is important to note the quality of the question that has been generated that can significantly influenced by the nature of different intelligence platforms as artificial intelligence reliance on understanding complex medical concepts vary among different models. It is necessary to be careful to ensure the platform has made accurate medical explanations avoid inaccuracies and flawed educational outcomes [8].

### **REDUCTION OF WASTE AND ENVIRONMENTAL IMPACT**

Health care waste is an emerging public and environmental issue waste and dentistry is a significant contributor to biomedical waste. In the field of oral pathology this encompasses a range of materials that is used in taking biopsy specimens samples for diagnosis. Similarly, also such disposable instruments, chemical reagents, and contaminated sharps are part of this biomedical waste respectively [9]. Furthermore, artificial intelligence -enabled virtual microscopy is also said to bring down dependency on chemical reagents tremendously and reduce the use of glass slides for pathological diagnosis. Nevertheless, the application of deep learning has opened new opportunities for changing the traditional method of histological staining with the help of trained neural networks that would create histological stains digitally. Much quicker and more cost-effective alternative to the classic ways of the staining method [10]. This, in any case, would contribute towards sustainability in oral pathology by reducing waste of reagent chemicals, preserving resources, and encouraging eco-friendly histological analysis. Lastly, remote diagnosis in telepathology can facilitate the transfer of high-resolution images to share

### **Ethical Considerations**

Artificial intelligence is already being used in some areas of oral and maxillofacial surgery, such as improving the radiographic images, detecting fractures and abnormalities and cysts and tumors. Moreover, Oral pathologists encounter several challenges, including the nature of analyzing large volumes of histopathological images, the presence of risk of human error in detecting the abnormalities, and the variability of the results among the pathologists. However, the application of artificial intelligence has the potential to enhance workflow efficiency significantly by reducing time and error. It is necessary to acknowledge the limitations of using artificial intelligence. It is essential to establish a clear boundary for the use of artificial intelligence in clinical practice to ensure ethical and effective use [11]. Hence, major limitations with artificial intelligence systems are the lack of transparency, an ingredient of healthcare as transparency is essential in healthcare in explaining decisions [12].

Ultimately, as incorporating artificial intelligence into oral pathology artificial intelligence technology increasingly promises significant advancements also there is a potential for legal implications as well to ensure its safe and effective use. Consequently, careful consideration regarding the patient electronic health information to assure safeguarding them against any risk of breach [13, 14].

## CONCLUSIONS

In summary, the integration of artificial intelligence in oral pathology is still in its infancy, yet it holds significant potential for promoting sustainability. Artificial intelligence can enhance diagnostic accuracy, improve educational experiences, and enable efficient analysis of oral diseases. The use of digital pathology and artificial intelligence can minimize reliance on traditional materials used in oral pathology, such as physical glass slides and paper records. As artificial intelligence continues to evolve, it is expected to lead to significant improvements in clinical practice, education, and the environment.

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