Romanian Journal of Medical and Dental Education
Vol. 13, No. 3, May-June 2024

INTEGRATING AI IN THE DIAGNOSIS AND THERAPY OF MAXILLARY BONE DEFICIENCIES

Capatina Andreea[1], Asaftei Oana[1],Tibeica Andreea[1*],Agop-Forna Doriana[2], Shokraei Gholamreza[3*], Norina Forna[1]

1"Gr. T. Popa" U.M.Ph. - Iași, Romania, Faculty of Dentistry, Department of Implantology, Removable Dentures, Dentures Technology

2"Gr. T. Popa" U.M.Ph. - Iași, Romania, Faculty of Dentistry, Department of Surgery

3 Gr. T. Popa" U.M.Ph. - Iași, Romania ,PhD student

Corresponding authors: Agop-Forna Doriana , e-mail: drdorianaforna@gmail.com

*authors had an equal contribution as the first author

ABSTRACT

The aim of this study is to explore recent advancements in AI applications in dental diagnostics, focusing on the detection and management of maxillary bone deficiencies using panoramic radiographs and other imaging modalities and providing an overview of the **materials and methods** employed**,** presenting the results and discussions from existing research, and drawing conclusive insights. **Results** The application of AI in these studies has yielded impressive results, indicating that deep learning models can reliably identify periodontal bone loss. These findings underscore the potential of AI to significantly improve the early detection and diagnosis of periodontal disease, thereby enhancing patient outcomes. **Conclusions** Integrating AI in dental diagnostics not only means automating tasks but also improving their accuracy and reliability. Traditional methods for diagnosing periodontal disease involve both clinical and radiological examinations, which can be subject to observer variability and potential errors. AI systems, trained on large datasets, offer a high degree of consistency and reproducibility. The high intra- and inter-examiner correlation coefficients (ICC) reported in these studies highlight the reliability of AI-assisted diagnostics.

Key words: AI applications, bone deficiencies, panoramic radiographs, AI-assisted diagnostics

INTRODUCTION

The field of dental radiology has undergone a revolutionary transformation with the integration of artificial intelligence (AI). AI, particularly through deep learning analysis, has shown significant potential in increasing the accuracy and efficiency of diagnostics and therapeutic planning for maxillary bone deficiencies, such as periodontal bone loss. Additionally, deep learning and Diagnocat have revolutionized many fields, including medical imaging. Recent advancements have shown significant potential in automating and improving diagnostic and treatment planning processes in dentistry.

These advancements promise to improve the efficiency and accuracy of dental implant surgeries and other oral health procedures.

MATHERIALS AND METHODS

A systematically review of relevant scientific literature was conducted to determine the potential of AI in improving diagnostic and treatment planning processes in dentistry.

Electronic databases, included PubMed, Institute of Digital Dentistry, ScienceDirect, Diagnocat.com, International Journal of Oral Science, Nature Communications, IET Image Processing were searched using keywords such as "AI in mandibular bone diseases",

"AI applications in dentistry". Studies published between 2021 and 2024 were analyzed and selected to determine the benefits of AI in dentistry.

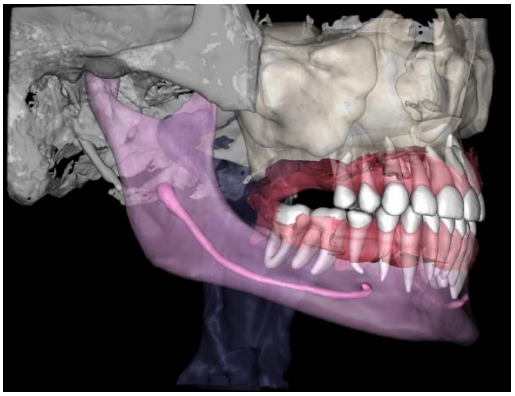

Figure 1.

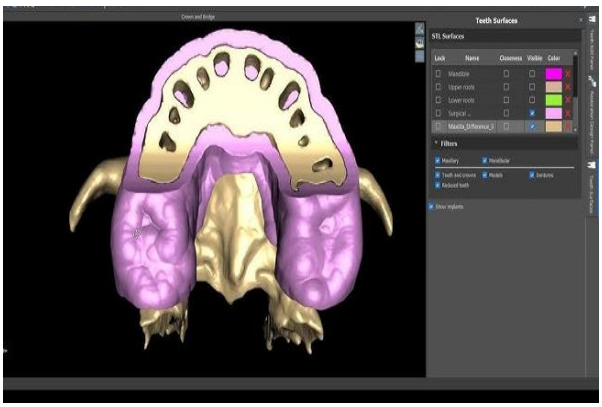

Figure 2.

RESULTS AND DISCUSSIONS

The role of AI in Dental Radiology

AI, particularly deep learning, has shown substantial potential in medical imaging due to its ability to analyze and interpret complex datasets. Convolutional neural networks (CNNs), a type of deep learning algorithm, have been particularly effective in identifying patterns in radiographic images that may indicate various dental conditions. Integrating AI into dental radiology can automate the detection of periodontal disease, thereby assisting clinicians in diagnosing conditions that would otherwise require extensive clinical examinations and expertise.

Recent studies have demonstrated the application of AI in detecting periodontal bone loss using panoramic radiographs. For instance, Ryu et al. employed a Faster R-CNN object detection method on a dataset of 4083 panoramic radiographs to detect teeth affected by periodontitis. This method was chosen for its robust performance in generating region proposals and accurately identifying objects in an image. The study achieved high performance metrics, with an area under the curve (AUC) of 0.88 for detecting affected teeth and 0.91 for the entire maxilla.

The future of AI in dental radiology involves expanding its capabilities to integrate multiple imaging modalities. Combining data from cone beam computed tomography (CBCT), intraoral radiographs, and panoramic radiographs can enhance diagnostic accuracy. AI algorithms can be trained to recognize and correlate features across different types of images, providing a comprehensive assessment of the patient's dental health.

Integration of AI in the Diagnosis and Therapy of Maxillary Bone Deficiency

Diagnocat uses AI to automatically segment CBCT (cone-beam computed tomography) images, generating detailed 3D models. These models include complete maxillofacial structures and can integrate data from intraoral scans (IOS), providing a unified and accurate picture. Diagnocat's automated segmentation process allows for the rapid creation of STL models needed for dental treatment planning and surgical guides, saving time and effort for clinicians.

This software can identify subtle anomalies that might be overlooked by the human eye, thereby enhancing diagnostic accuracy and aiding in the early detection of conditions such as bone loss or structural

irregularities. The AI's ability to process large datasets and recognize patterns contributes to a more reliable diagnosis and helps create detailed reports that can be used in patient consultations.

Guided Bone Regeneration (GBR): AI also plays a role in treatment, particularly in procedures such as Guided Bone Regeneration. GBR involves the use of barrier membranes to support bone growth, preventing soft tissue invasion into the bone defect area. Advances in AI help optimize the design and selection of these membranes, enhancing their biocompatibility and improving their performance in clinical settings. AI-based models can predict the outcomes of different treatment approaches, enabling more personalized and effective therapies.

Integrated Diagnosis: Centers like AI2D focus on integrating AI and data science to synthesize various biomarkers for precise diagnostics. This approach is particularly beneficial for complex cases of maxillary bone deficiency where traditional diagnostic methods may fall short. AI enables the combination of imaging data with other biological biomarkers to provide a comprehensive diagnostic picture, crucial for planning complex treatments and surgical interventions.

Deep Learning and Medical Imaging

The complexity of oral structures, coupled with variability in the quality of CBCT images, presents significant challenges for precise segmentation. Traditional methods often require manual intervention and are prone to errors due to low contrast between different tissues and the complex anatomy of the oral cavity. Recent developments in deep learning, particularly convolutional neural networks (CNNs), have shown great potential in overcoming these challenges by providing robust and accurate segmentation capabilities.

Applications of AI in Dental Implant Surgery

Deep learning methods facilitate end-to-end segmentation, enabling comprehensive preoperative planning. The ability to automatically identify and segment missing teeth based on the FDI Two-Digit Notation system is particularly beneficial. This system enhances dental assessment coverage and ensures precise capture of all relevant anatomical details.

Extended experimental evaluations have demonstrated the superiority of deep learning-based methods over traditional techniques. These assessments confirm that deep learning approaches can accurately segment various oral structures, even under challenging conditions. However, the use of these methods requires further investigation across diverse populations and clinical cases to ensure broader applicability.

Benefits of 3D Surgical Guides

Benefits of 3D Surgical Guides created based on 3D segmentation offer numerous advantages:

High Precision: Precise segmentation of dental and bone structures ensures accurate placement of implants and reduces surgical errors.

Increased Efficiency: Automated segmentation and rapid report generation save valuable time for clinicians.

Improved Patient Communication: Viewable 3D models facilitate patient understanding of proposed procedures, enhancing acceptance of the treatment plan.

CONCLUSIONS

The future of AI in dental radiology involves expanding its capabilities to integrate multiple imaging modalities. Combining data from cone beam computed tomography (CBCT), intraoral radiographs,

and panoramic radiographs can enhance diagnostic accuracy. AI algorithms can be trained to recognize and correlate features across different types of images, providing a comprehensive assessment of the patient's dental health.

Despite promising progress, several challenges remain. Ensuring the effectiveness of AI methods across diverse populations and varying image qualities is crucial. Moreover, integrating AI into everyday clinical practice requires user-friendly interfaces and adequate training for dental professionals.

The integration of AI and 3D segmentation technologies in dentistry represents an important step towards the digitization and modernization of this field. The use of Diagnocat and similar technologies not only enhances the accuracy and efficiency of procedures but also contributes to a better patient experience by providing them with a clearer understanding and confidence in the proposed treatments. As research and technological advancements continue, the future of dentistry is becoming increasingly automated, precise, and patient-oriented.

Acknowledgements

The authors would like to thank Prof. John D o e for the support and constructive comments and also to the staff of the XY Laboratory.

REFERENCES

1. Diagnocat Review - AI Diagnostics of 2D and 3D X-rays in Dentistry. (n.d.). Institute of Digital Dentistry.
2. Diagnocat Review - AI Diagnostics of 2D and 3D X-rays in Dentistry. (n.d.). Institute of Digital Dentistry.
3. Liu, Y., Xie, R., & Zhao, Y. (2024). Fully automatic AI segmentation of oral surgery-related tissues based on deep learning methods. *International Journal of Oral Science*, 16, 34.
4. Various authors. (2023). A comprehensive study on the application of deep learning in dental CBCT image segmentation. *Nature Communications*, 13, 2096.
5. Various authors. (2022). Medical image segmentation using deep learning: A survey. *IET Image Processing*, 16, 1243–1267.
6. Jiwoon Jeong, Jung Hun Kim, Jung Hee Shim, Nathaniel S. Hwang and Chan Yeong Heo, Bioactive calcium phosphate materials and applications in bone regeneration. (2019) 23:4
7. Manuel Toledano-Osorio, Francisco Javier Manzano-Moreno, Concepción Ruiz, Manuel Toledano, Raquel Osorio, Testing active membranes for bone regeneration: A review. https://doi.org/10.1016/j.jdent.2021.103580