Artificial Intelligence in Oral Medicine and Periodontology from Basics to Future Insights

Ola M Ezzatt [1,2]*

[1]*Department of Oral Medicine, Ain-Shams University, Egypt*

[2]*Central Lab of Stem Cells and Biomaterial Applied Research (CLSBAR), Ain-Shams University, Egypt*

*Corresponding author: Ola Mohamed Ezzatt, Department of Oral Medicine, Periodontology and Oral Diagnosis, Faculty of Dentistry, Ain-Shams University, 20 Organization of African Union St., Cairo, 1156, Egypt

Abstract

The term "artificial intelligence" (AI) generally refers to the capability of an artificial machine to perform a human task. Recently, AI have been attracting attention as a potential modern approach in different medical fields, including dentistry. This concise review aims to introduce the basic concepts of AI and evaluating the current literature investigating the AI applications in diagnosis, epidemiology or management of oral mucosal lesions or periodontal diseases, in order to demystify its possible clinical applications and highlight the chances and challenges in future research in oral medicine, periodontology and implant dentistry.

Keywords: Dentistry; epidemiology; machine learning; neural networks; oral diagnosis; mucosal lesions; periodontal; implant

Introduction

Artificial intelligence (AI) is a discipline of computer sciences concerned with designing an intelligent computer system, including hardware and software methods to produce similar characteristics to human intelligence such as behavior-understanding, perception, learning languages, interpretation, reasoning or problem solving [1]. Therefore, instead of traditional statistical techniques or software development, AI supports decision-making and task performance from variable and huge extracted digitalized data [2]. Thus, saving much of the time and manpower, besides being relatively accurate and standardized, which justify its applications in variable research areas including medical and technological domains. The researches and applications of AI in medical sectors are growing in the last few years, particularly in managing medical resources, as well as early detection and diagnostic applications [3-5]. Moreover, the impact of this ever-going technology in variable oral and dental fields evolved significant leaps which have been reviewed recently in literature [6-9]. However, the review of available researches investigating the AI applications in diagnosis, epidemiology or management of oral

mucosal lesions or periodontal diseases is not enough [10,11]. This review aims to evaluate the investigated fields of AI applications in the specialty of oral medicine, periodontology and implant dentistry to highlight the chances and challenges in the future research.

Artificial Intelligence Technologies Classification and Domains for Medical Applications

AI technology depends mainly on specific algorithmic patterns to identify the relationship between computer and human cognitive skills. AI is generally classified based on the degree of similarity to human intelligence into General AI, which depend on universal algorithm which can function in any environment as human mimic robotics, or Narrow AI relaying mainly on specific algorithms to analyze structured or unstructured data in order to perform functions within defined boundaries or expertise [3,4,8]. These AI technologies and algorithms are summarized in (Figure 1) highlighting their common applications in medical and dental field based on multiple recent scoping and systematic reviews [10,12-14].
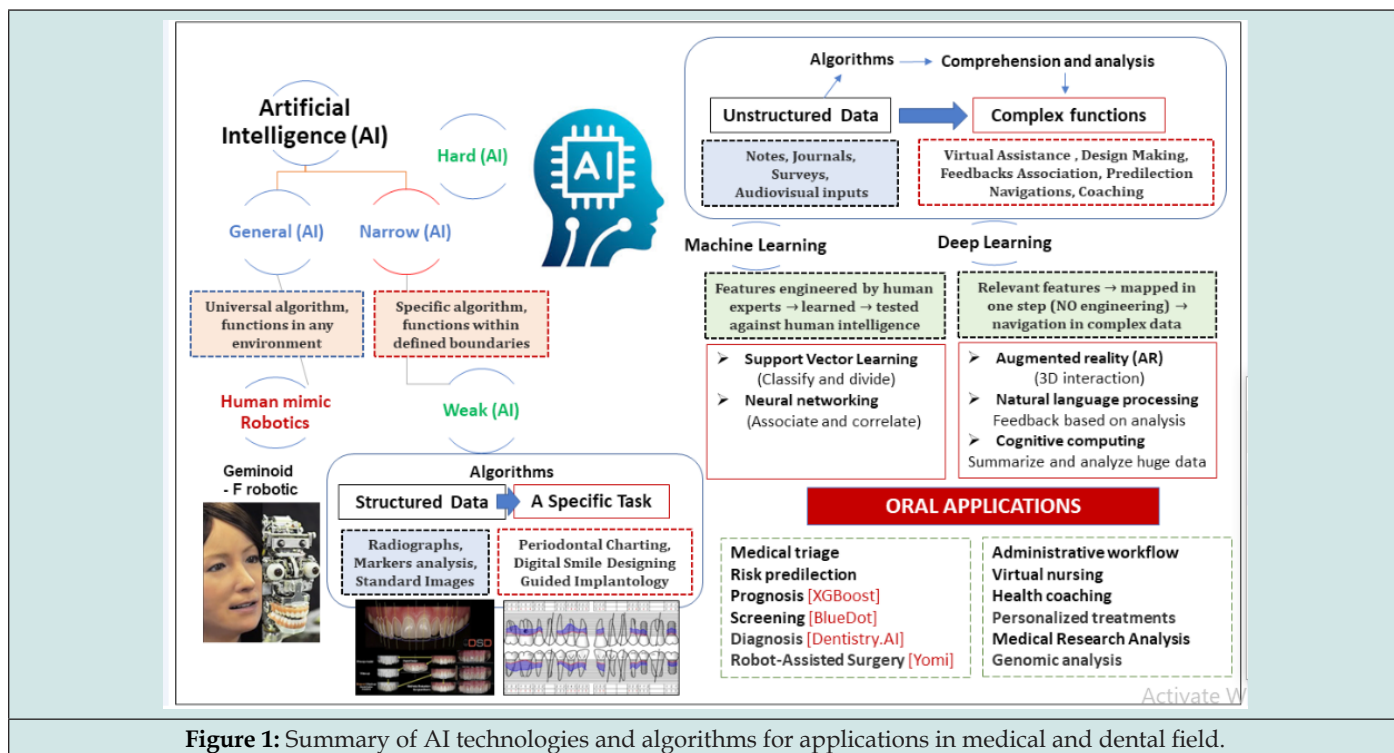
Figure 1: Summary of AI technologies and algorithms for applications in medical and dental field.

Artificial Intelligence applications in Oral Medicine Specialty

Oral medicine specialist is primarily concerned with the prediction, prevention, diagnosis and treatment of oral and maxillofacial diseases and disorders. Moreover, he/she is usually the first to see patients with orofacial symptoms [15]. Thus, performance of oral medicine specialist requires higher human intelligence skills which are necessary for accurate and quick analysis and interpretation of variable and huge clinical, radiological, histological, and cytological data [10]. Artificial Intelligence have been considered a useful tool in diagnosis and screening of oral diseases [9]. Researchers have documented its beneficial effect in diagnosis and classification of oral cancer, as well as differentiating normal from potentially malignant or malignant lesions based on input data as clinical images, pathological photomicrographs or autofluorescence and white light images [16-18]. Furthermore, machine learning models assisted clinicians in prediction of oral cancer prognosis and response to treatment and in prediction of the development of oral cancer from oral potentially malignant lesions [19]. AI was also helpful in identification of cervical node metastasis using radiological images [20]. Diagnosis of osteoporosis, in addition to identifications and classifications of variable temporomandibular joint and musculoskeletal disorders as well as dental caries, and orthodontic problems based on CT, MRI images, panoramic and cephalometric views are also part of the AI applications in the field which have been recently summarized in a systematic review by Patil et al. [9] and Tovalino et al. [6] in 2022. Artificial intelligence had the potential to predict the recurrence of salivary gland malignancies, diagnosis of Sjogren's syndrome, prediction of facial nerve injury with salivary gland surgery or tumors using different machine leaning algorithms with high accuracy and predictability [21] .Compound technology based on input devices as intraoral camera scanners or virtual reality equipment, with AI based software have been used in rapid screening and diagnosis of variable oral lesions and associated systemic diseases, as well as dental education in the field of oral medicine [6,10].

Artificial Intelligence applications in Periodontology and Implant Dentistry

The publications on various AI applications in periodontology and implant dentistry have been growing from the early 2010s, However, a considerable percentage of this literature was derived from technical reports, conference proceedings usually on computer-science sources rather than periodontology or implant specific journals [14]. The majority of the published original research focused on the processing of variable data sets including radiographic or clinical images, as well as immunological or microbial biomarkers in crevicular fluid [6]. The AI algorithms in these studies were preliminary trained for recognition of various periodontal features and have been tested for different applications as image assisted diagnosis of periodontal and gingival diseases, staging and grading of periodontal disease, assessment of peri-implant health, detection of apical pathology or periodontal bone loss. The machine learning was evaluated also in predicting gingivitis or periodontal hopeless teeth, in assessing correlation between ageing and mobility and between periodontitis parameters and the diseased areas, as well as the association between systemic health conditions and periodontal disease. The detailed analysis of published literature in the field of AI research in periodontology

was recently reviewed by Scott et al in 2023 [11] . Regarding AI applications in implant dentistry, this technology was applied for profiling of peri-implantitis, predicting implant success, recognition of implant type, optimization of implant designs and for guided and robotics navigation systems for implant placement [22]. Studies to assess these AI models in implant dentistry have been recently reviewed and further clinical studies were recommended to assess their accuracy in clinical practice [23].

Chances, challenges for AI applications in oral medicine and periodontology

Generally, artificial intelligence in the field of oral medicine and periodontology can reduce observational errors and fatigue, thus helps in analyzing medical and dental records and assisting oral medicine and periodontal specialist with their cognitive learning skills. Furthermore, virtual and augmented reality technologies could improve the educational environment in the field. AI can also open up doors for developing precision medicines and new drugs. This will eventually lead to more efficient and cost-effective services and education. The entire process at the same time increases the amount of investment in the market. Unfortunately, introducing any new technology within a service usually encounter a group of challenges, such as, lack of hard-ware, infrastructures, ongoing cost maintenance, data sharing ethics, and the fact that it requires more training, profound knowledge and specialization. Regarding research opportunities in this field, researches should be designed using standardize methodology to compare the outcomes from independent examiners on unseen data against the proposed AI outcomes to reduce risk of bias. Moreover, it should be considered that healthcare in oral medicine and periodontology is a multitask approach, thus it is not reasonable to replace this comprehensive service with a single AI algorithm. Dentists in all specialties need to understand the basic concepts of AI and possible applications in their discipline to adapt to the continuous change in healthcare. Overall, this concise review gave a future insight into the possible applications of artificial intelligence in the field of oral medicine and periodontology and offered the readers a large pool of references to identify future and variable era of research in this field.

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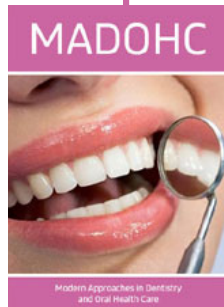
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