ROLE AND IMPLICATIONS OF ARTIFICIAL INTELLIGENCE IN DENTISTRY: A REVIEW

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Abstract *- Objective: This review highlights the importance of Artificial intelligence in various aspects of dentistry. Presently, artificial intelligence has gained its acceptance and magnitude in various fields including dentistry. When we consider that John McCarthy first established this area of computer-aided learning known as artificial intelligence in 1956, the introduction of ChatGPT demonstrates just how far artificial intelligence has already progressed in this short period of time.*

Results: AI has been shown to have various uses in the different aspects of dentistry. The applications of ai are seen in different fields like in endodontics; it can measure working length, observing the anatomy of the pulp space, foretelling the feasibility and potentiality of stem cells of the dental pulp, scrutinizing periapical lesions, root and tooth fractures and estimating the prognosis of retrodontics. In radiology can help in diagnosis. In orthodontics it helps in treatment planning. In periodontics it helps in differentiation between chronic and aggressive periodontitis. In oral pathology detection of precancerous lesions can be detected.

Keywords*: Artificial intelligence; convolutional neural networks (cnn); artificial neural network; artificial intelligence in dentistry; VGG -16.*

INTRODUCTION

Artificial Intelligence is a concept of using a digital entities like computer aided devices and software that aim to muse similar to the human intellect. AI is developed via researching how thought works and investigating the neural networks of the human brain. These endeavors of research develop systems and software that are intelligent. The key elements of AI are shown in Fig 1.A few terms to know:

Machine learning- This is an entity of AI. It is a branch that offers computers with propensity to master the programming without being definite.

Deep Learning – This entity is a subdivision of machine learning, gives AI the capacity to replicate the neuronal network of the human brain. It can clarify patterns, noise, and other reasons for ambiguity in the data.

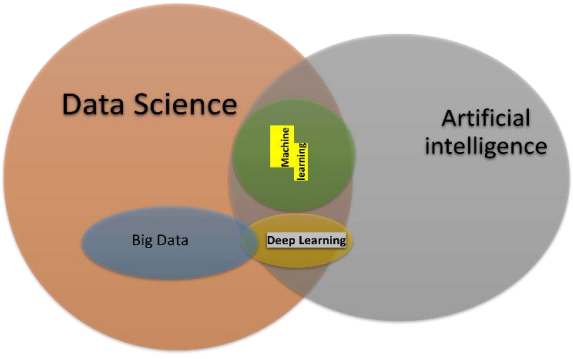

Fig 1: Key elements of AI systems

Research towards sophisticated machines, or any machine that comprehends its environment and behaves in a way that enhances its chances of success, is termed as AI in computer science. AI tools have experienced substantial testing as clinical research tools, specifically to support making choices for prognostic and representation, as well as every phase of evaluation and following medical care, because of their outstanding abilities and functions in comprehending major information patterns. [1]. AI has been shown to boost quality, precision, and efficacy to the extent possible for healthcare professionals quickly and financially as well. [3].

In our daily life we already have many similar softwares such as Siri, Alexa and other voice command devices. AI is applicable in the health field as it can give appointment times, calculate accurately medical dosage, check for drug interactions, and so on.**Sub Heading 1**

1. MAIN TEXT

The majority of dental applications employ supervised learning, where the training data consists of a large number of samples, each with different characteristics or features (such as pictures of the patient, their sex, age, how many cavities they have, and so on) and determination of ground truth (e.g., whether there was a previous endodontic visit or not) [2]. The biological neuron system with a large number of connections of neurons that are utilized in "learning" is mimicked by artificial neural networks (ANNs) and is used by its algorithm to comprehend the relationship between attributes and the ground truth [2].

AI can learn from multiple information sources (multimodal data) to diagnose beyond human capabilities. For example a fundus photograph with other medical data such as age, BMI, gender, smoking habits, BP, and the likelihood of diabetes to predict heart diseases.[4]

Artificial intelligence has the possibility to fundamentally change the disciplines of medicine and dentistry through the development of responses to various clinical issues and thereby simplifying physicians' work. [3]. Artificial intelligence (AI) uses in the dental sector are still uncommon. However, the advancement of these innovations has left a bearing on electronic recordkeeping, radiograph and pathological examination, and caries detection. [3]. Endodontic studies using artificial intelligence has grown in tandem with the emergence of other dental disciplines. Regarding the use of AI, endodontists' expertise has to be updated [3]. As a result, this review aims to put forth the applications of AI in all dental sectors.

2. APPLICATIONS OF AI IN DENTISTRY [Fig 2]

1. It is used in dental imaging diagnosis, decision support, drug discovery.
2. It assists and supports the medical professional in making a diagnosis and treatment planning.
3. Due to data analytics it can assist in improvising the precision and efficiency of diagnosis and prognosis of dental diseases, provides digitized guide for treatment plan and stimulate and assess potential results, and project accuracies.
4. It can inform the patient of the best treatment plan, can inform the patient if the dentist changes the plan, can inform patient if other dentist does the same treatment at a cheaper price
5. Gives patient reason for change of treatment plan
6. Gives patient a report of treatment plan, different treatment plans, and best plan, which is affordable
7. It makes the dentist more accountable as all data is recorded.
8. If information is stored in a blockchain like cryptocurrencies everyone can access data & can make a treatment plan and can assess if the dentist is cheating the patient or not. If data is placed in the blockchain then machines are able to learn more and be more autonomous in the future when appropriate codes are written. This is also helpful in police investigation as all information is accurate and cannot be manipulated by the dental practitioner.
9. Can help in the diagnosis as it can catch all the small details the dentist might miss on the radiograph as the dentist is in a hurry and is mainly focused on the patients chief complaint.

10. It can schedule appointments, assist in making a diagnosis, check for any drug interactions, help in keeping track of inventories.
11. A complete understanding of the company requirements, income streams, expenditures (profit & losses), and patient population—including how many are new patients and how many are retained patients—can be provided by AI to assist dentistry practice owners with operational tasks. [5]
12. Can be in an app form such that it can let the dentist as well as the patient know when the next appointment is. It can have all the medical data stored so any medical professional can easily get the medical records. If the treatment plan is shown on the app then the patient can show that plan to another dentist for a second opinion.

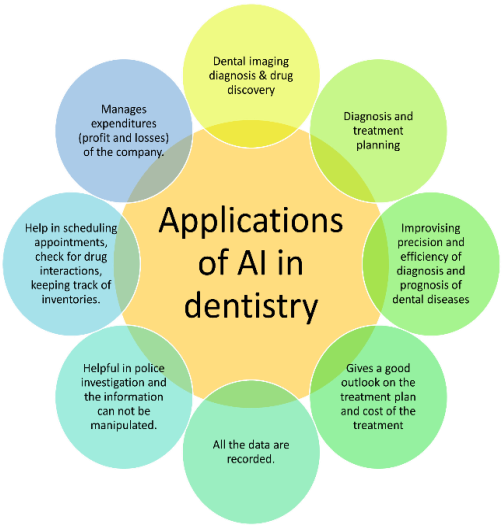

Fig 2: Applications of Artificial Intelligence in Dentistry

3. DENTAL IMPLICATIONS OF AI

1. Radiology- AI has a propitious capability to ascertain and locate anatomical structures. They possess the expertise to name and categorize distinct teeth from periapical radiographs. CNN has a accuracy rate of 95.8-99.45%. CNN can detect and diagnose dental caries. In 3000 periapical radiographs accuracy was 75.5-93.3%[6]
2. Orthodontics -Diagnosis of Orthodontic cases is an extensive plan of action which comprises of data procured from dental and facial structures including patient's desires. The neoteric developments in the Machine learning can be employed for cephalometric tracing and model analysis via automated image recognition, thereby demonstrating relatively high reliability. Orthodontic diagnostics over a period of time with the help of cumulative records and literature analysis, has paved it process towards computerized process. Diagnosis of orthodontic procedures is initiated from identification of discrepancy in space between pre- treatment protocol and the existing ideal occlusion, hence semi-automated 3-D visualized treatment objectives (VTO) may be employed. In orthodontics it also helps in treatment planning to get a predictable outcome. Since teeth extraction is a common entity in orthodontic treatment plan, ANN could be instituted to decide whether extraction is required before orthodontic treatment. [3,4] ANN's has shown to provide an accuracy of 80-93% in determining the need of extraction in clinical cases. [6]
3. Periodontology- American academy of Periodontology (1999) gave the classification of periodontal diseases: aggressive and chronic. Clinically, microbiologically, histopathologically or genetically or combination of any of these tests could not differentiate between the various types. Papantanopoulos & colleagues used ANN to differentiate between aggressive and chronic periodontitis by employing immunological variables such as leukocytes, ILs & igG antibody titre. One ANN presentation was considered to be 90-98% accurate in differentiating patients with

aggressive or chronic periodontitis. An ANN with monocyte's, eosinophils, neutrophil count & CD4+/CD8+ T cell ratio as input provided the best presentation. [6]

Figure 2 illustrates the general steps for a hybrid driven architecture of deep neural networking and the typical CAD processing to robotically ascertain and distinguish periodontal bone loss. In Figure 3, the created CNN is employed to determine the level of periodontal bone, the level of the cementoenamel junction (CEJ), and the existence of teeth and implants. [7] In a retrospective study conducted by Ghala Alotaibi et al. where AI was used as a diagnostic tool to investigate the osseous bone loss from the periapical radiographs. A data file including 1724 periapical radiographs of maxillary and mandibular anterior teeth with periodontitis (2015-2020) was retrieved and randomly allocated into datasets of 10% testing, 20% validation and 70% training. With the help of deep machine learning, the validation in diagnosing normal Vs periodontal disease was agnostic considered to be 73.0%, and 59%. This retrospective data divulged that the deep CNN algorithm (VGG-16) was functional enough to ascertain osseous loss in intraoral periapical x rays, and has a shown to have sufficient capability to reveal the intensity of alveloar bone loss. The study concluded that CAD system could be an effectual tool to guide the diagnosis and staging of periodontal diseases.[8]

4. OPERATIVE DENTISTRY

Usually visual and tactile examinations or radiographs are used to make diagnosis. When one observes deep fissures, tight interproximal contacts, and secondary lesions, it may prove challenging to identify the initial phases of lesions. Ultimately, numerous lesions become apparent once dental caries reaches an advanced state, necessitating more involved interventions like dentalcrowns, root canals, or even implants.[4]

The diagnosis of carious lesions, vertical root fracture, periapical diseases, pulp space therapies and assessment of tooth wear have been extensively researched in relation to operative dentistry. Each of the greyscale pixel in a 2D radiograph has a magnitude, or brightness, that reflects how dense it is of the object. The machine learning algorithm may acquire the trend and provide an estimation for segmenting the tooth, dental caries, etc. through analysing the aforementioned data. Lee et al established a CNN to pinpoint dental caries on periapical radiographs. A CNN algorithm was recommended by Kuhnisch et al. to locate caries in intraoral images. In an assessment of the affordability of AI against dental diagnostics for proximal caries detection, Schwendicke et al discovered that AI was both superior and less expensive.[4]

Studies demonstrate that AI is capable of recognizing lesions promptly at the earliest. For this to work there must be interdisciplinary cooperation between the clinician and the computer scientist. The clinician will label the radiograph image with the location of caries while the data scientist will make a data set & a machine learning algorithm. Finally, evaluate and verify the outcome's precision and correctness.[4]

5. ENDODONTICS

Radiographic pictures are often utilized by endodontists to inspect, gauge, and assess the state of the tooth's root that is below the gumline [Figure 3]. These images may additionally be utilised by AI models to evaluate the structure, dimensions, tissue viability, and even the likelihood of treatment success for those hidden areas of the tooth. Then, different aspects of the anatomy of the tooth root and the potential pathologies can be discovered, situated and categorized by deep learning algorithms. This is advantageous in comprehending specific fissures and lesions in or around the tooth, as well as specific tooth features. Mandibular molars all have the same type of root canal, however there are a few unusual variations that can happen. To minimize treatment failure CBCT is used. Due to its higher radiation it's not used on a regular basis. To vanquish such problems AI can be employed to distinguish the given data with the help of CNN to discover if the distal root of the mandibular first molar has more than one canal. Studies have shown that the anatomy can be assessed using CNN. CNN has proven to have an accuracy rate of 86.9%, but

however there are certain barriers like the image has be to fed manually into the system, time consuming, the images should be of sufficient size and should concentrate on smaller areas to permit the system to focus on the object being examined. Research also has highlighted on the adoption of CBCT scanning and electronic apex locators to find the apical foramen with the help of AI models. The artificial neural network (ANN) algorithms utilized during the investigation were capable of to pinpoint the apical foramen precisely as well as determine the working length of a tooth with accuracy rate of 93%.[6]

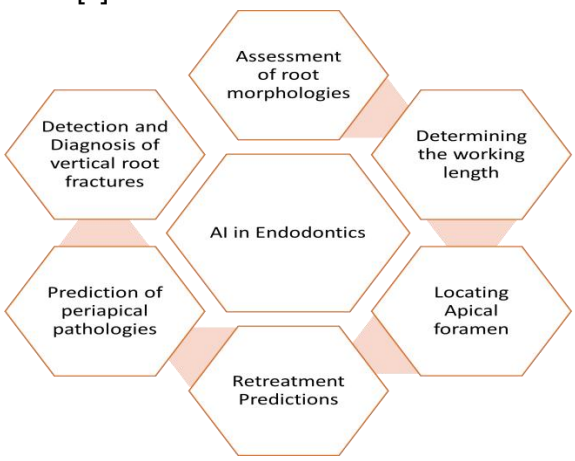

Fig 3: Applications of AI in Endodontics

6. ORAL PATHOLOGY

Earliest detection of various oral diseases provides good prognosis. Some oral lesions can be precancerous or cancerous Oral potentially malignant disorders (OPMDs), that consist of visible oral lesions, are an important warning sign of cancer and can be spotted during routine examinations of the mouth by a dental practitioner. [9] This sort of assessment unfortunately isn't performed enough times during dental testing, which is the problem. CNN has proven to be an effective tool in the diagnosing lesions of head and neck region. ML and CV technologies haven't yet progressed enough yet to help safeguard us against mouth cancer. But there's an excellent possibility it might occur when there is greater accessibility to effectively identified information. A study was done using a CNN algorithm to differentiate and classify the clinical signs and radiographic features between two maxillary tumors: ameloblastoma and keratocystic odontogenic tumour. The specificity and precision to rule out the diseases by the algorithm was 81.8% and 83.3%. [6]

Two deep learning-based computer vision algorithms were employed in a recent work on "Automated Detection and Classification of Oral Lesions Using Deep Learning" to categorize oral lesions. More than 2,000 images were evaluated using ResNet-101 image classification and Faster R-CNN object recognition with the objective of resolving the following two inquiries:

1) Are there any lesions?

2) Are lesions a potential risk for Malignancy?

Despite its flaws, the AI system produced favorable outcomes. For locating oral lesions, image classification acquired a precision rate of 87%, and for distinguishing those that needed referral for treatment, it acquired a reliability of 78%. With solely 41% precision, the objects detection performed somewhat worse, spotting lesions that elevated the possibility of cancer.[9]

4. Limitations of AI in dentistry

There are several challenges ranging from collecting, storing & analysis and digitalization of patients medical data. The primary challenge is a dearth of excellent instruction data. A large storehouse will be needed to backup the data of the different patients.

5. Excellent training information

If relevant data is not made available for AI systems to learn from, they can't function accurately. This entails applying annotations to name key items and emphasize pertinent zones, such as bounding boxes or polygons. Publicly obtainable datasets are often a valuable resource for

instruction in artificial intelligence. The issue with dental AI, meanwhile, isn't a lack of desire or capacity to assemble data sets or gain access to those already in existence. Instead, the knowledge necessitates to train artificial intelligence in dentistry must be anonymized or gathered with patients' approval.[9]

6. The Future of AI in Dentistry

Future dental care has a mountain of promise for machine learning and computer vision systems, from improving early diagnosis of oral cancer to boosting the clinical efficacy of orthodontics.[9]

As already seen, it's challenging to overestimate the value of artificial intelligence in dentistry. AI dental care technologies enhance diagnostic precision, cut expenses, and enhance long-term patient outcomes when used in conjunction with human dental practitioners. The capacity of AI to streamline dental diagnosis and treatment is additional major benefit. Dentists' judgement on clinical data is unreliable, and investigations indicate that various practitioners' assessments are not always consistent. Innovative, revolutionary dental technologies provide a way to vastly improve consistency, which enhances patient health. In other words, patients and academia expect benefiting tremendously via CV and ML.

CONCLUSION

While the clinician is the one who makes the final decisions regarding diagnosis and treatment, the AI assistant boosts patient confidence in the process and may alleviate some of the anxiety that is frequently experienced by dental patients by providing them with a real-time second opinion that is visual and simple to understand. As an outcome, it provides patients with assurance surrounding the preciseness of the diagnosis and lessens the skepticism commonly seen among dental patients.[5]

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Not Applicable

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