ARTIFICIAL INTELLIGENCE IN DENTISTRY- A NEW TREND.

Dentistry

Dr. Smitha Cn	Professor, Dept. Of periodontology, Guru Nanak Dev Dental College & Research Institute, Sunam
Dr. Sumanpreet Shergill	Reader, Dept. Of periodontology, Guru Nanak Dev Dental College & Research Institute, Sunam.
Dr. Sanjeev Jain	Professor and Head, Dept. Of Periodontology, Guru Nanak Dev Dental College & Research Institute, Sunam
Dr. Divya Saxena	Professor, Dept. Of Periodontology, Guru Nanak Dev Dental College & Research Institute, Sunam
Dr. Gaurav Pandav	Associate professor, Dept. Of Periodontology, Guru Nanak Dev Dental College & Research Institute, Sunam
Pancy Bansal	P.G student, Dept. Of Periodontology, Guru Nanak Dev Dental College & Research Institute, Sunam

ABSTRACT

Artificial intelligence is the ability of any machine to perform tasks using an algorithm that usually requires a human mind. It has the capability to mimic the intelligence of humans to undertake complex predictions and make quick decisions in the healthcare sector. Currently, AI has remarkably increased its presence and significance in a wide range of sectors including the dental sector.1 In dentistry, AI has been adopted in all the major dental specialities i.e. operative dentistry, periodontology, orthodontics, oral and maxillofacial surgery, and prosthodontics. The majority of the AI applications in dentistry work based on radiographic or optical image diagnosis.3 The models of AI such as convolutional neural networks and artificial neural networks have shown a variety of applications in endodontics which includes - studying the anatomy of the root canal system, forecasting the viability of stem cells of the pulpal tissues, measuring working lengths, pin pointing the root fractures and periapical lesions and forecasting the success in case of re-treatment procedures.1 In the field of periodontics, Deep learning analysis using radiographs can help in diagnosing and treatment planning of periodontal diseases by the early detection of periodontal changes bone loss, and changes in bone density and detection of peri-implantitis. This helps in early intervention in implantology. Artificial neural network can be used effectively in classifying the patients into various stages of periodontitis group based on their immune response profile.2 Future applications of this technology involves scheduling appointments, providing patient care, considering drug interactions, provinding a prognostic diagnosis and a helping hand in robotic endodontic surgery. Before incorporating AI model into the routine clinical operations, it is important to determine the cost-effectiveness and applicability of these models.1

once seemed like a science fiction is now becoming a reality in the health care. One of the most fascinating subject i.e the human brain has long piqued the interest of scientists and researchers. The scientists were unable to understood and create a flawless model that mimics the human brain. Since the past decades, scientists have been tirelessly working to advance the "artificial intelligence" (AI). In 1956, John McCarthy was the first one to introduce the field of applied computer science known as "Artificial Intelligence", also called a "machine intelligence". This "fourth industrial revolution", often known as artificial intelligence or AI, employs the computer technology to imitate a smilar critical thinking, decision - making, and intelligent behavior to that of a human mind. Our daily lives have already been impacted by it through various office and practice management software. Siri (introduced by apple), Alexa (introduced by amazon) and other voice command devices are a few examples of applications that have built intelligent conversational user interfaces for any device, application language, or environment using artificial intelligence in every corner of the house. Virtual and physical AI i.e. robotics are both applicable in the health care sector. The formulae for estimating the medication dosage, diagnosis and prognosis, scheduling patient appointment, drug interactions, mantaining the electronic health records, and imaging are the main arena for the virtual type. The physical aspect includes rehabilitation, telepresence, robotic support in any surgery, and companionable robots for the elderly care.

The word "AI" is used when the computer imitates the analytical functions, such as "learning and problem- solving" that humans frequently associate with a human mind. AI has been reviewed to increase accuracy, efficiency, and precision along with medical experts more quickly and affordably.1

Currently, medicine uses a branch of the artificial intelligence i.e. machine learning and deep learning.4

*   **Machine learning (ML) -** In this branch, the AI system learns to perform intelligent tasks without a particular set of rules or knowledge. The AI identifies patterns from a larger data sheet without human assistance. It gains exposure through random examples and gradual adjustments in the data.4

*   **Deep learning (DL) -** It is a sub-branch of ML where the system not only learns the patterns but also identifies the hierachy pattern building from the old and new data. A popular DL algorithm i.e. the artificial neural network (ANN) is a structure composed of many small communicating neuron like units. It includes - an input layer, an output layer and multpile hidden layers in between (these hidden layers do not depict their value ouside).4
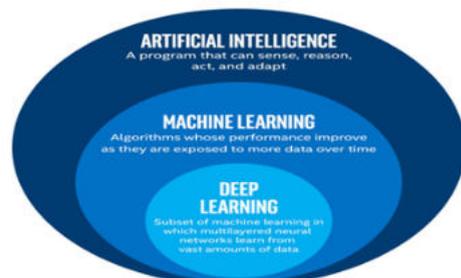
In the field of medicine and dentistry, subclass of ANN i.e. convolutional neural network (CNN) is widely used. This AI uses special connection of the neuron like units and mathematical operations to process signals such as sound, image and video.4

Schematic representation of the neural networks. (a) Shallow neural networks - composed of an input layer, a few hidden layers and an output layer. (b) Deep neural networks - composed of an input layer, multiple hidden layers and an output layer. (c) Convolutional neural networks - uses filters to scan a small neighbourhood of inputs.4
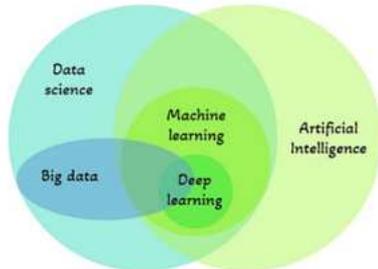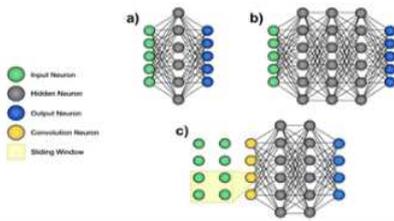
Artificial Intelligence system and its key elements[1]

- **Working Of The Models Of Ai**

AI works in two phases -
1. Training (1st phase) - The parameters for the model are determined here. It identifies data from previous examples.
2. Testing (2nd phase) - all the above data is applied to motion.

These models had been considered as black boxes as the source of their data collection and their way of doing so had remain unknown but the new advanced AI generates a heat map on collecting the input data and gives a valid prediction.[1]

- **Hierachy Of Ai System**
- **Input -** The data includes - voice data, medical or treatment records, radiographic and clinical images and biological samples. The neuron like units processes this data.
- **Output -** The result produces - prognosis, diagnosis, treatment and/or disease prediction. It can perform cephalometric analysis or recognize lesions based on diagnosis. It can predict the treatment via the provided input by distinguishing the normal structures, stimulating and evaluating the outcomes and CAD/CAM. The artificial intelligence program may anticipate the disease or its prognosis by the analysis of the gene , related risk factor or outcome prediction of the disease.[1]
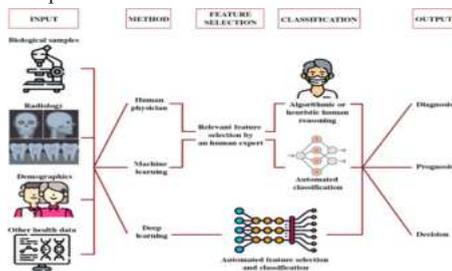
- **Applications Of AI In Dentistry**
- **Role of AI in patient management -** it helps perform the following tasks in management -
1) Marking appointments according to the preference of both patient and the clinician.
2) Alerting the clinician about the patient's medical history prior to the treatment.
3) Notifying both the clinician and the patient for a checkup on any genetic or lifestyle change which could increase the disease susceptibility.
4) Manage patient insurance records and its documentation.
5) Assisting in diagnosis and treatment planning.
6) A regular reminders for those who are on tobacco cessation journey.
7) Providing tele-assistance in emergencies when the clinician could not be contacted due to any reason.
8) A detailed and accessible patient record including the radiographs, medical and dental history, clinical photographs etc.[2]

- **Role of AI in oral medicine and radiology**

1) Lesions of the oral cavity can be diagnosed and screened. These can be classified into suspicious mucosa i.e altered than the normal. These lesions can be identified for premalignant and malignant changed.
2) It can interpret the sizes of unerupted premolars and canines with accuracy during the mixed dentition period.
3) The machine learning AI can also detect abnormality in enlarged lymph nodes of both head and neck region once a previous data of normal and abnormal nodes has been recorded by a radiologist.[2]

- **Role of AI in oral pathology**
1) AI can be used to examine tissue samples followed by both histological and histo-chemical processing of the sample to locate minor abnormalities to establish accurate diagnosis.
2) AI can accurately establish a diagnosis on oral cancer by studying the genes involved.[2]

- **Role of AI in pediatric dentistry**
1) Smart pain control gadgets by AI are the effective methods for an injection free practice.
2) Various movies, animations, videos and virtual reality games can be used as a positive reinforcement in pediatric patient for behavior management.[2]

- **Role of AI in periodontics**
1) AI models can be used for diagnostic procedures and detection of abnormalities/ pathologies.[8]
2) AI model allows patient group analysis and planning of any surgical procedures if required.[8]
3) Early detection of periodontal changes which includes change in bone density, bone loss, peri-implantitis etc. can help in early detection of periodontal disease using deep learning analysis.
4) This tool allows early detection of grade and severity of periodontitis in patients.[2]
5) AI allows to understand the underlying bone contour and the accurate dimensions for re-establishing an esthetic appearance for the patient.
6) AI allows to detect the implant system using deep learning based object detection software from panoramic radiograph.
7) Breath analyzers using AI determines whether the subject suffers from oral or extra-oral halitosis and in rare cases if a systemic diseases is involved as a cause.

- **Role of AI in oral and maxillo-facial surgery**
1) It has clinical applications in image guided surgery in the cranial area including implant surgery, removal of tumor and foreign bodies, biopsy and temporomandibular joint surgery.
2) The image guidance allows a more thorough surgical resection which decreases the need for revision procedures.
3) A study on head and neck cancer attempts to use convolutional neural networks to perform segmentation of the organs at risk from cancer via CT images.
4) It helps perform genetic programming that gives a better prognosis for those with oral cancer and a history of tobacco smoking/chewing, alcohol drinking, squamous cell carcinoma and the presence of oncogene.
5) The ANN can allow identification and grading of the patients who are at a high risk of oral cancer or are in a precancerous stage. it also helps in planning an effective treatment regime for the same.[2]

- **Role of AI in prosthetic dentistry**
1) It allows fabrication of ideal esthetic prosthesis for the patient by studying the various factors including the anthropological calculations, facial measurements, ethnicity and also the patient's choice.
2) It helps in manufacturing the inlays, onlays, crowns and bridges.
3) It replaces the old time consuming methods of laborious conventional casting and also minimizes error in the final prosthesis.[2]

- **Role of AI in orthodontics**
1) An accurate diagnosis and treatment plan can be developed by analysis of radiographs and photographs using the intraoral scanners and cameras. This eliminated the older process of impression making and other lab based procedures.
2) The amount and direction of tooth movement and the final outcome can be shown directly to the patient via images and videos using AI algorithms and statistical analysis.

3) Three-dimensional scans and virtual models help assessing the cranio-facial and dental abnormalities.
4) With the help of 3D scans, aligners can be customized. This algorithm can give an earlier plan of how a particular tooth of the patients will rotate or move under certain amount of force. These AI aligners not provide precise treatment which reduces the chances of error and the time for treatment.[2]

• Risks And Limitations Of Ai

Development of technology comes with its pros and cons. AI allows machines to make automated decisions that were previously made by humans, it can significantly impact the healthcare sector and services delivered to people. While AI in dentistry could reduce human load in the subjectivity of decisions and improve healthcare, it may create a bias that could result in incorrect or discriminatory decisions in some groups of a population. The risks and limitations of AI may arise during the conceptualization stage, during the development stage or the implementation or final stage. During a research, scientists demanded the data by the AI to be detectable, accessible, interoperable, and reusable by machines i.e. the FAIR principles (Wilkinson et al. 2016).[6] The challenges encountered with AI are -

1) **Bias and limited generalizability** - many datasets that train the oral and dental AI do not manage the inclusiveness and representativeness, including data like - age, gender, race and others. During collection of data a bias may be generated as an insurer and a clinician would have different set of priorities.
2) **Accessibility** - Data in many cases is not available due to privacy reasons which can cause an obstruction in the data collection and consideration for an appropriate diagnosis from the previous records.
3) **Interoperability** - even if the problem of data privacy is managed, the limited technology use in health care sector poses a problem for the vast spread of AI. The methodology for the treatment of a particular diagnosis and the terminology for the same can differ in various region creating another hurdle for the AI.
4) **Truthfulness** - the data is present is to be scanned for the correct or incorrect diagnosis. A particular standard and a set of rules are to be set for the data that acts as an input source for the disease detection.[6]
5) **Mechanism or system complexity -** The AI system is a well staged operation. It is an expense tool for the treatment planning which requires proper trained officials to input the data.[2]

• Clinical Applications Of Ai

AI has made a powerful hold in the health care sector as every clinician opts for a faster technology that allows them to make diagnosis more accurately, is cost efficient and produces minimal error.[9]
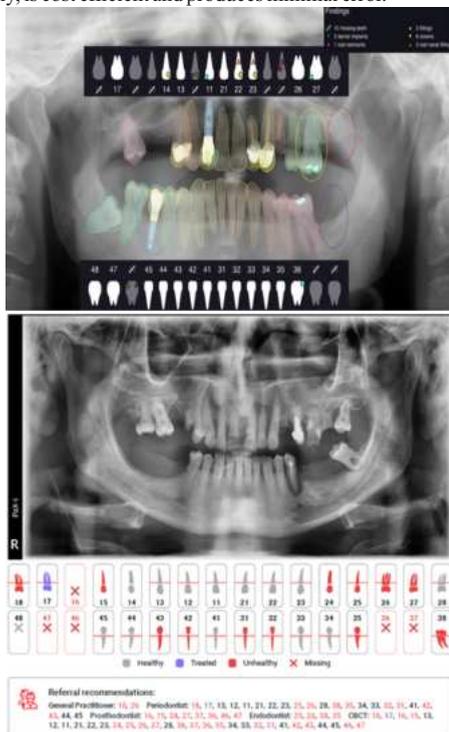

Fig. Analysis Of Radiographs By Various Ai Programmes (a) Represents Apox[5], (b) Represents Diagnocat[7], (c) Represents Ai: Dental

Nowadays, many new AI softwares are developed - Apox, denti.AI, Adravision, diagnocat AI, dentalXrai, smiles.ai and many more (many pending FDA approval). These allow faster diagnosis and treatment planning for the patient by identification from previous recorded data. In diagnostic imaging, the advantages of AI can produce automatic reading of the images while the radiologists concentrates on the interpretation of complicated pathologies. In dental studies, pre-clinical studies have been conducted to visualize root morphology accurately and improve image interpretation in dental radiology.[9]

Although, the resolution of the AI analyzed intra-oral radiographs for the tooth examination is not very detailed, changes in the calcification of the dental tissues and ossification of the surrounding bone can be easily identified, it can also identify dental diseases like caries (tooth decay), periodontal bone loss and lesions of the bone.[7]

Even though technology is growing and learning new data everyday, on uploading the radiographs few of the AI programs had a low sensitivity detection for periapical lesions, over and underfilled canals and failed to detect periapical cysts, intramaxillary cysts and separated instruments in the canal. This clearly states that AI can never replace a clinician for the diagnosis rather can be a second chair to detect pathologies faster.

In orthodontics, for smile designing via aligners, the smile can be recorded via a dental camera or scanner. This data is then automatically uploaded to the AI software resulting in images pre and post the treatment along with the treatment plan of the duration and movement of the tooth.
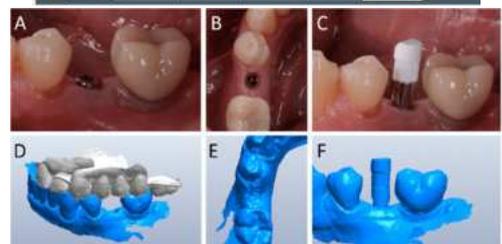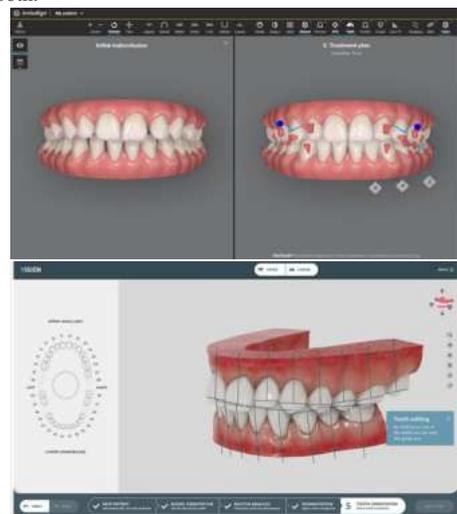
For the implant placement and prosthesis fabrication, AI programme can record the oral tissues and tooth/implant via the intraoral scanner more precisely replacing the tedious lab work and misfits for the prosthesis.

CONCLUSION

AI has its significant role in both medical and dental healthcare sector. The AI system could be the next fastest growing technology in both dental diagnosis and the correct interpretation of the radiographs. According to some researchers, it could act as an expert opinion in dental emergencies and for those who are non-specialists or in a learning phase. AI can help achieve instant diagnosis and treatment planning if the recorded history is precise and has proper documentation of radiographs and clinical photographs.

AI could never actually replace the dental specialist but could be the best assistant one could ask for. It can allow the dentist to have a comfortable practice with maintained records, appointment schedule and minimal errors.

Dentistry is a field that greatly requires the support of efficient technology as it still lacks a standard level of quality. For eg. if the patient goes to a different dentist, they might get different opinions and treatment plan on a particular problem. AI integration will lead to a unique treatment plan for each patient using the software assistance, from planning to treatment and follow-up. Thus with time the software will have the ability to learn, grow and improve its performance from the previous recorded data.

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