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Artificial Intelligence in Dentistry: It's current applications and future outlook

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1. ABSTRACT

Artificial intelligence (AI) is the machine intelligence for perceiving, assimilating and drawing conclusions from data as opposing the conventional human form of collecting and setting up inferences from the data.
The term AI is not a new one and has been with us since quite some time now, but the use has rocketed in the near past. With lives becoming more fast and people becoming more competitive, AI does a lot of work and with great expertise. Contrary to human minds doing all the work, AI is based on the data framework fed to it and it then uses its stored information to generate results in a comparatively shorter period of time.
AI has taken the world by a storm and dentistry is no exception. With today's ever changing world, dentistry has welcomed AI into its system with open arms. We can find use of the new intelligence in almost all the specialities of the profession, ranging from endodontics, periodontics, prosthodontics, oral and maxillofacial surgery, oral and maxillofacial pathology, orthodontics to oral radiology.
This review focuses on the history of the development of AI in dentistry, its current concepts and the future prospects of the technology as far as the science of dentistry is concerned.

Keywords : Artificial intelligence; artificial intelligence in dentistry; applications of AI; AI in diagnosis; future of AI; robotic assistants; imaging; dentistry.

2. INTRODUCTION

"Artificial intelligence (A.I.) is generally defined as the property of machines that mimic human intelligence as characterised by behaviours such as cognitive ability, memory, learning, and decision making.[(1)]"
With the world opening up its horizons each day and life becoming more convenient it is customary to think of robots to do most of the work. Humans have always been fascinated to understand the intelligence of the brain and to open the secrets that it holds, this long quest has led us today into the "Fourth Industrial Revolution" that is the world of an artificial intelligence.
Scientists have been working tirelessly for many years now to advance the field of "artificial intelligence" (AI). This field of applied computer science, the artificial intelligence was originally introduced by John McCarthy in 1956 [(2)].
Lives of people have been surrounded by numerous electronic devices and their increasing use has helped data assimilation for AI. AI can in a much simpler way carry out processes which require human expertise. It basically focuses on learning and problem solving, the attributes which are commonly associated with humans.
AI is becoming integrated with our lives and it is because of the rapid development of three cornerstones of current AI technology—big data (coming through digital devices), computational power, and AI algorithm [(3)]
AI can be well studied under two sub heads, namely, machine learning and deep learning.

- Machine learning (ML), the branch where the system learns to execute tasks without a prior learning or without human assistance, based on a large entry of dataset available to it.
- Deep learning (DL) is the one in which the system learns from patterns of data.[4]

AI today is in every bit around us, ranging from a smartphone to a smartwatch, "Hey Siri", "Ok Google" and "Alexa" are the most common ones with which we are well versed. We today have AI in almost all fields like the automobile industry, financial and statistical analysis, robotics, medicine, pharmacy, dentistry, etc.
Artificial intelligence can be used in the field of medicine and it has also proved to be successful in detection of diseases, remotely treating the patients, robot assistance, hastening drug development and many more. Many studies have been conducted to explain the importance of AI in healthcare sector. The medical sector can incorporate AI for patient treatment and care by using wearables which have sensors that record data like pulse, heartbeat, blood pressure, temperature, physical activity, etc[5]
AI has taken the world by a storm and dentistry is no exception. With today's ever changing world, dentistry has welcomed AI into its system with open arms. We can find use of the new intelligence in almost all the specialities of the profession, ranging from endodontics, periodontics, prosthodontics, oral and maxillofacial surgery, oral and maxillofacial pathology, orthodontics to oral radiology and even in forensic odontology.
AI can be used in a dental set up in imaging, prescription writing, robotic assistants, data compilation, hospital management, keeping patient records, setting up appointments and sending reminders for those appointments. AI can also be used to keep an inventory of the various resources available with a dentist or a dental hospital, the utilisation and set up alarms when stocks are running low.
The following areas in dentistry have applications of AI:

A. Diagnosis and treatment planning - Added precision in radiography, detection of carious lesions and prescription writing.
B. Face/Voice recognition for staff and attendance keeping.
C. Restoration designs, shade matching, CAD/CAM, quality enhancement of prosthesis, aligner designing, etc.

D. AI can also be employed in a dental office in ledgers, inventory management, etc. [6]

AI can make clinician's work easier as it has the potential to revolutionise both dental and medical sectors. Applications of AI in dentistry are not very common yet [2], but they can be incorporated to bring out softwares for assistance.
This review aims to bring to light the various clinical applications of AI and the future that might be in store.

3. METHODOLOGY

Since the topic has been gaining a lot of importance in the past couple of years, great amount of information is available. As an initial measure Google Scholar was used to document a sample of the articles available for this review, thereafter databases such as Science Direct, ADA, FDI, PubMed were used for articles published upto April 2023. We found eight peer reviewed articles on the topic. The internet, since it has a vast array of information was used to gather the required insights of the topic. The sources on the internet, written by professionals and published on reliable websites and journals, have been mentioned in the references. The citations have been kept to a time frame of last three years.

4. APPLICATIONS OF AI IN DENTISTRY

Dentistry today has many AI based systems to modernise the traditional practices. These systems are aimed at improving the clinician's efficacy and precision on various aspects. The dental aspect of AI based technology can be used in simple tasks like detection of cavities to even gender and age estimation when it comes to forensic odontology. [5]

4.1) In Oral Medicine & Radiology

Lesions in the oral cavity can be diagnosed with better precision and can be grouped under benign, pre malignant or malignant with greater expertise using AI based softwares. [7]
It can also be used in predicting sizes of unerupted teeth, detection of pathologies on a dental radiograph, size estimation of a cyst/tumour, detection of dental caries, periapical changes.

The biggest advantage of this technology in radiology is that we often tend to miss minute details, because we might be more focused on the broader aspects or on more complex problems, for example a proximal cavity between two teeth might very often go undetected. The technology will help reduce such errors with great expertise. Eyes can be deceptive, but incorporating AI in the diagnosis will help reduce chances of errors at first appointment, or even during a follow up. [8]

4.2) In Oral & Maxillofacial Surgery

OMFS has seen a boom in the use of AI guided technology with the introduction of robotic surgeries, guided implant placements, biopsies, resection of tumour, removal of cysts and foreign bodies, and TMJ surgeries. Studies demonstrate that an oral implant surgery guided by AI showed more accurate results when compared to manual procedures performed by experienced surgeons, and AI guided surgery showed no difference in results between freshers and trained professionals.[7]

AI has shown to be a boon with lesser operation time, more intra operative accuracy, and safer manipulation around delicate structures without tissue trauma. AI has decreased the need to carry out re-surgeries due to image guidance and a more comprehensive surgical approach in the first place. Surgery has seen a rapid revolution, all thanks to AI, today there are several surgeons who, carry out surgical procedures with the help of robots.

4.3) In Prosthodontics

An AI based design assistant called **RaPid** has rapidly gained application in prosthodontics, since it has combined numerous aspects like face dimensions, race, anthropological measurements, ethnicity, and most importantly patient preferences in order to generate the optimal aesthetic prosthesis. [2]

In prosthodontics, a typical treatment progresses as, for thepreparationof a dental crown which includes tooth preparation, impression making, pouring and trimming of cast, designing the restoration, fabrication of the prosthesis, try-in, and finally its cementation. AI majorly comes into play with the step of designing of the restoration, it can be used in shade matching, shade selection,

When talking of prosthetic dentistry what is worth mentioning is the introduction of CAD/CAM in the field. The CAD/CAM technology is used in manufacture of crowns, bridges, inlays&onlays. Today, it has replaced the laborious and tedious conventional procedure and has also reduced the element of human error.

4.4) In Restorative Dentistry

Dental caries is the most common dental disease which the clinicians come face to face with each day and so its diagnosis in an early stage is of prime importance. In a regular clinical practice, a dentist uses a probe and tactile and visual senses to identify areas of demineralisation, since such a criteria is subjective and varies from person to person, so it may be common to miss out on certain cavitated lesions. Traditionally, tactical and visual senses coupled with radiographs are the only means of caries detection.

In today's era with AI it is possible to detect areas of demineralisation with greater expertise and missing out on a carious lesion has decreased manifolds due to the added precision of AI based softwares.

AI can detect such lesions because it works by -

a) It examines each tooth individually.
b) Studies the anatomical landmarks of that tooth.
c) Forms an AI based image.
d) Gives results by comparing the landmarks with the tooth in question.

4.5) In Endodontics

Artificial intelligence is gaining more popularity in the field of endodontics. Its use can be mapped to both diagnosis of diseases and its treatment planning. It can detect even minute changes that the human eye cannot possibly read. AI can be used in endodontics in the following domains -

1. Detection of periapical lesions
2. Detection of root fractures
3. Determination of working length
4. Determination of root canal morphology

AI can learn patterns of grayscale and detect changes from expected morphologies and hence help in the detection of lesions or fractures.

4.6) In Periodontics

Periodontitis is a common problem which affects a vast majority of population and eventually may lead to tooth mobility and tooth loss, if not treated properly. Since PPD has to be checked using a probe and calculation of CAL is also a manual process generally, errors tend to arise as these are subjective measurements.

AI can help in diagnosis and treatment formulation of periodontal diseases by early detection of changes in the periodontium. It can analyse bone loss and its pattern, bone density and even peri- implantitis. AI based systems can be used to classify patients, based on their immune response profile into aggressive and chronic periodontitis group.(7)

4.7) In Orthodontics

Orthodontic treatments are long lasting and may often cause irreparable changes to the patient, hence it is important that a proper treatment schedule be sought off before starting the treatment. AI technology can be used to identify the outcome of treatment beforehand and even show the results to patients. AI finds use in model analysis, cephalometric analysis, in prediction of tooth extraction or proximal stripping, in prediction of surgical outcomes, in deterring VTO & for studying maturity indicators. (5)

The use of intraoral cameras and scanners has made diagnosis and even treatment planning easier, their use mitigates a lot of steps like impression making and even the problem of model storage as everything is stored digitally. Their use is more accurate than the ones achieved by human perception.

3D scans and models developed virtually are helpful in the assessment of craniofacial & dental defects. The use of 3D scans has brought about the field of customised treatment in the field of orthodontics, where in an aligner can be directly printed for the patient as per customisation.(7)

4.8) In Pediatric Dentistry

AI has opened a new gateway of pain control and management in pediatric dentistry. With the advancement in tech, movies, animations, 4D goggles and VR based games, AI has helped in behaviour modification and shaping among the patients and hence has helped in removal of common obstacles for a pedodontist. (7)

4.9) In Oral & Maxillofacial Pathology

Oral and Maxillofacial Pathology (OMFP) is concerned with examining and diagnosing pathological conditions in the oral region.

AI can be used to scan large volumes of tissue sections for histochemical studies and it can be used to point out minor details which help in diagnosis and formulating a clinical decision.

AI can also be used to predict people at risk for certain types of cancers using genetic data as a basis. It is noteworthy that AI can be used in risk prediction of cleft lip and palate.(3)

4.10) In Forensic Odontology

The field of forensic medicine has sought use in dentistry in cases where identification of remains becomes a problem. The field is an ever increasing one and AI has been used extensively in this field.

AI can be used in forensic odontology with effective result output for estimation of age & in gender identification. It is often also employed for analysing bite marks and lip marks. (2)

4.11) In Public Health Dentistry

Apart from being a part of individual dental care, AI can also be used to expand and provide benefits at community levels.

AI based tools can help in setting up closer linkages to people at community levels and can be used to impart quality dental care to those who have limited to no dental care at present.

Use of AI based tools will improve general public's attitude towards the utilisation of dental services by enabling a more effective health promotion campaign. (9)

Apart from providing benefits to community, AI can also be used to set up standardisation for various steps in a survey and can also help to decrease interviewer's bias in a study.

4.12) In a Clinical Setting

AI plays a major role in running of a clinical practice smoothly. AI helps remove the day to day difficulties that a dentist has to face, it can find use in record keeping, stock registry, ledger maintenance, calculation of commissions, patient appointments and recalls and improving inter departmental communication.

The most recent advancement is a voice command operated dental chair, which is entirely voice and sense enabled and removes the need to even touch the chair to make arrangements according to the patient.

Table 1 : Overview of applications of AI in dentistry

Dental Speciality	Major applications
Oral Medicine & Radiology	• Diagnosis of lesions • Precise interpretation of radiographs • Assessment of minuscule details • Detailed formulation of treatment plan
Oral & Maxillofacial Surgery	• Robotic surgeries • Guided implants • Tumour/cyst surgeries with better precision
Prosthodontics	• Facial, tooth measurements with exceptions in the picture • Restoration designing • Shade matching & selection • In CAD/CAM
Restorative Dentistry	• Early diagnosis of caries • Detection of areas of demineralisation
Endodontics	• Detection of periapical lesions • Detection of root fractures • Working length determination • Studying root canal morphology • To decide treatments in cases of apicoectomy or hemisections.
Periodontics	• Early detection of changes in periodontium • Assess patterns of bone loss • Analysing bone density
Orthodontics	• In model and cephalometric analysis • Prediction of treatment options • For studying maturity indicators • Defining VTO

Dental Speciality	Major applications
Pedodontics	• Pain control • Behaviour shaping and modification • Patient management
Oral & Maxillofacial Pathology	• Diagnosis of pathologies • Scanning tissue data • Risk prediction
Forensic Odontology	• Age estimation • Gender prediction • Bite mark and lip print identification
Public Health Dentistry	• Strengthen community level health care • Effective health promotion campaign • Standardisation of surveys and remove interviewer's bias

5. LIMITATIONS OF AI IN DENTISTRY

Since AI is comparatively newer to dentistry, following can be taken as its shortcomings:

1. The setting up and maintenance costs are very high.
2. Understanding of machines and systems associated is a complex process.
3. Requires adequate training to gain expertise.
4. There might also be chances of data dredging and data snooping bias.

6. FUTURE OUTLOOK

Future of the AI technology depends on establishment of newer models related to the field and on working at dentist centered projects.

The technology has seen a lot of advancement since its inception and has been gaining popularity as far as its applications are concerned, for a brighter future the bar needs to be raised to be able to detect early changes even at molecular levels, to detect changes invisible to the human eye. Future research has to be based on identification of problems so that even primordial levels of prevention can be brought into the picture.

7. SUMMARY

AI technologies can help professionals in providing high end dental treatment to the patients. AI tools can be used as supplemental measure to increase precision and predict better treatment outcomes.

AI based systems can be used to hasten up processes like data storing and data retrieval in a clinic and in turn increase the productivity of the dentist by sharing the extra load.

Since AI is the future and it also helps to increase the accuracy of diagnosis, they can very well be used as secondary tools and at some places as primary tools to do certain stuff.

8. DISCUSSION

This review focuses on the current trends of AI in dentistry and its various applications in the field. Since AI is the latest trend and it does add up to the level of comfort for a practitioner by increasing efficiency in a lot of possible things, it still has to be updated as per the latest norms for which there is a need of improved computer technology, better softwares and reliable hardwares with an uninterrupted supply of input in the form of data so that the technology has an increase in its database at regular time intervals.

Dentistry today also talks about evidence based dentistry (EBD), where in the clinical knowledge of cases and patient variations are used as means of evidence for treatment of future cases of similar types. Since

EBD is concerned with a professional's knowledge of the subject and AI based technologies are based on the operator's expertise, this opens a new area of research where EBD can be amalgamated with AI.
AI helps in faster and more efficient work life balance by reducing the time for carrying out processes which a human would have taken a lot of time for. It also tends to decrease chances of human error. Faster accumulation of knowledge on a lot of different subjects at once is also possible, it is also helpful in the field in terms of prescription formulation, precision medicine, standardisation of judgement criteria, but since it is a machine based system, machine based errors may arise.
The data required for training AI in medical and dental fields, is often complex and sensitive and since the level of healthcare services are different for different countries, the data set and training type of AI based tools in one part of the world may not hold true in the other part of the world and hence there is often a disparity in utilisation and propagation of such systems at equal levels in all the countries.
AI is growing day and night today and what is alarming is that they may soon replace humans in every field and hence may increase unemployment ratio by taking up jobs which were originally meant for humans, hence a legislation in this field is the need of the hour and in the same regard Sam Altman, the CEO of OpenAI has asked for a regulation of AI technology [(10)]
AI is a powerful tool and has the power to bring about a revolution in the medical and dental fields as well, they are good options to serve as supplementary and secondary factors, but the entire reliability upon such systems is still a questionable matter.

9. CONCLUSION

AI even though a new introduction to the field has grown tremendously over the past few years. AI systems play a pivotal role in precise and immediate diagnosis and a treatment plan for solving complex problems too, so it would not be wrong to say that this technology holds a bright future in dentistry.
These systems increase the comfortability level of a dentist and do reduce human error but they cannot be thought of to be able to replace dentist in all domains of a treatment, as their is a basic requirement of a good patient-doctor relationship before initiation of any treatment and that comes from an understanding of patient's mental attitude, needs, anxiety and expectations from the treatment, which will always be second to impossible to be incorporated into a robot.
AI has to still be integrated into the field of dentistry properly, but what is required is that it is done in a controlled manner with AI being secondary to a practitioner always, so that the decision making power always stays with the dentist. What today seems to be the biggest problem is that for the integration of such a change in the field a continuous and comprehensive training is required, for which a lot of institutions are not currently prepared.

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13. REFERENCES

1. Ranganathan S, Nakai K, Schonbach C. Encyclopedia of bioinformatics and computational biology: ABC of bioinformatics. Elsevier; 2018 Aug 21.
2. Paridhi A, Pradnya N. Artificial Intelligence in Dentistry: Past, Present, and Future. Cureus. 2022;14(7).

3. Ding H, Wu J, Zhao W, Matinlinna JP, Burrow MF, Tsoi JK. Artificial intelligence in dentistry—A review. Frontiers in Dental Medicine. 2023 Feb 20;4:9.
4. Nguyen TT, Larrivée N, Lee A, Bilaniuk O, Durand R. Use of artificial intelligence in dentistry. Current clinical trends and research advances. J Can Dent Assoc. 2021;87(l7):1488-2159.
5. El Joudi NA, Othmani MB, Bourzgui F, Mahboub O, Lazaar M. Review of the role of Artificial Intelligence in dentistry: Current applications and trends. Procedia Computer Science. 2022 Jan 1;210:173-80.
6. KayeGary, NarayanAditya, Nia Frank. Artificial Intelligence and Its Use in Dentistry. 2021 March 1.
7. Banerjee M. Artificial Intelligence in Dentistry: A Ray of Hope. Artificial Intelligence. 2021;13(2).
8. Dr Miguel Stanley. Artificial intelligence in dentistry. Dental Tribune.2023 March 7
9. SchwendickeFalk,Blatz Markus, UribeSergio, Cheung William, Mahesh Verma, Jina Linton, and Young Jun Kim. Artificial Intelligence for dentistry. FDI White Paper
10. Clayton James. BBC News. 2023 May 17. (https://www.bbc.com/news/world-us-canada-65616866)