

DENTRONICS-A REVOLUTION IN DENTISTRY**Dr. Aastha Gajavalli¹, Dr. Suchetha Aghanashini², Dr. Sapna Nadiger³, Dr. Anusha D.⁴, Dr. Vinodhini⁵**^{1,4}Postgraduate, Department of Periodontics, D A P M R V Dental College, Bangalore.²MDS, Professor and Head, Department of Periodontics, D A P M R V Dental College, Bangalore.^{3,5}MDS, Reader, Department of Periodontics, D A P M R V Dental College, Bangalore.***Corresponding Author: Dr. Aastha Gajavalli**

Postgraduate, Department of Periodontics, D A P M R V Dental College, Bangalore.

Article Received on 24/12/2023

Article Revised on 13/01/2024

Article Accepted on 02/02/2024

ABSTRACT

Robotics is a branch that has multiple applications. Robotic surgery obtains results with high precision and accuracy. They have ability to operate in a contained space inside the human body. Robots are for non-invasive or minimally invasive surgery and to obtain better quality outcomes of surgery. However, it is challenge to develop a mechanical device (e.g. a robotic arm) that has dexterity same as human's arms and a computer system that can recognise its surrounding, and a control that uses robotic arm to perform tasks same as a human being. Artificial intelligence (AI) includes a wide range of emerging technologies. The rise of Artificial Intelligence eases the analysis of larger data feasible, that provides dependable information and enhances the decision-making process. AI is eventually improving the practice of surgery with the use of imaging, navigation. This paper provides a review of existing applications and concepts of robotic systems and artificial intelligence in dentistry. Dentronics is as an emerging accomplishment in dentistry using lightweight robots for fulfilling different needs in clinical dentistry. It involves the development of framework, application of it in a specific dental area, and conducting assessments for evaluation.

KEYWORDS: Artificial intelligence; Dental robots; Dentistry; Dentronics; Machine learning; Robot.**INTRODUCTION**

Dentist plays major role in diagnosis and planning the treatment outcome of oral health of patient. The efficiency of dentist and their work can be increased by use of newer technologies like Artificial intelligence like robots. By use of robot technology in dental clinic, dentists and assistants can be benefitted in many ways- such as reduction in mental and physical overload of dentists. This is because of the abilities of robot- they do not tire and are able to repeat the work indefinite times.^[1]

The idea of robotics was first applied in 1969. The first realistic humanlike robot -Showa Hanako was created such that it was capable of performing and exhibiting responses just like a human.^[5]

With this new age and advances, Artificial intelligence including robotics have proved to be significant in dentistry- leading to development of Dentronics. It was introduced to replicate the agility of surgeon's hand and assist them in surgery. It acts as an accessory tool that reduces clinician's workload and improves precision and accuracy in diagnosis, decision-making, prognosis, treatment planning and outcomes. It also operates the dental procedures efficiently, thereby providing more

time for the clinician to focus on patient interaction and treatment. It manages different tasks related to patient appointment scheduling, document arrangement and management, and prescription writing.^[6]

Tokyo's Showa University developed a realistic robot that performs many different types patient reactions and responses. It mimics gag reflex, same as patient, which is common during dental procedures. It can blink, moves its eyes, nods its head, performs movement of tongue and even gets exhausted when having to keep its mouth wide open for long time.^[4]

The research conducted, claimed that robotic systems improve reliability, duplicability and precision in their applications. These advances improve the overall quality of healthcare and outcomes. However, research has to be done as there are lesser studies associated with robotics technology that are used in dental application.^[1]

Dentronics

It is hypernym of broad field of recent technologies, involving robot systems and artificial intelligence, along with hardware, software, human machine interaction, robot safety and assistive functions. It comprises of

diagnostic, predictive and invasive human centred technological tools and equipments which improve reliability, reproducibility, precision and competence in the field of dentistry.^[1]

Artificial Intelligence

Artificial intelligence is a branch of computer sciences that was first explained by John McCarthy in 1956. It has the capability to replicate human intelligence which helps clinician to predict and carry out complex decision making in health care.^[2]

The main fields in Artificial intelligence involve.

- Machine Learning
- Deep Learning
- Artificial Neural Networks
- Robotics.^[9]

Neural networks (NNs) consists of artificial neurons which are close to human neural networks and mimic the human brain and its cognitive skills of solving, learning and decision making.

These have 3 layers.

Input layer- where information is stored in the system

Hidden layer- where data is processed

Output layer- where system decides what to do.^[9]

ADVANTAGES

- Reduces technical and bodily overload of dentists.
- Reduces the difficulties faced by clinician regarding hygiene, medical examination, diagnosis and treatment planning.
- Do not tire and are able to repeat their work for indefinite time, providing time for dentists to interact with patients.
- Focused on using robots in implant placement with 3D navigation.^[1]

Applications of Artificial intelligence in dentistry

1) interactive force sensitive robotics

It explains mechatronics, robotic control, security and human machine intercommunication in field of robotics.

- Mechatronics- the light weight design and use of joint torque sensors results in reflexive and submissive joints.
- Control- it works by simulating the behaviour of human motor control.
- Safety- it is an important aspect and helps to prevent injuries of human coworkers in accidental collision. A robot system should be provided with "CE" marking which confirms safety, health and protection standards.^[1]

- Human robot interaction.

Various modes such as physical, contact free, contact based or auditory are available.

In case of physical communication- robotic estimation of applied forces can then estimate magnitude, direction and duration of touch.

Contact free interaction methods like visual interaction, voice recognition and foot-pedal controlled commands.

Programming- time consuming conventional process has evolved to become more efficient.^[1]

2) Machine Learning

It makes use of large amount of data to improve and enhance from experience. Speech identification, augmentation and training, learning and detection of objects are different aspects of machine learning.^[1]

AREAS OF APPLICATION OF DENTRONICS

1) Oral medicine

ANN (artificial neural network) helps in risk assessment of oral cancers.

For the assessment of MRONJ (medication related osteonecrosis of jaw) AI-aided systems such as ANN, SVM (support vector machine), logistic regression and decision tree have proven to be successful.^[9]

2) Maxillofacial surgery

Transoral robotic assisted surgery -Use of computer enhanced system to guide surgical tools for enhanced view of pathology in head and neck area.

Another robotic application for dental implant placement is **YOMI**- produced by NEOCIS where arms of robot drills holes in jaw and places implant in the required site.^[5]

Other applications include use of 3D photography, intraoral scanning and images, digital imaging for planning orthognathic surgical procedures and assessing its results.

Application -the surgeon controls the robot at the time of the surgery after which the robot does the preplanned tasks in the operation theatre- milling and drilling of bones, placement of osteotomy cuts, selection and placement of plates, surgical planning, etc.^[5]

3) Robotic Education

Designed to mimic humans, a full body patient simulation system known as **SIMROID** was introduced and has following - can verbally express pain, blink, shake head, perform movements of jaw, tongue, elbow and wrist along with other functions to induce saliva flow and bleeding.

SIMROID was invented at The Nippon Dental University Kokoro in collaboration with the manufacturer of dental equipment Morita Manufacturing. It is a realistic dental training robot for dentists than the conventional technique.^[5]

The Smiling Robot' is a human Like robot- in which the operator controls the movements. It has feature of voice recording to read out the instructions to the patient.^[6]

Another such invention is **ROBOTUTOR** which was created to compare efficacy of different types of health education for demonstration of tooth brushing technique- "Bass brushing method", thus saving dentist's chair side time. It comprises of a toothbrush that brushes using a robot arm on dental models and an auditory recording on the side with instructions. A questionnaire was used to evaluate its effectiveness.^[7]

4) *Prosthodontics*

Yuan et al. explained a tooth preparation system that uses robot with the following components.

1. Intraoral 3d scanner.
2. CAD-CAM software.
3. Low heat laser.
4. Robotic arms.
5. Tooth fixture connecting robotic arm to the target tooth.

Robots can be used to test tooth filling materials, dental implant materials, dental impression materials.

Time consuming conventional methods of determining the dental arch might be taken over by robot for fabrication of complete dentures, thereby saving time.

A software was developed to make removable prosthesis easier and faster known as RAPID. (combined with the application of CAD/CAM).

CRS robot manufactured in Canada- is a 3 D virtual tooth setting programming software that completes the entire procedure.^[5]

5) *Periodontics*

Yauney et al. made use of an AI system on a CNN (convolutional neural network) to form connections between periodontal disease and systemic conditions. The outcomes revealed that AI could diagnose disease and act as a diagnostic instrument.

In another study, Papantopoulos et al. considered immunologic parameters like cells- white blood cells, interleukins, and IgG antibody titres to state the differences between aggressive and chronic periodontitis.

Krois et al made use of CNNs (convolutional neural network) to predict periodontal bone loss by using panoramic dental radiographs. This facilitates easier diagnosis and treatment planning for periodontal diseases.^[10]

The ability of toothbrushes to clean the tooth surfaces, the difference in effectiveness between hand and robotic brushing is compared and tested. Results showed that robotic brushing of teeth is an easier and better option for plaque removal studies and might even replace clinical studies in future.^[1]

Driesen et al in an in vitro robot study, developed the Braun Oral-B Ultra Plaque Remover (EB5 brush head and D7 handle) which mimics normal clinical toothbrush in use. A hybrid new brush head (EB9) having longer

bristle tufts was made to improve interdental penetration.^[7]

The Panda robot (Franka Emika, Munich, Germany) was developed, which comprises of seven degrees of freedom and performs its movements with a precision of $< \pm 0.1$ mm and a deviation of $< \pm 1.25$ mm. It was concluded that Panda robot was definitely able to perform this task. However, balance between sensitivity and strength of the overall setup is challenging.^[8]

The CNN (convolutional neural network) models are helpful in diagnosis and assessment of periodontally compromised teeth with the use of radiographs.

Use of SVM (support vector machine) to distinguish between aggressive and chronic periodontitis by examining the presence of subgingival plaque.^[10]

5) *Endodontics*

To enhance accuracy in root canal treatment, Nelson et al explained about "**vending machine**" which supplies necessary root canal instruments to the dentist.

CAD (computer aided diagnosis) makes use of artificial intelligence for detection of periapical lesions, vertical root fractures.

According to Ekert et al, CNN (convolutional neurons network) was successful in detecting periapical lesions on panoramic radiograph, enhancing the precision and reliability.

According to Saghiri et al, ANNs (artificial neurons network) are an accurate method to determine working length of tooth.

The study on stem cell viability by Bindal et al, using neuro fuzzy interference system was proven to be successful.

This robot was created to enhance the accuracy in endodontic treatment and provide quality root canal therapy. With the use of computer assisted endodontic technology, the micro robot accomplishes access opening, cleaning and shaping of the canals and obturation of the root canal system. It provides precise treatment with less errors relieving stress of the dentist.^[3]

6) *Orthodontics and jaw movement*

Robotic technology can be used to adapt orthodontic wires to the tooth. Edinger created a system that imitate condylar movements.

Use of ANN (artificial neural network) to diagnose the need for orthodontic extraction depending on malocclusion.

CNN (convolutional neural network) helps to assess treatment outcome.^[10]

Suresmile (OraMetrix, Richardson, Tex) is a computer-aided customized archwire bending system. It comprises of a robotic system mounted on to table or base support surface.^[7] This technology is used for automatically bending archwires according to specific shape to tooth. There are tools and heating device along with the use of

CAD/CAM, 3D imaging and computers for the manufacturing of orthodontic appliances.^[3]

7) *Pediatrics*

Artificial Intelligence used pain control gadgets which is the new step towards injection-free pedodontics practice. Newer Behavior modification aids for pediatric patients are- 4D goggles, playing movies, animations and virtual based games.^[3]

9) *Radiology*

The positioning of Xray source and sensor is performed by a 6-DOF robot arms without any side effect.^[8]

Studies have proven that due to accuracy and precision, robot system is superior than the conventional approach.

10) *Robot assistant*

Includes human and robot interaction, touch display input, speech input and visual gestures.

11) *Airway Management*

Lately, the development of smart watches made it easier to track fitness and health of an individual. Similar to this another system was introduced- such as “apnea detector” that assists in diagnosis of sleep apnea.

With the use of tracheal GPS (module output), localization of tracheal rings is possible, thereby helping in diagnosis of respiratory problems.^[1]

12) *Implants*

The Artificial Intelligence models were made to identify the implant type by using periapical and panoramic radiographs and it was shown to have an accuracy of 93.8-98%.

They were successful in assessing osseointegration success to be 60-80%.

They are also useful in reduction in the load at the implant-bone interface by 36.6%.

The latest system of computer assisted surgery for guided implant placement is achieved by getting 3D constructed model that resembles the patient’s jaw obtained from CBCT imaging data which is then implemented to drill a jaw splint at the site planned by a software system.^[5]

In 2017, YOMI (Neocis, Miami, FL, USA) was the world’s first to computerize navigation robotic system that was affirmed by the FDA to increase the clinical accuracy of dental implant surgery. It was invented to offer assistance in both the planning(pre-operative) and the surgical(intra-operative) phases of dental implantation surgery.^[7]

Obstacles in implementing this technology.

- 1) Expensive
- 2) Difficulties with patient compliance
- 3) Require more expertise
- 4) Acceptability issues
- 5) Dentists should always be careful when interpreting information by artificial intelligence. Safeguarding

medical information under HIPAA (health insurance portability and accountability act 1996) is necessary.

Artificial intelligence needs algorithm for solving question. These programs require clinicians and computer engineers for further development of the technology.^[2]

Future Considerations

As inferred by studies, it is implied that the use of robotic technology in dental sciences enhances precision, reproducibility, and reliability. The amount of research carried out in robot enhanced dentistry is restricted due to the lack of accessibility of systems. There is less expertise in programming and regulation of robotic systems. Hence, the analysis to be performed in this area requires a partnership between dentists and engineers which might show alterations.

Most of the researches involving dentistry and engineering in robot enhanced dentistry includes dental implantology, that is invasive in nature and might affect the undertaking of this solicitation between dentists and patients. Therefore, research in the assistive robotic dentistry has proven to be of more significance in this robotic-enabled era.^[7]

CONCLUSION

Dentistry is heading towards the period of robotic assisted and data driven technologies, however artificial intelligence cannot be fully implemented in dental practice and study as it is expensive and difficult to handle.^[1]

The advantages of these neural networks are better efficiency, accuracy and precision, less time consuming than the traditional methods.^[10] Artificial Intelligence has great impact on the health care which leads to the investment and interest of researchers and companies. As Artificial Intelligence-based services are flourishing into the market, their advantages are becoming more prominent. For improvement and success of dentronics, dentists should enhance their knowledge of digital and human interaction.

Although robots have been developed for applications such as multimodal movements, surgery, and for other specialities of dentistry- however, their applications in areas like chemical and physical biofilm disruption have to be further investigated.^[2]

REFERENCES

1. Grischke J, Johannsmeier L, Eich L, Griga L, Haddadin S, Dentronics: towards robotics and artificial intelligence in dentistry, Dental materials, 2020 June 1; 36(6): 765-78.
2. Chen YW, Stanley K, Att W. Artificial intelligence in dentistry: current applications and future perspectives. Quintessence Int, 2020 Mar 1; 51(3): 248-57.

3. Das H. Robotics in dentistry: the next generation technology. Dental Reach. Available online: <https://dentalreach.today/dental-education/robotics-in-dentistry-the-next-generation-technology/> (accessed on 23 December 2020), 2019.
4. Dimri D, Nautiyal S. Dental robotics-get going. International Journal of Science and Healthcare Research, 2020; 5(2): 424-6.
5. Syed S, Dawadi TB, Zaheen Khan M. Robotics Using Artificial Intelligence in Dentistry. DTC Journal of Computational Intelligence, 2022; 1(1): 1-4.
6. van Riet TC, Sem KT, Ho JP, Spijker R, Kober J, de Lange J. Robot technology in dentistry, part two of a systematic review: an overview of initiatives. Dental Materials, 2021 Aug 1; 37(8): 1227-36.
7. Mishra, Supriya & Johnson, Lynn & Upadhyay, Palak. (2023). DENTRONICS, ROBOTICS, AI in dentistry. European Chemical Bulletin, 12. 2630.
8. Mönnink C, Eich L, Haddadin S, Stiesch M, Grischke J. Dentronics: tooth cleaning with a tactile collaborative robot--an in vitro proof of concept. International Journal of Computerized Dentistry, 2023; Apr 1(2): 26, 167-174.
9. Altalhi AM, Alharbi FS, Alhodaithy MA, Almarshedy BS, Al-Saaib MY, Aljohani AS, Alshareef AH, Muhayya M, AL-harbi NH, ALHARBI FS, Alhodaithy M. The Impact of Artificial Intelligence on Dental Implantology: A Narrative Review. Cureus, 2023 Oct 30; 15(10).
10. Alzaid N, Ghulam O, Albani M, Alharbi R, Othman M, Taher H, Albaradie S, Ahmed S, AlBaradie S. Revolutionizing Dental Care: A Comprehensive Review of Artificial Intelligence Applications Among Various Dental Specialties. Cureus, 2023 Oct 14; 15(10): e47033.