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Robotic Technology in Prosthetic Dentistry: A Review

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***Abstract*:-**

- ***Objective***

The purpose of the article is to present a narrative review of the literature related to application of robotic technology in prosthodontics.

Dentistry has made a significant technical transition from manual techniques to digital technology. Applications of robotics have become more and more popular in many medical fields, including dentistry, as a means of streamlining manual procedures and enhancing accuracy. The main applications of robotic interventions in prosthodontics are in the design and manufacture of complete or partial dentures, as well as in assisting with dental implantology surgical procedures. In both situations, significant advancements have been made, enabling treatments with high success rates to be carried out with a better degree of accuracy with significantly reduced amount of time required for completion of procedure.

- ***Materials And Methods***

A literature search was performed in the online databases – PubMed, Science Direct, Medline and Google Scholar with the following:

- ***Conclusion***

Robotic assistance in prosthodontics has led to tremendous progress specially in laboratory work and placement of implants. However, using these intricately built robots for various prosthodontic procedures needs close supervision from a trained dentist. Clinical judgment and specialist competence of dentist are indispensable.

Keywords:- *Robotics, Prosthodontics, Implantology, Dentistry.*

I. INTRODUCTION

The field of prosthodontics has been evolving and proving its capacity to adjust to new demands. Newer ideas, methods, and materials have an impact on prosthetic dentistry education, research, and clinical practice. The use of robots in prosthetic dentistry is one of these advancements.[1]

The term "robot" was first used by playwright Karel Capek in his 1921 production of Rossom's Universal Robot. The Czech term "robota," which denotes forced labor, is where the word "robot" originates. With his science fiction novel I Robot, published in 1950, author Isaac Asimov first introduced readers to the multidisciplinary field of engineering and science known as robotics.[2] Robot is defined by the Robot Institute of America as "a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized equipment through various programmed motions to accomplish a variety of tasks."[1] Robots are human inventions that help to decrease human effort in dangerous working settings, improve the accuracy and efficiency of the task being done, and reduce manual labour altogether.[3]

Robotic systems are designed to be intelligent surgical instruments, not to replace human surgeons. They help to improve surgical treatments' accuracy, reliability, and safety. Their ability to open a line of communication between preoperative surgical plans and the operating room is maybe their most important expertise. Dental implants and complete or partial dentures can be created with robotics in prosthetics. Robotic technology in prosthodontics is an entirely new concept, thus theoretical and technological advancements will be seen in research on robots used in prosthetic dentistry.[2]

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II. APPLICATIONS IN PROSTHODONTICS

A. Dental Patient Robots

These were introduced for the education of dental students. These include simple phantom heads having only functional cephalic region to geminoids which mimic various head movements, expressions on the face, and simoroids that provide dentists with emotional feedback, especially regarding when it comes to pain and discomfort.[4]

B. Teeth Arrangement Robots

CRS Robotics Corporation, Canada, developed a single manipulator robotic system with six degrees of freedom (DOFs) for the fabrication of a complete denture. (1) CRS robot, (2) electromagnetic gripper, (3) computer, (4) a central control system with tooth-arrangement and robot control software for tooth-arrangement, motion planning and control, (6) light source device, and (7) light-sensitive glue are the main parts of the system[5]

A virtual 3D tooth-arrangement program is created using VC++ and OpenGL. The following tasks are performed by this virtual 3D teeth arrangement software: (a) generates or selects a file pertaining to the patient's medical history, and employs an expert's experience to design a jaw arch based on the patient's measurements for the jaw arch; (b) examines three-dimensional virtual teeth on a screen and adjusts each tooth's position. This robot system can handle a maximum load of 3 kg and has a repeatability precision of +/- 0.05 mm. Its highest line velocity is 4.35 m/s. Nevertheless, it was discovered that the artificial teeth were difficult for the system to precisely grip and manipulate.[6,7]

A 50-DOF multi-manipulator tooth-arrangement robotic system with 14 independent manipulators, a dental arch generator, and a slipway mechanism was then constructed. Its mode of action is straightforward, proficient, and simple to control. It just takes 30 minutes to complete the manufacturing of the entire denture using this robotic technique. The robotic system's accuracy is noted. For a single multi-manipulator, the repeatable positioning precision is ±0.07 mm, and for the robotic system as a whole, it is ±0.10 mm..[6,7]

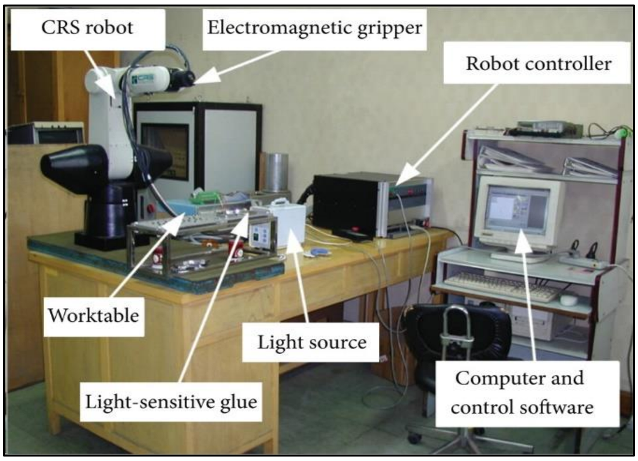

Fig 1: CRS Teeth-Arrangement Robot System for Complete Denture

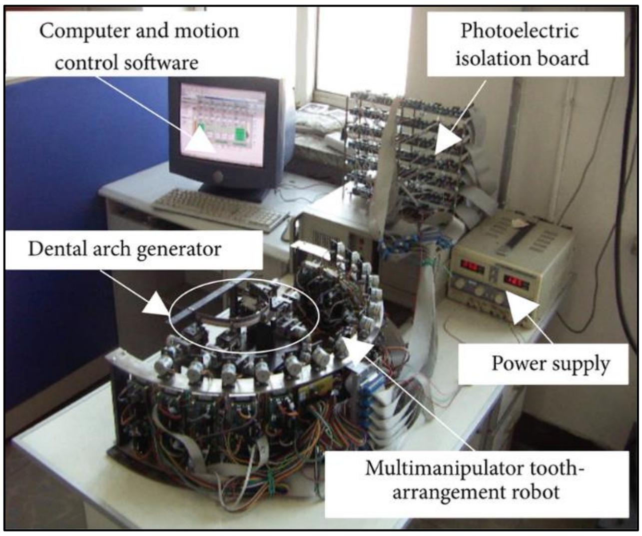

Fig 2: 50 Degrees of Freedom Multi-Manipulator Tooth-Arrangement Robot System

C. Dental Implantology Robots

Precision in implant placement is crucial to the success of dental implant therapy. Dental professionals employ navigation and surgical template guidance technologies to decrease implant placing errors.The application of robots in implant surgery facilitates more precise and stable implant placement.

The first dental implant placement supervised by a robot was first demonstrated by Boesecke et al in 2002. With 48 dental implants positioned within 1-2 mm of the apical border during implant osteotomy, the device, which has a working region scope of 70 cm, completed the implant drilling guide to assist the surgeon.[8]

Later, a 3-DOF robotic system with a stereo camera was developed, which ensured that the implant placement followed the preoperative protocol by detecting and adjusting the dental handpiece. The computer automatically carried out the pre-planned surgical operation to guarantee the proper cutting spot and force application.[9]

In 2017, the first computerized navigation robotic system in history to be granted FDA approval to improve the clinical accuracy of dental implant surgery was designated as YOMI (Neocis, Miami, FL, USA). By limiting the drill's depth, orientation, and location, haptic robotic technology from YOMI provides physical guidance that precludes the operator from making a custom surgical guide and hand deviation. Vibrational feedback is used by the navigation system to prepare dental implant osteotomy with excellent predictability and precision.[10]

Zhao unveiled the first automated implant placing technology in the world in 2017. It was possible to do surgical procedures without a dentist's assistance, and surgical duties have a high degree of autonomy when it comes to automatic modification. Nevertheless, there aren't many validation data available for the robot's intelligent decision-making or the viability and dependability of implant placing.[11]

Fig 3: Yomi Dental Implantology Robotic System

D. Robots for Tooth Preparation

Tooth preparation is routine work of clinicians; their main goal is to reduce the size of the tooth to create room while causing the least amount of damage to the healthy tooth material. In Yuan et al.'s presentation, they described a tooth preparation robotic system that consisted of the following components: (a) a tooth fixture that secures the target tooth to the robotic tool and prevents the adjacent tooth from being cut by the laser; (b) a 6-DOF robotic arm; (c) an effective low-heat laser suitable for hard tissue preparation; (d) CAD/CAM software to create a 3D laser motion path and design the target shape for tooth preparation; and (e) an intraoral 3D scanning device to gather 3D information about the subject's teeth fixture, opposing teeth, adjacent teeth, and the target tooth. A tooth preparation system that utilized micro-robots to modulate a picosecond laser device demonstrated an accuracy that satisfied clinical standards, with an error of roughly 0.089 ± 0.026 mm. Further research is required in the field of robotic technology for tooth preparation.[11]

III. ADVANTAGES AND DISADVANTAGES

➢ *Advantages of Robotics*

- Exceptionally great precision and accuracy.
- Sturdy and resilient, permitting constant use without interruption.
- Capable of accurately analyzing and assessing quantitative data that is entered into the system.

➢ *Disadvantages of Robotics*

- Unable to use any qualitative information as there is no judgement of the situation.
- Continuous monitoring by an experienced dentist is required.
- Fairly expensive and unattainable for an ordinary individual.

IV. CONCLUSION

The employment of robots in prosthetic dentistry is now a reality, despite the field being in its early stages. In this era of swiftly evolving concepts and technologies, high quality research is required to reap the benefits from this remarkable innovation. Robotic help in prosthetic dentistry will remain a contentious issue in the years to come. When utilized under the guidance of a skilled dentist, the employment of sophisticated and highly specialized robots helps to improve the precision and accuracy of a variety of prosthetic treatments. Robotics cannot replace a skilled dentist, but will enhance the outcome of certain prosthetic treatments.

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