

## Robotics in the Contemporary Era of Conservative Dentistry and Endodontics

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### Abstract

In the era of contemporary clinical dentistry one can come across numerous technological advancements including artificial intelligence, virtual reality, augmented reality etc. Invention and application of 'Robots' in the domain of health science apart from other fields of human life is a new avenue and showing promising results. Dental health science is not exception to this, and robots have already engulfed many specialities of dentistry including Oral Implantology, Oral Surgery and Prosthodontics. However, there are fewer research articles showing application of robotics in the field of Conservative Dentistry and Endodontics. Therefore, the aim this research paper is to show case the details of robotics in the arena of Conservative Dentistry and Endodontics and creating awareness among dental professionals abouts its usage.

**Keywords:** Artificial Intelligence; Endodontics; Robots; Robotics in Dentistry; Science and Technology

### Introduction

There is a tremendous advancement triggering in science and technology in the contemporary era of human mankind across the globe including all fields [1]. Invention of 'Robots' is an example for the changing paradigm in the technologic field of 20<sup>th</sup> century. The term 'Robot' was first coined by a scientist called Karel Carpel in 1920, who is a Czech writer. He published the science fiction script titled Rossum's Omnipotent Robots, in which the word 'Robot' is mentioned. Robot is a 'Czech word' having the meaning of 'Labor' or 'Drudgery' [2].

In Dentistry, application of robots represents a revolutionary breakthrough in the domain of dental research and clinical practice. In addition to digital dentistry and intelligent dentistry, introduction of robots is revolutionizing patient care with advanced technological integration, minimally invasive procedures and improved treatment procedure outcomes and patient experiences [3]. A better knowledge

of current status, challenges, and future directions of dental robots is highly warranted among all clinicians to provide efficient, making quick decision and maximise the advantages of 'Digital dentistry.' Therefore, the aim of this research review article is to enlighten the readers in detail about the major contributions, applications, limitations and limitations of robots in Clinical Endodontics and Conservative Dentistry.

**History behind the development of robots**

Masahiro Mori was the first person who put forward a representative definition of robots at the first robotics' conference held in Japan in 1967 [4]. According Masahiro Mori robots can be defined as "A flexible machine with seven characteristics such as intelligence, semi-human, slave, automatic, semi-mechanical, versatility, individuality and mobility." Later the American National Standards Institute defined a 'Robot' as a mechanical device that can be programmed and can perform certain operations and mobile tasks under automatic control [3,4].

**Application of dental robots in the current scenario**

Due to rapid pace of research development in the modern science and technology worldwide, introduction of robotics has gained interest among all fields. Robotics has been used in many arenas like electronics, aerospace, medicine and machinery science. Among these fields, application of robots in 'medicine' has attracted increasing attention and has become a popular research area and social concern. This innovative technology has been introduced in major specialties of dentistry such as Oral Implantology, Orthodontics, Endodontics, Prosthodontics and Oral Surgery [5].

Recently in 2023, Liu., *et al.* [4] from Japan performed a literature search using databases such as MEDLINE, IEEE and Cochrane Library using the MeSH terms like 'robotics' and 'dentistry.' They found forty-nine articles based on selection criteria consisting of 12 research studies on prosthodontics (24%) and 11 articles on dental Implantology (23%). Scholars from China published the most articles on dental robots, followed by Japan and the United States. The number of articles published from 2011 to 2015 were found maximum. Finally, authors concluded that due to enormous advancement of science and technology, the use of robots in dental science has resulted the development of intelligent, precision, and minimally invasive dental treatments. Automatic tooth-crown preparation robots, tooth-arrangement robots, drilling robots and orthodontic arch wire-bending robots that fulfil clinical requirements have been advancing [4]. Therefore, research and application of robots in the dental education, dental treatment and research area can give pave for new directions for the future of dentistry.

**Types of robots**

'Medical Robots' are mainly divided into three types and it is elaborately described in table 1. The successful application of medical robots has also garnered enthusiasm for research on robotics in dentistry, which breaks through the previous oral diagnosis and treatment models and promotes a new avenue for technological innovation [5]. In addition to these, there are fully automatic robotic systems and semi-automatic human collaborative robotic systems developed. Da Vinci Surgical system is another type robotic system come under robot-assisted systems which are fully operated by a surgeon [5,8-10].

Types of Robots		Description
1.	Macro Robots	Includes Home daily-care robots and smart wheelchairs. Includes Brain-surgery, minimally invasive surgical robots, medical endoscopic devices and eye-surgery robots.
a.	Rehabilitation Robots and	
b.	Surgical Robots	
2.	Micro-medical Robots	-
3.	Bio-Robots	Are medical robots that can think, perceive and judge like humans.

**Table 1:** Types of medical robots [5].

### Application of robots in the contemporary era of conservative dentistry and endodontics

#### In root canal treatment

In endodontic specialty, a robot called the 'Omin Phantom' with a haptic virtual reality simulator has been developed to help operator to efficiently train in endodontic procedures [4,6]. During root canal treatment, there are chances of a K-shaped file or rotary file breaking in the root canal causing root perforation. Therefore, using a simulated K-file along with 'Omin Phantom,' the operator can experience the process of burring the enamel and dentin and cleaning the inner surface of the root canal walls. In addition to this, Hong Seok at 'Columbia University' proposed a project named 'The Advanced Endodontic Development' which aimed to develop an intelligent micro-robot that can perform endodontic treatment automatically [4,5].

Dong, *et al.* in 2007 [7], developed a multifunctional endodontic microrobot to enhance the efficiency of root canal therapy. They discussed the mechanical design and manufacturing of this robotic system and its innovations. According to these authors because of the conceptual robotic design, the robot will be mounted on several teeth in the patient's mouth and 3D tooth model will be built using two-dimensional radiographic images. A prescription system will design the treatment procedures and the micro-robot will perform automated root canal drilling and filling. Understanding the automatic treatment process through computer control by fixing it on the patient's teeth can help clinician to understand probing, cleaning, drilling and filling of the cavities. Robots also can help the endodontists to prepare the cavity by running the drill with more precision and smoothness thereby reducing the iatrogenic damage [7].

Toosi, *et al.* in 2014 [11] from Iran developed a 'Haptic Virtual Reality Simulator' for root canal treatment. The advantage of this system was that the operator can burr the enamel and dentin until reaching the pulp chamber and then clean the internal surface of a root canal using a simulated K-file. The advantage of this robot in endodontics helps improving the training for new learners in the domain of endodontics [11]. In the next year (2015), Razavi, *et al.* [12] again from Iran invented a 'Haptics-based Tooth Drilling Simulator' which had the advantage of capability to run in a real-time fashion. These scientists incorporated the force calculation ideas to a uniform sensation of force. This is a new approach which calculates the feedback force, and the speed of haptic loop execution and increased approximately eight times in the process of a haptics-based tooth-drilling simulation [12].

Another advancement happened in the endodontics is the development of micro-endodontic robots in order to overcome the limitations of old-aged conventional traditional endodontic treatment like insufficient mouth opening. Hence advent of these micro robots can enable patients to obtain more accurate, safe, and reliable root canal treatment [11,12]. However, still research is going on for invention of new design and manufacturing of microsensors and actuators.

#### Limitations of Robots in Endodontics

Although dental robots have enormous applications in endodontic dentistry including many advantages, several critical issues concerning privacy, ethics and patient security must be strong considered. Usage of robots in endodontics results is an expensive setup. As a result, patients mainly females are less agreeing to take treatment given by robots. Unclear patient acceptance and patient compliance also results in limited use of robots. In terms of initial cost, maintenance, the requirement for additional components, and the necessity to program the robot to perform the task, practical robots are found typically expensive compared to conventional treatment given by dentists or clinicians [11,12].

#### Conclusion

The advent of robotics in dentistry is still in its infancy and requires some more time for the acceptance and adoption of this innovative technology. Definitely it is not a 'Fiction' but a 'Reality/Future' and in the near future, robots will change the existing conventional dental treatment procedures' model and guide new directions for further development. It does not take a long time to make 'a futuristic dream come true' in the techno-verse era of Endodontic Dentistry.

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