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ARE WE SMART ENOUGH TO USE SMART TECHNOLOGY' INTERNET OF THINGS (IoT) IN DENTISTRY? - A NARRATIVE REVIEW

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ABSTRACT: Today's world is 'Internet Era'. It reached to nook and corner of the world and every alternative person walking on the road holds a smart phone. The internet plays a major role in day-to-day life. Usage of different applications of internet spread its tentacles in to all the industries, including health system and dentistry is no exception. Some of the dental clinicians are already using internet-based applications in their practice and providing predictable services to their patients. Technology along with smart gadgets are becoming trend in the dentistry. One such application is using Internet of Things (IoT) in dental practice which is spreading slowly like 'water under the rug'. This narrative review aimed to discuss various Internet of Things (IOT) using in dental field.

KEY WORDS: Internet of Things (IoT); Dental Use; Artificial Intelligence (AI); Internet of Dental Things IoDT); Advanced Technology.

INTRODUCTION: Internet of Things (IoT) works with big network connected to various gadgets which can receive and transmit the data. IoT will become a revolution in dentistry in the future, which can benefit both the patient and the dental clinician. While a patient is seeking dental treatment, lot of hesitations, due to discomfort, number of visits, fears etc. The IoT loaded technology can give best solutions for these. IoT

devices help the patient to monitor their own health and can share the same information to their dentist easily.

Internet of Dental Things [IoDT] is the alternative name for the use of IoT in dentistry. [1] It is nothing but, the objects, public and internet are linked together buttoned up the digital technology. There are 3 types of IoT: 1. Physical world (with physical objects, example-sensors, wearables and smart phones), 2.Virtual world (Information connects from devices connected to the IoT network), 3. Cloud (Computer process system handles all the data sent through Internet). The common sensors which are using in IoDT are: a. Accelerometers, b. Capacitive sensors, c. Motion sensors. [2]

In general, other than medical field, IoT benefitting a lot, unfortunately, IoT is still at infantile stage in the dentistry. But some of the dental specialities of dentistry are practicing IoT application-based treatment and experience positive results. [3] The latest IoT based technology is available for the clinicians, some are already using successfully by the dentists, and some are very new to the dental field. They include:

1.**Smart Tooth Brushes**: These IoT incorporated smart brushes will give good explanation to majority of the patients who routinely asks their dentist about how frequently to clean their teeth. These smart brushes can track the data about how many times patient is brushing, how much pressure applying while brushing. Some of the brushes even having the provision of in-built cameras which can take the pictures of teeth. Patient can directly send these pictures to their dentists for evaluation of the teeth such as having cavities in their teeth, fracture of the tooth portion etc. [4-7]

2.**Smart Dental Implants**: The success of any implant depends on its proper integration with bone. To assess the osseointegration of the implant, regular radiographic evaluation is the fundamental protocol. The latest inventory in implant technology is ‘smart dental implants’ which can perform the job without taking regular radiographs. The smart dental implants are incorporated with the sensors which can passively assess the bone growth and tracks the osseointegration. The sensor is called “ Ti-PEEK hybrid implant” which was developed by Iranian researcher Prof. Alireza Hassan Zadeh, at Beheshti University. The sensor made up of with Titanium and PEEK material. These implants which are embedded in the implants does not require any battery support to function, whereas works by means of ‘microfabrication method. The data will be sent to a reader device, in turn the readings will be transfer to a ‘data logger’.[5],[8,9]

3.**Spot Dental Implant**: Sometimes the dental clinicians will face peculiar situations, like patient comes with radiograph of an implant placed in the jaw. Patient does not have any other data about that implant. To complete the rest of the work, the dental clinician face difficult situation because there is no data about

which system was used by the previous dentist. To identify the data about that unknown implant, IoT provides solution through Artificial Intelligence (AI) based applications. This application will work on the radiographs which were taken for the unknown implant by company name from thousands of available implant models from the data base with the help of Proprietary Deep Learning [PDL]algorithms. This application can identify the implant model even from simple IOPA radiograph and reveals us the dimensions and other properties of that unknown implant.[4]

4.**Tooth-Mounted Diet Sensors**: The type of food consumed by the patient will have effect on their natural teeth also apart from general health, such as consumption of high carbo diet, salt intake and consumption of alcohol etc., will have negative effects on the natural teeth. It is very difficult to monitor physically and sometimes patient may not give correct history. Research from Tufts University school of engineering came with a solution by attaching small sensors [2mm x 2mm] either on the patients' natural teeth or artificial teeth. These sensors will track the sugar, salt and alcohol intake by the patient chemical changes occurring in the patient mouth and simultaneously the readings will be sent to the linked mobile phone wirelessly. Also, these sensors can track the food intolerances, allergies and eating disorders. According to Fiorenzo Omenetto, the sensors will aid in assessing the problems before and also helpful to the dentist to render preventive treatments. [4]

5.**Wearable biosensor system**:Due to the increasing health awareness among the general public, availability of advanced technology and gadgets with the concept of minimally invasiveness, introduction of wearable biosensors came to lime light, which can help to monitor cortisol, glucose and alcohol. Some of the advanced Biomarkers can monitor patient B.P; heart rate, body temperature, ECG etc. The data will be transfer to mobile phones to assess and interpret and verify and uses for follow- up visits.[1], [2],[10]

6.**RFID [Radio Frequency Identification]**: Useful to identify the goods, track the shipments with out intervention of humans. RFID can gather the information. It is already using in dentistry, both for clinical use as well as nonclinical use. It is also very useful in forensic odontology used as denture identification in prosthodontics. [11] RFID system contains one tag [transponder] attached to an object like instruments and dentures etc , which releases the signals received by the 'reader' with the applications of softwares. [12,13,14]

7.**Teledentistry**: The combination of advanced technology of dentistry and information technology together serve dental care across remote and inaccessible geographical areas where the patients will get the consultation from the clinician through telecommunication by videoconferencing, sending radiographs and photographs.[15] The patients will convey their health information through phone to dentists who stays remotely. Dentists will chat with the patients via video calls and if necessary, the patients will bring to the

dental clinics to provide needy treatments. Usage of smart phone is benefit for both the patient and the clinician. [16] For oral health enhancement of rural population, in many parts of the world, teledentistry services and various dental programmes together providing the dental services to the needy patients. Thus, teledentistry could be a great modality to remove the gap regarding dental care between rural remote areas and civilized urban areas There is a clear-cut difference between dental care in urban areas and remote rural areas. The teledentistry can close the gap between these two.[17]

8. **Smart Mouth Guards**: The mouth guards are commonly used to protect the teeth in bruxism patients. They are preparing with either hard acrylic resin or soft flexible resin. Their job is only safeguarding the teeth during functioning. The dentist will not have any information regarding the concentration of pressure on the affected teeth. This problem can be addressed by the application of IoT. By incorporation of pressure indicating sensors in the 'smart mouth guard'. Even the smallest vibration of pressure will be noticed by these sensors and will send alerts through blue tooth or smart phone. [2,5,18,19]

9.**Artificial Intelligence (AI)**: Now the revolutionary technology adopted by all the industries including health sector and there is no exception for dentistry. Almost all the specialities of dentistry already using AI based dental treatments and happy with the results. The AI based algorithms are using to identification of future health risks includes from simple caries and fractures of roots to pre-malignant, oral cancer, maintaining patient data, virtual dental assistants, examination light etc. [3,20,21]

10. **Intra oral scanners**: Making accurate impressions of the patient jaws is the starting of some of the speciality treatments, which is a challenging procedure. Required proficiency to record accurate details of both hard and soft tissues of the oral cavity. Some of the clinical situations are very challenging to the dentist such as severe gagging, small mouth opening etc. AI based technology will become answer for these challenges. One such device is an 'Intra oral scanner' which is latest arsenal to record the soft and hard tissues of oral cavity. It is a simple, painless, easy to use and accurate details can be reproduced.[2,3,22]

11.**CRISPR [Clustered Regularly Interspaced Short Palindromic Repeats]**: It is a cancer fighting method by means of 'genomic editing'. The research is underway in dentistry to switch off the oral cancer-related genes. Also using in periodontics to change the functioning of the plaque formation bacteria as well as tooth decay.

12. **3D Printers** : Some of the clinicians are inclined towards 3D printing to prepare complete dentures, temporary and permanent crown and bridge works, RPDs and aligners for orthodontic treatments. 3D

restorations are accurate and consumes less chair side time. Presently this technology is not cost effective. [1,2,19,24]

13. **Robotic Surgery**: This technology is not new for the dentistry. Clinicians are using this technology to do tooth fillings, scaling, extraction of teeth and some of the TMJ treatments. Robotic surgery is claiming for its accuracy, precision and showing good results for the patients. [1]

14.**Pearlii** : This is an IoT based application which will allow self-tracking and monitoring of one's own oral health. Patients easily can install this app in their smart phone. This Pearlii application can also scan photos and send to clinicians to get instant advice. [23]

CONCLUSION: Latest technology and gadgets are always welcomed by the dental field. Whenever new technology comes there are people to use and support, and equally people are against for sometimes, later they will realise the advantages of that technology and start using it. In this present competitive world, it is not enough new technology introducing, but the clinicians who must gain knowledge about that technology and start using it.

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