Futuristic Trends in Odontology

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ABSTRACT

Odontology is the division encompassing all disciplines involving the various fields of dentistry and cranio & maxillofacial research, ranging from basic structures to molecular studies related to oral health and disease. Scientific study of the macroscopic and microscopic structure and diseases of teeth such as tooth decay, compromised periodontal tissue health, dental plaque and calculus, dentinal hypersensitivity, misaligned teeth and Dentofacial orthopedics, etc are dealt under its umbrella. Here, in this chapter we would like to give a briefly introduce odontology and its branches and futuristic trends in odontology that will change the face of future.

Keywords—dentistry; artificial intelligence; augmented reality; virtual reality; cytogenetic; nanotechnology

I. INTRODUCTION

Odontology deals with thediagnosis and study of the causes and effects of diseases affecting the oral and maxillofacial region. The Term "Odontology" takes its origin from French word odontologie, odont- + -logie -logy. Mouth is one of the most important organs with essential functions like eating and speaking. It also serves as a window into the rest of the body as many systemic conditions appear through oral lesions as their first symptoms.

Dentistry is the study, examination, investigation, diagnosis, prevention, and treatment of diseases, disorders and conditions of the oral cavity, especially the teeth, and to an extent related conditions in the maxillofacial area [1]. According to the 1997 American Dental Association House of Delegates, "Dentistry is defined as the evaluation, diagnosis, prevention and/or treatment (non surgical, surgical or related procedures) of diseases, disorders and/or conditions of the oral cavity, maxillofacial area and/or the adjacent and associated structures and their impact on the human body that is provided by a dentist, within the scope of her/his education, training and experience, in accordance with the ethics of the profession and applicable law" [2].

II. HISTORICAL BACKGROUND

In the early medieval times, teeth ailments such as decayed teeth and mouth sores were treated by barbers who used their sharp instruments and dexterity to take on the role of dentists. They were then called the "***Barber Surgeons***". England was the first to forbid barbers from practicing surgery and this practice came to an end when the last barber- surgeon passed away in 1820. A renowned surgeon coming from France, Pierre Fauchard, who is also known as the "***father of modern dentistry***", revolutionized dental surgery in the late 17th and early 18th century with his outstanding modifications of dental instruments, inspired by instruments used by jewelers, watchmakers, and even barbers that he believed could potentially be employed in dentistry. [1]. Fauchard was also the first to pioneer and invent many methods to replace lost teeth.

Next came the era of modern dentistry in which greater emphasis was given to high quality and high definition scientific evidence which will be used in protocol setting and deciding treatment of every illness. ADA defines **Evidence-Based Dentistry** (EBD) as an approach to oral healthcare that requires judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise, and the patient's treatment needs and preferences (Adopted by FDI General Assembly September, 2016 in Poznań, Poland) [3].

Relevant scientific data will be applied to testify patient's oral health and used to educate upcoming future dentists. It is important for dentists to be able to keep up with new research in preventive, diagnostic and treatment of oral disease, and newly studied etiology of diseases, especially in regards to patient safety. A dialogue must be created between dental practitioners and dental researchers so that patient's treatment is always backed by scientific evidence.

III. BRANCHES OF ODONTOLOGY

We all are aware of general dentistry but for specialized needs, dental treatments are divided into many headings; be it for the patient or the community. The various branches of Odontology are classified in the Figure 1 and are arranged in random order. Each branch requires additional training in the dental school since each division focuses individually on the diagnosis, interpretation and treatment and maintenance of the oral and dental health care.

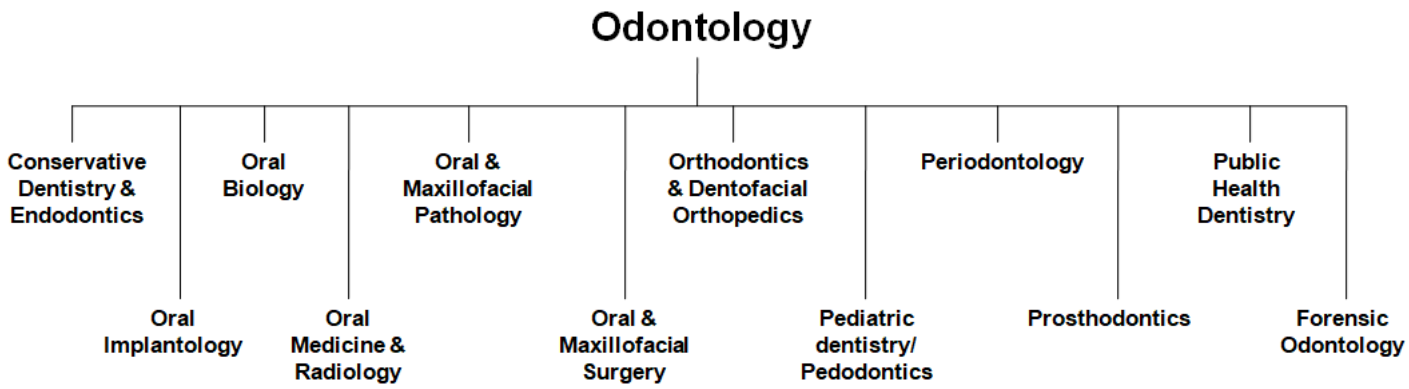

Figure 1: Branches of Odontology

1. **Conservative Dentistry and Endodontics:** It is specialized with the evaluation, diagnosis and prompt therapy of the dental pulp and diseases of periapical tissue. It encompasses minimal invasive technique preserving maximum healthy tooth structure.
2. **Oral Implantology:** It is the art and science of replacing missing teeth lost due to caries, congenitally missing or extracted with dental implants onto which prosthesis can be attached.
3. **Oral Biology:** It is the branch concerned with scientific **r**esearch to discover new diagnostic markers and aid in the development of therapeutic modalities in dental and craniofacial pathobiology.
4. **Oral Medicine and Radiology**: It is concerned with clinical examination, evaluation and diagnosis of oral mucosal diseases along with the study and radiologic interpretation of oral and maxillofacial structure diseases.
5. **Oral and Maxillofacial Pathology** It deals with the study, examination, diagnosis, and the treatment of oral and maxillofacial diseases caused by various etiologies ranging from environmental to genetic to epigenetic etiology.
6. **Oral and Maxillofacial surgery:** This branch deals with extractions of decayed or impacted teeth or for orthodontic purposes, and surgery of the jaws and other associated structures.
7. **Orthodontics and Dento-facial orthopedics:** The branch which diagnoses and treats malaligned teeth and modifies midface and mandibular growth in both growing and developed age groups with the help of various growth modulating appliances or camophlage techniques.
8. **Pediatric dentistry:** This branch is curating all dental needs of children ranging from preventive to treatment oriented.
9. **Periodontology:** It deals with the examination and diagnosis followed by conservative and surgical management of diseases of the periodontium. It also deals with placement and maintenance of dental implants.
10. **Prosthodontics:** Concerned with replacement of lost teeth by fabrication of dentures, crowns, bridges and implant placement. Prosthodontists also replace other missing maxillofacial structures like ears, eyeballs, resected jaws, etc by means of intraoral or extra-oral prostheses.
11. **Public Health Dentistry:** It deals with the study of epidemiology and application of data to make and modify social and public health policies relevant to oral health. It has community level approach in prevention and treatment rather than an individual.
12. **Forensic Odontology:** It is the branch dealing with disaster victim identification and analysis of human teeth in legal context in the criminal justice proceedings. This is also known as Forensic Dentistry.

IV. FUTURISTIC TECHNOLOGIES INTRODUCING IN DENTISTRY

A. Artificial Intelligence

The dawn of Artificial Intelligence began in 1943 and term "artificial intelligence" was adopted in 1956 by John McCarthy at a conference in Dartmouth. Artificial intelligence has machine learning, neural networks, and deep learning as the current subsets. Limitations of machine learning are overcome with deep learning and neural networks make the diagnosis process more accurate, rapid and efficient. The American National Standard Dictionary of Information Technology (ANSDIT) defined AI as the capability of a machine to carry out tasks often associated with human intellect, such as thinking, learning, and self-improvement [4]. Dentistry has used artificial intelligence because of the conveniences that technology improvements and digitalization make possible.

- *In **Conservative dentistry***, AI is being used for the interpretation of dental radiographs for detection of carious or restored teeth.

- *In **Endodontics***, AI may be used to evaluate the morphology of the root canal system, locate root fractures, discover periapical diseases, estimate the vitality of dental pulp stem cell populations, assess working lengths, and assess the outcome of retreatment therapies [5].

- *In **Orthodontics***, AI serves to predict patient's extraction needs in treatment plan accurately with high success of treatment plan for extraction cases and in determining when to utilize maximum anchorage [6]. It may be possible to use neural networks built with deep learning to identify TMJ osteoarthritis [7]. AI analyses craniofacial radiographs like cephalograms (CEPH) and orthopantomogram (OPG) and hand-wrist radiographs and interpretations using landmarks can be extended even further [8].

- *In **Oral and Maxillofacial Surgery***, AI is used to assess and enhance the patient's specific post-orthognathic surgery image forecasts, including those that foresee how the procedure would affect facial beauty and the appearance of age [9], and predicting nerve paresthesia following impaction surgeries [10].

- *In **Oral and Maxillofacial Pathology***, neural networks is useful in detecting tumors, cysts and other lesions of the jaw whether they are of odontogenic origin or not using panoramic radiographs. This provides patients with the advantages of cheaper costs and easier accessibility compared to CT or MRI [11].

- *In **Implantology***, AI can be used to distinguish the stage of therapy and access quality of osteointegration on panoramic radiographs [12, 13].

- *In **Periodontology***, AI can be used to diagnose the stage of periodontal damage, determine the degree of periodontal bone, the junction of the enamel and the cement, and the position of the teeth., and accurately predict prognosis of periodontal disease in the young population [14, 15, 16].

- *In **Oral oncology***, AI is using a series of clinical photographs demonstrating lesions of different grades of OSCC to train and apply that information to automatically differentiate future cases by applying an algorithm easily. This way, an easy, conservative and relatively cheaper tool is available to practitioners for detecting OSCC early and improving the prognosis of oral cancer [17].

B. **Augmented Reality**

Augmented Reality (AR) means that through the use of holographic technology, digital visual components, audios, and other sensory inputs create an improved, interactive replica of the real world. It can be used both for educating professionals and for clinical purposes. In clinical practice, generated clinical information can be seen on the patient immediately, combining the physical and digital worlds. Anotheriapplicationsiisiusingidigitaliinformationitoieffectively communicate with the patient using three-dimensional models, stationary visual aids like photos, collages and motion pictures. A study was conducted where AR increased the effectiveness and safety of craniofacial recontouring in fibrous dysplasia cases [18], also one study evaluated the results and stated that mandibular angle oblique split osteotomy is more effective [19]. AR has been used to get higher-accuracy 3D-CT images; thereby enhancing visibility of intra-operative distraction osteogenesis and implant placement [20, 21, 22].

C. **Virtual Reality**

It uses a dedicated headset that completely disconnects the user from the outer world and to immerse them in a lifelike virtual environment. With the help of a VR capture device, specialist will be able to stream surgeries to a large audience allowing medical students witness major as well as minor procedures in the operation theatre setup virtually [23]. For both children and adults visiting the dentist, multiple studies have shown that VR is a useful technique to reduce anxiety [24, 25, 26].

D. **Teledentistry**

Teledentistry is one of the current hot topics in dentistry. People who live in rural areas rarely have access to dentists because of distance and doctors also are reluctant because of overwhelming patient load in the OPD. The spread of teledentistry has the potential to drastically alter this. Teledentistry provides cheaper prevention practices and allows patient to consult with the convenience of virtual visits and follow ups at a touch on the mobile. After the advent of COVID-19 pandemic, remote medical care's importance has been realized as one of the most valuable means and it sets a background for incorporating teledentistry in general practice.

E. **Computer-assisted designing and 3D-printing**

The industry is already undergoing a revolution as a result of computer-assissted design (CAD) and computer-assisted manufacture (CAM), involving 3D printing, which transforms manufacturing units into more cost-effective, highly efficient and more productive digital labs. With emergence of CAD/CAM technology, the tooth which has been prepared by the dentist for crown placement will be replicated either using conventional impression materials or using intraoral cameras and converted into a computer image. Using this image as template, a crown is then produced in office using this CAD/CAM machine thus efficiently reducing the long waiting time and limiting the use of poor performing temporary crowns. 3D printers can also be employed to generate orthodontic patient models, surgical guiding templates, aligners or retainers, and other dental prosthetics, appliances and equipments precisely and quickly; thus the tasks that would take longer to do using traditional approaches will be completed by enhancing workflows and resulting in reduced manual errors and labor requirements, endowing the technology with time and cost-efficiency.

F. **Intraoral camera**

The biggest challenge for a dentist as well as the patient is poor visibility is poor even when the mouth opening is adequate and good illumination and mouth mirror is used. Intraoral cameras offer wide perception, crisp interpretation, and ease of execution. Thus, intra oral camera (IOC) has become a crucial tool in providing oral health care. The cumbersome IOC stations are now replaced with IOCs having USB compatibility and are light in weight and comfortable to use, and yield better image quality. IOCs in conjunction with remote technologies promises an excellent technique to deliver practical or simulator training and hands-on workshops in continued education (CDE) to dental practitioners and students remotely while keeping costs down and allowing for two-way engagement [27].

G. **Smart Toothbrushes**

Smart toothbrushes collect patient's information and provide patient's brushing habits to the practitioners, thereby ensuring that the patient is brushing his/her teeth in the adequate way with the help of its companion app. These apps also provide youngsters with engaging games helping them to maintain the positive habit of routinely cleaning their teeth. These toothbrushes have special handles as they are filled with sensors which provide real-time feedback through the app, alerting when the user is applying heavy and unnecessary pressure, and showing when and where the user is brushing, and even teaching them the appropriate way of brushing.

H. Digital Workflows

Healthcare has to reap the benefits of digitalization applying AI in the analysis of dental x-rays, scans, and samples. With the help of embedded softwares, digitalization eases interoperability. An efficient tool in health economics is the electronic health record (eHR), which features standardized diagnostics, organized assessments, and systematic patient data gathering speeding up dent al procedures making patients happier and improving the quality of their visits. With increasing digitalization, dentists can increase the ir efficiency, improve their quality of patient care, and make more accurate diagnoses. In short, these are a way to merge the physical w orld with technology and rely more on the technological side as a dentist. This means automating specific tasks that would otherwise re quire a fair amount of manual effort and quickly completing patient check-ins, forms, waivers, and other documentation.

I. Biomarkers

As dental technology improves, dentists should be able to diagnose dental and systemic diseases with greater accuracy. For example, saliva collection is noninvasively and used to obtain current status of the oral microbiome, indicating information such as collagen breakdown, enzyme levels, and various inflammatory markers thus screening for these markers can predict future course of disease and help in early prevention. For centralized clinical laboratory operations, assay kits are being created as point-of-care devices for quick and more standardized forms which have flexible microprocessor architecture, a miniature sensor technology, and an analyzer with integrated mechanical and optical interfaces. These features are designed to meet the needs of researchers in the future [28]. Salivary reflects:

i) Natural substance concentrations in tissue fluid and a wide range of compounds that have been added for medicinal, addiction treatment, or entertainment purposes
ii) Hormonal status
iii) Emotional status
iv) Immunological status and responsiveness
v) Nutritional and metabolic status and effect
vi) Neurological effects

J. Regenerative Dentistry and Stem Cells

A study was conducted at the Harvard University in which a synthetic, therapeutic, light-curable, biomaterials was developed for dental treatments that supported native dental stem cells inside teeth to repair and regenerate dentin. It can be used as restorative material and can be placed directly over pulp stimulating the native stem cell population for repair and regeneration bagging them an award in material category [29]. With regenerative dentistry, one will be able to provide your patients with tooth repair that doesn't involve invasive treatments and has promising great impact in the field of dentistry.

K. Cytogenetic Techniques

A broad spectrum of genetic imbalances, starting from chromosome number aberrations to specific gene alterations, are seen in or al squamous cell carcinoma. Oral oncogenesis transforms progressively involving multiple epigenetic changes which requires solid research for in depth characterization of the tumor. Cytogenetics have the potential to detect these aberrations prior to their clinical manifestation and can serve as both prognostic biomarkers and promising tool in prevention of progression [30]. Cytogenetics include conventional methods of karyotyping, physical mapping, numerous banding techniques, molecular cytogenetics, in situ hybridization (fluorescent and multicolored fluorescent), phylogenetic analysis, karyotyping, comparative genomic hybridization, ligation probe analysis, and novel technique of next-generation sequencing. Pathognomic diagnostic and prognostic data of specific abnormalities in cancer can be analyzed through molecular cytogenetics.

L. CRISPR and Genetic Engineering

Techniques like Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and Gene editing modifies genetic code producing favorable results biologically allowing scientists to manipulate and potentially eliminate hereditary disease. Greatest benefit of genetic engineering is that will weapon against cancers and many genetic conditions improving life expectancy and living standards. Many studies are undergoing to study the use of CRISPR to inactivate various oral cancer- associated genes. In order to find mammalian cell genes that crucially influence oncogenic cell survival, uncontrolled proliferation, metastatic migration, and drug resistance. Liu Z et al used CRISPR-Cas9 in their study for unbiased screening of T cells in entire genome. Such findings inspire us to investigate newer targets for cancer remedies both therapeutic and immunologic [31]. Using this technique, we can eradicate plaque-forming bacteria and even remove various cancer causing oral genes as a preventive as well as therapeutic modality.

M. Nanotechnology or Nanoscience

It includes atomic or molecular level applied science research and development that has a significant impact on almost every face of human health and wellbeing, including pharmaceutical research, clinical diagnosis, and supportive immune system therapies. It has been demonstrated that nanoparticles are more effective than conventional materials and have greater capabilities in terms of surface chemistry and bonding. Additionally, their antibacterial properties hold promise for all medical treatments, including endodontics in particular. Nanomaterials are a helpful tool in dentistry offices for a range of procedures including pulp regeneration, drug administration, root repair, cleaning, obturation, and canal filling because of their versatility. Such dental applications of

nanotechnology have prompted the growth of the discipline of nanodentistry. Based on their structure and the presence of nanopores, they include dendrimers, nanotubes, nanocapsules, nanoshells, nanorings, nanobelts, nanospheres, fullerenes, nanowires, nanorods, liposomes, and quantum dots. The development of traditional treatment modalities and advances in nanotechnology have the potential to enhance dental care [32].

V. CONCLUSION

In the current times, Dentistry has done tremendous improvements from its beginning, and the future for dental professionals is bright. In order to facilitate diagnosis, treatment planning, and treatment outcome prediction, dental radiology now primarily uses artificial intelligence and neural networks. Artificial neural networks and convolutional neural networks more specifically are the two most widely utilized varieties of artificial intelligence neural networks.

Artificial intelligence has advanced quickly in recent years, and in the near future it may become a common tool in contemporary dentistry. Better precision, efficiency and accuracy, better monitoring, and time saving are some of the benefits of AI. AI can be a game changer by providing accurate patient stratification for precise medicine, provide personalized treatment plans and targeted preventive care ultimately empowering the patient and facilitating self-care and independent health monitoring to stay well.

In the fields of oral and maxillofacial surgery, preventative dentistry, conservative and endodontics and orthodontics, augmented reality and virtual reality have been found useful as clinical practice tools. Before patients even undergo any operations, doctors can utilize virtual reality technology to show them what to expect from the procedure. Additionally, AR and VR have the potential to contribute to dental education by improving the pre-clinical training and education of students.

Teledentistry cannot completely replace face-to-face appointments, especially for diagnosis and certain treatments. However, teledentistry offers the convenience of virtual visits from home, saving patients travel and waiting time, while also providing greater access ibility for those with mobility issues or living in remote areas. The application of IOCs in diagnosis, treatment planning, goal setting, oral hygiene instructions, and maintenance can improve patient compliance. Advantages include emergency assessment, prompt pain relief, aid in monitoring treatments and safely delivering care.

It is advantageous to use saliva for biomarker detection because it has real-time diagnostic values, is relatively safer than blood sampling, makes it simple to collect multiple samples, can be done at the patient's bedside, is noninvasive, simple, and inexpensive, poses little risk of cross-contamination, is more cost-effective in terms of sampling, shipping, and storage, requires less manipulation during diagnostic procedures, and does not clot like blood. Limitations include the fact that salivary levels of some markers are not necessarily a reliable indicator. Various systemic disorders, numerous medications, and radiation may affect salivary gland function, which in turn affects the quantity and composition of saliva. Additionally, saliva contains proteolytic enzymes derived from the host or oral microorganisms, and these enzymes can affect the composition of saliva.

While studies are still going on teeth regeneration technologies and it is still in their early stages, we predict that regenerative dentistry will make its way into the mainstream and become a sought-after treatment for patients worldwide.

Cytogenetic studies, especially when using molecular cytogenetic methods, provide vital information about the onset and spread of oral cancer. Understanding the development and progression of these modifications requires a more thorough evaluation of them in light of particular markers. Recent years have seen the emergence of novel technologies like NGS that show promise in the more effective detection of these mutations. For the treatment of OSCC, several drug-targeted gene treatments are used and being further studied; however that can be achieved only by cytogenetic analysis, although there are certain issues with expense and practicality that must be resolved for the sake of the patient. To evaluate the findings and improve therapies for OSCC patients, a multidisciplinary approach between doctors, researchers, and cytogeneticists can be very important.

Nanoparticle-impregnated scaffolds and tissue engineering triads mimic extracellular matrix encouraging the development of host tissues in animals. They are suitable for a variety of dental applications because of their low toxicity, antibacterial effects, and improved protein-surface interactions.

CRISPR can be used in diagnostics to swiftly and effectively identify genes related in the growth, proliferation, metastasis, and medication resistance of many cancers. In addition to surgical management, chemotherapy, and radiation therapy, CRISPR mediated immune-therapy is a well known treatment form. CRISPR will be a turning point in the treatment of cancer. For the full clinical application of this novel gene editing tool, research and development are still needed in order to address issues like off-target effects, editing efficiency of CRISPR/Cas9 system, protocol development for its efficient delivery into the target tissue and cell population.

Dental health's future offers plenty of possibilities. The area of dentistry is constantly evolving and adapting as a result of the advent of new technologies. These recent developments represent the future of dental healthcare, improving the patient experience. These emerging trends are the blueprint for oral healthcare. The future of oral health is promising with promises to improve patient experiences.

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