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IP International Journal of Periodontology and Implantology

Journal homepage: https://www.ijpi.in/

Review Article

Artificial intelligence (AI) and recent advancements in periodontology

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ARTICLE INFO

Article history:
Received 02-08-2022
Accepted 20-08-2022
Available online 17-09-2022

Keywords:
Advancements in Periodontology
Diagnosis
periodontal disease
Nanotechnology
Microdentistry
Scaffold
Nanoparticles
Biomarkers

ABSTRACT

Periodontics is one of the important field in dentistry in which we come across various conditions that are related to oral and systemic health. Periodontal diagnosis is the pillar of successful treatment planning since prevention and proper treatment depend on the accuracy and precision of specific diagnostic techniques. Periodontics has evolved in recent years in the field of Nanotechnology, 3-D printing, stem cell therapy etc. Hence this article illustrates current practices and recent advancements in periodontology.

1. Introduction

Periodontal disease or periodontitis is among the most common health conditions that has spread its roots among our society since ages. Its incidence is rapidly increasing nowadays in the light of changing dietary conditions and Oral-Health-Related-Quality of life by causing impaired function and esthetics which mainly represents second main cause of tooth loss in adults. Prior to the diagnosis was made utilizing probes and clinical indications of ailments alongside radiographs.[1] Nowadays, numerous advancements have been introduced in the advanced Probing systems which could help in identifying the exact precise measurements of pocket depth and the clinical attachment loss. As per the advancements in the Probing systems, newer radiographic strategies have also been created which provides us a 3-D view on the defects present in periodontal disease. However the standard protocol or procedure for treating periodontal ailment has been scaling and root planing, but since past few decades new techniques in adjunct with scaling and root planing has been introduced, which are not only effective and helpful in eliminating the disease but are also recovering the loss of periodontal tissue as was attained by flap surgeries, for the normal functioning of the periodontium and the attachment apparatus. The various advancements introduced are listed as follows:-

1. Artificial Intelligence
2. Nanotechnology
3. 3-D Printing
4. Periodontal Biomarkers
5. Stem Cell Therapy
6. Microdentistry

2. Artificial Intelligence (AI)

In Artificial Intelligence with the help of computer, knowledge of various kind of software and algorithms, analysis of large data can be made easier, as it provides the

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https://doi.org/10.18231/j.ijpi.2022.022

correct information in very less time by which human tasks becomes much more effortless.

Due to current progress in computational understanding, digitization in data acquisition, use of artificial intelligence is expanding in various fields. Nowadays AI has become quite popular in the field of medicine and dentistry i.e healthcare as it provides accurate diagnosis & treatment planning of various diseases efficiently.[2] In the field of Periodontics, "Periosim" which is considered as a robotic arm that is widely used in evaluating periodontal pockets by utilizing tactile sensation to differentiate between soft and hard tissues displayed on the visual monitor.

3. Nanotechnology

Nanotechnology is defined as the branch of science and engineering committed to designing, producing and using structures, devices and system by manipulation of atoms & molecules at nanoscale. Nanotechnology shows superior quality and results than traditional methods used for diagnosis, prevention & treatment.

In Nanotechnology, nanomaterials like bioactive glass, carbon nanomaterials, titanium nanotubes coated dental implants and most recently nanoceramics are used to treat bone defects by bone regenerationand scaffold preparation.[2] Titanium coated implants have been proven to improve the speed of process of osseointegration, thereby decreasing the duration of treatment by 1-3 months. Nanoparticles because of their small size are used for local drug delivery in areas which are inaccessible such as periodontal pocket subgingivally.[3]

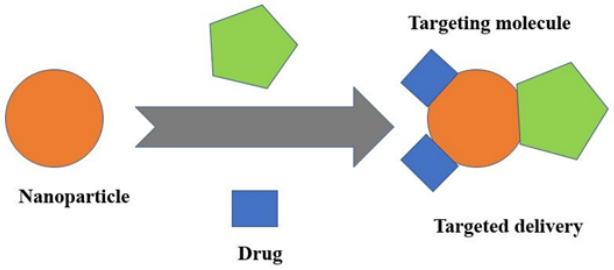

Fig. 1: Schematic diagram showing use of nanoparticles in local drug delivery system.

In toothpaste or mouthwashes metallic nanoparticles are incorporated to prevent the formation of biofilm in oral cavity. Nanorobots are widely being used for anaesthetic induction. Further research in nanotechnology is still undergoing to provide better products for treating periodontal diseases.

4. 3-D Printing

3-D printing is the term used to describe additive process manufacturing approach that builds material layer by layer. It uses information from CAD software that measures thousands of cross-sections of layers to build exact replica of each product that has to be used. Recently, 3-D printing has become a subject of great interest in dentistry. As it enables small quantities of customized goods to be produced at relatively low costs and they are precise.

In dentistry, 3-D printing is being used to fabricate stone models, custom impression trays, dental prosthesis and is also being investigated to provide tissue scaffolding in bone grafting and ridge augmentation procedures in periodontology and implantology.

3-D printers work in a manner identical to traditional laser or inkjet printers. 3-D printer uses a powder or liquid resin that is slowly built from an image on a layer by layer basis. Bioprinting is the most common application of additive manufacturing[4] that is getting most popular these days. 3-D Bioprinting techniques can be categorized into:-

1. Extrusion
2. Droplet jet Bioprinting
3. Photocuring based Bioprinting
4. Cell electrospinning Bioprinting

5. Applications in Periodontolgy

3-D Printed Bioresorbable Scaffold for Guided Bone and Tissue Regeneration:

Most recent progresses in the field of tissue engineering has led to the development of "3-D printed" tissue scaffolds. These multiphasic scaffolds consisting of both hard which are bone and cementum and soft tissues both gingiva and periodontium components of periodontium, are not only tissue-specific but are also proficient mechanically.[5]

These 3 dimensional scaffolds have been investigated in different periodontal treatment procedures such as socket preservation, guided tissue and bone regeneration, direct or indirect sinus lift and alveolar ridge augmentation. The aim of these scaffolds is to promote formation of bone, PDL, cementum and re-establishment of the lost connection between them due to the pre existing periodontal disease.

The three dimensional scaffolds are most commonly fabricated from biodegradable polymers, either they are natural such as cellulose or chitosan or they are synthetic basically Polycaprolactone(PCL) or Polylactide (PLA) etc. Among various materials, the most popular is the Polycaprolactone (PCL) that has been widelybeing used as a scaffold material due to its successful outcomes in bony regeneration in intrabony bone defects.[6]

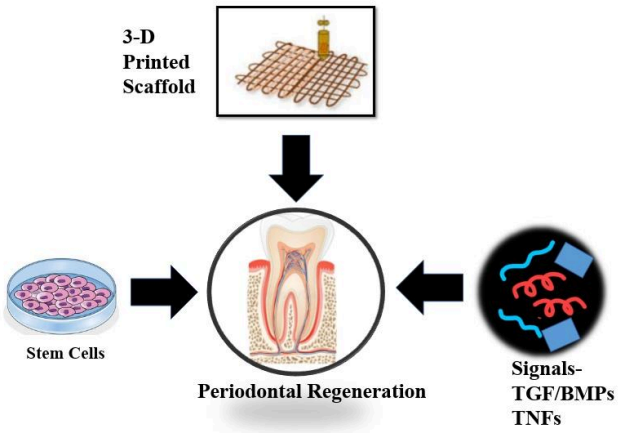

Fig. 2: Printed scaffolds used in periodontal regeneration.

5.1. Socket preservation

The extraction the of tooth leads to both loss of width and height of alveolar ridge and moreover as the jaw bone has a natural tendency to become narrow and lose its original shape because bone resorbs quickly this results in poor prognosis resulting in 30-60% loss in bone volume in first few months and the patient is left with very few treatment options. Therefore recent advancements has allowed the use of 3-D Printed Scaffolds to preserve the socket and maintain the dimensions of extraction socket.

5.2. 3-D Printing for Implant placement

Implant placement to replace the missing teeth is a routine procedure done by dental professionals worldwide. Implant placement is a technically challenging procedure and if not done accurately, it can lead to various complications such as poor esthetics, damage to anatomically important structures, infections, perimucositis, periimplantitis and ultimately implant failure.

All these complications can be avoided by fabrication of surgical stents or guides using 3-D printing. It helps in accurate three dimensional placement of the implant thus preventing unwanted damage to underlying anatomic structures and also helps in placing the implant specifically in the esthetic zone.

6. Periodontal Biomarkers

Previously periodontal diseases were diagnosed with periodontal probes and radiographs only. However in recent years biomarkers are being used to detect Periodontal diseases even at very early stages before the disease has just progressed thereby destruction to periodontium can be prevented and the tooth could be saved. Biomarkers- a diagnostic aid, which is defined as the characteristic i.e objectively measured and evaluated as an indicator of normal biological process, pathogenic process or pharmacological responses to the therapeutic intervention that is being performed.[4]

Various types of biomarkers are MMP-8, MMP-9, TNF, IL-1, Osteocalcin, Alkaline Phosphatase (ALP), Cathepsin-B, C-Reactive protein can be detected in saliva, blood,urine or GCF by chairside tests. Different chair side kits are available for detection of biomarkers for periodontal diseases, by which risk factors can be detected even before the start of illness.[7] Biosensors are also used to detect particular biomarkers for periodontal diseases by generating signals in coming contact with measuring chemical & biological reactions.

Table 1: Various biomarkers used for detection of periodontal disease.

Inflammatory	Collagen Breakdown	Bone Remodelling
β- glucuronidase	α 2-macroglobulin	Alkaline phosphatase
C-reactive	MMP-8	Osteoprotegerin
I1-1β	MMP-9	Osteoprotegrin
I1-6	Aspartate aminotransferase	SPARC/osteoneetin
MIP 1α	Alanine aminotransferase	RANKl

Recent technologies like PCR Lab On Chip (LOC) works on the principle of immunoassay is being used. Another device that works on this principle is IMPOD(Integrated Microfluidic Platform for Oral Diagnostics) can detect various salivary proteins in lesser amount of sample with high accuracy.

7. Stem Cell Therapy

Stem cells are the pluoripotent cells that have the potential to develop into many different types of cells in the body. Stem cells serve as a repair system for the body. Stem cells derived from the apical papilla are known as SCAP that are present in immature roots of permanent teeth. These stem cells i.e SCAP produces odontoblast like cells in the body which forms the root dentin.[8] SCAP also plays vital role in apexogenesis. Stem cells that are derived from periodontal ligament are known as PDLSCs which are mainly located in perivascular space of periodontium. These PDLSCs have features of mesenchymal stem cells which are mainly used in periodontal tissue repair.

8. Microdentistry

Periodontal microsurgery is the successor of conventional periodontal surgery that aims to reduce the surgical trauma and open up new possibilities for better patient care. The use of surgical prism loupes or surgical microscopes has introduced markedly less invasive surgical incisions & flap

reflection in periodontics.

Microsurgical instruments have been introduced, which have reduced all surgical movements to a pinch mechanism between thumb and index fingers, guiding movements by direct vision.[9–12] Several types of ophthalmic knives such as the crescent, lamellar, sclera & spoon knife can be used in periodontics, as using smaller instruments under magnification allows surgeons to enhance their surgical skills and acquire better results. Microsurgical incisions & suturing with 6-0 & 7-0 sutures are utilized for primary wound healing.

Recently Three-Dimensional On-screen Microsurgery System (TOMS) as an alternative to operating microscope has been discovered, which can now allow the surgeons to view microsurgical field in a wide three dimensional view in a video monitor.

9. Conclusion

In recent years various developments are being made in the field of science and technology which has accompanied in understanding the etiology and risk factors responsible for periodontal disease. These recent advancements has provided us a wide opportunity newer treatment modalities that can create a huge difference in the field of periodontology. However there is much yet to be discovered to eliminate all the barriers and equip us with even more better technologies and techniques for future.

10. Source of Funding

None.

11. Conflict of Interest

None.

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Cite this article: Sood R, Sharma E, Garg R, Kaur S, Chhavi, Anshul. Artificial intelligence (AI) and recent advancements in periodontology. *IP Int J Periodontol Implantol* 2022;7(3):99-102.