Journal of Indian Dental Association Madras (JIDAM), 2023; Volume No: 10, Issue No: 4

Review Article | ISSN (O): 2582-0559

PRECISION DENTISTRY- AN OVERVIEW

Aarudra Devi, Nikita Ravi, Anita Logaranjani, Jaideep Mahendra.

[1,2,3,4]Department of periodontics, Meenakshi Ammal Dental College and Hospital, Chennai, Tamil Nadu, India, *Corresponding Author's Email: drjaideep.perio@madch.edu.in

Abstract

Dentistry is stuck between the one-size-fits-all approach towards diagnostics and therapy employed for a century and the era of stratified medicine. The present review presents the concept of precision dentistry, i.e., the next step beyond stratification into risk groups, and lays out where we stand, but also what challenges we have ahead for precision dentistry to come true. Current approaches for enabling more precise diagnostics and therapies focus on stratification of individuals using clinical or social risk factors or indicators. Most research in dentistry does not focus on predictions — the key for precision dentistry — but on associations. We critically discuss why both approaches (focus on a limited number of risk factors or indicators and on associations) are insufficient and elaborate on what we think may allow to overcome the status quo.

INTRODUCTION:

Like any other medical field, dentistry has not remained untouched by innovative progression. The biggest breakthrough in the field of dentistry in the later long time has been the approach of precision dentistry[1]. There is no doubt that establishing a correct diagnosis and treatment plan is one of the critical parts of the dental management of the patient. Precision dentistry is a contemporary, data-driven, and multi-dimensional approach to oral healthcare. It takes into consideration variability in the environment, genes, and life. The success of precision dentistry is contingent on its preventive, personalized, and participatory nature[2].

WHAT IS PRECISION DENTISTRY?

Precision dentistry, also known as personalized dentistry, refers to a dental care approach that tailor's treatment and preventive strategies to the individual characteristics, needs, and preferences of each patient[3]. This approach takes into consideration individual changeability in environment, qualities, and way of life. It's different from the traditional treatment methods, which involve developing treatment strategies for the average person without considering the differences between people.

This practice leverages advanced technologies, such as genetic testing, digital imaging, and data analytics, to develop customized treatment plans that enhance the accuracy, effectiveness, and outcomes of dental care[2].

LEADING BENEFITS OF PRECISION DENTISTRY:

The use of precision dentistry influences how dentists care for patients and how medical facilities allocate their resources to help patients(2). Precision dentistry reduces diagnostic errors, helps avoid adverse effects, and enhances the results of dental treatments. Precision dentistry offers many benefits including:

A)PERSONALIZED TREATMENT:

Precision dentistry can create a treatment plan that is tailored to each patient's needs(4). This allows for treatments that are customized to the patient's unique dental anatomy, genetics, and lifestyle. This customized approach guarantees that people get the best and most productive dental consideration, which leads to effective and efficient care [4].

B)EARLY DETECTION AND PREVENTION.

Advanced diagnostic tools, such as genetic testing and biomarker analysis, can identify potential dental issues before they become serious, enabling early intervention and prevention [2]. Analyzing molecular markers helps to reveal disease risk or its presence before the appearance of its severe clinical features.

(Received 04th December 2022; Accepted 25th July 2023; Published 30th October 2023)

Therefore, doctors can able to focus on prevention, or early intervention, instead of treating the condition in advanced stages. Currently, numerous genetic tests are available. These tests, enable dentists to identify the patient's susceptibility to a particular disease. Patients with specific genetic morphology are likely to develop certain dental conditions. It helps to provide preventive measures to prevent them from occurring [2].

C)REDUCED DISCOMFORT AND RECOVERY TIME

Incorporating advanced technologies like laser dentistry, can help to reduce discomfort during procedures and promote rapid healing. It helps to relieve patient anxiety, causing lesser tissue damage, and reduce bleeding, and swelling, which reduces recovery time and improves patient compliance [3].

D)REDUCTION OF TRAIL AND ERROR PRESCRIPTION.

The majority of patients do not get enough benefit from the first-time prescription they receive. This is because, differences in genes in different patients, impact drug metabolizing enzymes and drug targets. Unlike traditional methods, that rely on standard protocols, precision dentistry tailors treatments based on individual patient characteristics, such as genetic information, oral microbiome analysis, and detailed imaging. This enables dentists to select the right treatment approach and helps to prevent costly and frustrating trial-and-error prescriptions[2].

TECHNOLOGICAL ADVANCEMENTS AND PRECISION DENTISTRY:

Precision dentistry enhances dental care by providing more accurate, detailed, and personalized dental treatments. It revolutionizes dentistry and improves patient comfort, and outcomes by increasing efficiency, precision, and personalized dental procedures[5]. Some of the common technological advancements are ;

1. 3D IMAGING

The utilization of 3D imaging can be described as a transformation of dentistry because it gives a more accurate and detailed view of a given patient's oral anatomy. Compared to 2D imaging, this advanced technology offers a better view of the patient's teeth and jaw and aids in detecting anomalies. A few examples of 3D imaging techniques are seen below [7]

B) ENHANCED PRECISION

Employing digital imaging, 3D printing, and computer-aided design/manufacturing (CAD/CAM) technologies enhances both the precision and effectiveness of dental treatments. High-resolution 3D imaging techniques, like cone beam computed tomography, deliver intricate views of dental anatomy, assisting in precise diagnosis and treatment preparation [3].

C) BETTER PATIENT COOPERATION

Customizing treatment plans to meet individual needs increases patient engagement and improves adherence to follow-up appointments and preventive care. Precision dentistry helps to provide information and knowledge on every patient's genetic information [2]. This allows doctors as well as patients to make the right adjustment at an early age to prevent the disease's development. The convenience of fewer visits, less invasive procedures, and quicker recovery times associated with precision dentistry is a significant advantage, making them more likely to opt for these treatments [2].

a) CONE BEAM COMPUTER TOMOGRAPHY

It Is the most commonly used 3D imaging technique. It enables production of three-dimensional images of teeth, soft tissues, and bone [6]. Rotating around the patient's head, the single scan can create cross-sectional images of the teeth, which are very detailed, allowing the dentist to give a comprehensive understanding of anatomical features and pathology[7]. Applications of CBCT in Dentistry are as follow:

- Implant planning- accurate dental implantation by examining anatomical markers and bone density.
- Root canal therapy- identifying complex root canal systems that are hard to see with 2D X-rays
- Orthodontics- assessing tooth and jaw positioning to plan the best action for alignment and correction.
- Surgical planning- for oral surgeries such as wisdom teeth removal or jaw realignment [7].

b) INTRAORAL SCANNERS.

High-quality 3D digital impressions of teeth and gums are captured using intraoral scanners [2]. They render procedure more comfortable for the patient, as well as more precise and efficient result, thus become more reliable. Patients now have the opportunity to be scanned with quicker speed and in less pain, all with no messy impression materials.Integration with CAD/CAM systems to create orthodontic appliances, restorations, and other dental prostheses helps improve the efficiency of the process [8].

c) 3D PRINTING

In precision dentistry, the revolution of creating and use of surgical guides, appliances, and dental restorations is revolutionized by the employment of 3D printing. 3D printing is used in the majority of dental restorations, such as crowns and bridges, with minimal need for adjustments due to their precision. It is possible to fabricate personalized dentures that fit with better comfort and functionality.[7]

- Orthodontics: The clear aligners, as in Invisalign, are printed through 3D printing technology to p rovide individualized and timely orthodontic treatment.
- Implantology- anatomically accurate models of a patient's mouth can be printed to aid in the planning and execution of implant procedures.
- Maxillofacial surgery- dentists can use 3D printed models of a patient's anatomy to plan complex surgeries, increase accuracy, and reduce the risk of complication[7].

2. MINIMALLY INVASIVE TECHNIQUE

A minimally invasive technique would have preserved the natural anatomy of the tooth as much as possible while being effective during treatment. Minimally invasive dentistry rests on three basic principles: preservation, prevention, and minimal intervention. Minimally invasive dental procedures offer important benefits, fundamentally transforming patient experiences and outcomes in dentistry. These approaches are always associated with reduced pain, rapid recovery time, and lowered risk of complications that would otherwise be encountered [9].

3.ARTIFICIAL INTELLIGENCE

It will revolutionize dental practice because it can produce predictive diagnostic abilities. With the integration of these AI technologies, dental practitioners can now accurately analyze complex imaging data. This can identify early signs of oral diseases, including caries, periodontitis, and oral cancers [3]. The capability of AI to analyze and interpret huge amounts of data complements precision dentistry's focus on individualized care. Together, they form a symbiotic relationship that enhances the potential for improving patient outcomes [10].

Its primary uses include:

a) **Improved diagnostic accuracy**- one of the most significant functions of AI is early diagnosis. AI algorithms excel in pattern recognition making them ideal for identifying anomalies like dental caries in dental images and radiographs that the human eye might miss. This aids in the early detection of dental issues, enabling prevention and timely management [3].

b) **Personalized treatment plans**- precision dentistry is based on tailoring treatment to each patient's unique characteristics. AI improves this by analyzing large databases of patient information to recommend the most effective treatment plans based on factors such as genetics, medical, history, and lifestyle.

c) **Predictive analysis for treatment outcomes** – AI algorithms can provide insights

into how a treatment is likely to progress and the final outcome. This is particularly useful for long-term treatments such as orthodontics and periodontics, where patient compliance and biological variability can influence results.

d) **AI in dental education and training-** AI is also transforming dental education by providing students with advanced tools for learning and practice. These systems offer real-time feedback to improve their skills and gain confidence before working with real patients.[3]

4.SURGICAL GUIDES

A surgical guide in precision dentistry is an assistive device that helps the clinician improve the quality of the procedure performed and even the quality of prostheses that can be placed on implants with particular relevance to the practice of implant dentistry. These guides are made from the impression of the patient using CBCT and optical devices [11]. The advantages of surgical guides in dentistry include the following:

a) **Enhanced accuracy** – surgical guides provide an opportunity for the clinicians to make accurate implant placements and even successful treatments and advance further implant treatment down to sub-millimetre levels and this reduces risks of complications and improves both functional and aesthetic aspects. This is very fundamental in cases where There is Limited Space for Placement of implants And Jaw Bone Limitations.

B) Minimal tissue damage– in this case, placers of implants are accurate enough so that tissue damage is minimized and there are faster recovery times and reduced pain for the patient.

c) Virtual planning – The implant can be virtually planned and surgical guides allow straightforward communication and practice with the patient over implant treatment which is much different from the conventional methods – wherein there are no expectations so let's be reasonable .[11]

5. LASER DENTISTRY:

Lasers are used in dentistry to provide accuracy and control in a variety of different processes. They have changed the course of the procedures to a less sensitive and less discomfort-causing treatment with faster recovery. The development of laser technology in the dental industry has not only improved the treatment's absolute precision but also introduced new dimensions of the treatment altogether(9). Some of the applications of lasers in dentistry include the following:

a) Cavity detection and removal – lasers tend to identify developing cavities and surface decay spots that are often difficult to realize with normal procedures.

b) Gum disease treatment – lasers eliminate infected and diseased gingival tissues, hence assisting in the healing process and reducing any aggressive healing procedures.

c) Biopsies and lesions removal – it is possible to use lasers to take a small tissue sample for a biopsy or removal of small oral lesions with ease as well as faster recovery time.

d) Endodontics therapies – the usage of lasers during endodontics procedures allows for the disinfection of root canals hence more precise procedures can be carried out.

e) **Orthodontic treatment** - -lasers assist in the precise placement and adjustment of braces and other orthodontic appliance [9].

6. REGENERATIVE DENTISTRY

Regenerative dentistry is a subspeciality discipline of precision dentistry that is defined as "The repair or the regeneration of dental tissues and structures by the application of biological or engineering techniques. Shifting the focus towards regenerative medicine, the term encompasses the restoration of function and esthetics of tissues around and of the teeth, and structure by utilizing stem cell therapy, tissue engineering, and biomaterials [15]. key concepts in regenerative dentistry are

i. Stem cell therapy – stem cells are the types of cells that have the potential to develop into a myriad of cells including dental pulp cells, dentin and periodontal ligament cells. Such cells can be taken from the dental pulp, the bone marrow, or the umbilical cord blood(15).

. **ii. Tissue engineering** pertains to the development of biological substitutes capable of

functioning further than tissue integration by physically engineering tissues in vitro or through the application of cells in vivo. [12]

iii. Biomaterials – other types of biomaterials that are used in regenerative procedures such as hydrogels, bioactive glass, or calcium phosphate cements that are used for scaffolds would help support stem cell growth and further differentiation into tissue in regenerative dentistry [15]

As a result, the utilization of regenerative strategies in precision dentistry complements the existing capacity to deliver individualized treatment protocols that aid in the natural repair and regeneration of dental tissue. There is optimism for the development of regenerative medicine techniques for the dental precision field as the research continues to concentrate on [15]

- Improving stem cell therapy efficiency and efficacy.
- Creating advanced biomaterials and scaffolds that closely resemble native tissue.
- Delving into fundamental molecular processes of dental tissue repair.
- Individualized treatment approaches that consider DNA and specific patient features.[16]

7. GENOMICS

Within the scope of biology, genomics enabled scientists to possess the entire design of biological information in the form of DNA that contains all genes of an individual. Genetic data drives an individual's risk of developing clinically significant conditions, interaction with medications, and maintenance of overall health [17]. In this regard, the discipline of genetics in dentistry, which has emerged in recent decades, carries a promise of being able to customize dental care around the patient – thereby increasing treatment efficacy and results [18].

Next, the global burden is dental caries which is pointed out to be a major chronic disease that has a multifactorial cause that includes genetic determinants of enamel, saliva, and microbiome. Surely, if dentists were able to determine the risk of the development of caries concerning the patient`s genes, they could advise more effective and preventive methods such as fluoride treatment and dietary changes, thus controlling the incidence of caries better than general recommendations [14].

Within the realm of dental care, genomics has the potential to be transformative, particularly in periodontal disease. Many genetic predispositions have been reported to increase the risk of various forms of periodontitis. Genetic risk assessments should help dentists discern which patients are at risk and allow them to take preventive action by performing such actions as adjuvant cleanings for those patients or offering antimicrobial agents for oral use in advanced periodontitis [18].

Genomics profiling can have a major role in the concept of early oral cancer detection through the identification of aberrant genetic mutations and the development of cancer biomarkers. Furthermore, the therapeutic regimens for oral cancer can be improved by incorporating the genomic profiles of patients into the treatment strategies [18].

Genomics can elucidate the possibilities of how a patient's teeth may move during an orthodontic procedure. Dentists can evaluate certain regions within the human genome and relate the specific genetic markers to tooth mobility to help them know how fast a tooth can be moved which assists in the development of a better treatment plan(14). Due to natural events, some people may develop traits such as over-retained teeth, over-jet, and underbites. Genetic makeup predisposes some people to develop more severe malocclusions with the advanced age. The use of genomics will enable orthodontists to appreciate such tendencies; thus, making it possible to intervene at an early age while reducing the costs of later corrections [18].

8. NANOTECHNOLOGY

Nanotechnology in precision dentistry is one of the fast-growing branches that helps in providing better dental care by utilizing the properties of materials and devices at the nanoscale [19]. Here are some key areas where advancement in technology is making its impact.

1. Nanomaterials in restorative dentistry

- Nanocomposites – these materials contain particles measuring less than 100 nm which improve the mechanical, aesthetic, and wear properties when compared to the traditional composites.
- Nano adhesives – increase the bond strength between restorative materials and dental tissues, thus prolonging the duration of dental restorations [21].

2. Nanotechnology in the prevention of oral diseases

- Antibacterial nanoparticles – for example silver, zinc oxide, and other nanoparticles are added to some dental materials to prevent the growth of bacteria and infection(20)
- Nanoparticles for targeted Drug delivery – a method that employs particles about 100 to 800 nm to administer drugs to an infection site in the oral cavity or in regions of inflammation thereby increasing treatment efficiency[21].

3. Introduction of New Diagnostic Devices

- Nanosensors – These can identify the early stages of oral diseases caused by microbes and treat them even before the appearance of the disease.
- Imaging - Additionally, these nano-particles can improve diagnostic imaging methods such as X-ray and MRI allowing clear visualization of conditions of oral structures and content.

4. Promoting Oral Health

- Nanoscale Coating – Used on teeth and dental implants to shield them from decay and abrasion, potentially decreasing the future dental restoration requirement.
- Toothpaste – The use of nanoparticles in toothpaste and mouthwash for improving teeth cleaning and remineralising enamel [20].

TREATMENT MODALITIES IN PRECISION PERIODONTICS PERIODONTICS AND MINIMALLY INVASIVE TECHNIQUE:

- Although effective in treating gingival problems, traditional periodontal surgery is often a more invasive approach, which leads to increased patient discomfort and slower healing times due to increased tissue disruption. The rise of minimally invasive techniques has transformed the way periodontal procedures are carried out. Minimally invasive periodontal surgery focuses on conserving soft tissue as much as possible and using tunnel technique to treat single gingival recession 22.
- In mucogingival surgery, microsurgical methods are essential in achieving desired treatment outcomes. Microsurgical procedures are proven to be effective in reducing operative trauma and discomfort, improving the predictability of gingivoplasty procedures, and making root coverage procedures extremely predictable 22.
- Techniques such as the single-flap approach have shown excellent clinical results in securing blood clot stability In bone defects. Flapless surgery using Er: YAG laser could be an effective adjunct in minimally invasive surgery to facilitate surgical procedures and obtain enhanced healing and regeneration. However, the development of endoscopy may be required for the precise detection of diseased soft tissue and calculus 25.
- A periodontal endoscope is a nonsurgical device that allows for visualization of subgingival closed pockets without the need for surgical interventions, reducing the risk of surgical complications.
- Advantages of minimally invasive techniques in periodontics
  - minimally invasive therapy differs from traditional nonsurgical treatment because it guides the treatment in a more reconstructive manner, reduce the surgical trauma, increases the wound stability.
  - It mostly prioritizes smaller incisions, resulting in reduced discomfort and swelling after surgery. This produce faster healing, allow quicker return to normal function. this technique minimize disruption to healthy gum tissues

- Finally the most important benefit of minimally invasive technique is preservation of gum tissue. This leads to more natural-looking gums, significantly impact patient self-confidence and overall well-being(26).

PIEZOELECTRIC SURGERY

This technique utilizes sonic vibration with specialized instruments to remove bone with greater precision. This technique minimizes trauma to adjacent tissues compared to traditional methods, leading to faster healing and reduced postoperative discomfort [22].

The piezoelectric device is a versatile tool used for the preparation of the implant site. it can be used in healthy bone conditions to minimize mechanical and thermal damage to the bone.

Another main application of piezoelectric device is bone grafting. Placement of dental implants are only possible if sufficient residual bone volume is available. Different technique for ridge augmentation have been found to be more effective by using methods [22].

The removal of the graft itself is another important aspect of the piezoelectric device. if it performed with conventional method like using chisel , it increases the risk of damaging teeth roots and soft tissue structures. Therefore, the use of piezoelectric device is a safer option, reduce the risk of iatrogenic slippling and serious complication.

Nowadays, this piezoelectric devices is used in various dental fields, including orthodontics, oral and maxillofacial surgery, orthognathic surgery and even in computer assisted surgery for osteotomies. This device enhance high precision cutting, reduce the risk of nerve damage making it most popular choice for doctors as well as patients [22].

COMPUTER GUIDED SURGERY

This technology includes 3D imaging and digital planning to precisely map the bone anatomy and determine the implant position. This procedure allows for minimal flap reflection in turn leads to minimal invasive implant placement, thus eliminating the need for the more extensive surgical procedure,

The main advantages of this guided surgery include a reduction in the duration of the surgery, reduced trauma, and increased precision than conventional surgery. Some disadvantages like increased costs, and the need for specific instruments, and tools may be present

This computer-guided surgery is indicated mostly in patients where the placement of the implant is planned near critical anatomy, such as proximity of the inferior alveolar nerve or maxillary sinus [22].

IMMEDIATE IMPLANT PLACEMENT

in certain conditions with favorable bone density and careful planning, minimally invasive techniques allow for immediate implant placement after tooth extraction. This reduces the number of surgeries thereby reducing the overall treatment plan.

To achieve this, a careful analysis of certain factors such as tooth position, form of periodontium, tooth shape, and position of the bone crest before tooth extraction is needed. However, it is associated with certain surgical risks of damaging vital structures. with the aid of computer-guided navigation, this complication is reduced [22].

BIOMARKERS IN PRECISION PERIODONTICS

Biomarkers refer to an objectively measured indicator of normal biological processes, pathological conditions, or pharmacological responses to therapeutic interventions. The main advantage of this biomarker assessment is the accessibility of diagnostic specimens that can be obtained by simple methods that are low invasive(23). Periodontal samples include plaque, gingival crevicular fluid, and saliva produce outstanding diagnostic capacity.

Biomarkers in periodontology can be classified as follow:

1. Predictive markers.

This marker is used before disease occurrence to identify risk factors early and estimate the overall patient risk, aiming for optimal disease prevention. For this purpose static markers are used. they are genetic markers.

Patients with specific immunophenotypes are more prone to impaired elimination of periodontal pathogens, which results in excessive periodontal destruction.

It has been proposed that certain SNPs in the IL1β, IL1RN, VDR, and TLR4 may have high susceptibility to develop a destructive form of periodontitis, while polymorphisms in the ILIB, IL1RN, IL6 VDR, CD14, and MMP1 genes might be responsible for general susceptibility to chronic periodontitis [27].

2. prognostic marker

the most frequently used prognostic markers are genetic markers. these biomarkers serve as a valuable tool in treatment planning, enabling clinicians to predict issues, minimize treatment complications, select most effective treatment pathway and set the maintenance regimen for optimal treatment stability (23)

3. Diagnostic markers

Diagnostic markers comprise various indicators that can disclose disease onset, disease progression, and disease activity. This group comprises biochemical and microbiological markers that can identify various disease-related parameters.[24]

4. Inflammatory biomarkers

These markers include both pro-inflammatory and anti-inflammatory markers. Since these markers are elevated in both gingivitis and periodontitis, they are mostly used to estimate disease activity, progression and compliance with administered treatment.

5. Soft tissue markers

these markers are used for monitoring various soft tissue degradation, matrix metalloproteinases and growth factors are the most repurposed markers in periodontology.[28]

FUTURE CHALLENGES IN PRECISION DENTISTRY:

Personalized dentistry is a growing field that uses advanced technology and data-driven techniques to tailor dental care to individual patients. Although it offers tremendous potential, but it also faces many challenges:

I. High cost

Initial investment in advanced diagnostic equipment, imaging technology, and treatment materials can be prohibitive. This includes the cost of 3D printers, digital scanners and AI based software, which can be a barrier for many dental practices(3).

ii. Equal access parity

Higher costs can make a difference in access to standardized dental care, as the right population is unlikely to benefit from these improvements. Ensuring equal access is a big challenge(11).

iii. In data privacy protection

Accurate dentistry relies heavily on the collection and analysis of vast amounts of patient data, including genetic information. Protecting this sensitive data from breaches and ensuring patient privacy is paramount(3).

iv. Interdisciplinary collaboration

Precision dentistry often requires collaboration between geneticists, bioinformaticians and dentists. Facilitating effective communication and collaboration between departments can be difficult(3).

v. Patient acceptance and education

The patient must understand and be committed to a standard dental protocol. Educating patients about the potential benefits and risks, and addressing any concerns, is important to maximize acceptance(17).

vi. Education and Training

Dentists and dental professionals need ongoing education and training to effectively use new technologies and interpret complex data. Thorough training is essential(17).

vii. Ethical concerns

The use of genetic information in dentistry raises ethical issues, including concerns about genetic privacy, potential discrimination, and informed consent. Addressing these ethical considerations is crucial [17].

CONCLUSION

Precision dentistry represents a transformational approach to dentistry, emphasizing a personalized treatment plan based

on genetic, environmental, and lifestyle details This approach does not pretend to provide patient outcomes are improved not only by tailoring interventions to specific needs but also by improving preventive care early detection and targeted strategies It holds the promise that it's about of effective, efficient, patient – centered oral health care. The adoption of this model is likely to dramatically improve overall dental health and well-being, setting a new standard for the future of dental care [17].

REFERENCES

1. Romeo patni – personalized dentistry: *Approaching a ney way for diagnosis and treatment of oral diseases,may 1, 2020.*
2. Northridge dental - precision dentistry.
3. Rewant Chauhan, Dental Tribune- *precision dentistry and artificial intelligence: a symbiotic revolution*, August 31, 2023.
4. James D. Beck et al -*Advances in Precision Oral Health – periodontal 2*000, February 2020.
5. Rafael Silva – *Disruptive technology – technological advancements and precision medicine – the shift towards personalized care,* September 23, 2024.
6. Silverman - Pomdental – cone beam ct vs traditional ct. why cbct is ideal for your teeth scanning.
7. Rendulich - Centerforoms – *specialty 3d imaging.*
8. Edgerlydentistry – digital intraoral scanner
9. Unicorn denmart – *minimally invasive dentistry:* benefits and technique, July 25,2024.
10. Darrell M.West and John R. Allen – *how artificial intelligence is transforming the world,* April 24,2018.
11. Shahzaid nasti, saba Anjum, Sufiyan M Kalekhan – *surgical guides: precision redefined in implant placement,* December 02, 2023.
12. Mrunal S. Chapekar – *tissue engineering: challenges and oppurtunities*, June 12,2000.
13. Ashif Iqbal – *Genomics in personalized dental care*, 2024.
14. Unicorn denmart – *Personalized dentistry: how genomics is shaping dental care*, October 16, 2023.
15. Salim Kapadia – *Regenerative dentistry:* stem cells and the future of tooth repair, April 20, 2024.
16. Rahul Gotadki – *market research future* – adult stem cell market, December 2024.
17. Falk Schwendicke – *precision dentistry*- what it is, where it fails, and how to get there, march 14, 2022.
18. Arthur M. Lesk – *introduction to genomics,* august2023.
19. Unicorn denmart – *clinical applications of nanotechnology in dentistry*, October 6,2024.
20. Ensanya Ali Abou Neel, Laurent Bozec – *nanotechnology in dentistry: prevention , diagnosis and therapy,* October 08, 2016.
21. Shiza Malik and Yasir Waheed – *emerging applicatios of nanotechnology in dentistry*,November 15, 2023
22. K.S.N.Nikilesh, Gagandeep Singh Gill, Papakayala Satish- *precision dentistry in action: minimally invasive technique in periodontics and implantology*- a narrative review, July 31, 2024.
23. Mrunalini Gundelly, Santosh V.Pusuluri, Rekha R.Konduganti, Manasa Ambati – *precision medicine in periodontics:* a literature review, august 09, 2024.
24. Mia Rakic, Natasa Pejcic, Neda Perunovic and Danilo Vojvodic – *a roadmap towards precision periodontics*, march 03, 2021.
25. Walsh JT., et al- effect of the dynamic optical properties of water on midinfrated laser ablation- *lasers in surgery and medicine,*1994.
26. Ting CC.,et al – effect of Er,Cr:YSGG laser irradiation on the root surface: morphologic analysis and efficiency of calculus removal. *Journal of periodontology*,2007.
27. Verma K, Singh A : biomarkers in periodontal health and diseases.2024.
28. Kornman KS, Page RC, Tonetti MS – the host response to the microbial challenges in periodontics, *periodontal* 2000.
29. Buduneli N, Kinane DF – Host derived markers related to soft tissure desturation and bone degradation in periodontics,2010.