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CUSTOMIZED PERIODONTICS: A BLUEPRINT FOR ACCURATE PERIODONTAL TREATMENT – A NARRATIVE REVIEW

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ABSTRACT:
Personalized periodontics is an emerging paradigm in dental medicine that redefines periodontal care through precisionbased strategies. Recognizing that periodontal disease progression and response to therapy vary significantly among individuals, this approach integrates genetic, microbial, immunological, and lifestyle data to deliver tailored diagnostics and treatments. Biomarkers such as IL-1β, MMP-8, and microbial DNA profiles, along with systemic indicators like HbA1c and host-response polymorphisms, enable more refined staging and grading of disease. Therapeutic decisions are increasingly guided by real-time biosensors, AI-driven risk models, and individualized treatment protocols that range from non-invasive interventions in low-risk patients to biologically guided regenerative therapies in complex cases. Digital tools and multi-omics platforms further support dynamic monitoring and decision-making. This paradigm offers enhanced clinical outcomes, improved patient engagement, and more efficient use of healthcare resources. As research evolves, the integration of chairside diagnostics and molecular precision will likely become standard in periodontal care.

KEYWORDS: *Personalized Periodontics, Biomarkers , Precision Medicine, Periodontitis*.

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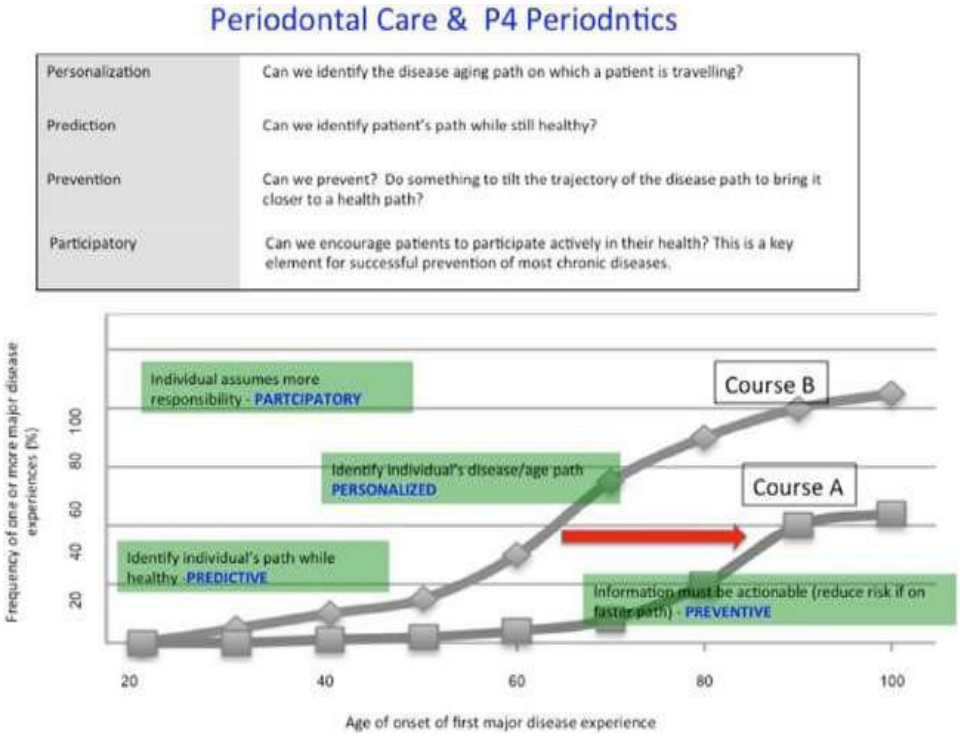
INTRODUCTION :

The development of customized periodontics is a promising step toward a medical paradigm of ailments management, which acknowledges the individual as the key player in the treatment of highly complex conditions. A recreational approach to complete periodontal disease care must take into account factors such as stress, obesity, cardiovascular disease, tobacco, and uncontrolled diabetes.

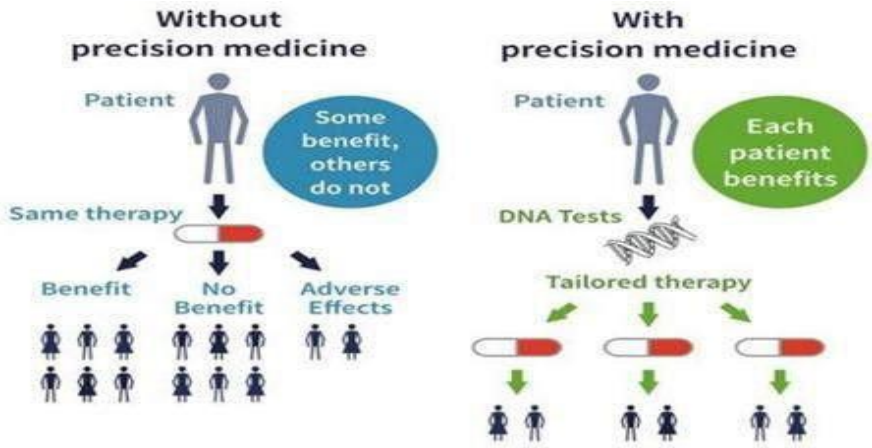
Customizing oral healthcare choices, procedures, and/or products to meet the unique needs of each patient is the focus of personalized medicine. As an extension of personalized medicine, the 'P4 medicine' concept incorporates predictive, personalized, preventative, and participative elements [1]. More than five years ago, Leroy Hood[2] came up with the term "P4 medicine" to depict the ongoing transition in medicine from a reactive to a proactive field, where the ultimate objective is to maximize each person's well-being rather than just treat their disease.



It is believed that periodontal diseases are complicated conditions with different treatment results. The inflammatory response of the person and other modifying and predisposing variables ultimately decide the clinical appearance and prognosis of periodontal disease, even if bacteria are the cause. Each person has specific genetic and environmental variables that impact the course of their disease. In the diagnosis, treatment, and management of periodontal diseases, the unique inflammatory response of each individual and related regulatory variables must be considered.

We can identify at-risk patients and diagnose periodontitis early, when it is easier to treat, by using a predictive method based on the application of advanced diagnostic procedures.

It is a customized preventive measure based on the microbiological and genetic state of a particular patient. individualized care according to each patient's particular medical circumstances. The adoption of Participatory periodontology—a concept that encourages networked individuals to take a leadership role in their own health care—will highlight the patient's active involvement. One component of the 4 P approach to therapy is personalized periodontics. Personalized periodontics takes into consideration individual variances in circumstances, behavior, lifestyles, and genetic characteristics.



II. WHY DO WE NEED TO INDIVIDUALIZE PERIODONTAL CARE

Numerous remarkable clinical research conducted between the late 1960s and the mid-1980s effectively streamlined the causes of gingivitis and periodontitis to identify bacterial buildups on teeth as the main cause.

Landmark longitudinal research at the University of Michigan and the University of Gothenburg followed the important findings of a major "cause" of gingivitis and periodontitis, establishing fundamental guidelines for periodontitis prevention and treatment.

The underlying concept that bacterial buildup on teeth predictably caused gingivitis and, if left untreated, advanced to periodontitis was well confirmed by clinical experimental investigations of gingivitis in dental students and experimental studies of periodontitis in dogs. The idea that there was a straightforward linear association between bacterial accumulations and the onset and severity of periodontal disease was not supported by the specifics of several of those investigations or by the findings of other healthcare professionals.[3]

III. IDENTIFYING INDIVIDUAL RISK FOR PERIODONTITIS

Individual validation of a set of risk variables is necessary to determine a person's risk for developing periodontitis. A method to stratify patients using combinations of several risk variables must be employed since a chronic illness such as severe chronic periodontitis has numerous risk factors.

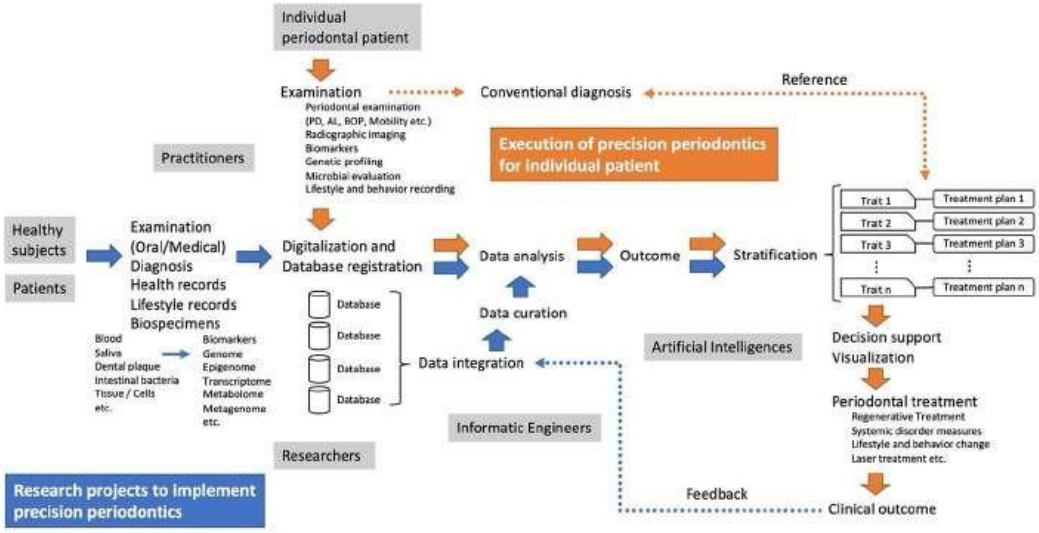
Step 1: Identify probable periodontitis risk factors

To identify certain traits associated with variations in patients' periodontal clinical signs, severity or progression, responsiveness to therapy, or systemic effects of periodontitis.

Step 2: Clinical validation of putative risk factors is required.

Step 3: In order to facilitate diseases prevention and treatment, clinical utility requires the use of risk factors to categorize people into categories.

Individualizing periodontitis risk, prevention, and treatment begins with predetermined criteria that divide each patient into distinct, mutually exclusive groups.



Risk Profiling and Diagnostic Tools

Accurate risk stratification combines clinical indices with molecular, genetic, and microbiological assessments.[6]

Biomarker or Tool	Sample Type	Clinical Insight
Interleukin-1β (IL-1β)	Gingival crevicular fluid	Indicates local inflammatory burden
Matrix metalloproteinase-8 (MMP-8)	Saliva	Reflects tissue breakdown activity
Porphyromonas gingivalis DNA	Subgingival plaque	Quantifies pathogenic load
HbA1c	Blood	Links glycemic control to periodontal risk
IL-10 and TNF-α SNP panels	Buccal swab	Reveals host-response genetic variability

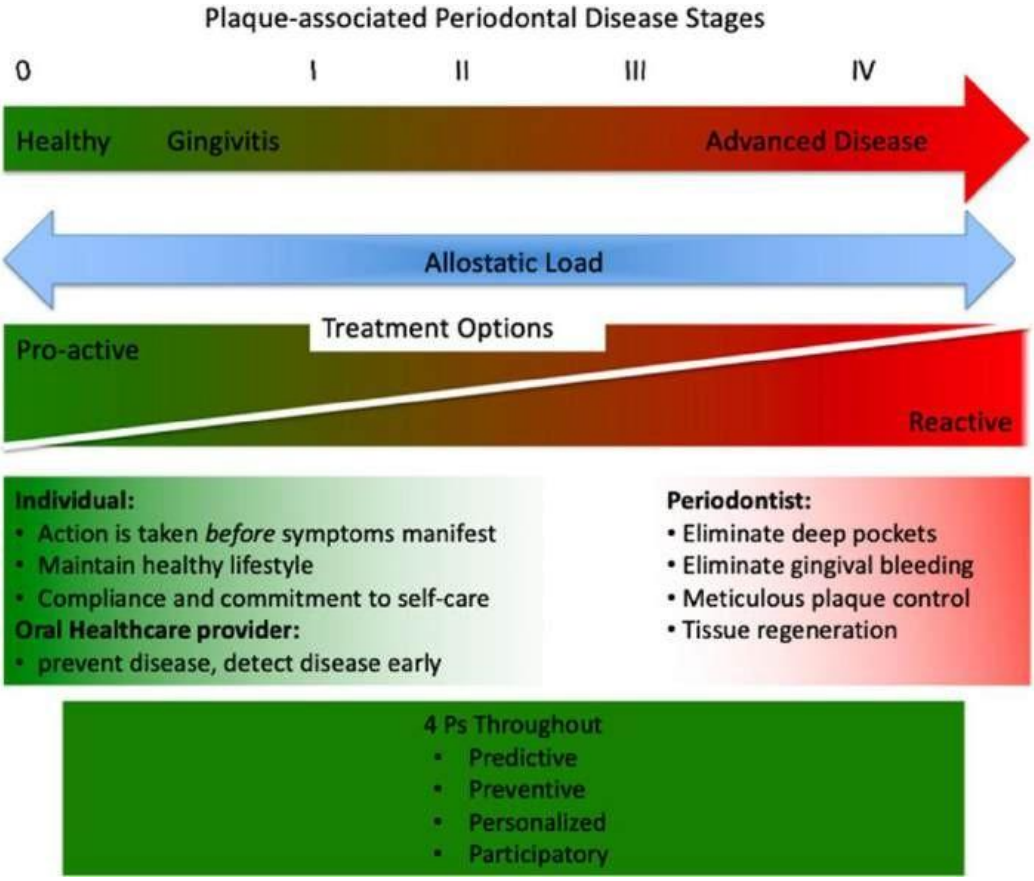
Combining these data points with probing depths, attachment levels, and radiographs enhances predictive accuracy for disease progression and guides personalized intervention intensity.

IV. RISK FACTORS AND INDIVIDUALIZED TREATMENT APPROACH 1) LIFESTYLE AND PERIODONTITIS

- Since it is now well acknowledged that periodontal diseases are complex, multidimensional chronic conditions, socioeconomic and environmental factors—such as lifestyle and educational attainment—can significantly affect how they appear clinically.
- This section examines the effects of various lifestyle choices that must be taken into account when developing a personalized care model for the management of periodontal diseases. These factors include alcohol, tobacco, prescription and recreational drugs, uncontrolled diabetes, obesity, malnutrition, allostatic load, and psychological stress.
- As a result, smoke cessation programs and alcohol consumption reduction strategies utilizing both conventional and more recent motivational and pharmacological techniques should be incorporated into tailored approaches to the management of periodontal disease.[7]
- For numerous years, the negative consequences of tobacco usage have been known.[8] All types of tobacco use have a negative impact on the development and course of therapy for peri-implant and periodontal diseases. They are also closely linked to changes in host/inflammatory responses, microbiology, and genetic traits specific to each tobacco user. Excessive alcohol intake may also make the negative consequences of tobacco usage worse. [9]
- It is commonly known that drugs are widely used for both medicinal and recreational purposes. In the context of individualized treatment for patients with periodontal disease, the wide range of effects of medications and the behavioral side effects that go along with them are quite important. Prescription medication side effects on the periodontium are very well established and include

altered inflammatory responses, increased gingival bleeding, and drug-induced gingival overgrowth.

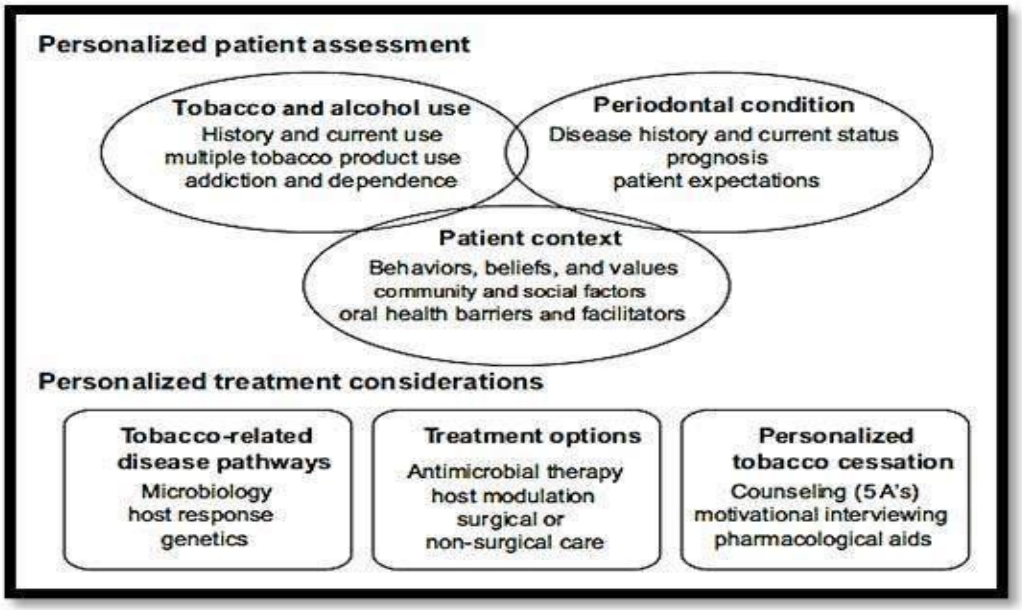
- **Stress and Micronutrients**: The role of vitamins (vitamin A, carotenoids, the vitamin B-complex, vitamin C, vitamin D, vitamin E, and coenzyme Q10) and minerals (calcium, magnesium, iron, zinc, potassium, copper, manganese, and selenium) in human physiology and the impact of their deficiencies on periodontal health and disease have not received much attention, despite decades of suspicion regarding the importance of diet and nutrition, particularly vitamins and other micronutrients. The majority of these micronutrients, if not all of them, have been connected to the development of periodontitis. However, nothing is known about how they may enhance periodontal treatment outcomes.
- It is evident that determining a patient's micronutrient deficiencies is a crucial component of individualized periodontal assessment and treatment, as several micronutrients can affect a wide range of biologic processes, including as wound healing and innate and adaptive immunity. In the context of customized periodontics, the function of stress and allostatic load is a crucial study
- The work by Sabbah et al. reviews research that looks at the connection between stress and periodontal diseases as well as the various stress assessment tools.[10] Most importantly, it is shown that persistent and frequent exposure to stressors causes systemic consequences, which are now known as allostatic load.
- Discovering composite biological markers as a risk factor for periodontal disease might be crucial in the field of individualized periodontics, as evidenced by the rapidly evolving research on the connection between allostatic load and periodontal illnesses. In addition to aiding people, this might help with customized periodontics by assisting in the targeting of therapies at certain risk levels, which could aid in the integration of policies that promote oral and general health.



- **Obesity:** The mounting data that obesity is a risk factor for periodontitis is only the beginning and not yet help us comprehend how it can affect patient care. There are concerns about the

methods for determining or measuring the risk at the level of one individual or tooth. Due to the lack of evidence about the possible advantages of weight loss in mitigating the detrimental and compounding impact of obesity on periodontal disease, we are unable to choose and suggest treatment plans that may be most effective in counteracting the obesity effect.[11]

- Professionals should follow established guidelines for evidence-based and individualized healthcare, making clinical decisions that take into account the unique characteristics of each patient, rather than restricting clinical judgments to body mass index thresholds or other indicators of overweight or obesity, as there is insufficient evidence to support specific treatment strategies for obese individuals.
- This demands an increasingly interactive approach to patient care that is focused on healthy lifestyle strategies to address modifiable risk factors supplemented by personalized choices of professionally rendered therapies[12].



CUSTOMIZED THERAPEUTIC PATHWAYS

Personalized treatments align intervention modalities with individual risk profiles and disease severity[13]:

1. **Mild, low-risk cases**

o Emphasis on patient education and rigorous oral hygiene o Standard scaling and root planing o Maintenance visits every 3–4 months

2. **Moderate-risk cases** o Adjunctive local antimicrobials or host-modulation agents o Focused mechanical debridement of deeper pockets o Maintenance every 6–8 weeks 3. **High-risk or refractory cases**

- o Surgical approaches (flap surgery, regenerative procedures) o Systemic antibiotic therapy selected via susceptibility testing
- o Intensive maintenance (every 4–6 weeks) with biomarker monitoring[14]

CLINICAL WORKFLOW CHART ❖ [Patient Assessment] ❖ [Risk Stratification] ❖ [Targeted Diagnostics] ❖ [Personalized Treatment Plan] ❖ [Implementation & Monitoring] ↺ (biomarker feedback loops)

BIOMARKERS IN PERSONALIZED PERIODONTICS

Personalized periodontics leverages biomarkers to stratify risk, monitor disease activity, and guide individualized therapy[15]. Here's a structured summary of key biomarkers with supporting evidence:

Inflammatory Biomarkers

Biomarker	Source	Clinical Role	Evidence
IL-1β	GCF, saliva	Indicates active inflammation and tissue destruction	Elevated in progressive periodontitis; linked to IL-1 gene polymorphisms
TNF-α	GCF, serum	Promotes osteoclastogenesis and bone resorption	Associated with severe periodontitis and systemic inflammation
IL-6	Saliva, serum	Amplifies inflammatory cascade	Correlates with disease severity and systemic comorbidities

Genetic and Epigenetic Markers

Marker	Sample Type	Clinical Insight	Evidence
IL-1 gene SNPs	Buccal swab	Predicts susceptibility to aggressive forms	Validated in Caucasian cohorts
TLR4 polymorphisms	Buccal swab	Modulates host response to bacterial LPS	Linked to chronic periodontitis risk
DNA methylation profiles	GCF, tissue biopsies	Reflects epigenetic regulation of inflammation	Emerging tool for risk stratification

Microbial Biomarkers

Biomarker	Source	Clinical Role	Evidence
P. gingivalis DNA	Subgingival plaque	Keystone pathogen in dysbiosis	Detected via qPCR and metagenomics
T. forsythia, T. denticola	Plaque samples	Associated with advanced disease	Included in validated microbial panels

Enzymatic and Matrix Markers

Biomarker	Source	Clinical Role	Evidence
MMP-8	Saliva, GCF	Collagen degradation; marker of active disease	Elevated in periodontitis; used in chairside tests
Chitinase	Oral rinse	Tissue remodeling and inflammation	Combined with MMP-8 improves diagnostic accuracy

EMERGING TECHNOLOGIES

- **Wearable biosensors** (e.g., mouthguard-based LOCs) enable real-time salivary biomarker monitoring and wireless data transmission[16]

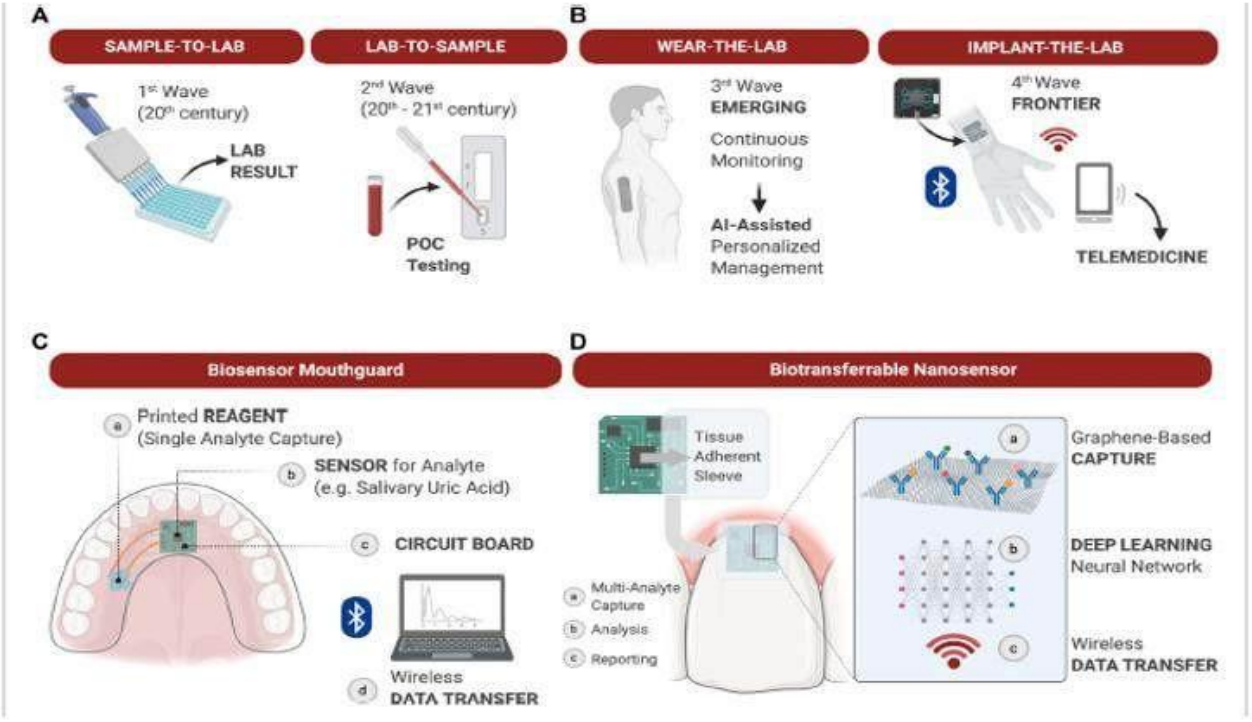


Figure 3: The evolution of diagnostic devices and wearable lab-on-a-chip's (LOC) for precision medicine applications.

- **Metabolomic markers** like isovalerate, butyrate, and glucose show promise in distinguishing health vs disease[17] • **AI-assisted biomarker analysis** improves predictive modeling and personal physiological threshold detection
- **Microbiome editing** using tailored probiotics or bacteriophages.
- **3D-printed scaffolds** seeded with autologous stem cells for site-specific regeneration.

Challenges and Future Directions

- Standardization of biomarker panels across diverse populations
- Validation of decision-support algorithms in multi-center trials
- Cost-effectiveness analyses to justify broader implementation
- Training clinicians in interpreting complex molecular data
- Ensuring patient access and engagement with digital tools

Conclusion

Personalized periodontics provides a customized, evidence-based approach for enhancing periodontal health. By integrating comprehensive risk profiling, molecular diagnostics, and digital decision support, clinicians can deliver precision care that maximizes clinical outcomes, enhances patient satisfaction, and uses resources efficiently. Continued research, validation studies, and technology refinement are essential to fully realize this paradigm shift.

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