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"Clinical Diagnosis in Periodontics Revisited: A Systematic Review"

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Abstract
A complete clinical diagnosis is an important step before starting with the treatment procedure of a patient. Within latest scope of periodontics, it is based on the data collected from the patient's clinical history and thorough oral examination.
A proper diagnosis is of utmost importance in any treatment planning. Inflamed and bleeding gingiva, increased pocket depth and soft tissue aberrations present different and varied clinical pictures, so a complete knowledge of the normalcy and interpretation of underlying pathologic changes in diseased state is a must for reaching a correct diagnosis. Diagnosis must not only identify the essential component to disease, but must analyze the type, distribution and severity of the disease.
A thorough clinical examination is necessary activity to formulate a diagnosis and to formulate comprehensive treatment plan. A precise diagnosis is most important for formulation of appropriate treatment plan for periodontal diseases.
Today we know that the current understanding of development of disease is multifactorial and involves site specificity, periodontal pathogens, host responsiveness, genetic, systemic, and behavioral risk factors
The newer available chairside side tests for host and bacterial markers of periodontal disease offer exciting prospects for monitoring of site specificity of disease but due to its high cost and not so easily available in all countries it is used only in few countries now a days. But in near future these diagnostic instruments will occupy their worthy place in periodontal diagnosis and will make diagnostic procedures more accurate, precise, informative and less time consuming.
Keywords: clinical diagnosis, periodontal disease, chairside tests
***Key Message**- A thorough clinical examination is necessary important to conclude a diagnosis and formulate a treatment plan. Various entities like microbiology, immunology, systemic, genetic, and behavioral factors should be kept in consideration whilst assessing the patient along with clinical and radiological assessment.*

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I. INTRODUCTION

The word 'Diagnosis' has arisen from the Greek word gnosis- "to know" and Dia -"through". In clinical practice, management of any disease depends on how well the clinician collects history from the patient, followed by a detailed clinical and radiological examination and if required laboratory investigations and consultations. The collected data helps in diagnosis and treatment of the disease.[1] A precise diagnosis is often sentinel step to formulate a comprehensive treatment plan

, leading to relief of periodontal infections. A misdiagnosis diagnosis leads to wrong treatment and prolongation of the patient's periodontal problem.[2]

The goal of recent research in periodontal diagnosis is understand the development of disease and its application in the future.[3] The current systematic view periodontal disease is subject related susceptibility which infers that there is generalization of person's susceptibility and host defense mechanisms.[3] Recent immunocytochemically based approach has offered a new avenue in periodontal diagnostic research. The availability of complementary information on pathologically altered tissues has provided new diagnostic products to evaluate patient periodontal status as chair side diagnostic tools.[4]

DIAGNOSTIC TECHNIQUE IN PERIODONTOLOGY

A Historical review

The historical diagnosis was made from physical signs and symptoms. In ancient China inflammatory lesions of the gingiva were recorded by differences mobility of tooth and fetid breath.[5] Hippocratic (1923) formulated diagnosis of periodontal disease considering changes in the gingival color alongwith bad breath.[6] The penultimate and diagnosis of dental disease was published by Pierre Fauchard (1728).[7] His diagnostic description of gingival and periodontal disease included color and form change of the gingiva, recession, mobility of tooth and pain. John Hunter (1771) demonstrated swelling, tenderness, and bleeding upon slight manipulation in scurvy patients.[8]

CLINICAL EVALUATION OF PERIODONTAL DISEASE

An Early Approach

In early eighteenth-century diagnosis was largely based upon detection of suppuration in gums. This coined the term "pyorrhea alveolaris".[9] Riggs (1876) in United States and John Younger (1905) in Europe narrated the changes of the marginal tissues precisely.[10,11] They also found the mobility of tooth and migration in advanced cases. In early twentieth century that the suppurative etiology of periodontal disease was nullified.[12] Prinz (1978) included these symptoms of pyorrhea: root denudation, occlusive disturbance, fremitus, progression of mobility and pain on percussion, granulation tissue pocket, sub gingival calculus, jaw pain during teeth suppuration.[13]

The periodontal probe was the sentinel attempt to quantify the severity of periodontal disease. GV Black (1915) was the first to describe the systematic use of a probe for periodontal pocket exploration.[14]

Rest of the features of the clinical examination including gingival bleeding evaluation, recession, migration of tooth and gingival color changes have been used in examination for years. Specific indices have been formulated for gingivitis (Gingival Index), plaque (Plaque Index), calculus, bleeding, and periodontitis (PDI).

Occlusion and mobility of tooth evaluation have been used for ages. Miller (1975) deviced a quantifying mobility scale for lateral movements recording whilst a tooth was placed between two handles of instrument.[15] Muhlemann (1951) invented a tool to calculate the horizontal displacement known as Muhlemann's periodontometer.[16] Karolyi (1901) postulated theories resulted in notification of occlusion and recording of tooth mobility.[17]

History

GV Black mentioned in his book, Special Dental Pathology in 1924 "*the use of very thin flat explorers to determine the depth of the pockets*".[19]

FV Simoton in 1925, first described use of periodontal probe. Simoton called the probe as a "periodontiometer".[20]

In his understanding of periodontal pocket treatment , HK Box (1928) found set of six periodontal probes. Unfortunately, Box, never described the instruments.[21]

Frequent periodontal probing for diagnosis was accepted very slowly. Periodontal books in 1930's mentioned charts and probe use but didn't mention the pocket depth recordings.

PERIODONTAL PROBE GENERATIONS

Philstrom et al[18] organized probes into three generations in 1992. **Watts**[23] further added fourth and fifth generation probes. (**Table 1)**

First Generation Probes[24,25]

These are conventional hand instruments having a handle, shank, and a working end. The working end has got calibrations in mm and/or color coding to signify the measurements. These probes are mostly used by general dentists and periodontists. (**Table 2)**

Disadvantages of conventional probes[31]

It shows inaccuracy due to several non-controllable variables in manual recording, pain caused by probing, irregularity in probing force, inconsistency in probe diameter, unavailable stable reference point, obstructions, faulty anatomy of the crown and root, probe angulations, access to the area, various degrees of tissue inflammation of base of pocket.

Second Generation (pressure sensitive) Probes[32-36] (Table 3)

- Second generation instruments are sensitive to pressure which allows for a standardized probing pressure.
- Scientific literature illustrated that probing pressure should be standardized and not exceed 0.2 N/mm^2 led to the invention of these probes. **(Hefti AF 1997)[26]**
- Do not require computerization in the operatory.

Limitations of 2nd generation probe[40]

Difficulty in recording the data and calculating the attachment level, no digital read out, no storage of data, examiner bias

Third Generation Probes (automated/ computer linked electronic constant pressure)[48- 50](Table 4)

- Despite advancement in second-generation probes, other errors like examining the probe, tabulating data and calculating attachment level, still needed to be taken care of.
- Third-generation probes were invented to decrease the errors, by standardizing pressure as well as digitalizing probe recording and storing the data on computer.
- This generation comprises computer-aided direct data capture so as to decrease examiner bias and allowing more precision.

Fourth generation probes[26]

- Fourth generation consists of three-dimensional (3D) probes. Currently under development, the aim of these probes is to record sequential probe positions along the gingival sulcus.
- They attempt to extend linear probing in a serial manner to account continuous and 3D pocket under examination.
- Till now, all probes were painful, invasive & penetrate the junctional epithelium, so a next generation was introduced to overcome these limitations.

Fifth Generation (the ultrasonic periodontal) Probe[58,59]

- Although previous generation probes were advanced, still they were invasive and can cause pain to patients.
- Their probe tip usually crosses the junctional epithelium.
- To overcome these shortcomings, Fifth generation probes are being developed. These probes will have 3D design, will be non-invasive.
- Fifth generation probes without being invasive will identify the attachment level.
- The sole fifth generation probe available, which is UltraSonographic (US) probe (Visual Programs, Inc.), detects, images and maps upper boundary of the periodontal ligament by using ultrasonic waves.
- Hinders and Companion founded US probe at NASA Langley Research Center.[59] The tiny intraoral probe has an ultrasound beam projection area similar in size to width of the periodontal ligament space for precise coupling. It provides sufficient signal strength and depth of penetration to image the periodontal ligament space.

Advantages

- Ultrasonic periodontal probing has the capability of detecting much smaller increments of anatomic change with the promise of earlier detection of tissue breakdown and additional histological information, such as tissue thickness and inflammation
- Periodontal ultrasonography is likely to yield more information with less error, which will aid in a better understanding of the pathogenesis of disease, thus permitting earlier diagnosis and intervention.
- Hand piece design is ergonomically modified to facilitate intra-oral use and ultrasound probes are a significant improvement over previous design.
- To detect condition of gingival tissue, quality and extent of epithelial attachment to tooth surface.
- Faster and painless technique Disadvantages

- Costly
- Technique sensitive

Non-periodontal probes

Name of probe	Purpose	Author name	Year
Detc Tar probe[60]	Calculus detection	Kasaj A, Moscos I, Rohrig B et al	2008
Diamond probe[61]	Halitosis	Zhou et al	2000
Periotest[62]	Tooth mobility	Schulte et al	1992
Periotemp[63]	Subgingival temperature	Wolff et al	1997

Peri – implant probing[64]

Implants not to be probed with metal probes because of:

- Injury to the junctional epithelium.

The risk of scratching the surface of the implant or abutment thus making them more plaque retentive and prone to peri-implantitis.

Probes for peri-implant probing

Name of probe	Markings	Color coding	Special features
Colorvue probe (Hu-Friedy)	3-6-9-12	Yellow tip and black markings	Flexible, rounded tip Convenient twist-on design
Periowise probe	Green=0-3mm Red mark at 5mm Red=7-10mm	Green- gingivitis Red - periodontitis	Flexible rounded tip 0.5 mm

Tooth mobility[65]

Various mobilometers used to measure tooth mobility **(Table 5)**

The Periotest Method[73,74,75] The "Periotest Value" depends to some extent on tooth mobility, but mainly on the damping characteristics of the periodontium. The Periotest calculates the reaction against a reproducible impact applied to the tooth. The Periotest value is bio physical variable. Contact time between the tapping head & the tooth varies by 0.3 - 2 milliseconds.

The following ranges should be considered:[76]

Range	Interpretation
-8 to + 9	Clinically firm teeth
10 to 19	First distinguishable sign of movement
20 to 29	Crown deviates within 1 mm of its normal position
30 to 50	Mobility is readily observed

Subgingival temperature

Many authors have advocated a lower subgingival temperature (2°C) as compared to sublingual temperature (37°C). [77-82] **Wolff at al (1997)**[83] observed subgingival temperature (with Periotemp) keeping in mind, gingival crevicular fluid enzymes, cytokines and subgingival plaque flora. He found relationship between subgingival temperature and health of periodontal tissues.

Subgingival temperature	Condition of periodontal tissues
34.53	Healthy
34.91	Gingivitis
35.74	Periodontitis

He concluded that: 1) GCF volumes, enzymes and cytokine levels generally increased with worsening of diagnosis; 2) Subgingival temperature and GCF enzymes are correlated; 3) Subgingival temperature and GCF cytokines are not correlated.

Mukherjee et al (1978)[77] measured the temperature 104 pockets of various depths using thermistor needle. He found that 1) the temperature of the periodontal pockets did not vary significantly with increase in pocket depths; 2) Clinically, classification on the severity of periodontitis considers pocket depth as only to the inflammatory state of periodontium, this may explain the reason for absence of correlation between the temperature of the periodontal pockets and the pocket depths.

Oral malodor (Table 6)

Breath odor can be defined as the subjective perception after smelling someone's breath. It can be pleasant, unpleasant, or even disturbing, if not repulsive. If unpleasant, the terms *breath malodor, halitosis,* or *bad breath* can be applied. These terms, however, are not synonymous with *oral malodor,* which has its origin in the oral cavity.

II. CONCLUSION

A complete clinical examination is critically important data collection activity that is necessary to arrive at a diagnosis and to develop a relevant treatment plan. An accurate diagnosis is the first step towards development of a well-designed and appropriate treatment plan that leads to resolution of periodontal infection. An incorrect diagnosis often leads to an ill-conceived treatment approach that ultimately leads to negative impression of dentist on his/her patient.

As the understanding of the nature of periodontal disease has changed in the last two decades with evidence that periodontitis does not affect all people, at all times, at same rate and is site specific in nature. Today we know that the current view is that the disease process itself is considered to be site specific and has a multifactorial origin in which periodontal pathogens, host response, and genetic, systemic, and behavioural risk factors interplay to develop the disease process. In light of this information, consideration should be given to including microbiologic, immunologic, systemic, genetic, and behavioural factors, in addition to the traditional clinical and radiographic parameters, when assessing patient status.

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Tables:

PERIODONTAL PROBE GENERATIONS (Philstrom et al 1992)[18]
FIRST GENERATION PROBES
1. William's probe 2. University of North Carolina (UNC)- 15 probe 3. Community Periodontal Index of Treatment Needs probe (CPITN) 4. University of Michigan 'O' probe 5. Marquis colour coded probe 6. ZIS probe 7. Naber's probe 8. Goldman Fox probe 9. Plast-O-probe 10. Novatech probes
SECOND GENERATION PROBES
1. Probe by Gabathuler and Hassell (1971) 2. True Pressure sensitive probe 3. Borodontic probe 4. Probe by Armitage 5. Pressure probe by Van der Veldon 6. Probe by Polson 7. Yeaple probe 8. Prock probe 9. PDT Sensor probe
10. Hawe-click probe 11. Vinevalley Probe
THIRD GENERATION PROBES
1. Foster Miller probe/ Jeffcoat probe 2. Florida probe 3. Go probe 4. Accutek probe 5. Torronto Automated probe 6. Perioprobe 7. Interprobe
FOURTH GENERATION PROBES (Watts 2000)[23]
• Three-dimensional (3D) probes, these probes are aimed at recording sequential probe positions along the gingival sulcus
FIFTH GENERATION PROBES (Watts 2000)[23]
• The Ultrasonic Periodontal Probe

Table 1: Generation of periodontal probes

FIRST GENERATION PROBES (CONVENTIONAL OR MANUAL PROBES)[24,25]				
NAME	**AUTHOR(S)**	**YEAR**	**MARKINGS**	**Special features**
WILLIAMS'S PROBE[26]	Charles H.M. Williams[27]	1936	1 mm, 2 mm, 3 mm, 5 mm, 7 mm, 8 mm, 9 mm and 10 mm.	prototype or benchmark for all the first-generation probes
UNC-15 PROBE[26]	Hunter	1994	5,10,15 mm	Preferred probe in clinical research when conventional probes are required
WHO (CPITN) PROBE	George S Beagrie & Jukka Ainamo[28]	1978	1. CPITN C PROBE (CLINICAL)[26,28]-Markings at 3.5, 5.5, 8.5 and 11.5 mm 2. CPITN E PROBE (EPIDEMIOLOGICAL)[26,28]-Markings at 3.5 and 5.5 mm	Screening and monitoring of patients with CPITN Index
The Michigan 'O' probe[26]	Sigurd P. Ramfjord	1981	3,6,8 mm	A modification of this probe with Williams' markings also is available known as University of Michigan 'O' probe.
Marquis color coded probe or Hu-Friedy color coded probe[26]	Hu- Freidy	1965	3, 6, 9, and 12 mm	The probe is colour coded by alternately coloured or black and silver bands
Naber's probe[26]	Dr. Claude Nabers	1965	NABER'S 1N- no markings NABER' 2N – 3,6,9 and 12 mm NABER'S 3N – 1,2,3,5,7,8,9,10 mm	It is used for measuring into the furcation area between the roots of a tooth & to determine the extent of furcation involvement on a multi rooted teeth. It has a curved working end for accessing the furcation area
The PCP12 probe with Marquis markings	Hu-Friedy	1968	It has alternating shades every 3 mm	The probe is on a modified shank, intended to make it easier to align the probe with the vertical axis of the teeth
Goldman – Fox probe[26]	Goldman Fox	1873	1-2-3-5-7-8-9-10 mm	rectangular in cross section. Flat probes used to assess periodontal pocket depths, attachment levels, anatomy configurations & gingival bleeding.
ZIS probe[26]	Muhleman	1960	3, 6 and 9 mm	115 degree angle between shank and tip and tip end exceeded the long axis by 13 mm
Plast-O- Probe[29,30]	Schmid	1967	3, 6 and 9 mm	The flexible blade shaped tip granted better access to pockets and adaptation of the probe to the root surface
Novatech probes[26]	Dr. Ronald Goldstein	1968	1-2-3-5-7-8-9-10 mm	Unique right angle design for improved adaptability in posterior regions

Table 2: First generation of probes

SECOND GENERATION PROBES (PRESSURE SENSITIVE PROBES)[32-36]				
NAME	AUTHOR(S)	YEAR	MARKINGS	Special features
Probe by Gabathuler and Hassell[37]	Gabathuler and Hassell	1971	3,6,9 mm	Probing forces were transferred from the tip to the sensor via a piston arrangement, and the electric potential generated in the piezo element was amplified, stored on

				tape, or converted into a printer signal.
True pressure sensitive probes (TPS)[38,39]	Hunter et al	1990	colour-coded black/white bands marked at 1,2,3,4,5,6,7,9 and 10 mm	Objective of quantitative gentle probing
Borodontic probe[40]	Breen HJ, Rogers PA, Johanson NW	1992	1,2,3,5,7,8,9 and 10 mm	The tines are mounted in a hinged handle adjusted to 0.25 N (25 gm). The accuracy of the tine was checked using a photomicroscope, for borodontic the accuracy was tested by using the ingestrom machine®

Probe by Armitage[41]	Armitage	1977	Calibrated for forces from 0.15 N to 0.35 N in 0.05 N increments.	Pressure sensitive probe holder to standardize the insertion pressure and determine how accurate probing pressure of 25 pounds affected the connective tissue attachment.
Pressure probe by Van der Velden[42]	Van der Velden	1978	Calibrated from 0 to 9 mm in 1 mm increments	pressure-sensitive probe with a cylinder and piston connected to an air-pressure system. Subsequently, it was modified with a displacement transducer for electronic pocket depth reading
Probe by Polson[43]	Polson	1980	The instrument consists of two parts: a hand piece having the overall size and shape of a large fountain pen and a small electronic control box having a knob for pre-setting the probing force	sterilised periodontal probe tip is inserted into a chuck at the front of the hand piece. The examiner probes the gingival sulcus, increasing the pressure until an audible "beep" is heard from the control box. This indicated that the preset probing force – e.g., 25 gm- has been reached. The depth of probe tip insertion into the sulcus is then recorded.
Yeaple Probe	Borsboom and co-workers[44]	1981	Probing force was 0.13 N for standard measurements, but forces of 0.26 N and 0.57 N were also possible.	used in studies of dentinal hypersensitivity
The PDT Perio and PDT Sensor Probes[45,46]	Philstorm	2001	result of the latest in thermoplastic technology	Virtually non-abrasive in use and especially safe around implants. It provides consistent reading between visits and among clinical staff members

Vivacare pressure – sensitive periodontal probe system[47]	Bergenholtz A et al	2000	The viva care probe is equipped with a 0.5mm ball tip with a tactile rim to minimize tissues trauma, and better detect irregularities on the root surface.	The tip is connected to a special spring mechanism, which controls the pressure extended to the probe tip. The force indicator lines coincide at approximately 20g force

Table 3: Second generation probes

THIRD GENERATION PROBES (AUTOMATED/ COMPUTER LINKED ELECTRONIC CONSTANT PRESSURE)[48-50]				
NAME	AUTHOR(S)	YEAR	MECHANISM	SPECIAL FEATURES
Foster Miller Probe/Jeffcoat Probe	Jeffcoat et al[51]	1986	The probe extends a thin metal fibre along the tooth surface into the sulcus and detects a slight accelerational increase when encountering the CEJ, and then undergoes final extension, under constant force on reaching the base of the pocket.	Has controlled probing pressure and it is used for automated detection of cementoenamel junction(CEJ)
Toronto Automated Probe	McCulloch and Birek[39]	1987	The sulcus is probed with a 0.5mm nickel titanium wire that is extended under air pressure.	The probe provides an estimate of biophysical integrity of the dentogingival junction by measuring intrapocket probing velocity (Tessier et al. 1994)[52]
Florida Probe	Gibbs et al[53]	1988	Its features include: probe hand piece, digital readout, a foot	They also can record missing teeth, recession, pocket depth, bleeding,

			switch, a computer interface and a computer	suppuration, furcation involvement, mobility and plaque assessment.
Perioprobe	Meissner G, Oehme B et al[54]	2000	Perioprobe is computerized electronic probe which consists of a hand-piece with a disposable probe sleeve unit with a ball shaped end point (0.5mm diameter).	The microcomputer keeps track of where the measurements are taken (initial programming of selected teeth is of course necessary), stores the measurements and can calculate means scores.
Go Probe System[55]	Arthur F Hefti	1997	it allows you to use any periodontal probe and our new wireless keypad as the input device for your perio charting and record creation during perio exams.	The system will increase patient treatment acceptance
Accutek Probe	Goodson and Kondon[56]	1988	used fibre optic technology	The signal can be processed for direct output on a liquid crystal display or stored in computer memory for subsequent listing or transfer to a host computer.
InterProbe[57]	The Dental probe Inc., Glen Allen, VA	1988	It measures pocket depth using an optical encoder which is attached to a disposable plastic fiber probe tip that retracts within a sleeve when pressed into a periodontal pocket.	Painless as InterProbe gently slides in but Stainless steel probes push the gingival away from the tooth, causing pain. Provides repeatable measurement of pocket depth and attachment loss as probing pressure is constant.
				Disposable tip eases concerns by patient about cross contamination.

Table 4: Third generation probes

Instrument	**Year**
Elbrecht's indicator	1939
Werner's oscillator	1942
Beyeler and Dreyfus vibrometer	1947
Znirner's oscillograph	1949
Manly's device	1951
Muhlemann's Macroperiodontometer and Microperiodontometer[66,67,68]	1954
Picton's Gauge	1954
Parfitt's transformer	1958
Joel's technique	1958
Goldberg's device	1961
Korber's transducers	1962
USAFSAM Periodontometer (O'Leary and Rudd)	1963
Pameijer's device	1973
Laser method (Ryden)[69]	1974
Persson and Svensons devices	1980
Periotest (Siemens AG, Bensheim,Germany)	1992
Laser vibrometer method(Castellini P et al)[70,71]	2009
Resonance frequency analysis(Kanth et al)[72]	2014

Table 5: Instruments to check tooth mobility

Method	Author	Year	Function
Halichek[84]	Tonzetich J	1977	Is a specialized gas chromatography test that measures individual gases of bad breath
Dark field or phase contrast microscopy[85]	Moriyama T	1989	Measures spirochetes and motile organisms in bad breath
Halimeter[86]	Rosenberg et al	1991	First successful halitosis measuring device, detects volatile sulphide compounds in bad breath
Organoleptic rating[87]	Rosenberg and Mcculloch	1992	Scoring method to check halitosis
Saliva incubation test[88]	Quirynen M	2003	Detects presence of gases in bad breath
Gas chromatography[89]	Murata T	2006	Quantifies presence of specific compounds present in someone's breath

Table 6: Methods to check oral malodor