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ADVANCED DIAGNOSTIC AIDS IN PETIODONTOLOGY: A REVIEW ARTICLE

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ABSTRACT
The rise of these innovative treatments has led to a greater requirement for advanced radiographic imaging in the field of periodontics. Despite advancements in imaging technology, intraoral radiography continues to be the primary imaging method used in periodontics. Researchers are relying heavily on digital imaging in clinical research centers to evaluate the impact of treatments and to examine the development of periodontal disease. In addition, the primary objective of diagnostic procedures is to identify the disease process as early as possible. This enables the implementation of highly effective preventive measures and minimally invasive interventions.

Keywords: Intraoral Radiography, Periodontics, Preventive Measures, Root Length, Examine

INTRODUCTION

Periodontitis is a group of related diseases that are linked together and have varying host responses to bacterial infection in the affected area. The diagnosis of periodontitis has progressed due to technological advancements and a better understanding of the pathophysiology of the condition. Considering the historical context around the development of these diagnostic procedures, it is beneficial as more advanced and precise diagnostic methods are being developed. Initially, diagnostic procedures focused mostly on the observable physical manifestations and symptoms shown by the individual who was ill. In ancient times, medicine was practiced by shamans who employed techniques such as bloodletting, cupping, and purgatives to rid the body of what they believed were the causative agents, often referred to as demons as shown in figure1.[1]

FIG 1: TREATMENT PRACTICE

"According to Marti-Ibafiez, the primary focus of medicine was not the diagnosis of various diseases. Instead, they believed that all diseases were caused by the intrusion of a foreign body, possession by a spirit, or the departure of the soul".[2] Centuries ago, the pioneers of medicine began to take a keen interest in closely observing patients in order to identify the distinct signs and symptoms of various diseases. Later, in China, resarchers found inflammatory lesions present in gingiva which includes tooth mobility and unpleasant breath.[3-5] Hippocrates was responsible for transferring the practice of medicine from the realm of superstition and religion to the sphere of rationality.[6] Hence, hippocrates reported the four humors, namely blood, phlegm, yellow bile, and black bile, were essential components of medicine as shown in figure 2.[7,8]

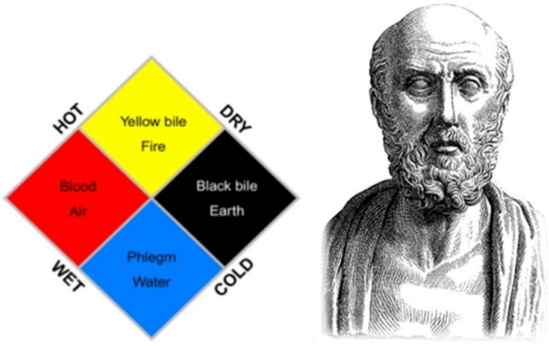


FIGURE 2: BALANCE OF THE FOUR HUMORS

In addition to above, the hippocratic clinical diagnostic of PD disease have identified & shown the alterations in gingival pigmentation as a symptom of bad breath.[1,9] In other words,

researchers concluded that “the senses of touch, sight, smell, and, to a lesser degree, taste and hearing have been the earliest methods for diagnosing disease via the use of these instruments”.[1] Systematic diagnosis did not emerge in contemporary medicine and dentistry until the sixteenth century, when the tools of scientific study were devised. This was the beginning of the development of systematic diagnosis.[1] Moreover, remarkable advancements in dental anatomy were made by Eustachius in 1563, followed by contributions from Bartholin, Stensen, Malphigi, Highmore in 1651, and Tomes in 1848. [8,5,10,11] In dentistry, like in medicine, a diagnosis was based on a full description and physical examination that included taking a patient's complete medical history and observing, palpating, percussioning, and auscultating the patient's teeth and gums.[12] These inventions ultimately enabled precise measurement and diagnosis in the health sciences.[1,13,6]

Pierre Fauchard published the first comprehensive codification of dental diseases. His detailed explanations of gingival and periodontal diseases encompassed various manifestations such as alterations in gingival color and shape, gum recession, tooth mobility, pain, and unpleasant breath odor.[14] John Hunter, an anatomist from the eighteenth century, observed and recorded the occurrence of swelling, tenderness, and bleeding in cases of gum scurvy, even with minor provocation.[15] In 1799, Joseph Fox, a trailblazer in the field of dental education, established structured dental curricula at London's Guy's Hospital. Different patterns of calculus and gingival recession were carefully observed by him as shown in figure 3.[16,1]

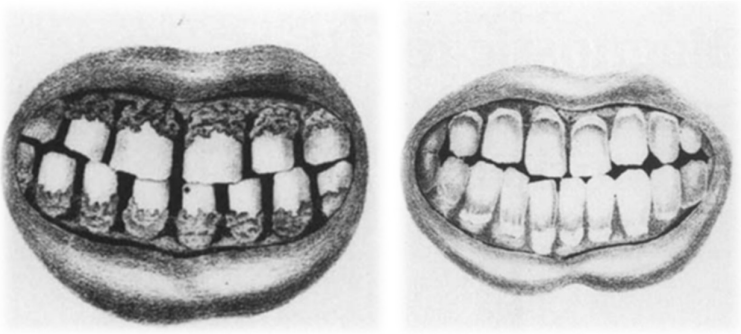


FIGURE 3: THE NATURAL HISTORY AND DISEASES OFTHE TEETH DEMONSTRATING DIFFERENT TYPES OF CALCULUS FORMATION

EVALUATION OF DISEASE

Dental practitioners in the 18th century made little contributions to the development of new diagnostic procedures. Between 1734 and 1887, there was a significant dispute on the underlying cause of this illness, whether it was systemic or local in nature. Multiple writers have suggested that the cause of the condition is related to the alveoli, and the diagnosis mostly involves identifying the presence of suppuration.[1] The term "pyorrhea alveolaris" became widely used due to this perspective.[1,5] Among the first to advocate for the local etiology idea of periodontal diseases were John Younger [17], an American, and Riggs [18], an American, in 1901. Both provided extensive descriptions of the clinical alterations affecting the marginal tissues. Additionally, they saw that teeth were mobile and migrating, which is a sign of severe disease. According to Colyer [19], periodontal disease is characterized by the progressive disappearance of the gum tags between the teeth (papillae) and the obliteration of

the typical festoons. The idea that periodontal disorders were caused by suppurative alveoli was not rejected until the early 1900s.[20,21,22] These include teeth separation, increasing tooth mobility, disrupted bite alignment, vibrating sensation upon tapping, formation of pockets with inflamed tissue, exposure of the tooth root, presence of calculus below the gumline, pus formation, and jaw pain upon waking up.[23] The examination procedure recommended by the researchers documented medical history, through physical examination, tooth mobility, deeping gingival trough, suppuration, lymph node involvement, tooth migration or separation, the presence of granulation tissue, calculus, mouth odor , X-rays and culture to detect Plaut-Vincent organisms. It is fascinating to observe the shift in attention towards bacterial examination and fetor ex oris as factors with diagnostic significance, as evidenced by recent developments. [24,25] The periodontal examination was clearly a neglected area of dental treatment, as highlighted by a textbook from the 1950s. In order to detect probable causes of discomfort, it said that enough time should be set out for a comprehensive examination of each tooth surface. Furthermore, a thorough investigation of the gingival sulcus on every root surface was essential to identify the development of pockets and calculus presence. Typically, this comprehensive examination takes at least half an hour. Even though medical tools like the clinical thermometer, stethoscope, otoscope, and sphygmomanometer were established, dental disease was not frequently assessed using quantitative approaches until the late nineteenth century. [1] The first person to talk about the meticulous utilization of a probe to examine periodontal pockets was G.V. Black. He precisely measured the depth of these pockets using flat, thin probes.[26] It seems that these probes were not calibrated properly as shown in figure 4.

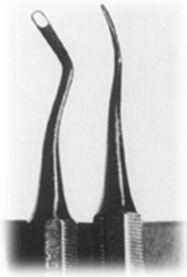


FIGURE 4: EXPLORER

In 1925, Simonton introduced a novel device for measuring crevicular depth called the University of California periodontometer.[27] These probes were calibrated on both the right and left sides as shown in figure 5.[27]

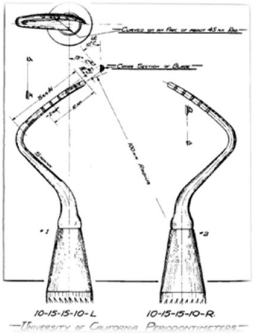


FIGURE 5: PROBE

In 1931, Merritt, the creator of a widely-used medical instrument, emphasized the importance

of thoroughly examining the mouth, specifically the gingival crevice. According to Merritt, any examination that neglects this area cannot be considered comprehensive.[28] Despite several significant limitations, the periodontal probe has remained the main instrument for the clinical evaluation of periodontal pathology.[29] Doubts about the veracity of probing data were raised as far back as 1971.[30] This worry was based on the impact of force variability on tissue penetration, as well as the consideration of other factors such as the angle of the probe and the histological state of the underlying tissues. A number of researchers conducted a comparison between histological measures and clinical data obtained via probe measurements.[1]

In 1980, Listgarten examined and analyzed the accuracy of probing and found that the depth of the probe seldom matches the depth of the pocket. Consequently, it was determined that the gap grows as the inflammation level rises which includes probing force, degree of inflammation of gingival tissues, angulation of the probe ,ocket configuration, type & location of calculus and d egree of healing with long junctional epithelium following treatment.[31] Despite the challenges in interpreting probing depth findings, the periodontal probe remains a straightforward and rather dependable tool for assessing the overall periodontal health of a set of teeth.The user's text is "[31]". A significant number of dental clinics in the late 19th century were still without electric examining lights. [32] In the early 20th century, the introduction of electricity enabled the development of dependable dental examining lights, which were a significant upgrade over gas lighting. The number 32 is enclosed in square brackets as shown in figure 6. Additionally, researchers also found that, due to lack of clearance of convenient method recording , visual symbols come into picture which includes pocket, bleeding on probing, furcation involvement & tooth mobility.[33,34]

FIGURE 6: DENTAL LIGHT POPULARIZED

CLINICAL DIAGNOSIS

Occlusion And Tooth Mobility

Karolyi et al., found the effects of occlusal trauma first. [35] Later on, Miller et al., in their study found a graduated mobility scale to document the lateral tooth movement. [33] After this, Muhlemann et al., reported & created a more precise recording device for displacement.[36] Similar instrument was also developed by Picton et al.,[37] Then in 1980, researchers found a standard clinical scale with 3 gradations which was very similar to by Miller study , it was then refined by Muhlemann and Prichard.[38]

Gingival inflammation assessemnt-

Researchers have found that a gingiva which is said to be healthy will be pink in colour, scalloped in contour, firm & resilient in consistency & knife edge margins. On the other hand, inflammated gingiva includes oedematous gingiva, loss of knife edge margin, red colour gingiva and bleeding on probing.[39] Inflammation of the gingiva and the tissues that support the periodontium is a common symptom of periodontal disease. This inflammation in these tissues is mostly caused by dental plaque (DP), which is always located around the tooth near the gingival sulcus. [40] Dental plaque is the primary source of this inflammation. In the event

that the irritation is not healed by home or professional treatment, such as scaling and root planing (SRP), gingivitis may develop as a consequence. Certain instances have the potential to develop into periodontitis if they are not treated. In addition to above, reseachers ahve shown that, imbalance between the host and bacteria is the root cause of periodontitis, which ultimately leads to loss of clinical attachment & bone.[41] Haffajee et. al., in 1992 used periodontal temperature probe (Peritemp , ABIODENT, inc, Danvers, MA, USA) to assess subgingival temperature and found temperature increased due to inflamed sites.[42]

Assessment of loss of Periodontal attachment –

According to a study, loss of periodontal attachment means apical migration of junctional epithelium which utimately leads to gingival recession / True pocket formation . Addition to above, the depth of healthy sulcus = 1-3 mm. Here, recession can be measured by adding sulcus pocket depth and distance between CEJ. For true pocket clinical attachment level is measured by distance between CEJ & base of pocket. In cases where gingival margins are located coronal to CEJ ,then clinical attachment level will be measured by subtracting distance from free gingival margin to CEJ from pocket depth.[39] Addition too this, researches have shown that the use of conventional periodontal probes to calculate attachment loss not provide accurate results due to diameter of probe tip, insertion force and angulation of probe.[39] Thus, to overcome these problems, standardization of peridontal probe were developed like constant prressure probes and electronic probe with & without computerized capturing techniques. [39] At present, there are total 5 generations of periodontal probe have been classified by reseachers which are listed below:-[39]

1. First generation periodontal probe
2. Second generation periodontal probe
3. Third generation periodontal probe
4. Fourth generation periodontal probe
5. Fifth generation periodontal probe

RADIOGRAPHICAL ASSESSMENT [43]

The radiographic image is created when X-rays, also known as Röntgen rays, penetrate the target region and expose the silver halide emulsion on the film. They are used to evaluate bone support by one of three primary methods. These include the analysis of the radiographic image, the quantification of measurements, and the manipulation of the image using processing techniques. On the other hand, the structures with a higher density, such as teeth or bone cause a more significant reduction in the X-ray beam compared to lower-density structures like soft tissue.[43]

VARIOUS DIAGNOSTIC AIDS[43]

A. PERIAPICAL VIEW

Advantage

1. Minimize distortion of the bone-to-root relationship while imaging the root apex .
2. Achieve an accurate representation of the bone height along the root surface, (central ray must be perpendicular to the area of interest and the intraoral film).(as shown in figure 7)

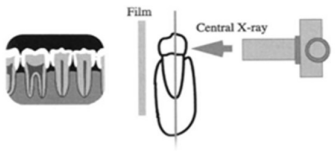


FIGURE 7: X-RAY IS PERPENDICULAR TO THE AREA OF INTEREST

Disadvantage

1. Susceptible to operator error, especially in the maxillary molar regions .
2. Distorted bone tooth relationship
3. Foreshortening or elongation
4. Bone may even appear to cover enamel of the teeth, making misdiagnosis possible(as shown in figure 8).

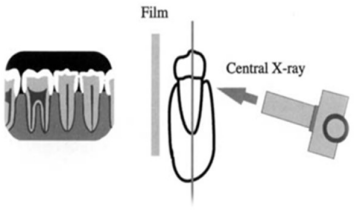


FIGURE 8: ALVEOLAR BONE APPEARS SUPERIMPOSED

BITEWING RADIOGRAPHS

In this, X-ray beam is placed perpendicular to the bone and the tooth root, thus minimizing the distortion of the location of the bone height along the tooth root.(as shown in figure 9)

Disadvantage

1. Limited view of the osseous crest
2. Even moderate bone loss due to periodontitis may preclude.

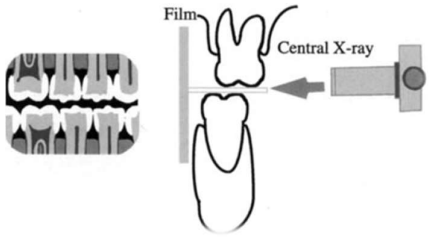


FIGURE 9: BITEWING FILM

VERTICAL BITEWING FILM

According to researchers, in this technique film is placed straight in mouth parrllel to anterior or posterior teeth showing bone height in terms of moderate to severe bone loss.(as shown in figure 10)

Advantage

1. Radiation dose is reduced compared with individual periapical films.
2. Bone height is imaged very accurately along the root.

FIGURE 10: DIAGNOSTIC VERTICAL BITEWING FILM

B. DIGITAL RADIOGRAPHY

In 1991, Gendex Dental System was introduced , which was a new direct digital system by named Visualix. (Here, radiation dose was 6 times less than D speed film). It works on 4 principles i.e. generation, processing , arching & presentation of imaging.(as shown in figure 11) It includes 2 kinds of radiography i.e. direct & indirect.

Advantage = Manipulate on computer screen (changing density, contrast & magnification).

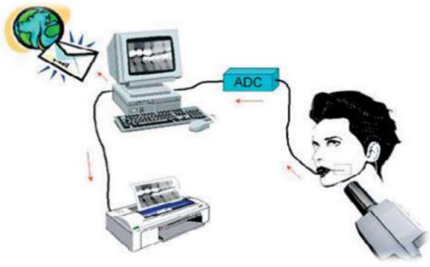


FIGURE 11: DIGTAL RADIOGRAPHY

i) DIRECT

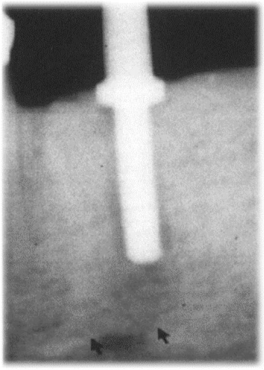


FIGURE 12: DIRECT RADIOGRAPHY

Here, sensor made up of silicon chip which is sensitive to light & has scintillator layer that convert x-ray to light. This includes 2 solid state sensor-

a) Charge coupled device (CCD) = It is a good conductor metal. This technology records the images in 4 steps i.e. generation, collection, transfer and measurement.(as shown in figure 12)
b) CMOS (complementary metal oxide semiconductor)= Principle is common to CCD but difference was more electronic components controlled the conversion of photon energy which later on, simplify magnification & reduces cost production.(as shown in figure 13)

ii) INDIRECT

FIGURE 13: CMOS- DIRECT RADIOGRAPHY

Researchers found that, phosphor crystals are placed on plates after they have been developed into resin form. These photostimulable crystals grab energy from x-rays by raising electron energy levels. Then, LASER beam used to scan of image plate.This convert energy stored in photostimulable crystal to light. Array of photomultiplier collet light, convert electrical charge by analog- to-digital convertor.[43]

Advantage

1. Reduce exposure to x- ray
2. Superior gray–scale resolution 256 colors of gray
3. Colorization & enlargement of image
4. Freedom to manipulate (orientation, sharpness, contrast & pseudocolor alteration)
5. Decrease processing time
6. Storage into small hard drive (space saver)
7. Easily transmitted to other office
8. Environment friendly
9. During implant placement, conventional films disrupt aseptic procedure & waste time.

C. SUBSTRACTION RADIOGRAPHY

"This technique was initially shown by Zeidses des Plantes in 1935. They discovered that this technique allows for the accurate detection of changes in a radiograph that are not of diagnostic value.By taking a photo of the radiograph using a video camera, digitalization was accomplished. By obliterating the image's unchanged anatomical components, this technique allows for both qualitative and quantitative visualization of even minute changes in bone density".[43]

Limitation

1. Very sensitive to any physical noise.
2. Any change in contrast / intensity of sequential images provide inaccurate result.
3. Density & contrast influenced by processing time, temperature of developer .

Computer Assisted Densitrometric Image Analysis System (CADIAS)

"It was introduced by Urs Brägger et al 1988. According to him, here a video camera measures the light transmitted through a radiograph then the signals are converted to grey scale images.

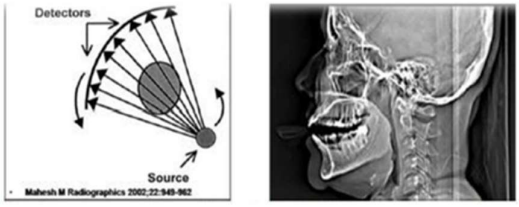
Camera is inter faced with computer and image processor for storage and mathematic manipulation of image. It offers an objective method for studying alveolar bone changes quantitatively". [43]

Advantage

1. Measures quantitative changes in bone density longitudinally.
2. Highly sensitive, reproducible & accurate

Computer Tomography

The 1979 Nobel Prize in Physics was shared by Godfrey Hounsfield and Allan MacLeod Cormack. A sequence of scintillating detectors or ionizing chambers is connected to an x-ray tube that, via the subject, emits a collimated x-ray beam. The x-ray tube and detectors (continuous rings) spin within each other. One turn of the x ray tube while the patient is stationary. Between 1 and 5 millimeters, the table will shift to accommodate the subsequent scan. CT scanners can image very thin slices with the use of a revolving fan beam.(as shown in figure 14)



(a)rotating the ray source with a wide fan beam (b) CT scan taken for oral implant planning

FIGURE 14: CT

Advantage

1. "Eliminates the super imposition of images of structures superficial / deep to the area of interest.
2. High contrast resolution (tissues less than 1%.)
3. Multiple scans of a patient (axial, coronal, or sagittal planes)".

Disadvantage

1. "Specialized equipment and setting.
2. Radiologists and Technicians need to be knowledgeable of the anatomy, anatomic variants and pathology of the jaws.
3. Higher radiation
4. Metallic Restorations (ring artifacts) ,impair the diagnostic quality of the image".

Indication

1. "Accurate information regarding the topography of osseous structure is needed.
2. Soft tissue contour and dimension
3. To check continuity and density of the cortical plates.
4. Vertical height of the residual alveolar ridges.
5. Density of the medullary space and basilar bone.
6. When determining how much space is available above the mandibular canal or amount of bone below maxillary sinus to receive a dental implant or whether there is a space occupying lesion in the maxillofacial region".

MICROBIOLOGICAL ASSESSMENT [44]

Immunoassays

Testing patient samples for microbial antigens could substantially enhance the speed of diagnosis. These include tests for latex particle agglutination and co-agglutination, as well as enzyme-linked immunoassays and direct immunofluorescence antibody assays. The

advantages of these tests, such as their technical ease, speed, specificity, and affordability, have not swayed medical microbiology laboratories from traditionally using culture methods. Despite their numerous benefits, these tests unfortunately exhibit limited sensitivity and a low negative predictive value.

Automated and semiautomated techniques

This technique have been accessible for some years, although their promise for fast diagnosis has not been fully recognized. These may be categorized into two primary groups: equipment for identifying and assessing susceptibility, and systems for blood culture. While many identification and susceptibility testing tools need the same amount of time as conventional procedures, others get findings within a single business day. The complete healthcare advantages are realized when a laboratory is operational 24/7 and physicians are accessible to obtain and promptly respond to the information at any time of the day or night. Blood culture technologies have significantly enhanced the capacity to identify the presence of bacteria in the bloodstream. Growth is identified by the production of a radiometric signal or the presence of a fluorescent or colorimetric indicator. The majority of accurate positive findings are identified within a time frame of 24 to 36 hours. When a blood culture system is used in conjunction with an automated identification or susceptibility testing apparatus, it is possible to acquire identification and susceptibility findings for many blood culture isolates simultaneously. Certain blood culture methods have been modified to allow for the automated or semi-automatic cultivation of Mycobacterium TB and other mycobacteria. These commercial methods decrease the reliance on biochemical processes for identifying organisms, eliminate the several laborious and time-consuming procedures between isolating and reporting clinically important microorganisms, provide quick findings, and conduct tests with more consistency. Commercial microbiological systems are subject to constraints.

CONCLUSION

Accurate identification of the condition is necessary for the success of the treatment. The accuracy of diagnosing medical conditions has significantly improved due to advancements in diagnostic procedures. Advancements in radiography have allowed for precise examination of the structure of periodontal bone and the ability to track changes in its architecture over time.Various chair-side diagnostic kits can be used to identify bacterial, host-derived products, and immunological activity in the periodontal pocket. Due to advancements in diagnosis, our treatment planning has improved, and we have seen better outcomes after periodontal treatment.

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