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Clinical Risk Assessment- An Inevitable Tool in Periodontal Disease Diagnosis: A Short Review

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Review Article

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ABSTRACT

Background: The ideal dental practice involves identifying patients and populations who are at enhanced risk of developing periodontal disease and treating them with the proper intervention that helps not only in preventing the disease progression but also aids in reducing the severity burden. As dental practitioners look to optimize the therapy and patient outcomes, the function of risk assessment and management is becoming increasingly important.

Aim: This article aims in reviewing the application of risk assessment and disease management to the general population and to groups at risk of developing periodontal disease.

Review Results: There are various scientific evidences emerging during the recent decades that aids in better understanding of the underlying etiopathogenesis and various risk factors associated with periodontal diseases for their incidence, progression, and severity. Correlating the clinical examination findings with the available diagnostic investigations has become a primary mode of determining the disease prognosis to evaluate the risk assessment ratio in the treatment of periodontal diseases.

Conclusion: Risk assessment can aid in the prediction of a patient's risk of acquiring the periodontal disease and enhance the skills of clinical decision-making. Patient commitment to a self-care oral health routine, in turn, is a critical component of effective periodontal disease management.

Clinical Significance: Risk assessment in clinical practice helps in identifying the higher risk group of disease exposure, thereby predicting the future outcomes of the disease and thus helps in minimizing the need for invasive periodontal therapy, improve patient treatment outcomes, and, ultimately, lower the oral health care expenditures. Such patients are thus advised to take an active role in maintaining oral health care by brushing, flossing, and rinsing with an antimicrobial mouth rinse on a regular basis.

Keywords: Implant Risk Assessment, Risk Assessment, Risk Determinants, Risk Factors, Risk Indicator, Periodontitis.

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Introduction

The prevention and treatment of disease are predicated by accurate diagnosis, elimination or reduction of causative agents, risk management, and alteration of the harmful effects of a disease. As the American Academy of Periodontology has stated, "the clinical use of risk assessment will become a component of all comprehensive dental and periodontal evaluations also part of all periodic dental and periodontal examinations".[1] The disease risk usually varies for each individual. The term risk according to Kleinbaum et al is defined as the probability that an individual will develop a specific disease in a given period.[2] The term 'risk factor' was coined by Dr. William Kannel in 1961.[3] Risk factors can be environmental, behavioral, or biologic factors that, when present, can increase the likelihood of an individual to develop the disease. Risk factors must be biologically plausible i.e. casual association must be present between cause and outcome but that does not mean they will develop the disease. Risk factors that cannot be modified are termed risk determinants/background characteristics. Risk indicators are putative or probable risk factors that were identified in cross-sectional studies but not confirmed in longitudinal studies. Risk predictors/markers are those that are associated with increased risk for disease but they do not cause disease. They have the ability to predict subjects at high risk of disease.

The other statistical parameters that would influence the risk assessment of any periodontal disease would include absolute risk, attributable risk, relative risk, and odds ratio. Absolute risk is the probability of an individual to develop the disease over a specific period of time. Attributable risk is determined by subtracting incidence of disease exposed to risk factor and incidence of disease not exposed. Relative risk is the ratio of a disease-exposed group with disease unexposed group. The odds ratio is the odds of having the disease if one gets exposed to a risk factor with ones not exposed to the risk factor.

There are various parameters such as risk factors, risk indicators, risk determinants, and risk markers that determine the risk assessment prognosis of periodontal disease. Thus this literature review aims in providing a detailed description of such risk assessment factors associated with the periodontal disease, thereby providing the health care professional to choose a better treatment option available for preventing the further progression of the disease and to achieve a disease-free homeostasis.

Risk Factors Associated with Periodontal Disease

Tobacco use

Smoking is a well-known risk factor for periodontitis and there is a direct relationship that exists between the prevalence of periodontal disease and smoking. The heat from smoke creates negative pressure on the oral cavity that reinforces calculus deposits and attachment loss. Nicotine causes a significant decrease in the protein secretion, collagen synthesis, and damage to the cell membrane of fibroblasts, these, in turn, impair the periodontal wound healing. In longitudinal studies, smoking was established as a true risk factor with an odds ratio in the range of 2.0 to 7.0 for periodontitis, whereas the current smokers had an odds ratio of 2.5 to 3.97, former smokers, light smokers, and heavy smokers had an odds ratio of 1.68, 3.25 and 7.28 respectively.[4-7] A systematic review revealed that smokers have approximately 80% risk for periodontitis in the case of quitters when compared with never-smokers.[8]

Diabetes

There is always a two-directional relationship between diabetes and periodontitis. Diabetes contributes to vascular compromise, decrease in cell-mediated immunity, and high glucose content in blood which augments for more bacterial growth. Pima Indians in Arizona have the highest prevalence (40-50%) of type 2 diabetes.[9] The onset of bone loss and attachment loss is 3 times greater in those with diabetes than in non-

diabetics. Studies have documented the odds ratio of 2.6 to 11.4 between diabetes and poor diabetic controlled individuals.[10] Periodontal ligament cells with insulin-dependent diabetics exhibited an altered response to growth factors and diminished ability to form mineralized tissue.[11]

Obesity

NHANES III stated that waist-hip ratio, BMI, subcutaneous fat are correlated with periodontal disease.[12] Obesity is considered to be a risk factor for low physical activity level in females more than males in a developing country.[13] People consuming lower than recommended dietary allowance (RDA) of vitamin C and calcium have higher progression disease rates.[14] Obese patients with high levels of insulin resistance were at 1.5 times more increased risk for periodontitis when compared with healthy individuals.[15]

Cardiovascular diseases

Inflammatory marker such as C-reactive protein is a predictor for myocardial infarction and stroke. This C-reactive protein is found to be predominant in periodontitis patients. Cardiovascular disease has an odds ratio of 1.2 to 2.8 for periodontitis.[16] Desvarieux and colleagues have found a correlation between subclinical atherosclerosis and periodontal bacterial burden.[17] Although precise mechanisms have been noted for tooth loss, bone loss, and poor dental hygiene status with cardiovascular diseases, there were also some pathogenic processes that remained unknown.

Pathogenic bacteria and Microbial tooth deposits

Quality of the plaque is considered as a risk factor more than the quantity of the plaque since the disease has been progressed even with a minimal quantity of microbial deposits. Regarding the quality of the plaque, bacteria that were found to have significant association includes Aggregatibacter actinomycetemcomitans which are correlated with aggressive periodontitis, and bacteria such as Porphyromonas gingivalis, and Tannerella forsythia are associated with chronic periodontitis.[18] Four hundred microbial species have been found in subgingival plaque few of them are capable of causing destruction of the tissue that leads to the progression of periodontal diseases. Stronger correlations have been found with Bacteroides forsythus, Prevotella intermedia, Peptostreptococcus micros, Fusobacterium nucleatum, and adult periodontitis.[19-22]

Tooth related factors

Developmental groves, cervical enamel projections, enamel pearls, tooth position, root proximity, defective restorations and margins, furcation, bifurcation ridges can predispose the periodontium to disease since these factors acts as microbial plaque retentive areas. Also, at the individual tooth level, occlusal discrepancies were considered as a risk factor for periodontal disease.

Other related factors

Drugs such as calcium channel blockers, cyclosporine, and anticonvulsants also contribute to periodontal diseases by inducing gingival overgrowth.[23] Some chewable drugs alter the pH and composition of plaque and make the microbial deposits adhere more to tooth surfaces. Chemotherapy associated with bone marrow transplantation has also been shown to affect gingival health. In the case of pregnancy, gingival changes are observed which include aggravated gingival inflammation, edematous gingiva, bleeding present on probing, and an increase in gingival crevicular fluid. There has also been an association between alcohol consumption and periodontitis. According to NHANES III data, a linear correlation was associated between the number of alcohol drinks/week and clinical attachment loss. The odds ratio of 5 drinks/week has 1.22, 10 drinks/week has 1.39 and 20 drinks/week has 1.67 risks for periodontal disease progression.[24]

Risk Determinants Associated with Periodontal Disease

Genetic factors

Strong familial aggregation and dominant mode of aggressive periodontal diseases were observed in 40-50% of siblings and close relatives, suggesting the influence of genetic factors in periodontal disease. Kornman et al observed alterations in specific genes that encode interleukin-1α and interleukin-1β for chronic periodontitis in nonsmoking subjects.[25] Karimbux et al determined the odds ratio for chronic periodontitis where IL-1α IL-1β and composite genotype had the odds ratio of 1.48, 1.54, and 1.51 respectively.[26] Neutrophil abnormalities, monocytic hyperresponsiveness, and monocyte/macrophage receptor alterations in the Fc portion of antibody are present in localized and aggressive periodontitis. Genome-wide association of 1,020 adults revealed 13 loci associated with periodontal disease.[27]

Age

Degenerative age-related changes increase the susceptibility for periodontal disease. The mean annual rate of bone loss observed in 70-year old subjects was 0.28mm while for 25-year old is 0.07.[28] Over 70-years old, moderate or severe periodontitis has been determined in 86% of subjects while one-fourth of the subjects had lost their teeth.[29] However, younger patients have more risk for periodontal disease when they have a longer period of exposure to causative factors.

Sex

NHANES III data provided a higher prevalence in males than in females for attachment loss and deeper probing depths. Male to female prevalence ratio for probing depth were 1.3 and 1.1 at 18-65 years of age and 1.7 and 1.4 at 65-80years of age.[30] But the correlation between sex and disease is not that strong and consistent.

Socioeconomic status

Blacks of low socioeconomic status predominantly had more prevalence than White and Mexican-American counterparts.[31] In low socioeconomic status individuals, gingivitis and inadequate oral hygiene maintenance were often found. However, this risk can be reduced by dental awareness and by frequent dental visits.

Race and Ethnicity

Several different racial populations have shown different expressions of periodontal disease. NHANES I survey found that periodontitis was more prevalent in blacks than whites with a periodontal index score of 1.28 and 0.76 respectively.[32] Grossi et al observed that Native Americans, Asians, or Pacific Islanders were associated with severe bone loss.[33]

Psychological Factors

Poor oral hygiene raises glucocorticoid secretion that is found to be associated with periodontitis, this suppresses the immune function and increased insulin resistance. During emotional and physiologic stress, there is an increased chance of necrotizing ulcerative gingivitis (NUG) to occur. Men who experience stress and anger on daily basis have a 43% risk for developing periodontitis.[34] Periodontitis patients who respond to therapy are less stressed than the stressed individuals who do not respond well to therapy.

Risk Indicators Associated with Periodontal Disease

Viruses

Deep periodontal pockets were observed in human cytomegalovirus and active replication of virus was seen in periodontal defects. Contreras et al observed that herpesvirus in subgingival sites possess a higher risk for

severe chronic periodontitis.[35] The accelerated rate of chronic periodontitis was observed in HIV-seropositive patients. Linear gingival erythema was predominant in AIDS patients. The viral load has shown a positive association with periodontal diseases. These patients require professional therapy and home care to maintain periodontal health.

Osteoporosis

Osteoporosis has shown a strong relationship with alveolar bone resorption. According to the NHANES III study, women with low bone mineral density and high calculus index presented more clinical attachment loss than women with normal bone mineral density with high calculus index.[36] Persson et al found a positive correlation of osteoporosis with an odds ratio of 1.8 for periodontitis.[37] However, longitudinal studies with larger populations are required to confirm the association between osteoporosis and periodontal disease.

Infrequent dental visits/poor compliance

Infrequent visits of patients for more than or equal to 3 years have increased risk for severe periodontitis. Another study revealed even after 6 year period there is no increase in clinical attachment loss or bone loss.[38] So, interventional and longitudinal studies are required to obtain a significant correlation between infrequent dental visits and periodontitis. However, supportive periodontal therapy is required to maintain good periodontal health.

Oral hygiene

Oral hygiene in a population is an important risk indicator for assessing the stage of periodontitis irrespective of age. Epidemiological studies suggested that individuals with poor oral hygiene revealed higher severity and prevalence of periodontal tissue loss when compared with individuals having good oral hygiene.[30] A 15-year follow-up study demonstrated that individuals with good oral hygiene had minimal change in their periodontal status and high specificity for the absence of gingival inflammation when compared with controls.[39] Oral hygiene is considered an important indicator for periodontal diseases in population studies but this parameter does not predict the future development of periodontal tissue loss and also its not effective in indicating or preventing aggressive periodontitis. However, good oral hygiene always presents a positive effect on the level of gingival inflammation.

Diagnostic tests

Diagnostic tests are true valuable indicators of active periodontal disease and based on the tests, they have been classified as host inflammatory products and mediators, tissue breakdown products, and host-derived enzymes. PERIOTEMO is a device that measures the subgingival temperature to the precision of 0.1°C. Microbial testing can be done on the plaque, blood and gingival crevicular fluid samples and analysis like immunoassay, enzyme analysis, polymerase chain reaction, DNA probes and microbial culturing can be performed. Chairside diagnostic kits are commercially available as Perioscan, Dipstick test, Omnigene, TOPAS, Periocheck, Evalusite, BANA, MyPerioID, etc. Chairside test kits are classified as microbiological, biochemical, and genetic tests.[40] These kits provide immediate results that provide an aid to periodontal diagnosis.

Risk Markers Associated with Periodontal Disease

Previous history of periodontal disease

Patients with a history of severe loss of attachment have an increased risk for further attachment loss. Regarding implant survival, subjects with a previous history of periodontitis have a risk ratio of 1.03 when compared to healthy periodontium subjects.[41] Patients who did not have any history of periodontitis also get affected but the risk for developing loss of attachment in periodontal disease is less.[41]

Bleeding on probing

Bleeding on probing and clinical attachment level are, reliable clinical indicators for gingival inflammation. Lack of bleeding on probing indicates the absence of present inflammation. The specificity for bleeding on probing was 88% and sensitivity was 29%.[42] Bleeding on probing when combined with increased probing depth is a predictor of future attachment loss but it alone does not present as a predictor for attachment loss.[42]

Clinical Risk Assessment and Periodontal Disease

Risk assessment involves the assessment of identifying individual elements that predispose a patient to develop periodontal disease or influences the progression of existing periodontal disease. Assessment of risk in an individual would allow the practitioner to observe the extent and severity of the periodontal disease progression and can maintain the periodontal health following active therapy. The ultimate goal of risk assessment is to maintain long-term periodontal health through proper prevention, early intervention, and activated therapy.

Beck in 1994 gave 4 principles for assessing risk in an individual. It consists of the identification step, multivariate risk assessment step, assessment step, and targeting step. The identification step involves identifying the individual risk factors that were associated with the disease. The second Multivariate risk assessment step involves procuring models to be procured effectively to distinguish between health and disease. The third assessment step involves screening individuals for many factors and assessing with models. The final targeting step involves exposure to the risk factor is reduced by intervention or prevention.[43]

Levels of Risk Assessment

Interaction of risk factors determining the expression of disease progression has led to the advancement of multi-level risk assessment.[44] In multi-level risk assessment, the risk is assessed in layers depending upon the level of the patient's risk status. The initial assessment helps to identify patient-level risk factors through medical and social history. When treatment commences, risk assessment aids local risk factors at full mouth level. Later on, when the treatment progresses, the clinician will look for tooth and site-specific risk analysis. Based on considering all these levels, a risk assessment model is mapped to each stage of patient diagnosis, treatment, and its management.

Models of Risk Assessment

Periodontal risk calculator

It is a computer-based assessment tool introduced by Page et al in 2002.[45] Total of 11 factors like patient age, smoking history, diabetes, bleeding on probing, history of periodontal surgery, pocket depth, restorations or root calculus present subgingivally, radiographic bone height, furcation involvements, and vertical bone lesions are evaluated and each factor has a scale of risk from 1 to 5. The periodontal risk calculator is calculated for the prediction of future periodontal disease and it provides a 5 point risk scale that is used to balance the risk assessment according to time and cost. A 3 point scale is also used to obtain risk for pocket depth and radiographic bone height using an algorithm that is compared to the patient's age.[45]

Periodontal risk assessment tool

It was given by Lang and Tonettiin in 2003 and it evaluated 6 factors such as Probing depths ≥ 5mm, tooth loss, full-mouth bleeding on probing percentage, genetic or systemic conditions, smoking, and radiographic bone loss to age ratio.[46] These factors are plotted as a hexagonal model as minor, moderate, and high-risk

profiles. Low periodontal risk assessment implies that patients are within low-risk for all the factors or may be present with one moderate risk factor category. Moderate periodontal risk assessment indicates that the patient has at least two factors in the moderate category with or without one parameter in the high-risk category. In case of high-risk periodontal risk assessment, high numbers of pockets with high bleeding on probing percentages are found and these patients can be converted into moderate risk if appropriate therapy is advised.[46]

Oral health information suite (OHIS)

Oral health information suite (OHIS) was proposed by Page et al in 2005. The information is protected under US patents.[47] This system consists of a suite of tools for dental caries, periodontal disease, and oral cancer. It quantifies the risk and examinations (clinical and radiographic) and can be performed along with history taking through questionnaires. Once the diagnosis is done, a risk score is calculated, and accordingly, the treatment protocol is modified. Post-treatment risk is performed on the time of re-examination. This system helps to analyze the patient in a refined manner and provide appropriate treatment modalities.

Periodontal risk assessment model by Chandra

This model was proposed by Vishwa Chandra in 2007.[48] It includes all the 6 factors that are estimated in the hexagonal periodontal risk assessment tool. He also added two more factors which include dental status-systemic factor interplay and psychosocial factor. This model is assessed during supportive or post-treatment and the categories obtained are low, medium, and high-risk categories.

Cronin/Stassen BEDS CHASM Scale

Cronin/Stassen BEDS CHASM Scale was proposed by Cronin and Stassen in 2008.[49] It comprises of four-step risk assessment where the odds ratio for Body Mass Index (BMI), Ethnicity, Diabetes, Stress, attended college, plaque level, age (greater than 65), smoker and male were estimated and correlated with the standard risk assessment index. A total score of 19 denotes the highest risk for periodontitis.

Simplified method: Union of European Railway Industries (UniFE) tool

This tool was proposed by Trombelli and colleagues in 2009.[50] The objective of this model is to simplify the risk assessment protocols based on the UniFe parameters obtained from patients' medical records. UniFe Parameters evaluated are bone loss/age records, bleeding on probing score, smoking habits, diabetic status, and the number of sites involved with probing depth ≥ 5mm. Individual parameter score 0 to 4 was based on the severity and risk score was evaluated by calculating the sum of individual scores and categorized as low, medium-low, medium, medium-high, and high-risk category.

Disease Risk Score (DRS)

Disease Risk Score (DRS) was proposed by Lindskog et al in 2010.[51] A web-based analysis tool was given which calculates the risk for dentition at level 1 and tooth at level 2 for chronic periodontitis. Systemic and local predictors were estimated and analyzed. Local predictors include bleeding on probing, plaque, angular bony destruction, pocket depth, endodontic pathology, furcation involvement, radiographic marginal bone loss, marginal dental restorations, and tooth mobility. Systemic predictors include age, family history of periodontitis, smoking habits, skin test result, systemic disease, patient compliance, disease awareness, socioeconomic status, and therapist's experience with periodontal care.

American Academy of Periodontology (AAP) risk assessment tool

American Academy of Periodontology calculated the risk with a web-based questionnaire where 13 items were listed and self-assessment could be done by the public. The questionnaire is in yes or no response format except for age and their flossing habit. Forage, the options are whether the patient is <40 or 40-65 or >65 years and for the flossing habit, it is asked whether flossing is done daily, weekly, or seldom. This creates awareness among the public by determining one's self-risk calculator for periodontal diseases.[1]

Dentorisk

Dentorisk was proposed by Lindskog et al in 2010 and he included 20 factors which included both systemic and local predictors. It is evaluated under a computerized assessment tool and it also has a prognostication program. Two levels of assessment for done for overall patient's dentition and individual tooth assessment which predicts the future prognostication based on therapy.[51]

Risk assessment based individualized treatment (RABIT)

Risk assessment-based individualized treatment (RABIT) was proposed by Teichin 2013.[52] It considers a modified approach for individualized risk-based recall schedules during active therapy and also during the course of treatment. The patients are categorized into low, medium, or high-risk category based on periodontal disease progression.

Genetic test

Genetic tests predict whether that particular individual possess a combination of two IL-1 genotypes.[53] A recent study demonstrated that composite genotype after a 2-year period of periodontal therapy does not possess any association with clinical attachment loss. Genetic testing has been found to have greater potential for future periodontal research. Periodontal bacteria have the ability to cause alterations in cellular DNA methylation. Due to the effects of aging, stress, and environment, the expression of periodontal disease undergoes epigenetic modifications which modify the gene and disease expression. Martin et al 2016 revealed the ability of bacteria to produce epigenetic modifications in oral epithelial cells that were mediated by histones.[54]

Artificial intelligence

Artificial neural networks are the models created with brain neural networks. The networks are connected to the computer to detect the input and obtain conclusions by analyzing the patterns obtained by the data. It accurately predicts the risk for dental diseases. Natural and artificial networks are available. Natural networks are composed of neurons which are connected with other neurons with synapses and dendrites and an electrical signal is produced when a particular threshold is reached. Artificial networks mimic the organizational structure by creating small processors in a similar pattern and the pattern is recorded when the neuron threshold has reached similar to biological neuron. Artificial neural networks for periodontal risk assessment can be done with 2 types of algorithms. They are called as Lavenberg Marquardt algorithm and Scaled Conjugate Gradient algorithm.[55] When two artificial network systems were compared, it was shown that the Lavenberg Marquardt algorithm was better than the Scaled Conjugate Gradient algorithm since it converges faster with lesser iterations and the square error was less in all the phases.

Risk Factors and Assessment in Implants

Surgical risk factors for implants were given by Arlinin 2015.[56] He classified risk factors into patient-related: systemic risk factors, patient-related: local risk factors, operator-related: extrinsic risk factors, and biomaterials related: extrinsic risk factors.

The patient-related: "Systemic" Risk factors included in patient-related "Systemic" Risk Factors are age, health or disease condition, gender, any absolute contraindications (alcoholism, uncontrolled diabetes, liver failure, pregnancy, chemotherapy, radiotherapy, etc.), relative risk factors (osteoporosis and osteopenia, hyperparathyroidism, Parkinson's disease, Paget's disease, auto-immune diseases), involvement of medications and history of periodontitis.[56] The patient-related: "local" risk factors are quality/quantity of alveolar bone, soft tissue quality/quantity, poor plaque control, resorption of bone, short or narrow implants, and occlusal loading which can occur at early or late stages of loading.[56] Operator-related extrinsic risk factors are considered as surgical techniques and protocols, implant placement whether it's immediate or delayed and whether it is done as submerged or non-submerged, implant position, prosthetic related risks during loading, screw-retained or cement-retained, and impression techniques.[56] Biomaterials related extrinsic risk factors are the strength of the material used (pure or alloyed titanium or ceramic), implant microstructure (smooth or rough), and macrostructure (thread design, flat or conical or platform shift, length of the implant, diameter, and shape of implant (straight-walled or tapered).[56]

Thus the sequence of implant therapy includes subjective assessment by initial examination along with history taking, objective assessment where the clinical and radiographic examination is done, risk factor assessment where diagnosis and prognosis are made, followed by treatment plan and maintenance.

Conclusion

Clinical risk assessment paves the way for better prognostication in the modern day of periodontal practice. It allows dental professionals to improvise in their prognostic and treatment-related outcomes where particular risk factors can be targeted that ultimately leads to reduced risk for periodontal diseases. Hence a thorough understanding regarding the clinical risk assessment throws light not only on better diagnosis but also to establish a prompt treatment thereby reducing the progression of periodontal disease.

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