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Indices for measuring periodontitis: a literature review

Kunaal Dhingra[1] and Kharidhi Laxman Vandana[2]

[1]*Department of Periodontics, N.S.V.K Sri Venkateshwara Dental College, Bangalore, Karnataka, India;* [2]*Department of Periodontics, College of Dental Sciences, Davangere, Karnataka, India.*

Indices are important tools to measure, quantify and treat periodontitis both in epidemiological and clinical situations and are based on the prevailing understanding of the pathogenesis of periodontal disease. However, there is dearth of literature on collective information of periodontal indices formulated to date. This article collectively describes the evolution and the present concept of formulation of periodontal indices based on the multi-factorial nature of periodontal disease and also provides some direction for future periodontal indices. Periodontal indices have evolved from the simple Russell's index to the current usage of measurement of clinical attachment level in the recording of indices. The use of dichotomous measurements and the Genetic Susceptibility Index are the new additions to the periodontal indices. Nevertheless, an ideal would be an index that will keep pace with the ever changing concept of the pathogenesis of periodontal disease.

Key words: *Periodontal Index, periodontitis, epidemiology*

Periodontitis is the inflammation of the periodontium that is accompanied by apical migration of the junctional epithelium, leading to destruction of the connective tissue attachment and alveolar bone loss[1]. The assessment of its disease activity is important because periodontal disease still remains a major cause of tooth loss for some segments of the population. In addition, periodontal infection has recently been implicated as a possible risk factor for serious systemic vascular disease[2].

Lord Kelvin (1824–1907), the famous British mathematician and physicist, once famously remarked *Until you can count it, weigh it, or express it in a quantitative fashion, you have scarcely begun to think about the problem in a scientific fashion.* This statement aptly describes the essence of the indices, which have formed the pillar of epidemiological studies to quantify and measure the world wide prevalent periodontal disease.

Epidemiologic studies are conducted to describe the health status of populations, elucidate the aetiology of diseases, identify risk factors, forecast disease occurrence and assist in disease prevention and control[3]. On the other hand, an index which is an essential tool of epidemiology results in a number describing the relative status of the population on a graduated scale with definite upper and lower limits, designed to permit and facilitate comparison with other populations classified by same criteria and methods[4]. Various indices have been formulated and tried to date to measure periodontal disease but there is still a lack of collective data on these indices in terms of their evolution, future and their merits and limitations. This paper aims to provide an insight to their evolution along with the present concept of formulation of periodontal indices based on the multi-factorial nature of periodontal disease and also some direction for future periodontal indices.

A HISTORY OF INDICES

The formulation of the various indices has been rooted in the prevailing understanding of the aetiology and progression of periodontal disease at the time. The following passages provide an appraisal along with the shortcomings of indices used for measuring periodontitis, in chronological order, which is also summarised in *Table 1*.

Russell's Periodontal Index (PI)

Realising the lack of valid indices for determining the prevalence and epidemiological characteristics of periodontal diseases, Russell developed the first index for periodontal disease, the Periodontal Index (PI) in 1956 to facilitate the surveillance of periodontal disease in concordance with the already widely used DMFT (Decayed, Missing and Filled Teeth) index[5,6]. Russell

Table 1 Description of periodontal indices

Serial No.	Index	Author and year	Salient features
1.	Periodontal Index	Russell (1956)	• First index for periodontal disease • A weighted categorical scoring system • No longer considered valid
2.	Periodontal Disease Rate Index	Sandler and Stahl (1959)	• Each tooth is assessed utilizing radiographs and clinical measurements
3.	Periodontal Disease Index	Ramfjord (1959)	• More sensitive version of the PI for use in clinical trials • Scores the gingival status first using a 0 to 3 scale while clinical attachment level is scored on a scale from 4 to 6, on a selected group of teeth – 'Ramfjord teeth'
4.	Gingival Bone Count Index	Dunning and Leach (1960)	• Subjective measurement of gingival status is combined with proportionate measurements of bone loss from radiographs • Time consuming, thus, not used
5.	Gingival Periodontal Index	O'Leary (1967)	• Mouth is divided into six sextants and the highest score for each segment either gingival (0–3) or periodontal (4–6) is recorded • Not much used
6.	Navy Periodontal Disease Index	Grossman and Fedi (1974)	• Derived from gingival (0–2) and pocket (0, 5 and 8) scores of the six Ramfjord teeth
7.	Community Periodontal Index for Treatment Needs	World Health Organization (1982) by Ainamo, Barmes, Beagrie, Cutress, Martin and Infirri	• Assesses the presence or absence of gingival bleeding on probing, supra or subgingival calculus and periodontal pockets by using 0.5 mm ball tip WHO probe • Advantages include simplicity, speed and international uniformity, hence, popular
8.	Periodontitis Severity Index	Adams and Nystrom (1986)	• Assesses the presence or absence of periodontitis as product of clinical inflammation and interproximal bone loss determined radiographically using a Schei ruler • Use limited to longitudinal studies and lacks validation
9.	Extent and Severity Index	Carlos *et al.* (1986)	• Extent score is % of sites examined having attachment loss more than 1 mm whereas, the severity score is average loss of attachment per site among disease sites • Simple, reproducible
10.	National Institute of Dental and Craniofacial Research (NIDCR) protocol	NIDCR (1988–1994)	• Periodontal examination consisted of measurement of periodontal supporting tissues including attachment loss, probing pocket depth and furcation involvement • Used in U.S. National Health and Nutrition Examination Survey (NHANES III)
11.	Periodontal Index for Treatment	Eaton and Woodman (1981–1985)	• Clinical assessment of six teeth is done with a specially designed periodontal probe • Simple rapid and reliable periodontal screening
12.	Periodontal Screening and Recording Index	American Academy of Periodontology (1991)	• Divides mouth into six sextants and greatest score in each sextant of mouth is determined and recorded by using a plastic PSR probe • Simple, fast and preferred by patients
13.	Community Periodontal Index	World Health Organization (1997)	• Modification of CPITN index • Useful in periodontal research, especially to reduce the time needed for examinations when the study population comprises a large number of individuals
14.	Periodontitis Index	Albandar *et al.* (1999)	• Classifies each person as having either mild, moderate or advanced periodontitis, or with no periodontitis, based on the number (or percentages) of teeth showing certain thresholds of probing depth and attachment loss
15.	Dichotomous Periodontal Index	Dye *et al.* (2002), Tezal *et al.* (2004), Borrell *et al.* (2006), Brothwell and Ghiabi (2009), Persson *et al.* (2005)	• Record the presence or absence of pocket or clinical attachment loss against a cut-off point
16.	Genetic Susceptibility Index for periodontal disease	Moustakis *et al.* (2007)	• Used for both single nucleotide polymorphisms and microbial component of periodontal disease

created the PI criteria (0, 1, 2, 6 and 8) based upon the signs of periodontitis and the sequence in which they usually appear, i.e. inflammation, pocket formation, and loss of function. Although often referred to as a scaled scoring system, the PI was actually a weighted categorical scoring system[6]. In 1967 Russell provided a refinement in the form of treatment needs based on the PI; i.e. PI scores in the range of 0.1–1.0 require simple prophylaxis, 0.5–1.9 require minimal periodontal treatment, 1.5–5.0 require elaborate and protracted treatment while 4.0–8.0 require full mouth extraction[7]. Since PI was the first of the periodontal indices, it was extensively used in the epidemiologic surveys of numerous populations, including the first two national surveys in the United States[8]. The major advantage of PI is that the calibration of the examiner is easy, the

method is quick and a minimum of equipment is required[4]. However, the PI was flawed, conceptually and methodologically, in that gingivitis is no longer considered to be the equivalent of early periodontitis and the index did not measure features specific for periodontitis (in contrast to gingivitis), such as pocket depth, clinical attachment level, and radiographic bone loss. Consequently, the index is no longer considered valid although its modification (periodontal sites were probed, and gingivitis and periodontitis were reported separately) was used in the third US national survey in 1981[8].

Periodontal Disease Rate Index and Periodontal Disease Index

In 1959, Sandler and Stahl formulated the Periodontal Disease Rate (PDR) Index in which each tooth was assessed utilising radiographs and clinical measurements like mobility, pocket depth and appearance of gingiva, to be classified as affected or not affected. According to the authors, PDR appeared to have a fairly good relationship to Russell's PI when measuring the incidents of disease[9]. In the same year, Ramfjord came out with the Periodontal Disease Index (PDI), intended as a more sensitive version of the PI for use in clinical trials. The PDI scored the gingival status first using a 0–3 scale (based upon Russell's PI and Schour and Massler's Papillary Marginal Attachment gingival index) while the clinical attachment level was scored on a scale from 4 to 6, on a selected group of teeth called 'Ramfjord teeth'[6]. Its main advantages were easy calibration of examiners and it was an accurate tool to assess periodontal status as it was based on measurements rather than estimation[4]. However, it was time consuming due to a high requirement of precision and also in primitive populations with many middle aged and older people, much time has to be spent on removing calculus to determine the location of cementoenamel junction[4]. Although the PDI was never used for national estimates of periodontal disease in the USA, it was used for various epidemiological surveys in India and Michigan and various clinical trials of therapeutic or preventive procedures[6,10–12]. The revolutionary concepts of clinical attachment level and Ramfjord teeth, i.e. partial mouth recording are now being used for USA national oral health surveys[6].

Gingival Bone Count Index

In 1960, Dunning and Leach formulated the Gingival Bone (GB) Count Index, in which the subjective measurement of gingival status is combined with proportionate measurements of bone loss from radiographs to produce a composite score. The GB count may be used as a composite index, morbidity or cumulative index. Since it combines clinical examination with reading of radiographs, it is one of the most time consuming of all the methods, and is thus not extensively used[4,9,13].

O'Leary Gingival Periodontal Index

The next index was the O'Leary Gingival Periodontal Index formulated in 1967, in which the mouth was divided into six sextants and the highest score for each segment either gingival (0–3) or periodontal (4–6) was recorded and the sum was divided by the number of segments to give the GPI score for the individual. For periodontal score, the clinical attachment level was recorded at the mesial facial line angle. The main advantages of this index were quick appraisal of the health status of each area of the patient's mouth and the scores were helpful in determining the personal, facility and equipment needs of patients[14]. GPI has not found much usage, but the methodology of the index has been used in some studies[15,16] and even a modification of the GPI has been used in an oral health survey in five countries by measuring pocket depth instead of clinical attachment level[17].

Navy Periodontal Disease Index

In 1974, Grossman and Fedi developed the Navy Periodontal Disease Index (NPDI) under the navy periodontal screening examination to aid the general practitioner in the early recognition and diagnosis of periodontal disease and in particular for screening of periodontal disease in the navy dental corps. The NPDI was derived from the gingival (0–2) and pocket scores (0, 5 and 8) of the six Ramfjord teeth. The highest combined gingival and pocket score for any one tooth is the patient's NPDI score while NPDI total is the total score for all the six teeth[18]. Hancock and Wirthlin on examination of 98 young adult patients with the NPDI, found that the NPDI total offered a wider range of scores (than NPDI score) that would give the clinician a better indication of the extent of involvement[19].

Community Periodontal Index for Treatment Needs

The Community Periodontal Index for Treatment Needs (CPITN) was developed in 1982 as a World Health Organisation (WHO) initiative. When the WHO Global Oral Data Bank was initiated in 1969, Russell's PI and Greene and Vermillion's Simplified Oral Hygiene Index were the two preferred methods for data accumulation. It became clear that these two indices were not wholly satisfactory and in 1977, a WHO Scientific Group meeting was convened in Moscow which produced a prototype index, the Technical Report Series (TRS) 621[20]. Following extensive discussions

and testing the CPITN index was developed from TRS 621 by exclusion of Ramfjord's teeth and inclusion of use of the WHO probe, and was thus described in 1982 by Ainamo and colleagues and accepted by WHO in 1983 for inclusion in oral health surveys basic methods[21]. CPITN assesses the presence or absence of gingival bleeding on probing, supra or subgingival calculus and periodontal pockets by using a 0.5 mm ball tip WHO probe. In epidemiological surveys, 10 index teeth are examined, but only the worst finding from the index teeth is recorded per sextant of teeth. In determining the individual's treatment needs, only the worst finding from all the teeth in a sextant is recorded, resulting in six scores[22]. The main advantages include simplicity, speed and international uniformity, due to which CPITN had worldwide usage and CPITN results are now included in over 500 publications[21,23]. However, there are several weaknesses, as compiled by Baelum and Papapanou[24] which include:

- The hierarchical principles underlying its use are not universally valid.
- The partial recording approach of the CPITN may grossly underestimate the prevalence of deep pockets.
- CPITN yields extensively distorted estimates of the prevalence and severity of periodontal destruction in a population.

Based on the limitations identified by several authors during years of research, the WHO proposed some changes to the CPITN in 1987 and again in 1997[25].

Periodontitis Severity Index

Adams and Nystrom developed the Periodontitis Severity Index (PSI) in 1986 which assesses the presence or absence of periodontitis as the product of clinical inflammation and interproximal bone loss determined radiographically using a Schei ruler[22]. The reported advantages of the PSI are that healthy sites can be distinguished from diseased sites, ratio data can be produced, avoidance of the arbitrarily weighted clinical observations and also direct measurements of periodontitis severity can be made. The disadvantages are that in order to recalculate the PSI over time, further radiographs are necessary and also, radiographs do not permit buccal or lingual PSI calculations[26]. Due to these limitations the PSI is limited to longitudinal studies and lacks validation[22].

Extent and Severity Index

In 1986, Carlos *et al.*[27], with the aim of devising a method that would achieve maximum data reduction while remaining sensitive to both the extent of disease (the number of sites affected within the mouth) and the severity of disease (the stage of advancement of periodontal destruction), formulated the Extent and Severity Index (ESI). Under this index, in two designated quadrants, loss of attachment is determined in two periodontal sites, i.e. mid-buccal and mesio-buccal of each tooth except the third molars. This results in 28 measurements for each subject. For an individual, the extent score is the percentage of sites examined that have attachment loss more than 1 mm whereas, the severity score is the average loss of attachment per site among the disease sites. The ESI for a population is the average extent and severity scores for the individuals examined. Its advantages are that it is simple, reproducible method which appears to yield informative description of periodontal disease status of a population and requires only minimal training of examiners[27]. However, as the ESI measures attachment loss in only 28 sites in contralateral quadrants, it has the same potential for inaccuracy as other partial measurements[28]. Also, Hunt and Fann[29] found that in a scenario with increasing severity and lower prevalence, the proportional underestimation by ESI becomes larger.

National Institute of Dental and Craniofacial Research (NIDCR) protocol

During the third USA National Health and Nutrition Examination Survey (NHANES III) conducted from 1988 to 1994, the National Institute of Dental and Craniofacial Research (NIDCR) protocol for periodontal disease assessment was used. In this, the periodontal examination consisted of measurement of attachment loss, probing pocket depth and furcation involvement. The periodontal examination was carried out in two randomly selected quadrants, one maxillary and one mandibular. All fully erupted teeth in these two quadrants were assessed, excluding third molars. The assessment of the attachment loss and probing pocket depth was done at two sites per tooth, the mesiobuccal and mid-buccal surfaces by using the NIDCR periodontal probe[30]. A third site (distal-facial) for periodontal assessment was added in 2001[6]. Assessment of furcation involvement was made on five posterior teeth using explorer number 17 (maxillary molars and premolars) and explorer number 3 (mandibular molars). Partial furcation involvement (grade I) was scored in sites where the explorer was definitely catching into, but did not pass though, the furcation. Total furcation involvement (grade II) was used when the explorer could be passed between the roots and through the entire furcation. In fact, NHANES III was the first national survey to assess the periodontal involvement of the furcation area of teeth[30].

Periodontal Index for Treatment

Further, Eaton and Woodman (1981–1985) developed the Periodontal Index for Treatment (PIT) in which the

clinical assessment of six teeth (all first molars and maxillary right and mandibular left central incisors) is completed with a specially designed periodontal probe (PIT probe with markings at 4, 6, 8 and 11 mm and a 0.5 mm ball tip). The maxillary sites are probed on the palatal side while the mandibular sites are probed on the buccal side, and scores are given from 0 to 3. The overall patient score (PIT score) is recorded as the highest score of the six test teeth. Eaton and Woodman examined 406 UK Royal Navy and Royal Air force personnel in 1989 using this index with and without bitewing radiographs and concluded that the PIT technique when used in conjunction with bitewing radiographs provided simple rapid and reliable periodontal screening[31].

Periodontal Screening and Recording Index

The next periodontal index to be developed was the Periodontal Screening and Recording Index (PSR). The concept of periodontal screening first arose in 1988 when the American Academy of Periodontology (AAP) approved the development of a Periodontal Disease Detection Day, in collaboration with the American Dental Association (ADA). The AAP committee decided to use a modified CPITN procedure for periodontal screening and a position statement on the use of this screening procedure was developed which later evolved into the professional education brochure on a Periodontal Screening and Recording system. Subsequently, in 1990, the PSR was reviewed and further modified by ADA committee and in 1991 it was endorsed by the ADA as a useful tool for assessing the periodontal status of patients. In 1992, Procter and Gamble Company (P&G) became the official sponsor of PSR system and helped in active distribution of PSR training programme kits and promotion of the PSR system among the dentists in USA from 1992 to 1994[32]. Subsequently, the PSR system became highly popular in the USA and the Canadian Dental Association and Canadian Periodontist Association also adopted the index in August, 1995[33].

The PSR index divides the mouth into six sextants and the greatest score in each sextant of the mouth is determined and recorded by using a plastic PSR probe that has a 0.5 mm diameter ball tip and a colour-coded band extending 3.5–5.5 mm from the tip. The scores range from 0 to 4. Each code can have an asterisk (*) placed depending on the presence of periodontal abnormalities such as furcation involvement, mobility, mucogingival problems, or recession. Code X is given for sextants with fewer than two teeth. Its merits include simplicity, and also Piazinni in 1994 found PSR to be on an average nine times faster than a conventional evaluation[33]. Additionally, the PSR score showed significant associations with probing depths and attachment levels in comparison to radiographs[34]. Patients seem to relate better to the numerical values used in the PSR system, especially when the patient receives the PSR colour brochure following the examination. The brochure provides photos and detailed explanations of each PSR score to further enhance the patient's understanding of their periodontal condition[35]. However, PSR can underestimate the level of periodontal involvement and also the asterisk code does not specify which method is to be used for detection of the periodontal abnormalities[33].

Community Periodontal Index

In 1997, the CPITN index was modified to the Community Periodontal Index (CPI) by inclusion of measurement of 'Loss of attachment' and elimination of 'Treatment needs' categories and is now included as a part of WHO – Oral Health Surveys. In this index, the periodontal status is assessed with a 0.5 mm ball tip periodontal probe with black band markers at 3.5, 5.5, 8.5 and 11.5 mm. This index takes into consideration 10 teeth in the oral cavity i.e. 17, 16, 11, 26, 27, 37, 36, 31, 46 and 47 and subsequently evaluates the occurrence of gingival bleeding, presence of supra- and subgingival calculus, periodontal pockets with probing depths between 3.5–6.0 mm, as well as clinical attachment loss. Although this system analyses a limited number of teeth, it has been shown to be representative of full mouth records. For this reason, the CPI is useful in periodontal research, especially to reduce the time needed for examinations when the study population comprises a large number of individuals. In addition, this method allows the elaboration of preventive and therapeutic programmes as well as the quantification of biological and environmental risk factors related to the disease onset and progression. Also, it has been shown that in periodontally healthy young individuals, CPI teeth could be an appropriate source of samples for the subgingival detection of *Actinobacillus actinomycetemcomitans* in comparison to randomly selected teeth[36]. However, the CPI has been criticised for being an old-fashioned paradigm to assess disease. Especially among adolescents, the validity of the hierarchical record of conditions of interest (bleeding, calculus and periodontal pocket) is questioned[37].

Periodontitis Index

More recently, Albandar *et al.* described the Periodontitis Index to measure the prevalence and severity of periodontitis in the US population. This index classifies each person as having either mild, moderate or advanced periodontitis, or with no periodontitis, based on the number (or percentages) of teeth showing certain thresholds of probing depth and attachment loss. The

reason for using both the number and percentages of teeth with a given criterion in this classification system is because the NHANES III examined only two randomly selected quadrants (half-mouth), and the use of percentages has the potential to reduce the underestimation due to this partial recording. The index also assesses the extent of furcation involvement of teeth for assessment of the periodontal status of the person[30]. Because this index does not combine parameters of different diseases, it does not endure some of the validity limitations found in the other indices mentioned earlier. In the absence of periodontal inflammation and pocketing, the Periodontitis Index does not regard the presence of attachment loss alone as a measure of periodontitis[3].

In an excellent review on epidemiology and risk factors of periodontal diseases, Albandar[3] noted that because of lack of resources or the desire to simplify the examination process, many epidemiological studies of periodontal diseases have used partial recording methods to assess the occurrence and severity of disease. Partial recording protocols, however, systematically underestimate periodontal disease prevalence, and the degree of underestimation is influenced by the type of protocol used. It is important to note that the EAS survey and the NHANES III used partial-mouth examinations whereby only the midbuccal and mesiobuccal tooth surfaces of one maxillary and one mandibular quadrants were examined[3]. Kingman and Albandar[38] showed that this method significantly underestimates the prevalence of attachment loss and suggested an inflation factor (ratio of true prevalence of a condition based on the full mouth score to the prevalence of the condition based on partial recording protocol) to adjust for the bias in these estimates. Using this inflation factor for the prevalence rates, it was found that United States seniors have a very high level of chronic periodontitis and tissue loss comparable to the rates reported in the EAS survey and the NHANES III[3].

INDICES AND THEIR CURRENT TRENDS

Dichotomous Periodontal Index

Currently, apart from regular periodontal indices, various dichotomous measurements of periodontitis in the form of presence or absence of pocket or clinical attachment loss against a cut-off point have been assessed.

Dye *et al.*[39,40] conducted two studies on the relationship between blood lead levels and periodontal bone loss and also the relationship between periodontal disease attributes and *Helicobacter pylori* infection among adults in the US. In these studies, the periodontal pocket depth was expressed as a dichotomous variable, either not present or at least one dental site with a pocket depth of 5 mm or more, because the distribution of advanced pocketing did not produce a stable variable to support the development of an extent index. The value 5 mm was selected as the cut-off point as the periodontal probing depths in the range of 5 mm will generally classify an individual as a chronic periodontitis case with moderate destruction.

Tezal *et al.*[41] conducted a cross sectional study on relationship between alcohol consumption and periodontal disease during NHANES III survey, in which the severity of periodontal disease was represented by clinical attachment loss (CAL) dichotomised using 1.5 mm as the cut-off point, which is the upper quartile of its distribution in the NHANES III population. Using this same cut off point of 1.5 mm dichotomous CAL, Akhter *et al.*[42] conducted a study to identify a possible relationship between stress and periodontal disease in residents of a rural area in Japan.

Also, Borrell *et al.*[43] conducted a prospective study to examine whether individual- and neighborhood-level socioeconomic characteristics were associated with periodontal disease. Severe periodontitis was defined as a combination of at least two interproximal sites with clinical attachment levels of 6 mm or above and at least one interproximal site with pocket depths of 5 mm or above. This dichotomous definition was chosen rather than a continuous definition because the former would be more relevant to clinicians and public health professionals.

Recently, Brothwell and Ghiabi[44] conducted a survey to determine the distribution and determinants of periodontal health in adult members of the Sandy Bay First Nation in Manitoba, Canada. They used Bivariate analysis to find variables significantly associated with two outcome variables: dichotomous mean CAL ($\leq$2.5 and >2.5 mm) and the dichotomous severe periodontitis (one or more sites with >5 mm CAL). Persson *et al.*[45] conducted a study to assess if a history of smoking is associated with chronic periodontitis and medical history in older subjects. In this study, the dichotomous radiographic evidence of alveolar bone loss (defined as the distance between the bone level and the cement-enamel junction $\geq$4.0 mm) was assessed by using the score '0' as no evidence of alveolar bone loss and score '1'as any other condition.

Genetic Susceptibility Index for periodontal disease

Currently, terms such as molecular epidemiology and genetic epidemiology have been coined to depict the change from 'traditional epidemiology' concerned with disease determinants at the community or social level (upstream) over to 'modern epidemiology' which is concerned with determinants operating at individual level or even below i.e. at the organ, tissue, cell or

molecular level (downstream). The inability of individual life-style factors to explain disease occurrence at the population level has led to a firm belief that further explanations are found in biological variation between individuals, i.e. in the biochemical, molecular and genetic make-up of individuals[46].

Recently, Moustakis *et al.*[47] formulated a Genetic Susceptibility Index (GSI) for both single nucleotide polymorphisms (SNPs) and microbial components of periodontal disease. The researchers took 850 records of 675 Caucasian periodontitis and control patients. The records incorporated genotypes of SNPs (sixty two triplets) like *CARD15* (Caspase recruitment domain-15) and *TGFB* (Transforming growth factor-β), records of seven bacterial species (*Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis*, *Prevotella indermedia*, *Tannerella forsythensis*, *Peptostreptococcus micros*, *Fusobacterium nucleatum* and *Campylobacter rectus*), ethnic origin as well as age, gender, smoking status, periodontal status (pocket depth and attachment loss), and severity assessment (valued over a nominal scale: healthy = 0, mild periodontitis = 1, and severe periodontitis = 2). A statistical process of Association Rule Mining (ARM) was used to derive GSI from genotypes of SNPs.

The GSI derived from genotypes of SNPs is shown in *Table 2*. GSI scores correlate well with disease presence. When the overall score is <1, the predisposition toward healthy status is 85% and when it is higher than 4, the predisposition toward disease is 88%. In addition, when score value ranges between 1 and 2, there is a 50/50 chance toward either disease or healthy status. Similarly, GSI scores linked with microbial values (all microbial percentage values were added and formed an *m* metric) to elucidate the probability of an individual being periodontal healthy was formulated and is shown in *Table 3*. The GSI scores correlate well with the sum percentage of the periodontitis associated bacteria. For example, when the susceptibility index is ≤1, the individual can harbour a high percentage (≤35%) of the seven microbial species and still be periodontal healthy. Conversely, when susceptibility increases (>4) even at low percentage (≤35%) of bacteria, the probability of healthy status is low, only 12%[47].

Table 2 Genetic Susceptibility Index (GSI) values and disease status[47]

GSI	No. of records	Health (%)	Disease (%)
GSI ≤ 1	206	85	15
1 < GSI ≤ 2	102	50	50
2 < GSI ≤ 3	169	29	71
3 < GSI ≤ 4	130	23	77
GSI > 4	68	12	88

Table 3 Genetic Susceptibility Index (GSI) values linked with microbial values (*m* metric)[47]

	Probability of healthy status		
	m (%) value range		
GSI values	0, ≤3 (%)	>3, ≤35 (%)	>35 (%)
GSI ≤ 1	97		44
1 < GSI ≤ 2	63		32
2 < GSI ≤ 3	36		4
3 < GSI ≤ 4	67	22	3
GSI > 4	12		0

According to the authors, genetic susceptibility to disease manifestation is already confirmed and in particularly for periodontal disease, various studies provide sufficient evidence. However, what is missing is an operational tool which will take research results a step forward. Once, genetic susceptibility profile reaches the clinical practice level then it will become part of the patient's records. The clinician will be able to use the genetic profile of the patient, and via concrete and valid models and procedures incorporate genetics into medical decision-making and reasoning. Thus, GSI points towards the integration of genotype and phenotype information and the improvement of clinical practice and decision-making[47]. However, further studies are required to validate and apply GSI for periodontal screening and prevention programmes.

FUTURE PERIODONTAL INDICES – A PROSPECTIVE VIEW

The prevalence of periodontitis has historically been measured using the extent and severity of loss of attachment and/ or probing pocket depth in millimetres, and represents an accretion of the manifestations of past disease with little or no indication of present disease activity. To best assess present disease activity, a dependable method of quantifying periodontal disease incidence is essential[2]. Each periodontal index formulated to date has its own merits and limitations.

The following are the possible options available to the dental community to move closer towards formulating an ideal periodontal index. Firstly, radiographic bone levels are closely related to clinical attachment level which is the gold standard for scoring periodontitis. With the advent of digital radiographic systems like computer assisted subtraction radiography in the field of periodontics, it is possible to detect bone level differences as small as 0.5 mm between an initial and a follow-up radiograph taken during periodontal examination[48]. Thus, the combination of measurement of clinical attachment level and digital radiographic systems into a single periodontal screening method will prove to be a useful tool for scoring periodontitis in

clinical trials. However, digital radiographic techniques are not practical for population based studies as they are technique sensitive, expensive and time consuming[48].

Secondly, the finding of additional attachment loss or radiographic bone loss between two examination periods of index recording confirms that disease has progressed but does not reliably predict the future destructive events. Considerable work is in progress to develop assays that identify ongoing periodontal destruction. Levels of inflammatory mediators, host derived enzymes, tissue breakdown products and other biochemical markers in gingival crevicular fluid are possible sources for future tests to accurately detect progressive periodontitis[48]. Periodontal indices based on the values of these assays, to categorise the patients into with and without periodontal disease, are a possible step in the future direction. However, they should be simple, reproducible and reliable for the formulation and successful application of a periodontal index system.

CONCLUSION

Periodontal indices have contributed to identification, prevention and treatment of periodontal disease over the years since their inception. These indices are based on the prevailing understanding of the pathogenesis and progression of periodontal disease. Thus, with the better understanding of the periodontal disease process these indices have changed from the simple Russell's Periodontal Index to the current Moustakis's Genetic Susceptibility Index. Each of these indices has its merits and limitations, so, an ideal index which detects the ongoing progressive periodontal destruction and also identifies the active and inactive sites of disease, is the need of the hour.

This review is a preliminary attempt to provide the general dental as well as specific periodontal community with collective information about the important landmarks in dental epidemiology namely the periodontal indices. We hope that this information will not only upgrade the knowledge of the dentists but also help in formulation of new and improved periodontal indices.

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Correspondence to:
Dr K. L. Vandana,
Department of Periodontics,
College of Dental Sciences,
Davangere, Karnataka,
India.
Emails: vanrajs@gmail.com;
kunaaldhingra@yahoo.co.in