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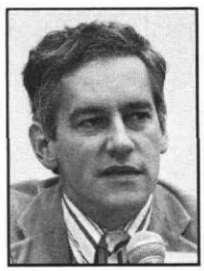

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Epidemiology and indices of gingival and periodontal disease

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Abstract

This paper reviews some of the commonly used indices for measurement of gingivitis and periodontal disease. Periodontal disease should be measured using loss of attachment, not pocket depth. The reliability of several of the indices has been tested. Calibration and training of examiners seems to be an absolute requirement for a satisfactory inter-examiner reliability. Gingival and periodontal disease is much more severe in several populations in the Far East than in Europe and North America, and gingivitis seems to increase with age resulting in loss of periodontal attachment in approximately 40% of 15-year-old children.

Introduction

Epidemiological data form the basis for planning and evaluation of dental care programs throughout the world. When epidemiological data have been collected, the amount of disease found has to be quantified by using indices.

It is the purpose of this paper to (1) review some of the more commonly used indices for the study of gingival and periodontal disease, and (2) describe some of the epidemiological trends in the natural history of gingivitis and periodontal disease in children.

Selection of Indices

An index is a numerical value describing the relative status of the population on a scale with definite upper and lower limits[1]. The use of indices permits comparison between different populations classified by the same criteria and methods.

A large number of gingival and periodontal indices have been described in the dental literature. In order to evaluate different indices it is important to estimate two parameters: reliability and validity.

Reliability is the ability of a given test to give the same result when applied twice to the same object. In the case of gingival and periodontal indices, reliability can be estimated by having an examiner examine the same patient twice.

Validity of an index indicates to what extent the index measures what it is intended to measure. Determination of validity is dependent on the availability of a so-called validating criterion.

Pocket depth may not reflect loss of periodontal attachment as a sign of periodontal disease. This is because gingival swelling will increase the distance from the gingival margin to the bottom of the clinical pocket (pseudo-pockets). Thus, depth of the periodontal pocket may not be a valid measurement for periodontal disease.

Apart from the validity and reliability of an index, important factors such as the purpose of the study, the level of disease in the population, the conditions under which the examinations are going to be performed etc., will have to enter into choice of an index. Since these factors vary considerably from one study to another, no single index will be appropriate for all types of studies.

Measurement of Gingivitis

Four indices commonly used in recent studies on gingival inflammation in children and young adults are presented in Table 1.

The diagnostic criteria employed in three of these indices are described in Tables 2 to 4. In the index described by Ainamo & Bay,[6] only absence or presence of bleeding after gentle probing is recorded.

Both the index described by Löe & Silness[2,7] and the index described by Suomi & Barbano[3] as modified by Suomi,[4] are based on a combination of criteria. As an example, score 1 in Suomi & Barbano's index (Table 4) is based on changes in color, volume, and texture, as well as presence or absence of stipling.

An example of an index which is based on only one symptom is the bleeding index used by Mühleman and coworkers. The criteria for the Papillary Bleeding Index[5] are described in Table 4. As seen from this table, bleeding is the only symptom which is recorded. An increasing score is assigned according to an increased tendency of the gingival tissue to bleed.

The index described by Ainamo & Bay,[6] considers only presence or absence of bleeding on gentle probing of the gingival tissue. Thus, this index represents a simplification of the index developed by Mühleman and coworkers (Table 4). When compared to the index described by Löe & Silness (Table 3), you can see that it represents score 2 and 3 in this index. The index described by Ainamo & Bay has proved to be useful in a number of epidemiological and clinical trials performed in the Scandinavian countries during recent years. The diagnostic criteria — bleeding or no bleeding — are assumed to be relatively easy to interpret. Therefore this index is assumed to be relatively insensitive to examiner differences.

Table 1. Four indices commonly used in recent studies on gingival inflammation in children and young adults.

Name (abbreviation)	Reference
Gingival Index (GI)	Löe & Silness 1963[2]
Gingivitis Index	Suomi & Barbano 1968[3] Suomi 1968[4]
Papillary Bleeding Index (PBI)	Saxer & Mühlemann 1975[5]
Gingival Bleeding Index (GBI)	Ainamo & Bay 1976[6]

Table 2. Diagnostic criteria for the Löe & Silness gingival index.[2,7]

Score	Criteria
0	Normal gingiva.
1	Mild inflammation — slight change in color, slight edema. No bleeding on probing.
2	Moderate inflammation — redness, edema and glazing. Bleeding on probing.
3	Severe inflammation — marked redness and edema. Tendency to spontaneous bleeding. Ulceration.

Table 3. Diagnostic criteria for the gingival index developed by Suomi & Barbano[3] and later modified by Suomi.[4]

Score	Criteria
0	Absence of inflammation — gingiva is pale pink in color and firm in texture. Swelling is not evident and stippling usually can be noted.
1	Presence of inflammation — a distinct color change to red or magenta is evident. There may be swelling, loss of stippling and the gingiva may be spongy in texture.
2	Presence of severe inflammation — a distinct color change to red or magenta is evident. Swelling, loss of stippling and a spongy consistency can be noted. There is either gingival bleeding upon gentle probing with the side of an explorer or the inflammation has spread to the attached gingiva.

Measurements of Periodontal Disease

Those indices described up to now only consider gingival inflammation. Recording of loss of periodontal attachment is not included in any of them.

The diagnostic criteria for the Periodontal Index (PI) developed by Russell,[8,9] are based on gingival inflammation and loss of periodontal attachment (Table 5). This index has been used mainly for epidemiological purposes, and a variety of different populations in developing countries have been examined using this index.

Table 4. Diagnostic criteria for the Papillary Bleeding Index developed by Saxer & Mühlemann.[5]

Score	Criteria
0	No bleeding.
1	Bleeding some seconds after probing.
2	Bleeding immediately after probing.
3	Bleeding on probing spreading towards the marginal gingiva.

Table 5. Diagnostic criteria described by Russell.[8,9]

Score	Criteria
0	Negative. There is neither overt inflammation in the investing tissues nor loss of function due to destruction of supporting tissue.
1	Mild gingivitis. There is an overt area of inflammation in the free gingivae which does not circumscribe the tooth.
2	Gingivitis. Inflammation completely circumscribes the tooth, but there is no apparent break in the epithelial attchment.
6	Gingivitis with pocket formation. The epithelial attachment has been broken and there is a pocket (not merely a deepened gingival crevie due to swelling in the free gingivae). There is no interference with normal masticatory function, the tooth is firm in its socket, and has not drifted.
8	Advanced destruction with loss of masticatory function. The tooth may sound dull on percussion with a metallic instrument; may be depressible in its socket.

When comparing the criteria proposed by Ramfjord[10,11] (Table 6) to the criteria developed by Russell we find that the criteria for score 1 and 2 are almost identical in the two indices. In those cases where no loss of attachment is recorded, Ramfjord's Periodontal Disease Index (PDI) is equivalent to the gingivitis score. If the gingival crevice extends apically to the cemento-enamel junction, the tooth is assigned a higher Periodontal Disease Index score and the gingivitis score for the same tooth is then disregarded.

Both the index proposed by Russell and the index proposed by Ramfjord have criteria based on gingival inflammation as well as loss of periodontal attachment.

Another possibility is to distinguish between gingival inflammation and periodontal disease and record gingivitis and loss of attachment separately.

When recording periodontal disease, a distinction should be made between pocket depth and loss of attachment.[12] Pocket depth is the distance from the gingival margin to the bottom of the clinical pocket. Since swelling of the gingival tissue due to inflammation may increase the depth of the pocket in cases where no loss of attachment has taken place, pocket depth may not be a valid measurement of periodontal disease.

Loss of attachment is the distance from the cemento-enamel junction to the bottom of the clinical pocket. Both pocket depth and loss of attachment are measured using a periodontal probe, and usually recorded to the nearest millimeter.

Reliability, Sensitivity and Statistical Analysis of Indices of Gingivitis and Periodontal Disease

The reliability of the various indices for gingival and periodontal disease have been studied to some extent in the literature. Lack of inter-examiner reliability has been demonstrated by, among others, Davies et al.[13] as part of an epidemiological training course. In this study the index proposed by Russell was used and the results clearly indicate that without any calibration or training the inter-examiner reliability was low. Later studies conducted by Smith et al.,[14] Alexander et al.,[15] and Shaw & Murray[16] have shown that training programs can be effective in reducing inter-examiner as well as intra-examiner agreement in recording gingivitis.

When evaluating the reliability of gingival indices remember that the first examination might influence the results of the following examination. This was indicated in a study by Birkeland & Jorkjend,[17] where an examiner examined the same children twice at two hour intervals. The analysis showed that no differences were found between the number of gingival units recorded as 0. The number of gingival units scored as 1 decreased slightly, while the number of gingival units scored as 2 increased slightly from the first examination to the second. Several explanations may be available for this phenomenon. The authors suggest that the first examination increased the tendency of the gingival units to bleed. Another explanation may be a shift in diagnostic criteria. Probably both explanations are partly valid. The fact is, however, that reliability of gingival indices is a difficult parameter to estimate, since the object being measured is not constant.

Table 6. Diagnostic criteria described by Ramfjord.[10,11]

Score	Criteria
0	Absence of signs of inflammation.
1	Mild to moderate inflammatory gingival changes, not extending around the tooth.
2	Mild to moderately severe gingivitis extending all around the tooth.
3	Severe gingivitis characterized by marked redness, swelling, tendency to bleed and ulceration.

One of the only ways of comparing the performance of different indices is to apply several indices in the same study. The experimental gingivitis model has been used extensively in studies on the plaque- and gingivitis-preventive effects of a variety agents.[18] Reanalysis of data from one of these trials[19] showed that the gingival index developed by Löe & Silness[2] was more sensitive than the Papillary Bleeding Index developed by Mühlemann and his co-workers.[5] Furthermore, the Gingival Exudate Measurement[20] proved to be more sensitive than the Gingival Index.

The same study showed that only slight reduction in the sensitivity of the Löe & Silness Gingival Index was observed if the scale was reduced from a 4-point scale to a 2-point scale using bleeding as the criterion. Similar findings have been made by other groups.[21]

The non-parametric nature of many indices of gingival and periodontal disease prohibits statistical analysis using regular parametric statistical methods. One possible solution is to apply statistical methods which have been designed to analyse non-parametric data.[22] Another possibility is to tabulate the frequency with which the different scores are found. This type of measurement is parametric in nature and can be analysed using parametric statistics.

Epidemiology of Gingival and Periodontal Disease

Epidemiology has been defined as the study of disease distribution and determinants in man.[23] A number of reviews on the epidemiology of gingival and periodontal disease have already been published in the literature.[24,25,26] The present review is limited to the preva-

lence of gingivitis and periodontal disease in children with respect to such commonly used epidemiological background variables as age, sex and geography.

Geographical Variation in Prevalence of Gingival and Periodontal Disease

Russell and coworkers[25] demonstrated that wide variations in periodontal disease in a given age-group exists across the world. Similar conclusions were reached by Ramfjord et al.[26] and Barmes.[27] The general trend was that some populations, especially in the Far East, were more likely to be affected by periodontal disease than Europeans and North Americans. This has been substantiated by a series of epidemiological studies performed in Sri Lanka during the last decade. In 1969 Waerhaug[28] presented data which documented a very high prevalence of periodontal disease in a sample of several thousand persons ranging in age from 13 to over 60. When the data were compared to data for Norwegian students, periodontal disease was shown to be much more severe in Sri Lanka. When the same analysis was performed after adjustment for differences in oral hygiene however, very small differences were found.

In a longitudinal survey conducted by Löe and coworkers the baseline examination showed that the number of gingival units with a score of 2 or more was almost seven times higher in Sri Lanka than in Norway.[29] The same study showed that before the age of 20, loss of periodontal attachment was considerably higher in Sri Lanka than in Norway. When the annual rate of attachment loss was studied on a longitudinal basis, the individuals from Sri Lanka tended to lose two to three times as much periodontal attachment per year as the individuals from Norway.[30]

One of the explanations for the high prevalence of periodontal disease in early age in many developing countries could be a higher tendency toward calculus formation. A recent epidemiological study of more than 600 6- to 15-year-old schoolchildren in one of the major cities in Sri Lanka showed that calculus was found as early as age 6.[31] At the age of 15 more than half of the six surfaces scored for calculus were covered by calculus. No data which would allow a direct comparison with European or American populations seems available, but the general impression is that calculus is not found as frequently in these populations.

Prevalence of Gingival and Periodontal Disease in Relation to Age and Sex

Most of the early studies on the epidemiology of gingival and periodontal disease were limited to adult populations. This led to the view that periodontal disease is a disease of adulthood. More recent studies, however, have clearly demonstrated that gingivitis is already present during the first years of life. In one of these studies[32] three-year-old children from four different geographical areas in Denmark were examined. Of a total of 80 gingival units, 15 to 20 units were bleeding on gentle probing. The accumulation of plaque was also relatively high, 30 to 40 tooth surfaces out of 80 were covered with a layer of plaque, which could be seen with the naked eye after careful drying (score 2 according to Silness & Löe).[33]

A recent longitudinal Swedish study can be used to describe the situation from the age of three through school age.[34] In this study 162 children were followed longitudinally and examined when they were three, four, and five years of age.

This study seems to indicate that the level of gingival inflammation decreases through preschool age, but preventive dental care programs now established in many Scandinavian municipalities may explain this decrease: the age-trend observed in this study may partly be due to better oral hygiene with increasing age.

One of the few surveys which includes data from early childhood to the late teen-ages was published by Parfitt.[35] The PMA-index[36] was used in a modified form. A steady increase in the severity index was noted from the age of three until the age of 13. From the age of 13 until the age of 17 a decrease in the severity of gingivitis was noted.

A large survey of a community in the southern part of Sweden[37] showed that in three-year-old children, 5% of all surfaces showed bleeding gingiva on gentle probing. This percentage increased through the teen-ages and reached a level of about 35% at the age of twenty.

Part of the explanation for the increase in gingivitis during childhood may be found in data published recently by Mackler & Crawford[38] and by Matsson.[39] In Matsson's study six four-to five-year-old children and six 23- to 29-year-old adults were studied. Before the initiation of the study, intense oral hygiene procedures were practiced. This reduced the frequency of bleeding units to a very low level. During the study all oral hygiene procedures were stopped, and the development of plaque and gingivitis studied. In the children, no gingival inflammation developed over a twenty-one day period with no oral hygiene, while marked gingivitis developed during the same period of time in the adults. A number of different explanations for this finding can be found, including different host responses to dental plaque. Future studies should further clarify this interesting aspect of the etiology of gingival disease in children.

Some studies have shown less gingivitis in girls than in boys of similar age, while other studies have shown the opposite trend. Whether these differences are truly related to sex, or whether they only reflect the difference in oral hygiene or oral cleanliness be-

Table 7. Summary of clinical studies on periodontitis in children and young adults.

Author (year)	Population	Pocket depth	Loss of attachment	Age in years 11-14	15	16	17
Sheiham[41] (1969)	English	> 3 mm	—	11%	21%	28%	36%
Downer[42] (1970)	English			24%	—	—	—
	Negro or mixed	> 3 mm		45%	—	—	—
Axelsson et al.[37] (1975)	Swedish	4 mm	—	—	17%	—	—
Bowden et al.[43] (1973)	English	—	> 1 mm	—	47%	—	—
Lennon et al.[44] (1974)	English			—	41%	—	—
	Non-European	—	> 1 mm	—	84%	—	—

tween the two sexes[40] seems open for discussion.

Gingivitis studies are important because this condition may lead to irreversible breakdown of the periodontal tissues. Since we are not, at the present time, able to determine whether a given level of gingival inflammation in a given child will result in loss of periodontal attachment, our efforts at preventing periodontal disease must be to obtain a general reduction in the level of gingivitis. Thus, epidemiological data on frequency of periodontal disease in individuals below the age of twenty becomes important.

The literature contains studies in which the pocket depth has been recorded, studies where loss of attachment has been recorded and studies where bone-loss has been determined on radiographs. Table 7 is a summary of some of the more extensive epidemiological studies published in the literature.[37,41,42] As always, when data from various epidemiological studies are compared, due regard should be given to the inter-examiner reliability, and to the different criteria used. In general, we can conclude that pockets of three to four millimeters or more are found in 20 to 30% of 11 to 15-year-old children.

True loss of periodontal attachment has been recorded in two British studies, also summarized in Table 7. Both studies included 15-year-old children, and the frequency of children with loss of attachment of one millimeter or more was 40 to 47%.[43,44]

Three studies are available in which radiographic examination of loss of alveolar bone was performed.[45,46,47] Similar diagnostic criteria in the diagnosis of bone loss on bite-wing radiographs seem to have been employed and the study populations seemed to be similar in many respects. However, prevalence of loss of alveolar bone, varied from 1 to 51% of the individuals (Table 8).

When the individuals examined by Davies et al.[47] were re-examined three years later, 44 to 68% of the individuals showed loss of alveolar bone on radiographs. Further studies seem to be indicated in this area.

Summary

1. An index of gingivitis should be simple, easy to communicate to professionals, as well as laymen, and be amenable to simple statistical analysis. Indices which consider bleeding as the only diagnostic criteria seem to fulfill these criteria and have proven valid in a number of recent epidemiological studies and clinical trials conducted on children.
2. Periodontal disease is most clearly expressed as loss of periodontal attachment measured from the cemento-enamel junction to the bottom of the clinical pocket: pocket depth should not be confused with loss of periodontal attachment.
3. Gingival inflammation has been shown to increase in prevalence and severity with increasing age. The reasons for this are not well known now. Permanent,

Table 8. Summary of radiographic studies on alveolar bone loss in children.

Author (year)	Population	Prevalence of periodontal bone loss
Hull et al.[45] (1975)	14 years English	51%
Blankenstein et al.[46] (1978)	13-15 years English and Danish	1%
Davies et al.[47] (1978)	11-12 years English	19-37%

irreversible loss of periodontal attachment has been recorded in up to 20% of 15-year-old children.

4. When the influence of such factors as sex, socio-economic background, medical disorders etc., on gingival inflammation are to be studied, due regard should be given to oral cleanliness. Comparing different population groups should be done only for individuals with the same level of plaque.
5. Loss of periodontal attachment is always preceded by gingival inflammation, therefore the ultimate goal of preventing gingival inflammation is to prevent irreversible break-down of the periodontal structures.

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