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A comparison of four epidemiological methods of assessing periodontal disease

II. Test of Periodontal Indices

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Periodontal disease was assessed using PI and P. D. I. and radiographic and mobility assessments. Analysis of data by worst score in the mouth and by individual teeth indicated that PI did underestimate the severity of periodontal disease. P. D. I. diagnosed destructive periodontal disease in 45.0 per cent of mouths and 38 per cent of teeth considered free of destructive periodontal disease using PI. P. D. I. detects more destructive periodontal disease than PI at the lower radiographic scores (4 and 5); at radiographic scores 6 and 7 the disparity between the P. D. I. and PI decreased. The measurements of mobility underestimated the severity of periodontal disease; ninety five per cent of all teeth examined were considered to have a mobility score of 0 whereas 20 per cent were considered free of periodontal disease using PI. Radiographic examination did not add significantly to the PI and P. D. I. examinations.

Introduction

Periodontal disease is assessed by the presence or absence and the severity of gingivitis, periodontal pocketing, clinical mobility and alveolar bone loss. The Periodontal Index (PI) (Russell 1956) and the Periodontal Disease Index (P. D. I.) (Ramfjord 1959) are frequently used indices of gingivitis and periodontal pocketing. Ramfjord (1959) has also developed a scoring system for assessing clinical mobility. Alveolar bone loss has been assessed from radiographs.

The present analysis was carried out to investigate the relationship between the Periodontal Index, Periodontal Disease Index, mobility and radiographic scores.

Methods

The selection of the sample and the method of clinical and radiographic examination have been described (Sheiham and Striffler 1970).

Test of Periodontal Indices

Comparison of indices by individual tooth scores.

Five two-way frequency tables were compiled for each tooth showing the distribution of scores for one method of examination for each score by one of the other methods. These tables, which are not given in this paper, show for each tooth (2, 3,

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. . . . 15, 18, 19, ... 31) and the number of times a score of 0 by PI corresponded to a radiographic score of 0, of 4, of 5, etc.; the number of times a tooth scored as 1 by PI was scored 0, 4, 5, 6, or 7 radiographically, and so on through the five combinations of examination methods.

The 28 individual tooth tables for each combination of ratings were then summed to give the total frequency with which each combination of scores occurred. If all 1976 subjects had all 28 teeth scored by each of the four procedures being compared, the total frequency in each table would be 1976 $\times$ 28 = 55,328; however, many subjects had missing teeth and also there were some missing data for each type of score. Consequently, the total frequencies in these summary tables are less than the 55,328 possible and vary from table to table because of varying amounts of missing data for the different indices.

The individual tooth tables are not given in this paper. They were studied to find out how the incidence of pocket formation varied from tooth to tooth and whether pocket formation could be determined independently of the method used to diagnose it. If so, it would be possible to estimate the absolute efficiency of each of the examination procedures to detect pockets. It was found that the teeth cannot be considered independent of each other – a diagnosis of pocket formation for one tooth is not independent of the diagnosis for other teeth in the mouth – and the method of examination used, to some extent, defines the condition to be diagnosed so that what is called disease by one procedure differs from what another procedure calls disease.

Therefore, two methods of data analysis were carried out to ascertain the relation between the periodontal scoring methods.

First a comparison of the indices was made by worst scores per mouth.

Comparison of indices by worst scores per mouth

A comparison of the most severe condition (score) recorded for each examination procedure in each mouth was made for three combinations of procedures:

1. PI with PDI
2. PI with mobility
3. PDI with mobility

The number of teeth affected is not taken into consideration here, only the highest score in the mouth by each examination, the highest scores by the different procedures are not necessarily all for the same tooth; different teeth in the same mouth may appear more severely affected depending on the type of examination. What is sought here is the number of subjects found to have apical migration of the epithelial cuff

Table I

Comparison of worst PI and worst PDI and mobility scores

Worst Scores		Worst PI Scores Per cent				
		0	1.2	6	8	Total
PDI	0	0.0	0.0	0.0	0.0	0.0
	1–3	0.0	5.0	0.1	0.0	5.1
	5	0.5	40.3	17.4	1.0	59.2
	6	0.1	4.1	18.7	3.1	26.0
	7	0.0	0.1	3.8	5.8	7.9
	Total	0.6	49.5	40.0	9.9	100.0
Mobility	0	0.6	46.0	31.0	0.2	77.8
	1	0.0	3.4	8.5	0.6	12.5
	2	0.0	0.1	0.5	9.1	9.7
	Total	0.6	49.5	40.0	9.9	100.0

Table II

Comparison of worst PDI and worst mobility scores

Worst Mobility Scores	Worst PDI Scores Per cent					
	0	1–3	5	6	7	Total
0	0.0	5.0	53.2	17.4	2.2	77.8
1	0.0	0.1	4.8	5.7	1.9	12.5
2	0.0	0.0	1.1	3.0	5.6	9.7
Total	0.0	5.1	59.1	26.1	9.7	100.0

by one type of examination and none by another type. Tables 1 and 11 show the percentage frequencies for the comparisons of worst scores recorded in the three combinations listed. Comparison of worst PI and worst P. D. I. scores in Table 1 show that not a single mouth was found to be completely free of periodontal disease in the latter examination and only 0.6 per cent of mouths were completely free of disease according to the PI. The relative frequency (and its 95 per cent confidence interval) with which the P. D. I. examination diagnosed apical migration of the epithelial cuff in a mouth where none was found by PI is 45.0 per cent ($42.8 \leq P \leq 47.3$).

Comparison of worst PI and worst mobility scores in Table 1 shows a combination of some mobility (M = 1 or 2) and no pocket by PI method in 3.5 per cent of the cases (the 95 per cent confidence limits are $2.8 \leq P \leq 4.5$). On the other hand 31.2 per cent of the cases were scored as having no mobility and at least one pocket by PI.

Comparison of worst P. D. I. and worst mobility scores in Table 11 shows a combination of some mobility (M = 1 or 2) and no apical migration of the epithelial cuff by P. D. I. in only 0.10 per cent of the cases (95 per cent confidence limits are $0.01 \leq P \leq 0.36$); 72.7 per cent of the subjects were scored as having no mibility but at least one tooth with apical migration of the epithelial cuff by P. D. I.

Second, summary tables and corresponding percentage distributions for five combinations were compiled. Only the percentages are presented. The five combinations of examination procedures so tabulated are:

1. PI versus radiographic scores (Table III)
2. P.D.I. scores versus radiographic scores (Table VI)
3. PI versus P.D.I. (Table IX)
4. PI versus mobility scores (Table XI)

Table III

Percentage distribution of radiographic scores for given values of PI: summary data for 49,890 teeth

PI	Radiographic Scores					
	0	4	5	6	7	Total
0	20.54	0.60	4.38	0.03	0.00	25.55
1	28.72	0.89	10.83	0.07	0.00	40.51
2	10.52	0.47	8.45	0.10	0.00	19.54
6	2.08	0.16	9.77	1.04	0.02	13.07
8	0.02	0.00	0.65	0.63	0.13	1.33
Total	61.88	2.12	33.98	1.87	0.15	100.00

5. P.D.I. scores versus mobility scores (Table XIII)

With each of these tables there is a table of conditional probabilities showing the percent of the time that each score by one procedure was assigned to a tooth having a specific rating by the other procedure.

Comparison of index scores for teeth

1. *PI and Radiographic Scores*

Clinical periodontal pocketing cannot be diagnosed with certainty by radiographs without the use of indirect methods such as metal or gutta percha points. However, for ease of comparison, it is assumed that radiographic scores of 5, 6, or 7 are suggestive that there is or has been pocketing. No destructive periodontal disease was found using PI around 86 per cent of all teeth examined by the two methods (Table III); 60 per cent of the time PI and radiographic evidence agreed that there was no destruc-

Table IV

Conditional probabilities (in percents) of PI scores for given radiographic scores

Radiographic Scores	PI Scores				
	0	1,2	6	8	Total
X = 0	33.20	63.41	3.36	0.04	100.00
X = 4	28.30	63.97	7.64	0.09	100.00
X = 5	12.88	56.74	28.75	1.63	100.00
X = 6	1.51	9.14	55.59	33.76	100.00
X = 7	0.00	1.33	14.67	84.00	100.00

Table V

95 per cent confidence limits on the probability of detecting a pocket by PI for given (nonzero) radiographic scores

Radiographic Scores	Estimated Probability PI > 2	95 per cent Confidence Limits
X = 4	7.7 per cent	6.2 ≤ P ≤ 9.7
X = 5	30.4 per cent	29.7 ≤ P ≤ 31.1
X = 6	89.4 per cent	87.2 ≤ P ≤ 91.1
X = 7	98.7 per cent	92.8 ≤ P ≤ 100.0

Table VII

Conditional probabilities (in per cents) of PDI scores for given radiographic scores

	PDI Scores					
	0	1–3	5	6	7	Total
X = 0	19.90	43.61	35.84	0.63	0.02	100.00
X = 4	14.51	35.44	48.54	1.41	0.09	99.99
X = 5	3.59	13.68	68.81	12.64	1.28	100.00
X = 6	0.00	0.22	16.63	56.37	26.78	100.00
X = 7	0.00	0.00	5.33	14.67	80.00	100.00

tive periodontal disease; two per cent of the time incipient bone loss (X = 4) was found on the radiograph and no pocket was found by PI while 24 per cent of the time bone loss (X = 5, 6, 7) was found on radiographs corresponding to teeth having no pocket according to PI. As indicated by the conditional probabilities of PI scores for given radiographic scores, a large proportion of the discrepancy between the PI scores over 2 and the radiographic scores of 5, 6, or 7 occurred in the X = 5 category; there the conditional probability of diagnosing a pocket by PI was only 30.4 per cent. In the X = 6 and X = 7 categories the probability of diagnosing a pocket increased to 89.4 per cent and 98.7 per cent respectively (Tables IV and V).

2. *P.D.I. and Radiographic Scores*

No destructive periodontal disease (P.D.I. < 5) was diagnosed around 46 per cent of all teeth examined by the two methods (Table VI); 36 per cent of the time P.D.I. and the radiographic evidence agreed that there was no destructive periodontal disease; one per cent of the time incipient bone loss was found on the radiograph and mild gingivitis was found by P.D.I. while only six per cent of the time bone loss (X = 5, 6, 7) was found on radiographs corresponding to teeth having no scores of five or more (gingivitis) according to P.D.I. The biggest disagreement between results of these two types of examinations was that 36 per cent of teeth scored as showing no evidence of bone loss (X = 0) on the radiographic examination received a score of five in the P.D.I. examination (Table VIII): 22 per cent of all the teeth examined (Table VI). It is interesting to note that 35 per cent of teeth with incipient bone loss (X = 4) showed signs of gingivitis (P. D. I. = 1–3) (Table VII). A comparison between the conditional probabilities of PI and P.D.I. scores for a given radiographic score indicates that P.D.I. detects more destructive periodontal

Table VI

Percentage distribution of radiographic scores for given PDI scores: Summary data for 49,825 teeth

PDI	Radiographic Scores					
	0	4	5	6	7	Total
0	12.31	0.31	1.21	0.00	0.00	13.84
1	24.51	0.69	3.79	0.00	0.00	28.99
2	2.05	0.03	0.54	0.00	0.00	2.62
3	0.42	0.03	0.32	0.00	0.00	0.78
5	22.18	1.03	23.38	0.31	0.01	46.91
6	0.39	0.03	4.30	1.05	0.02	5.79
7	0.01	0.00	0.44	0.50	0.12	1.07
Total	61.88	2.13	33.98	1.86	0.15	100.00

Table VIII

The probability of detecting destructive periodontal disease by PI and PDI for given (nonzero) radiographic scores

Radiographic Score	Estimated Probability PI > 2	PDI > 3
X = 4	7.7	50.0
X = 5	30.4	82.7
X = 6	89.4	99.8
X = 7	98.7	100.0

Table IX

Percentage distribution of PI scores for given values of PDI: summary data for 49,958 teeth

PDI	PI Scores					
	0	1	2	6	8	Total
0	12.66	1.17	0.01	0.00	0.00	13.85
1	3.72	20.11	5.10	0.08	0.01	29.02
2	0.02	1.04	1.53	0.04	0.00	2.63
3	0.02	0.24	0.48	0.04	0.00	0.78
5	8.87	17.31	11.88	8.54	0.27	46.87
6	0.26	0.59	0.52	3.81	0.58	5.77
7	0.01	0.02	0.02	0.57	0.47	1.08
Total	25.56	40.49	19.54	13.07	1.34	100.00

disease than the PI at the lower radiographic scores (X = 4); 50 per cent compared with 8 per cent and at X = 5, 83 per cent compared with 30 per cent. However, as X becomes more severe this disparity decreases: 100 per cent compared with 89 per cent and 99 per cent for X = 6 and 7 respectively (Table VIII).

3. *PI and P.D.I.*

Considering the gingivitis scores (P.D.I. = 1, 2, 3 and PI = 1, 2) as comparable for the two methods, the conditional probabilities of both the methods scoring gingivitis is 87 per cent, (Table X), accounting for 28 per cent of all teeth (Table IX). However, 38 per cent of teeth with PI scores of less than six (normal or gingivitis) had P.D.I. scores of five or more (Table IX); these P.D.I. scores indicate bone loss or pocketing.

Table X

Conditional probabilities (in per cents) of PI scores for given PDI scores

PDI	PI Scores				
	0	1, 2	6	8	Total
0	91.42	8.57	0.01	0.00	100.00
1, 2, 3,	11.59	87.90	0.48	0.03	100.00
5	18.93	62.27	18.22	0.58	100.00
6	4.48	19.33	66.10	10.09	100.00
7	1.11	2.95	52.21	43.73	100.00

Table XI

Percentage distribution of mobility scores for given values of PI: summary data for 50,048 teeth

PI	Mobility Scores			
	0	1	2	Total
0	25.31	0.24	0.01	25.56
1	40.05	0.45	0.01	40.51
2	19.09	0.42	0.02	19.53
6	11.13	1.84	0.08	13.05
8	0.03	0.15	1.17	1.35
Total	95.61	3.10	1.29	100.00

4. *PI and Mobility*

Pockets were detected by PI around 64 per cent of the teeth having a mobility rating of one and around 97 per cent of the teeth having a mobility rating of 2 (Table XI). Only 1.2 per cent of the teeth with no pocket according to the PI had a non-zero mobility score assigned (Table XI).

5. *P.D.I. and Mobility*

Ninety-five per cent of the teeth examined had mobility scores of 0 (Table XIII). The conditional probability of diagnosing destructive periodontal disease by P.D.I. around teeth with a 0 mobility score was 52 per cent, with a 1 mobility score the probability was 94 per cent; 99 per cent of teeth with a mobility score of 2 were considered to have destructive periodontal disease (Table XIV).

Discussion

Jamison (1963) has shown that the PI underestimates the severity of periodontal dis-

Table XII

Conditional probabilities (in per cents) of PI scores for given mobility scores

Mobility	PI Scores				
	0	1, 2	6	8	Total
M = 0	26.47	61.86	11.64	0.03	100.00
M = 1	7.80	27.96	59.28	4.96	100.00
M = 2	0.47	2.48	6.51	90.54	100.00

Table XIII

Percentage distribution of mobility scores for given values of PDI: summary data for 49,964 teeth

PDI	Mobility Scores			
	0	1	2	Total
0	13.79	0.06	0.00	13.85
1	28.90	0.11	0.01	29.01
2	2.61	0.01	0.01	2.63
3	0.77	0.01	0.00	0.78
5	45.07	1.55	0.24	46.87
6	4.08	1.14	0.56	5.78
7	0.39	0.22	0.46	1.08
Total	95.62	3.10	1.28	100.00

ease as assessed by P.D.I. However, the PI in contrast to the P.D.I. was not designed to accurately measure the severity of periodontal disease in individuals or around individual teeth. In addition, the PI is a reversible index whereas the P.D.I. is irreversable. Because of these characteristics of the two indices, comparisons between the PI and the P.D.I. and radiographic scores must be viewed with caution. The differences between the PI and P.D.I. are illustrated by the findings for comparisons of these two indices and radiographic scores. When the probabilities of diagnosing destructive periodontal disease by PI and P.D.I. are compared to radiographic diagnosis, the probability of diagnosing destructive periodontal disease was much higher by P.D.I. than PI when up to one third of the alveolar bone was resorbed. After that level of bone loss the differences in the probabilities were not great (Table VIII). This finding suggests that the PI is more likely to underestimate the severity of periodontal disease in persons with early bone loss.

The PI is a measure of morbidity whereas the P.D.I. is a measure of lifetime periodontal disease. Therefore it was not surprising that dental radiographic scores contributed less to the P.D.I. than to the PI. For example, in only six per cent of cases that gingivitis only was diagnosed by P.D.I. was bone loss diagnosed on radiographs. On the other hand, 36 per cent of teeth scored as showing no radiographic evidence of bone loss were considered as having destructive periodontal disease by the P.D.I. (Table VI). Using the PI, bone loss was diagnosed radiographically but not by PI around 24 per cent of the teeth examined. These findings confirm those reported by Jamison (1963). Jamison (1963) found that radiographic scores contributed considerably more to the PI than to the P.D.I. However, the high probabilities of diagnosing destructive periodontal disease by PI and by P.D.I. (Table VIII) throw some doubt on the usefulness of radiographs in epidemiological investigations of periodontal diseases.

One of the objectives of the study was to assess the value of clinical tooth mobility measurements in diagnosing periodontal disease which was not diagnosed by one of the other three methods used. It was found that mobility measurements underestimate the severity of periodontal disease. For example, 72.8 per cent of subjects scored as having no mobility had destructive periodontal disease as assessed by P.D.I. (Table II); similar findings were found in the analysis of individual teeth (Table XIII).

It was concluded that radiographs and mobility measurements did not add significantly to the two commonly used periodontalindices, PI and P.D.I. In addition, they did not increase the precision of detecting differences in the severity of periodontal disease in population groups.

Table XIV

Conditional probabilities (in per cents) of PDI scores for given mobility scores

Mobility	PDI					
	0	1, 2, 3	5	6	7	Total
M = 0	14.43	33.75	47.14	4.27	0.41	100.00
M = 1	1.87	4.19	50.03	36.69	7.22	100.00
M = 2	0.00	1.09	18.94	43.66	36.31	100.00

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