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Validity and reliability of partial examination to assess severe periodontitis

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Abstract

Objectives: To compare the extent and severity index (ESI) with a gold standard represented by actual readings of loss of attachment on six sites around all teeth present (excluding third molars).

Methods: Five standardized dentists ($\kappa = 0.6$) examined 712 subjects $\geqslant$20 years of age at a dental school (1993–1995). Sensitivity, specificity, positive and negative predictive values, and true and apparent prevalence were established.

Results: True severe periodontitis prevalence was 95.8%. ESI underestimated the severity (0.1 mm), extent (4%), and prevalence (16%) of periodontitis. The severity, as established by ESI, coincided 23.4% with the gold standard. ESI failed to identify 16.7% of subjects with severe periodontal disease, but specificity and positive predictive value were very high.

Conclusions: The underestimation of severe periodontitis through ESI may lead to inadequate recommendations for further treatment. Accurately identifying subjects with severe periodontitis requires a full-mouth examination. Because the ESI relies on measurements taken on only 28 periodontal sites to estimate the periodontitis status of the entire mouth, the validity and reliability of ESI may be modified by the prevalence of severe periodontal disease and the distribution of disease according to age and operational definitions.

Key words: epidemiology; extent and severity; periodontal disease; reliability; validity

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As in the case of other clinical entities assessed from an epidemiological perspective, signs of periodontal disease have been used as indicators of periodontitis. The many indices developed to measure such signs (for example, Ramfjord 1956, Greene 1974, Löe 1974, Massler 1974, O'Leary 1974, Russell 1974, Barmes et al. 1986) have diverse shortcomings. Most importantly, an ideal index should be reproducible and valid, in that the measurements ought to reflect adequately the variable the index was designed to describe. The many indices designed over the years have focused on different analysis units – periodontal site, tooth, person. Consequently, there have been various interpretations of diverse features of periodontal disease, including how representative certain sites and certain teeth are of the status of the entire mouth. Partial measurements, as opposed to full-mouth measurements, have traditionally been employed in periodontal epidemiology to make the assessment effort less time-consuming and less costly. Some of these approaches have targeted one upper and one lower quadrant (Carlos et al. 1986, Brown et al. 1990), randomly selected, either contralateral or on the same side of the mouth. The underlying assumption is that periodontal disease affects dentition in a symmetrical manner across the midline (Hirschfeld & Wasserman 1978, Löe et al. 1978a, b, Burmeister et al. 1984, Listgarten et al. 1989). If this premise is true, a periodontal assessment may be accurate and more efficient by examining only a few sites rather than every periodontal site.

The question remains as to whether certain periodontal sites – e.g., those more accessible to examination such as mid-buccal and mesio-buccal, which have been used in large surveys (Miller et al. 1987) – accurately reflect prevalence and severity of periodontitis at the population level. Various attempts have been made to quantify the detrimental effect of partial measurements (Alexander 1970, Downer 1972, Mills et al. 1975, Ainamo & Ainamo 1985, Haffajee et al. 1985, Carlos et al. 1986, Hunt 1987, Kingman et al. 1988, Hujoel & Loesche 1990, Hunt & Fann 1991, Diamanti-Kipioti et al. 1993, Papapanou et al. 1993). No unequivocal answer has been found, however.

One of the more recent indices, the extent and severity index (ESI) (Carlos et al. 1986), has enjoyed substantial popularity, because it not only establishes the *severity* of periodontitis as the mean attachment loss in diseased sites, but also incorporates the proportions of all sites that are affected by periodontitis (*extent*). Because the ESI measures attachment loss in only 28 sites in contralateral quadrants, it has the same potential for inaccuracy as other partial measurements. The present investigation compares the sensitivity, specificity, positive and negative predictive values, and true and apparent prevalence calculated by ESI with those found using a ''gold standard.'' Our study also measured the strength of correlation between the two components of the index and the attachment loss readings derived from the gold standard.

Material and Methods

We examined adult patients referred to the Periodontology Specialty Clinic at the National University Dental School in Mexico City between January 1993 and November 1995. Data were obtained following a standardized protocol that included operational definitions laid out for examiners (Table 1). Loss of attachment was determined in the six periodontal sites (disto-buccal, mid-buccal, mesio-buccal, mesio-lingual, mid-lingual, and disto-lingual) of each tooth except third molars.

Five examiners recruited from the resident program in periodontology were trained and standardized to conduct the exams in a fully equipped dental clinic. Examiners used a dental chair, an air/water syringe, a dental mirror, Michigan periodontal probes, and Gracey periodontal curettes. A pilot study in 15 patients (who were not included in the final study group) was undertaken to familiarize examiners with the data collection process, refine data audit procedures, and evaluate intra- and inter-examiner agreement. Intra- and inter-examiner agreement (κ) each were 0.6, including $\pm$ 1.0 mm.

Data were first collected on paper forms and subsequently entered in a computer database. After data quality audits were implemented, the periodontal measurements were analyzed using NCSS® (Kaysville, UT, USA) and WIN EPISCOPE 1.0a® (Programa epidemiológico de dominio público. Financiado con el proyecto CONS I+D P50/98 del Gobierno de Aragón). Data analyses initially used student's *t*-test and one-way ANOVA. The mean loss of attachment was obtained for each site; the extent of periodontitis (proportion of sites affected by periodontitis) was calculated using the criteria listed in Table 1.

ESI validity was obtained by calculating sensitivity, specificity, and positive and negative predictive values overall and by age group. Confidence intervals were established using a normal approximation to standard error for proportions. True and apparent prevalence of periodontitis were calculated by age group. The extent and the severity of periodontitis were determined by measuring all 168 sites, 140 sites, or the 28 ESI sites and contrasted by sex and age group. The 28 sites comprised by ESI were eliminated from this contrast to remove the bias resulting from using those sites both in the full-mouth assessment and in ESI (Fleiss et al. 1987). The reliability of the diagnosis of periodontitis was obtained by comparing the severity from ESI with that from the 140 sites using Cohen's κ. The effects of sensitivity, specificity, and true prevalence on apparent prevalence and predictive values were estimated.

This study design adhered to the recommendations laid out by the Institutional Review Board of the National University Dental School.

Results

A total of 712 participants $\geqslant$20 years of age were examined. The mean age and SD among women was 45.2 $\pm$ 13.5 years, and among men 47.1 $\pm$ 14.4 years ($p > 0.05$). Table 2 presents the distribution by age and gender. As a whole, 15,160 teeth were examined; the mean number of teeth present was 21.3 (21.0 in women and 21.7 in men). The mean number of teeth present declined from 25.0 in the 20–29-year-old group to 16.8 in the 60+ group ($p < 0.001$)

Table 1. Operational definitions of variables

Variable	Operational definition
age	in years. Information obtained from clinical records
loss of attachment (LOA)	estimated by subtracting from the probing depth the distance from the gingival margin to the cemento-enamel junction
healthy subject	all sites with LOA $\leqslant$1 mm
site with periodontal disease	site with LOA $\geqslant$2 mm
tooth with periodontal disease	at least one site with LOA $\geqslant$2 mm
subject with mild/moderate periodontitis	person with at least one site with LOA $\geqslant$2 mm
subject with severe periodontitis	person with at least two sites with LOA $\geqslant$4 mm or at least one site with LOA $\geqslant$5 mm
extent of periodontitis	percent of examined sites with periodontal disease: extent = (Σ diseased sites $\times$ 100)/all examined sites
severity of periodontitis	mean loss of attachment of diseased sites.
prevalence of periodontitis	percent of subjects with atl least one site with periodontal disease
prevalence of severe periodontitis	percent of subjects with at least two sites with LOA $\geqslant$4 mm
extent and severity index	ESI = (E, S) where E is rounded up to the nearest integer. The ESI for a group is the mean of the individual scores from the mid-buccal and mesio-buccal aspects of all teeth (except third molars) in contralateral quadrants of the dentition. This results in a maximum of 28 measurements per subject
gold standard	LOA in 6 sites (disto-buccal, mid-buccal, mesio-buccal, mesio-lingual, mid-lingual, and disto-lingual of all teeth in mouth). These appraisals result in a maximum of 168 measurements. The gold standard of 140 sites (168 sites – 28 ESI sites) was defined to avoid the bias produced when the ESI examined sites are included in the gold standard, causing sensitivity and specificity to increase only by the fact that the same measurements are in both assessments (Fleiss et al. 1987)

Table 2. Distribution of the study population by age group and gender

Age (years)	Gender					
	female		male		total	
	n	%	*n*	%	*n*	%
20–29	55	12.3	34	12.8	89	12.5
30–39	111	24.9	51	19.2	162	22.8
40–49	127	28.5	71	26.7	198	27.8
50–59	80	17.9	63	23.7	143	20.1
⩾60	73	16.4	47	17.6	120	16.9
total	446	100	266	100	712	100

Table 3. Mean number of teeth by age group and gender

Age (years)	Gender	*n*	Mean	SD	Sum	Min	Max	Range
20–29	female	55	24.76	3.17	1362	11	28	17
	male	34	25.38	3.66	863	7	28	21
	total	89	25.00	3.36	2225	7	28	21
30–39	female	111	22.94	3.83	2546	10	28	18
	male	51	24.90	2.57	1270	18	28	10
	total	162	23.56	3.59	3816	10	28	18
40–49	female	127	21.50	4.49	2730	5	28	23
	male	71	21.04	5.29	1494	9	28	19
	total	198	21.33	4.78	4224	5	28	23
50–59	female	80	19.02	5.79	1521	6	28	22
	male	63	21.59	4.46	1360	11	28	17
	total	143	20.15	5.38	2881	6	28	22
⩾60	female	73	16.64	6.89	1214	2	28	26
	male	47	17.00	6.84	799	3	28	25
	total	120	16.78	6.84	2014	2	28	26
total	female	446	21.02	5.55	9374	2	28	26
	male	266	21.75	5.55	5786	3	28	25
	total	712	21.29	5.56	15,160	2	28	26

ANOVA, $F = 47.9$, $p < 0.001$ for age group.
ANOVA, $F = 2.9$, $p = 0.08$ for gender.

(Table 3). Furthermore, extent and severity values increased with older age, regardless of the number of sites being evaluated.

For the overall population, ESI found a mean loss of attachment of 3.7 mm, while the gold standard reported 3.8 mm ($p = 0.03$). ESI found that 64.4% of the sites were affected, compared with 68.3% for the gold standard ($p = 0.001$). Mean percent extent differences were identified between the gold standard and the 28-site assessment for the 30–39-year-old group ($t = -2.6$, $p = 0.009$) and in the 40–49-year-old group ($t = -2.5$, $p = 0.012$). Differences were also identified in the mean severity reading obtained from the 28-site assessment and the gold standard for the 50–59-year-old group ($t = -2.9$, $p = <.001$). In participants older than 60 years of age, the ESI and the gold standard did not differ significantly (Table 4). Periodontitis was more severe in men (4.0 mm) than in women (3.7 mm) ($p = 0.001$) using the gold standard; ESI measurements also concluded that differences were significant. Using the gold standard, the extent of periodontitis was found to be higher in men (70.5%) than in women (66.7%) ($p = 0.04$); ESI measurements were not significantly different (Table 5).

Table 6 includes reliability values contrasting the number of participants deemed to have no severe periodontitis and severe periodontitis according to ESI (28 sites), and according to the gold standard (140 sites). The ESI classified 27 persons with non-severe periodontitis as non-severe. And 568 participants were considered to have severe periodontitis by both ESI and the gold standard. The agreement between diagnoses was 0.836, but when agreement by chance was controlled through κ, this coefficient was reduced to only 0.265.

In terms of ESI validity, it was found that sensitivity was 83.3%. Out of 682 persons with severe periodontitis, ESI would identify 568, missing 16.7%. Specificity values indicated that ESI would correctly identify 27 (90%) of 30 persons without severe periodontitis. The positive predictive value was 99.4%, as only three persons identified through ESI as affected by severe periodontitis ($n = 571$) would not have that level of disease. The negative predictive value was only 19.1%, however, as 114 (80.9%) persons would be incorrectly considered not to have severe periodontitis (Table 6).

ESI measurements have significant correspondence with actual increments in severity ($r = 0.82$, $p = 0.01$) and extent ($r = 0.88$, $p = 0.01$) values (Figs 1 and 2).

In Fig. 3, we present variations in apparent prevalence and predictive values derived from ESI measurements when true prevalence is modified. When the latter is 100%, apparent prevalence is only 83%; the positive predictive value tends to increase, and the negative predictive value tends to decrease. Generally speaking, ESI underestimates true prevalence.

At the individual site level, we found that the locations with higher mean loss of attachment were the disto-buccal and disto-lingual sites of the upper first molars and the mesio-buccal and mesio-lingual sites of the lower central incisors. Table 7 shows the proportion of times individual sites had attachment loss ⩾2 mm; highest values were found in the disto-buccal and disto-lingual sites of the upper first molars. The least-affected sites were the mid-buccal sites from the upper central incisor to the upper first premolar.

Discussion

The present study is not the first evaluation to compare the validity or reliability of partial measurements compared with full-mouth assessments. This investigation, however, incorporated a carefully designed gold standard with six periodontal sites measured per tooth in a very large number of participants with established, advanced periodontal problems, objectively screened and categorized. Furthermore, estimates for true prevalence of severe periodontitis have not been included in the previous reports.

In the present study, we determined how close the estimates of apparent and true prevalence were when ESI was

Table 4. Extent and severity of periodontitis by age group according to the different evaluations

Age (years)	*n*	Severity (mean ± SD, mm)			Extent % (mean ± SD)		
		168 sites*	140 sites**	28 sites***	168 sites†	140 sites††	28 sites†††
20–29	89	3.0 ± 0.6	3.1 ± 0.6	3.0 ± 0.7	51.8 ± 25.6	52.4 ± 68.9	48.9 ± 26.5
30–39	162	3.6 ± 1.0	3.6 ± 1.0	3.6 ± 1.1	64.9 ± 23.6	65.9 ± 25.8	59.6 ± 25.5
40–49	198	3.8 ± 1.1	3.8 ± 1.2	3.7 ± 1.2	68.8 ± 23.2	69.8 ± 23.8	64.1 ± 25.9
50–59	143	4.0 ± 1.2	4.1 ± 1.3	3.7 ± 1.2	72.1 ± 21.9	72.6 ± 23.0	69.4 ± 22.9
⩾60	120	4.3 ± 1.6	4.3 ± 1.6	4.2 ± 1.8	78.9 ± 20.6	79.4 ± 20.8	76.6 ± 23.7
total	712	3.8 ± 1.2	3.8 ± 1.2	3.7 ± 1.3‡	68.3 ± 24.1	68.9 ± 18.3	64.4 ± 26.2‡‡

Differences among age groups.
*$F = 15.1$, $p < 0.001$.
**$F = 15.0$, $p < 0.001$.
***$F = 11.1$, $p < 0.001$.
†$F = 16.9$, $p < 0.001$.
††$F = 16.6$, $p < 0.001$.
†††$F = 15.4$, $p < 0.001$.
Differences between ESI and the gold standard.
‡$t = -2.18$, $p = <.001$.
‡‡$t = -3.85$, $p = .029$.

Table 5. Extent and severity of periodontitis by gender according to the different evaluations

Gender	*N*	Severity (mean ± SD, mm)			Extent % (mean ± SD)		
		168 sites	140 sites	28 sites	168 sites	140 sites	28 sites
female	446	3.7 ± 1.2	3.7 ± 1.2	3.6 ± 1.2	66.7 ± 23.9	67.4 ± 19.4	63.4 ± 26.1
male	266	4.0 ± 1.2	4.0 ± 1.3	3.8 ± 1.3	70.5 ± 24.3	71.4 ± 16.8	66.0 ± 26.3
total	712	3.8 ± 1.2	3.8 ± 1.2	3.7 ± 1.3	68.2 ± 24.1	68.9 ± 18.3	64.4 ± 26.2

Comparison by gender.
Severity: 168 sites, $t = 13.1$, $p = <0.001$.
Severity: 28 sites, $t = 5.7$, $p = 0.017$.
Severity: 140 sites, $t = 13.9$, $p < 0.001$.
Extent: 168 sites, $t = 4.2$, $p = 0.041$.
Extent: 28 sites, $t = 1.7$, $p = 0.188$.
Extent: 140 sites, $t = 4.5$, $p = 0.034$.

Table 6. Reliability and validity of the extent and severity index; distribution of periodontitis by severity, 28 versus 140 sites (gold standard)

28 sites, severe PD	140 sites, severe PD		
	yes	no	total
yes	568	3	571
no	114	27	141
total	682	30	712

		Confidence interval 95%
κ	0.265	0.212–0.317
sensitivity	83.3%	80.4–86.1
specificity	90.0%	79.3–100
positive PV	99.4%	98.9–100
negative PV	19.1%	12.7–25.6
true prevalence	95.8%	94.3–97.3
apparent prevalence	80.2%	77.3–83.1

PD, periodontitis; PV, predictive value.

administered to identify severe periodontitis. While severity and extent values tended to increase with older age, the magnitude of the disease differed when estimated with ESI or with the gold standard. Generally speaking, these characteristics in an index are of importance to determine the weight that can be ascribed to the measurements undertaken. An instrument with poor reliability can be expected to misclassify subjects, leading to erroneous conclusions about the epidemiological profile. High reliability means less chance of realizing certain types of biases that undermine information quality.

The contrasting results that have been reported in studies aiming to identify the presence and prevalence of severe periodontitis stem, to a considerable extent, from the indices and the operational definitions of disease used (Moore et al. 1982, Burmeister et al. 1984, Brown et al. 1996). Such definitions have included, for example, four or more sites with a periodontal pocket ⩾5 mm (Robertson et al. 1987); eight or more teeth with loss of attachment ⩾5 mm (Moore et al. 1982, Burmeister et al. 1984); ''at least eight or more teeth with at least 5 mm of attachment loss, where at least three of them are not first molars or incisors'' (Vrahopoulos 1995); and 4 or more sites with attachment loss ⩾5 mm, at least one of them with a periodontal pocket greater than 4 mm (Beck et al. 1990). This glimpse at the diversity of definitions and thresholds suggests that a direct comparison across studies is fraught with difficulties. We need to better understand the criteria to diagnose periodontitis objectively for population-based research.

Studies that purport to assess the validity of partial measurements to determine the presence of periodontitis suggest some general trends based on similarities in the findings. Using ESI, Brown et al. (1996) found higher severity and extent of periodontitis associated with older age. Just as we established through the present study, they also found that men had worse periodontitis than women and suggested that the partial evaluation underestimated the prevalence of periodontitis. Using only four sites per tooth, Kingman et al. (1988) concluded that partial measurements systematically underestimate disease prevalence. Our findings in a study population with substantial periodontal involvement (as in the design by Kingman & Albandar (1997)) support this conclusion. Again using only four sites per tooth, Diamanti-Kipioti et al. (1993) compared periodontal conditions by means of various indices (including ESI). They concluded that partial measures offered acceptable estimates of the individual means of

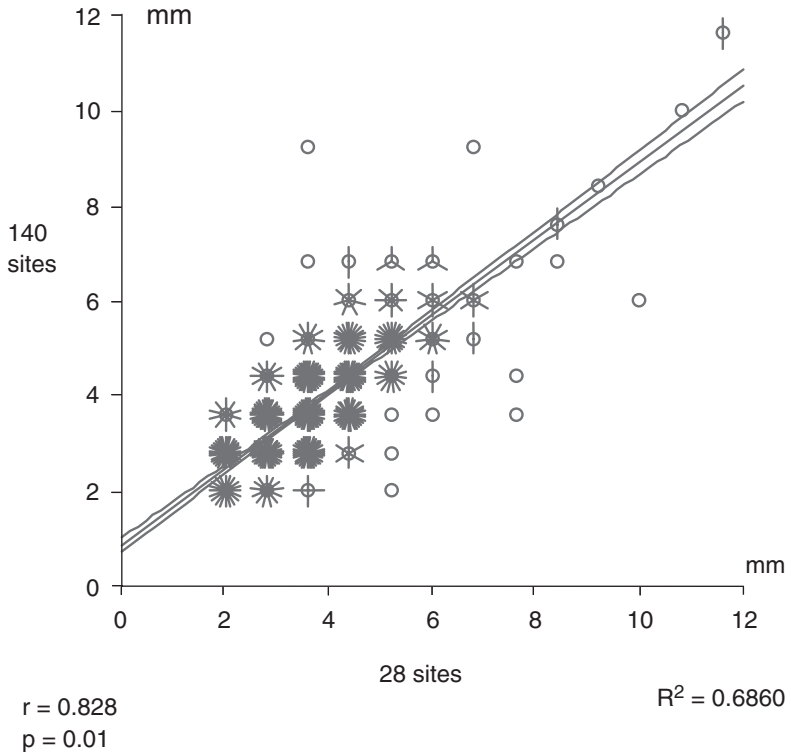

Fig. 1. Correlation between the evaluation of severity using 140 sites and the evaluation of 28 sites.

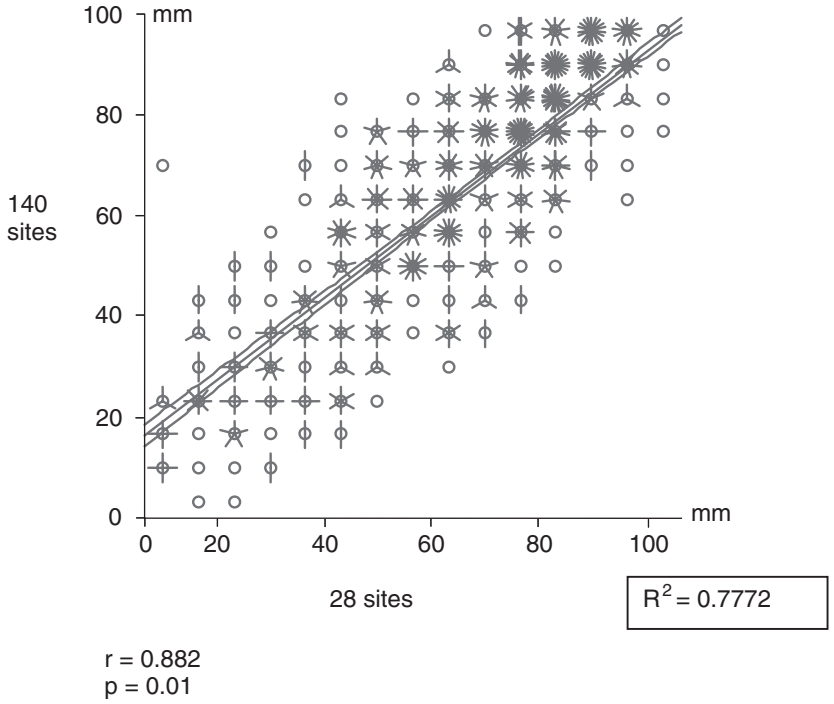

Fig. 2. Correlation between the evaluation of extent using 140 sites and the evaluation of 28 sites.

sites affected by periodontitis but underestimated the prevalence of severe disease. Our results substantiate these conclusions. Hunt & Fann (1991) compared the partial measure of loss of attachment through ESI with the full-mouth measure of only two sites (mesial and buccal). Their conclusion supported the notion that ESI underestimates the prevalence of periodontitis. Hunt & Fann (1991) consistently found that in a scenario with increasing severity and lower prevalence, the proportional underestimation by ESI becomes larger. The distortions ascribable to partial measurement vary according to the prevalence of the disease, the approach to evaluate attachment loss (in particular the positioning of the probe), the array of dental care services available, and the distribution of disease by age.

Some studies have looked at the comparison between partial- and full-mouth measures using indices other than ESI. They seem to coincide, however, with the prevalence underestimation inherent to partial-mouth measures (Benigeri et al. 2000, Eaton et al. 2001). Contrary to our findings, Eaton et al. (2001) reported that ESI overestimates the extent of the disease; operational definitions of disease and indices employed may account for discrepancies. At the end of the day, the lack of agreement in the scientific literature with regard to the representativeness of various partial measure approaches may be caused by the dissimilar prevalence of severe periodontitis in the populations investigated. The present investigation summarized some of the scenarios found and their features when the prevalence of periodontitis varied from 0% to 100%.

Our findings with regard to the involvement of individual sites and teeth support past reports for the most part. From NHANES III data, it was found that 27% of mesio-buccal and 20% of mid-buccal sites had loss of attachment $\geqslant 2$ mm (Brown et al. 1996, Albandar et al. 1999). When contrasted with the 28 sites surveyed by ESI, they found essentially the same results that we obtained with a more comprehensive appraisal of periodontal sites; the main difference was the considerably higher proportion of affected sites in our study (between 60% and 80%). Diamanti-Kipioti et al. (1993) reported that the mesio-lingual sites were more severely affected, but we found that distal sites were more seriously affected, just as Eickholz & Kim (1998) did. Eickholz & Kim (1998) had suggested that these sites were very influential in the variations found in loss of attachment. Since these specific sites are not part of the ESI measures, the greater weight ascribed to the variation in precisely those sites may be an important reason for the

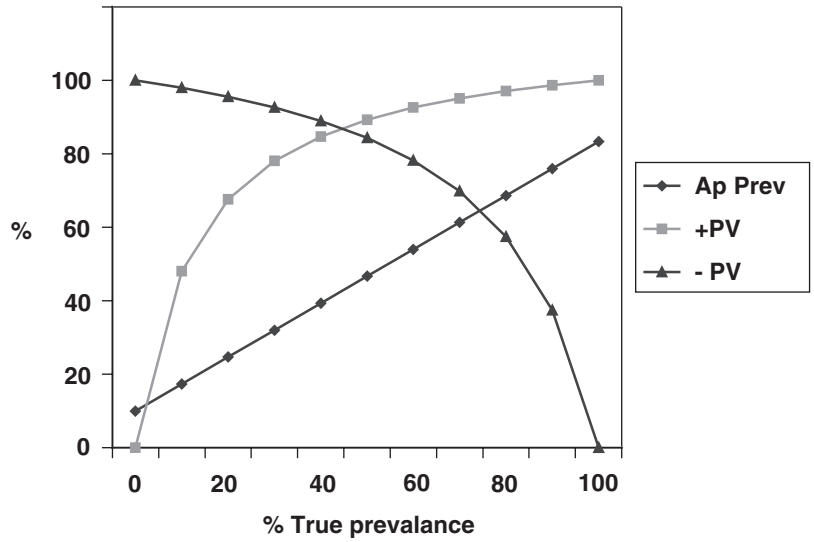

Fig. 3. Effect of the true prevalence over the apparent prevalence and predictive values (28 versus 140 sites).

Table 7. Percent of sites most and least affected by periodontal disease

Most affected sites				Least affected sites			
place	tooth	site	% affected	place	tooth	site	% affected
1	26	disto-buccal	83.5	**153**	37	mid-buccal	51.3
2	16	disto-buccal	81.6	**154**	22	mid-lingual	51.3
3	16	disto-lingual	80.7	**155**	24	mid-lingual	51.2
4	16	mesio-lingual	80.1	**156**	25	mid-bucal	50.7
5	26	disto-lingual	79.8	**157**	13	mid-lingual	50.5
6	17	mesio-lingual	77.9	**158**	23	mid-lingual	50.2
7	16	mesio-buccal	77.8	**159**	33	mid-buccal	49.4
8	26	mesio-lingual	77.4	**160**	24	mid-buccal	48.9
9	46	disto-buccal	77.2	**161**	14	mid-lingual	46.7
10	26	mesio-buccal	77.1	**162**	15	mid-buccal	46.5
11	27	disto-buccal	76.8	**163**	23	mid-buccal	46.3
12	42	disto-buccal	76.2	**164**	13	mid-buccal	45.7
13	17	disto-lingual	76.1	**165**	22	mid-buccal	43.9
14	47	mesio-lingual	75.9	**166**	12	mid-buccal	43.3
15	27	mesio-buccal	75.9	**167**	11	mid-buccal	43.0
16	36	disto-buccal	75.0	**168**	21	mid-buccal	41.7

underestimation of extent and severity that appears to consistently affect ESI. Grbic & Lamster (1992) had already reported that teeth more often affected were upper molars and lower incisors, and less often affected were upper incisors. A minor addition to the latter category through our findings was the upper premolars.

In summary, our investigation on a very large number of patients with severe periodontitis found that ESI underestimated the extent, severity, and prevalence of periodontitis when compared with a full-mouth assessment. Such underestimates were accurately quantified, in contrast to previous reports. ESI nevertheless identified differences by gender and age. ESI has poor reliability and thus opens the door to substantial misclassification of patients. The success of partial-mouth measurements depends on the true prevalence of periodontitis among the study population and on the age distribution. The number of sites affected in each person may be underestimated with partial measures, as well as the proportion of persons with severe periodontitis.

References

Ainamo, J. & Ainamo, A. (1985) Partial indices as indicators of the severity and prevalence of periodontal disease. *International Dental Journal* **35,** 322–326.

Albandar, J. M., Brunelle, J. A. & Kingman, A. (1999) Destructive periodontal disease in adults 30 years of age and older in the United States, 1988–1994. *Journal of Periodontology* **70,** 13–29.

Alexander, A. (1970) Partial mouth recording of gingivitis, plaque and calculus in epidemiological surveys. *Journal of Periodontal Research* **5,** 141–147.

Barmes, G., Parker, W., Lyon, T. & Fultz, P. (1986) Indices used to evaluate signs, symptoms and etiologic factors associated with diseases of the periodontium. *Journal of Periodontology* **56,** 643–651.

Beck, J. D., Koch, G. G., Rozier, R. G. & Tudor, G. E. (1990) Prevalence and risk indicators for periodontal attachment loss in a population of older community-dwelling blacks and whites. *Journal of Periodontology* **61**, 521–528.

Benigeri, M., Brodeur, J. M., Payette, M., Charbonneau, A. & Ismail, A. I. (2000) Community periodontal index of treatment needs and prevalence of periodontal conditions. *Journal of Clinical Periodontology* **27,** 308–312.

Brown, L., Brunelle, J. A. & Kingman, A. (1996) Periodontal status in the United States, 1988–91: prevalence, extent, and demographic variation. *Journal of Dental Research* **75,** 672–683.

Brown, L., Oliver, R. & Loe, H. (1990) Evaluating periodontal status of US employed adults. *Journal of the American Dental Association* **121,** 226–232.

Burmeister, J. A., Best, A. M., Palcanis, K. G., Caine, F. A. & Ranney, R. R. (1984) Localized juvenile periodontitis: clinical findings. *Journal of Clinical Periodontology* **11,** 181–192.

Carlos, J. P., Wolfe, M. & Kingman, A. (1986) The extent and severity index: a simple method for use in epidemiologic studies of periodontal disease. *Journal of Clinical Periodontology* **13,** 500–505.

Diamanti-Kipioti, A., Papapanou, P., Moraitaki Tsami, A., Lindhe, J. & Mitsis, F. (1993) Comparative estimation of periodontal conditions by means of different index systems. *Journal of Clinical Periodontology* **20,** 656–661.

Downer, M. (1972) The relative efficiencies of some periodontal partial recording selections. *Journal of Periodontal Research* **7,** 334–340.

Eaton, K. A., Duffy, S., Griffiths, G. S., Gilthorpe, M. S. & Johnson, N. W. (2001) The influence of partial and full-mouth recordings on estimates of prevalence and extent of lifetime cumulative attachment loss: a study in a population of young male military recruits. *Journal of Periodontology* **72,** 140–145.

Eickholz, P. & Kim, T. S. (1998) Reproducibility and validity of the assessment of clinical furcation parameters as related to different probes. *Journal of Periodontology* **69,** 328–336.

Fleiss, J., Park, M., Chilton, N., Alman, J., Feldman, S. & Chauncey, H. (1987) Representativeness of the ''Ramfjord teeth'' for epidemiologic studies of gingivitis and periodontitis. *Community Dentistry and Oral Epidemiology* **15,** 221–224.

Grbic, J. T. & Lamster, I. B. (1992) Risk indicators for future clinical attachment loss in adult periodontitis. Tooth and site variables. *Journal of Periodontology* **63,** 262–269.

Greene, J. (1974) The oral hygiene index – development and uses. *Journal of Periodontology* **45,** 625–635.

Haffajee, A., Socransky, S., Goodson, J. & Lindhe, J. (1985) Intraclass correlation of periodontal measurements. *Journal of Clinical Periodontology* **12,** 216–224.

Hirschfeld, L. & Wasserman, B. (1978) A long-term survey of tooth loss in 600 treated periodontal patients. *Journal of Periodontology* **49,** 225–237.

Hujoel, P. & Loesche, W. (1990) Efficiency of split-mouth designs. *Journal of Clinical Periodontology* **17,** 722–728.

Hunt, R. (1987) The efficiency of half-mouth examinations in estimating the prevalence of periodontal disease. *Journal of Dental Research* **66,** 1044–1048.

Hunt, R. & Fann, S. (1991) Effect of examining half the teeth in a partial periodontal recording of older adults. *Journal of Dental Research* **70,** 1380–1385.

Kingman, A. & Albandar, J. M. (1997) Validity of partial recording of attachment loss in early onset periodontitis. *Journal of Dental Research* **76,** (Spec. Issue): 229 (abstract 1722).

Kingman, A., Morrison, E., Loe, E. & Smith, J. (1988) Systematic errors in estimating prevalence and severity of periodontal disease. *Journal of Periodontology* **59,** 707–713.

Listgarten, M. A., Slots, J., Rosenberg, J., Nitkin, L., Sullivan, P. & Oler, J. (1989) Clinical and microbiological characteristics of treated periodontitis patients on maintenance care. *Journal of Periodontology* **60,** 452–459.

Löe, H. (1974) The gingival index, the plaque index and the retention index systems. *Journal of Periodontology* **45,** 610–616.

Löe, H., Anerud, A., Boysen, H. & Smith, M. (1978a) The natural history of periodontal disease in man. Study design and baseline data. *Journal of Periodontal Research* **13,** 550–562.

Löe, H., Anerud, A., Boysen, H. & Smith, M. (1978b) The natural history of periodontal disease in man. The role of periodontal destruction before 40 years of age. *Journal of Periodontology* **49,** 607–620.

Massler, M. (1974) The P-M-A index for the assessment of gingivitis. *Journal of Periodontology* **45,** 592–601.

Miller, A., Brunelle, J., Carlos, J., Brown, L. & Loe, H. (1987) *Oral health of United States adults. The National Survey of Oral Health in U.S. employed adults and seniors: 1985–1986, National findings*. Epidemiology and Oral Disease Prevention Program. National Institute of Dental Research, U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, NIH Publication No. 87-2868. pp. 9–11, 164–165.

Mills, W., Thompson, G. & Beagrie, G. (1975) Partial mouth recording of plaque and periodontal pockets. *Journal of Periodontal Research* **10,** 36–43.

Moore, W. E. C., Holdeman, L. V., Smibert, R. M., Hash, D. E., Burmeister, J. A. & Ranney, R. R. (1982) Bacteriology of severe periodontitis in young adult humans. *Infection and Immunity* 1137–1148.

O'Leary, T. (1974) The periodontal screening examination. *Journal of Periodontology* **45,** 617–624.

Papapanou, P., Wennstrom, J. & Johnsson, T. (1993) Extent and severity of periodontal destruction based on partial clinical assessments. *Community Dentistry and Oral Epidemiology* **21,** 181–184.

Ramfjord, S. (1956) Indices for prevalence and incidence of periodontal disease. *Journal of Periodontology* **30,** 51–59.

Robertson, P. B., Buchanan, S. A., Armitage, G. C., Newbrun, E., Taggart, E. J. & Hoover, C. I. (1987) Evaluation of clinical and microbiological measures to predict treatment response in severe periodontitis. *Journal of Periodontal Research* **22,** 230–232.

Russell, A. (1974) The periodontal index. *Journal of Periodontology* **45,** 585–591.

Vrahopoulos, T. (1995) The apical border plaque in severe periodontitis. An ultrastructural study. *Journal of Periodontology* **66,** 113–124.

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