COMMUNITY
DENTISTRY AND
ORAL EPIDEMIOLOGY
ISSN 0301-5661

Using partial recording to assess tooth wear in older adults

**James G. Steele and
Angus W. G. Walls**
Department of Restorative Dentistry, Dental
School, Newcastle upon Tyne, UK

Steele JG, Walls AWG: Using partial recording to assess tooth wear in older adults. Community Dent Oral Epidemiol 2000; 28: 18–25. © Munksgaard, 2000

Abstract – *Objectives:* To establish whether partial recording can be used for the measurement and reporting of tooth wear data in samples of adult populations, whilst maintaining the usefulness of the index. *Methods:* Using whole mouth coronal tooth wear data from a large random population sample of 1200 dentate older adults in England, several different partial recording systems were investigated to establish which teeth would maintain a high level of sensitivity for the most economic use of codes and index teeth. Tooth wear data were recorded on a surface-by-surface basis on all teeth in the sample using the tooth wear index. *Results:* Five different partial mouth recording systems were assessed, including half-mouth scoring, assessment of just upper or just lower anterior teeth, assessment of all anterior teeth and use of six index teeth. The 12 anterior teeth were the ones most often affected by moderate or severe wear, and when all 12 teeth were used as the index teeth few wear cases were missed, and all the most extensive and severe cases of coronal wear were classified as having some wear. A limited index of only six anterior teeth (three uppers and three lowers) was almost as sensitive, but allowed less flexibility when reporting the extent of coronal wear. Other systems for partial recording were less sensitive. *Conclusions:* Partial recording using six or 12 anterior teeth is appropriate for measuring and reporting tooth wear data in large population surveys.

Wear of the natural teeth is increasingly being recognised as an important dental condition at all ages. A number of indices of tooth wear have been developed (1–11) but few have yet been used extensively for research purposes. Large population studies, which are conducted to monitor oral health and inform the allocation of resources to oral health care, often record data on a number of different conditions. This is particularly true for older adults, amongst whom the condition of the crowns of the teeth, the presence of root caries, periodontal disease, tooth wear and soft tissue lesions, as well as the design and condition of any dentures, may all be important issues. In practical terms it is difficult to train examiners to measure any one of these conditions to a high level of calibration let alone all of them, while the full assessment of all of them would make for a time-consuming examination. As a general rule if an index can be simplified while still maintaining its sensi-

tivity and specificity, time and resources will be saved. Furthermore, examiner training will be made easier and calibration may be improved. One way of doing this is to use a partial mouth recording. This approach has been used widely in dental surveys, most notably to assess periodontal disease where different studies have used different combinations of index teeth and in some cases half-mouth recording (12–18).

Of the indices available for the measurement of tooth wear, that developed by Smith & Knight is one of the most comprehensive and widely used (8, 19, 20), although it has its shortcomings (21). The aim of this paper is to evaluate a number of possible partial mouth approaches, using the scoring system from this index. As well as establishing the sensitivity of these partial mouth approaches, we also investigate how these data may be handled to maximise their flexibility and specificity. Other indices in addition to the one used here may be

equally valid and a high degree of calibration between different indices is to be expected. The findings reported here should be transferable to most of the indices of coronal tooth wear. The ultimate purpose of this is to inform the process of data collection, so that researchers can choose the approach to data collection which best suits their needs.

Material and methods

Data from random samples of 2028 older adults aged 60 years or over from three different communities in England were subjected to analysis. Of these, 1211 were dentate, and a full assessment of their oral condition was made, including tooth wear measurement of all teeth. The assessment was undertaken by one of four trained and calibrated examiners using good lighting in the subject's own residence. Full details of both the sampling and the examination procedure have already been published (22, 23).

The wear data were collected according to the index described by Smith & Knight (8) on a surface-by-surface basis on each tooth. Buccal, lingual, occlusal/incisal and cervical surfaces were examined on each tooth and a score given for each. The measurement criteria for, and the public health and treatment implications of, cervical wear differ from coronal wear so analysis is restricted to the measurement of coronal wear. At the computation stage a single score was generated for each tooth, by taking the highest surface score.

This index uses a score from 0 to 4 and the diagnostic criteria we used for each of these scores are given in Table 1. During data collection, we combined codes 0 and 1 which represent very minor wear. Distinguishing between them is difficult (21) and while the difference between such low scores

may be of value amongst children and young adults, it is of little relevance in an older population. In the subsequent analysis the range of codes was further amalgamated, so that on each tooth there were only three measures of severity to consider: everything up to but not including grade 3 is considered minimal wear, grade 3 is reported as moderate wear and grade 4 as severe wear (see Table 1). Individual teeth with grade 3 wear are fairly common amongst older adults. Grade 4 is sufficiently severe to have exposed secondary dentine (in younger subjects it may expose the vital dental pulp). Although these will be related to potential treatment need, the groupings do not have any direct bearing on the threshold at which treatment will be required.

The way in which data ultimately will be presented is an important determinant of how they are handled. Tooth wear can be locally severe but not widespread (affecting only a few teeth), widespread but only moderate, or both widespread and severe. In order to determine the sensitivity and specificity of the different simulated partial mouth recording systems to be tested, subjects were placed into one or more of six different wear categories based on the full mouth examination. The categories are necessarily arbitrary and have no direct implications as to treatment need, but are used to describe different patterns of extent and severity covering a broad range of possibilities. The six categories were:

Category A – Any moderate or severe wear. This group of subjects included anybody who had any teeth with moderate (grade 3) or severe (grade 4) wear. Category A is in effect a "catch all" category into which a large proportion of the sample will fall. It will include cases with wear at an earlier stage and affecting fewer teeth than the other categories, but it is rather non-specific and in popula-

Table 1. Diagnostic criteria for different grades of tooth wear on coronal surfaces

| Grade	Surface	Criteria
0/1	All	No dentine exposed
2	Buccal/lingual/occlusal	Loss of enamel exposing dentine for less than one-third of surface
	Incisal	Loss of enamel just exposing dentine
3	Buccal/lingual/occlusal	Loss of enamel exposing dentine for more than one-third of surface, but without pulp exposure or exposure of secondary dentine
	Incisal	Loss of enamel and extensive loss of dentine, but without pulp exposure or exposure of secondary dentine
4	Buccal/lingual/occlusal	Complete loss of enamel on a surface or exposure of secondary dentine or pulp
	Incisal	Exposure of secondary dentine or pulp
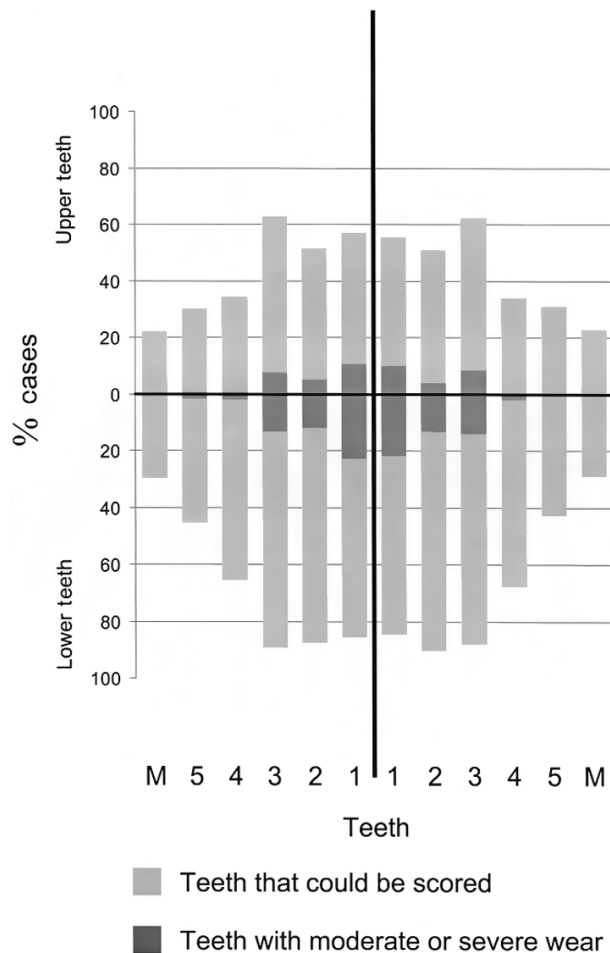
Fig. 1. Percentage of cases where individual tooth types could be scored for wear (lightly shaded) and the percentage of cases where the individual tooth types were affected by wear of one or more of the coronal surfaces to grade 3 or 4 (dark shaded). "M" indicates molar teeth. In these cases the most severely affected tooth was the one scored.

tions where wear is more widespread it will include a huge diversity of cases.

Category B – Multiple moderately or severely worn teeth. This group comprised people who had several teeth (four or more) showing moderate or severe wear.

Category C – Widespread moderately or severely worn teeth. Individuals with a minimum of seven teeth or more affected to grade 3 or 4 constituted the cases in this category.

Category D – Any severely worn teeth. Individuals with any teeth affected to grade 4 constituted the cases in this group.

Category E – Multiple severely worn teeth. This category comprised individuals with four or more severely worn teeth.

Category F – Widespread severe wear comprising

individuals with seven or more teeth affected to grade 4. Although few in number these individuals constitute the most severely affected cases where both the extent and the severity of the wear was high.

By selecting data from various groups of index teeth, we simulated different part-mouth recordings. We then evaluated their suitability for large-scale epidemiological use. Five different combinations of teeth were selected and then tested after analysis of how frequently moderate and severe wear scores occurred on individual teeth and how frequently the teeth were in a condition which could be scored. The five part-mouth recordings were also designed with the ease of the examination and examiner training in mind. The five part-mouth recordings were:

- A half-mouth recording (right or left)
- Six or eight lower anterior teeth (with and without first premolars)
- Six or eight upper anterior teeth (with and without first premolars)
- Twelve anterior teeth (six upper, six lower)
- Six anterior teeth (three upper on one side and three lower on the other side).

Evaluating the epidemiological usefulness of the five different part-mouth selections involved estimating their sensitivity, that is, their ability to detect participants with some wear, but also testing that that they were specific enough to distinguish the different categories of wear in the reduced data set. This was done by cross-tabulating the data sets from the full mouth recording with those from the five limited recording systems for each of the six categories described above.

Results

Figure 1 shows the frequency with which different teeth were present and in a condition that could be scored, and the frequency with which wear scores of 3 or 4 appeared on different teeth. Extensively restored or crowned teeth cannot be given a code to reflect the wear of tooth tissue; the total height of each bar represents the percentage of all dentate individuals to whom a wear code could be given for that tooth type. The "moderate or severe wear" bar is the percentage of all dentate subjects who recorded that level of wear for the tooth type in question. Molars were frequently missing, unscorable or difficult to identify, so the data for the most severely affected molar are reported.

In Tables 2 to 4 the sensitivity of the index is re-

ported. For the part-mouth recordings reported here, sensitivity is defined as the percentage of all cases in each of the six wear categories which would have been detected as having some wear of grade 3 or grade 4. At this stage it does not give any indication of whether particularly severe or widespread wear would have been distinguishable in such cases, but simply whether any categories would have been completely missed.

The pattern of affected teeth is fairly symmetrical about the midline (see Fig. 1). Understandably the rate of detection was reduced where data from only one side of the mouth were considered. Eighty percent of all cases with any wear of grade 3 or 4 were detected and a few cases of more widespread moderate or severe wear were not detected as having any wear. Up to 8% of the cases where between one and three teeth had grade 4 wear were missed.

Lower anterior teeth (canines and incisors) were most commonly affected by wear of grade 3 or 4 (see Fig. 1). When data from only the lower anterior teeth were analysed (Table 3), the majority of these cases were still detected as showing some wear, but one of the cases with widespread moderate wear (category C) and one of the cases with more than three severely affected teeth (category E)

Table 2. Number of missed cases and sensitivity when using half-mouth recordings (left or right teeth)

Wear extent and severity category	Cases	Left side teeth examined and scored at grade 3 or worse		Right side teeth examined and scored at grade 3 or worse	
		Missed cases	Sensitivity	Missed cases	Sensitivity
Category A (any teeth: grade 3+)	533	97	81.1%	85	84.1%
Category B (over 3 teeth: grade 3+)	198	2	99.0%	1	99.5%
Category C (over 6 teeth: grade 3+)	60	0	100.0%	0	100%
Category D (any teeth: grade 4)	157	13	91.7%	7	95.5%
Category E (over 3 teeth: grade 4)	47	0	100%	0	100%
Category F (over 6 teeth: grade 4)	15	0	100%	0	100%

Table 3. Number of missed cases and sensitivity when using lower anterior teeth or upper anterior teeth as index teeth

Wear extent and severity category	Cases	Lower incisors and canines examined and scored at grade 3 or worse		Upper incisors and canines examined and scored at grade 3 or worse	
		Missed cases	Sensitivity	Missed cases	Sensitivity
Category A (any teeth: grade 3+)	533	82	84.6%	278	47.8%
Category B (over 3 teeth: grade 3+)	198	5	97.5%	62	68.7%
Category C (over 6 teeth: grade 3+)	60	1	98.3%	6	90.0%
Category D (any teeth: grade 4)	157	11	93.0%	59	62.4%
Category E (over 3 teeth: grade 4)	47	1	97.9%	14	70.2%
Category F (over 6 teeth: grade 4)	15	0	100%	4	73.3%

Table 4. Number of missed cases and sensitivity when using all 12 anterior teeth as index teeth (uppers and lowers) and using six anterior index teeth (upper right and lower left)

Wear extent and severity category	Cases	All incisors and canines examined and scored at grade 3 or worse		Six index incisors and canines examined and scored at grade 3 or worse	
		Missed cases	Sensitivity	Missed cases	Sensitivity
Category A (any teeth: grade 3+)	533	19	96.4%	108	79.7%
Category B (over 3 teeth: grade 3+)	198	0	100%	1	99.5%
Category C (over 6 teeth: grade 3+)	60	0	100%	0	100%
Category D (any teeth: grade 4)	157	4	97.5%	11	93.0%
Category E (over 3 teeth: grade 4)	47	0	100%	0	100%
Category F (over 6 teeth: grade 4)	15	0	100%	0	100%

Table 5. The sensitivity and specificity of a partial recording index using all 12 anterior teeth as index teeth compared to a full mouth recording. The sensitivity and specificity are given where equivalent categories of extent of wear are set at different levels

Category	Equivalent extent using 12 index teeth	Sensitivity	Specificity
C (>6 teeth, grade 3+)	>4 teeth	100%	94%
	>5 teeth	98%	97%
E (>3 teeth, grade 4)	>2 teeth	100%	98%
	>3 teeth	98%	100%
F (>6 teeth, grade 4)	>5 teeth	100%	99%
	>6 teeth	60%	100%

Table 6. The sensitivity and specificity of a partial recording index using only six anterior teeth (three upper and three lower) as index teeth compared to a full mouth recording. The sensitivity and specificity are given where equivalent categories of extent of wear are set at different levels

Category	Equivalent extent using six index teeth	Sensitivity	Specificity
C (>6 teeth, grade 3+)	>1 tooth	100%	84%
	>2 teeth	97%	94%
E (>3 teeth, grade 4)	>0 teeth	100%	92%
	>1 tooth	94%	98%
F (>6 teeth, grade 4)	>1 tooth	100%	96%
	>2 teeth	93%	99%

were not picked up as having any wear of grade 3 or worse. When the index teeth were extended to include the first premolars the increase in sensitivity was marginal and only of any benefit where the extent of tooth involvement was very limited.

Upper anterior teeth also showed frequent severe wear, particularly the upper central incisors, despite these teeth being missing or unscorable in over 40% of cases (see Fig. 1). The sensitivity using this group of teeth was much poorer than for the lower anterior teeth alone (Table 3). Only 90% of cases of widespread moderate wear (category C) would have been recorded as having any moderate or severe wear at all. Four of the 15 most severely affected individuals (category F) would have been completely overlooked.

Table 4 considers a part-mouth system which recorded data from all 12 canines and incisors in both jaws (or as many as were present). Where there were any more than three teeth with moderate or severe wear (categories B, C, E and F) the sensitivity of this partial recording system would have picked up all of these cases at least as having some moderate or severe wear. Even if the system were simplified further to record only teeth with severe wear by using only two codes (severe wear or not), these index teeth would have allowed all of the cases where there were several severely affected teeth and widespread severely affected teeth (categories E and F) to be detected as having some severe wear.

One even more economical system was investigated, using half of the upper anterior teeth and half of the lowers, six teeth in total. The upper right and lower left anterior teeth are reported in Table 4, but the findings for the upper left and lower right were very similar. Even for category A, the sensitivity was equivalent to a half-mouth recording at this level. When only two codes were used and teeth were scored simply as severely affected (grade 4) or unaffected (grades 0–3), all cases with more than three teeth with severe wear (categories E and F) were identified as having some moderate or severe wear, but 28% of widespread moderate wear cases would have been lost had only severe wear been recorded.

It is of some importance that, by measuring only index teeth, it is still possible to distinguish the cases where wear is widespread from those where it only affects one or two teeth. Tables 5 and 6 show

the sensitivities and specificities of the two part-mouth recordings which are potentially most useful (those reported in table 4) in cases where there is particularly severe or extensive wear (categories C, E and F). It is impossible to match the three categories precisely once the index teeth are used, so two sets of data are given for each; the first uses the maximum number of affected teeth which will yield 100% sensitivity and then shows the specificity of the simulated part-mouth recording. The second simulates a situation where the number of affected teeth to be used as a cut-off point for reporting is increased by one in order to improve specificity (and allow more flexibility), while observing the effect on sensitivity. As an example (see Table 5), if the twelve anterior teeth are scored, reporting the proportion of the sample with more than four teeth affected to grade 3 or 4 will detect all cases that would fall into category C if a full mouth record were made (sensitivity 100%), but a few with less widespread wear would also be included (specificity of 94%). If the proportion with more than five teeth (rather than *more than four teeth*) were reported, a few category C subjects would be missed, but the specificity would improve a little. With 100% sensitivity, the specificities are still high, but a very small sacrifice in terms of sensitivity will usually yield a slightly higher specificity.

Discussion

The tooth wear index (TWI) is a useful tool although it has its shortcomings (21). Where the objective is clinical monitoring or to obtain highly detailed data on subtle differences in the pattern of tooth wear (particularly where the sample is drawn from groups of people with a tooth wear problem) it may be appropriate to collect complete data from all surfaces of all teeth using the index in its original or a modified form. The partial recordings, using groups of index teeth, are intended as a way of making the index more applicable for larger-scale population surveys, where the need to measure several different disease processes, or a very large sample, puts constraints on the length of the examination or on the ability to calibrate examiners.

Although scores for three surfaces were available, only a single tooth wear code was computed for each tooth (by taking the worst score from the three available). Unless the analysis being undertaken requires a very detailed breakdown (for example, to try to isolate different aetiologies of wear), this is a pragmatic way to handle the data. Rather than collecting three codes per tooth and computing the worst score later (the approach used here), it has also proved practical to record only the worst score per tooth at the time of the examination (24).

Measuring and describing both extent and severity in a single index is a substantial problem, and one which is shared with the measurement of periodontal disease (12). Widespread moderate wear is not necessarily any better or worse than localised but severe wear, it is just a different pattern. A partial recording system to collect epidemiological data in these cases needs to be flexible, but the index teeth should still allow detection of cases where there is everything from local severe to widespread moderate wear, or perhaps even widespread early wear. This is an issue of sensitivity. Of the five part-mouth systems assessed, the most sensitive and economic were those where only the 12 anterior teeth or the six index anterior teeth (three uppers, three lowers) were used. Where both grade 3 and grade 4 wear were recorded using these part-mouth systems, little sensitivity was sacrificed, even where there were only a few affected teeth.

The other property required of a partial recording is that it should be capable, not just of detecting cases where widespread or severe wear exists, but of ensuring that the extent of wear (the number of teeth affected) can still be accurately identified using just a part-mouth recording. This is related to the specificity of the group of index teeth, but because of the nature of tooth wear, where both extent and severity may be important, it is not amenable to a simple calculation of specificity. However, the data reported show that when scoring only the 12 anterior teeth, the numbers of worn teeth are still very closely related to the results obtained from scoring the whole mouth. For example, all cases in category C (more than six teeth with moderate or severe wear) had at least five teeth affected by moderate or severe wear when the 12 anterior index teeth only were used. Where the reduced part-mouth record is used (three upper and three lower anteriors) the number of affected teeth is smaller and if sensitivity is not to be compromised the specificity tends to be lower.

Precisely how the data are reported is a separate issue and will depend on the nature of the sample and the objectives of the study. The important point is that, provided that wear scores of 3 or

above are recorded, both of the partial recording systems shown in Table 6 will allow a degree of flexibility in the way the data are reported. Where resources are very limited, little sensitivity is lost using the six index teeth (three upper, three lower), but there is a risk of losing specificity when the data are reported. The 12 tooth record will allow much more specific reporting.

The possibility of just recording grade 4 wear was considered. Recording two codes only ("severe wear" or "no severe wear") would make training and calibration easier, particularly as grade 4 wear is relatively easy to score since it depends on very clear diagnostic criteria that are relatively easy to measure. However, recording only severe wear of grade 4 would have meant that only 80% of the cases of moderate or severe widespread wear (category C) would have been detected as having any wear at all, suggesting that early detection of important problems would be impaired. The inability to detect such cases of widespread tooth wear may be seen as the main shortcoming of using a dichotomous score of this sort. For this reason we would recommend that for older individuals, teeth should be recorded as having one of at least three codes according to the TWI criteria, one representing less than grade 3, one representing grade 3 and one representing grade 4.

The intention of the analysis was to investigate whether it was possible to reduce the number of codes collected, without impairing the ability to present meaningful data about the extent or severity of wear in the population, in other words, to evaluate the cost of the exercise in terms of sensitivity and specificity. In the context of a large oral health survey, this investigation shows that cost to be rather small.

The benefit side of the cost-benefit equation is measured by the reduction in the time spent examining and also possibly training, and by less inter-examiner variability. Using the two most efficient systems reported here, only 12 or six codes need to be collected compared with 32 if a single tooth score is recorded on all teeth, or 96 if every surface of every tooth crown is coded. The length of the examination is broadly in proportion to the number of surfaces recorded, as each surface has to be examined, called and entered. In a complete dentition, the duration of the full wear examination varies greatly, but will usually take between 2 and 4 min, depending on the number of teeth and ease of examination, so the time saved by radically reducing the number of wear codes will be considerable.

Training is simplified where the range of tooth types is reduced because the range of diagnostic criteria will be reduced; for example, posterior tooth wear needs additional criteria from anterior tooth wear because of differences in morphology. As a result, improvements in inter-examiner calibration might be expected, but this needs further investigation.

Tooth wear can affect all age groups and societies and is an irreversible and progressive condition. This study was conducted on a sample of older adults from an industrialised Western population. Different cultural groups may have different patterns of restoration which could affect the specificity thresholds or the codes used, but there is no specific reason to believe that the same index teeth should not also be appropriate. For younger populations where there is a need to detect wear at an early stage, the slightly more sensitive and specific 12 anterior index teeth may be preferable. The coding system may also be subject to variation according to the age of the group and objectives of the research. For younger groups, codes recording earlier wear, for example all five codes in the Smith & Knight index, may be necessary. Assuming that different wear indices correlate closely with each other, the index teeth described should also be appropriate for other indices of coronal wear.

Conclusion

Amongst older adults, partial recording systems for coronal tooth wear, where only the 12 anterior teeth are coded, allow for sensitive and detailed analysis. A system using only six anterior index teeth is also sensitive, but may allow for less flexibility in reporting. The data reported here were from a group of older adults.

Acknowledgements

References

1. Parma C. Paradontopathien. Leipzig: Johan Ambrosius Barth; 1960.
2. Pollman L, Berger F, Pollman B. Age and dental abrasion. Gerodontics 1987;3:94–6.
3. Murphy TR. The gradient of dentin exposure in human molar tooth attrition. Am J Phys Anthropol 1959;17:179–86.

4. Akpata ES. Molar tooth attrition in a selected group of Nigerians. Community Dent Oral Epidemiol 1975;3:132–5.

5. Hand JS, Hunt RJ, Reinhardt JW. The prevalence and treatment implications of cervical abrasion in the elderly. Gerodontics 1986;2:167–70.

6. Hugosen A, Bergendal T, Ekfeldt A, Helkimo M. Prevalence and severity of incisal and occlusal tooth wear in an adult Swedish population. Acta Odontol Scand 1988;46:255–65.

7. Oilo G, Dahl BL, Hatle G, Gad AL. An index for evaluating the wear of teeth. Acta Odontol Scand 1987;45:361–5.

8. Smith BGN, Knight JK. An index for measuring the wear of teeth. Br Dent J 1984;156:435–8.

9. Johansson A, Omar R. Identification and management of tooth wear. Int J Prosthodont 1994;7:506–16.

10. Silness JMB, Johannessen G. Prevalence, pattern and severity of incisal wear in dental students. Acta Odontol Scand 1994;52:178–81.

11. Johansson A, Haraldson T, Omar R, Kiliaridis S, Carlsson GE. A system for assessing the severity and progression of occlusal tooth wear. J Oral Rehabil 1993;20:125–31.

12. Carlos JP, Wolfe MD, Kingman A. The extent and severity index: a simple method for use in epidemiologic studies of periodontal disease. J Clin Periodontol 1986;13:500–5.

13. Aucott DM, Ashley FP. Assessment of the WHO partial recording approach in identification of individuals highly susceptible to periodontitis. Community Dent Oral Epidemiol 1986;14:152–5.

14. Cutress TW, Ainamo J, Sardo-Infirri J. The community periodontal index of treatment needs (CPITN) procedure for population groups and individuals. Int Dent J 1987;37:222–33.

15. Bentley CD, Disney JA. A comparison of partial and full mouth scoring of plaque and gingivitis in oral hygiene studies. J Clin Periodontol 1995;22:131–5.

16. Baelum V, Fejerskov O, Manji F, Wanzala P. Influence of CPITN partial recordings on estimates of prevalence and severity of various periodontal conditions in adults. Community Dent Oral Epidemiol 1993;21:354–9.

17. Diamanti-Kipioti A, Papapanou PN, Moraitaki-Tsami A, Lindhe J, Mitsis F. Comparative estimation of periodontal conditions by means of different index systems. J Clin Perio 1993;20:656–61.

18. Papapanou PN, Wenstrom JL, Johnsson T. Extent and severity of periodontal destruction based on partial clinical assessments. Community Dent Oral Epidemiol 1993;21:4:181–4.

19. Smith BG, Robb ND. The prevalence of toothwear in 1007 dental patients. J Oral Rehabil 1996;23:232–9.

20. Donachie MA, Walls AWG. Assessment of tooth wear in an ageing population. J Dent 1995;23:157–64.

21. Donachie MA, Walls AWG. The tooth wear index: a flawed epidemiological tool in an ageing population group. Community Dent Oral Epidemiol 1996;24:152–8.

22. Steele JG, Walls AWG, Murray JJ. Methodological issues involved in sampling a population of the elderly for a dental survey. Community Dent Health 1995;12:77–82.

23. Steele JG, Walls AWG, Ayatollahi SMT, Murray JJ. Major clinical findings from a dental survey of the elderly in three different communities. Br Dent J 1996;180:17–23.

24. Steele JG, Sheiham A, Marcenes W, Walls AWG. The National Diet and Nutrition Survey: people aged 65 years and over. Vol. 2: report of the oral health survey. London: The Stationery Office; 1998.