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Development of an Index for the Prevalence of Root Caries

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Introduction.

The disease of root caries is not a new phenomenon. In fact, anthropological evidence suggests quite the contrary. Anthropological digs have produced jaw and dentition remains which demonstrate that root caries not only occurred in these ancient peoples but also was often found to be the dominant form of dental caries as compared with coronal dental caries.¹⁻³ The interpretation of findings from anthropological evidence must, of course, be cautious, given the inherent selectivity that has operated to collect and preserve any given "anthropological find". Regardless of whether the unearthed remains are from scattered individuals or from a given social subset of the total population, the likelihood is negligible that the unearthed remains are, in fact, a representative sample of the original population. Interestingly, however, the evidence from these ancient anthropological findings has received a note of confirmation within the past decade as a result of a detailed dental survey of primitive natives in New Guinea.^{4,5} Intra-oral examination of these natives, whose life style and diet are thought to be similar to those of many ancient hunter/nomadic people, revealed that caries lesions on their root surfaces were far more common than caries lesions on the crowns of their teeth.

However intellectually interesting these anthropological observations and debates prove to be, the dental profession's current interest in the disease of root caries represents a pragmatic recognition of an oral disease for which our suspicions run high and our knowledge remains low. One of these suspicions is that root caries may become the dominant active dental decay disease in adults over the next fifty years. In fact, given how little we do know about this disease of root caries, it may already be the dominant active dental decay process in adults. Certainly, the factors behind such suspicions are widely recognized: first, the demographic shift in the age distribution of our population, commonly referred to in the popular press as the "aging of America"; second, the increasing retention of teeth into the later years of life, due to the combined effects of widespread exposure to fluoride plus the possible changes in professional and lay preventive habits, including suspected dietary intake alterations; and third, the current lack of feasible and widely utilized methods to prevent gingival recession associated with periodontal disease. These factors all suggest that more people will enter the middle and late adult years with more teeth which are still subject to periodontal disease and which, hence, will be susceptible to root caries.

Clearly, though, the near total lack of epidemiologic data on any aspect of the dental caries process in adults prevents even a well-educated guess as to whether root caries will be found to be the dominant form of active decay in middle-aged and older adult patients. One competitor for the dominant decay process in adults would have to be primary decay on the increasing number of virgin sites on the coronal surfaces with which teenagers in developed nations are now entering adulthood. Another competitor would be recurrent or secondary decay associated with

existing restorations. Regardless of whether root caries proves to be the leading dental caries problem in adults or is merely one of several dental caries problems in adults, there is a definite need to conduct descriptive epidemiologic surveys to establish the who, what, where, and when of root caries, as well as to conduct analytical epidemiologic studies which focus on the etiology of and/or risk factors associated with this disease. Of course, clinical trials to test preventive agents and regimens as well as restorative treatments will be run concurrently with our gathering of knowledge about the disease process itself. Despite the fact that the pressures to produce data on root caries from descriptive, analytical, and experimental epidemiologic studies have already led to an RFP on root caries from the National Institutes of Health, and despite the fact that we will undoubtedly see a rapid increase in the number of Principal Investigator-initiated root caries grant proposals, it is essential to acknowledge that several fundamental problems must be sequentially addressed and resolved if we are to have confidence in the value of our root caries data. Specifically, we must address the following fundamental issues: (1) the definition of, (2) the measurement of, and (3) the reporting method for the disease of root caries.

The purpose of this presentation is to initiate discussion on several of these fundamental problems associated with the defining, measuring, and reporting of root caries in the expectation that ensuing discussions can — as rapidly as possible — lead to a valid and consensus approach to the study of the root caries process.

Defining the root caries lesion.

Establishment of a common set of criteria for defining the root caries lesion is clearly one of the most fundamental steps that must be accomplished if data from various studies are to be comparable. These as-yet-to-be-developed common criteria must include: (1) visual-tactile criteria, (2) radiographic criteria, and (3) surface location criteria.

The visual-tactile criteria are probably the most important, if we are to achieve a common definitional consensus, since it will undoubtedly be the major method of detection over the next five to ten years. Currently, there are no visual-tactile criteria that have achieved a status comparable to the consensus criteria for coronal lesions that are described by Radike in the ADA publication, *Proceedings of the Conference on the Clinical Testing of Cariostatic Agents* (1968).⁵ This set of criteria for coronal lesions currently serves as "the standard" for research throughout the world. It is probably worthwhile to note that there are certainly specific research questions regarding coronal decay for which the consensus criteria are not sufficiently refined, especially regarding the stage of development of the caries lesion. Thus, on occasion, an alternative, more detailed set of criteria has been employed. However, the benefits derived from the widespread use of a common set of criteria obviously enhance the value of each research project using that common set of criteria.

The literature to date, while having no common source for citing visual-tactile criteria for root caries, generally defines root caries as "a soft, irregularly shaped, progressive,

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destructive lesion either (1) totally confined to the root surface or (2) involving the undermining of enamel at the cemento-enamel junction, but clinically indicating that the lesion initiated on the root surface." While this definition might suffice for a clinical lecture to dental students or practitioners to convey a general notion of a root caries lesion, it falls woefully short of providing a detailed and quantifiable set of descriptors that would suffice for conducting rigorous epidemiologic studies.

A closer scrutiny of the elements of this definition will serve to reveal the diagnostic uncertainties that would follow any attempt to initiate a study based on these criteria. The color has been described as being various shades of brown or black, any one of which would qualify as a visual clue. While "softness" is an essential element described in most reports on active lesions, some researchers address the issue of arrested root caries lesions and state that these arrested lesions are recalcified and feel "hard" to tactile probing. The irregular shape seems to be commonly observed but certainly may not be an absolute requirement upon which to eliminate a possible lesion as being defined as a root caries lesion.

What is needed is a well-worded and succinct paragraph which, in an adequate and utilitarian manner, sets forth a working definition (much in the style of the Radike definition of coronal caries). While it is entirely rational to argue that too few investigations have been conducted *in toto* (much less by any one investigator) to permit the setting forth of such a set of visual-tactile criteria for widespread adoption at this time, in the spirit of provoking thought and discussion, I would suggest that the following description of visual-tactile criteria for epidemiologic studies might adequately serve as initial, but to-be-modified, visual-tactile criteria.

Caries lesions on the roots of teeth are diagnosed as being in one of two categories:

(1) Lesions exhibiting gross cavitation.

Any root surface area which exhibits a frank cavitation and either:

- (a) a darkened, discolored appearance, *OR*
- (b) a tacky or leathery feel upon probing with moderate pressure.

(2) Lesions without gross cavitation.

Any root surface area which provides a darkened, discolored appearance, either:

- (a) with a tacky or leathery feel upon probing with moderate pressure (assumed to be active lesions), *OR*
- (b) without any tactile evidence (assumed to be inactive lesions).

This latter category — *i.e.*, classification of a root caries lesion based solely upon a darkened, discolored area with no tackiness upon probing — is perhaps the most controversial suggestion. Its long-term fate as a viable category, it seems to me, will depend upon two sets of observations that will emerge from future studies: (1) primarily, whether any phenomenon other than caries can produce a discolored area on a root surface, and (2) secondarily, whether its frequency of occurrence justifies a separate category, *i.e.*, if it proves to be a rare occurrence, it might add little to the value of epidemiologic data relative to the diagnostic complexity that it might introduce.

In addition to the need to diagnose untreated lesions (active and inactive), there is a need to develop criteria for the identification of treated lesions. The great majority of root lesions today, according to practitioners, are restored with relatively easily identifiable materials

such as amalgam, gold, cements, and composites. However, it is entirely plausible that, given the broad, shallow nature of many early lesions, the favored form of treatment for these broad, shallow lesions may be simple disking, possibly followed by a chemotherapeutic treatment. Given the general reluctance of most practitioners to drill into root surfaces, the appeal — and perhaps the logic — of a minimal disking procedure to remove decayed tissue for shallow lesions is likely to be high. The final result would be a treatment modality that would leave no history of disease at the site. Serendipitously, the treatments for coronal caries have always provided an easily identifiable restoration. This may not prove to be the case for all the treatments of root caries.

The measurement of root caries: instrumentation and calibration.

Nearly all epidemiologic investigations on root caries to date have adopted the tactile instruments traditionally associated with the detection of coronal caries — namely, the standard dental explorer. While I am certain that this was a "natural first step", and that this instrument will continue to be used both in the studies now under way and in those studies soon to be initiated, I would suggest that careful experimentation be undertaken regarding the validity and reliability of the standard dental explorer for the detection of root caries lesions. It seems to me that the instrument of choice to detect a tactile difference between sound enamel and decayed enamel may not necessarily be the instrument of choice to detect a tactile difference between sound cementum or dentin and decayed cementum or dentin. The latter tactile comparison on the roots of teeth certainly attempts to detect tactile sensation within a far more limited range than does the former comparison, which is performed on the crowns of teeth.

Of course, one is always hopeful that the Twentieth Century will make its presence felt in one's own area of professional concern. Toward that hope, I would like to imagine that a modern technology will soon replace our "ancient probes and picks" with a more objective and quantitative technique for the detection of caries lesions — on the roots as well as on the coronal portion of teeth. Until the advent of a revolutionary technological advance for the detection of decayed tooth tissue, the most immediately productive investigations will undoubtedly focus upon the "discovery" of the best explorer or probe.

A second major issue that must be addressed early in the development of an index to measure root caries concerns the establishment of calibration standards. While the calibration standards for the DMFS index evolved over a three-decade span after the introduction of the DMFS index, this leisurely pace was more a reflection of the state of the art of dental epidemiologic studies in that era than a planned process. Today, state-of-the-art dental epidemiology demands that a suitable standard be established within a relatively short time period. One method to ensure attention to the issue of calibration from the onset would be to establish an initially reasonable, if arbitrary, standard which might be modified if early investigations produced a more suitable, functionally-derived standard for calibration.

One could reasonably begin with the working standards that are now traditionally applied in calibration sessions regarding the measurement of coronal caries. In the detection of coronal dental caries, examiners are considered to

be acceptably calibrated when both their intra- and inter-examiner reliability scores exceed 90% for whole mouth scores. The adoption of these relatively high initial standards for the measurement of root caries would place the appropriate pressures upon investigators both "to define root caries best" and "to develop the best instruments" for the measurement of root caries. Modification of these initial standards could follow if the evidence after two to three years suggested that a different standard is indicated.

The reporting of root caries.*

A brief review of the methods for the reporting of root caries that were found in the literature prior to 1980 is a logical starting point in the search for a new index.^{4-5,7-12} The most frequently-employed method of reporting root caries has been to report the percent of study populations exhibiting one or more lesions. The attractiveness of this measure, which can be used for either prevalence or incidence studies, was its clarity and simplicity. Primarily, it was useful in descriptive studies, comparing one population with another. However, it is a relatively gross measure that (1) ignores the severity of the disease in an individual (or within a population), (2) does not identify the true "population at risk", and (3) fails to account for the effect that differing rates of missing teeth would have on the measure. Because of these characteristics, this measure is best suited to descriptive comparisons of surveyed populations but has no potential use in analytical studies for risk factors or etiologies, or in clinical trials for therapeutic or preventive agents. Even within descriptive surveys, the relative crudeness of this measure does not recommend it as an index of choice.

A count of the number of root caries lesions per person, the second most commonly used method for reporting root caries, represented an improvement because it introduced a measure of severity. This method, which permits a more detailed analysis for risk factors and etiologies, is closely analogous to the coronal caries measures of DMF and DMFS, since it uses the entire dentition as the unit at risk. While the notion of the entire dentition being the unit at risk is a reasonable assumption regarding coronal caries in children, teenagers, and young adults, the huge variation in tooth survivorship and extent of gingival recession undermine the validity of this assumption for the study of root caries in older adults. It is simply not reasonable to assume that a known or equal number of units at risk exists either for individual or for cross-cultural comparisons.

The third method used for reporting root caries, a count of the number of root caries lesions per tooth present, is a severity measure that does account for the variation in tooth survivorship. The denominator in this measure is a refinement in the delineation of the population at risk: Only teeth that are present are at risk. While this measure can be reported as a count of root caries lesions per 100 teeth present in a population, it is more powerful as an analytical tool when reported as a count of root caries lesions per tooth present in an individual. This latter form of reporting retains the individual as the unit at risk, thus allowing analysis for risk factors associated with an individual.

Despite the improvements this latter measure introduced, a count of the number of root caries lesions per tooth present does not identify the true intra-oral unit at risk as its denominator. This denominator, the number of teeth present, can be envisioned as having two compo-

nents: (1) teeth present with gingival recession, and (2) teeth present without gingival recession. Since the latter component represents teeth that are not at risk for supra-gingival root caries, only the former component, teeth with gingival recession, should comprise the denominator. The use of both components in the denominator inflates the denominator and thus leads to an underestimation of the attack rate of root caries.

There is clearly a need to develop a universally adopted method for the reporting of root caries. The limitations of the previously described reporting methods serve to clarify the characteristics that such an index should possess. First, the index should fulfill the criteria for reliability, validity, economic feasibility, and ease and speed of application. Second, the index should reflect the most current knowledge about root caries, incorporate the best elements from the existing measurement methods, and be useful and flexible enough to serve as the reporting method for a number of years.

The Root Caries Index (RCI)¹³⁻¹⁵ is a method for reporting root caries that measures the severity of the disease and delineates the true intra-oral population at risk (*i.e.*, the denominator). The formula for the Root Caries Index is:

$$\left(\frac{\text{No. of root caries lesions}}{\text{No. of teeth or surfaces with gingival recession}} \right) \times 100 = \text{RCI Score}$$

The result is, in epidemiologic terms, an attack rate for the disease of root caries.

The data for this index are collected on a form that repeats the format shown in Fig. 1 for each tooth in the arch. The columns represent the four surfaces of a root: the mesial, distal, buccal, and lingual, respectively. It is recognized that a tooth with multiple roots and extreme recession might present two or even three of each surface. However, this occurrence is judged to be rare enough so that a rule to govern this observation should suffice rather than overly complicate the data collection form to accommodate the possibility. The suggested rule is that when multiple root surfaces are exposed, the most severely affected surface be recorded for that tooth. The rows represent the conditions that could occur on these surfaces. Essentially, the root surface is characterized as: missing (M); showing no association with gingival recession (NoR); or exhibiting one of three subconditions associated with

		TOOTH SURFACE			
		M	D	B	L
F I N D I N G S	R-N	1	1	1	1
	R-D	2	2	2	2
	R-F	3	3	3	3
	NoR	4	4	4	4
	M	5	5	5	5

Fig. 1

*The following sections are, in large part, reprinted from reference 14.

CALCULATIONS OF RCI

a) BY SURFACE:

ONLY ONE FINDING RECORDED USING THE FOLLOWING LOGIC,

M OVER NoR OVER R-D OVER R-F OVER R-N

b) BY TOOTH:

USE THE FOLLOWING LOGICAL HIERARCHY,

	SCORE TOOTH
1) MISSING	M
2) R-D ON ANY SURFACE	R-D
3) IF NO R-D, R-F ANYWHERE	R-F
4) IF NO R-D OR R-F, R-N ANYWHERE	R-N
5) IF NO RECESSION ANYWHERE	NoR

Fig. 2

gingival recession — (1) recession present, surface decayed (R-D), (2) recession present, surface filled (R-F), or (3) recession present, surface normal or sound (R-N).

The scoring of root surfaces is relatively straightforward, as indicated in Fig. 2. The row categories are treated as mutually exclusive categories, and only one finding is checked for each surface. A designation of missing (M) is made for a whole tooth, not a single surface. Once a tooth is judged to be missing, all root surfaces are recorded as missing. A judgment of no recession (NoR) is made if the cemento-enamel (CE) junction cannot be visualized. Judgments for the categories of decayed (R-D) and filled (R-F) are based on clinical observations that were previously discussed. Judgments for a sound surface (R-N) are made when none of the other categories applies (*e.g.*, no decay, no filling, not missing). The presence of calculus in the absence of any other findings on that surface is recorded as sound (R-N), on the assumption that decay will not frequently be under a band of calculus.

Note that the data collection format presented in Fig. 1 has arbitrary numbers in each box. These are solely to facilitate the keypunching of data and do not represent any numerical relation to each other. If data on the quantification of recession in a study were desired, then these arbitrary numbers could be omitted, either an ordinal or interval-ratio scale could be established to quantify recession, and this could be recorded in each box.

By definition, the Root Caries Index rests upon the assumption that gingival recession is a necessary antecedent condition before root caries can develop and that gingival recession must be evident at the time of examination. Theoretically, it is possible to envision two situations in which this assumption would not be upheld, and consequently the Root Caries Index would underestimate the extent of the disease. First, root caries might develop in the presence of recession of the epithelial attachment but in the absence of gingival recession (*i.e.*, an absolute periodontal pocket). Second, root caries could initiate on a root surface exposed by gingival recession with a secondary local inflammatory process leading to a swelling of the

gingival tissues which covered the lesion (*i.e.*, a relative periodontal pocket). While both clinicians and researchers have observed such lesions within periodontal pockets, the reported frequency is rare. Whether these lesions represent a different bacterial disease process — one that is subject to different environmental or risk factors — will be determined only through future investigations.

In the development of the Root Caries Index, the decision to define root caries as only those lesions associated with gingival recession is based both on the weight of epidemiologic evidence already gathered and on certain pragmatic considerations. That all the studies to date have investigated precisely this phenomenon — root caries associated with gingival recession — provides the weight of existing epidemiologic evidence. When pragmatic considerations inherent in epidemiologic studies — such as examination time, examination validity, and examiner reliability — are taken into account, the Root Caries Index remains a utilitarian choice. Moreover, until technological advances are developed to aid in the identification of subgingival caries lesions, this philosophical question is a moot point. Nonetheless, it is important to recognize that this assumption underlies this index and to clarify precisely what the index does, and does not, measure.

Conclusions.

We are at a critical junction between the state of the art for the reporting of root caries and the demand placed on the research and service components of the oral health system. If progress is to be made, it is imperative that a uniform reporting method for root caries be developed and adopted.

In the evolution of a root caries measurement method, the Root Caries Index represents a refinement of the delineation of the true intra-oral "population at risk" to the disease process. The resulting index is a true attack rate for supragingival root caries lesions. The Root Caries Index may prove to be a feasible and utilitarian method for reporting root caries in descriptive and analytic epidemiologic studies as well as for assessing the result of preventive and treatment agents in clinical trials. This development should permit more meaningful comparison of populations, clearer interpretations regarding risk factors, and more precise assessment of preventive and treatment agents.

While an attempt has been made to consider a variety of assumptions contained within the proposed index, nothing less than a full and open discussion of assumptions — assumptions of both commission and omission — by concerned oral epidemiologists will produce an index robust enough to stand the stress and strain of field-testing and time.

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Development of an Index for the Prevalence of Root Caries: Discussion of Dr. Katz' Presentation

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When I was asked to respond to Dr. Katz' paper on the development of an index for the prevalence of root caries, I was most pleased to accept for reasons of: (1) my own involvement as an investigator with the subject; (2) my recollection as a former clinical instructor who, years ago, found himself telling dental students that the cervical radiolucency found on a radiograph was usually caused by anatomic configuration rather than by a disease process; and (3) my present awareness as a dental school administrator that the demographic characteristics of the patients in our teaching clinics are changing in very significant ways. It will be through the prisms provided by that background that the following observations on Dr. Katz' presentation will be made.

To begin with, I found Dr. Katz' statement regarding the possibility that root caries may be the dominant active dental decay process in adults to be very interesting. Whether or not it is true, it is a dramatic way of indicating that the emergence of root caries as a public health problem is an important sequela to the demographic changes and the changes in dental health care practices which have occurred in recent years. Certainly, his association of root caries with periodontal disease is appropriate and consistent with the positive correlation between both disease processes and age. Employing the Root Caries Index (RCI) which he developed, Dr. Katz has supported this perception through his analysis of data previously collected by Hazen *et al.*¹, in which he demonstrated clearly the importance of acquiring more knowledge and understanding of root caries. That analysis, reported in 1982², revealed that the average subjects in Hazen's study entered their thirties with only one out of 100 of their surfaces having been attacked by root caries, while they entered their sixties with better than one out of five of their surfaces with recession having been so affected. The analysis also showed that there was an 18-fold increase in the average number of surfaces with root caries per subject between ages 20 and 64.

I agree with the position taken by Dr. Katz that descriptive, analytical, and experimental epidemiological studies are needed in order to provide data that are essential for a more thorough understanding of root caries and the development of appropriate preventive and treatment modalities than exist at the present time. To that end, his focus on the definition, measurement, recording, and reporting of root caries is a necessary first step.

One comment that I would like to make regarding the author's proposed description of visual-tactile criteria for epidemiological studies concerns his inclusion of inactive lesions among those which would be recorded by an examiner(s). It seems to me that, with the importance of establishing and maintaining the examiner reliability that is critical to the success of epidemiological studies, it is not helpful to introduce an element which could seriously erode that reliability. Unless it is important to identify as many root caries lesions as possible in order to make statistical analysis valid, the well-accepted concept that it does not create a serious problem systematically to omit questionable lesions would appear to apply. Given the focus of the Root Caries Index on surfaces and subjects *at risk*, it would seem that a sufficient number of frank lesions could be identified to produce meaningful results, since the denominator is smaller than would otherwise be the case. Similar logic could be applied to the recording of treated root caries lesions. If one were not to include in the recorded data those treated lesions which do not leave an easily identifiable restoration (e.g., amalgam, gold, composite, etc.), there would result an under-counting of treated root caries, but the validity of the data that depends on examiner reliability would be protected.

I was intrigued by Dr. Katz' suggestion that a more sensitive instrument than the standard dental explorer might some day be developed in order to provide a more objective and quantitative technique for the detection of caries lesions, coronal and root surface, than exists at present. His reference to the far-more-limited range of tactile sensation between sound and carious cementum or