Clinical Decision Making for Caries Management in Root Surfaces

A Report for the NIH Consensus Development Conference on Diagnosis and Management of Dental Caries Throughout Life

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The Management of Root Caries

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1.0 OBJECTIVES AND QUESTIONS

1.1 Objectives

This report on the management of root caries was prepared for the NIDCR Consensus Development Conference, Diagnosis and Management of Dental Caries Throughout Life. Its purpose is to present the evidence for the diagnosing, and intervening in the disease known as root caries so that clinicians can communicate to their patients the best information for their joint decisions on care.

1.2 Background

This report flows from a model of clinical decision-making that recognizes that the first critical decision in management is the diagnosis or the probability that a patient has the condition of interest. Such probabilities are dependent on the results of the diagnostic test in the context of the prevalence and incidence of the disease in the general population, as modified by the patient's history and current risk markers and risk factors. Once a post-test probability is sufficiently high to warrant intervention, then a decision on the appropriate intervention is required. In that context, the next questions to be asked are: Are there one or more efficacious interventions, and if so, what is the most appropriate from perspectives of both effectiveness and relative cost effectiveness.

Horowitz (1) has outlined the methods and processes that were to be used to prepare reports for this consensus conference. Two workshops were held; after the first workshop each reviewer prepared preliminary questions that should be addressed in the review. For the management of root caries, the preliminary questions were:

1. What is the pre-examination probability of root caries in North American populations from which dentists' patients are drawn?
2. How accurate are the methods we have to diagnose root caries?
3. How accurate are the methods we have to predict root caries?

4. How efficacious are the methods for prevention and restoration?

At the second July 12-13, 2000, workshop for reviewers, the questions were discussed and areas of overlap with other investigators were either eliminated or adjusted. Areas and the corresponding investigators that potentially overlapped with this review included:

1. Risks of developing caries (D Zero);
2. Prevention among high risk groups (RTI)
3. Prevention among low risk groups (G Rozier).

We recognized that the question of diagnosis of root caries was to be addressed by other reviewers. Nonetheless, we needed to review the natural history of the condition including its prevalence and incidence, and the accuracy of diagnosis at the various stages in order to be able to assess the potential efficacy of care at each stage.

Thus, after the second workshop, the preliminary questions were refined to the following final questions.

1.3 Final Questions

1. Among North American populations, what is the natural history of root caries?
   Natural history would include descriptions of :
   - case definitions of lesions at different stages;
   - activity of lesions (active, inactive);
   - rates of progression from stage to stage;
   - reversibility of lesions by stages (under natural conditions);
   - outcomes of untreated root caries.

2. How accurate and reliable are the methods we have to diagnose active and inactive root caries?

3. For persons with root caries, what are the differences in outcomes (absolute improvement in teeth retained and functional, relative improvement in teeth retained and functional, or numbers needed to treat) between subjects randomly assigned to receive therapeutic care and those not receiving such interventions (by stage of lesion).

These questions were submitted in late July 2000 along with the relevant 'key concepts', 'key articles', limited to human studies, in English, from 1966, for adults, with the appropriate focus on diagnosis, treatment/therapy and outcomes/prognosis.

2.0 SEARCH STRATEGY

The searches using the search hedge (Appendix 1) from both Medline and Embase were returned in late August. As it turned out, the questions were so specific that the retrieval was small. Thus, the search was expanded to a core search on root caries within the limits applied. The databases were linked and reviewed as one to find the articles that were relevant to the questions.

3.0 DATABASES

The searches resulted in 292 references from Embase and 535 from Medline which were imported into EndNote 4. Twelve duplicates and eight that were incomplete were deleted, resulting in a final database of 807 references.

4.0 ABSTRACTION AND QUALITY CHECKS

The annotated references, i.e., with authors, date, title, journal, and abstracts, were printed then read independently by at least two people who indicated whether they felt the article should be considered in addressing the final three questions. In all 203 (113 by one and 90 by two or more) of the 807 articles were initially selected by one or more

of the reviewers. The 203 were then reviewed by two reviewers to achieve consensus and 94 were selected for retrieval and copying.

In reading the copied articles, the reference lists were checked and citations that appeared to relate to our questions, or provided additional information, e.g., prevalence data, were added back into the databases and also retrieved and copied. Some of these were found in the original 807, but others had not been identified in the original searches. The final database consists of 161 references (94 originally selected, 67 added - one on the recommendation of the external reviewer).

The copied articles in the final database were then scanned and identifying keywords (prevalence/incidence, diagnosis, treatment, natural history) were then manually edited into the 'keywords' section of the EndNote reference and saved in the database. In this way, articles that could be used to address more than one question (for example, both incidence and natural history), were marked for later retrieval to address each question.

4.1 Inclusion/exclusion/abstraction criteria

Using the 'keyword in any field' searching capacity of the Endnote program, articles relevant to each question were identified, selected and read more completely. Generally articles were included if they addressed the question and arrayed the data so that it could be abstracted. Articles were excluded where upon closer reading they did not address the question or where we could not abstract the data. Specific inclusion and exclusion criteria and the numbers of studies retrieved and included are identified at the start of each of the relevant sections.

Ideally, the evidence should have been selected from studies with strong design, as described by AHCPR (2) and others' criteria, and which had high scores when critically appraised. Recommendations for therapy are classified, according to AHCPR, from good (A) or fair (B) evidence to support; to insufficient evidence to support (C); to fair (D) to good (E) evidence to not support a particular maneuver. The classification of the

recommendations is related to the strength of the study design that ranges from randomized controlled studies (I) to expert opinion (III).

Other than for prevalence and incidence, there were very few high quality studies that addressed our questions. For the other questions, we had so few studies that we could not exclude relevant studies on the basis of critical appraisal scores and so we did not use any system of quality scoring to exclude studies. However, the limits of the studies are pointed out in the evidence table. Since the final inclusion criteria were not restrictive, the conclusions on the classification of the recommendations are often tentative.

The information from each included study was abstracted directly into the appropriate evidence table. For estimates of prevalence, only the most recent national study (3) was selected in order to give the most current data which could apply generally. Articles on the natural history did not lend themselves to abstraction into an evidence-table.

5.0 FINDINGS

5.1 Evidence for Prevalence and Incidence

5.1.1 Prevalence

Root caries is common. Nearly twenty years ago, the American Dental Association's Council on Dental Health and Health Planning (4), reported that '...practitioners can expect to find at least one carious lesion on the root surface in approximately 40% to 50% of their adult patients... and for those older than 50 approximately one of every five surfaces with recession will be attacked...'.

The evidence for prevalence is informed by the most recent study, the 1988-1991 NHANES III national survey (3). Nearly 8400 people were examined of which 7,726 were dentate and 6,726 of those included in the root caries findings. Selected results

are shown in Table 1; the adjusted prevalence for US adults, as measured by those with one or more lesions, was 25.1%. Prevalence increased with increased age, such that by age 75 years and over, 55.9% had one or more lesions. Severity as measured by the mean number of root decayed and filled surfaces (RDFS) was 1.2, of which 58.3% were filled. As expected severity was also age-dependent. Not shown in the table is the finding that women had lower prevalence (23.3% vs 27.1%), lower mean scores (1.0 vs 1.4 RDFS) and lower proportions filled (50.0% vs 64.3%). From the NHANES III study, and as a very rough guide for clinicians, past the age of 34, the prevalence of root caries is 20% - 22% less than a person's age. For example a person aged 50 would have a probability of 28%-30% of having one or more RDFS.

The NHANES III results found somewhat lower prevalence and severity of root caries than did the 1985-86 NIH study of over 15,000 employed adults and 5,600 seniors (5). For example, in the NIH study, for the age group 60 - 64 years, the prevalence was well over 50% (54.4%). For seniors, the prevalence ranged between 63% and 71%, depending on the age group.

5.1.2 Incidence

The database was searched for articles that had the term 'incidence' in any field and 24 were identified and read to determine if the data could be included in an evidence table. As seen in Table 6, studies were excluded if they describe incidence in populations outside North America, members of clinical trials (unless representative of the community), or members of specialized groups, e.g., institutionalized, low-income, medically compromised. Table 2 shows the results that were obtained from seven articles (6-13) that met the inclusion criteria of representative, community-dwelling, residents in North America. These seven represent only five studies since four articles report incidence for different periods in two studies.

The annual incidence estimates in the two right-hand columns were calculated from data in the articles by dividing the final net incidence by the number of years of the

study as per Hand et al. (7). This implies that the incidence is constant over the study period, which is not the case, but is one way to reduce the information to terms that the clinician can use for decision-making.

As seen the incidence of people acquiring one or more new cavities annually is hugely variable from 6% - 7% to 29% - 38%. The two highest rates of incidence were reported for the shorter duration studies 16 - 18 mos. Studies with follow-up periods of 36 months or more, found the annual net increments of persons to be in the range of 6% to 14.6%; still more than a two-fold difference. Even though the Long Island study subjects were considerably younger (mean age = 39.9) than subjects in the other studies, the incidence was still within the range of rates seen in older adults from Carolina to Ontario.

The incidence of lesions is reported using the annual increment of lesions per person and per 100 surfaces at risk. Again the two shorter studies report extremely high incidence rates; as between .52 and 1.08 new RDFS per person per year and annual incidence per 100 surfaces at risk of 2.1 to 3.5 surfaces. Studies of longer duration estimate the annual incidence per person to be between 0.08 and 0.36 RDFS; greater than a four-fold difference. Again the length of the study influences the calculated annual incidence; the 5 year results of the Piedmont study (11) found lower annual incidence of lesions than did the 3 year results of the same study (10).

Calculating a duration/sample-size weighted central estimate of the results of the four longest studies (7, 8, 11, 12) shows that the 8.2% of subjects would be expected to acquire one or more new root caries in one year. Those four, plus the Birmingham AB study (9), show that dentate people would, on average, be expected to acquire 0.19 new RDFS per year.

Clarkson (14) adds a further cautionary note when she points out that the conventional incidence studies would not pick up restorations of secondary root caries leading to an understatement by as much as 2/3 of the actual incidence of the lesions.

5.2 Description of lesions

5.2.1 General

Root caries is a disease that is expressed as a soft, progressive lesion found on a tooth root surface that has lost its connective tissue attachment and thereby has become exposed to the environment of the oral cavity (15-17). The lesion is variously found at the cemento-enamel junction (CEJ), or wholly on the root surface (18), or is seen to have spread to undermine the adjacent enamel (19), or is half or more of the distance apical to the CEJ (20, 21). Lesions are most often apparent on tooth roots where the gingiva has receded, but up to 10% to 20% of lesions appear subgingivally (22-24). Katz has also described seven diagnostic conventions for researchers to identify root caries (25). They include the category of recurrent root decay and protocols for scoring lesions that extend beyond one surface.

Katz has described the distribution of the disease among arches and tooth surfaces. Root caries was found most frequently in the mandibular posteriors (buccal and proximal) followed by maxillary anteriors (proximal), maxillary posteriors (lingual and proximal) and then mandibular anteriors (buccal and proximal)(19). Others have also described the distribution by tooth(26). Banting' has stated that more of the lesions are located close to the gingival margin (27). However, among periodontally treated patients with 157 new lesions 51% were found to occur at the margin of restorations, 25% at the cemento-enamel junction, 7% at the gingival margin and 17% confluent with other lesions (28).

The systems used to describe root caries lesions are neither precise nor consistent (29). In 1973, Sumney et al. defined root surface caries as '... cavitations in the tooth structure below the cemento-enamel junction which did not involve the adjacent enamel. In their eyes, lesions were shallow, ill-defined, softened areas, usually discolored, and characterised by penetration and destruction of the cemental surface of the tooth and underlying dentin' (17).

Finnish investigators have used a more strict definition of root caries, namely a soft lesion of which more than half was located on the root surface. In their counts, they did not include restorations on the roots, or root lesions adjacent to restorations (20).

Hellyer et al. (30) have described the texture of lesions as:

- Hard - hard as the surrounding tooth tissue
- Leathery - penetrated by a new Ash 6 probe under moderate pressure with resistance to withdrawal; and
- Soft - easily penetrated by a new Ash 6 probe under modest pressure with no resistance to withdrawal

Beighton and others (31) have described root surface caries according to four categories:

i. colour (yellow, light brown, dark brown and black);
ii. dimensions (length, width and depth in mm);
iii. distance from the gingival margin (in mm); and
iv. texture (hard as the surrounding tooth structure, leathery, and soft as determined by probing using moderate pressure as per Hellyer et al. (30)).

Using these four categories they categorized the need for treatment that ranges from:

- none - apply chemotherapeutic treatment (fluorides and chlorhexidine) for leathery towards hard lesions which were easily cleaned by the patient;
- debride (removal of carious tissue only);
- restore (all soft lesions, plus leathery lesions difficult to maintain by the patient, and lesions having lost surface to the extent that the pulp was threatened). These categories were tested for validity against microbiological samples of the lesions (see findings on diagnosis).

Thus, while there is consensus that there is a disease of root caries that can be expressed on the roots of human teeth, the descriptors of the condition vary and are subjective. Descriptors used to define a lesion are based on color, texture, surface

smoothness, depth of the lesion, and distinctiveness of the border, overlayed with whether the lesion is deemed to be active or inactive. The variability in the diagnostic criteria, plus whether restored roots are included in the count, impacts greatly on the estimates of prevalence and severity of the condition (24, 29, 32-35). For long term incidence studies, the variability in diagnostic criteria and the difficulty in separating the true reversals from examiner error (11, 36), limits the validity of the estimates of prevalence and is one of the limits to modeling the natural history of the disease (37).

5.2.2 Active or inactive lesions?

As cited by Nyvad and Fejerskov (38), Miller (39) was one of the first to attempt to distinguish active and inactive root caries. Hix and O'Leary (40) defined active root caries as '... cavitation or softened area in the root surface which might or might not involve adjacent enamel or existing restorations...generally well-established, discolored and characterized by penetration and destruction of the root surface and underlying dentin. The point of a Hartzel No. 3 explorer could easily be inserted into the carious area with moderated finger pressure...'. They scored surfaces affected as active, restored or recurrent.

In 1984 Katz (41) wrote that the lesions could be classified into 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 leather feel upon probing with moderate pressure.
2) Lesions without gross cavitation.
   Any root surface area which provides a darkened discolored appearance, either:
   a) with tacky or leather feel upon probing with moderate pressure (assumed to be active lesions); or
   b) without any tactile evidence (assumed to be inactive lesions).

He (42) later refined his definition of active and inactive lesions as:

1) Active lesions.

   Any root surface area with or without frank cavitation which exhibits:

   a) a darkened, discolored appearance; and

   b) a tacky or leathery feel upon probing with moderate pressure.

2) Inactive lesions exhibiting gross cavitation.

   Any root surface area which exhibits frank cavitation with a darkened, discolored appearance but without a tacky or leathery feel upon probing with moderate pressure.

Nyvad and Fejerskov (43) have also provided descriptions for active lesions as soft and yellowish to brownish. Inactive lesions were described as smooth, hard, shiny and black. This was later restated (44) to describe active caries as being well defined, showing a yellowish or light brownish discoloration, softened or leathery on probing with moderate pressure, and frequently covered by visible plaque. They described inactive caries as having dark brownish or black discoloration, a typically smooth and shiny surface, which is hard on probing with moderate pressure, and margins that may be smoothed off.

The most recent classification of active/inactive lesions was provided by Rosen et al. (45). They described root surface lesions as:

1. initial active - no cavity, discolouration, rough;
2. initial inactive - no cavity, discolouration, smooth;
3. manifest active caries - cavity, soft;
4. manifest inactive caries - cavity, hard.

Investigators assume the linkage between increased numbers of microbes and the activity of lesions. This assumption was examined by Beighton et al. (31). They have shown that organisms (measured as total colony forming units -CFU), Gram-positive pleomorphic rods (including Actinomyces spp.), mutans streptococci, lactobacilli and yeasts were most prevalent in lesions that were soft, declining in leathery and hard lesions. This finding is consistent with Bowden's extensive review (46). Thus, the

'softness' criteria in defining active lesions, has been validated by the presence of microbes which are assumed to be actively advancing the lesion.

5.3 Natural history of root caries

The natural history of a disease refers to well-defined stages of disease (47). Conventionally, these are:

i. Stage of pathological onset;
ii. Pre-symptomatic stage; from onset to the first appearance of symptoms and/or signs - the stage at which screening programs are aimed; and
iii. Clinically manifest disease, which may progress to a fatal outcome, or be subject to remissions and relapses, or regress spontaneously leading to recovery.

Only one article (48) was found that explicitly claimed to address the natural history of root surface caries. In that study the investigators examined 94 extracted teeth with 155 lesions. They found that, at the earliest stage, the lesions were small and round, which then appeared to have coalesced to form typical larger elliptical lesions which could extend to the facial or lingual surface. Proximal surfaces were almost always the first surface attacked. Others (37) have proposed a model of the natural history whereby the sound tooth moves from one surface to increasingly diseased states on additional surfaces. Only the latter group has observed the same teeth in the same subjects in a longitudinal study but the investigators found it difficult to separate true changes from scoring inconsistencies.

Billings (49) has provided a staging classification, termed the Root Surface Caries Severity Index, as follows:

Grade I (Incipient)

i. surface texture: soft, can be penetrated with a dental explorer;
ii. no surface defect;
iii. pigmentation: variable light tan to brown.

Grade II (Shallow)

i. surface texture: soft, irregular, rough, can be penetrated with a dental explorer;
ii. surface defect: less than 0.50mm in depth;
iii. pigmentation: variable, tan to dark brown.

Grade III (Cavitation)

i. surface texture: soft, can be penetrated with a dental explorer;
ii. penetrating lesion, cavitation present greater than 0.50 mm in depth, no pulpal involvement;
iii. pigmentation variable, light brown to dark brown.

Grade IV (Pulpal)

i. deeply penetrating lesion with pulpal or root canal involvement;
ii. pigmentation variable, brown to dark brown.

5.4 Evidence for diagnosis

There is no classification system to rank study designs for diagnosis. Ideally, the results of a diagnostic test would be verified against an independent 'gold standard' using patients with a full range of disease. For root caries such a study might follow the design where teeth are probed, radiographed, then extracted and sections examined for their histopathology. The sensitivity and specificity or likelihood ratios can then be derived by comparing the results of the diagnostic methods with the histopathology - the gold standard. There is an obvious problem in obtaining ethical approval for such a study. Compromises, therefore, have to be made to use already extracted teeth, or to compare clinical probing with radiographs.

In one such study, Schupbach and others (50) examined the histopathology of both inactive lesions and active lesions classified according to the Billings' staged criteria. Most lesions in cementum (which we assume was Billings' Grade I lesion) exhibited a uniform demineralization of both cementum and the underlying dentin. Two other patterns of demineralization were also seen; radially oriented radiolucent strips located between the bottom of the microcavity in cementum and the cemento-enamel junction

with halo-like areas of increased radiolucency at the endings of the strips in the peripheral dentin, and uniform demineralization of cementum and peripheral dentin below a mineralized surface.

Initial dentin lesions (Billings' - Grade II?) showed a step-wise destruction of peripheral dentin with penetration of micro-organisms along multiple small, perpendicularly oriented, clefts. The clefts tended to expand laterally and toward the root canal often fusing with each other forming micro-cavities which then appeared to enlarge. Advanced lesions (Billings' - Grade IV?) demonstrated two patterns. The first showed more than one radiolucent area which varied in depth and extent along the exposed root surface. The second was a saucer-shaped radiolucent area extending into dentin.

Arrested lesions also showed two patterns: one described as 'truly arrested' where the lesions were almost completely remineralized; the second 'mixed' where there were areas of active and remineralized tissue.

Aside from not reporting the diagnostic criteria precisely according to the Billings' grades, the authors did not report the data in the form that we can use the histopathology to calculate the accuracy (sensitivity, specificity, etc.) of the classification system. However, we do have some confidence that 'sensitivity' of the Billings' classification system is validated by the presence of organisms deeper into the lesion.

The database was then searched on all fields using the terms 'diagnosis', and 'reliability'. The search identified 57 articles, which were reviewed to determine if they met the criteria of inclusion into an evidence table. The inclusion criteria were: primary studies, or systematic reviews; studies of true caries over a range of disease (sound to diseased); and comparisons of diagnostic categories with one or more independent assessments. Among 52 studies excluded from the table were non-systematic reviews and predictive tests. Six studies were not included in the evidence table but were cited in the text to describe lesions. Five studies were found to enter into the evidence table on diagnosis and the results from the three reliability studies were reported in the text.

Table 3 shows the abstracted results of the five diagnostic studies (31, 51-54). None of them provides strong evidence. The accuracy of the sensitivity and specificity values for radiographs, calculated from two studies that provided sufficient (albeit somewhat inconsistent) data, are unlikely to apply in everyday practice since the radiographs were taken on single extracted teeth and the 'gold standard' - hand examination - was not 24 karat. The study on the modified explorer again used a weak gold standard. The two final studies did not provide sufficient data to calculate the sensitivities or specificities but were included since they used microbiological profiles of the lesion (not the surface) to show that there is some validity to the texture classification system, but little validity to color classification of lesions.

Reliability of few of the diagnostic systems has been reported. Rosen et al. have shown that three examiners achieved intra-examiner Kappa scores of 0.47 - 0.51, and inter-examiner Kappa scores ranging from 0.30 - 0.51 on their four category classification system (45). Banting (29), in a review paper, reported on a previously unpublished study of the reliability of two examiners ratings of root surface decay from radiographs. The bitewing radiographs showed over 100 lesions but the examiners agreed on only 28 lesions, on 64% of all calls, for a Kappa of 0.58. Mojon et al.(55) have reported that two examiners achieved at best fair (Kappa 0.36, 0.42) intra-examiner agreement but somewhat better (Kappa = 0.61) inter-examiner agreement using the Hellyer et al. (30) criteria for texture and the Fejerskov et al (44) criteria for activity.

5.5 Evidence for therapy

The database was searched for the occurrence of the word 'treatment' in any field. The search identified 69 articles, which were reviewed to determine if they met the criteria for inclusion in the evidence table. The inclusion criteria limited studies to: primary studies of any kind - controlled/uncontrolled; valid diagnostic and outcome criteria i.e., diagnostic systems used by others or closely resembling others; duration - one year or more; number of subjects - no minimum. Seven studies were entered into the evidence

table on remineralization and four for the restoration evidence table. As seen in Table 6, 58 studies were excluded; these consisted of trials of less than one year duration; expert opinion; technique (how to); and non-systematic review articles.

5.5.1 Remineralization

Featherstone (56) holds that the demineralization and remineralization processes ...'.are comparable...' to those of enamel caries, however the extent and ability to remineralize roots may be compromised due to the higher organic content of the roots.

The evidence gleaned from the seven studies on remineralization is seen in Table 4. In four of the studies the investigators randomly assigned the test and control interventions. However, each of these studies has characteristics that limit the confidence of the findings. The study with the highest level of quality was conducted over four years in Birmingham AB (57) and was limited only by the apparent lack of 'blinding' of examiners and subjects. Even with that limitation the recommendation is graded at the A level indicating that this is good evidence. The Boston and Portland study (58) spanned only one year; the Netherlands (59) study ran one year with no blinding and both were therefore judged to provide fair evidence upon which to make a recommendation (B). The Texas study (60) was limited by the few (6) subjects, imbalance in the random allocation, and lack of blinding. For one regimen (home use of fluoride gels) where there were no controls, it was seen to provide insufficient evidence upon which to base a recommendation – C; for the recontouring and smoothing and home use of fluoride gels it rates a tentative B. The other three studies (43, 61, 62) were conducted over 1 to 4 years, but lacked control groups of any kind, which must limit the confidence readers place in the findings.

5.5.2 Restoration

Table 5 shows the findings of the four studies showing the evidence for the restoration of root caries lesions. The evidence for restoration recommendations is thus neither plentiful nor strong. The outcomes are intermediate, that is, they are measured on

clinical retention and acceptability of the restoration as compared to a health related outcome such as longevity of the tooth or improvement in functional ability. The strongest study (63) was conducted on 50 subjects with 104 lesions. While the allocation to treatment groups was random, the study ran for only 12 months, and there was a relatively large (31%) loss to follow-up. Thus the grade of the recommendation is set at (a weak) B or '... fair evidence to support the recommendation...'. Others might well argue for a lower grade of recommendation given the study's limitations.

The other studies (60, 64, 65) lacked control groups, but with retention rates of 97% or higher would seem to demonstrate '... dramatic results of uncontrolled experiments...' so they are classified as II-3 level studies. However, each study ran for only 2 or 3 years and again the long-term effects, especially potential harms, can not have been fully demonstrated. Thus, the recommendation for each is graded as C or '...insufficient evidence to recommend for or against...' the findings.

6.0 CONCLUSIONS

6.1 Prevalence and incidence

For a new patient, the best estimate of the probability of root caries comes from the NHANES III study. With no other information, a dentist could expect that the probability of a new patient having one would correspond to the age-specific prevalence estimated by the 1988-91 survey. From age 40 on this probability is very roughly 20% less than their age (i.e., a 50 year old has a ~ 30% probability of having had one or more RDF lesions). Severity, as measured by the mean number of lesions, also increases with age, reaching over 1 lesion by age 45-54, over 2 lesions by age 65-74 and over 3 lesions by age 75. These baseline estimates would be adjusted, up or down, by the risks identified by the patient's symptoms and history.

For a yearly re-examination of a previous patient, the central estimate, derived from the incidence table, is that the community-dwelling population has probability of roughly 8%

(odds of 1:11) of acquiring one or more lesions per year. Dentate patients would be, on average, expected to acquire 0.19 new surfaces per year. Again these estimate should be adjusted up or down by the patient's previous experience and other risks.

In a perfect world, dentists would be able to use these estimates as pre-test probabilities to apply the results of their diagnostic examinations and other adjunctive tests to establish post-test probabilities of true lesions. As we have seen and will discuss later, the evidence for the accuracy of currently available diagnostic tests is lacking.

6.2 Natural history

Only one of the models (37, 48, 60) of the natural history of disease deals with the disease progression among the same teeth in the same individuals. Practitioners have little to guide them as to the probabilities of the lesion moving, or the time that it takes to move, forward (or backward) through the stages. In normal, healthy patients the impression is that the lesion advances slowly. We do know from the studies on remineralization, that early lesions appear to arrest with the application of fluorides.

6.3 Diagnosis

Based on the evidence, practitioners lack valid and reliable methods to diagnose root caries with predictable accuracy. There is correspondence between the clinical diagnosis and the penetration of lesions by microbiota (31). However, the accuracy of the various diagnostic classification systems was not assessed in a true clinical setting (51, 53), and the strength of the evidence is, therefore, weak. The fair to poor reliability of the diagnostic criteria (45, 55) even when using radiographs (29) may be further indication of the lack of clear-cut case-definitions/diagnostic standards. In one study, color was discounted as a valid diagnostic criterion (54).

Two studies rating radiographs against hand-held, clinical examination of extracted teeth both have inconsistencies in the reported findings such that the confidence in the values in the 2X2 table derived from data reported in the paper is not absolute. Perhaps because of that, the derived estimates of sensitivity, and especially specificity, are not robust.

Practitioners are left with systems of diagnosing the disease which have low reliability, and for which the accuracy is unknown. While in reality, there is little to recommend one over the other, the texture components of the Billings (60) and the Hellyer (30) systems have at least been shown to correspond to histopathology (50) and penetration by micro-organisms (31).

6.4 Therapy

6.4.1 Remineralization

Based on the summary analysis of the evidence, practitioners could expect to remineralize/arrest their patients' root surface lesions with:

- Daily NaF (0.05%) rinses in a fluoridated community (I, A) (57);
- APF (12000 ppm) gel, at four-month intervals, along with extensive home care consisting of daily 5000 ppm NaF gel daily and twice daily brushing with a fluoride dentifrice (I, B) (58);
- Fluoride varnish at three-month intervals (I, B)(59); and
- Chlorhexidine varnish at three-month intervals (I, B)(59).

Other combinations of fluorides for which the evidence of efficacy is less strong include:

- a mean of 7 fluoride varnish applications per year plus twice daily lozenges or rinses (II-3, C)(61);
- 16 daily gels at home plus home rinsing(II-3, C) (62) and
- use of fluoride dentifrice plus 2, 2 min applications of sodium fluoride to lesions (II-3, C) (43)

For the one other remineralization protocol, the evidence is very tentative:

- Recontouring, smoothing and daily NaF gel applications (I, C) (60).

The use of fluoride in its various forms and in combination is supported by all studies in the evidence table building confidence in the recommendation for its use in home dentifrice, daily rinses or gels, and applied clinically at three to four-month intervals. However, the evidence for chlorhexidine comes from one arm of one study containing 16 subjects with only 9 of 62 initial lesions actually hardening - hence the tentative B grade of recommendation.

6.4.2 Restoration

Based on the results, practitioners could restore their patients' root surface lesions with (Grade of recommendation):

- Composites (I, B) (63);
- Composites with bonding agents (II-3, C) (64, 65);
- Glass Ionomer Cements (I, C) (60).

7.0 Discussion

This systematic review demonstrates a lack of evidence upon which to decide, with a strong degree of confidence, on the most appropriate methods for practitioners to manage root caries. The first area of concern is the lack of evidence for the accuracy of the diagnostic methods. No proper study was found that allows us to calculate the accuracy of clinical diagnosis or adjunctive clinical tests such as radiographs. Indeed so few studies were found, that studies of weaker design, some containing data inconsistencies, were included in the evidence table just to have something to report. Compounding the problem of the diagnostic accuracy, is the demonstrated evidence of the low inter-examiner reliability of the existing diagnostic categories.

Practitioners are left to diagnose root caries with the clinical descriptions, especially the soft/leathery/hard probing criteria, provided by Billings (60) and Hellyer (30) which, to a limited degree, have been validated.

All estimates of disease prevalence and incidence were made with the same or similar unreliable diagnostic methods. Thus, the lack of robust diagnostic methods spills over into estimates of the prevalence and incidence of root caries lesions and impedes our ability to fully describe the natural history of the disease. One system assumes that the disease can only develop on exposed roots. While that may or may not be true, lesions are found below the free gingival margin and practitioners need to examine all surfaces above the gingival attachment.

Evidence for the risk factors for and prevention of root caries is to be found in the other appropriate reviews from the Consensus Conference.

For the treatment of root caries the available evidence supports remineralizing with fluorides rinses (I, A) and, somewhat more tentatively, fluoride gels and varnishes, chlorhexidine varnish (1, B), and very tentatively recontouring and remineralizing with fluoride (I, B). While there is only one strong study that shows that lesions can be 'reversed' with fluorides, the other studies of weaker design or shorter duration support this finding. The evidence for the efficacy of recontouring followed by home-treatment with sodium fluoride gels was demonstrated among only 16 lesions in six people.

Evidence for the restoration of lesions is even more tentative; we found no studies that compared methods of restoring root caries over what would be considered a sufficiently long term. The longest study was 3 years in duration; the only controlled comparison ran for one year. From the very limited data, dentists may restore root caries with composite resins (I, B), although conventional practice may allow glass ionomer (I, C) or even amalgam (no studies).

Generally, the studies on the management of root caries do not offer strong evidence to assist dentists in the care of patients; the studies are both few in number, and compromised in design, execution, or duration. The literature is so limited that the issues around which approach might be more appropriate in terms of patient preferences, costs, and efficiency can not be addressed. Clearly research is needed to: validate the accuracy of, or develop valid, diagnostic methods; add to the evidence on the efficacy of therapeutic measures through more rigorous design extending over longer periods; and begin to address issues of patient-based measures of outcomes.

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