THE MANAGEMENT OF ROOT CARIES

An Evidenced Based Report

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THE MANAGEMENT OF ROOT CARIES

An Evidenced Based Report

1.0 Background and purpose

Root caries is a disease of humans, which manifests as lesions on the root surfaces of teeth producing loss of the natural tooth structure. The lesions progress to deeper and deeper levels of the root as well as spreading laterally to enwrap it. Ultimately a lesion can progress to involve the pulp, threatening the viability of the tooth, producing pain and eventual tooth loss. When located between the teeth, the lesions are difficult to access and therefore difficult to excise and restore. In otherwise healthy, North American populations, root caries lesions increase with age.

This report sets out to provide evidence-based guidelines on the management (diagnosis, prediction, prevention, and treatment) of root caries for Toronto Public Health staff based on the best available evidence.

2.0 Target population

This report is aimed at the management of root caries among people, but especially seniors, who are eligible for care from Toronto Public Health. Toronto is a multicultural metropolis of about 2.4 million people of which 19% are seniors (Toronto District Health Council, 1998). Dental diseases are more common among lower income people (Locker and Ford, 1994). Disability as measured by diminished performance of activities of daily living (ADL) would be expected to limit people's abilities to maintain preventive home-care practices and to visit a dentist. Visiting is known to depend on having higher incomes, having dental insurance, (Miller & Locker, 1999) and having natural teeth - rather than complete dentures (Bullen, 1982). Utilization of private dentist's services declines once people reach aged 65 since all of the above determinants decline. Thus, residents of seniors homes (who are often over 85 years of age) and the poor independently-living elderly are more likely to experience dental diseases, less likely to be served by private dentists and more likely to become clients of Toronto Public Health.
Toronto Public Health dental staff provide care to seniors in seniors' residences and to independently-living seniors. By and large, clinical services for seniors is demand based; patients present for care, are treated but are not recalled for preventive maintenance. A few return requesting preventive care, but most are seeking care to alleviate new symptoms. Until now, dental staff have had no evidence-based guidelines to assist them in determining the most appropriate care. Thus, staff of the health department need guidelines to serve their dentate, elderly, lower income, multicultural clientele.

3.0 Clinical problem

While root caries is a subject of substantial interest in dental literature, little has been done in terms of identifying criteria for clinical decision-making in order to guide the clinician in its management. Such criteria would include a precise case-definition, complete description of the natural history, diagnostic and predictive test cut-offs and guidelines for prevention and treatment based on high quality clinical trials.

For the purpose of this report, we use Katz’ description (1986) of root caries lesions: "...soft, irregularly shaped, dark colored, progressive lesions either totally confined to the root surface or involving the undermining of enamel at the cemento-enamel junction, but clinically indicating that the lesion initiated on the root surface...". The lesions tend to occur in areas covered by bacterial plaque and form slowly. A variety of factors contribute to causing a gradual porosity under the plaque which progresses to a small carious lesion that may eventually form caries that will require treatment (König, 1990).

According to Katz (1986), the lesions can be active or inactive. Lesions are believed to be active, with or without frank cavitation, if they exhibit both a darkened and discoloured appearance as well as a tacky or leathery feel when probed. Inactive lesions are stated to be identical to active lesions except that their surface does not feel tacky or leathery when it is probed.

Root caries is primarily a dental condition association with aging populations (Kitamura et al., 1986; Beck, 1990). Statistics Canada’s population predictions show both an increase in the total number of individuals aged 65 and older, as well as an increase as
a percentage of the total population. At present, Statistics Canada estimates that those aged 65 and older account for 12.4 percent of the population and predicts that proportion to increase to over 21 per cent in 2026. Thus, dental practitioners are likely to encounter increasing numbers of older patients and, even if the prevalence of the disease stays constant, will need to manage root caries more often.

4.0 Clinical flexibility

This report deals with the management of root caries in those seniors attending or expected to attend the Toronto Public Health dental clinics and those in institutions served by the seniors' preventive program.

The findings and conclusions report may not be generalizable to younger patients with unusual susceptibility to root caries or to those with severe disabling conditions which might prejudice the effects of preventive or interventions shown successful in more representative groups.

5.0 Structure of this report

The findings of the current review are presented in this evidence-based report. The structure of this report is based on the template proposed at the RCDSO/CDHSRU Workshop (Leake et al., 1996). The template covers the following areas:

1. Search strategy
2. Inclusion criteria
3. Summary of evidence
4. Comparison of Outcomes
5. Evidence-based recommendations and any minority views
6. Comments or suggestions for further research.

6.0 Evidence for root caries prevention, diagnosis, and treatment
6.1 Search Strategy

The search for scientific evidence on the research questions was performed using five different databases. Limiting the searches to local holdings and articles in either English of French, we conducted the following computerized literature searches:
1. Medline <1966 to August 1999>
   i. Abstract = Caries
      or Title = Caries
      Yield = 13527 articles
   ii. Textword = Root
        or Title = Root Caries
        Yield = 29474 articles
   iii. The two sets of references 1 & 2 were combined
        Yield = 221 articles

2. Pubmed
   i. Subject heading = Root Caries
      Yield = 19 articles

3. The same search strategy described for Medline was used for biological
   abstracts, nursing collection and Ageline, but did not yield any articles that had
   not been identified in the previous searches.

Following this, the research assistant screened the literature cited in the 240
papers to identify any other articles that might yield evidence relevant to the research
questions a further 58 articles were identified. The abstracts of the 298 articles were then
screened by the senior investigators and 204 were excluded because they were unrelated
to the topic e.g., root fillings as an endodontic procedure, or in-vitro studies. Thus, 94
were retrieved and copied from the library at the Faculty of Dentistry, University of
Toronto. The senior authors then read and scored all 94 articles to obtain the evidence
for this review.
6.2 Inclusion/Exclusion Criteria

At the first stage, we selected only those papers that involved human subjects, which were available at the University of Toronto and were written in either English or French. At the second stage the senior investigators selected only articles that were relevant to the topic. At the third stage, we selected the best available evidence using inclusion criteria and the strength and quality of the studies according to the level of evidence classification system developed by the Canadian Task Force on the Periodic Health Examination (CFTPHE, 1994) and the checklists.

The CFTPHE system of ranking the quality of evidence applies to assessing the evidence for the efficacy of an intervention and to a lesser extent assessing causation, since ethically and practically, investigators can not randomly allocate suspected causes to subjects. The CFTPHE system does not apply to studies assessing the strength of the evidence on the prevalence or incidence of disease, diagnostic or predictive tests, or economic evaluation. However, quality appraisal criteria for such studies have been assembled (Leake, 1999) and were employed to critically appraise the evidence from studies designed to answer those questions and to score the quality of the studies on efficacy of interventions.

The two senior authors (JLL, PAM) scored all 94 studies independently. Where their scores differed by two or more points, the investigators met to establish a final score for that study. The findings of the included studies were abstracted directly into evidence tables by one person (ER) in consultation with one of the senior authors (JLL). A separate evidence table showing the relevant findings of each study was constructed for each section of this report.

6.2.1 Inclusion/Exclusion Criteria for Prevalence Studies

Given that this report is designed to guide dentists working in the Toronto Public Health clinics we decided that reports of the extent of the disease in North American populations could be of relevance. In order to relate the findings to populations, only studies reporting the prevalence or severity of root caries in mean numbers per person
were considered. We identified and copied 20 potential studies which were then scored by the two senior authors using the critical appraisal form on prevalence and incidence. All studies with scores of 6 or higher from one or both of the authors were retained for this report. Of 19 studies, 5 were discarded and 14 were retained and are summarized in Table 1.

In addition to these general population prevalence studies, we identified 6 studies that described the prevalence of root caries in special populations in North America; none was excluded. Of these 6, 2 of were also listed in the normal population prevalence evidence table since the investigators (Streckfus et al., 1990; Hawkins et al., 1998) compared the prevalence of root caries between the general and the special populations and the remaining 3 were specific to special populations.

6.2.2 Inclusion/Exclusion Criteria for Incidence Studies

As with the selection of prevalence studies, we limited incidence studies to North American populations. Eight (8) incidence studies were identified, copied and scored. Studies with scores of 6 or higher from one of the two authors were retained for this report and are summarized in Table 3.

6.2.3 Inclusion/Exclusion Criteria for Studies on Determinants of Root Caries

We identified 40 studies that purported to examine the determinants of root caries. Since determinants could well be the same across cultures, studies conducted both within and outside of North America were identified. However, since studies of single factors do not allow for the control of confounders, we elected to exclude all studies that did not examine the relative importance and the statistical significance of the determinants using regression methods. Since longitudinal studies provide a higher level of evidence than do descriptive or cross-sectional studies, we also rejected all prevalence studies and included only longitudinal or incidence studies (Level of evidence II-2).
With the application of these exclusion criteria, 6 studies remained. Of these, 3 (Beck et al., 1988; Joshi et al., 1993; Lawrence et al., 1995) were included in the earlier incidence table, Table 3.

6.2.4 Inclusion/Exclusion Criteria for Studies on the Prevention of Root Caries

We identified 9 studies that examined the prevention of root caries. All studies with scores of 10 or above from one or both of the authors were retained. Two (2) studies were excluded, leaving 7 studies to be included in the evidence table, Table 5.

6.2.5 Inclusion/Exclusion Criteria for Studies on Root Caries Diagnostic Tests

From our literature search we identified 6 studies that examined diagnostic methods for root caries. These studies were generally weak in design and to have any findings for the evidence table, studies with scores of 3 or above from one or both of the authors were retained. Three (3) studies were thereby excluded, leaving 3 studies to be included in this report (Table 6).

6.2.6 Inclusion/Exclusion Criteria for Studies on Root Caries Therapies

Our literature search yielded 4 articles on available restorative therapies for root caries. Due to the limited number of studies, we elected to retain them all - Table 7. For remineralization, there were 8 studies. We excluded all those without control groups thereby retaining 4 (Table 8).

7.0 Summary of evidence

First we hold to the convention that the disease is root caries and that the lesions are the manifestation of the disease. The etiology and natural history of root caries is still poorly understood. The only universally acknowledged condition is that there needs to be a susceptible root surface in order for a root lesion to develop (Newbrun, 1986). The lesions can begin either in a tooth's cementum or dentine (White et al., 1994).
Because of the cementum and dentine's much higher organic content than enamel (55% versus 0.2-0.4%), they are stated to be more vulnerable than enamel to demineralization (Hoppenbrouwers et al., 1986). The stated theory is that a root lesion is the result of both a proteolytic and a demineralization process with microbiota implicated as the biological agents (Fure & Zickert, 1990; Ravald et al., 1993; Scheinin et al., 1994; Lawrence et al., 1995).

The etiology of root caries is however, not straightforward. Beck et al. (1987) found that different teeth have different susceptibilities and that in spite of having the most recession, mandibular anterior teeth were the least likely to develop root caries.

7.1 Prevalence

Prevalence and incidence rates only help paint a picture of the epidemiology of root caries. The lack of a precise diagnosis for root caries means that the rates quoted here may be influenced by what Banting (1993) refers to as "...the different populations studied, dissimilar observation periods, the lack of uniformity of diagnostic criteria, and the inclusion/exclusion of other conditions...". All these factors contribute to some variation in the prevalence and incidence rates quoted here.

Table 1 displays the prevalence rates reported in 14 North American studies on root caries for adults ranging from 18 years of age and older. In the literature, the prevalence of root caries is measured in at least three ways - prevalence (% of people affected) and two severity indices. The first severity index describes the average number of affected root surfaces per person within a given population. The second, the root caries index (RCI), is defined according to the formula:

\[
(\text{No. of root caries lesions}/\text{No. of teeth or surfaces with gingival recession/person}) \times 100
\]

The RCI was developed by Katz in the 1980's (Katz, 1984) and according to him, it "...delineates the true intra-oral population at risk...". The RCI takes into account the number of sites within a person that have gingival recession, presumed to be at higher susceptibility. This is also called the attack rate and is the number of lesions per 100 presumably susceptible (i.e., those with recession) surfaces.
The RCI is a measure of the prevalence per exposed root surfaces and does not therefore convert to a simple estimate of prevalence or intensity in the population. In contrast the mean number of affected root surfaces per dentate person gives the clinician a simpler method to estimate the likely burden of disease in his/her clinical population. However, part of the literature reports only RCI scores. Therefore, studies reporting prevalence in persons or the mean number of lesions will be used in this report although attack rates will be cited for included studies.

Because root caries is primarily associated with older age it is important to examine studies by age-group. To illustrate, if we compare results of studies that look at individuals aged 18 and over with studies looking at individuals aged 50 and older, we see a substantial difference in reported RCI scores (Table 1). The largest study demonstrates this difference in prevalence; 18% of females and 24% of males of working age had one or more root carious lesions, whereas between 61% and 66% of seniors had one or more lesions. Prevalence in other studies of seniors ranged from 46% in Florida (Heft and Gilbert, 1991), 51% among white adults in North Carolina (Graves et al., 1992) 63% in Iowa (Beck et al., 1986), and 71% in Ontario (Locker et al. 1989; Locker and Leake, 1993). While the prevalence estimate is dominated by the national data in the United States Department of Health and Human Services (USDHHS, 1987), the other studies are consistent with 62%-63% (odds ~ 5:3) of dentate older adults having root caries. For seniors, the more recently published NHANES III (Winn et al., 1996) data show considerably lower estimates of prevalence (47%-56%), but close to the same levels of severity. The major outlier is the Hawkins et al. (1998) study, but they studied only 62 dentate people, all aged 85 and older.

For younger populations the estimates are again dominated by the large United States (USDHHS, 1987) study and the NHANES III (Winn et al., 1996) data. For working age adults, the estimate of prevalence is approximately 20% or odds of 1:4.

Severity scores from the USDHHS (1987) and NHANES III (Winn et al. 1996) demonstrate that as age increases, so does the mean number of affected root surfaces per person. For example, in the USDHHS survey, at age 18 to 19, the number of root surfaces per person was 0.11; at age 45 to 49, this increases ten-fold to 1.06 root surfaces per person and at ages 70 to 74, the severity almost triples again to 3.11 root
surfaces per person and at ages 70 to 74, the severity almost triples again to 3.11 root surfaces per person. Given the prevalence data from USDHHS and NHANES III we might expect that seniors would have between 2.2 and 3.5 (say 2.8) lesions. Since these occur in those among the 50% to 70% (say 60%) of people over aged 65 who are affected, they should be expected to have roughly 4.7 surfaces affected.

While the relationship between older age and number of root surface caries per person is obvious, there appears to be a direct relationship between the number of teeth and the number of affected root surfaces per person (Beck, 1993). This has been statistically confirmed by regression in a number of studies (Beck et al., 1988; Ravald & Birkhed, 1992; Joshi et al., 1993; Locker & Leake, 1993; Joshi et al., 1994; Vehkalahti & Paunio, 1994). For example, the population studied by Streckfus et al. (1990), exhibits only 1.7 root surface lesions per person, where the average number of teeth was only 12.5. In comparison, the population studied by Papas et al. (1995b) exhibits 4.4 root surface caries where the average number of teeth was 21.6.

Evidence Table 2 examines the prevalence of root caries among special populations. Note first that the prevalence displayed by residents of institutions is somewhat different from the prevalence displayed in the general population. The institutionalized population in the Streckfus et al. (1990) study shows a moderate level of root caries (2.7 root surface lesions per person) but others such as those studied by Banting et al. (1980), show a markedly high prevalence of root caries (7.3 lesions per person) especially since this is a relatively young group (ranging up from 35 years of age).

7.1.1 Implications of Prevalence Studies

Clinicians in Toronto Public Health can expect that from 50% to 70% of their dentate patients over age 65 will have root caries lesions and for those affected to have roughly 4.7 surfaces affected. For those living in institutions the prevalence appears likely to range from 1.5 root decayed teeth and 2.1 to 3.8 root decayed surfaces.
7.2 Incidence of root caries

Table 3 presents the evidence on the incidence of root caries in North America in individuals aged 18 to 82. Hand, Hunt and Beck report on the same dentate elderly (aged 65+ at start) adults living in Iowa in two articles, at 18 months and again at 36 months. At the 18-month follow-up, men (30.6%) had a higher incidence of root caries than women (28.7%). At 36 months, the annualized incidence of both the percent of people developing one or more new lesions (14.6% vs. 29.4%) and the mean increment of lesions (0.36 vs. 0.57) was lower than at the 18-month period. This apparent reduction of incidence is curious, but illustrates the finding from the Table 2, namely that the incidence rates from longer studies are lower than those from studies over shorter periods. Perhaps this is the result of the reversals seen in clinical trials of preventive agents (Wallace et al., 1993) which has been attributed to the dynamic environment of demineralization and remineralization in which root caries develop. It may also be the result of loss to follow-up as discussed below in the context of the Lawrence et al. studies (1995, 1996).

Leske and Ripa (1989) followed younger (mean age 39.9 years at start), dentate people from Long Island, New York over 36 months and found annualized incidence rates of 6.2% of people and 0.15 new lesions per person. The population studied by Joshi et al., (1993) over 24 months was older, which may account for the higher reported incidence rate.

The study by Wallace et al. (1993) is one of two studies beyond 36 months in duration. While this study tested the efficacy of preventive regimens, one of the three groups was an untreated control. The placebo group experienced a significantly larger yearly increment in root caries than did the other groups. However, the incidence of 0.2 surfaces per person per year is far smaller than rates found in any of the other studies, especially when the advanced age (60 years and above) of the subjects is considered.

The 36 month study by Lawrence et al. (1995) included non-institutionalized adults aged 65 and above in North Carolina, USA. The results of the study were stratified according to race and illustrated that older blacks were less likely to develop root caries than their white counterparts. Their report of the same subjects after 5 years (Lawrence et al., 1996) illustrates the problem of loss to follow-up. Contrasting the three and five
year results it is apparent that those who remained at five years were healthier (had more teeth) at baseline and had experienced less decay in the initial three year period of the study - see summary of their 1996 report in Table 3. Those available for examination at 5 years were clearly the 'healthy survivors'. Estimating incidence must be based on studies that have low loss to follow-up.

7.2.1 Implications of Incidence Studies

All but one of the estimates of incidence come from studies in the United States. Using the data from the four studies of three years duration among populations that are not exclusively Black, (Hand et al., 1988, Leske and Ripa, 1989, Lawrence et al., 1995, Locker, 1996) the percent of dentate subjects experiencing one or more new lesions per year ranges from 6.2% to 14.6%. These same three studies found mean increments in severity of ranging from 0.15 to 0.36 new RDFS lesions per year. Calculating a duration/sample-size weighted central estimate of the results of the four longest studies shows that the 8.2% of subjects would be expected to acquire one or more new root caries in one year.

Those four studies, plus the Birmingham AB study (Wallace, 1988), show that dentate people would, on average, be expected to acquire 0.19 new RDFS per year. Given that all the new lesions must occur in the 8.2% patients who acquire one or more, examiners should expect to find an average of roughly 2.3 new lesions for those patients who have at least one new lesion (.19 divided by .082). Given that most of the patients returning to the Toronto clinics seek care for new symptoms, clinicians should expect to find almost all of their returning, elderly patients with one or more new lesions.

7.3 Determinants of Root Caries

As seen by the studies on prevalence and incidence the epidemiologic triad of age, sex and race are major determinants of root caries. The number of root lesions is higher among older people compared to younger, whites as compared to blacks, and men over 50 as compared to women over 50 (USDHHS, 1987). If we limit our examination of the
determinants of dental caries to the highest level of evidence, longitudinal studies that examine the factors using regression techniques (Level II-2), six studies contribute to this section (Beck et al., 1988; Ravald & Birkhed, 1992; Joshi et al., 1993; Ravald et al., 1993; Scheinin et al., 1994; and Lawrence et al., 1995).

The evidence from these studies is shown in Table 4. The picture, however, is far from clear, with some studies finding some determinants significant and others finding the same determinants insignificant. Even within the first study (Beck et al., 1988), there is contrasting direction of the risks of disease relative to the number of teeth, with more teeth being protective and fewer teeth being causally related.

If we consider the determinants at two levels, general and local, general factors found to determine root caries include:

- age
- retired or unemployed
- social integration and support (protective effect)
- resides in a fluoridated community for 30 years or more (protective effect)
- has impaired daily living activities
- perceives more problems since age of 40
- perceives that teeth have a negative impact on appearance
- high anxiety
- use of sugared foods
- current use of tobacco
- recent onset of illness
- taking antihistamines
- has taken calcium

Local factors include:
- having 23 or more teeth (protective effect - two studies)
- having teeth
- having 9 or fewer teeth
• having root fragments
• wearing partial denture
• having high baseline coronal caries (two studies)
• having high baseline root caries (three studies)
• having recession (not significant in males, significant in females and in a second study)
• having recession in combination with pocketing
• bleeding on probing
• plaque (significant two studies; not significant in third study)
• presence of *lactobacilli* (significant one study - OR = 8.6; not significant in a second study)
• presence of *prevotella intermedia*

The results of the studies have not been reported in a consistent fashion, thus any attempt to combine the results or to identify the strongest risks across the six studies would not be valid. Scheinin et al. (1994) report the strongest relationships: these were previous root decayed and filled surfaces (RDFS -OR = 12.8) and lactobacilli (OR = 8.6). Lawrence et al. (1995) found taking antihistamines and perceiving more problems (OR ≥ 4.0) and various combinations of probing and recession measures (OR 3.35 - 4.50) had medium strength and Ravald et al., (1993) found that bleeding on probing predicted 38% of the variation. Whether these factors, even if convincingly seen as risks elsewhere, would increase the risk of root caries in older persons in multicultural Toronto is also not clear.

7.3.1 Implications of Determinants Studies

Until the determinants become more precisely defined, practitioners can only be advised to keep the general factors in mind when taking a history and the local factors when examining a patient. For the Toronto staff dentists, the background prevalence of 50% to 70% probably influences their 'index of suspicion' more than any of the determinants. However living alone, a past history of root caries and various
combinations of recession and pocketing should probably raise the probability of root caries above the background (population) prevalence levels.

7.4 Prevention of Root Caries

Seven studies were retained which provide evidence that root caries is preventable (Table 5). These methods include:

- Water fluoridation
- Fluoride dentifrice
- Topical APF gel
- Fluoridated mouthrinses
- Saliva stimulation

7.4.1 Water Fluoridation

Fluorides in water have been demonstrated as effective in three studies (Burt et al., 1986; Hunt et al., 1989; Stamm et al., 1990). All of the studies are descriptive which would ordinarily mean that the evidence is of level III. However, since they are dealing with residence history, the studies might be considered as longitudinal which would raise their quality measure to Level II. All find a difference between residents in fluoridated and non-fluoridated communities, but in Iowa (Hunt et al., 1989) the difference is only apparent for those who have lived 41 or more years in the fluoridated community.

7.4.2 Fluoride Dentifrice

Only one study (Jensen & Kohout, 1988) has demonstrated the effect of dentifrice on root caries among older adults in Iowa, USA. The study is a randomized clinical trial and therefore of strong design but of only one year duration thus limiting its validity. Over the span of the study a 67 percent lower incidence of root caries was reported in the dentifrice group, with a 12-month caries incidence of 0.14 for the dentifrice group and 0.43 for the control group.
7.4.3 Topical Fluorides: APF Gel, Varnishes and Daily Mouthrinse

While extensive research has been conducted in establishing the efficacy and effectiveness of APF gels in preventing coronal caries (Leake et al., 1999), little research has been done on their potential for reducing the number of root caries. Wallace et al. (1993) assessed the effect of a 48-month preventive program among older adults living in Birmingham, Alabama. Participants were randomly assigned to have semi-annual topical APF gel (1.2 per cent F) applications, to rinse daily with 0.05% fluoride, or a control of a daily placebo rinse. Both test groups showed lower caries incidence than the control.

In a second study with no negative control group, Ravald & Birkhed (1992) found that there was no difference between fluoride varnish (Duraphat), stannous fluoride gel, and 0.05% daily fluoride rinses. However, the power of the study was less than 20% to detect the mean difference of 1.1 lesions.

7.4.5 Saliva Stimulants

Mäkinen et al. (1995) tested whether saliva stimulants, sweetened with either xylitol or sorbitol, reduced the incidence of caries as compared to no saliva stimulants. Subjects, recruited at the Veterans Administration Medical Center (VAMC) in Dayton, Ohio, were allocated to saliva stimulans sweetened with either xylitol or sorbitol. Non-users of saliva stimulants composed the study's control group.

The authors report very little data, stating only that a 6-month follow-up demonstrated a significant decline (p<0.05) in the active supragingival root surface caries in both of the saliva stimulant groups compared to the control group, and this rate stayed significantly lower over the 2.5 years of the study. The authors acknowledge that the results should be interpreted cautiously due to the high loss to follow-up and resulting few subjects at the end of the study. There was no report that the subjects were randomly allocated to the groups, nor that the interventions were kept distinct, i. e., that the subjects did not share or trade the gum or lozenges.
7.4.6 Evidence-Based Recommendations

The use of fluoride dentifrice (Level I-B; Jensen & Kohout, 1988), the semi-annual application of 1.2 per cent topical APF gel (Level I - A; Wallace et al., 1993) and the daily use of a 0.05 per cent fluoride mouthrinse (Level I-A; Wallace et al., 1993) and the stimulation of saliva with xylitol or sorbitol sweetened lozenges (Level II - B; Makinen et al., 1995) are efficacious and can all be recommended by examination of the primary studies. In the context that rinses and APF gels are efficacious, the Raval & Birkhed (1992) study provides evidence of the efficacy of fluoride varnishes -Duraphat (Level I-B). While a pro-active recall program component would need to be instituted to apply the semi-annual chairside topical fluorides, within the present program operating methods, clinicians could confidently recommend the use of fluoride dentifrice and mouth-rinses and chewing non-sucrose gums.

7.4.7 Need for Further Research

While these studies successfully offer preventive options for root caries, the Raval & Birkhed study lacked power to demonstrate superiority of one method over another. Further studies over longer periods with larger, more diverse subject populations are needed to compare relative costs, as provided by the number need to treat (NNT), and patient acceptability of these preventive methods.

7.5 Diagnostic Tests

7.5.1 Diagnostic Methods

Table 6 shows the limited evidence on the accuracy of diagnosis of root caries. The diagnostic methods examined include the use of conventional and modified explorers (Newitter et al., 1985); macroscopic examination, which the investigators state corresponds to clinical examination (Nordenram et al., 1988); and lesion colour (Lynch and Beighton, 1994).
The paradigm for appraising the evidence on diagnostic test is different than that used for assessing causality or the efficacy of care. A proper study for a diagnostic test means comparing the test results against a valid independent measure of truth, conventionally described as a gold standard, over a range of disease severity and alongside other similar conditions with which the condition of interest can be confused. Examples of a gold standard that would be valid include pathological sections, obtained from biopsy or post-mortem, examined under microscope. No rating scheme, similar to that of the Canadian Task Force for Preventive Health Care on efficacy, exists for studies of diagnostic testing. Thus Table 6 has a comments column where the weaknesses of the design is described.

The strongest study is that of Nordenram et al. (1988) who showed that conventional clinical methods of drying, probing and inspecting under good light produce test results with a sensitivity of .79 and a specificity of .74. However, their gold standard, radiographic appearance, was not validated by histological sections for root caries as far as we could determine.

The other two studies (Newitter et al., 1985; and Lynch and Beighton, 1994) provide little evidence for use of a modified explorer or colour given the weakness of their gold standard.

7.5.2 Evidence-Based Recommendations

Given the findings in Table 6, clinicians have no reason to change from the conventional use of standard clinical methods (drying, inspecting in good light, and probing) to diagnose root caries. With the sensitivity and specificity values reported and a prevalence of 60% - 70% clinicians can expect positive predictive values in the range of 81% or higher and negative predictive values in the range of 70% or lower.

7.5.3 Need for Further Research

Studies need to be conducted using histopathology as the gold standard. While the evidence for the use of a modified explorer is weak, given the gold standard, there may be some promise in this instrument. Other, more technologically advanced methods
may be developed for root caries as they have been proposed for coronal caries and they too need to be tested against a valid gold standard.

7.6 Predictive tests

7.6.1 A proposed model

Knowing the markers of future root caries would help practitioners predict those who might benefit from more frequent examination and preventive care. Unfortunately no predictive test has been described and tested. Jones (1995) has proposed a risk assessment model based on the recent incidence of root caries. Again the model has not been tested, however it may be of some use until a proven model is available. In the model, the patient’s risk is determined by the number of root caries that he/she developed over the past three years. Based on this, he/she will be classified as either of low, moderate or high risk.

According to the model, the following clinical criteria are used to classify patients as being at low, moderate or high risk for future root caries (Jones, 1995):

**Low risk** – No root caries in the past three years. Individuals who are classified in this category commonly have a good dental hygiene and receive regular oral care.

**Moderate risk** – 1 or 2 new root lesions in the past three years. In addition, individuals with mild to moderate gingival recession or individuals on multiple medications may also be classified as moderate risk, provided that their incidence of root caries is not superior to 1-2 new root caries in the past 3 years.

**High risk** – More than 2 new root lesions in the past three years. Individuals with severe recession, xerostomia, or who have received full mouth reconstruction should also be classified as high risk.

Given the results shown in Table 4, other factors such as fluoridation, the baseline caries experience, social supports, prescription drug use, and bleeding on probing might be added to the risk assessment protocol. Departmental staff reviewing this paper also pointed out that from their experience, patients who were no longer able to maintain
personal oral hygiene, the result of deteriorating mental or physical conditions, seemed to have much higher risk of developing root caries.

7.6.2 Need for Further Research

Our recommendations are extremely limited by the lack of evidence on the risk assessment of root caries. Additional research to develop and validate risk-assessment methods for root caries is needed.

7.7 Therapy

7.7.1 Caries Removal Methods

The literature on the removal of root caries is extremely limited. It appears that root surface caries are commonly treated using the same methods as used for coronal caries. However, root caries lesions differ greatly in location and in pathology prompting examination of specific caries removal techniques.

Tavares et al. (1988) evaluated the Caridex root caries removal system. This system uses N-monochloro-2 aminobutyric acid that is delivered through a pumping system to an applicator tip. The investigators report that all root surface caries were successfully removed by using the Caridex system in combination with a spoon excavator.

The advantages of this removal method are stated to be: the decreased need for local anesthesia and rotary instruments; the system removes only dentin; and reduced discomfort (compared to more severe discomfort felt with the use of rotary drills) felt by the patients. Conversely, the main disadvantage of this method is the additional time it requires.
7.7.2 Restoration Materials

Studies evaluating restoration materials for the treatment of root caries are scarce and weak. Four studies are found in the evidence table, Table 7. None of them examined amalgam, even as a control. Again one staff dentist who reviewed this report, claimed that where amalgam could be placed, it lasted longer.

7.7.2.1 Composite Resin

It appears that there is a wide acceptance of composite resin adhesives for the restoration of root caries. Only one (Levy et al., 1989) had a control or comparison group, but it ran only one year and had a huge loss to follow-up in the composite resin group. Two others examined composite resins over one (Sheth et al., 1988) and three (Duke et al., 1991) years but neither had a control group.

7.7.2.2 Glass-Ionomer

Two of the four studies examined glass ionomer. Levy et al., (1989) compared the use of a micro-filled composite resin (Silux™) and glass-ionomer cement (Ketac-Fil™) for the restoration of root caries. While the loss to follow-up was lower in the GIC group the rate of full retention was only 52%, and only 70% were clinically acceptable. Mechanical retention was not employed in the study and the investigators felt that retention would have been higher if they had used it. In the other study of GICs (Billings et al., 1985) all 16 lesions had complete retention.

7.7.3 Evidence for remineralization

The evidence gleaned from the four studies with control groups on remineralization is seen in Table 8. However, each of these studies has characteristics that limit our confidence in the findings. The study with the highest level of quality was conducted over four years in Birmingham AB (Wallace et al., 1993) and was limited only by the apparent
lack of 'blinding' of examiners and subjects. Nonetheless, the recommendation is graded at an A level indicating that this is good evidence. The DePaola study (1993) spanned only one year; the Netherlands (Schaeken et al., 1991) study ran one year with no blinding but both were judged to provide fair evidence upon which to make a recommendation (B). The Texas study (Billings, Brown, Kaster, 1985) was limited by the few (6) subjects, imbalance in the random allocation, and lack of blinding but was retained to demonstrate the weak level of evidence for recontouring and smoothing (13 teeth). It provides insufficient evidence upon which to base a recommendation - C, but the protocols may be followed for other reasons.

7.7.4 Evidence-Based Recommendations

Given that there was no comparator we can not recommend the use of the Caridex root caries system in conjunction with a spoon excavator for the routine removal of root surface caries. In addition, the alleged increased time factor to accomplish the caries removal plus the inability to prepare mechanical retention would place this technique behind the conventional technique.

Given the loss to follow-up, the superior retention of restorations performed with composite resins compared to glass-ionomers, and the higher rate of clinical acceptability of composite resins but only over 6 and 12 months of follow-up (Levy et al., 1989), a recommendation to use composite resins in the restoration of root caries must be tentative at best. Again the investigators' recommendation, to include mechanical retention, without having studied that procedure is of limited strength.

We see the recommendations to use composite resins and undercuts (mechanical retention) as I-C.

For remineralization, practitioners could expect to remineralize/arrest their patients' root surface lesions with:

- Daily NaF (0.05%) rinses (I, A) - Wallace et al., 1993;
- APF (12000 ppm) gel, every four months, along with extensive home care (I, B) from DePaola, 1993;
- Fluoride varnish (I, B) every three months - Schaeken et al., 1991; and
• Chlorhexidine varnish (I, B) every three months - Schaeken et al., 1991.
For recontouring and smoothing with NaF applications, the evidence is less robust (I, C) - Billings et al., 1985.

The use of fluoride is supported the four studies in the evidence table, building confidence in the recommendation through the consistency of the findings. However, the evidence for chlorhexidine varnish comes from one arm of one study on 16 subjects, with only 9 of 62 lesions actually hardening - hence the tentative B classification of recommendation and keeping in mind its known staining properties.

7.7.4 Need for Further Research

Proper studies comparing amalgam and other restorative materials need to be conducted over a sufficient period (2 years or longer) to evaluate the restorative techniques. The recommendations for remineralization would be much more definite if we had supporting evidence from additional studies over longer periods and with greater numbers of subjects.

8.0 Summary of findings and recommendations
1. Clinicians in Toronto Public Health can expect that from 60% to 70% of their dentate patients over age 65, to have root caries lesions, and for them to have, on average, roughly 4.7 surfaces affected (Table 1). For those living in institutions the prevalence appears likely to range from 1.5 root decayed teeth and 2.1 to 3.8 root decayed surfaces.
2. Toronto staff re-examining a previous patient can expect between 6% and 15% (1 in 7 to 1 in 17 - average of 1 in 9) of dentate elderly recall patients to have a new lesion. Given that all the new lesions must occur in these patients, examiners should expect to find an average of about 2.6 new lesions for those patients who have at least one new lesion.
3. Until the determinants of root caries become more precisely defined, practitioners can only be advised to keep the general factors in mind when taking a history and the local
factors when providing the clinical examination. For the Toronto staff dentists, the background prevalence of 50% to 70% probably influences their estimate of the prior probability of disease more than any of the determinants. However living alone, a past history of root caries and various combinations of recession and pocketing should raise the probability of root caries above the background (population) prevalence levels.

4. Clinicians have no reason to change from the conventional use of standard clinical methods (drying, inspecting in good light, and probing) to diagnose root caries. With the reported sensitivity and specificity values and a prevalence of 50% - 70%, clinicians can expect positive predictive values in the range of 81% or higher and negative predictive values in the range of 70% or lower.

5. The following clinical criteria may be used to classify patients as being at low, moderate or high risk for future root caries (Jones, 1995), but these have not been tested in any study:
   - **Low risk** – No root caries in the past three years. Individuals who are classified in this category commonly have a good dental hygiene and receive regular oral care.
   - **Moderate risk** – 1 or 2 new root lesions in the past three years. In addition, individuals with mild to moderate gingival recession or individuals on multiple medications may also be classified as moderate risk, provided that their incidence of root caries is not superior to 1-2 new root caries in the past 3 years.
   - **High risk** – More than 2 new root lesions in the past three years. Individuals with severe recession, xerostomia, or who have lost their ability to maintain their oral hygiene or who have received full-mouth reconstruction might also be classified as high risk.

6. For prevention the following interventions are efficacious:
   - Fluoride dentifrice (Level I-B; Jensen & Kohout, 1988),
   - Semi-annual application of 1.2 per cent topical APF gel (Level I-A ; Wallace et al., 1993)
   - Daily use of a 0.05 per cent fluoride mouthrinse (Level I-A; Wallace et al., 1993)
• Stimulation of saliva (Level II-B; Makinen et al., 1995)

• Application of fluoride varnishes - Duraphat (Level I-B; Ravalld & Birkhed, 1992).

7. For restorations, conventional practice is to use composite resins with mechanical retention (I-C; Levy et al., 1989).

8. For remineralizing, evidence from the few studies supports the use of fluorides, whether they be in the form of daily 0.05% NaF rinses (I: A, Wallace et al. 1993); APF gels every four months (I: B, DePaola 1993); and varnishes at 3 month intervals (I: B, Schaeken et al., 1991). For chlorhexidine varnishes (every three months) the evidence is from only one study with 16 subjects (I: B, Schaeken et al., 1991) and for recontouring and smoothing for 13 lesions (I: C, Billings et al., 1985).
<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects [sample (# dentate)]</th>
<th>Age</th>
<th>Mean Teeth Present (#)</th>
<th>Persons with 1 or more RDF (%)</th>
<th>Severity (RCI, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beck et al. (1986)</td>
<td>Older adults from Iowa, USA  [867 (520)]</td>
<td>65+</td>
<td>18.8</td>
<td>63</td>
<td>2.3 root surfaces per person</td>
</tr>
<tr>
<td>Burt et al. (1986)</td>
<td>Two populations in New Mexico, USA – one with an optimal fluoride level and one with 5 times the optimal fluoride level [315 (315)]</td>
<td>Adults (range not given)</td>
<td>Optimal fluoride: 23.8</td>
<td></td>
<td>RCI = 6.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5x Optimal Fluoride: 7.3</td>
<td></td>
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<tr>
<td>Kitamura et al. (1986)</td>
<td>Older adults from Washington, USA [24 (24)]</td>
<td>55 - 95</td>
<td>23.9</td>
<td></td>
<td>RCI = 17.7%  (includes institutionalized population sample)</td>
</tr>
<tr>
<td>US Department of Health and Human Services (1987)</td>
<td>2 groups of US individuals: one group of employed adults, and one group of senior citizens recruited through senior centres [20,818 (20,818)]</td>
<td>18+</td>
<td>Employed: 24 Seniors: 10</td>
<td>Employed: Males = 24 Females = 18</td>
<td>18-19: 0.11 20-24: 0.23 25-29: 0.43 30-34: 0.54 35-39: 0.52 40-44: 0.89 45-49: 1.06 50-54: 1.37 55-59: 1.52 60-64: 2.44 65-69: 2.90 70-74: 3.11 75-79: 3.41 80+: 3.52</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Weighted mean = 20.1</td>
<td>Seniors: Males = 66 Females = 61</td>
<td>(root surfaces per person)</td>
</tr>
<tr>
<td>Wallace et al. (1988)</td>
<td>Dentate older adults from Alabama, USA [603 (603)]</td>
<td>60+</td>
<td>23.5</td>
<td>69.7</td>
<td>RCI = 8.1%</td>
</tr>
<tr>
<td>Locker et al. (1989)</td>
<td>Random start selection of middle aged and older adults from East York, Canada [973 (183)]</td>
<td>50 – 88</td>
<td>17.9</td>
<td>56.8 (37.2% had untreated decay)</td>
<td>1.3 root surfaces per person</td>
</tr>
<tr>
<td>Stamm et al. (1990)</td>
<td>Dentate A) fluoridated (1.6 ppm) and B) non-fluoridated (0.2 ppm) populations in Ontario, Canada</td>
<td>18 years and older</td>
<td>Fluoridated: 24.8 Non-fluoridated:</td>
<td>Fluoridated: 20.3 Non-fluoridated: 35.9</td>
<td>Adjusted modified RCI: Fluoridated: 2.5%</td>
</tr>
<tr>
<td>Study</td>
<td>Subjects [sample (# dentate)]</td>
<td>Age</td>
<td>Mean Teeth Present (#)</td>
<td>Persons with 1 or more RDF (%)</td>
<td>Severity (RCI, etc.)</td>
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<tr>
<td>Streckfus et al. (1990)</td>
<td>Lower income adults; predominantly black population from Maryland, USA [100 – includes institutionalized population (100)]</td>
<td>65+</td>
<td>12.5</td>
<td>1.7 root surfaces per person</td>
<td>Non-fluoridated: 6.0%</td>
</tr>
<tr>
<td>Heft &amp; Gilbert (1991)</td>
<td>Older adults from Florida, USA [949 (674)]</td>
<td>65+</td>
<td>Mean = 76.5</td>
<td>46</td>
<td>1.5 root surfaces per person</td>
</tr>
<tr>
<td>Graves et al. (1992)</td>
<td>Black and white older adults from North Carolina, USA [1000 (809)]</td>
<td>65+</td>
<td>White: 19.9, Black: 15.8</td>
<td>White: 51, Black: 36</td>
<td>White: 1.9 root surfaces per person; Black: 1.2 root surfaces per person</td>
</tr>
<tr>
<td>Locker &amp; Leake (1993)</td>
<td>Older adults in Ontario, Canada [907 (710)]</td>
<td>50 – 90</td>
<td>Mean = 62.6</td>
<td>70.9</td>
<td>3.6 root surfaces per person</td>
</tr>
<tr>
<td>Papas et al. (1995b)</td>
<td>Healthy, independent middle-aged and elderly adults with a minimum of six teeth [237 (141)]</td>
<td>50+</td>
<td>21.6</td>
<td></td>
<td>4.4 root surfaces per person</td>
</tr>
<tr>
<td>Winn et al. (1996)</td>
<td>Probability sample of US people - NHANES III survey [8377(7336)] 6726 dentate included in the root caries analysis</td>
<td>18+</td>
<td>Not stated</td>
<td>Age Prevalence % 18-24 6.9, 25-34 13.6, 35-44 20.8, 45-54 28.7, 55-64 38.2, 65-74 47.0, 75+ 55.9, All (adj) 25.1</td>
<td>Mean RDFS 0.3, 0.6, 1.0, 1.2, 1.7, 2.2, 3.1, 1.2</td>
</tr>
<tr>
<td>Hawkins et al. (1998)</td>
<td>Self-selected dentate elderly individuals in North York, Canada [62 (62)]</td>
<td>85+</td>
<td>14</td>
<td>29.4</td>
<td>0.7 RDFT per person</td>
</tr>
<tr>
<td>Study</td>
<td>Subjects: Sample size (dentate)</td>
<td>Age</td>
<td>Mean Teeth Present (#)</td>
<td>Persons with 1 or more RDF (%)</td>
<td>Severity (RDI, etc.)</td>
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<tr>
<td>Hix &amp; O'Leary (1976)</td>
<td>Dentate middle-aged to older adults with periodontal disease [244 (244)]</td>
<td>Group with treatment: 50.8 (mean)</td>
<td>Group with treatment: 22</td>
<td>Group with treatment: 45</td>
<td>Group with treatment: 2.1 root lesions per person</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group without treatment: 47.3 (mean)</td>
<td>Group without treatment: 23.5</td>
<td>Group without treatment: 58</td>
<td>Group without treatment: 3.8 root lesions per person</td>
</tr>
<tr>
<td>Banting et al. (1980)</td>
<td>Dentate institutionalized older persons in London, Ontario [59 (59)]</td>
<td>35+</td>
<td>16.1</td>
<td>83</td>
<td>7.3 root lesions per person</td>
</tr>
<tr>
<td>MacEntee et al. (1985)</td>
<td>Institutionalized older adults in Vancouver, Canada [250 (73)]</td>
<td>Mean: 84</td>
<td>Mean in dentate group: 18</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Kitamura et al. (1986)</td>
<td>Canadian nursing home population [23 (23)]</td>
<td>55-95</td>
<td>20.4</td>
<td>RCI = 17.0%</td>
<td></td>
</tr>
<tr>
<td>Streckfus et al. (1990)</td>
<td>Institutionalized older adults on hypertension medication in Baltimore, USA; average # of medications taken 1.7 (averaged with non-institutionalized population sample) [100 – includes non-institutionalized population (100)]</td>
<td>65+</td>
<td>11.8</td>
<td>2.7 root surfaces per person</td>
<td></td>
</tr>
<tr>
<td>Hawkins et al. (1998)</td>
<td>Self-selected nursing home residents in North York, Canada; primarily female [1313 (1313)]</td>
<td>85+</td>
<td>11.9</td>
<td>47.4</td>
<td>1.5 RDFT per person</td>
</tr>
</tbody>
</table>
Table 3: Incidence of Root Caries in North American Populations

<table>
<thead>
<tr>
<th>Study</th>
<th>Length of Study</th>
<th>Subjects [sample (# dentate)]</th>
<th>Age</th>
<th>Mean Teeth Present at Baseline</th>
<th>Persons with 1 or more new RDF lesions per year (%)</th>
<th>Severity (RCI, etc.) per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand, Hunt &amp; Beck (1988)</td>
<td>18 months</td>
<td>Probability sample of dentate individuals, living in two rural counties in the State of Iowa, USA [~752(451)] - 60% dentate at baseline</td>
<td>65+</td>
<td>Men: 18.8</td>
<td>Men: 30.6%</td>
<td>Net increment of new surfaces: Men = 0.64 Women = 0.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Women: 18.9</td>
<td>Women: 28.7%</td>
<td>Mean attack rate new lesions per 100 &quot;susceptible&quot; root surfaces Males: 3.5 Females: 2.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Both sexes: 18.8</td>
<td>Both sexes: 29.4%</td>
<td>Net increment of new surfaces Fluoridated: 0.65 Non-fluoridated: 0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fluoridated: 18.4</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Non-fluoridated: 18.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand, Hunt &amp; Beck (1988)</td>
<td>36 months</td>
<td>Follow-up of elderly from 2 rural counties in Iowa, USA [ ?? (371)]</td>
<td>65 at baseline</td>
<td>18.8</td>
<td>14.6%</td>
<td>Net Increment: 0.36 new root surfaces</td>
</tr>
<tr>
<td>Leske &amp; Ripa (1989)</td>
<td>36 months</td>
<td>Dentate non-institutionalized subjects from fluoride-deficient communities in Long Island, NY [796 (796)]</td>
<td>20-65</td>
<td>Mean = 39.9</td>
<td>6.2%</td>
<td>Net Increment: 0.15 root surfaces for the whole population; 0.8 root surfaces per person for those who developed root caries</td>
</tr>
<tr>
<td>Joshi et al. (1993)</td>
<td>24 months</td>
<td>Dentate middle and older aged</td>
<td>45-82</td>
<td>21.5</td>
<td>38.3%</td>
<td>1.08 per 100</td>
</tr>
</tbody>
</table>

29
<table>
<thead>
<tr>
<th>Study</th>
<th>Length of Study</th>
<th>Subjects [sample (# dentate)]</th>
<th>Age</th>
<th>Mean Teeth Present at Baseline</th>
<th>Persons with 1 or more new RDF lesions per year (%)</th>
<th>Severity (RCI, etc.) per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wallace et al.</td>
<td>48 months</td>
<td>Randomly selected dentate urban, geriatric, non-institutionalized population in an optimally fluoridated area: Group A with a placebo mouthrinse daily, Group B with semiannual applications of APF gel with a placebo mouthrinse, and Group C with daily fluoride mouthrinse [?? (466)]</td>
<td>60+</td>
<td>At least 15</td>
<td></td>
<td>Net increment of new surfaces: Group A = 0.23 Group B = 0.07 Group C = 0.1</td>
</tr>
<tr>
<td>Lawrence et al.</td>
<td>36 months</td>
<td>Subjects from the Piedmont 65+ Dental study; non-institutionalized older adults from North Carolina, USA; both Caucasian and Black [?? (452)]</td>
<td>65+</td>
<td>Black = 17.6 White = 21.0</td>
<td>Black = 9.7% White = 13%</td>
<td>Net increment of new surfaces: Black = 0.18 White = 0.27</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>Mean Attack Rate: New lesions per 100 susceptible root surfaces per person Black = 0.87 White = 1.43</td>
<td></td>
</tr>
<tr>
<td>Lawrence et al.</td>
<td>60 months</td>
<td>As above: [810 (363)]</td>
<td>65+</td>
<td>20.2</td>
<td>Black: 30%/5 = 6% White: 35%/5 = 7%</td>
<td>Net increment of new surfaces: Black: 0.52/5 = .10 White: 0.42/5 = .08</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Mean Attack Rate: New lesions per 100 susceptible root surfaces per person Black = 0.48 White = 0.44</td>
<td></td>
</tr>
<tr>
<td>Locker (1996)</td>
<td>36 months</td>
<td>At baseline [907 (702)] 493 dentate examined at 36 mos</td>
<td>50 + (74.9% aged &gt;64)</td>
<td>18.9</td>
<td>27.4%/3 = 9.1%</td>
<td>0.66 RDFS /3y = 0.22 per person pa</td>
</tr>
</tbody>
</table>

30
Table 4: Determinants* of Root Caries  (*denotes protective effect)

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Type of Study (analysis)</th>
<th>Population [Sample (# dentate)]</th>
<th>Factors Examined</th>
<th>Outcome and Effect</th>
<th>Level of Evidence</th>
</tr>
</thead>
</table>
| Beck et al. Int Dent J | 1988 | Incidence (Linear regression) | Dentate, non-institutionalized, older population in two Iowa counties [--- (445)] | Males:  
*23 or more teeth  
9 or fewer teeth  
No. of periodontal pockets >3mm  
No. of RDFS  
Recent onset illness  
Current smoker  
Use of smokeless tobacco  
High anxiety index  
*Social integration/support  
Number of surfaces with recession  
Former smoker  
Females:  
*23 or more teeth  
9 or fewer teeth  
Number of surfaces with recession  
No. of RDFS  
No. of periodontal pockets >3mm  
No. of DFT (coronal)  
Examiner effects  
*Fluoridated town > 29 yr  
Older age  
Recent onset illness  
Sugared foods  
Social participation | 18 month incidence of root caries  
( ≥ 1 new RDFS) R² = 0.48  
Significant (negative relationship)  
Significant  
Significant  
Significant  
Significant  
Significant  
Significant (negative relationship)  
ns  
ns  
18 month incidence of root caries  
( ≥ 1 new RDFS) R² = 0.47  
Significant (negative relationship)  
Significant  
Significant  
Significant  
Significant  
Significant (negative relationship)  
Significant  
Significant  
s | II-2 |
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Type of Study (analysis)</th>
<th>Population [Sample (# dentate)]</th>
<th>Factors Examined</th>
<th>Outcome and Effect</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ravald &amp; Birkhed</td>
<td>1992</td>
<td>Incidence over months 12-36 of three year study (Stepwise multiple regression)</td>
<td>Adults referred for periodontal care in Linköping Sweden [101(99)]</td>
<td>Root DFS</td>
<td>24 month incidence of RDFS (R² = 0.28)</td>
<td>II-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Root plaque score</td>
<td>Contribution to R² at each step</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Teeth n</td>
<td>0.18</td>
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<td></td>
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<td>0.05</td>
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<td></td>
<td>0.05</td>
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<tr>
<td>Joshi et al.</td>
<td>1993</td>
<td>Incidence over 16 months (Logistic regression)</td>
<td>Middle-aged and older adults from Boston USA [130 (130)]</td>
<td>High baseline DFS</td>
<td>≥ 1 new RDFS</td>
<td>II-2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Having ≥ 22 teeth</td>
<td>Significant OR = 1.14</td>
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<td></td>
<td></td>
<td>Mean plaque score ≥ 2.0</td>
<td>Significant OR = 2.63</td>
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<td></td>
<td></td>
<td>Significant OR = 2.69</td>
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</tr>
<tr>
<td>Ravald et al.</td>
<td>1993</td>
<td>Incidence over yrs 9-12 of 12 yr study (Stepwise multiple regression)</td>
<td>Adults referred to Specialist Dental Services in Linköping, Sweden [-- (27)]</td>
<td>Bleeding on probing Age</td>
<td>Root DFS% (equivalent to RCI)</td>
<td>II-2</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Plaque score</td>
<td>R² = 0.58</td>
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<td></td>
<td></td>
<td>Lactobacilli</td>
<td>R² at each step</td>
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<td></td>
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<td></td>
<td></td>
<td>Dietary habit index</td>
<td>Significant .38</td>
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<td></td>
<td></td>
<td>Mutans streptococci</td>
<td>Significant .58</td>
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<tr>
<td>Scheinin et al.</td>
<td>1994</td>
<td>Incidence over 3 yrs (Logistic regression)</td>
<td>Adult population initially aged 47-79 yr - mean 62 yr [-- (96)]</td>
<td>Past RDFS</td>
<td>≥ 1 new RDS over three years</td>
<td>II-2</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Lactobacilli</td>
<td>Significant OR = 12.8</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Candida</td>
<td>Significant OR = 8.6</td>
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<td>Mutans streptococci</td>
<td>ns</td>
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<td>Buffer Effect</td>
<td>ns</td>
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<td></td>
<td>Percentage of teeth with visible plaque</td>
<td>ns</td>
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<tr>
<td>Study</td>
<td>Year</td>
<td>Type of Study (analysis)</td>
<td>Population [Sample (# dentate)]</td>
<td>Factors Examined</td>
<td>Outcome and Effect</td>
<td>Level of Evidence</td>
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<tr>
<td>Lawrence et al.</td>
<td>1995</td>
<td>Incidence over 3 yrs (Logistic regression)</td>
<td>Black and white non-institutionalized elderly population in North Carolina, USA [6 (452)]</td>
<td>Blacks:</td>
<td>≥ 1 new RDFS over three years</td>
<td>II-2</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Wearing partial dent.</td>
<td>Significant OR = 3.43</td>
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<td></td>
<td>≥ 1 root fragments</td>
<td>Significant OR = 3.31</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>≥ 2mm mean gingival recession</td>
<td>Significant OR = 1.75</td>
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<td></td>
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<td></td>
<td></td>
<td>Prevotella intermedia present</td>
<td>Significant OR = 2.74</td>
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<td></td>
<td>Teeth have negative impact on appearance</td>
<td>Significant OR = 2.24</td>
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<td></td>
<td>Has impaired daily living activities</td>
<td>Significant OR = 1.67</td>
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<td>Whites:</td>
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<td>Worst gingival recession (WGR)</td>
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<td></td>
<td></td>
<td>≥ 4mm when average pocket depth (APD)</td>
<td>Significant OR = 4.50</td>
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<td>&lt; 2mm</td>
<td>Significant OR = 3.81</td>
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<td>APD ≥ 2mm when WGR &lt; 4mm</td>
<td>Significant OR = 3.35</td>
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<td></td>
<td>WGR ≥ 4MM and APD ≥ 2mm</td>
<td>Significant OR = 4.00</td>
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<td></td>
<td>Taking antihistamines</td>
<td>Significant OR = 2.45</td>
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<td></td>
<td>Has taken calcium</td>
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<td>Perceives more problems since age 40</td>
<td>Significant OR = 4.99</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Retired/unemployed</td>
<td>Significant OR = 3.17</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Subjects [Total (final sample)]</td>
<td>Ages</td>
<td>Prevention Method</td>
<td>Effect</td>
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<tr>
<td>Burt et al.</td>
<td>1986</td>
<td>Two populations in New Mexico, USA – one with an optimal fluoride level and one with 5 times the optimal fluoride level [315 (315)]</td>
<td>Adults</td>
<td>Lifetime exposure to: Fluoride in water at 5X optimal vs Fluoride in water at optimal level</td>
<td>Root Caries Index 1.2 in 5X optimal community 6.0 in optimal community</td>
<td></td>
</tr>
<tr>
<td>Jensen &amp; Kohout</td>
<td>1988</td>
<td>Dentate, older adults living in non-fluoridated areas. Individuals on fluoride therapy, antibiotics, or with severe periodontal disease were excluded [913 (810)]</td>
<td>54+</td>
<td>12 month trial of 0.1%(1100 ppm) fluoride toothpaste</td>
<td>Increment of: 0.43 RDFS in control 0.14 RDFS in test 67% reduction in root surface caries incidence (p=0.014)</td>
<td></td>
</tr>
<tr>
<td>Hunt et al.</td>
<td>1989</td>
<td>Probability sample of dentate individuals living in Iowa, USA [520 (445)]</td>
<td>65+</td>
<td>Long term residence in: Communities with water fluoridation vs life-long residence in non-fluoridated communities</td>
<td>Root caries increment per person over 18 mo. Non-fluoridated communities: 1.11 RDFS Fluoridated communities: - resident for 5-40 yr 1.04 - 1.24 RDFS - resident for 41-61+ yr 0.54 - 0.59 RDFS</td>
<td></td>
</tr>
<tr>
<td>Stamm et al.</td>
<td>1990</td>
<td>Dentate populations from 2 communities in Ontario – one community with fluoridated water the other without</td>
<td>18 years and older</td>
<td>Water fluoridation</td>
<td>It appears that there is a significant difference in the root caries increments between the fluoridated group and the non-fluoridated group. While an adjusted RCI of 2.5% was reported in the former group, an RCI of 6.0% was reported in the latter.</td>
<td></td>
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<tr>
<td>Ravald and Birkhed</td>
<td>1992</td>
<td>Adults treated for periodontal disease</td>
<td>Three groups: A. Duraphat group (n=34) B. 0.4% stannous fluoride gel (n = 33) C. 0.05% sodium fluoride mouthrinse solution (n = 32) (147 (99))</td>
<td>Incidence over 36 months of: Mean Root DFS Individuals with ≥ 1 A: 3.1 (SEM 0.75) 19 B: 2.3 (SEM 0.82) 14 C: 2.9 (SEM 0.60) 17 No difference between groups</td>
<td></td>
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</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Subjects [Total (final sample)]</td>
<td>Ages</td>
<td>Prevention Method</td>
<td>Effect</td>
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<tr>
<td>Wallace et al.</td>
<td>1993</td>
<td>Randomly selected dentate urban, geriatric, non-institutionalized population in an optimally fluoridated area</td>
<td>Group A daily placebo mouthrinse&lt;br&gt;Group B semiannual APF gel + placebo mouthrinse&lt;br&gt;Group C daily fluoride mouthrinse [466 (466)]</td>
<td>Incremental RDMFS&lt;br&gt;A: 0.91 (sd = 2.99) p≤.05 A vs B and A vs C&lt;br&gt;B: 0.27 (sd = 2.71)&lt;br&gt;C: 0.26 (sd = 2.72)&lt;br&gt;More reversed root caries were identified in the daily fluoride mouthrinse group</td>
<td></td>
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</tr>
<tr>
<td>Makinen et al.</td>
<td>1995</td>
<td>Adults recruited at the Veterans Administration Medical Center in Dayton, Ohio. The subjects have underlying disease, poor oral health, and various drug and alcohol abuse tendencies [200(200)]</td>
<td>Adults</td>
<td>Polyol-containing saliva stimulants (gum or dragees) sweetened with&lt;br&gt;- xylitol (X)&lt;br&gt;- sorbitol (S) vs no saliva stimulant (Control)</td>
<td>&quot;Rate of active supragingival root caries&quot; (SGRSC) dropped significantly in both saliva stimulant-using groups compared to the control group (p&lt;0.05) and stayed significantly lower during the rest of the observation period. The decrease in SGRSC was not significantly different between the two therapy groups (p&lt;0.06).</td>
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</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Subjects</td>
<td>Age</td>
<td>Gold Standard</td>
<td>Diagnostic test</td>
<td>Results</td>
</tr>
<tr>
<td>----------------------</td>
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<td>---------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Newitter et al.</td>
<td>1985</td>
<td>6 extracted teeth stored in physiologic saline solution</td>
<td></td>
<td>Six teeth unanimously diagnosed as sound or decayed by five dentists.</td>
<td>5 blindfolded dentists using tactile sense with</td>
<td></td>
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<td></td>
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<td></td>
<td>Note: 5 dentists originally examined 26 teeth; agreed on 10 (38%) from which 6 were selected</td>
<td>A: Conventional explorer</td>
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<td>B: Modified explorer with a 30 degree angle at tip</td>
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<tr>
<td>Nordenram et al.</td>
<td>1988</td>
<td>52 extracted teeth with well-maintained crowns</td>
<td>65-95</td>
<td>Radiographic appearance of 104 root surfaces which ranged from sound to decayed</td>
<td>Macrosopic examination using good light and explorer of the 104 proximal root surfaces (corresponds to clinical examination)</td>
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<tr>
<td>Lynch &amp; Beighton</td>
<td>1994</td>
<td>395 primary root lesions in 117 patients attending the Royal London Hospital</td>
<td>29-80</td>
<td>Clinical presentation of lesions as Soft, Leathery and Hard</td>
<td>Colour of lesion as defined by standard colour charts</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Subjects</td>
<td>Ages</td>
<td>Restoration Method Control</td>
<td>Restoration Method Test</td>
<td>Design and Rx Classification Effect</td>
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</tr>
<tr>
<td>Billings, Brown, Kaster</td>
<td>1985</td>
<td>54 active lesions among 6 patients studied over 2 years</td>
<td>31-71</td>
<td>No controls</td>
<td>Cavitated (16 lesions)- GIC</td>
<td>Cavitated II-3, C</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Loss to follow-up = 0%</td>
<td>Loss to follow-up = 0%</td>
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<td></td>
<td></td>
<td></td>
<td>16 lesions had complete retention</td>
<td>16 lesions had complete retention</td>
</tr>
<tr>
<td>Sheth, Jensen, Wefel, Levy</td>
<td>1988</td>
<td>123 lesions among 38 people over 1 year</td>
<td>55-80</td>
<td>No controls</td>
<td>Light activated composite resin plus dentin bonding agent</td>
<td>II-3, C</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Loss to follow-up = 21%</td>
<td>Loss to follow-up = 21%</td>
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<td></td>
<td></td>
<td>Retention rate = 96.9% of 97 remaining restorations</td>
<td>Retention rate = 96.9% of 97 remaining restorations</td>
</tr>
<tr>
<td>Levy et al.</td>
<td>1989</td>
<td>104 restorations among 50 adult volunteers with one or more active root caries lesions over 1 year</td>
<td>25-76</td>
<td>45 glass ionomer cement restorations (Ketac-Fil) with no mechanical retention</td>
<td>59 microfilled composite resin restorations (Silux Microfill Composite) with dentin bonding agent (Scotchbond) and no mechanical retention</td>
<td>I, B</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Loss to follow-up = 49% of composites; 7% of GICs</td>
<td>Loss to follow-up = 49% of composites; 7% of GICs</td>
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<tr>
<td></td>
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<td></td>
<td>GIC - 42 available for examination at 1 yr</td>
<td>GIC - 42 available for examination at 1 yr</td>
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<td>52% fully retained; 70% clinically acceptable</td>
<td>52% fully retained; 70% clinically acceptable</td>
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<td>Composite resin - 30 available for examination at 1 yr</td>
<td>Composite resin - 30 available for examination at 1 yr</td>
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<td></td>
<td></td>
<td>76% fully retained; 86% clinically acceptable</td>
<td>76% fully retained; 86% clinically acceptable</td>
</tr>
<tr>
<td>Duke, Robbins, Snyder</td>
<td>1991</td>
<td>32 root lesions among 38 people needing restoration of ≥ 2 cervical lesions over 3 years</td>
<td>44-70</td>
<td>No controls</td>
<td>32 restorations with adhesive and composite resin</td>
<td>II-3: C</td>
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<tr>
<td></td>
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<td></td>
<td>Loss to follow-up = 8%</td>
<td>Loss to follow-up = 8%</td>
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<td></td>
<td>100% retention over 2 yr</td>
<td>100% retention over 2 yr</td>
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<td></td>
<td></td>
<td>97% retention over 3yr</td>
<td>97% retention over 3yr</td>
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<tr>
<td>Study</td>
<td>Year</td>
<td>Subjects</td>
<td>Ages</td>
<td>Restoration Method Control</td>
<td>Restoration Method Test</td>
<td>Design and Rx Classification Effect</td>
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<tr>
<td>Billings, Brown, Kaster</td>
<td>1985</td>
<td>54 active lesions among 6 patients studied over 2 years</td>
<td>31-71</td>
<td>Incipient - no controls</td>
<td>Incipient (20 lesions) home use of NaF gels in trays</td>
<td>For Incipient lesions II-3 (C) Of 20 test lesions: 14 arrested 3 active 3 progressed to shallow lesions and treated under that regimen</td>
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<td>Shallow (5 lesions) Polish and home use of NaF gels in trays</td>
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<td></td>
<td>Shallow (13 lesions) Recontoured, then smoothed plus home use of NaF gels in trays</td>
<td>For Shallow Lesions I: B Control: 1 of 5 arrested Test: 13 were 'clinically sound'</td>
</tr>
<tr>
<td>Johansen, Papas, Fong, Olsen</td>
<td>1987</td>
<td>Project 1 - 30 private patients, most with active caries</td>
<td>45 - 76</td>
<td>No Controls</td>
<td>Daily home oral hygiene plus 16 days of NaF gels in trays at home followed by 2 min rinses plus non sugar gum (ad lib?)</td>
<td>II-3 (C) Project 1 after 4 years % of lesions remineralized 53% medical patients 61% healthy patients Project 2 after 2 mos to 6 years 77% of lesions remineralized</td>
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<td>Project 2 - 94 patients referred to Tufts University with high caries</td>
<td>45 and older</td>
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<tr>
<td>Schacken, Keltjens, VanDer Hoven</td>
<td>1991</td>
<td>Netherlands? 44 perio patients each with ≥ 2 RDFS</td>
<td>Mean 44.4 yr</td>
<td>Standard 3 mo maintenance program</td>
<td>1) Standard 3 mo maintenance program + Duraphat varnish at 3 mo intervals 2) Standard 3 mo maintenance program + Chlorhexidine varnish at 3 mo intervals</td>
<td>1 (B) Percent of lesions 'hardening' Control - 3% Duraphat - 11% Chlorhexidine - 15% p &lt; .05 McNemar's Chisq</td>
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<tr>
<td>Wallace, Retief, Bradley</td>
<td>1993</td>
<td>At base, 603 community representative subjects with surfaces filled, decayed and at risk 466 returned for 4 year examination</td>
<td>60 and older</td>
<td>Placebo rinse</td>
<td>1) APF gel 2X yearly and placebo rinse 2) 0.05% NaF daily</td>
<td>1: (A) After 4 years mean number of reversed lesions =: 1.11 control 1.01 APF gel 1.53 NaF rinse (p&lt; .05)</td>
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<tr>
<td>Study</td>
<td>Year</td>
<td>Subjects</td>
<td>Ages</td>
<td>Restoration Method Control</td>
<td>Restoration Method Test</td>
<td>Design and Rx Classification Effect</td>
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<td>Depaola</td>
<td>1993</td>
<td>42 test and 41 controls all with ≥ 1 early, active, buccal lesions over one year 35 and 36 remained at one year.</td>
<td>Mean 70.5</td>
<td>Extensive OHI plus 5000 ppm neutral NaF gel 3X yearly at 4, 8 and 12 mos</td>
<td>Extensive OHI plus 12,000ppm APF gel 3X yearly</td>
<td>1: (B) [only one year study] Percent of patients experiencing one or more lesions arresting: Fluoride gel 31% Placebo gel 10% Chisq p&lt;.025 Percent of initial (soft) lesions arrested: Fluoride gel 91% Placebo gel 40% Chisq p&lt;.01 Percent of early cavitated lesions arrested: Fluoride gel 57% Placebo gel 8% Chisq p&lt;.001</td>
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<td>Emilson, Ravald, Birked</td>
<td>1993</td>
<td>Sweden 15 perio patients referred for root caries therapy - 770 exposed root all believed at risk</td>
<td>Mean 56.6 yr</td>
<td>No control</td>
<td>Intensive OHI, polishing and fluoride varnish at 3, 6 and 9 mo Mean # treatments = 7 (Range = 6-10)</td>
<td>II - 3: C Of 502 sound surfaces 67 progressed Of 69 inactive lesions 15 progressed Of 99 active lesions 30 progressed and 37 became inactive</td>
</tr>
</tbody>
</table>
Literature Cited


Bullen MEB. The utilization of dental services by Ontario adults, 1979-80. Thesis submitted for the degree of Master of Science, Faculty of Dentistry, University of Toronto; 1982.


Hawkins RJ, Main PA, Locker D. Oral health status and treatment needs of Canadian adults aged 85 years and over. Special Care in Dentistry 1998;18(4):164-169.


Leake JL. Checklists for appraising evidence in health care. Toronto, Canada. Faculty of Dentistry, University of Toronto Clinical Epidemiology Course Package (DEN1040H) 1999.


Studies not included


