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The Dynamic Behavior of the Early Dental Caries Lesion in Caries-active Adults and Implications

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Abstract

Objective—To describe the full range of behavior of the visible, non-cavitated, early caries lesion in caries-active adults with substantial fluoride exposure, and to consider implications.

Methods—The data were from the Xylitol for Adult Caries Trial (X-ACT), collected annually for 33 months using condensed ICDAS caries threshold criteria. Individual tooth surfaces having a non-cavitated caries lesion were included and the Patterns of transition to each subsequent annual clinical examination to sound, non-cavitated or cavitated, filled or crowned were determined. The resulting sets of Patterns for an individual tooth surface, looking forward from its first appearance as a non-cavitated lesion, were combined into one of four behavior Profiles classified as Reversing, Stable, Oscillating or continuously Progressing, or were excluded if not part of the caries continuum. The distributions of Profile types were assessed using the Rao-Scott Chi square test, which adjusts for clustering of tooth surfaces within teeth.

Results—Inter-and intra-examiner Kappa scores demonstrated acceptable calibration at baseline and annually. 8084 tooth surfaces from 543 subjects were included. The distribution of Profile types differed significantly between coronal and root surfaces. Overall two-thirds of all coronal non-cavitated lesions were first seen at baseline, half Reversed, over a fifth were Stable, 15% Oscillated and only 8.3% progressed to cavitation, filled or crowned in 33 months or less. (6.3% consistently Progressed plus 2.0% inconsistently, a subset of Oscillating, which oscillated before progressing to cavitation). Approximal, smooth and occlusal coronal surfaces each were significantly different in their individual distributions of Profile types. Xylitol showed no significant and consistent effect on this distribution by tooth surface type. This was in keeping with the X-ACT Trial's lack of effect of xylitol at the non-cavitated plus cavitated lesion thresholds combined.

Conclusions—This study demonstrated the full dynamic range of early caries lesion behavior. The great majority were not progressive and few (8.3%) became cavitated over 33 months in caries-active adults using fluorides. Important caries management implications favoring recorded longitudinal monitoring, prevention of active risks and minimal restoration only after direct visual determination of cavitation are discussed.

Introduction

Fifty years ago Brudevold, McCann, and Gron (1) described caries, based on enamel chemistry as a dynamic and reversible process modulated by fluoride, and not due to simple and ever progressing enamel solubility. Yet few clinical longitudinal studies have provided a full dynamic description, as most have focused only on lesion progression. While today most dentists know of this dynamic nature of caries many do not follow its implications in prevention and treatment decisions.

The first large-scale, systematic, longitudinal study of the early caries lesion by Backer Dirks (2) described the dynamic clinical nature of the early, non-cavitated caries lesion. Between 7 and 15 years of age, half the approximal early caries lesions observed radiographically did not progress. On buccal surfaces early caries often developed soon after eruption; on 48% of these surfaces in 6 months and on 84% within 18 months. Subsequently many disappeared (51%) or failed to progress (36%), and only 13% became cavitated over 7 years in that pre-fluoride caries era. Data from the Tiel-Culemborg studies were then used by Backer Dirk's colleagues to further document this dynamic nature of caries (3). Without community water fluoridation (CWF), more surfaces with early lesions were observed to reverse to sound status, but more also progressed to cavitation. With CWF more lesions were stable. In a subsequent study (4) with CWF, a high proportion of all lesions remained as early enamel lesions: 93% of buccal and 86% of approximal lesions had not progressed into dentin over periods up to eleven years. Without CWF the comparable frequencies were 65% for both surfaces. Cavitation was markedly reduced with CWF, but not the total number of caries lesions. Overall, lesion retardation was then less pronounced at younger age.

Most studies of approximal caries progression rate have used radiographic assessment and been in children and adolescents, not adults. This method underestimates visible enamel lesions (5) and has high variations in both observer performance and validity of detection of cavitation (6). In 1971-77 in older adolescents 35.6% of radiographically detected lesions did not progress beyond the dentino-enamel junction in six years. Progress was slower with age (7). In a 1983 review Pitts (8) concluded that approximal lesion progress was slow, that very many lesions detected radiographically remained unchanged for long periods, and that only 20 percent that extended to the dentin-enamel junction were clinically cavitated in that high caries era. Mejare (1998) (9) described slow but continuous increase in enamel and dentin caries from 11-22 years with preventive interventions but not CWF. Hintze (10) demonstrated a much slower rate of progress of occlusal and approximal lesions in Danish adolescents using fluoride toothpaste. In 1999 for young adults using fluoride toothpaste and having approximal lesions showing enamel caries radiographically at baseline, only 4-8% were directly observed after tooth separation to have become cavitated at each six monthly examination over 2.5 years, with this risk declining greatly over time (11).

Lawrence and Sheiham 1997 (12), in one of the few studies to account for dynamic states of the early caries lesion, found the mean rate of progress of approximal caries in Brazilian adolescents was 62% lower with CWF, with the effect more pronounced for inner enamel than for dentin lesions. The lesion reversal rate was 33% with CWF and 24% without

fluoridation. The majority of lesions were stable or reversed and were in enamel. The rate of progress was about a third that reported just a decade earlier.

Ferreira Zandoná (2012) (13) used the International Caries Detection and Assessment System (ICDAS) and radiographs to observe caries lesions longitudinally in children, with a focus on lesion progression to cavitation in a high risk population of Puerto Rican children without CWF. Occlusal and other pit and fissured surface lesions were more likely to cavitate than early lesions of approximal and smooth surfaces and to do so sooner. Active lesions were increasingly more likely than inactive ones to progress to cavitation, and also with increasing ICDAS severity scores at baseline. Only 1% of surfaces sound at baseline progressed to cavitation by 24 months and 3% by 48 months,

The full range of behaviors of early caries lesions in large numbers of adult subjects is not adequately described ; this paper describes the dynamic nature of early caries lesions in adults determined to be caries-active at baseline, and discusses its implications in caries management.

Methods

The data come from the Xylitol for Adult Caries Trial (X-ACT), a randomized, placebo controlled clinical trial conducted at three clinical sites over 33 months with caries-active adults aged 21-80 living in communities with water fluoridation (CWF) and with 91% reporting use of other fluorides (ClinicalTrials.Gov NCT00393055). The trial's public website URL is http://xactstudy.org. Caries-active status was defined in terms of having at least one cavitated lesion present or clinically documented in the year prior to study enrollment (16). Subjects were asked to consume 5 × 1mg xylitol or placebo lozenges daily.

Simplified caries status threshold criteria (15, 19) were used, combining ICDAS 1 and 2 threshold categories (19) into non-cavitated coronal lesions and uncavitated or minimally (<0.5mm) cavitated root lesions as a single X-ACT score D_1. ICDAS category 3 or above were combined to record cavitated coronal lesions and cavitated root lesions (≥ 0.5mm) as X-ACT score D_2.

Of 691 randomized trial subjects, 543 with complete data for all exams at Baseline, 12, 24 and 33 months were included in this analysis. They did not differ in demographics or personal oral health behaviors from the full complement (17).

Individual tooth surfaces having a non-cavitated carious lesion (D_1) identified at any of the four examinations were eligible for initial inclusion in the analysis. For each of these surfaces, the transition Pattern from the first identification of the lesion to the next examination was determined, as well as all further Patterns. Thus, for a lesion identified at the baseline exam, transition Patterns were determined for the baseline-to-12 month period, the 12 month-to-24 month period, and the 24 month-to-33 month period. If the lesion was identified at a later examination, the number of transition Patterns that could be determined was reduced, to two if the lesion was first identified at the 12 month examination, and to one if the lesion was identified at the 24 month examination. The possible states for a tooth surface were sound (S), non-cavitated (D_1), cavitated (D_2), filled (F) or crowned (C).

These transition Patterns were then combined into Profiles. The behavior Profile of a specific tooth surface looking forward from its first observation as a D_1 lesion, could consist of three, two, or one transition depending on at which examination the non-cavitated lesion was first identified. The types of Profiles, classified using Boolean logic, were labeled Reversing, Stable, Oscillating, or continuously Progressing, or were excluded. Reversing surfaces changed from D_1 to S and may be thought of, relatively, as remineralizing overall. Stable surfaces had no observed change from D_1, remained as D_1, and may be thought of as not remineralizing or demineralizing overall. Oscillating surfaces changed in at least part of their Profile from D_1 to S and S to D_1; some of these were then observed to have become cavitated. They may be thought of as labile in status, moving between demineralization and remineralization, and with some remineralizing potential . Progressive surfaces changed from D_1 to D_2, F or C and may be thought of as consistently progressing and demineralizing. Other surface transitions were removed from consideration as they were not part of the caries continuum. These resulted if a tooth number was recorded incorrectly, e.g. with a missing morphologically similar adjacent tooth; or for a missing or unscoreable tooth in the set of Patterns, e.g. due to tooth extraction or orthodontic treatment obscuring a tooth surface during the trial. They also occurred with some implausible scoring of transitions such as from F to S, D_2 to D_1 and D_2 to S. Total excluded surfaces was 3487 of all 80,304 scored surfaces (4.3%).

Future individual tooth surface Profiles of early lesion behavior were analysed within annual periods of first occurrence and then viewed across all 33 months. They were assessed in total for crown versus root surfaces; for approximal, smooth and occlusal coronal surfaces; and for xylitol versus placebo by surface type.

The distributions of Profile types were assessed using the Rao-Scott Chi square test (20), which adjusts for clustering, defined on a subject-tooth basis and treating profiles between subjects as independent.

Results

Intra-examiner reliability weighted Kappa scores for distinguishing S vs D_1 vs D_2 scores for the full complement of the X-ACT trial were: Baseline 0.63, 12 months 0.84, 24 months 0.66, 33 months 0.67. This trial was shown to be well calibrated for inter- and intra-examiner visual assessments of non-cavitated and cavitated caries lesions (14, 15, 17).

Of the 80,304 surfaces that were ever scored in these subjects, 5408 (6.7%) progressed to a new cavitation (D_2), filled (F),or crowned (C) at some point during the study. The majority of these developed in surfaces never observed to have a non-cavitated (D_1) lesion during the annual study assessments, and were therefore not included in this analysis. Among the 8084 included surfaces, 674 (8.3%) progressed from a non-cavitated lesion to cavitation, filled or crowned.

The behavior Profiles of 8084 early caries lesions were initially classified by time of first appearance at Baseline, 12, 24 or 33 Months, by location, and then by being Reversing, Stable, Oscillating or consistently Progressing over future time. This classification is first

shown as a percentage of all Profiles for coronal and root surfaces at each time point (Table 1). At 24 months, future Oscillating Profiles can no longer be classified, due to lack of time for future observations. At 33 months, no future Profile classifications can be made and the data shows only the percentage of initially observed early lesions at that time. Reversing Profiles are most common, with decreasing frequency of Stable and Oscillating Profiles, and with Progressing lesions least common. There are significant differences in the frequencies of types of Profiles for crown versus root surfaces at baseline, 12 and 24 months, with root surface profiles more likely to be Progressing. This may reflect inherent differences in response to caries challenge of these structurally distinct surfaces, as well as a possible xylitol effect on early root caries.

Therefore, additional analyses of behavior Profiles of early caries lesions were arranged separately by coronal (Fig 1) and root surfaces (Fig 2) as a percentage of all Profiles across the total period of observation. All types of Profiles declined over time (Fig 1). This is due in part, but not entirely, to the time dependent nature of how Profiles are constructed from longitudinal observations, with declining opportunity for Profile development with decreasing future time. Such a limitation would apply to any method of observation. Two thirds of all early lesions were first observed at Baseline. Overall half of all early lesions reversed, over a fifth were stable, 15% oscillated and only 8.3% irreversibly progressed to D_2, F or C over 33 months or less (6.3% consistently Progressive plus 2.0%, inconsistently progressive, a subset of Oscillating Profiles, which oscillated before progressing to cavitation). 5.9% of early lesions were first observed at 33 months and were unclassifiable due to lack of future observations.

The number of root surfaces lesions is far smaller, 273 of 8084 or 3.4% of all early lesions observed in this study. Root surface Profiles (Fig 2) formed a recognizably related but not identical distribution over 33 months.

The distribution of behavior Profiles of non-cavitated coronal caries lesions first observed at each time point, by tooth surface, is displayed in Table2. This demonstrates that the distribution of future behavior Profile types from Baseline, 12 and 24 Months is significantly different within each coronal surface type – approximal, smooth and occlusal.

The X-Act Trial of Xylitol as a caries preventive showed no consistent, significant or clinically meaningful benefit from xylitol, in caries-active adult subjects living in fluoridated communities, over 91% of whom also used other fluorides. This was so when assessed for cavitated lesions (14) and for non-cavitated plus cavitated lesions (17) of crown and root surfaces combined. Despite a significant xylitol effect on root caries assessed at the more advanced cavitated threshold (≥ 0.5mm) (18), there were no significant differences in the distribution of Profile types for root surface early lesions for xylitol versus placebo, from Baseline, 12 or 24 months forward (data not shown).

The distribution of Profile types for xylitol and placebo, looking forward from each time point, was constructed separately for approximal, smooth and occlusal coronal surfaces (Table 3). These distributions of Profile types did not differ significantly for xylitol versus placebo, on approximal or occlusal surfaces at any time. However, smooth coronal surfaces

showed a significant difference in Profile distribution observed from Baseline and from 24 months, but not from 12 months forward. There were too few root lesions for their similar analysis.

In summary, the distribution of future behavior Profile types of early caries lesions varied by tooth surface type but not for xylitol versus placebo, with the possible exception of coronal smooth surfaces, which were inconsistent in treatment effect. This is in keeping with the lack of a practical, significant or consistent xylitol effect, already described for the X-ACT Trial at the combined D_2 plus D_1 level, for coronal plus root lesions. (17) Early lesion Profiles were visually observed to be very dynamic, with the great majority Reversing or Stable. Only 8.3% of early caries lesions were observed to consistently or inconsistently progress to cavitation/filled/crown over 33 months or less.

Discussion

Subjects in this study were caries-active despite appreciable fluoride exposure, and so they were suitable for an analysis of caries lesion behavior. They can be considered to represent a typical, contemporary adult population which is or should be under caries management.

All methods of lesion assessment have limitations including the visual methods here applied. So too do advanced technological methods reflecting mineral status, not yet applied in full scale trials. The reliability of visual assessments in this study has been established and described (15, 16, 17). Their validity relies on ICDAS criteria (19), including lesion threshold validity (21). Although clinical diagnostic standards for approximal caries have long included radiographs, this also has well defined, substantial and much ignored limitations (5, 6, 7).

It is important to note that the D_2 threshold used can include cavitation in enamel only, whereas the usual clinical threshold is cavitation extending to or into dentin. So, the determination of cavitated status of coronal lesions is here an overestimate compared with the usual clinical practice standard. Even so the proportion of D_1 lesions becoming cavitated was low (8.3%). It is a weakness of this study that newly F and C surfaces, previously observed to have been D_1, were presumed to have become D_2. In addition the majority of surfaces becoming F or C was not observed to pass through the D_1 stage and so could not be included. This may limit the resulting view from this study of early caries lesion behavior in a large sample. Study replication in a closed treatment system is desirable. Study of untreated adults would also be insightful but not as generalizable to this population.

Lesion behavior Profiles are time dependent, requiring a minimum of two additional observations for Oscillating Profiles, and one additional observation for Reversing, Stable, and Progressing Profiles. These outcomes are possible over longer and shorter time intervals than analyzed here, and so would tend to increase or decrease in number with more or less time. Within the constraints of the X-ACT data set, this study analyses and is limited to observations at approximately one year intervals across three years.

The full dynamic nature of the early caries lesions is very apparent from Figures 1 and 2. This strongly supports the cogency of a comprehensive diagnostic and preventive approach

in caries management. Since few early lesions (8.3%) were observed to progress to cavitation, filling or crown in up to three years in caries-active persons, and since clinical methods used to infer cavitation are so imprecise, (5, 6, 7) it is now prudent that a decision to restore be made only after direct visual observation has confirmed cavitation in all surfaces, not just occlusal and smooth surfaces.

The absence of a consistent and clinically meaningful degree of xylitol effect in shifting early , coronal lesion behavior away from progression in these caries-active adults is in keeping with the negative X-ACT Trial results (14, 17). Table 3 fails to show any consistent, significant xylitol effect on the distribution of profile types by coronal tooth surface type. Thus a therapeutic effect at the precavitation threshold is not supported by this study. In addition, no clear beneficial shift was observed for early root versus all early coronal lesions , despite a xylitol effect at the more severe cavitation threshold (18). This lends further caution to an interpretation of a benefit of xylitol for root caries.

Expectation that clinical trial efficiency could be improved by inclusion of early lesion assessment is discouraged by this study, and in a separate analysis the X-ACT trial failed to demonstrate efficiency using this type of data (17). Knowing the behavior Profiles of early caries lesions helps explain why. Caution would also be prudent for use of visual scoring of early caries alone, in caries trials at any age, since a high proportion of D_1 lesions (91.7%) did not reach cavitation in 33 months .

In the pre-fluoride era, caries reversal was regarded by many clinicians as a rare curiosity in an epidemic of the disease, but was in fact quite common even then (2). The proportion of early lesions which reverse, are static, or oscillate without becoming cavitated has continued to the present day to increase and cavitation has continued to dramatically decrease in adolescents (15) and in caries-active adults as here demonstrated.

Yet many clinicians appear to be still applying outmoded and non-scientifically supported inferences, standards or precedents about the present and future status of early lesions, to attempt to justify more invasive treatment. This study supports the contemporary approach (22, 23, 24) for longitudinal recorded observations at defined lesion thresholds, risk-based prevention of etiologic factors determined to be active, and then minimally invasive restoration only if indicated by definitive, direct visual determination of cavitation, not inference thereof from radiographs. Cavitation should be directly confirmed, assisted by tooth separation for approximal crown and root surfaces. Unfortunately, few reimbursement systems are configured to support a longitudinal approach to diagnosis and diagnostic codes using lesion thresholds, to justify treatment determination. Written standards for caries treatment, periodically updated in the light of improved scientific evidence, and their adoption in insurance systems will be a necessary impetus to long overdue change in these systems.

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References

1. Brudevold F, McCann HG, Gron P. Wolstenholme GE. Caries resistance as related to the chemistry of enamel. Caries Resistant Teeth. 1965:121–140.
2. Backer, Dirks O. Posteruptive changes in dental enamel. J Dent Res. 1966; 45:503–510.
3. Pot TJ, Groenveld A, Purdell-Lewis DJ. The origin and behavior of white spot enamel lesions. Nederlands Tijdschrift voor Tandeheelkunde (Suppl). 1977; 85:6–18.
4. Groenveld A. Longitudinal study of prevalence of enamel lesions in a fluoridated and non-fluoridated area. Comm Dent Oral Epi. 1985; 13:159–163.
5. Rugg-Gunn AJ. Approximal carious lesions. A comparison of the radiological and clinical appearances. Br Dent J. 1972; 133:481–4. [PubMed: 4511888]
6. Gröndahl HG. Some factors influencing observer performance in radiographic caries diagnosis, and decision strategies in radiographic caries diagnosis. Swed Dent J. 1979; 3:157–172. 173-180. [PubMed: 298380]
7. Gröndahl HG. Radiographic caries diagnosis. A study of caries progression and observer performance. 1979; 3(Suppl):1–32.
8. Pitts NB. Monitoring of caries progression in permanent and primary posterior approximal enamel by bitewing radiography. Comm Dent Oral Epi. 1983; 11:228–35.
9. Mejàre I, Källestål C, Stenlund H, Johansson H. Caries development from 11 to 22 years of age: a prospective radiographic study. Prevalence and distribution. Caries Res. 1998; 32:10–16. [PubMed: 9438566]
10. Hintze H. Caries behaviour in Danish teenagers: a longitudinal radiographic study. Int J Paediatr Dent. 1997; 7:227–34. [PubMed: 9482028]
11. Hintze H, Wenzel A, Danielsen B. Behaviour of approximal carious lesions assessed by clinical examination after tooth separation and radiography: a 2.5-year longitudinal study in young adults. Caries Res. 1999; 33:415–422. [PubMed: 10529525]
12. Lawrence HP, Sheiham A. Caries progression in 12- to 16-year-old schoolchildren in fluoridated and fluoride-deficient areas in Brazil. Comm Dent Oral Epi. 1997; 25:402–411.
13. Ferreira, Zandona A.; Santiago, E.; Eckert, GJ.; Katy, BP., et al. The natural history of dental caries lesions: a 4-year observational study. J Dent Res. 2012; 91:841–846. [PubMed: 22821238]
14. Bader JD, Vollmer WM, Shugars DA, Gilbert GH, Amaechi BT, Brown JP, et al. Results from the Xylitol for Adult Caries Trial (X-ACT). J Am Dent Assoc. 2013; 144:21–30. [PubMed: 23283923]
15. Banting DW, Amaechi BT, Bader JD, Blanchard P, Gilbert GH, et al. Examiner training and reliability in two randomized clinical trials of adult dental caries. J Public Health Dent. 2011; 71:335–344. [PubMed: 22320292]
16. Bader JD, Shugars DA, Vollmer WM, Gullion CM, Gilbert GH, Amaechi BT, Brown JP, et al. Design of the xylitol for adult caries trial (X-ACT). BMC Oral Health. 2010:10–22. [PubMed: 20429938]
17. Brown JP, Amaechi BT, Bader JD, Gilbert GH, Makhija SK, Pineda J, Leo MC, Chuhe C, Vollmer WM. Visual scoring of non-cavitated caries lesions and clinical trial efficiency, testing xylitol in caries active adults. Comm Dent Oral Epi. 2013 doi:10.1111/cdoe.12082.
18. Ritter AV, Bader JD, Leo MC, Preisser JS, Shugars DA, Vollmer WM, et al. Tooth-surface specific effects of Xylitol: Randomized trial results. J Dent Res. 2013; 92:512–517. [PubMed: 23589387]

19. International Caries Detection and Assessment System Coordinating Committee. Report of a Workshop. Baltimore, MD: Mar 12-14. 2005 Criteria Manual: International Caries Detection and Assessment System (ICDAS II).

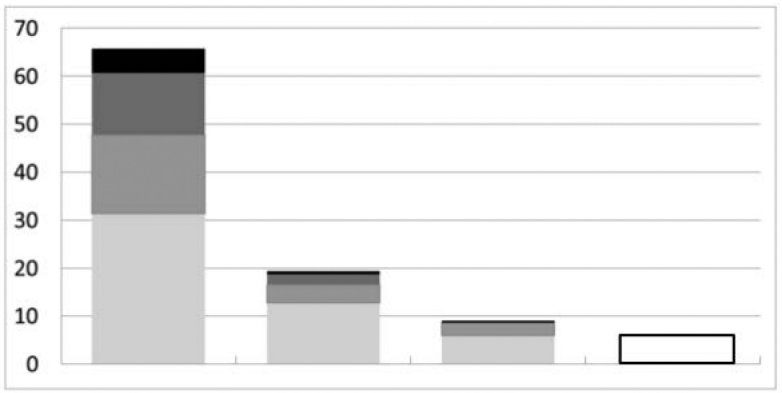
20. Rao JN, Scott AJ. A simple method for the analysis of clustered binary data. Biometrics. 1992; 15:385–397.

21. Ismail A, Sohn W, Tellez M, Amaya A, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Comm Dent Oral Epi. 2007; 35:170–178.

22. Curtis B, Warren E, Pollicino C, Evans RM, Schwartz E, Sbaraini A. The Monitor Practice Programme: is non-invasive management of dental caries in private practice cost effective? Australian Dent J. 2011; 56:48–55. [PubMed: 21332740]

23. Brown, JP.; Dodds, MWJ. Prevention in Clinical Oral Health Care. Elsevier; St Louis: 2008. Dental caries and associated risk factors (chapter 4) and Prevention strategies for dental caries (chapter 15) in Cappelli DP and Mobley CC.

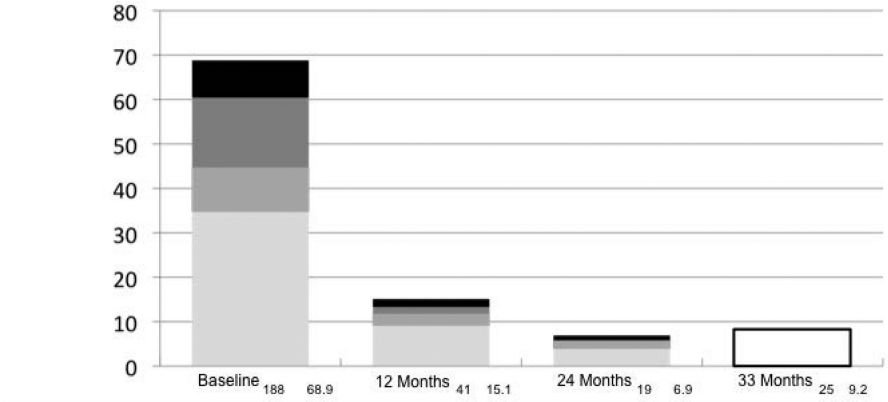
24. Doméjean S, White JM, Featherstone JD. Validation of the CDA CAMBRA caries risk assessment – a six year retrospective study. J. Calif Dental Assoc. 2011; 39:709–15.



	Baseline 5128 65.7	12 Months 1520 19.4	24 Months 703 9.0	33 Months 460 5.9
Consistently Progressing *	5.1	0.7	0.4	+
Oscillating	12.9	2.1	+	+
Stable	16.4	3.9	2.7	+
Reversing	31.3	12.7	5.9	+
Unclassified				5.9

* Consistently Progressing to cavitated lesion, filled or crowned
\+ This profile not possible at this time point due to insufficient time for future observations

Figure 1.
Future behavior profiles of non-cavitated coronal caries lesions, first observed at times indicated. Percentage (%) of all such lesions over 33 months



	Baseline 188 68.9	12 Months 41 15.1	24 Months 19 6.9	33 Months 25 9.2
Consistently Progressing *	8.4	1.8	1.1	+
Oscillating	15.8	1.5	+	+
Stable	9.9	2.6	1.8	+
Reversing	34.8	9.2	4.0	+
Unclassified				9.2

* Consistently Progressing to cavitated lesion, filled or crowned
\+ This profile not possible at this time point due to insufficient time for future observations

Figure 2.

Future behavior profiles of early root surface caries lesions, first observed at times indicated. Percentage (%) of all such lesions over 33 months

Table 1

Future behavior profiles of early caries lesions on coronal and root surfaces, first observed at time indicated. Percentage (%) of such lesions at each time point

		Reversing	Stable	Oscillating	Progressing *	
Baseline						
Crown	**(n=5128)**	47.7%	24.9%	19.7%	7.7%	p=0.003
Root	**(n=188)**	50.5%	14.4%	22.9%	12.2%	
12 Months						
Crown	**(n=1520)**	65.3%	20.2%	10.8%	3.7%	p=0.046
Root	**(n=41)**	61.0%	17.1%	9.8%	12.2%	
24 Months						
Crown	**(n=703)**	66.0%	30.0%	+	4.0%	p=0.036
Root	**(n=19)**	57.9%	26.3%	+	15.8%	
33 Months						
Crown	**(n=460)**	+	+	+	+	
Root	**(n=25)**	+	+	+	+	

Two-tailed p-values based on Rao-Scott chi square test adjusting for clustering of surfaces within teeth

* Progressing to cavitated lesion, filled or crowned

+ This profile not possible at this time point due to insufficient time for future observations

Table 2

Future behavior profiles of non-cavitated coronal caries lesions by surface type, first observed at time indicated. Percentage (%) of such lesions at each time point

		Reversing	Stable	Oscillating	Progressing *	
Baseline						
Approximal(n=2129)		48.8%	22.9%	21.6%	6.8%	
Smooth	**(n=2269)**	43.1%	30.1%	19.8%	7.0%	p<0.001
Occlusal	**(n=730)**	58.6%	14.7%	14.0%	12.7%	
12 Months						
Approximal(n=767)		63.9%	22.3%	10.3%	3.5%	
Smooth	**(n=559)**	62.3%	20.8%	13.4%	3.6%	p<0.001
Occlusal	**(n=194)**	79.9%	10.3%	5.2%	4.6%	
24 Months						
Approximal(n=379)		63.1%	33.0%	+	3.9%	
Smooth	**(n=282)**	69.1%	28.4%	+	2.5%	p<0.001
Occlusal	**(n=42)**	71.4%	14.3%	+	14.3%	
33 Months						
Approximal (n=242)		+	+	+	+	
Smooth	**(n=189)**	+	+	+	+	
Occlusal	**(n=29)**	+	+	+	+	

Two-tailed p-values based on Rao-Scott chi square test adjusting for clustering of surfaces within teeth

* Progress to cavitated lesion, filled or crowned

+ This profile not possible at this time point due to insufficient time for future observations

Table 3

Future behavior profiles of non-cavitated coronal approximal, smooth surface, and occlusal surfac caries lesions, for xylitol vs placebo, first observed at time indicated. Percentage (%) of such lesions at each time point

		Reversing	Stable	Oscillating	Progressing *	
APPROXIMAL						
Baseline						
Xylitol	**(n=1026)**	50.9%	22.0%	20.9%	6.2%	p=0.343
Placebo	**(n=1103)**	46.9%	23.7%	22.2%	7.3%	
12 Months						
Xylitol	**(n=339)**	61.9%	23.6%	11.5%	2.9%	p=0.527
Placebo	**(n=428)**	65.4%	21.3%	9.3%	4.0%	
24 Months						
Xylitol	**(n=188)**	63.8%	32.4%	+	3.6%	p=0.944
Placebo	**(n=191)**	62.3%	33.5%	+	4.2%	
33 Months						
Xylitol	**(n=123)**	+	+	+	+	
Placebo	**(n=119)**	+	+	+	+	
SMOOTH SURFACE						
Baseline						
Xylitol	**(n=1248)**	42.3%	31.9%	20.0%	5.8%	p=0.035
Placebo	**(n=1021)**	44.0%	28.0%	19.6%	8.4%	
12 Months						
Xylitol	**(n=306)**	61.8%	21.9%	12.1%	4.2%	p=0.538
Placebo	**(n=253)**	62.8%	19.4%	15.0%	2.8%	
24 Months						
Xylitol	**(n=145)**	63.4%	35.2%	+	1.4%	p=0.022
Placebo	**(n=137)**	75.2%	21.2%	+	3.6%	
33 Months						
Xylitol	**(n=103)**	+	+	+	+	
Placebo	**(n=86)**	+	+	+	+	
OCCLUSAL SURFACE						
Baseline						
Xylitol	**(n=397)**	57.9%	15.6%	13.4%	13.1%	p=0.814
Placebo	**(n=333)**	59.5%	13.5%	14.7%	12.3%	
12 Months						
Xylitol	**(n=93)**	78.5%	10.8%	5.4%	5.4%	p=0.959
Placebo	**(n=101)**	81.2%	9.9%	4.9%	4.0%	
24 Months						
Xylitol	**(n=20)**	55.0%	25.0%	+	20.0%	p=0.068

		Reversing	Stable	Oscillating	Progressing *	
Placebo	**(n=22)**	86.4%	4.5%	+	9.1%	
33 Months						
Xylitol	**(n=17)**	+	+	+	+	
Placebo	**(n=12)**	+	+	+	+	

Two-tailed p-values based on Rao-Scott chi square test adjusting for clustering of surfaces within teeth

*Progress to cavitated lesion, filled or crowned

+This profile not possible at this time point due to insufficient time for future observations