Behavior and Progression of Early Carious Lesions in Early Childhood: A 1-year Follow-up Study

Thaís Manzano Parisotto, DDS, MS, PhD
Marinês Nobre dos Santos, DDS, MS, PhD
Lidiany Karla Azevedo Rodrigues, DDS, MS, PhD
Luciana Scarlazzari Costa, BS, MS, PhD

ABSTRACT

Purpose: The purpose of this 1-year follow-up study was to evaluate the behavior/progression of early carious lesions (active noncavitated carious lesions) by surface and type of tooth in early childhood.
Methods: A total of 179 3-and 4-year-old preschoolers took part in this study. Clinical examinations were conducted by a calibrated examiner using a mirror, ball-ended probe, gauze for cleaning and drying of teeth, and artificial light. The World Health Organization criteria, with an added measurement of early carious lesions (ECLs), were employed for the caries examinations. Descriptive statistics and logistic regression were used in the statistical analysis.
Results: After a 1-year follow-up, the study population developed 1.60±1.64 new carious lesions. Children with caries activity at baseline showed much higher risks of developing new lesions than caries-free children (odds ratio=17.3 for ECL development, OR=24.5 for cavitations/fillings). Most ECLs remained active/unchanged after 1 year, whereas approximately 36% were arrested. Approximately 10% of the ECLs became cavitated, were filled, or were missing due to caries at follow-up. ECLs turned into cavities or fillings more frequently in the posterior region.
Conclusion: This study's findings support the conservative management of ECLs since, after 1 year, the majority of lesions were active/unchanged or were arrested on the smooth surfaces of primary teeth. (J Dent Child 2012;79(3):130-5)
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In the last few decades, there has been much progress in the field of caries prevention among children, adolescents, and adults. Caries prevalence has been reduced significantly due to the widespread use of fluoridated toothpaste and fluoridated tap water as well as sealant use.[1,2] In Brazil and other developing countries, however, dental caries remain highly prevalent, especially in early childhood.[3,4]

Caries development and progression in primary enamel and dentin shows particularities compared to permanent teeth, making the former more susceptible to the carious process. The chemical composition of primary teeth associated with inorganic and organic tissue content might explain the different responses of primary teeth against demineralization and remineralization. Primary enamel shows a lower calcium content, slightly lower calcium-to-phosphate ratio, higher water content, and higher organic content[5-7] than the permanent enamel. These differences highlight the importance of investigating predictors of future caries in primary teeth.

Dr. Parisotto is graduate student and Dr. dos Santos is professor, Department of Pediatric Dentistry, University of Campinas School of Dentistry at Piracicaba, Brazil; Dr. Rodrigues is professor, Department of Operative Dentistry, School of Pharmacy, Dentistry and Nursing, Federal University of Ceará, Fortaleza, Brazil; and Dr. Costa is professor, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.
Correspond with Dr. Nobre dos Santos at nobre@fop.unicamp.br

In this respect, the early identification of caries can be a good strategy for reducing caries development in early childhood, especially because the consequences of this disease include severe pain, low oral health-related quality of life, and loss of school days.[8,9] The first clinical signs of dental caries are early carious lesions (ECLs) and white chalky spot lesions, which can progress to cavitations if no effective preventive measure is applied.[10]

There are few longitudinal studies available in the literature regarding the ability of ECLs to progress to cavitated lesions, particularly in children with early childhood caries (ECC). Thus, the purpose of this study was to evaluate the behavior/progression of ECLs (active noncavitated carious lesions) by surface and type of tooth in early childhood over a one year period.

METHODS

STUDY APPROVAL

The present investigation was approved by the Institutional Review Board of the University of Campinas School of Dentistry at Piracicaba, São Paulo, Brazil, (protocol nos. 015/2006 and 017/2008). Written informed consent was obtained from the parents of the children who participated.

SAMPLE DEFINITION

All 3- to 4-year-old children enrolled in public preschools in the fluoridated (0.6-0.8 ppm F) urban area of Itatiba, São Paulo state, in 2006 were invited to take part in this study. These low-income preschoolers were part of a larger longitudinal study, which investigated factors related to the etiology of ECC (eg, diet, socioeconomic factors, and biochemical and microbiological composition of dental plaque). The age ranges of 3 to 4 years at baseline and 4 to 5 years at follow-up were chosen because all primary teeth have erupted by then and no permanent teeth have completely erupted yet.

After performing a pilot study at baseline, the minimum sample size required to represent the city population was established (N=172) with a 5% standard error, a 95% confidence interval, and a caries prevalence of 0.72. The calculated number was increased by 10% to compensate for subject attrition, as this was a 1-year longitudinal study. As such, the estimated sample size comprised 189 preschoolers. In a further attempt to reduce subject attrition, all 3- to 4-year-old children enrolled in public preschools from fluoridated areas were invited to participate.

Exclusion criteria included children with syndromes or chronic systemic diseases, those whose parents did not attend scheduled school meetings at the study entrance/exit times to understand its aims and/or its importance, those whose parents refused to sign the informed consent forms, and who did not conform with the necessary procedures for the clinical examinations.

As a baseline incentive, a new toothbrush and a fluoridated dentifrice, as well as oral health preventive instructions, were provided to all children. Moreover, preschoolers with active caries were referred to the Public Health Oral Service of Itatiba.

CARIES RECORDING SYSTEM/CRITERIA

The diagnostic criteria used for ECC diagnosis in the present study was the World Health Organization's (WHO), with an additional measurement criterion for ECLs (WHO + ECLs) (Table 1).[11-13] As such, caries were recorded not only when frank cavitations were present, but also when ECLs were present. ECLs on smooth surfaces were considered when there was an active rough white spot lesion with a dull, opaque whitish surface without loss of continuity, which were usually adjacent to the soft tissue margins where dental plaque accumulates.

For the occlusal surfaces, ECLs were recorded for active lesions extending along the walls of the fissure, where increased roughness and opacity were evident. Arrested/remineralized ECLs in smooth surfaces were identified when the enamel was shiny whitish, brownish, or black, without clinically detectable loss of surface, typically located at some distance from the

Table 1. Codes Used in the WHO Criteria With an Additional Measurement Criterion For ECLs*

WHO + ECL codes	
A	Sound excluding early carious lesions
ECLs	Early carious lesion (white chalky spot lesion)
B	Cavitated, with no ECLs
BECL	Cavitated + ECLs
C	Filled + chronic cavity
CECL	Filled + cavity + ECLs
D	Filled, no cavity
DECL	Filled + ECLs
4	Missing as a result of caries
5	Missing due to any other reason

*Adapted from Nyvad et al.,[15] Assaf et al.,[12] and Parisotto et al.[11]

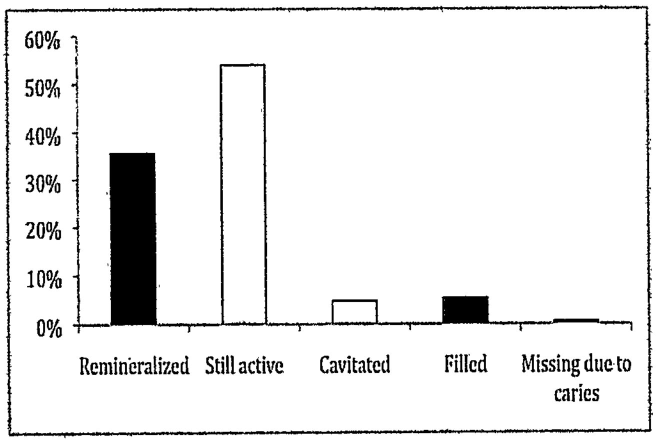

Figure 1. Changes in ECLs at the 1 year follow up examination.

gingival margin. Enamel can feel hard and smooth when the tip of the probe is moved gently across the surface. For the occlusal surfaces, arrested/remineralized ECLs were considered when there was intact fissure morphology and lesions extending along the walls of the fissure were shiny whitish.[13]

Cavities alone or adjacent to fillings were classified as active when a soft cavity floor was detected and as inactive when the cavity floor was hard and displayed different degrees of brownish discoloration. Gentle probing was used to check the tooth tissue textures (eg, rough, hard, and/or soft). Surfaces were classified as sound when normal enamel translucency was observed after drying the teeth with gauze. Children were considered to be caries-free if they showed neither decayed, missing, and filled surfaces (**dmfs**) nor ECLs. The units of evaluation in the clinical examinations were dmfs and decayed, missing, and filled teeth (**dmft**).

CALIBRATION OF THE EXAMINER

At first, clinical slides were used to train the examiner on the use of the WHO + ECL criteria. A clinical training session, using a gold standard for WHO + ECL criteria, was held to achieve an acceptable level of agreement before the intraexaminer reliability assessment. The entire time spent on the calibration process (eg, theoretical discussions, training, and calibration exercises) was 30 hours. Intraexaminer reliability (Kappa calculation) regarding all components of the diagnostic criteria was assessed by re-examination of approximately 10% of children (both at baseline and at follow-up), with a 1-week-interval period. Kappa values at baseline and follow-up for the teeth and tooth surfaces were 0.75/0.79 and 0.78/0.82, respectively.

CLINICAL EXAMINATIONS

The clinical examinations were conducted by a single dentist in the preschools, using a flashlight, mirror, and ball-ended probe. A gauze was used to dry or clean the teeth, enhancing the identification of ECLs. During the examinations, the examiner sat behind the child who was laying on a table. Findings were recorded by a dental assistant.

STATISTICAL ANALYSIS

Descriptive statistics such as means, standard deviation, and percentages were used to assess caries increment as well as ECL changes after a 1-year follow-up. Nominal logistic regression analysis, expressed by odds ratios (OR), was used to indicate the risk for developing carious lesions in the follow-up exam. The analyses were carried out using the SAS 9.1.3 software (SAS Institute Inc, Cary, N.C.) with a 5% significance level and a 95% confidence interval.

RESULTS

At baseline, 351 children were examined out of the 546 children who were invited to participate in the study. From baseline to follow-up, 172 children were lost because either they did not show up for the follow-up examination or they did not conform with the necessary procedures for the clinical examinations. Thus, the final sample size was 179 preschoolers representing all preschools in Itatiba.

Table 2 shows the mean numbers of surfaces/teeth affected by caries at baseline and at follow-up in the studied population, as well as the 1-year caries increase. The risk for future carious lesion development in the primary dentition, considering children with ECLs at baseline, is shown in Table 3. In order to perform this analysis, only children with ECLs and those who

Table 2. Mean Numbers of Decayed, Missing, and Filled Surfaces (dmfs) and Teeth (dmft) According to WHO + ECL Criteria

Caries index	Baseline (N=179)	Follow-up (N=179)	1-year increment (N=179)
dmfs + ECLs	5.60±8.22	7.20±9.85	1.60±1.64
dmft + ECLs	3.66±4.22	4.27±4.59	0.61±0.37

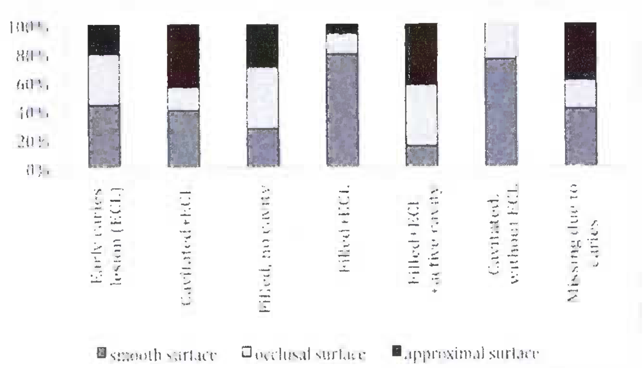

Figure 2. Distribution of decayed, missing, and filled surface increments by surface type in the children after the 1-year follow-up examination.

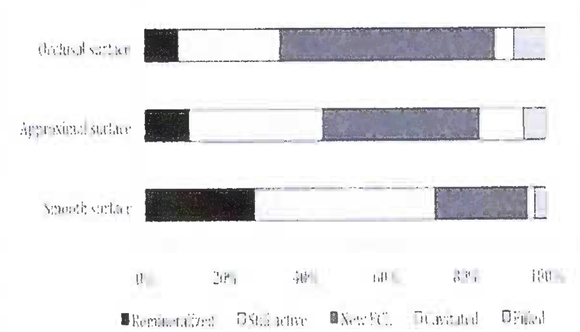

Figure 3. Changes in ECLs according to surface type in posterior teeth at the 1 year follow up examination.

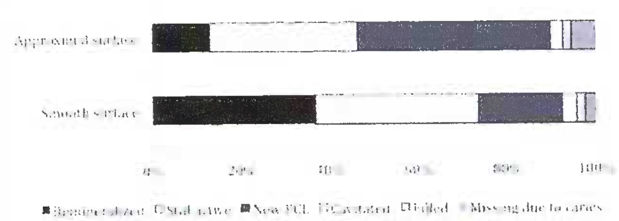

Figure 4. Changes in ECLs according to surface type in anterior teeth at the 1 year follow up examination.

were caries-free were considered thus their total number was 110. Children with ECLs at baseline were 17.3 times more likely to develop ECLs or sustain ECL activity and had a 24.5 times higher risk to develop cavitations or have restorations placed at follow-up than caries-free children (Figure 1). Figure 2 shows the distribution of dmfs increments according to surface type: smooth, proximal, and occlusal. ECLs were predominant in smooth and occlusal surfaces, while cavitation + ECLs and filling + ECLs + active cavities were predominant in occlusal and proximal surfaces. Figures 3 and 4 show the changes in ECLs by surface type in both anterior and posterior primary teeth. It is clear that ECLs which remained active/unchanged or were newly developed during the 1-year follow-up period correspond to major components of all surface types in both the anterior and posterior teeth. Most of the arrested lesions were on smooth surfaces. In posterior teeth, a higher number of ECLs progressed to cavitations and fillings compared to anterior teeth.

DISCUSSION

In the past few years, there has been a growing interest in diagnosing noncavitated lesions in epidemiological studies involving children.[14-16] This has been the case because a diagnosis limited to cavitations no longer agrees with the current understanding of the carious process.

The increase in the caries index with age (Table 2) is in agreement with previous studies.[3,17] This trend is observed because ECC is a rapid and progressive disease, especially considering primary teeth characteristics such as size and enamel and dentin composition. In this context, a study by Weinstein et al.[18] verified that, even with semi-annual fluoride varnish applications, children experienced an average of 8.6 new surfaces of primary tooth decay (even using WHO criteria) in a 3-year period. In the present study, the majority of children who developed carious lesions (cavitated or not) after 1 year were already caries-active (i.e., had ECLs) at baseline, but only 6 children who were caries-free at baseline developed caries (data not shown). Caries active children at baseline had a higher risk of developing caries (Table 3) corroborating studies by Peretz et al.,[17] Scalvos et al[19] and Grindefjord et al.[20]

Most ECLs remained either active/unchanged or were arrested after 1 year, whereas a minority became cavitated, were restored, or were missing due to the carious process (Figure 1). This is an interesting finding in terms of noncavitated lesions management, since it supports the belief that restorative treatment (which has a finite longevity) that does not need to be done immediately and conservative management of the ECL lesion can be attempted. This is in agreement with an American Academy of Pediatric Dentistry guideline[21] which states that modern management of dental caries should be more conservative, and should take into consideration an individual's risk for caries progression, understanding the disease process for that individual, and doing active surveillance of enamel lesions. The latter is based on the concept that treatment of disease may only be necessary if there is disease progression. Additionally, the majority of the arrested ECLs were found on smooth surfaces in both anterior and posterior teeth (Figures 3 and 4). A possible reason for this result is that smooth surfaces are more accessible to the fluoride effect, oral hygiene, and saliva.[22] On the other hand, it may also explain why occlusal and proximal caries progressed to cavitations or of restoration more frequently in the present study (Figure 3), which agrees with previous results.[20,22]

It is worth mentioning that on the occlusal surfaces (Figure 3), new ECLs were the major type of carious lesion that developed. Children with ECLs had a 17.3 times greater chance of continued development of ECLs or of sustained ECL activity (Table 3). Moreover, children presenting ECLs at baseline showed a higher likelihood of having cavities or restorations at follow-up. The increment of active cavities (cavitation + ECLs and restorations + ECLs + active cavities) and restorations without cavities were predominant in occlusal and proximal surfaces (Figure 2). In general, dentists are more likely to restore noncavitated pits and fissure lesions than smooth surface lesions. As such, if a dentist merely restored the questionable lesion, the

Table 3. Risk for the Development of ECLs*

	Follow-up condition			Estimated risks					
	Caries-free	ECLs	Cavitations/Fillings	ECL development/ECL maintenance			Cavitations/fillings development		
	N=50	N=43	N=17	OR	95% CI	*P*-value	OR	95% CI	*P*-value
ECL at baseline									
Present	8	33	14	17.3	6.9-42.9	<.001	24.5	8.6-69.6	<.001
Absent	42	10	3	1			1		

**Model-fitting information: −2 log likelihood (334.5), chi-square (46.2), degrees of freedom (2), significance (P<.001); OR=odds ratio; CI=confidence interval.*

lesion could be considered to have progressed in a longitudinal evaluation, which could overestimate the rate of caries progression.[22]

Considering proximal surfaces, most ECLs continued to be either active/unchanged or were newly developed in both the anterior and posterior teeth at follow-up. Although radiographs were not used to assess proximal anterior caries, the present study identified ECLs on their proximal surfaces because most children had interdental spacing which enabled a direct view of the surfaces. In the posterior teeth, ECLs were identified in the proximal surfaces when the adjacent surface was lost due to caries and when the extension of ECLs could be seen in the vestibular or lingual surfaces. This was a limitation of the current study. It should be emphasized, however, that unless there is enamel cavitation, radiographs do not show ECLs.

Few studies have evaluated the ability of ECLs to progress to cavitated lesions in ECC children (0-71 months old). Warren et al. [22] showed, however, that of the 144 noncavitated pit and fissure lesions in the primary dentition, 29% had progressed to either restored or frank decay status in the mixed dentition after 4 years. Our results showed a lower progression rate of ECLs on the occlusal surfaces (Figure 3). This may have happened because after only 1 year, lesions may have been less likely to progress than in 4 years. Grindefjord et al. [20] used younger children (2.5 years at baseline and 3.5 years at follow-up) to show that, of the lesions diagnosed at baseline as initial caries, 64% progressed to carious lesions over one year. This is not in accordance with our results (Figures 3 and 4), probably because they worked with suburban children with very high risks and a large proportion of immigrant backgrounds. Moreover, that study was performed more than 10 years ago, which was before the decrease in ECC prevalence in Brazil that occurred between 1996 and 2006.[16]

As it was previously mentioned, caries diagnosis criteria used in the present investigation were was based on field clinical examinations. As such, radiographs, dental operatory light and compressed air drying were not used—unlike in dental clinics, where they are commonly applied. Thus, one must be careful when extrapolating these results to other populations.

As caries profiles continue to change with time, it is important to develop studies that evaluate caries progression in young children in order to obtain additional insights into the implementation of effective measures to prevent and control ECC.

CONCLUSIONS

Based on this study, conservative management of ECLs is recommended, since most of them were either active/unchanged or were arrested on the smooth surfaces of primary teeth after 1 year.

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