Influence of Local Factors on Cementoenamel Junction–Alveolar Bone Crest Distance in Primary Dentition

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Objective: *This study illustrated the influence of local factors (dental biofilm, gingival bleeding, probing depth, proximal contact and proximal caries/inadequate restorations) on the cementoenamel junction (CEJ)-alveolar bone crest (ABC) distance in primary canines and molars of healthy children with complete primary dentition.* ***Study Design:*** *Two hundred and four patients have been examined clinically with regard to biofilm's presence, gingival status, probing depth, proximal contact and dental condition (carious lesions/restorations). Two bitewings of each patient were also taken. Eight dental surfaces (second molars mesial, first molars mesial and distal, and canines distal) could be analyzed per bitewing and the CEJ-ABC distance was measured using a digimatic caliper. Statistical analyses were controlled by dental arch, tooth type and surface. Mann-Whitney test was used to verify the association between CEJ-ABC distance and local factors.* ***Results:*** *After stratifying the data according to those influencing factors, the only local factor associated with increased CEJ-ABC distances in most of the different analyzed dental surfaces was the increased probing depth (>2mm), although only two dental surfaces showed statistical significance (p<0.01).* ***Conclusion:*** *Among the analyzed local factors, increased probing depth was the only factor that proved to be relevant in children's alveolar bone loss screening.*

Keywords: *periodontal diseases; alveolar bone loss, diagnosis; radiography, bitewing; dentition, primary; child, preschool*

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INTRODUCTION

Alveolar bone loss in primary teeth should be a concern in Pediatric Dentistry as there is evidence that many patients with juvenile periodontitis (especially the ones having two or more sites with alveolar bone loss) had also experienced bone loss in their primary dentition. This finding had been observed in retrospective longitudinal studies by comparison with matched controls.[1-2]

The diagnosis of alveolar bone loss in primary teeth has been based on the measurement of the distance between cementoenamel junction (CEJ) and alveolar bone crest (ABC).[1-12] Mostly, this distance has been assessed on bitewing radiographs with the use of diverse methods with different accuracies,[1-19] and distances of more than 2 mm in primary teeth have been considered alveolar bone loss either alone[1-2,6,9,14] or in conjunction with other criteria, such as the absence of intact lamina dura.[3-5,7-8,10-12]

Some studies have demonstrated that the CEJ-ABC distance in primary teeth may vary depending on age,[3,6,13,15-18] gender,[6,18] dental arch,[3,16,18] type of tooth,[6,13,15-16,18] interproximal caries or inadequate restorations,[3-4,6-7,11,15,18-19] proximal contact[4,11,15,18] and proximal calculus.[6] On the other hand, dental biofilm,[14,19] gingival bleeding[14,15,19] and probing depth[14-15] have not been associated with alterations in this distance. Thus, it seems that this distance could be influenced either by immutable physiological factors (inherent to each patient) such as age, gender, dental arch and type of tooth; or by local factors that can be modified by the patient and/or by professional treatment.

In mixed dentition, however, an additional complicating factor would be the exfoliation of neighboring primary teeth, which has been shown to be strongly associated with the alveolar bone height of primary teeth.[14] Despite this, most of the studies that evaluated the CEJ-ABC distance in primary teeth have been conducted in children with mixed dentition, or in populations presenting a significant age range, includ-

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ing either children with primary dentition (usually the minority) or children with mixed dentition. Therefore, in order to eliminate the effect of the exfoliation process, this study aims to investigate the influence of local factors such as dental biofilm, gingival bleeding, probing depth, proximal calculus, proximal contact and proximal caries/ inadequate restorations, on the CEJ-ABC distance in primary canines and molars of healthy children with complete primary dentition.

METHODS

Study population

During a one-year period, all patients, aged 2 to 5 years, who were scheduled for routine or initial examination in the pediatric dental clinic of a public university in Rio de Janeiro, Brazil, were asked to participate in this study. The local ethical committee approved the protocol and all parents who agreed to participate in the study signed an informed consent form on behalf of their children.

The initial study population consisted of 245 children who were selected based on the following criteria: no systemic disease or syndromes, non-intake of medicines that could interfere in the periodontal status (e.g., anticonvulsants), presence of all primary canines and molars showing complete eruption, absence of erupting or erupted permanent tooth, no fixed orthodontic or prosthetic appliances, need for bitewing radiographic examination and cooperation during examination. Two hundred and four (204) patients were short-listed for examination.

Clinical examination

All the selected children were examined in the pediatric dental clinic by a previously trained examiner. Clinical examination included the following measurements:

a) Dental biofilm: absence or presence of visible dental biofilm after drying of the dental surface with air.
b) Probing depth: measurements of the gingival sulcus depth were taken with a periodontal probe calibrated in millimeters (Hu-Friedy, PUNCBR15, Rio de Janeiro, Brazil) and all fractionated measurements were rounded to the nearest millimeter. Probing depths greater than 2mm were considered pathological.[20]
c) Gingival status: assessments were made according to the Gingival Index (GI).[21] Bleeding was recorded within 15 seconds after gentle probing.
d) Dental condition: presence of proximal cavitated carious lesions and adequate or defective restorations were recorded. Dental floss was used to facilitate the detection of overhanging restorations, and an explorer, to detect undercontoured restorations.
e) Proximal contact: presence or absence of proximal contact either due to physiological diastemas or to contact loss due to cavitated carious lesions were recorded. Dental floss was used once again to facilitate identification of proximal contacts.

All clinical parameters, except for the proximal contact, were recorded in 4 surfaces (mesial, distal, buccal and lingual) of all primary canines and molars. Nevertheless, for the purpose of this study, only the measurements of the primary second molars' mesial surface, primary first molars' distal and mesial surfaces, and primary canines' distal surface were used. Especially with regard to probing depth, whenever there was proximal contact between primary molars and/or between primary first molars and primary canines, four additional sites (mesiobuccal, distobuccal, mesiolingual and distolingual) were assessed for primary first molars, while only two additional sites were measured for primary second molars (mesiobuccal and mesiolingual) and for primary canines (distobuccal and distolingual). The highest measurement recorded for each proximal surface (buccal or lingual aspect) was considered.

Radiographic examination

Two bitewing radiographs were taken from each child with the aid of a pediatric bitewing film holder (MU-8400818-0, INPI, Brazil) modified from the Kwik-Bite film holder (Hawe-Neos Dental, Switzerland), in order to fit into preschoolers' mouth. Kodak Insight films (0 size) were exposed for 0.7 seconds by a Dabi Atlante X-ray machine (Raios X Spectro, Brazil) operating at 70 kVp and 10 mA. An automatic processor (Level 360 – Flat Co. Ltd., Japan) was used for the standardization of all radiographs.

All radiographs were viewed in a dark room against a light-viewing box without the aid of any magnifying glass. The CEJ-ABC distances were measured using a fifteen-centimeter digimatic caliper (Model #500-144B, Mitutoyo Sul Americana Ltda., Brazil), whose accuracy is the closest to 0.01 mm. This distance was then assessed in eight different sites of each bitewing, considering maxillary and mandibular teeth as follows: primary canines (distal surface), primary first molars (mesial and distal surfaces) and primary second molars (mesial surface).

The two tips of the digimatic caliper were set apart until one of them reached the CEJ and the other, the ABC, so as to measure this distance perpendicularly to the occlusal surface[18] (Figure 1). Values were measured as zero or negative, if the CEJ was at or below the ABC, respectively.

Proximal cavitated carious lesions were diagnosed or confirmed by radiographic examination when carious lesions extending into the inner part of the dentin could be observed. Also, properly contoured, undercontoured and overhanging proximal restorations were observed on bitewings, as well as the presence of proximal calculus, which was also recorded.

Additional exclusion criterion was employed because individual sites had to be excluded if CEJ or ABC could not be clearly identified on the radiograph. Then, if less than 60% of the available surfaces were readable for CEJ-ABC

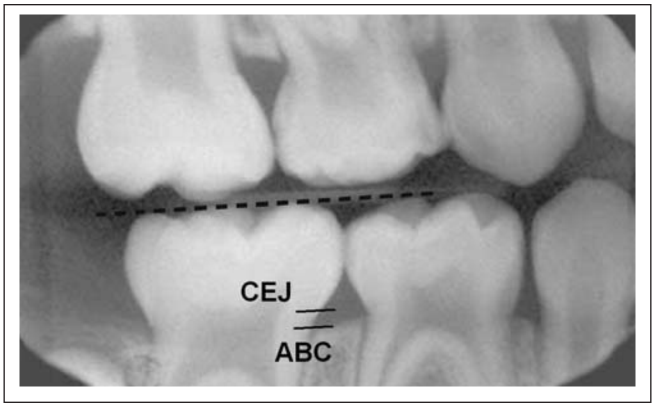

Figure 1. Measurement of the cementoenamel junction (CEJ)-alveolar bone crest (ABC) distance simulating the position of the digimatic caliper parallel to the occlusal surface of the primary tooth, according to the dotted reference line. The distance between the two continuous lines corresponds to the CEJ-ABC distance for the mesial surface of the primary mandibular right second molar.

distance on the pair of bitewings, the child was excluded from the study.[14]

Inter and intra-examiner reliabilities

Previously to clinical examination of the study population, an experienced examiner trained the single examiner of this research both for visible dental biofilm and probing depth assessments. Kappa statistic[22] and Weighed Kappa[23] were used to assess the inter-examiner agreement for 100 sites, evaluated, respectively, with regard to visible dental biofilm and probing depth. The visible dental biofilm presented a Kappa value of 0.70, while the calculated Weighed kappa for probing depth was 0.75. Both values are representative of good agreement, according to Byrt.[24]

To check the intra-examiner reliability for the measurements of the CEJ-ABC distance, 20 radiographs, selected at random, were measured twice, in a period of two days in between, by the single examiner of this study. Intraclass correlation coefficient (ICC)[25] was calculated to assess intra-examiner agreement, and a value of 0.89, with a 95% confidence interval of (0.845; 0.920) was found. This ICC value reflects good to excellent intra-examiner reliability.[26]

Statistical methods

For statistical purposes, some variables were dichotomized, as follows: Probing depth (2 mm or less / more than 2 mm), gingival status (non-bleeding sites – former 0 and 1 GI scores / bleeding sites – former 2 and 3 GI scores), and dental condition (adequate= sound/properly restored surfaces / inadequate= cavitated/poorly restored surfaces).

Graphs were constructed based on descriptive statistics and One-way ANOVA was used to check the influence of tooth type and surface, within each dental arch, on the CEJ-ABC distance at a significance level of 1%. In the presence of statistical significance, Tukey test was used to examine the differences among tooth types and between sites.

For the purpose of determining any association between CEJ-ABC distance (the response variable) and local factors (dichotomous explanatory variables), data was controlled by dental arch, type of tooth and tooth surface, and the Mann-Whitney test was used at a significance level of 1%. This approach has been chosen in order to eliminate the effect of these factors on the results.

RESULTS

Out of the 204 children, other 17 were excluded because less than 60% of the available surfaces were readable on their pairs of bitewings. The studied sample thus consisted of 187 children (Table 1). Among these children, 346 out of 2992 available proximal surfaces of the primary teeth were not shown on the radiographs, and CEJ or ABC could not be properly identified on 125 surfaces. Radiographic readings were thus performed on a total of 2521 primary tooth surfaces.

Age and gender proved to have no effect on CEJ-ABC distance in view of the very similar measurements obtained either for boys or girls at all ages (Figure 2). Conversely, there was great influence of type of tooth and tooth surface on CEJ-ABC distances within each dental arch ($p<0.001$). Tukey test showed significant statistical differences among all tooth types and sites for both maxilla and mandible

Table 1. Distribution of children by age and gender

Gender	Age (in years)						
	2	3	4	5	All	Mean	SD*
Female	3	31	35	8	77	3.62	0.73
Male	5	30	48	27	110	3.89	0.85
Total	8	61	83	35	187	3.78	0.81

*Standard deviation

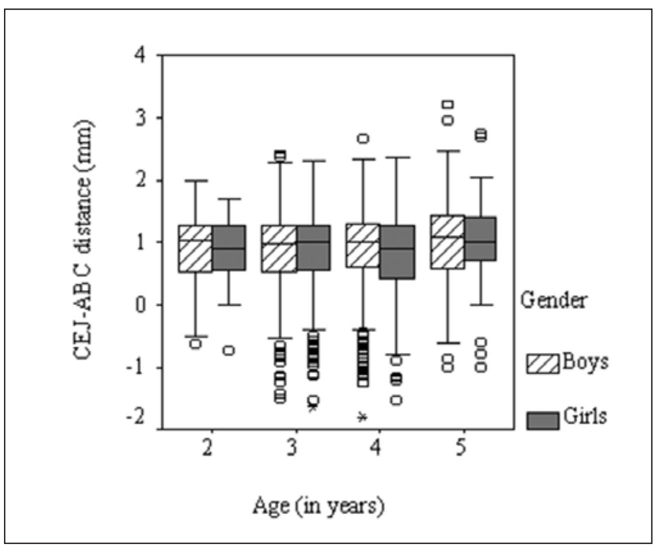

Figure 2. Distribution of the measured cementoenamel junction–alveolar bone crest (CEJ-ABC) distances (in mm) according to age and gender

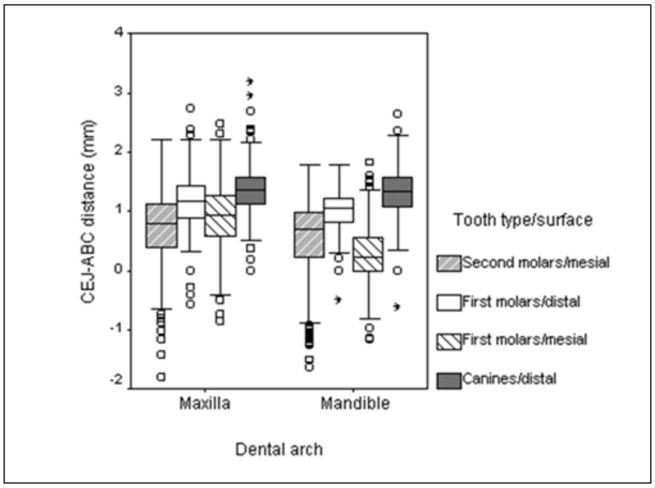

Figure 3. Cementoenamel junction–alveolar bone crest (CEJ-ABC) distance (in mm) by dental arch, type of tooth and tooth surface (One-way ANOVA; p<0.001). Tukey test showed significant statistical differences among all tooth types and sites for both maxilla and mandible (p<0.001).

(p<0.001). The highest values were observed for the distal surface of maxillary primary canines (mean= 1.38; range: 0.00 – 3.21), while the shortest distances were found for the mesial surface of the primary mandibular first molars (mean= 0.28; range: -1.14 – 1.84) – Figure 3.

Since all sites examined did not present proximal calculus, only the other five local factors were explored as possible explanatory factors for alterations in the CEJ-ABC distance. In general, there was no statistical association between visible dental biofilm or gingival bleeding and CEJ-ABC distance, once controlled by dental arch, type of tooth and tooth surface (Tables 2 and 3).

Increased distances were observed for higher probing depths, but there was a significantly statistical difference only for primary mandibular first molars (distal surface) and canines (distal surface) – Table 4.

In the absence of proximal contact there were increased CEJ-ABC distances in four of the eight different analyzed dental surfaces, but only primary maxillary first molars (mesial surface) showed statistically significant higher measures (Table 5).

The presence of inadequate dental condition (cavitated/poorly restored surfaces) showed increased CEJ-ABC distances in half of the different analyzed dental surfaces, but none of them presented statistically significant higher measures. It is important to emphasize, however, that the analysis of all primary canines and primary mandibular first molars (mesial) was jeopardized by the few cases of inadequate dental condition observed in these sites (Table 6).

DISCUSSION

Diagnosing periodontal disease in children is similar to diagnosing these problems in adults, except for the additional requirement of knowing the physiological changes that occur at the various stages of the child's dentition.[20] This study population was chosen mainly based on their stage of dentition (complete primary dentition) in order to minimize the effect of physiological changes on the CEJ-ABC distance in primary teeth. And even knowing that the target primary teeth were far from their exfoliation process, special care was taken not to measure the distal surface of primary second molars because it has been reported that the presence of an erupting permanent tooth follicle (in this case, the first permanent molars) may affect the radiographic image of the alveolar bone due to an effect on its mineral density.[14]

A non-linear increase in the CEJ-ABC distances with age, regardless of dental arch, type of tooth and tooth surface, has been observed in a retrospective longitudinal radiographic study because it took place between ages 4 to 6 and 9 to 12, while it remained stable between ages 6 to 9.[16] Despite being a cross-sectional study, it could be expected that children from the present study (age range 2 to 5) would have their CEJ-ABC distances influenced by age, but

Table 2. Mean CEJ-ABC* distance (in mm) by dental arch, type of primary tooth and tooth surface, according to dental biofilm accumulation

Dental Arch	Type of Tooth	Site	CEJ-ABC distance (mm): Visible dental biofilm: Present n	Present Mean	Present SD	Not present n	Not present Mean	Not present SD	p-value of Mann-Whitney test
Maxilla	Second molars	M	248	0.68	0.61	25	0.68	0.60	0.922
	First molars	D	256	1.17	0.47	26	1.20	0.37	0.402
	First molars	M	176	0.94	0.57	104	0.94	0.53	0.790
	Canines	D	171	1.36	0.40	113	1.41	0.41	0.146
Mandible	Second molars	M	346	0.51	0.66	26	0.80	0.57	0.024
	First molars	D	338	0.99	0.35	30	1.06	0.26	0.357
	First molars	M	228	0.24	0.51	107	0.34	0.50	0.151
	Canines	D	199	1.34	0.44	128	1.35	0.37	0.988

*CEJ-ABC= cementoenamel junction–alveolar bone crest
M= mesial; **D**= distal
n= number of examined sites
SD= standard deviation

Table 3. Mean CEJ-ABC* distance (in mm) by dental arch, type of primary tooth and tooth surface, according to gingival bleeding

Dental Arch	Type of Tooth	Site	Gingival bleeding: Present n	Present Mean	Present SD	Not present n	Not present Mean	Not present SD	p-value of Mann-Whitney test
Maxilla	Second molars	M	93	0.69	0.64	180	0.68	0.59	0.894
	First molars	D	104	1.22	0.51	178	1.14	0.42	0.141
	First molars	M	34	1.07	0.45	246	0.92	0.57	0.107
	Canines	D	34	1.44	0.44	250	1.37	0.40	0.524
Mandible	Second molars	M	133	0.57	0.52	239	0.51	0.71	0.806
	First molars	D	145	1.02	0.35	223	0.98	0.34	0.278
	First molars	M	48	0.25	0.51	287	0.28	0.51	0.473
	Canines	D	39	1.33	0.44	288	1.34	0.41	0.807

*CEJ-ABC= cementoenamel junction–alveolar bone crest
M= mesial; **D**= distal; **n**= number of examined sites; **SD**= standard deviation

Table 4. Mean CEJ-ABC* distance (in mm) by dental arch, type of primary tooth and tooth surface, according to probing depth

Dental Arch	Type of Tooth	Site	Probing depth: 2 mm or less n	2 mm or less Mean	2 mm or less SD	>2 mm n	>2 mm Mean	>2 mm SD	p-value of Mann-Whitney test
Maxilla	Second molars	M	152	0.62	0.61	121	0.76	0.59	0.061
	First molars	D	134	1.14	0.42	148	1.20	0.49	0.463
	First molars	M	258	0.92	0.54	22	1.17	0.66	0.049
	Canines	D	272	1.37	0.41	12	1.52	0.34	0.149
Mandible	Second molars	M	301	0.50	0.68	71	0.65	0.51	0.165
	First molars	D	288	0.95	0.34	80	1.16	0.30	<0.001
	First molars	M	316	0.28	0.51	19	0.20	0.51	0.698
	Canines	D	314	1.33	0.40	13	1.72	0.41	0.001

*CEJ-ABC= cementoenamel junction–alveolar bone crest
M= mesial; **D**= distal; **n**= number of examined sites; **SD**= standard deviation

Table 5. Mean CEJ-ABC* distance (in mm) by dental arch, type of primary tooth and tooth surface, according to proximal contact

Dental Arch	Type of Tooth	Site	Proximal contact: Present n	Present Mean	Present SD	Not present n	Not present Mean	Not present SD	p-value of Mann-Whitney test
Maxilla	Second molars	M	138	0.69	0.55	135	0.67	0.66	0.814
	First molars	D	137	1.21	0.39	145	1.14	0.52	0.077
	First molars	M	33	0.67	0.51	247	0.98	0.55	0.003
	Canines	D	35	1.29	0.39	249	1.39	0.41	0.244
Mandible	Second molars	M	284	0.53	0.64	88	0.54	0.71	0.573
	First molars	D	284	1.01	0.36	84	0.96	0.31	0.092
	First molars	M	57	0.22	0.51	278	0.29	0.51	0.381
	Canines	D	52	1.35	0.51	275	1.34	0.39	0.461

*CEJ-ABC= cementoenamel junction–alveolar bone crest
M= mesial; **D**= distal; **n**= number of examined sites; **SD**= standard deviation

Table 6. Mean CEJ-ABC* distance (in mm) by dental arch, type of primary tooth and tooth surface, according to dental condition

Dental Arch	Type of Tooth	Site	CEJ-ABC distance (mm) Dental condition Adequate† n	Mean	SD	Inadequate‡ n	Mean	SD	p-value of Mann-Whitney test
Maxilla	Second molars	M	255	0.66	0.60	18	1.03	0.57	0.027
	First molars	D	247	1.14	0.43	35	1.37	0.62	0.014
	First molars	M	258	0.95	0.55	22	0.88	0.58	0.287
	Canines	D	280	1.38	0.41	4	1.20	0.34	0.312
Mandible	Second molars	M	347	0.52	0.66	25	0.70	0.51	0.193
	First molars	D	313	0.99	0.33	55	1.06	0.41	0.028
	First molars	M	329	0.28	0.51	6	0.28	0.62	0.803
	Canines	D	325	1.34	0.41	2	1.28	0.35	0.851

*CEJ-ABC= cementoenamel junction–alveolar bone crest
†Adequate= sound/properly restored surfaces
‡Inadequate= cavitated/poorly restored surfaces
M= mesial; **D**= distance; **n**= number of examined sites; **SD**= standard deviation

actually, age and gender proved to have no influence on these distances (Figure 2). Nevertheless, the authors who suggested that a non-linear increase in CEJ-ABC distances would take place between ages 4 and 6[16] have included measurements of the distal surface of the primary second molars, which were not taken in the present study and that might have contributed to the observed increase in this age range due to the erupting process of the first permanent molars.

An influence of dental arch and/or type of tooth on CEJ-ABC distance in primary teeth has been demonstrated either by cross-sectional[3,6,13,15,18] or by retrospective longitudinal[16] studies and was confirmed by the present research (Figure 3). Therefore, the necessity of controlling statistical analyses by dental arch, type of tooth and tooth surface became suitable. Also, it seemed advisable to examine the CEJ-ABC distance as a continuous variable without specifying a threshold value for alveolar bone loss (e.g., the 2 mm previously proposed)[1-2,6,9,14] because a general cut-off value would not be adequate for all primary teeth as it has already been pointed out by some authors.[16,19] Besides, radiographic analyses were performed with a 0.01 mm accuracy because the studied population was too young to show alveolar bone loss diagnosed by previously reported threshold values; instead, they would probably present very subtle increase in the CEJ-ABC distance, which could be an alert to the development of alveolar bone loss in the future.

Negative values for CEJ-ABC distance have only been found by Needleman et al.[18] at the mesial surface of first permanent molars in children aged 7 to 9 and have not been previously reported in primary teeth. However, most of the different analyzed dental surfaces in the present research showed negative values for CEJ-ABC distance (Figure 3) and a possible explanation is the early dentition stage of the examined children (exclusively complete primary dentition) that was probably not yet totally affected by the continuous eruption of primary teeth due to attrition. The same explanation could be attributed to the findings of Needleman et al.[18] once negative values were only found for first permanent molars in children with early mixed dentition (7 to 9 years old), which means that those were probably newly-erupted teeth and had not undergone continuous eruption due to attrition as did their primary teeth.

The present results coincided with the findings of Sjödin and Matsson[14] with regard to the smallest mean CEJ-ABC distance found for the mesial surface of primary mandibular first molars with a comparatively high number of surfaces with a distance of 0.00 mm at this location. Those authors attributed this fact to a possible distortion due to the radiographic projection in this curving area of the mandibular arch. Nevertheless, other factors (such as anatomic differences in tooth sites) might explain these short distances at this particular site because primary mandibular canines are also located at this curving area and showed otherwise long CEJ-ABC distances not only in the present study, but also in the study of Sjödin and Matsson.[14]

Independent observations should preferably be used for statistical analyses, but this is not possible in site-based ones, which included multiple observations per subject. Thus, the positive correlations among sites of the same mouth (within-mouth correlations) tend to produce underestimated standard errors and overestimated statistical significance.[14,27-28] In the present study, however, these within-mouth correlations were very reduced when data was controlled by dental arch, type of tooth and tooth surface because the statistical analyses were performed with only two observations per child (distances from the right and left sides for each analyzed dental surface). Nevertheless, 1% significance level, lower than the traditional 5%, was chosen to minimize the possibility of electing a given dental surface as statistically associated to increased CEJ-ABC distances because of overestimated statistical significance.

After the data was controlled by the possible confounding factors (dental arch, type of tooth and tooth surface), it was observed that neither visible dental biofilm nor gingival bleeding was statistically associated with increased CEJ-ABC distances in all the different analyzed dental surfaces (Tables 2 and 3). Similar results have been previously reported[14-15,19] and the lack of association between dental biofilm or gingival bleeding and CEJ-ABC distances seems to be explained mainly by two aspects: a) the limitations inherent to cross-sectional studies in verifying associations between local factors and episodes that require time to be developed (as it occurs between biofilm accumulation, gingival bleeding and alveolar bone loss)[29]; and also the previously reported fact that primary teeth usually present less periodontal disease than permanent teeth, despite similar amounts of biofilm accumulation within a given time interval.[30-32]

Increased probing depth was related to increased CEJ-ABC distances in this study (Table 4), although this finding has not been observed in previous studies.[14-15] These contrastable results were probably due to methodological differences because those authors have assessed the distances by using rules with accuracies of 0.5 mm[14] and 1 mm,[15] while in the present study more precise accuracy was employed (0.01 mm) and the mean differences observed here were not higher than 0.40 mm. It is important to note, however, that although statistically significant, the differences were very small in clinical terms, and may not, therefore, be clinically meaningful.[18]

Absence of interproximal contact has also been associated with increased CEJ-ABC distances[4,11,15,18] although in the present study, a statistically significant association was only observed for the mesial surface of the primary maxillary first molars (Table 5). Also, most areas of contact between primary molars, irrespective of the dental arch, showed increased mean distances in the presence of inadequate dental condition (cavitated carious lesions/defective restorations), although none of them showed statistical significance. This observation was not in accordance with various previously reported studies on the influence of proximal dental caries/defective restorations on CEJ-ABC distance in primary teeth.[3-4,6-7,11,15,18-19] It is believed, however, that the lack of association between cavitated carious lesions/defective restorations and alterations in CEJ-ABC distances could be, once more, due to the limitations of cross-sectional studies in verifying associations between local factors and episodes that require time to be developed, mainly because children from the present study were in the early stages of dentition (exclusively complete primary dentition).

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. Presence of increased probing depth (>2 mm) was the only local factor associated with increased CEJ-ABC distances in most of the different analyzed dental surfaces.
2. The observed differences did not seem to be clinically meaningful; however, this local factor should be taken into consideration when children are screened for alveolar bone loss because of the usual slow course of periodontal disease.

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