DOI: 10.1111/j.1365-263X.2010.01073.x

The alveolar bone height of the primary and first permanent molars in healthy 6- to 9-year-old Jordanian children

GHAIDA AL JAMAL[1], OLA AL-BATAYNEH[2] & DIMA HAMAMY[2]

[1]Department of Oral Medicine and Oral Surgery, and [2]Department of Preventive Dentistry, Faculty of Dentistry, Jordan University of Science & Technology, Irbid, Jordan

International Journal of Paediatric Dentistry 2011; 21: 151–159

Aim. To establish a threshold cemantoenamel junction (CEJ)–alveolar bone crest (ABC) distance in healthy 6- to 9-year-old Jordanian children and determine the effect of pathological changes, physiological changes, gender, and age on the CEJ–ABC distance.

Design. Bitewing radiographs were made for 539 6- to 9-year-old children. Plaque index (PI), gingival index (GI), calculus index (CI), DMFS score, and pocket depth were all assessed through clinical examination. CEJ–ABC distance was measured from radiographs at the mesial surface of permanent first molars (PFM), and the mesial and distal surfaces of primary molars.

Results. The CEJ–ABC distance ranged from 0.00 to 4.49 mm, the mean for all surfaces was 0.84 ± 0.44 mm, no gender or age group differences were found. The mesial surface of the PFMs had the smallest mean CEJ–ABC distance. The CEJ–ABC distances were greater in the maxilla than in the mandible. No significant effect of PI, GI or CI on CEJ–ABC distance was found. Caries, faulty restorations, exfoliation, and partial eruption adjacent to measured surfaces had significant effect on the CEJ–ABC distance.

Conclusion. The mean CEJ–ABC distance was <1 mm. Threshold CEJ–ABC distances of 1.0 and 1.5 mm for PFMs and primary molars, respectively, are suggested to be used in 6- to 9-year-old children.

Introduction

Periodontal disease in the primary dentition is generally limited to the gingival tissues resulting in gingivitis; however, deeper involvement of the periodontium is occasionally seen[1]. One method for identification of individuals susceptible to periodontal breakdown is the early detection of bone loss in the primary dentition. For instance, it had been found that patients with localized juvenile (aggressive) periodontitis exhibited bone loss in the primary dentition in early childhood[2].

The correct diagnosis of periodontitis requires the concurrence of bleeding on probing and loss of periodontal support, however, assessments in large epidemiological surveys have focused only upon the accumulated destructive effect of the disease revealed by clinical measurements of loss of attachment or radiographic measurements of loss of marginal bone[3].

The diagnosis of marginal bone loss in the primary dentition includes the measurement of the distance between the cementoenamel junction (CEJ) and the alveolar bone crest (ABC) and therefore, baseline information on the normal range of CEJ–ABC distances is necessary for the diagnosis of abnormal bone levels[4].

Most studies of normal alveolar bone height are on the permanent dentition, and the radiographic interproximal CEJ–ABC distance in health has been reported to range between 1 and 3 mm[5,6]. Benn, however, found that the normal distance for adults ranged from 0.1 to 1.9 mm[7]. Very few studies on normal bone height in the primary dentition exist, these studies reported a normal CEJ–ABC distance of 1 ± 0.5 mm in the primary dentition[1,8,9], and a distance of more than 2 mm is usually considered to represent bone loss[1].

In general, the normal CEJ–ABC distance reported in the literature ranged between

Correspondence to:
G. Al Jamal, Department of Preventive Dentistry, Jordan University of Science and Technology, P.O. Box 4614, Irbid 21110, Jordan.
E-mail: ghaidaa@just.edu.jo; olabt@hotmail.com

0–2 mm and the threshold level for considering pathologic bone loss is usually >2 mm[5,10,11]. However, it is suggested that CEJ–ABC distances >2 mm at sites neighbouring an exfoliating primary tooth or a partially erupting permanent tooth are taken into account as a physiological process, while in other sites are considered pathological[1].

An increase in CEJ–ABC distance may indicate periodontal disease in children with other clinical findings, which in adolescents was often found to be preceded by bone loss in the primary dentition[1,2]. So assessment of CEJ–ABC distance would be an important step for early recognition and treatment of these patients for the purpose of preventing the transition of the disease from the primary to the permanent dentition[11].

A review on the epidemiology of periodontal disease in children and adolescents showed that when 2 mm was used as the threshold distance for bone loss, the reported prevalence of radiographic marginal bone loss varied from 1.0% in Sweden to 89.2% in Navajo Indians from New Mexico[12–14]. In another study it was found that children of Asian-Far Eastern origin had a higher percentage of sites with bone loss compared with children of Caucasian origin, being 29.5 and 19.7%, respectively; but this was lower than that of children of Middle-Eastern origin (35%)[15]. This wide variation in the prevalence rates reflect population differences or may be due to the use of a threshold CEJ–ABC distance which is inappropriate for some ethnic groups. It is acknowledged that variations exist in the size and morphology of teeth among different populations. However, it is not known whether such anatomical variations exist in the alveolar bone height. This raises the need for further studies to establish proper threshold CEJ–ABC distances that would be suitable for use in the different ethnic groups.

The aim of this study was to propose a threshold CEJ–ABC distance in the permanent first molar and primary molars area of 6- to 9-year-old Jordanian children using bitewing radiographs which might be suitable for use in children of Middle-Eastern origin. Physiological and pathological factors that might be affecting this distance will be studied when possible.

Materials and methods

Sample selection

Eight hundred children from elementary public schools were provided informed consent forms to their parents to participate in the study; all children lived in Irbid/Jordan. Children were selected according to the following inclusion criteria: children with no systemic or periodontal disease, no history of previous orthodontic treatment.

Seventy-two children did not want to participate in the study and were excluded; 189 children were excluded because they did not match the inclusion criteria or because they had dental radiographs taken in the past year.

Five hundred and thirty-nine subjects (251 male and 288 female) healthy Jordanian children ranging in age from 6 to 9 years old (mean 7.75 ± 1.035) were included in the study population which was assured to be homogenous with regards to race, diet, education, and socio-economic status from the history.

Clinical examination

Clinical examination was carried out by one examiner (DH) for all participants at the paediatric dentistry clinic at the Dental Teaching Center/Jordan University of Science and Technology. Decayed, missing, and filled surfaces (DMFS), exfoliating and partially erupted teeth were recorded for each child. This was termed condition of the surface.

A modified index based on the O'Leary index[16] and The Plaque Assessment Scoring System (PASS)[17] was used in obtaining the plaque index (PI) score and was also applied for obtaining the calculus index (CI). Measurements were obtained by recording both soft and mineralized deposits on all surfaces (buccal, lingual, mesial and distal) of the following teeth:

1. The 16 or 55 tooth, if 16 has not erupted
2. The 21 or 61 tooth, if 21 has not erupted

3. The 24 or either 64 or 63, if 24 has not erupted
4. The 46 or 85 tooth, if 46 has not erupted
5. The 41 or 81 tooth, if 41 has not erupted
6. The 44 or 84 tooth, if 44 has not erupted

If plaque/calculus was visible on the probe, the surface was counted as positive for plaque/calculus accumulation and given a score of 1 for plaque/calculus presence at that surface otherwise a score of 0 for no plaque/calculus. There were 24 possible plaque surfaces per patient. Gingival index (GI) scores were obtained for the teeth using the same method in scoring PI and CI. Gingivitis was considered present if there was bleeding on probing clinically. The plaque/calculus/gingivitis index for the child is the percentage of surfaces positive for plaque/calculus/gingivitis. For all three indices, the score of the patient would range between 0 and 1. Patients were considered not to have plaque, calculus or gingivitis if the score was between 0 and 0.13; if the score of patients was from 0.17 to 1.0 they were considered to have plaque, calculus or gingivitis.

Pocket depth for the four permanent first molars (PFMs) was assessed by clinical probing using a scaled periodontal probe; three areas on the mesial surface of each molar (mesiobuccally, mesiocentrally and mesiolingually) were measured and the largest reading was taken. Measurements were in 0.5 mm increments.

Radiographic examination

Two bitewing radiographs were obtained for each child using size 1 or 2 Kodak Insight films (Eastman Kodak Co, Rochester, NY, USA). Films were exposed to an X-ray source (Trophy, Croissy-Beaubourg, France) using 70 kVp, 7 mA and paralleling technique with Rinn®-XCP film holders and were developed in an automatic processor (XR 24; Dürr Dental, Bietigheim-Bissingen, Germany). Bitewing radiographs were selected according to the following criteria: no distortion, no overlapping interproximally, and inclusion of the mesial surfaces of the PFMs and primary first molars.

The radiographs were then examined under ideal conditions including the use of subdued lights; film masking and a conventional viewing box (Exal-Type F.I.D-1; Basingstoke, England) with a variable light intensity and a 5×magnifying lens. Radiographic analysis was done for 20 surfaces which included the mesial and distal surfaces of all primary molars and the mesial surfaces of the all PFMs. There were 539 pairs of bitewings which would yield 10,780 surfaces for examination of which 1514 surfaces were excluded and considered as missing values when they were not clear on the radiographs or when the teeth were missing.

The sample was further distributed according to the condition of the tooth surface examined clinically and radiographically into four groups:

- (N) group indicating normal surface with no caries or restoration;
- (C) group indicating surfaces with caries, multi surface caries (destroyed);
- (RS) group indicating surfaces with faulty restoration or stainless steel crown;
- (PEx) group indicating partially erupted permanent teeth or exfoliating primary molar.

A tooth was considered to be exfoliating if there was more than two-thirds of root resorption in one or more of the roots. Proximal caries, proximal restorations, presence of properly contoured or under-contoured and overextended restorations were noted for all surfaces examined and recorded. Presence or absence of proximal calculus at the same sites examined was also noted and recorded. The stage of eruption of neighbouring permanent teeth to the primary molars was recorded. A tooth was considered fully erupted if it had reached occlusion (based on clinical examination or partially erupted if the cusp tips were located supracrestally (based on radiographic examination) but had not reached occlusion.

The distances from CEJ to ABC for all 20 surfaces were measured using an electronic digital caliper (Mitutoyo, Tokyo, Japan) with 0.01 mm increments. All measurements were examined by a single examiner (DH). In order to check the accuracy of the measurements, radiographs of 60 children were randomly selected and reexamined after 4-weeks interval and the method error was calculated using Dahlberg's formula[18] where the mean error is calculated from the equation: $\mathrm{ME} = \sqrt{d^2/2n}$

where d is the difference between duplicated measurements and n is the number of remeasured sites. The method error was found to be 0.0079 mm and this is minimal with reference to the accuracy of measurements.

The study design was approved by the Institutional Review Board of the faculty of Medicine at Jordan University of Science and Technology and all study subjects provided written informed consent from their guardian. All bitewing radiographs were taken in accordance with the American Academy of Paediatric Dentistry (AAPD) Guidelines[19].

Statistical methods

The data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS v. 15) for windows (Chicago, IL, USA). Means and standard deviations and descriptive statistics were calculated for all CEJ–ABC distance measurements.

One way Analysis of Variance (ANOVA) was used to test the effect of condition of the surface and age on the CEJ–ABC distances. Independent t-test was applied to compare CEJ–ABC distances measured in males and females, in maxilla and mandible and to compare mesial and distal CEJ–ABC measurements for primary molars, it was also used to test the effect of gingival, plaque and calculus index when applicable on the CEJ–ABC distances. We studied the correlation of CEJ–ABC distance with the clinically measured pocket depth for the first permanent molars using bivariate correlation.

Results

The distribution of the included subjects according to age and gender is shown in Table 1 and the numbers of teeth included in the investigation are shown in Table 2.

The mean CEJ–ABC distance for all surfaces (mesial and distal surfaces of all primary molars and mesial surfaces of first permanent molars) was calculated for 9266 out of total 10,780 surfaces (1514 surfaces were excluded). The total CEJ–ABC distance ranged from 0.00 to 4.49 mm (mean = 0.84 ± 0.44). The PFM CEJ–ABC distance ranged from 0.00 to 2.97 mm (mean = 0.39 ± 0.32). The second primary molar CEJ–ABC distance ranged from 0.00 to 4.49 mm (mean = 1.07 ± 0.50). The first primary molar CEJ–ABC distance ranged from 0.00 to 4.14 mm (mean = 0.84 ± 0.46). The detailed individual surface measurements are listed in Table 3.

The mean CEJ–ABC distances for males and females were found to be close (0.74 and 0.72 mm, respectively) and the difference was not statistically significant ($P = 0.48$). When the mean CEJ–ABC distances measured in the maxilla were compared between males and females (0.83 and 0.82 mm, respectively), the difference was not statistically significant ($P = 0.68$). Similarly, mean CEJ–ABC distances in mandible did not differ significantly between males and females (0.70 and 0.68 mm, respectively; $P = 0.45$).

The mean CEJ–ABC distance for the different age groups were very close. It was 0.77 ± 0.17 mm, 0.73 ± 0.18 mm, 0.72 ± 0.17 mm and 0.71 ± 0.13 mm for the 6-, 7-, 8- and 9-year-old children, respectively. The differences were not statistically significant ($P = 0.49$).

When comparing CEJ–ABC distances measured in the maxilla and mandible, it was found that teeth in the upper jaw had a statistically significant greater CEJ–ABC distance than in the lower jaw (0.90 ± 0.51 mm *vs* 0.77 ± 0.55 mm, respectively; $P < 0.001$).

Table 4 displays the mean CEJ–ABC distances in the different groups representing

Table 1. Distribution of sample according to age and gender.

	Age				
	6	**7**	**8**	**9**	**Total**
Male	34 (13.5%)	73 (29.1%)	70 (27.9%)	74 (29.5%)	251 (46.6%)
Female	40 (13.9%)	77 (26.7%)	81 (28.1%)	90 (31.2%)	288 (53.4%)
Total	74 (13.7%)	150 (27.8%)	151 (28%)	164 (30.4%)	539 (100%)

Table 2. Total number of permanent and primary teeth investigated.

Tooth	*n*
Permanent first molar	2033
Primary second molar	1940
Primary first molar	1700

the condition of the tooth surface with *P*-values calculated from ANOVA test in the most right column. All mean CEJ–ABC distances were significantly differing in the four groups ($P < 0.05$). In general, the mean CEJ–ABC distances of PEx group was significantly the greatest followed by surfaces with restorations, crowns, or with caries. The smallest means were for surfaces in the N group which were less than 1 mm.

Maximum measurements did not exceed 1 mm for PFM and 1.5 mm for primary molars.

When the sample was distributed according to their plaque, calculus and gingival index, 485 (90.4%) children had plaque, 8 (2.3%) had calculus, and 19 (3.4%) had gingivitis. These indices had no effect on CEJ–ABC distance; the *P*-values were >0.05.

Table 3. Mean CEJ–ABC distance in mm at different surfaces measured in different teeth.

Surface measured	Number measured	Mean ± SD (mm)	Range (mm)	*P*-value
M16	499	0.46 ± 0.33	0–1.91	
M26	498	0.45 ± 0.33	0–1.96	
M36	517	0.32 ± 0.29	0–2.97	
M46	519	0.34 ± 0.31	0–2.49	
M55	492	1.13 ± 0.5	0–3.69	**
D55	493	1.21 ± 0.44	0–3.58	
M65	498	1.13 ± 0.49	0.2–3.29	NS
D65	497	1.16 ± 0.44	0.45–3.62	
M75	464	1.11 ± 0.62	0.35–4.06	***
D75	473	0.94 ± 0.46	0.24–3.68	
M85	470	1.03 ± 0.59	0–4.02	***
D85	476	0.84 ± 0.43	0–4.49	
M54	440	0.81 ± 0.47	0.12–4.14	**
D54	437	0.91 ± 0.49	0.19–3.37	
M64	428	0.81 ± 0.42	0.11–2.76	***
D64	425	0.91 ± 0.45	0–3.42	
M74	404	0.61 ± 0.3	0.05–3.13	***
D74	385	1.07 ± 0.58	0.12–3.32	
M84	428	0.6 ± 0.36	0–3.12	***
D84	413	0.97 ± 0.59	0–3.97	

**$P \le 0.01$; ***$P \le 0.001$.
CEJ–ABC, cemantoenamel junction–alveolar bone crest; M, mesial surface; D, distal surface; NS, not significant.

Significant differences between mesial and distal surfaces of all primary molars were found ($P < 0.001$) for all primary molars with no specific surface having consistently greater CEJ–ABC distance; the test, however, did not isolate between sound, carious or restored surfaces (Table 3).

No significant correlation was found between the CEJ–ABC distances measured radiographically at the mesial side of (16, 26 and 46) with the clinically measured pocket depth for the same tooth. However, there was a weak correlation (Pearson correlation coefficient = 0.09) between the CEJ–ABC distances measured radiographically at the mesial side of mandibular left PFM with the clinically measured pocket depth for the same tooth that was found to be significant at the 0.05 level.

Discussion

This study was designed in a cross-sectional manner aiming to establish normal values to differentiate between normal and abnormal CEJ–ABC distances in a healthy 6- to 9-year-old Jordanian children and to examine the effect of several factors on this distance to predict the presence of alveolar bone loss and aggressive/early periodontal disease. The age of the children was chosen to range between 6 and 9 years as it was found from a longitudinal study by Shapira *et al.* that the CEJ–ABC distance is stable at this period of growth so to avoid effect of growth spurts on this distance[4].

In epidemiological studies on the prevalence of periodontitis in children and adolescents, radiographic methods of measurements had commonly been used[20,21]. In this study, bitewing radiographs were chosen to measure the CEJ–ABC distance as they are generally taken for caries assessment in children, especially at the first visit according to AAPD Guidelines [19], and at the same time, they also show the bone height around the PFMs and first and second primary molars[20,22,23].

Table 4. ANOVA table showing the differences in mean CEJ–ABC in mm according to the condition of the teeth.

Surface measured	Condition of tooth surface: N (*n*) mean distance mm	C (*n*) mean distance mm	RS (*n*) mean distance mm	PEx (*n*) mean distance mm	ANOVA *P*-value
M16	(423) 0.49	(24) 0.40	(5) 0.54	(49) 0.59	*
M26	(432) 0.44	(27) 0.37	(6) 0.44	(35) 0.37	*
M36	(459) 0.30	(29) 0.52	(9) 0.50	(24) 0.60	***
M46	(458) 0.31	(28) 0.43	(8) 0.64	(24) 0.63	***
D55	(415) 1.15	(32) 1.47	(9) 1.24	(42) 1.65	***
M55	(342) 0.96	(85) 1.24	(15) 1.60	(56) 1.88	***
D54	(207) 0.62	(114) 0.90	(11) 1.14	(118) 1.40	***
M54	(270) 0.60	(83) 0.92	(3) 1.50	(95) 1.34	***
D65	(416) 0.60	(34) 0.92	(7) 1.50	(45) 1.34	***
M65	(450) 0.97	(85) 1.22	(14) 1.66	(53) 1.93	***
D64	(184) 0.62	(123) 0.88	(16) 1.25	(121) 1.35	***
M64	(268) 0.61	(70) 0.93	(5) 1.27	(101) 1.28	***
D85	(383) 0.78	(64) 0.92	(12) 1.01	(20) 1.85	***
M85	(325) 0.89	(102) 1.15	(19) 1.17	(34) 2.01	***
D84	(163) 0.60	(176) 0.97	(16) 1.12	(91) 1.64	***
M84	(346) 0.50	(69) 0.92	(7) 1.05	(25) 1.34	***
D75	(391) 0.86	(52) 1.12	(12) 1.03	(21) 1.96	***
M75	(315) 0.92	(117) 1.36	(16) 1.27	(28) 2.21	***
D74	(151) 0.65	(153) 1.04	(17) 1.179	(104) 1.69	***
M74	(320) 0.52	(72) 0.86	(7) 0.98	(26) 1.19	***

$^*P \leq 0.05$; $^{***}P \leq 0.001$.

The mean CEJ–ABC distance for the mesial surfaces of PFMs was 0.39 ± 0.32 mm and ranged between 0.00 and 2.97 mm, this was also similar to what was found in other studies[1,5,9]. The maximum values, however, did not exceed 1.00 mm for those in the N group (normal surface condition). For the first and second primary molars, the mean CEJ–ABC distance were 0.84 ± 0.46 mm and 1.07 ± 0.50 mm, respectively, with a mean of 0.95 ± 0.48 mm. This is comparable with findings of other studies where the mean was around 1.00 mm[1,8,9], whereas it is higher than what was found by Bimstein *et al.* where the CEJ–ABC distance for the first primary molars was 0.78 mm whereas for second primary was 0.97 mm[22]. However, maximum values in the N group in this study were less than 1.5 mm. This variation reflects population differences or may be due to the different methods used in each study such as the use of magnifying lenses and/or viewing boxes, digital sliding gauges and computer-assisted measurements.

The smallest mean CEJ–ABC distance was for PFM (0.39 ± 0.32 mm), which also had higher number of surfaces measuring 0.00 mm CEJ–ABC distance. However, this was not the case in other studies where mesial surfaces of primary first molars had higher number of surfaces measuring 0.00 mm CEJ–ABC distance and this was attributed to the radiographic projection in the curving area of the mandibular arch[1,5] These differences might represent anatomical variations, but on the other hand might be related to the effect of permanent teeth eruption on the primary dentition[4].

In several studies, the most frequently affected teeth by marginal bone loss were surfaces of the mandibular first primary molars[11,22,24], in another study, they found that the tooth most frequently affected was the second primary molar[15]. In this study, second primary molars had CEJ–ABC distances greater than 2 mm most frequently and they had the greatest mean (1.07 ±mm).

Many studies reported no differences in CEJ–ABC distances between mesial and distal surfaces[9]. In this study, however, there were significant differences between mesial and distal surfaces, with no specific surface having a greater CEJ–ABC distance consistently; this could be explained by the fact that the condition of the surfaces compared were not similar in terms of caries, restorations, and proximity to erupting or exfoliating teeth. No differences between right and left side for the same teeth were found here and this is similar to what had been reported by Shapira *et al.*[4].

Males did not exhibit any differences from females in their mean CEJ–ABC distances and this is similar to what was found by Bimstein *et al.*[22], Hart *et al.*[25] and Löe and Brown[26]. However, males had greater distances than females in another study[9]. The CEJ–ABC distance was not different among the four age groups (6–9 years) of the study sample although mean distances where getting slightly smaller with age, however, there would not be any relevance to this decrease when measurements fall way below the threshold CEJ–ABC distance. Similar results were found in a longitudinal study by Shapira *et al.* where the CEJ–ABC distance was stable at this period of age, while it increased between 4–6 and 9–12 years as a result of growth and development processes when the facial growth rate is maximal[4]. Sjödin and Matsson could not demonstrate any association between age and CEJ–ABC distance in 7–9 years age group and they related this to the narrow age interval of the children in their study[1]. On the other hand, Bimstein & Soskolne found that CEJ–ABC distances increased linearly with age and this may be due to the wider age group (3–11 years) in their study which included children during periods of facial growth spurts[8].

The results also showed that CEJ–ABC distances in the maxilla were significantly greater than in the mandible ($P < 0.001$). The same result was found by others[4,9,11] this might be related to differences in growth pattern or bone composition. In another study, however, surfaces with bone loss were evenly distributed between the mandible and the maxilla.[24] However, there would not be any relevance to this difference when measurements fall below the threshold CEJ–ABC distance.

The PI, CI, and GI indices were calculated at subject level and were found to have no effect on the CEJ–ABC distance; this is in concordance with previous studies[1,27–29]. In one study, however, a higher number of surfaces with bone loss tended to be associated with a higher prevalence of calculus[15]. The prevalence of calculus in primary teeth in patients who were found to have bone loss of ≥2 mm was 42%[11]. In our study, the number of cases positive for these indices was too small and limited studying their effect at surface level. However, the data obtained described the periodontal status of the group of children studied.

In this study, we investigated the effect of caries, restorations and crowns, exfoliation of teeth, and eruption of teeth on the CEJ–ABC distance. The variance components analysis revealed an association between partially erupted PFMs or exfoliating primary molars and greater CEJ–ABC distance measurements. This was also found by Sjödin and Matsson[1], and may be explained by the fact that during the stage of development, the alveolar bone crest may be located more apically. The presence of a follicle of an erupting permanent tooth or resorbing root of an exfoliating primary tooth may also have an influence on the radiographic image of the bone due to its effect on the mineral density of the ABC which in case of an erupting tooth was reversed[1].

From the same analysis, it was noticed that surfaces with proximal caries and restorations had an effect on CEJ–ABC distance; these surfaces had greater CEJ–ABC distances compared with sound surfaces. Needleman *et al.* found that the CEJ–ABC distance was significantly greater in areas of interproximal caries, interproximal restorations and open contacts[9]. However, Guelmann *et al.* suggested that the presence of a well-adapted Stainless Steel Crown (SCC) on a second primary molar does not affect the periodontal health of the neighbouring PFM[29]. Moreover, Bimstein *et al.* studied the effect of restorations on CEJ–ABC and found that inadequate amalgam restorations and inadequate crowns will increase the CEJ–ABC distance[30]. Sjödin and Matsson in 1992 reported that an association could not be ruled out between proximal caries, faulty restorations and increased CEJ–ABC distance due to insufficient data[1]. For our sample, the comparison between caries and faulty restoration groups showed significantly higher values for the latter, but limitation exists for interpretation of this finding due to the small number in this group.

As our children sample selection was random, most of the surfaces studied were falling under the normal surface condition group. The smaller number of surfaces falling in the other groups although it did not prevent statistical calculations but it could have masked greater variations or deviations from the normal range CEJ–ABC distances at surfaces where the number was less than 10 in some groups.

Summing up, the mean CEJ–ABC distance for all teeth was 0.84 ± 0.44; no differences were found in CEJ–ABC distances according to sex, age, or subjects' PI, CI, GI. Factors that were found to affect the CEJ–ABC distance included the jaw, condition of the tooth surface, and site. The smallest mean CEJ–ABC distance was at the mesial surface of the PFMs. Greater CEJ–ABC distances were found at surfaces next to partially erupting permanent teeth or exfoliating primary teeth followed by surfaces next to caries, restorations and SSCs.

As the measurement of the CEJ–ABC distance is continuous rather than discrete, a threshold that is applicable for one population may not be applicable to another and within the limitation of this study; our sample had smaller CEJ–ABC distances than what had been reported previously, so we suggest a 1.0 and 1.5 mm threshold distance to be used for the mesial surfaces of the PFM and both surfaces of the primary molars, respectively, in 6- to 9-year-old Jordanian children. Further research is necessary to explore these threshold distances at sound surfaces to avoid overestimating pathological bone loss; and to isolate the effect of partial eruption/exfoliation, restorations and SSC and caries on the CEJ–ABC distance, nonrandom samples are suggested to have enough surfaces in each of these surface condition groups.

What this paper adds?

- This paper adds additional data on the variation in CEJ–ABC distance with respect to jaw, eruption status and faulty restorations.
- New threshold CEJ–ABC distances are suggested for identification of pathologic ABC loss.

Why this paper is important to paediatric dentists?

- Paediatric dentists should be able to identify patients at risk of developing aggressive periodontitis through clinical and radiographic examination which requires a good knowledge of threshold CEJ–ABC distance above which is considered pathologic loss.
- In addition, knowledge of physiologic factors that increase the CEJ–ABC distance in the developing dentition is important to avoid false positive interpretations.
- Paediatric dentists should be aware of the effect of faulty interproximal restorations and SSCs on CEJ–ABC distance resulting in pocket formation and susceptibility to periodontitis.

References

1 Sjodin B, Matsson L. Marginal bone level in the normal primary dentition. *J Clin Periodontol* 1992; **19**(9 Pt 1): 672–678.

2 Sjodin B, Crossner CG, Unell L, Ostlund P. A retrospective radiographic study of alveolar bone loss in the primary dentition in patients with localized juvenile periodontitis. *J Clin Periodontol* 1989; **16**: 124–127.

3 Armitage GC. Periodontal diseases: diagnosis. *Ann Periodontol* 1996; **1**: 37–215.

4 Shapira L, Tarazi E, Rosen L, Bimstein E. The relationship between alveolar bone height and age in the primary dentition. A retrospective longitudinal radiographic study. *J Clin Periodontol* 1995; **22**: 408–412.

5 Kallestal C, Matsson L. Criteria for assessment of interproximal bone loss on bite-wing radiographs in adolescents. *J Clin Periodontol* 1989; **16**: 300–304.

6 Gjermo P, Bellini HT, Pereira Santos V, Martins JG, Ferracyoli JR. Prevalence of bone loss in a group of Brazilian teenagers assessed on bite-wing radiographs. *J Clin Periodontol* 1984; **11**: 104–113.

7 Benn DK. A review of the reliability of radiographic measurements in estimating alveolar bone changes. *J Clin Periodontol* 1990; **17**: 14–21.

8 Bimstein E, Soskolne AW. A radiographic study of interproximal alveolar bone crest between the primary molars in children. *ASDC J Dent Child* 1988; **55**: 348–350.

9 Needleman HL, Ku TC, Nelson L, Allred E, Seow WK. Alveolar bone height of primary and first permanent molars in healthy seven- to nine-year-old children. *ASDC J Dent Child* 1997; **64**: 188–196.

10 Bimstein E, Treasure ET, Williams SM, Dever JG. Alveolar bone loss in 5-year-old New Zealand children: its prevalence and relationship to caries prevalence, socio-economic status and ethnic origin. *J Clin Periodontol* 1994; **21**: 447–450.
11 Sjodin B, Matsson L. Marginal bone loss in the primary dentition. A survey of 7–9-year-old children in Sweden. *J Clin Periodontol* 1994; **21**: 313–319.
12 Jenkins WM, Papapanou PN. Epidemiology of periodontal disease in children and adolescents. *Periodontol 2000* 2001; **26**: 16–32.
13 Kallestal C, Matsson L, Holm AK. Periodontal conditions in a group of Swedish adolescents. (I). A descriptive epidemiologic study. *J Clin Periodontol* 1990; **17**: 601–608.
14 Wolfe MD, Carlos JP. Periodontal disease in adolescents: epidemiologic findings in Navajo Indians. *Community Dent Oral Epidemiol* 1987; **15**: 33–40.
15 Darby IB, Lu J, Calache H. Radiographic study of the prevalence of periodontal bone loss in Australian school-aged children attending the Royal Dental Hospital of Melbourne. *J Clin Periodontol* 2005; **32**: 959–965.
16 O'Leary TJ, Drake RB, Naylor JE. The plaque control record. *J Periodontol* 1972; **43**: 38.
17 Butler BL, Morejon O, Low SB. An accurate, time-efficient method to assess plaque accumulation. *J Am Dent Assoc*. 1996; **127**: 1763–1766; quiz 84–85.
18 Dahlberg G. *Statistical Methods for Medical and Biological Students*. London: G. Allen & Unwin ltd., 1940.
19 Guideline on prescribing dental radiographs for infants, children, adolescents, and persons with special health care needs. *Pediatr Dent* 2008; **30** (7 Suppl): 236–237.
20 Pierro VS, de Souza IP, Luiz RR, Barcelos R, Moraes RS. Reliability of two methods for measurement of alveolar bone level in children. *Dentomaxillofac Radiol* 2008; **37**: 34–39.
21 Eickholz P, Riess T, Lenhard M, Hassfeld S, Staehle HJ. Digital radiography of interproximal bone loss; validity of different filters. *J Clin Periodontol* 1999; **26**: 294–300.
22 Bimstein E, Delaney JE, Sweeney EA. Radiographic assessment of the alveolar bone in children and adolescents. *Pediatr Dent* 1988; **10**: 199–204.
23 Taylor GK, Macpherson LM. An investigation into the use of bitewing radiography in children in Greater Glasgow. *Br Dent J*. 2004; **196**: 563–568; discussion 41.
24 Sweeney EA, Alcoforado GA, Nyman S, Slots J. Prevalence and microbiology of localized prepubertal periodontitis. *Oral Microbiol Immunol* 1987; **2**: 65–70.
25 Hart TC, Marazita ML, Schenkein HA, Brooks CN, Gunsolley JG, Diehl SR. No female preponderance in juvenile periodontitis after correction for ascertainment bias. *J Periodontol* 1991; **62**: 745–749.
26 Loe H, Brown LJ. Early onset periodontitis in the United States of America. *J Periodontol* 1991; **62**: 608–616.
27 Maragakis GM, Polychronopoulou A, Papagiannoulis L. Association of cementoenamel junction–alveolar bone crest distance and proximal caries in primary molars. *J Clin Pediatr Dent* 1998; **23**: 45–50.
28 Pierro VS, de Souza IP, Luiz RR. Influence of local factors on cementoenamel junction–alveolar bone crest distance in primary dentition. *J Clin Pediatr Dent* 2009; **33**: 199–206.
29 Guelmann M, Matsson L, Bimstein E. Periodontal health at first permanent molars adjacent to primary molar stainless steel crowns. *J Clin Periodontol* 1988; **15**: 531–533.
30 Bimstein E, Zaidenberg R, Soskolne AW. Alveolar bone loss and restorative dentistry in the primary molars. *J Clin Pediatr Dent* 1996; **21**: 51–54.