PEDIATRIC DENTISTRY/Copyright © 1988 by
The American Academy of Pediatric Dentistry
Volume 10, Number 3

Radiographic assessment of the alveolar bone in children and adolescents

Enrique Bimstein, CD Jayne E. Delaney, DDS, MSD
Edward A. Sweeney, DMD

Abstract

The purpose of this study was to determine the prevalence of abnormal alveolar bone in children and adolescents. Radiographs of 1026 patients were classified as showing negative, questionable, or positive evidence of abnormal alveolar bone resorption, based on criteria that included the distance between the cementoenamel junction to the alveolar bone and the integrity of the alveolar crest. Approximately 9% of this population showed evidence of abnormal bone resorption related to periodontitis, proximal decay, stainless steel crowns, and pulp pathosis. The highest prevalence for children aged 4-11 years was 17.9% at age 7, whereas for adolescents aged 15-17 it was almost 7%. The most affected sites were found between the molars in the primary dentition and mesial to the first molar in the permanent dentition. The maxillary bone was more affected than the mandibular with the exception of sites where the alveolar defect was adjacent to proximal decay in the primary molars. These findings indicate that bite-wing radiographs should be examined for the early diagnosis of periodontal disease in children and adolescents.

Periodontal disease in children often has been described as being limited to gingivitis (Magnusson et al. 1981; Walker and Mackenzie 1982). However, evidence of more advanced forms of periodontal disease in the primary dentition has been presented in clinical and radiographic studies (Jamison 1963; Ngan et al. 1985; Mandell et al. 1987; Sweeney et al. 1987). In addition, apical migration of the junctional epithelium of primary human teeth has been shown in stained extracted teeth (Keszthelyi and Szabo 1987) and histologic studies (Soskolne and Bimstein 1977; Bimstein et al. 1985). Furthermore, periodontal bone loss has been detected in radiographic studies of the permanent dentition of adolescents (Hull et al. 1975; Jorkjend and Birkeland 1976; Blankenstein et al. 1978; Davies et al. 1978; Latchan et al. 1983; Gjermo et al. 1984).

The purposes of the present study were: to determine the prevalence and possible etiologic factors of abnormal bone resorption of the alveolar crest in the predominantly Hispanic population seen in a pediatric dentistry clinic in San Antonio, Texas; and to present simple objective criteria for the evaluation of abnormal bone resorption of the alveolar crest.

Materials and Methods

One thousand two hundred and sixty-one records constituting the emergency and recall records of the Mirasol Dental Clinic at San Antonio, which is operated by the Department of Pediatric Dentistry, University of Texas in San Antonio and the City of San Antonio, were reviewed. From these records, posterior radiographs in which proximal areas were considered "acceptable for examination" were selected based on the following criteria: (1) minimal evidence of distortion; (2) minimal overlapping between tooth surfaces; (3) a clear image of the alveolar bone crest and the cementoenamel junction (CEJ). In the case that more than one set of radiographs were present in the same record, the most recent radiographs were chosen for examination.

The projected images of the radiographs (9.6x), were examined on the screen of an ADA Products Inc. viewer (Milwaukee, WI), and the patients were rated as having negative (Group 1), questionable (Group 2) or definitive (Group 3) evidence of abnormal alveolar bone resorption based on the following criteria:

Group 1 — The distance between the alveolar crest to the CEJ was judged to be normal (< 2 mm) and without evidence of loss of cortical and inter-radicular bone (Fig 1, next page).

Group 2 — The distance between the alveolar crest to the CEJ was judged to be slightly increased (between 2 and 3 mm), but without evidence of loss of cortical and inter-radicular bone (Fig 1).

Group 3 — The distance between the CEJ to the alveolar bone crest was judged to be increased (> 3 mm), and

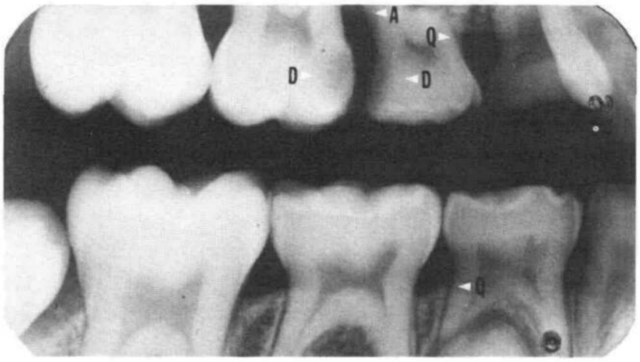

FIG 1. Bite-wing radiograph showing normal alveolar bone in the mandible, questionable (Q), and abnormal (A) alveolar bone resorption at the maxilla. Note the extensive proximal decay (D) adjacent to the abnormal alveolar bone resorption, and the normal increased distance from the CEJ to the alveolar bone at the distal area of the mandibular first primary molar.

clear evidence of loss of cortical and inter-radicular bone was seen (Figs 1-3).

In no case was the normal sloping of the alveolar bone associated with erupting permanent teeth, especially the first permanent molars, considered to be abnormal (Fig 3).

Following interexaminer calibration, which was obtained by examining and discussing the findings by the three examiners from 40 records selected at random, all the radiographs were rated by at least two examiners (EB and JD or EB and ES). In cases of disagreement the examiners discussed the reasons for the differing diagnoses and a mutually agreed diagnosis was recorded. After all the radiographs were rated, those of group 3 were subjected to a second examination by the three authors simultaneously and only those patients and areas in which unanimous agreement of bone loss was obtained remained recorded in group 3. To evaluate the reliability of the examination, 5 cases from group 1 and 10 cases from group 2 were mixed among the group 3 cases during the second examination; 2 of the examiners were unaware of their inclusion and none of the 3 were able to identify them by any other means than radiographic examination. The age in years to the nearest birthday, sex, ethnic origin (Hispanic or non-Hispanic surname), and number of quadrants measured were recorded for every child. For patients in group 3, the tooth type, area affected, and the possible parameters related to the abnormal bone resorption such as extensive proximal decay suggesting food impaction, pulpal pathosis, and the presence of a stainless steel crown (SSC) were recorded.

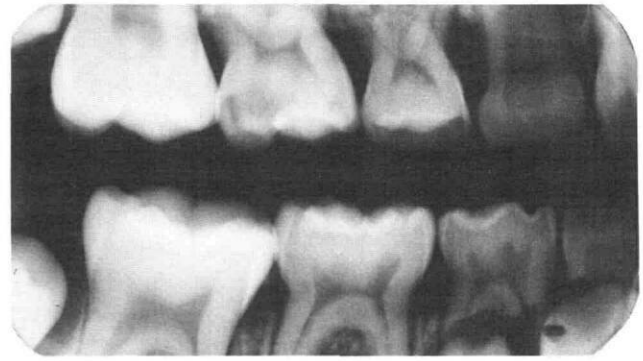

Fig 2. Bite-wing radiograph showing abnormal alveolar bone resorption from the mesial area of the maxillary canine to the distal area of the maxillary second primary molar. Note the normal increased distance from the CEJ to the alveolar bone, at the distal area of the mandibular first primary molar.

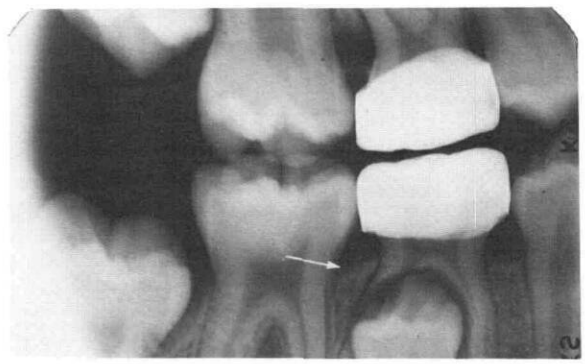

Fig 3. Bite-wing radiograph showing lack of cortical bone and abnormal alveolar bone resorption adjacent to the SSC on the second maxillary primary molar. Note the normal slope of the alveolar bone related to the eruption of the mandibular first permanent molar (arrow).

Results

From the total of 1261 records that were available, no age was recorded in 27 and thus were excluded from the sample. The remaining 1234 records from a "healthy" low income population with no history of systemic chronic disease were reviewed. Although no exact record was kept, it was noted that the examined population had a very high caries rate, probably due to the lack of fluoridation in San Antonio. The vast majority of the patients (94%) had a Hispanic surname. Radiographs missing from records were primarily found in the records of small children (3-4 year olds) and those from patients who attended the clinic for emergency treatment only; in addition, some radiographs did not meet the required criteria. However, in 1026 records (83.1% of the sample) at least one "acceptable" radiograph was found; 4 quadrants were examined in 82.1% of these patients, 3 in 9.1%, 2 in 4.8%, and 1 quadrant in 4%. No significant differences were found in age or sex distribution between the total population of 1234 patients (age range 2-18 years, mean 8.5, SD 3.9, 50.1% females) and the patients with radiographs (age range 2-18 years, mean 8.9, SD 3.8, 50.5% females (Table 1).

TABLE 1. Distribution of Patients by Age, Years, and Sex

All Patients																		
Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Male	6	31	69	63	58	62	46	50	48	20	34	23	32	30	16	17	3	616
Female	3	34	64	81	64	57	49	47	45	24	26	31	32	20	16	17	8	618
																		Total 1234
Patients with Readable Radiographs																		
Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Male	2	7	50	51	48	58	43	47	42	22	27	21	31	26	16	14	3	508
Female	1	12	42	67	60	54	47	40	37	24	24	30	30	17	13	15	5	518
																		Total 1026

In the second examination of the radiographs designated group 3 (which included 15 control cases from groups 1 and 2), only 1 case initially rated as a group 2 case, was rated higher as a group 3 case. On the other hand, upon review, 8 cases of the 99 with an initial classification of group 3, were downgraded to questionable (group 2). The final classification included 71 patients in group 2 and 91 cases in group 3 (6.9 and 8.9% of the children with readable radiographs, respectively). No significant differences in age and sex distributions were found among the patients within or between groups 2 and 3 (group 2 — mean age 8.5 years, SD 4.3, 52.1% females; group 3 — mean age 8.3 years, SD 3.4, 46.2% females).

TABLE 2. Distribution of Patients with Abnormal Alveolar Bone Resorption and Their Prevalence (P) among Patients with Readable Radiographs

Age in years	*Male* N	*Female* N	*Total* N	*P*
4	3	4	7	7.6
5	3	4	7	5.9
6	9	5	14	13.0
7	10	10	20	17.9
8	6	7	13	14.4
9	6	2	8	9.1
10	4	4	8	10.1
11	2	2	4	8.6
15	2	1	3	7.0
16	2		2	6.9
17	1	1	2	6.9
18	1	2	3	37.5
Total	49	42	91	8.9
Mean	8.4	8.1	8.3	
SD	3.4	3.4	3.4	

Among the patients with abnormal alveolar bone resorption (group 3), 4 quadrants were examined in 77 patients, 3 quadrants in 8, 2 in 4, and 1 quadrant in 2 patients. The prevalence of abnormal alveolar bone resorption was similar among the patients with 4 quadrants examined (8.7%) and the total population with readable radiographs (8.9%); therefore, the values for the total population with readable radiographs were chosen to be reported.

When the patients in group 3 were compared to the number of children with readable radiographs at the different ages (Table 2), two groups of children could be identified — those who had the abnormality in the primary and/or early mixed dentition (aged 4-11 years) and those who demonstrated it in the permanent dentition (aged 15-18 years).

Among the 91 patients in group 3, in 30 (2.9% of the patients with readable radiographs) all sites with abnormal bone resorption could not be related to any local factor and were considered to be periodontitis per se (Fig 2); 26 patients (2.5% of the patients with readable radiographs) had abnormal bone resorption only adjacent to extensive proximal decay (Fig 1); in 6 patients (0.6% of the patients with readable radiographs) it was adjacent to SSC only (Fig 3); and in 1 patient it was related to pulp pathosis only (0.1%). The remaining patients had abnormal bone resorption in different sites related to different etiologic factors (Table 3).

The prevalence of abnormal bone resorption was similar for both sides of the mouth, and the numbers for affected sites for the right and left sides of the mouth were pooled together. The highest prevalence of abnormal alveolar bone in the permanent dentition was found between the second premolars and first molars whereas

TABLE 3. Distribution of Patients with Abnormal Alveolar Bone Resorption (Group 3) by Possible Etiology, and Their Prevalence (P) Among Children with Readable Radiographs

Possible Etiologic Factor	*N*	*%*	*p*
Periodontitis	30	33.0	2.9
Proximal decay	26	28.6	2.5
Proximal decay and periodontitis	14	15.4	1.4
Proximal decay and pulp pathosis	6	6.6	0.6
Stainless steel crown (SSC)	6	6.6	0.6
Proximal decay and SSC	4	4.4	0.4
SSC, proximal decay and periodontitis	2	2.2	0.2
SSC and periodontitis	2	2.2	0.2
Pulp pathosis	1	1.0	0.1
Total	91	100	8.9

in the primary dentition it was between the two molars (Table 4). The maxillary bone was more affected than the mandibular with the exception of sites where the alveolar defect was adjacent to proximal decay in the primary molars (Table 4). Furthermore, in both permanent dental arches and in the maxillary arch of the primary and mixed dentitions the abnormal alveolar bone was related mostly to periodontitis, whereas in the mandibular primary dentition most of the affected crests were adjacent to extensive proximal decay (Table 4).

TABLE 4. Distribution of Sites with Abnormal Alveolar Bone Resorption

	*Area**	*Periodontal Disease*	*Proximal Decay*	*Preformed Crown*	*Decay and Pulp Pathosis*	*Total*
Permanent Dentition						
Maxilla	2M-1M	6				6
	1M-2P	13	1			14
	2P-1P	8				8
	1P-C	3				3
	Total	30	1			31
Mandible	2M-1M	5				5
	1M-2P	9				9
	2P-1P	6				6
	1P-C	1				1
	Total	21				21
Primary and mixed dentitions						
Maxilla	1M-2m	7	2	5	2	17
	2m-1m	43	29	8		80
	1m-c	55	11	2	2	70
	c-b	5	42			47
	Total	110	84	15	4	214
Mandible	1M-2m			1		1
	2m-1m	10	40	6	5	61
	1m-c	3	1			4
	c-b	5				5
	Total	18	41	7	5	71

* = Permanent molar, P = Premolar, C = Permanent cuspid, m = Primary molar, c = Primary cuspid, b = Primary lateral incisor, 1 = First, 2 = Second.

The age and sex distribution of the 30 patients who had periodontitis only is presented in Table 5. Among these patients:

- Four quadrants were examined in 26 patients — 3 in 2 and 1 quadrant in 1 patient.
- Twenty-five had bilateral abnormal alveolar bone resorption, whereas 5 patients had it unilaterally.
- The range of affected sites per patient was 1-11, mean 4.7, SD 2.3, the highest frequency being 3 sites in 8 patients.
- The total number of sites affected was significantly higher in the maxilla than in the mandible; however, this difference was significant only in the primary dentition (Table 6).
- Most of the affected areas in the primary dentition were located at the proximal surfaces of the first maxillary molar, and in the permanent dentition between the maxillary first molar and second premolar (Table 6).

TABLE 5. Distribution of Patients with Periodontitis Only by Age and Their Prevalence (P) Among Patients With Readable Radiographs

Age in years	*Male N*	*Female N*	*Total N*	P
4	1	3	4	4.3
5	2	2	4	3.4
6	1	1	2	1.9
7	1	2	3	2.6
8	1	2	3	3.3
9	1	0	1	1.1
10	0	2	2	3.3
11	0	1	1	2.1
15	1	1	2	4.7
16	2	0	2	6.9
17	1	1	2	6.9
Total	12	18	30	
Mean	10.5	9.2	9.6	

An interesting finding was that when primary teeth were close to being exfoliated, an increased distance between the CEJ and the proximal alveolar crest frequently was noted; however, since the alveolar crest was intact, this was considered as a normal characteristic of the shedding process (Figs 1, 2).

Discussion

The reported prevalence of radiographic evidence of periodontal disease, in the form of abnormal alveolar bone resorption, varies from a low of 0.6% for 13-15 year olds to 51.4% in 14 year olds (Hull et al. 1975; Blankestein et al. 1978; Gjermo et al. 1984; Latchan et al. 1983), and almost 7% for ages 15-17 years in the present study. While differences between reports could be related partly to different populations and ethnic groups, it is very likely that they result from the different examination criteria.

Parameters such as gingival color may be affected by examiner subjectivity; recognizing the CEJ with a periodontal probe is a difficult task (Jamison 1963), while probing depth accuracy is limited by the probe penetration into the junctional epithelium (Listgarten et al. 1976; Van der Velden 1979; Armitage et al. 1977). On the other hand, radiographic measurements may allow for a more subtle assessment of periodontal disease affecting the alveolar bone (Stoner 1972; Hull et al. 1975; Selikowitz et al. 1981). The particular criteria utilized in

Table 6. Distribution of Affected Sites in 30 Patients With Periodontitis Only

Teeth[*]	*Maxilla*	*Number of Sites in: Mandible*	*Both*
2M-1M	4	5	9
1M-2P	13	9	22
2P-1P	7	10	17
1P-C	4	1	5
1M-2m	2	0	2
2m-1m	28	10	38
1m-c	34	3	37
c-2[b]	6	0	6
Total	98	38	136

[*] M = Permanent molar, P = premolar, C = Permanent cuspid, m = primary molar, c = Primary cuspid, 1 = First, 2 = Second.

the present study were based on previous findings that described a normal distance between the CEJ to the alveolar crest between the primary molars of 1.0 ± 0.5 mm (Bimstein and Soskolne 1987) and up to 2 mm in the permanent dentition (Lennon and Davies 1974; Jorkjend and Birkeland 1976; Gjermo et al. 1984). Radiographs taken in a dental clinic with no standardization are not flawless. However, the selection of "acceptable for examination" radiographs and simple criteria, which involved evaluation of the distance between the CEJ to the alveolar crest, and the presence of an intact alveolar crest, allowed for a relatively simple and accurate evaluation (92% reliability). Furthermore, this type of evaluation under clinical conditions, rather than "laboratory" conditions, may be reproduced easily in further studies and by individual clinicians in their practices, allowing for comparison of the findings.

An inverse but significant relationship between dental caries and bone loss was observed by Hull et al. (1975) in a study on 14-year-old children. In the present study, proximal decay appeared to have a deleterious effect on the alveolar bone, mostly of the primary dentition; 5.1% of the patients with readable radiographs showed abnormal alveolar bone resorption adjacent to proximal decay and presumably food impaction (Table 3). However, it also was noted that not every case of extensive proximal decay was accompanied by a bone defect; this finding suggests that some children have a higher susceptibility to periodontal disease. The fact that the alveolar bone crest between the two primary molars was the only site at which the prevalence was higher in the mandibular than in the maxillary arch further suggests a relationship between proximal decay and abnormal alveolar bone resorption. This finding may be due to the higher susceptibility to decay of the distal surface at the mandibular than at the maxillary first primary molars (Bimstein et al. 1981). The finding that the most affected area in the permanent dentition was mesial to the first permanent molar is in agreement with previous studies that identified this area as a "risk" area (Hull et al. 1975; Hugoson et al. 1981; Latchan et al. 1983).

The decrease in the prevalence of abnormal alveolar bone resorption after 9 years of age and its lack at ages 12-14 years was the result of developmental changes in the dentition, shedding of the primary teeth, and eruption of the permanent, which did not allow for a definitive diagnosis.

It has been stated that preformed SSCs can be used succesfully to restore primary molar teeth without adversely affecting the health of the gingiva or the status of the patient's oral hygiene (Webber 1974). However, other studies indicate that clinical evidence of gingivitis may be found in association with the presence of an SSC, especially when inadequate crown crimp, length, contour and position, or cement remaining in the gingival sulcus are observed (Myers 1975; Sarafanov 1979; Ashrafi et al. 1981; Machen et al. 1981). In the present study, evidence of abnormal alveolar bone was found adjacent to SSCs in 1.4% of the patients with readable radiographs, suggesting that in certain patients with a tendency to develop periodontitis, an SSC may trigger the disease in the adjacent bone.

An increased distance between the CEJ to the alveolar bone crest near exfoliation time is in agreement with a previous study that indicated that with increasing age there is an increase in this distance (Bimstein and Soskolne 1987).

The information in this manuscript is limited to one time in life, and does not allow for the examination of the progression rate of periodontitis in young individuals; however, it clearly emphasizes the need for the clinician to be aware that children may develop periodontal disease affecting the alveolar bone. The fact that the presence or absence of signs of clinical inflammation may not be related to the integrity of the lamina dura (Greenstein et al. 1981) further emphasizes the importance of careful radiographic examination.

Children and adolescents susceptible to periodontal disease may and should be identified by radiographic means as early as possible in order to prevent the advance of an otherwise possibly destructive disease. The concept of a comprehensive oral health examination and treatment must include examination of the periodontal status of the patient — not only in adults but also in children and adolescents. Additional studies in other populations, utilizing the same criteria used in the present study, will allow for comparison between studies.

Dr. Bimstein is a senior lecturer, pediatric dentistry, Hadassah Fac-

ulty of Dental Medicine, The Hebrew University, Jerusalem, Israel; at the time of the study he was on sabbatical at the University of Texas, San Antonio. Dr. Delaney is an assistant professor and Dr. Sweeney is a professor, pediatric dentistry, University of Texas, San Antonio. Reprint requests should be sent to: Dr. Enrique Bimstein, Dept. of Pediatric Dentistry, Hadassah Faculty of Dental Medicine, The Hebrew University, Jerusalem, Israel.

Armitage GC et al: Microscopic evaluation of clinical measurements of connective tissue attachment levels. J Clin Periodontol 4:173-90, 1977.

Ashrafi MH et al: Inter-relationship between stainless steel crown, plaque accumulation, and gingival health. American Academy of Pediatric Dentistry Annual Meeting Reports (research abstr R-26), 1981.

Bimstein E et al: Distribution of caries in different tooth surfaces in 7-year-old children. Caries Res 15:324-30,1981.

Bimstein E et al: A clinical and histometric study of gingivitis associated with the human dentition. J Periodontol 56:293-96, 1985.

Bimstein E, Soskolne WA: A radiographic study of the height of the interproximal bone in the primary molar area. J Dent Res 66:912, 1987.

Blankenstein R et al: Prevalence of chronic periodontitis in 13 to 15-year-old children. J Clin Periodontol 5:285-92, 1978.

Davies PHJ et al: Periodontal bone loss in English secondary school children. A longitudinal radiological study. J Clin Periodontol 5:278-84, 1978.

Gjermo P et al: Prevalence of bone loss in a group of Brazilian teenagers assessed on bite-wing radiographs. J Clin Periodontol 11:104-13, 1984.

Greenstein G et al: Associations between crestal lamina dura and periodontal status. J Periodontol 52:362-66, 1981.

Hull PS et al: A radiographic study of the prevalence of chronic periodontitis in 14-year-old English school children. J Clin Periodontol 2:203-10, 1975.

Jamison HC: Prevalence of periodontal disease of the deciduous teeth. J Am Dent Assoc 66:207-15,1963.

Jorkjend L, Birkeland JM: Alveolar bone loss in the permanent first molars of Norwegian school children receiving systematic dental care. Community Dent Oral Epidemiol 4:22-24, 1976.

Keszthelyi HC, Szabo I: Attachment loss in primary molars. J Clin Periodontol 14:48-51, 1987.

Latchan NL et al: A radiographic study of chronic periodontitis in 15-year-old Queensland children. J Clin Periodontol 10:37-45, 1983.

Lennon MA, Davies RM: Prevalence and distribution of alveolar bone loss in a population of 15-year-old school children. J Clin Periodontol 1:175-82, 1974.

Listgarten MA et al: Periodontal probing and the relationship of the probe tip to periodontal tissues. J Periodontol 47:511-13, 1976.

Machen JB et al: The effect of stainess steel crowns on gingival tissue. American Academy of Pedodontics Annual Meeting Reports (research abstr R-27), 1981.

Magnusson BO et al: Gingivitis and periodontal disease in children, in Pedodontics — A Systemic Approach, Magnusson et al., eds. Copenhagen; Munksgaard, 1981 pp 141-59.

Mandell RL et al: Localized juvenile periodontitis of the primary dentition. ASDC J Dent Child 53:193-96, 1986.

Myers DR: A clinical study of the response of the gingival tissue surrounding stainless steel crowns. ASDC J Dent Child 42:33-36, 1975.

Ngan et al: Advanced periodontitis in the primary dentition: a case report. Pediatr Dent 7:255-58, 1985.

Sarafanov SR: Coronas de acero para molares primarios (evaluacion de dos tipos). Assoc Dent Mex 36:134-47, 1979.

Selikowitz HS et al: Retrospective longitudinal study of the rate of alveolar bone loss in humans using bite-wing radiographs. J Clin Periodontol 8:431-38, 1981.

Soskolne WA, Bimstein E: A histomorphological study of the shedding process of human deciduous teeth at various chronological ages. Arch Oral Biol 22:331-35, 1977.

Stoner JE: An investigation into the accuracy of measurements made on radiographs of the alveolar crests of dried mandibles. J Periodontol 43:699-702, 1972.

Sweeney EA et al: Prevalence and microbiology of localized prepubertal periodontitis. Oral Microbiol Immunol 2:65-70, 1987.

Van der Velden U: Probing force and the relationship of the probe tip to periodontal tissues. J Clin Periodontol 6:106-14, 1979.

Walker JD, Mackenzie IE: Periodontal disease in children and adolescents, in Pediatric Dentistry — Scientific Foundations and Clinical Practice, Stewart et al, eds. St Louis; CV Mosby Co, 1982 pp 623-39.

Webber DL: Gingival health following placement of stainless steel crowns. ASDC J Dent Child 41:186-89, 1974.