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Radiographic study of the prevalence of periodontal bone loss in Australian school-aged children attending the Royal Dental Hospital of Melbourne

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Abstract

Objectives: To investigate the prevalence of alveolar bone loss around the first permanent molars, and first and second deciduous molars in Australian school-aged children attending the Royal Dental Hospital of Melbourne.

Method: Nine hundred and ninety-five records were examined for useable bitewing radiographs. From these, radiographs of 542 Australian school children aged 5–12 years were used. The cervical–enamel junction (CEJ) to the alveolar bone crest (ABC) distance was measured using the transparent ruler on the magnifier. Each inter-dental site that was readable was scored as one for the following categories: *not available (NA); no bone loss (NBL)* – the CEJ–ABC was $\leqslant$2 mm; *questionable bone loss (QBL)*: the distance from the CEJ–ABC was >2 and <3 mm; and *definite bone loss (DBL)*: the distance from the CEJ to ABC was $\geqslant$3 mm.

Results: Seventy-one children (13.0%) were found to have 83 DBL sites, as determined by bone levels >3.0 mm from the CEJ. Seventy children had QBL lesions only, 50 children had DBL only and 21 children had both. The overall prevalence of bone loss was 26%. Second deciduous molars were found to be the most affected teeth with almost 75% lesions being distal. These teeth comprised 50% of the DBL lesions. 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 lower than that of children of Middle-Eastern origin (35.2%). When the data were analysed with relation to age, there was no relationship between age and prevalence of bone loss.

Conclusion: In the population studied, there was an overall prevalence of periodontal bone loss of 26% and DBL of 13% in an Australian school-aged group. Calculus was detected infrequently and, where present, was associated with bone loss.

Key words: bitewing radiographs; bone loss; school-aged children

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Periodontal disease is widespread infection affecting the tooth support of 10–15% of the population (Jenkins & Papapanou 2001). It presents in a number of forms, most commonly as chronic and aggressive periodontitis. Aggressive forms may be localized or generalized, and the localized form was previously called localized early-onset or juvenile periodontitis (JP). JP is characterized by circumpubertal onset, severe loss of attachment, rapid progress and, in its localized form, shows a pre-dilection for selected permanent teeth (Baer 1971). These aggressive forms, especially JP, have been linked to previous marginal bone loss in the primary dentition (Bimstein et al. 1988, Sjödin et al. 1989). These forms are hard to manage effectively, and early diagnosis and treatment are essential (Tonetti & Mombelli 1997).

Clinically, the incidence of periodontal disease in children is $<1\%$ (Tonetti & Mombelli 1997). A number of studies conducted previously investigated its prevalence in adolescents (14–19 years old), and indicated that ethnic backgrounds, education, age, gender and area of mouth could have an influence on the incidence of JP (Booth & Ashley 1989, Löe & Brown 1991).

Particularly high prevalences of periodontitis has been reported from countries in Africa and Asia (Ramfjord et al. 1968, Albandar & Tinoco 2002, Corbet et al. 2002), perhaps suggesting that race may have a role in periodontal disease. These findings are supported by reports of differences in the prevalence of periodontal disease between young individuals of different ethnic backgrounds living in Western Europe (Sjödin et al. 1993, Sjödin & Matsson 1992, Matsson et al. 1995). Sjödin and Matsson (1994) found that 13.9% of children with Asian-Far Eastern family names had marginal bone loss at $\geqslant 1$ proximal sites in the primary dentition compared with 3.1% for the remaining group of children. Matsson et al. (1995) reported that Vietnamese immigrant children were more greatly affected by destructive periodontal disease than Swedish children of the same age.

Destruction of bone remains the most important criterion for assessing the severity of periodontitis (Novak 2001). This is primarily diagnosed by radiographic evaluation of inter-dental bone levels loss, associated with deep clinical probing depths and tooth mobility. The destruction of bone has been found to be responsible for tooth loss (Lennon & Davies 1974). Bitewing radiographs are commonly taken in children for caries assessment, but they also show the bone height around the first molars, and first and second primary molars. Thus, analysis of these radiographs provides a good assessment of bone loss in children (Bimstein et al. 1988).

Previous studies using bitewing radiographs have shown that the incidence of bone loss in children and adolescents varies between 0.8% and 20% (Sweeney et al. 1987, Bimstein et al. 1988, 1994; Sjödin et al. 1993), which is much greater than that seen clinically. However, the authors are not aware of any studies reporting the incidence of bone loss in an Australian population. Therefore, the purpose of the present study was to describe the prevalence of alveolar bone loss (ABL) in a sample of 5–12-year-old Australian school children attending the Royal Dental Hospital of Melbourne, and to examine the possible influence of ethnic origin on ABL prevalence.

Method

Nine hundred and ninety-five records of children who had received dental treatment at the Royal Dental Hospital of Melbourne dating from 1998 to 2002, as part of the school dental service programme offered to children aged 5–17 years old, were examined for the presence of bitewing radiographs and their suitability for use in the study. Ethical approval was obtained from the Ethics in Clinical Research Committee of the Royal Dental Hospital of Melbourne.

Radiographs were considered acceptable for evaluation if they fulfilled the following criteria:

1. Minimal evidence of distortion
2. Minimal overlapping of inter-proximal contacts
3. A clear image of the alveolar bone crest (ABC) and the cervical–enamel junction (CEJ)

In the case where more than one set of radiographs were present in the same record, the initial radiographs were chosen for examination. In addition, exfoliating primary teeth and permanent teeth undergoing eruption adjacent to primary teeth were recorded, but the bone levels of these teeth and the adjacent sites were not included in this study. A tooth was considered to be exfoliating if the root resorption for one of the root surfaces had advanced to the extent that the radiographic image of the periodontal ligament was no longer discernible. A permanent tooth was considered to be under eruption if the cusp tips were located supracrestally but had not reached occlusion in the radiograph (Matsson et al. 1995). Exfoliating primary teeth and surfaces adjacent to erupting permanent teeth were excluded from the analysis because of a possible influence of these physiological conditions on the marginal bone height (Sjödin & Matsson 1992). Furthermore, only teeth that were fully erupted and shown to be in occlusion on the bitewing radiograph were utilized. Teeth restored with stainless-steel crowns were included only if the CEJ was visible (Needleman et al. 1997). An individual site was excluded if CEJ or ABC could not be identified on the radiograph.

The bitewings were examined with 10 times magnification using a 10 × Scale Lupe (Peak Optics, Hacienda Heights, CA, USA) on a light box (Medilite, Tucson, AZ, USA). The same examiner (J. L.) examined all the subjects, and the same loupes and radiographic viewer were used for all subjects. The proximal sites of first permanent molars, first deciduous molars and second deciduous molars were analysed for proximal ABL. The criterion for diagnosing ABL was a CEJ to the ABC distance >2 mm using a transparent ruler on the magnifier (Bimstein et al. 1994). Measurements were recorded to the nearest half millimetre (Sjödin & Matsson 1992). Each interdental area that was readable was scored as one of the following categories (Bimstein et al. 1994):

> *no bone loss (NBL)*: the distance from the CEJ to ABC is $\leqslant 2$ mm;
> *questionable bone loss (QBL)*: the distance from the CEJ to ABC is >2 and <3 mm; and
> *definite bone loss (DBL)*: the distance from the CEJ to ABC is $\geqslant 3$ mm.

However, the threshold for determining DBL was increased to 3 mm to take into account any false positives that may have arisen from bone resorption because of tooth eruption or tooth loss. The 2 mm threshold of Bimstein et al. (1994) was referred to as QBL and allowed comparison with previous studies.

The subjects' ethnic origins were determined primarily by their family names and, where possible, by the place of birth of the parents. They were then categorized into four categories: Asian-Far Eastern, Afro-Caribbean, Caucasian and Middle Eastern. The age of the subjects was determined by their last birthday. The effect of the presence of restorations, caries and calculus on alveolar bone height was statistically assessed using a two-sample *t*-test and by matching paired sites.

Results

Of the 995 records examined, 542 subjects had radiographs that could be used in this study. The other subjects were excluded as a result of not being within the age range studied, a history of systemic chronic disease, lacking any radiographs or lacking suitable radiographs. Bone levels were assessed in 542 racially diverse 5–12-year-old school children with 958 suitable bitewing radiographs. The study group consisted of 278 girls and 264 boys (Table 1). Twenty-eight subjects (5.2%) had mild asthma; otherwise, there was no history of medical illness.

The ABL area was suitable for radiographic examination in 17,710 sites. A total of 2718 teeth were excluded in the 453 subjects not fulfilling the inclusion criteria, and 5082 sites were excluded from the radiographs of those that were assessed. Of the sites examined, 137 had evidence of inter-proximal restorations, 107 had evidence of inter-proximal caries, 53 had evidence of calculus and 253 of periodontal ligament widening. The bone-level measurements resulted in a mean CEJ–ABC distance of 0.9 ± 0.32 mm for all tooth surfaces (Table 1). Individual sites displayed distances ranging from 0.0 to 5.0 mm (Table 1). One hundred and forty-one children (26%) displayed signs of bone loss and 71 children (13.1%) had DBL (Table 1). The 71 children having DBL were found to have 83 sites with a level of ⩾3 mm bone loss.

Figures 1–4 show the distribution of teeth and sites with bone loss. NBL was found in the majority of sites. QBL was found in 129 sites, and DBL was found in 83 sites. Second deciduous molars were found to be the teeth with highest number of sites with bone loss. High values for the CEJ–ABC distance were observed for the distal surfaces of the second primary molars (range 0.0–5.0 mm, data not shown). A greater number of sites with bone loss were noted in the maxilla.

The majority age groups in this study were 6-, 7- and 8-year-olds with a sample percentage of 22.3%, 24.5% and 19.4%, respectively (Table 2). Of the age groups examined, 7-year-olds were the largest group. Bone loss incidence ranged from roughly 21% to just over 30%.

Table 3 shows the ethnic breakdown of the subjects and the incidence of ABL in each group. Caucasians and Asian-Far Easterners were the majority population in the sample followed by the Middle Eastern and African-Caribbean children, being 44.8%, 44.5%, 10.0% and 0.7%, respectively. The incidence

Table 1. General data

No. of children	542
No. of boys	264
No. of girls	278
Age	5–12 years
Mean age	7.2 ± 1.5 years
Mean bone level	0.9 ± 0.32 mm SD
Overall no. with bone loss (%)	141 (26.0)
No. with QBL only (%)	70 (12.9)
No. with DBL only (%)	50 (9.2)
No. with both QBL and DBL (%)	21 (3.9)

QBL, questionable bone loss; DBL, definite bone loss.

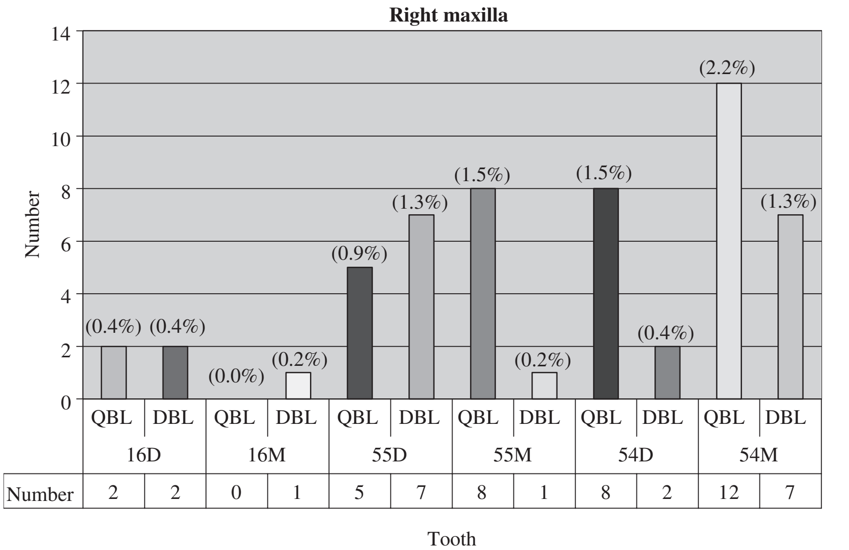

Fig. 1. Number and distribution of sites with bone loss in the right maxillary teeth, quadrant 1, with questionable bone loss (QBL), definite bone loss (DBL) and percentage prevalence in brackets.

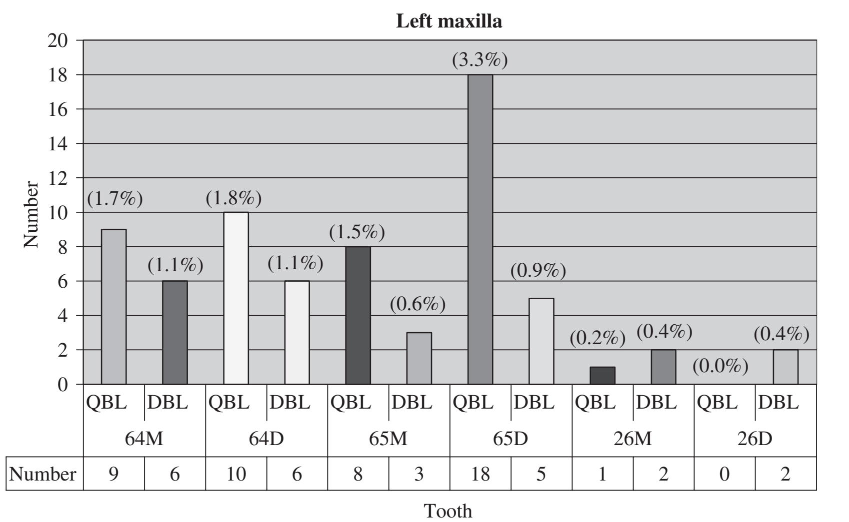

Fig. 2. Number and distribution of sites with bone loss in the left maxillary teeth, quadrant 2, with questionable bone loss (QBL), definite bone loss (DBL) and percentage prevalence in brackets.

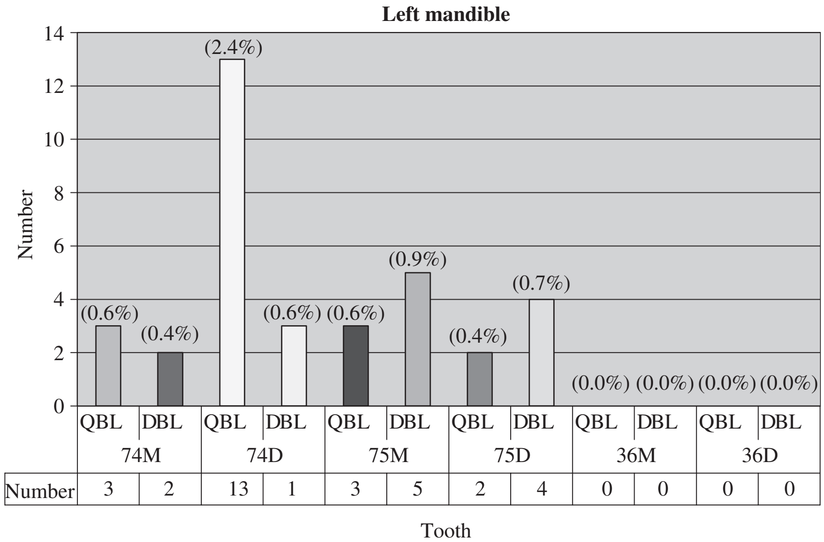

Fig. 3. Number and distribution of sites with bone loss in the left mandibular teeth, quadrant 3, with questionable bone loss (QBL), definite bone loss (DBL) and percentage prevalence in brackets.

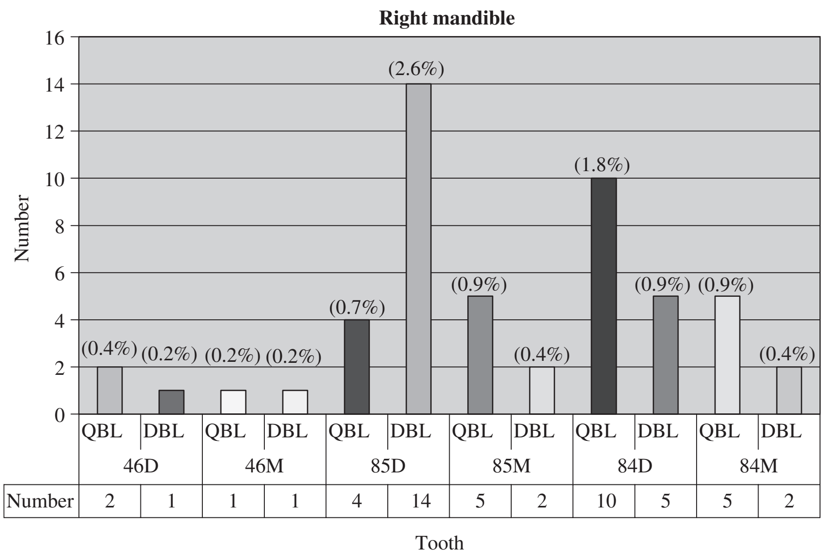

Fig. 4. Number and distribution of sites with bone loss in the right mandibular teeth, quadrant 4, with questionable bone loss (QBL), definite bone loss (DBL) and percentage prevalence in brackets.

of ABL found in each category was 29.5% in Asian-Far Eastern, 25% in Afro-Caribbean (although subject numbers were very small in this group), 19.7% in Caucasian and 35.2% in Middle Eastern.

The number of subjects in each ethnic category with calculus and with calculus and bone loss is shown in Table 4. Overall, 0.04% of the subjects had calculus. Five per cent of those with an Asian-Far Eastern background had calculus compared with 3% for Caucasians and 7.4% for Middle-Eastern children. All subjects with calculus had DBL. The sites with calculus showed a significantly greater distance between the CEJ and the ABC (1.8 ± 0.9 *versus* 1.2 ± 0.6 mm, $p = 0.005$). For sites with caries, the distance between the CEJ and the ABC was 1.7 ± 0.8 mm compared with that of no caries, 1.4 ± 0.7 mm, and approached significance, $p = 0.051$. The distance between the CEJ and the ABC around sites with restoration was 1.4 ± 0.8 mm compared with those with no restorations, 1.4 ± 0.7 mm, and was not statistically significant, $p = 0.59$.

Discussion

In epidemiological studies on the prevalence of periodontitis in children and adolescents, radiographic methods of measurements have frequently been used. Bitewing radiographs are commonly taken for caries assessment in children, but they also show the bone height around the first molars, first and second primary molars (Bimstein et al. 1988). Thus, analysis of these radiographs provides a good assessment of bone loss in children, and is a suitable screening method (Bimstein et al. 1988).

The normal distance between the CEJ and ABC has been shown to fall within the range of 0–2 mm and the threshold level for bone loss is >2 mm between the CEJ and ABC (Källestål & Matsson 1989). However, it is suggested that sites neighbouring an exfoliating primary tooth or an erupting permanent tooth are taken into account as a physiological process, while other sites are considered pathological (Sjödin & Matsson 1992). Because of the inherent limitations of radiographic evaluation, the threshold for bone loss in this study was raised to $\geqslant 3$ mm for DBL, any levels >2 mm to <3 mm for QBL and $\leqslant 2$ mm accounted for NBL (Bimstein et al. 1994).

In radiographic studies on the prevalence of periodontitis in children and adolescents, the reports vary between 0.8% and 20% (Sweeney et al. 1987, Bimstein et al. 1988, 1994, Matsson et al. 1995). To date, few previous studies have attempted to investigate the bone loss incidence in mixed dentitions (Bimstein et al. 1988, Matsson et al. 1995, Needleman et al. 1997). The authors are unaware of such studies in Australia. The marginal bone loss observed in the present study was almost exclusively restricted to primary teeth. Only nine DBL lesions and six QBL lesions were found in the permanent dentition. The mean distance for bone loss (0.9 mm) and greater number of lesions in the maxilla are in agreement with Shapira et al. (1995) and Needleman et al. (1997), who found similar results in much smaller subject groups with 33 and 223 subjects, respectively.

Table 2. Number of children in each age group and with bone loss (BL) in general, with definite bone loss only (DBL) and with questionable bone loss only (QBL) (percentage in brackets)

Age (years)	No. in each group (%)	No. with BL	No. with DBL (%)	No. with QBL (%)
5	71 (13.1)	15 (21.1)	8 (11.3)	10 (14.4)
6	123 (22.3)	31 (25.2)	16 (13.0)	21 (17.1)
7	133 (24.5)	38 (28.6)	23 (17.3)	21 (15.8)
8	105 (19.4)	24 (22.9)	8 (7.6)	18 (17.1)
9	67 (12.4)	20 (29.9)	11 (16.4)	12 (17.9)
10–12	43 (7.9)	13 (30.2)	5 (11.6)	9 (20.1)

Table 3. Number of children in each ethnic category with definite bone loss (DBL), with questionable bone loss (QBL) (percentage in brackets)

Ethnic origin	No. in each group (%)	No. with DBL (%)	No. with QBL (%)	Total no. with BL (%)	% of total *n*
Asian/Far Eastern	241 (44.5)	35 (14.5)	50 (20.7)	71 (29.5)	13.1
Afro-Caribbean	4 (0.7)	0 (0)	1 (25)	1 (25)	0.2
Caucasian	243 (44.8)	24 (9.9)	27 (11.1)	48 (19.7)	8.9
Middle-Eastern	54 (10.0)	10 (18.5)	14 (25.9)	19 (35.2)	3.5

Table 4. Number of children in each ethnic category with calculus, and with calculus and definite bone loss (DBL) (percentage in brackets)

Ethnic origin	No. with calculus (%)	No. with calculus and DBL
Asian/Far Eastern	12 (5)	12
Afro-Caribbean	0 (0)	0
Caucasian	8 (3)	8
Middle-Eastern	4 (7.4)	4

but caries and restorations can be considered. The far greater numbers of sites with bone loss than with caries or restorations alone suggest that these are not the sole cause of periodontal destruction in children. The current study found that the presence of caries and restorations did not have a significant effect on the bone height.

Reporting on the influence of age on periodontal bone loss, Sjödin & Matsson (1994) found that the prevalence of marginal bone loss at deciduous molars and at the distal surface of deciduous canines in 7-, 8- and 9-year-old children was 2.0%, 3.1% and 4.5%, respectively. The results of this study are of a similar magnitude (4.2%, 1.5% and 2.0%, respectively), but do not show an increase with age reported. This may be because of a difference in population numbers studied, and because the majority of subjects in this study were 6-, 7- and 8-year-olds whereas the study by Sjödin & Matsson (1994) was based on 7-, 8- and 9-year-olds. In addition, 9-year-olds only provided 12.4% of the results in this study as compared with 30.5% in that of Sjödin & Matsson (1992).

Calculus was detected in 24 subjects and at 53 sites, with slight differences between ethnic groups. These findings support previous clinical and radiological studies, that have detected the presence of calculus when probing (Miyazaki et al. 1991) or on examination of bitewing radiographs (Bimstein et al. 1988, Sjödin & Matsson 1994, Matsson et al. 1995, 1997). Sjödin & Matsson (1994) reported the prevalence of calculus in Asian children to be 18.6% and 3% in Swedish children. More recent studies by Matsson et al. (1995, 1997) reported that in 50% of Vietnamese children, calculus could be detected on their radiographs compared with 4% of Swedish children, and, interestingly, with no difference in bone loss between the two groups. The difference between this study and those in Sweden probably reflects the ethnic mix of the populations. Australia has a much wider mix of people than Sweden and this was evident in this study, whereas the Swedish population consisted of Swedes and Vietnamese only. Bimstein et al. (1988) noted that children with bone loss had a significantly higher prevalence of calculus. This finding is supported by our study. Subjects with calculus had DBL, and the presence of calculus was associated at a site level with a greater distance between the CEJ and ABL.

Ethnic origin was found to have an influence on bone loss in children. Our results have shown the highest bone loss prevalence for children of Middle-Eastern origin, then the Asian-Far Eastern population and the lowest for the Caucasian population. The Afro-Caribbean population had only four subjects and so have not been included in our analysis. The use of names to determine ethnic origin may have resulted in a number of subjects being wrongly classified. Every measure was taken in an attempt to classify subjects correctly, but this error still remains. Therefore, we have been cautious in making too many statements in our interpretation of the data. Sjödin & Matsson (1994) found that 13.9% of children with Asian-Far Eastern family names had marginal bone loss at $\geqslant 1$ proximal sites in the primary dentition compared with 3.1% for the remaining group of children. However, they did not study a Middle-Eastern population. In a retrospective study of presence of bone loss, Matsson et al. (1995) reported that Vietnamese immigrant children were more greatly affected by destructive periodontal disease than Swedish children of the same age. Among 42 Vietnamese immigrant children 6–17 years old, living with their parents in Sweden, 28% had experienced bone loss in their deciduous dentition compared with 5% of a control group of Swedish children. These results are similar to the findings of this study. However, for the other groups of children, the current study showed a prevalence over three times greater than that of Sjödin & Matsson (1994).

Previous reports have found a much lower prevalence of marginal bone loss in the deciduous dentition in children of European/Caucasian origin than in this study. This study and these previous papers also suggest that Asian-Far Eastern children may have a greater prevalence of bone loss. In assessing these studies, it is also important to recognize that bone loss prevalence data for deciduous teeth may be influenced by caries, restorations, calculus, imminent tooth exfoliation, the proximity of an exfoliating or erupting tooth, the ages of individuals assessed and the sample selection method (Jenkins & Papapanou 2001). Any combination of these entities could explain the variation in the prevalence rates (Löe & Brown 1991). Radiographic assessment of bone levels is unable to account for oral hygiene, We could see radiographic evidence of calculus in subjects as young as 6 years of age. This re-inforces the need to assess children of all ages for periodontal disease and calculus, undertaking full-mouth probing and removing any deposits found.

Not all the bone loss sites recorded may have been pathological, especially in the 7-year-old group. These may instead have been a result of the eruption of first permanent molars, as a significant number of sites of bone loss were at the distal surface of the second deciduous molar, although every effort was made to exclude this factor. The exfoliation of first and second deciduous molars may also influence the bone loss incidence found in 9–12-year-olds, which may account for the results for 9-year-olds found by Sjödin & Matsson (1994).

Previous studies found that teeth most frequently affected by marginal bone loss were the first deciduous molars (Sweeney et al. 1987, Bimstein et al. 1988, Sjödin & Matsson 1994). The findings of this study are contrary to this, where the tooth most frequently affected was the second deciduous molar, comprising 50% of the DBL lesions.

Bitewing radiographic studies tend to underestimate periodontitis, because of the amount of demineralization required for lesions to show on a radiographic film. In addition, there can be deviations from the optimal angulation that may decrease any measured distances between CEJ and ABC. The differing results from the studies examining occurrence of bone loss may also be because of differences in the methodology and diagnostic criteria used to define ABL, and the material examined (Hoover et al. 1981). Diagnostic variations include sites in which the evidence of bone loss was questionable and were not taken into consideration (Hoover et al. 1981), which may influence the prevalence results.

There are a number of methodological variations in the analysis of bone levels on bitewing radiographs. Hoover et al. (1981) recorded bone loss as present when the bone crest mesial/distal to the tooth was >2 mm from a line parallel to a line drawn from the CEJ of the tooth to that of the adjacent tooth. Sjödin & Matsson (1992, 1994) analysed radiographs with respect to marginal bone loss; a distance between the CEJ and marginal bone level >2 mm was required for bone loss to be noted. A third method has been used by Bimstein et al. (1994) with NBL (CEJ–ABC was $\leqslant$2 mm), QBL (CEJ–ABC was >2 and there was partial loss of the lamina dura in the crestal 2 mm) and DBL (CEJ–ABC was >2 and the lamina dura was completely absent in the crestal 2 mm). In the current study, we used a variation of the Bimstein et al. (1994) method. The threshold for DBL was increased to $\geqslant$3 mm to remove any inherent error in measuring bone loss from the radiographs, and to improve accuracy.

Previous reports have suggested that aggressive forms of periodontal disease in children may lead to further disease in adulthood (Sjödin et al. 1989, 1993, Shapira et al. 1994). Therefore, it is important to identify and treat these individuals before it is too late and tooth loss occurs. This means that early identification and the use of bitewing radiography provides an ideal diagnostic tool in this respect.

Of the 995 records examined, only 542 records were found to contain useful bitewings. The majority of excluded records were either not in the age range studied, lacked radiographs or lacked suitable radiographs. Radiographs that were available but having distortion, overlapping of inter-proximal contacts and unclear images of the ABC and the CEJ were of no use to the study. In addition to these factors, possible errors could have been introduced as a result of multiple operators taking radiographs with no standardization of the radiographic technique. However, only one person interpreted the radiographs, and we deliberately set the margin for DBL high to minimize these errors. In relation to other diagnostic purposes, overlapping in radiographs would not be of much use as it would be difficult to evaluate caries lesions in the inter-proximal areas. The number of radiographs excluded raises concern about the overall quality and diagnostic usefulness of the radiographs in the subjects' notes. Radiography in children is difficult, but a large number of radiographs are of no value or benefit to the patient, and may have exposed the child to unnecessary radiation. It should also be noted that the majority of radiographs were taken by undergraduate dental students, which may account for the large number of unusable radiographs.

In summary, 71 children (13.3%) were found to have 83 bone loss sites, as determined by bone levels >3.0 mm from the CEJ. Seventy children had QBL lesions only, 50 children had DBL only and 21 children had both. This figure is similar to previously published papers. Second deciduous molars were found to be the most affected teeth and these teeth comprised 50% of all DBL lesions. 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 lower than that of children of Middle-Eastern origin (35.2%). In addition, the children of Asian-Far Eastern origin had a higher percentage of sites with bone loss compared with children of Caucasian origin (14.5% *versus* 9.9% for DBL and 11.1% *versus* 20.7% for QBL), which is similar to previous studies. When the data were analysed in relation to age, there was no relationship between age and prevalence of bone loss. In conclusion, in the population studied, this report has shown an overall prevalence of periodontal bone loss of 26%, and DBL of 13% in an Australian school-aged group. Given the relatively high percentage of periodontal bone loss, examination of the bone levels should form part of any radiographic assessment of bitewings in children. Calculus was detected infrequently and, where present, was associated with bone loss. Therefore, children of all ages need to be assessed, not only for periodontal disease but also for the presence of calculus and this should be removed when found. Further investigation into what the presence of bone loss around deciduous teeth means for the permanent teeth, and subjects' probability of getting periodontitis is required.

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