A Controlled Study of Pre-Eruptive Intracoronal Resorption and Dental Development

Amani Al-Tuwirqi*/ W Kim Seow**

Aim: *To compare the prevalence of PEIR in Australian and Saudi Arabian children and to investigate the relationship of PEIR with dental development.* ***Study design****:Panoramic (PAN) radiographs of 842 Australian and 456 Saudi children were screened for PEIR. The dental ages of the children with and without PEIR were assessed from the PAN radiographs using the method of Demirjian and co-workers.* ***Results:*** *The subject prevalence of PEIR was not statistically significant between Australian (2%) and Saudi children (0.6%) (p>0.1). The teeth most commonly affected by PEIR were the mandibular second molars and premolars. Dental impaction was observed in 31% of teeth with PEIR compared to only 0.1% of control teeth (p<0.0001). Children with PEIR showed a mean delay in dental development of 0.54±0.85 years compared with age- and gender-matched controls (p<0.0001).* ***Conclusions:*** *The present study provides the first evidence that there are no differences in PEIR prevalence between Australian and Saudi populations, and that dental development is significantly delayed in children with PEIR.*

Key words*: pre-eruptive intracoronal resorption , dental impaction, pre-eruptive caries.*

INTRODUCTION

Dental development can be assessed by determining the dental age relative to the chronological age. This method is more reliable compared to assessing dental eruption as emergence of the teeth is discontinuous and a variable that can be affected by local factors such as premature loss of teeth, crowding and caries.[1] The method proposed by Demirjian and co-workers (1973; 1976) [2-3] which evaluates dental ages of children aged approximately 4-16 years using the PAN radiograph is currently one of the most popular techniques employed to assess dental development. Using this method, researchers have reported on the dental developmental rates of various populations compared to the standards of Demirjian and co-workers.[4-16] In other studies, dental development has been found to be accelerated in children with Amelogenesis imperfecta, and delayed in children with hypodontia as well as cleidocranial dysplasia and delayed puberty. [17-19]

Pre-eruptive intra-coronal resorption (PEIR) is a condition where unerupted teeth exhibit coronal radiolucencies consistent with resorptive loss of tooth structure within the crowns of unerupted teeth.[20] These defects are considered an important cause of hidden caries and are typically discovered on an incidental basis on routine radiographs.[20] They are often located in the crowns of unerupted teeth, within the dentin and adjacent to the dentino-enamel junction.[20-27] Most PEIR lesions are found on the central aspects of the crown, with smaller percentages in mesial or distal aspects.[25]

The subject prevalence of PEIR has been reported to be 2-6% in children with unerupted teeth and the tooth prevalence to be 1-2 %.[26-28] Premolars, second and third molars are commonly reported, probably because these teeth are usually unerupted when many children present for their PAN radiograph examination. In a study on bitewing radiographs, the permanent teeth which show the highest percentage of defects are the mandibular first molars (4%), and mandibular first premolars (2%). [26] In contrast, in another report which employed PAN radiographs, the highest prevalence of PEIR was noted in the maxillary first molars (4%) and the mandibular first molars (3%).[27] In the primary dentition, the prevalence of PEIR has not been previously reported, as radiological exposure of unerupted primary teeth is not commonly performed.

To date, the etiology of PEIR remains unclear. From the relatively small number of individual case reports available, no association

*Amani Al-Tuwirqi, BDSc, MPhil, DDSc, Assistant Professor & Consultant, Pediatric Dentistry Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
**W Kim Seow, BDS, MDSc, PhD, DDSc ,Pediatric Dentistry Department, School of Dentistry, University of Queensland, Brisbane, Australia.

Send all correspondence to:
Amani Al-Tuwirqi, Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
P.O. Box 80209 Jeddah 21589, Saudi Arabia .
Phone: +966 12 6403443I
Fax: +966 12 4603316
E-mail: aaltuwirqi@kau.edu.sa
dr_amani@msn.com

has been found between PEIR and gender, medical conditions, or fluoride supplementation.[20] Apart from two separate studies in the Australian population,[26-27] racial differences in the prevalence of PEIR have not been investigated previously. Furthermore, as PEIR is found in developing teeth, it is likely to be influenced by the rate of dental development. We hypothesize that the prevalence of PEIR varies in different population groups and that children with PEIR show delayed dental development compared to children without PEIR. The aim of the present study, therefore, was to compare the prevalence of PEIR in two population groups and investigate the relationship of PEIR with dental development.

MATERIALS AND METHOD

A total of 1298 PAN radiographs of children aged between 5-14 years was analysed in this investigation (842 Australian and 456 Saudi Arabian). These radiographs were exposed for screening and orthodontic purposes. Ethical approval and permission for the study was obtained from the relevant institutions and directors of the clinical facilities involved.

The Australian children were of white European descent, and randomly selected from a large health service district in the State of Queensland in Australia. Information regarding the origin of each subject was obtained from the parents' self-declaration of ethnicity in the children's consent forms, which were submitted for treatment at the community dental clinic. The PAN radiographs of the Saudi children were obtained from the Pediatric and Orthodontic Clinics at the Faculty of Dentistry, King Abdulaziz University (KAU) in Jeddah, Saudi Arabia.

Inclusion criteria included a healthy status, absence of chronic medical diseases and dental conditions such as hypodontia and amelogenesis imperfecta which are known to show altered dental development [17,29, 30]

Assessment of PEIR lesions

In the assessment of PEIR, only unerupted teeth, which have not emerged into the oral cavity were assessed. All radiographs were viewed on a standard radiographic light-box without magnification and examined for PEIR lesions in all unerupted teeth.[25-27] The PEIR lesions were recorded in standard data collecting sheets, according to the population group, subject and the tooth affected. Other pathology noted on the radiographs, such as impaction of the teeth was also recorded as in our previous studies. [25-27]

Examination of the radiographs was performed by the primary author (AA) who is a faculty staff member at KAU. Prior to this study, the examiner underwent training and calibration with another author (WKS). To determine intra-examiner and inter-examiner variability, twenty radiographs containing 20 teeth with PEIR were assessed twice. The kappa statistics for intra-examiner and inter-examiner variability were 0.87 and 0.98 which indicated high consistency.

Assessment of dental development

Dental development of the children was assessed from the PAN radiographs, employing the technique of Demirjian and co-workers (1973)[2] which involved determining the developmental stages of seven permanent teeth on the left side of the mandible. These teeth are the first and second permanent molars, first and second premolars, permanent canine and permanent central and lateral incisors. Eight progressive grades were used to stage the development of each tooth as shown on the radiograph. Using the tables of standards established by Demirjian *et al* (1976)[3], a numerical score for the stage of development for each of the seven teeth was obtained for every child, and a sum of the scores of the seven teeth was computed. The dental age was obtained by referring the sum of these scores to Demirjian's standard tables.[3]

The difference in dental age (DA) and chronological age (CA) at the time of exposure of the PAN radiograph demonstrates acceleration of dental development when (DA-CA) is a positive value and delay of dental development when it is a negative value.

Statistical analysis

The data were entered into Excel spreadsheets. The Chi-square test and the student's t test were used to determine statistical difference between the groups. The alpha value was set at 0.05.

RESULTS

Prevalence and distribution of PEIR-affected children in Australian and Saudi groups

Table 1 shows the prevalence and distribution of PEIR affected children in the study. A total of 842 PAN radiographs of Australian children aged 5-14 years of age were employed in the study (411 boys, and 431 girls) (Table 1). Of the 411 Australian boys, 9 (1.3%) had PEIR-affected teeth. By contrast, of a total 426 Australian girls, only 5 (0.6%) showed PEIR-affected teeth. In the Saudi children, out of 465 PAN radiographs, only one girl (0.2%) and 2 boys (0.4%) had PEIR-affected teeth (Table 1). As shown in Table 1, there were no statistically significant differences in subject prevalence between Australian and Saudi children ($p>0.1$), and no differences in gender distribution between the subjects with PEIR and those without PEIR in either population groups ($p>0.1$).

Table 2 shows the prevalence of PEIR in individual teeth. Among all the unerupted teeth examined (except third molars), the mandibular second molars (prevalence of 0.2% in Australian and none affected in Saudi children) showed the highest occurrence of PEIR followed in descending order, by mandibular second premolars (0.1% each in Australian and Saudi children), and first mandibular premolars (0.05% in Australian and 0.1% in Saudi children) (Table 2).

PEIR and dental development

Children with PEIR were compared with age- and gender-matched children without PEIR within each population group. The comparison was based on the difference between dental age (DA) and chronological age (CA) computed for each child. Fig 1 and Fig 2 show the (DA-CA) in each affected girl and boy in the Australian and Saudi groups compared to with age- and gender-matched controls without PEIR. As shown in Fig 1 in the Australian cohort, there were 5 girls and 9 boys who had PEIR lesions. The youngest Australian girl (G1) showed a (DA-CA) of 0.5 year compared to the mean (DA-CA) of 0.9±0.7 year in age-matched (5-6 year-old) control girls (Fig 1). Similarly, the second girl (G2) had a (DA-CA) of 0.1 year compared to a mean of 0.5±0.7 years of the 7-8 year-old control girls. The third and fourth girls (G3 and G4) showed (DA-CA) of -0.5 and -0.3 years compared to age-matched control girls who had mean (DA-CA) values of 0.7±1.2 year and 1.0±1.2 years (Fig 1). In contrast, the oldest girl (G5) showed a (DA-CA) of

Table 1. Subject prevalence of pre-eruptive intra-coronal resorption (PEIR)

Australian	Children without PEIR N (%)	Children with PEIR N (%)	Total N (%)	P value
Boys	402 (48%)	9 (1.3%)	411 (49%)	
Girls	426 (50%)	5 (0.6%)	431 (51%)	N.S.
Total N (%)	828 (98%)	14 (2%)*	842 (100%)	
Saudi Arabian	**Children without PEIR N (%)**	**Children with PEIR N (%)**	**Total N (%)**	**P value**
Boys	187 (41%)	2 (0.4%)	189 (41%)	
Girls	275 (59%)	1 (0.2%)	276 (59%)	N.S.
Total N (%)	462 (99%)	3 (0.6%)*	465 (100%)	

*p=0.13, N.S.: not significant

Table 2. Prevalence of pre-eruptive intra-coronal resorption (PEIR) in premolars and molars in Australian and Saudi children

Australian	Teeth without PEIR N (%)	Teeth with PEIR N (%)	Total N (%)
Max 1st Premolar	659 (13%)	0	659 (13%)
Max 2nd Premolar	876 (17%)	0	876 (17%)
Max 1st Molar	123 (2%)	1 (0.02%)	124 (2%)
Max 2nd Molar	977 (19%)	2 (0.05%)	979 (19%)
Mand 1st Premolar	643 (13%)	2 (0.05%)	645 (13%)
Mand 2nd Premolar	849 (17%)	6 (0.1%)	855 (17%)
Mand 1st Molar	108 (2%)	0	108 (2%)
Mand 2nd Molar	884 (17 %)	10 (0.2%)	894 (17%)
Total	5119 (100%)	21 (0.4%)	5140 (100%)
Saudi Arabian	**Teeth without PEIR N (%)**	**Teeth with PEIR N (%)**	**Total N (%)**
Max 1st Premolar	436 (14%)	0	436 (14%)
Max 2nd Premolar	517 (16%)	0	517 (16%)
Max 1st Molar	88 (3%)	0	88 (3%)
Max 2nd Molar	590 (18%)	0	590 (18%)
Mand 1st Premolar	429 (13%)	2 (0.1%)	431 (13%)
Mand 2nd Premolar	521 (16%)	3 (0.1%)	524 (16%)
Mand 1st Molar	61 (2%)	0	61 (2%)
Mand 2nd Molar	570 (18%)	0	570 (18%)
Total	3212 (100%)	5 (0.2%)	3217 (100%)

Max: Maxillary Mand: Mandibular

0.4 years compared to the (DA-CA) of 0.8±1.2 years shown by the corresponding age group (13-14 years) of control children.

In the case of Australian boys (B1-B9), the three youngest boys (B1-B3) were in the 5-6 year-old age group (Fig 1). The (DA-CA) of these children were 0.5, 0.3, and 0.5 years respectively compared to the mean (DA-CA) of 0.9±0.6 of 5-6 year-old control children. B4 had a (DA-CA) of 0.4 years compared to the (DA-CA) of 0.5±0.73 years of 7-8 year-old control children. B5-B7 were in the 9-10 year-old age group and showed (DA-CA) of 0.3, 0.6, and 0.2 years respectively compared to the mean (DA-CA) of 0.5±1.0 years of control boys (Fig 1). B8 had a (DA-CA) of 0.3 years which is less than the control mean of 0.5±1.2 years. B9 had a (DA-CA) of 0.5 years which was identical to that of the control mean.

Fig 2 shows the Saudi children with PEIR. As shown in Fig 2, there was a Saudi girl (G1) and two boys (B1 and B2) who had PEIR. G1, B1 and B2 showed (DA-CA) of -1.0, -3.0 and 2.3 years compared with the mean of 0.5±0.9, 0.6±0.6 and 0.6±0.6 years in age-matched control girls and boys respectively (Fig 2).

Table 3 summarises the (DA-CA) differences of the total children in the study. As shown in Table 3, the mean (DA-CA) difference of the Australian children with PEIR was 0.27±0.32 years compared with 0.69±0.2 years in children without PEIR giving a dental developmental delay of -0.42±0.12 years ($p<0.0001$). In Saudi children, the mean (DA-CA) difference was -0.57 ±2.68 years compared with 0.57±0.06 years in children without PEIR ($p<0.0001$).

Fig 1. Differences in chronological age (CA) and dental age (DA) in children with PEIR teeth compared with age- and gender-matched controls in the Australian group G: girls; B: boys

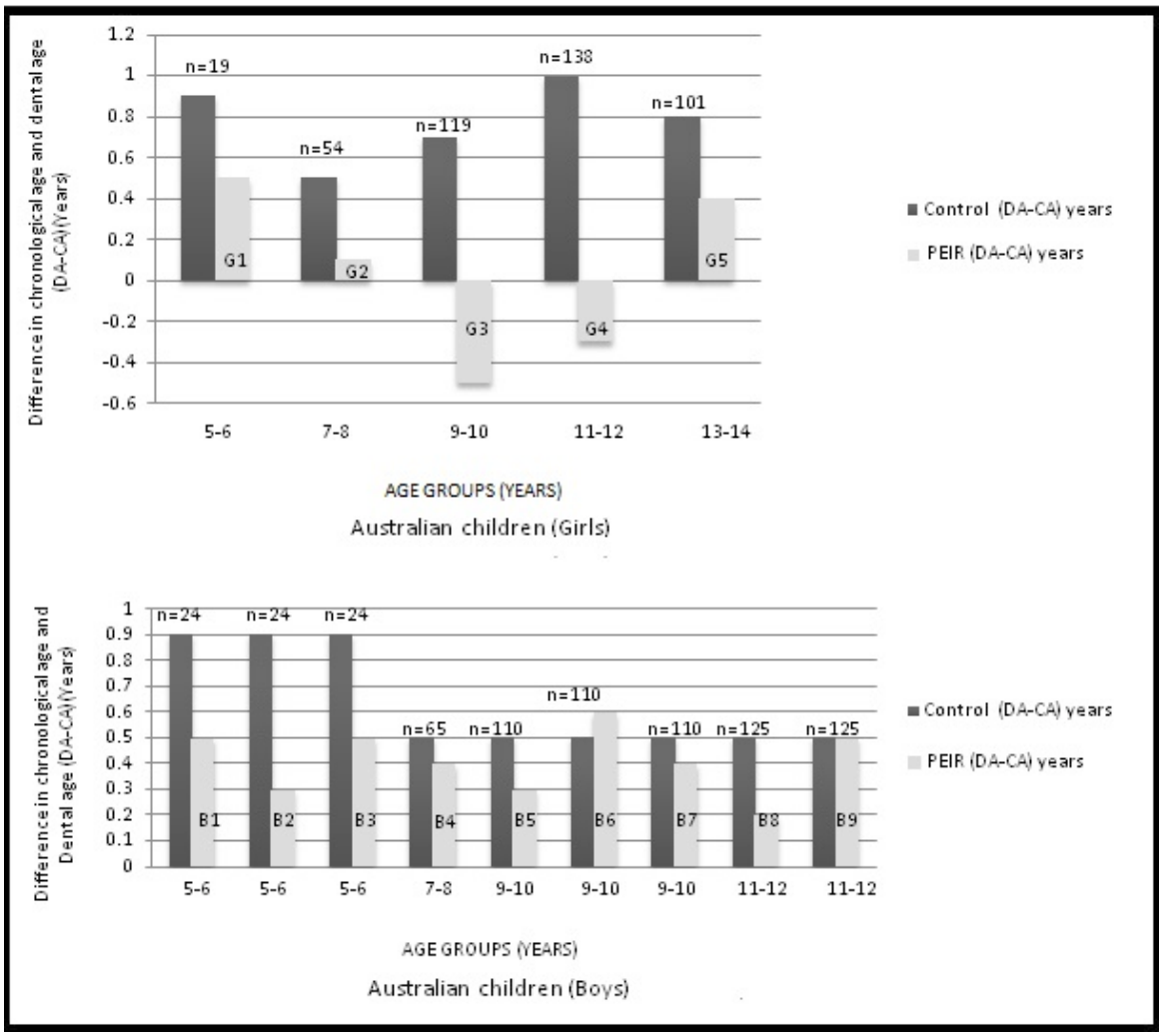


Fig 2. Differences in chronological age (CA) and dental age (DA) in children with PEIR teeth compared with age- and gender-matched controls in the Saudi group G: girls; B: boys

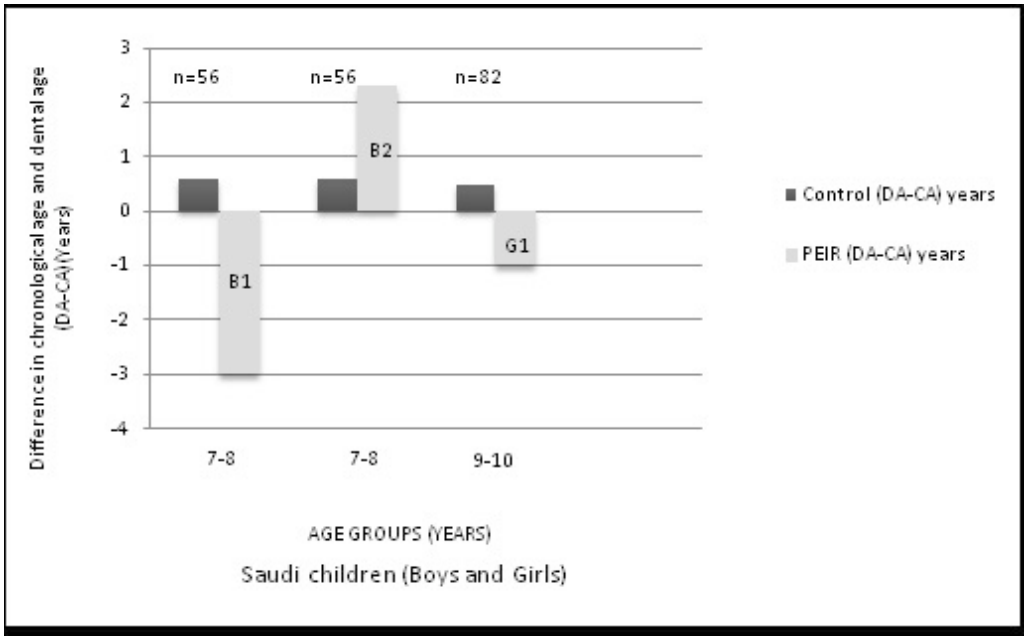


Table 3. Differences between dental age (DA) and chronological age (CA) of Australian and Saudi Arabian children with and without pre-eruptive intracoronal resorption (PEIR)

	Children with PEIR (DA-CA) (y)	Control children without PEIR matched for age and gender Mean (DA-CA) ± SD (y)	Difference between (DA-CA) of children with PEIR and controls (y)	p-value comparing (DA-CA) of children with PEIR and controls
Australian				
G1	0.5	0.9 ± 0.7	-0.4	
G2	0.1	0.5 ± 0.7	-0.4	
G3	- 0.5	0.7 ± 1.2	-1.2	
G4	- 0.3	1.0 ± 1.2	-1.3	
G5	0.4	0.8 ± 1.2	-0.4	
B1	0.5	0.9 ± 0.6	-0.4	
B2	0.3	0.9 ± 0.6	-0.6	
B3	0.5	0.9 ± 0.6	-0.4	
B4	0.4	0.5 ± 0.7	-0.1	
B5	0.3	0.5 ± 1.0	-0.2	
B6	0.6	0.5 ± 1.0	0.1	
B7	0.2	0.5 ± 1.0	-0.3	
B8	0.3	0.5 ± 1.2	-0.2	
B9	0.5	0.5 ± 1.2	0	
Mean of all Australian	0.27 ± 0.32 (n=14)	0.69 ± 0.2 (n=828)	-0.42 ± 0.12	p<0.0001
Saudi Arabian				
G1	-1	0.5 ± 0.9	-1.5	
B1	-3	0.6 ± 0.6	-3.6	
B2	2.3	0.6 ±0.6	1.7	
Mean of all Saudi Arabian	- 0.57 ± 2.68 (n=3)	0.57 ± 0.06 (n=462)	-1.14 ± 2.62	p<0.0001
Mean of all children in study	0.12 ± 1.04 (n=17)	0.66 ± 0.19 (n=1290)	-0.54 ± 0.85	p<0.0001

G1-G5: Individual girl children with PEIR, designated with numbers 1-5

B-B9: Individual boy children with PEIR, designated with numbers 1-9

SD: Standard deviation

PEIR and impaction of teeth

Table 4 shows the association of impaction with PEIR in the Australian and Saudi children. Of the 14 Australian subjects with PEIR, 6 children (43%) showed impaction of the teeth with PEIR and another 2 (14%) showed impaction of adjacent teeth. In case of Saudi children, only one child out of three with PEIR showed impaction of PEIR affected teeth (Table 4).

The control radiographs in both racial groups were also examined for prevalence of impaction. Table 5 shows the prevalence of impaction in teeth with and without PEIR. As shown in Table 5, in teeth with PEIR, impaction was present in 7 of 21 teeth (33%) and 1 of 5 teeth (20%) in Australian and Saudi children respectively. In contrast, in the control children without PEIR, 7 out of a total of 5119 teeth (0.1%) and none of 3217 teeth showed impaction in the Australian and Saudi children respectively. The differences in prevalence of impaction of teeth with and without PEIR in all children were statistically significant (p<0.0001).

Table 4. Comparing dental impaction associated with pre-eruptive intracoronal resorption (PEIR) in Australian and Saudi Arabian children

Australian	Tooth with PEIR	Impaction of tooth with PEIR	Impaction of tooth adjacent to tooth with PEIR
1 (M)	37	37	
2 (M)	44, 45		
3 (F)	47	47	
4 (M)	44		
5 (F)	26, 45, 47	26, 47	
6 (M)	37, 47		
7 (M)	37, 47	47	36
8 (M)	37		
9 (F)	44,45		
10 (M)	45	45	
11 (M)	17, 27		
12 (F)	37		
13 (M)	37	37	38
14 (F)	45		
Saudi Arabian	**Tooth with PEIR**	**Impaction of tooth with PEIR**	**Impaction of tooth adjacent to tooth with PEIR**
1 (M)	35, 45		
2 (M)	34		
3 (F)	34, 45	34	

Table 5. Prevalence of dental impaction in teeth with and without pre-eruptive intracoronal resorption (PEIR) in Australian and Saudi Arabian children

	Teeth with PEIR (Impaction absent) N (%)	Teeth with PEIR (Impaction present) N (%)	Teeth without PEIR (Impaction absent) N (%)	Teeth without PEIR (Impaction present) N (%)
Australian (N=5140)	14 out of 21 (67%)	7 out of 21 (33%)*	5112 out of 5119 (99.9%)	7 out of 5119 (0.1%)
Saudi Arabian (N=3217)	4 out of 5 (80%)	1 out of 5 (20%)$^{\beta}$	3212 (100%)	0 out of 3217
Total (N=8357)	18 out of 26 (69%)	8 out of 26 (31%)**	8324 out of 8331 (99.9%)	7 out of 8331 (0.1%)

*p<0.0001–comparing prevalence of impaction in teeth with and without PEIR in Australian children

$^{\beta}$p<0.0001 – comparing prevalence of impaction in teeth with and without PEIR in Saudi children

**p<0.0001-comparing prevalence of impaction of teeth with and without PEIR in all children in the study

DISCUSSION

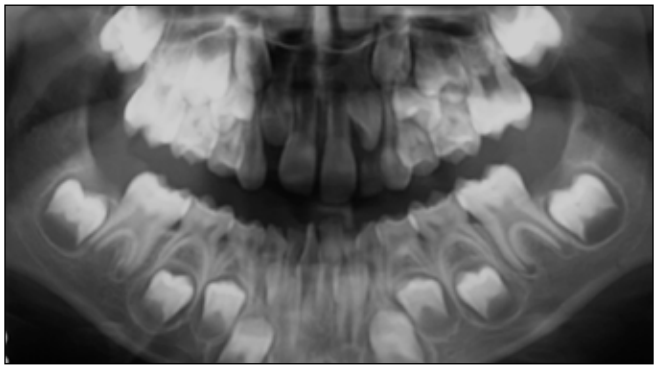
Although radiolucencies in the crowns of unerupted teeth have been observed in dental radiographs for a few decades,[20,22,25,31,32] the etiology of these lesions remains unclear.[33] The evidence for the resorptive nature of PEIR lesions is derived from histology which usually reports signs of resorption such as scalloping of the margins, and presence of osteoclasts.[25,28,33] As the majority of studies were based on individual cases [21,22,33] and single population groups[26], there is limited information on the influence of race and ethnicity in the etiology of PEIR and there have been no previous studies which examined dental development in PEIR.

In the present study, we reported that there is 2 % of Australian subjects with PEIR which is similar to previous reports of the same population.[26-27] Although this prevalence rate is higher than the 0.6% found in Saudi children, the difference was statistically insignificant. The lack of difference in PEIR prevalence between the two population groups found in this study demonstrates that ethnic background is unlikely to be a risk factor in PEIR. Other evidence supporting the present results is the fact that cases of PEIR have been reported from diverse population groups around the world.[21-23,34-40] A familial or genetic implication in PEIR cases has also not been reported previously, and PEIR has also not been associated with any general systemic or medical conditions.

The delay in dental development seen in children with PEIR may be coincidental, but this is unlikely given the fact that the majority of children with PEIR showed delay compared to control children without PEIR. The authors propose that the delay in dental development most likely results from an alteration of the teeth or alveolar bone that is observed with the PEIR lesions. Abnormalities of bone growth and metabolism have been associated with delayed dental development in children with cleidocranial dysplasia, delayed puberty and constitutional growth delay.[9,18,41] On the other hand, PEIR has not been associated with any known systemic conditions so the possible mechanisms for the developmental delay remain speculative.

It is unlikely that the delay in dental development directly results in resorption of the teeth. Although crown resorption has been reported in teeth which have been unduly retained and unerupted

PEIR in the unerupted mandibular right and left second molars



in the alveolar bone, [42] these previous cases are usually localized pathological states involving the delayed emergence of few teeth, and not generalized developmental delays. The present finding that approximately thirty percent of all teeth with PEIR are associated with impaction compared to less than one percent of teeth without PEIR confirms our previous observations that impaction of the teeth is associated with PEIR. [27] This finding fits with our previous hypothesis that dental impaction may lead to inflammation which facilitates the entry of resorptive cells from the tooth follicle into the dentin to trigger the formation of a PEIR lesion. [27]

Although PEIR is found in 2 percent of the population, the clinical significance of PEIR is still relatively unrecognized. PEIR has been proposed to constitute a large component of undiagnosed carious defects of the teeth[20], and the complications may be serious if the lesions remain undetected and the resorption continues for long periods and encroaches the pulp.[25] The PEIR lesions are usually sterile while the tooth is unerupted, however, they rapidly become colonized by the oral flora upon emergence into the oral cavity. The resorbed teeth often present with cavitated lesions which quickly become carious, so that the defects appear clinically similar to general carious lesion once the teeth are emerged.[20]

Although the dental age standards of Demirjian and co-workers [2,3] may not be directly applicable to the current populations, this does not pose a limitation to the present study, which employed the

standards as a tool to determine the relative rates of dental development of population groups. The present data thus showing that PEIR is significantly associated with developmental dental delay suggest the presence of other oral changes. It is recommended that further studies of PEIR be undertaken to improve the management of this clinically significant lesion.

CONCLUSION

The present study provides the first evidence that there are no differences in PEIR prevalence between Australian and Saudi population, and that dental development is significantly delayed in children with PEIR.

REFERENCES

1. Chaillet N, Nystrom M, Demirjian A. Comparison of dental maturity in children of different ethnic origins: international maturity curves for clinicians. J Forensic Sci ;50:1164-74.2005.
2. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol ;45:211-27.1973.
3. Demirjian A, Goldstein H. New systems for dental maturity based on seven and four teeth. Ann Hum Biol ;3:411-21.1976.
4. Qudeimat MA, Behbehani F. Dental age assessment for Kuwaiti children using Demirjian's method. Ann Hum Biol ;36:695–704.2009.
5. Peiris TS, Roberts GJ, Prabhu N. Dental Age Assessment: a comparison of 4- to 24-year-olds in the United Kingdom and an Australian population. Int J Paediatr Dent ;19:367-76.2009.
6. Mitchell JC, Roberts GJ, Donaldson AN, Lucas VS. Dental age assessment (DAA): reference data for British caucasians at the 16 year threshold. Forensic Sci Int ;189:19-23.2009.
7. Tunc ES, Koyuturk AE. Dental age assessment using Demirjian's method on northern Turkish children. Forensic Sci Int ;175:23-6.2008.
8. Rozylo-Kalinowska I, Kiworkowa-Raczkowska E, Kalinowski P. Dental age in Central Poland. Forensic Sci Int ;174:207-16.2008.
9. Kanbur NO, Kanli A, Derman O, Eifan A, Atac A. The relationships between dental age, chronological age and bone age in Turkish adolescents with constitutional delay of growth. J Pediatr Endocrinol Metab ;19:979-85.2006.
10. Leurs IH, Wattel E, Aartman IH, Etty E, Prahl-Andersen B. Dental age in Dutch children. Eur J Orthod ;27:309-14.2005.
11. Chaillet N, Nystrom M, Kataja M, Demirjian A. Dental maturity curves in Finnish children: Demirjian's method revisited and polynomial functions for age estimation. J Forensic Sci ;49:1324-31.2004.
12. Eid RM, Simi R, Friggi MN, Fisberg M. Assessment of dental maturity of Brazilian children aged 6 to 14 years using Demirjian's method. Int J Paediatr Dent ;12:423-8.2002.
13. Teivens A, Mornstad H. A comparison between dental maturity rate in the Swedish and Korean populations using a modified Demirjian method. J Forensic Odontostomatol ;19:31-5.2001.
14. Nystrom M, Kleemola-Kujala E, Evalahti M, Peck L, Kataja M. Emergence of permanent teeth and dental age in a series of Finns. Acta Odontol Scand ;59:49-56.2001.
15. Farah CS, Booth DR, Knott SC. Dental maturity of children in Perth, Western Australia, and its application in forensic age estimation. J Clin Forensic Med ;6:14-8.1999.
16. Al-Tuwirqi A, Holcombe T, Seow WK. A study of dental development in a Caucasian population compared to a non-Caucasian population. Eur Arch Paed Dent ;12:27-30.2011.
17. Kan W, Seow WK, Holcombe T. A case-control study of dental development of children with hypodontia and hyperdontia. Pediatr Dent ;32:127-33.2009.
18. Seow WK, Hertzberg J. Dental development and molar root length in children with cleidocranial dysplasia. Pediatr Dent ;17:101-5.1995.
19. Nystrom M, Aine L, Peck L, Haavikko K, Kataja M. Dental maturity in Finns and the problem of missing teeth. Acta Odontol Scand ;58:49-56.2000.
20. Seow WK. Pre-eruptive intracoronal resorption as an entity of occult caries. Pediatr Dent ;22:370-6.2000.
21. Walton JL. Dentin radiolucencies in unerupted teeth: report of two cases. ASDC J Dent Child ;47:183-6.1980.
22. Skaff DM, Dilzell WW. Lesions resembling caries in unerupted teeth. Oral Surg Oral Med Oral Pathol ;45:643-6.1978.
23. Holan G, Eidelman E, Mass E. Pre-eruptive coronal resorption of permanent teeth: report of three cases and their treatments. Pediatr Dent ;16:373-7.1994.
24. DeSchepper EJ, Haynes JI, Sabates CR. Preeruptive radiolucencies of permanent teeth: report of a case and literature review. Quintessence Int ;19:157-60.1988.
25. Seow WK, Hackley D. Pre-eruptive resorption of dentin in the primary and permanent dentitions: case reports and literature review. Pediatr Dent ;18:67-71.1996.
26. Seow WK, Wan A, McAllan LH. The prevalence of pre-eruptive dentin radiolucencies in the permanent dentition. Pediatr Dent ;21:26-33.1999.
27. Seow WK, Lu PC, McAllan LH. Prevalence of pre-eruptive intracoronal dentin defects from panoramic radiographs. Pediatr Dent ;21:332-9.1999.
28. Grundy GE, Pyle RJ, Adkins KF. Intra-coronal resorption of unerupted molars. Aust Dent J ;29:175-9.1984.
29. Seow WK. A controlled study of the development of the permanent dentition in children prematurely-born with very low birthweight. . Pediatr Dent ;18:379-84.1996.
30. Seow WK. Dental development in amelogenesis imperfecta: a controlled study. Pediatric Dentistry ;17:26-30.1995.
31. Yates JL, Williams JI. "Pre-eruptive caries": report of a case. J Tenn Dent Assoc ;58:20-2.1978.
32. Skillen WG. Intra-follicular caries. J Dent ;10:307-8.1941.
33. Seow WK. Multiple pre-eruptive intracoronal radiolucent lesions in the permanent dentition: case report. Pediatr Dent ;20:195-8.1998.
34. Nik NN, Abul Rahman R. Pre-eruptive intracoronal dentin defects of permanent teeth. J Clin Pediatr Dent ;27:371-5.2003.
35. Moskovitz M, Holan G. Pre-eruptive intracoronal radiolucent defect: a case of a nonprogressive lesion. J Dent Child (Chic) ;71:175-8.2004.
36. Kunz GT. Pre-eruptive intracoronal lesion of a mandibular first molar. Gen Dent ;45:574-6.1997.
37. Klambani M, Lussi A, Ruf S. Radiolucent lesion of an unerupted mandibular molar. Am J Orthodont Dentofacial Orthoped ;127:67-71.2005.
38. Johnson M, Harkness M. Pre-eruptive coronal radiolucency in a mandibular premolar: a case report and literature review. N Z Dent J ;93:84-6.1997.
39. Hata H, Abe M, Mayanagi H. Multiple lesions of intracoronal resorption of permanent teeth in the developing dentition: a case report. Pediatr Dent ;29:420-5.2007.
40. Davidovich E, Kreiner B, Peretz B. Treatment of severe pre-eruptive intracoronal resorption of a permanent second molar. Pediatr Dent ;27:74-7.2005.
41. Gaethofs M, Verdonck A, Carels C, de Zegher F. Delayed dental age in boys with constitutionally delayed puberty. Eur J Orthod ;21:711-5.1999.
42. Seddon RP, Smith PB. Early arrested development and coronal resorption of an impacted maxillary canine: Report of case. J Dent Child ;63:208-12.1996.