European Journal of Orthodontics 33 (2011) 492–497
doi:10.1093/ejo/cjq123
Advance Access Publication 24 January 2011

Dental age in patients with impacted maxillary canines related to the position of the impacted teeth

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SUMMARY The aim of the study was to determine whether there are differences in dental age (DA) using the method of Demirjian, in patients with impacted buccal or palatal maxillary canines in relation to unaffected controls. DA was estimated using Demirjian's method on panoramic radiographs of two groups of Caucasian patients. The study group consisted of 116 patients aged from 12 to 16 years (80 females and 36 males) that was further divided into 54 patients with unilateral or bilateral palatally impacted maxillary canines and 62 patients with buccally positioned canines. The control group of 116 subjects without canine impaction was matched to the study group by age and gender. Calculated DAs and differences between dental and chronological age (CA) were compared between the groups. Statistical analysis was performed using Shapiro–Wilk, Mann–Whitney *U*, and Student's *t*-test. DA was significantly lower in patients with impacted maxillary canines than in healthy controls and also when palatal or buccal ectopia was considered. The rate of dental development in patients with palatally impacted canines did not differ from that of subjects with buccal canine displacement. The differences between DA and CA were higher in healthy controls (increase in DA) than in patients with impacted maxillary canines. DA estimation using Demirjian's method may be lower than expected in subjects with maxillary canine impaction.

Introduction

According to Dewel (1949), no tooth is more interesting from a developmental point of view than the maxillary canine. This observation is supported not only by the longest period of development and calcification of its tooth bud but also the complicated sequence of movements during the course of migration—from the place of origin at about the end of the first year of life to the occlusal plane in the 9th–11th year of life (Dewel, 1949; Newcomb, 1959). This model of development favours a higher frequency of anomalies due to prolonged exposure of the canine bud to environmental factors and possible deviation from its usual migration path. Therefore, one of the more prevalent developmental anomalies of the maxillary canine is impaction, which has been observed in 0.8–3 per cent of studied populations (Nordenram and Stromberg, 1966; Shah *et al.*, 1978; Grover and Lorton, 1985). Palatal displacement of these teeth has been reported in 50–85 per cent of cases (Jacoby, 1983)—it exceeds that of buccal impaction by a ratio of 2:1 or 3:1 (Fournier *et al.*, 1982).

Newcomb (1959), when describing methods of early diagnosis and prevention of maxillary canine ectopia, stated that clinical experience had taught him that in patients with moderate to severe retardation of dental maturation potential impaction of permanent teeth was seen with few exceptions. He also postulated that the correlation between dental and bone age in these patients should be analysed. However, despite the importance of this observation, research on dental age (DA) in subjects with maxillary canine ectopia is limited.

McSherry and Richardson (1999) investigated the eruption paths of palatally positioned ectopic maxillary canines in three dimensions on cephalometric radiographs of patients between the ages of 5 and 15 years and compared them with eruption of normal canines. Ectopic canines moved more anteriorly than the normally erupting canines, while their vertical movement was less than normal. According to those authors, it implicated impaction of palatally positioned canines at a high level.

DA in patients with maxillary canine displacement has been determined by means of evaluation of dental eruption (Zilberman *et al.*, 1990). Those authors investigated a possible link between palatal canines and delay in development of the dentition as well as anomalies of the lateral incisors. They found that anomalies of the lateral incisors were four times more frequent than in the general population and linked positively with late development of the dentition and a relative absence of crowding.

Becker and Chaushu (2000) examined DA in patients with ectopic buccal and palatal maxillary canines, both erupted and unerupted. They used the radiographic criteria of tooth calcification advocated by Becker (1998) as more precise than tooth eruption pattern.

Among radiographic methods for DA estimation in children, Demirjian's method is widely used (Demirjian *et al.*, 1973, 1985; Demirjian and Goldstein, 1976). The popularity of the method is based on the availability of panoramic radiographs in orthodontic clinics. This method of DA estimation is based on rating the calcification stage of the seven left mandibular teeth, which are clearly visible on such radiographs. The criteria of the method comprise shape and proportion of root length (using the relative value to crown height rather than absolute tooth length), thus minimizing the influence of radiographic projection on the results of DA estimation (Kataja *et al.*, 1989).

To date, no information on DA assessed using Demirjian's method in patients with maxillary canine impaction has been published. Therefore, the objective of this study was to determine whether there are differences in DA according to Demirjian's method in patients with impacted buccal or palatal maxillary canines compared with unaffected controls.

Material and methods

The material consisted of the complete dental records and radiographs of patients with at least one impacted maxillary canine, selected from the archives of children treated for malocclusion or followed-up in the Out-Patient Orthodontic Clinic of the Regional Center of Dentistry in Warsaw during 1994–2004.

Analysis of the clinical files allowed for selection of the panoramic radiographs only of patients in good general health, presenting no general developmental malformations, and showing adequate physical and psychological development. Subjects with hypodontia were not included in the study.

All panoramic radiographs were taken using a Proline PM X-ray machine (Planmeca, Helsinki, Finland). Image magnification factor was constant and equalled 1.2. The radiographic films used were Foton XR-1N (15 × 30 cm; Foton S.A., Warsaw, Poland), the exposure time was 15 seconds, and the films were developed with Retina X Ray (Fotochemische Werke GMBH, Berlin, Germany). Only good quality radiographs were included.

The study group consisted of 116 panoramic radiographs of Caucasian patients aged from 12 to 16 years (80 females and 36 males). Two subgroups were also distinguished: 54 patients with unilateral or bilateral palatally positioned impacted maxillary canines and 62 patients with unilateral or bilateral bucally positioned impacted maxillary canines.

The control group comprised 116 panoramic radiographs of subjects with correctly positioned canines, bilaterally erupted canines, or almost completely erupted canines. The ages and genders of the control group were matched with those of the study group. This group was also further divided to match the number of radiographs of the study population.

DA in subjects in both the study and control groups was determined using Demirjian's assessment (Demirjian *et al.*, 1973, 1985; Demirjian and Goldstein, 1976). The examined teeth in the lower left quadrant comprised the central incisor, lateral incisor, canine, first and second premolars, and first and second molars. An eight-grade scale was used and each tooth was assigned an appropriate value representing its developmental stage (from A to H). Standard tables (separate for males and females) were used to assign to each evaluated stage an appropriate numerical score. These values were then summed, and the total score indicated the DA read out from standard tables.

In order to minimize the error in DA assessment, each panoramic radiograph was analysed twice by the same author (AKR), blinded to the status of the canine. The first assessment was carried out using a light box and the developmental stages of the teeth were entered into tables in a computer database. All images were then scanned and stored in a computer database, and the second assessment was performed on a computer screen. This enabled magnification of selected regions of interest in order to arrive at a more accurate evaluation of tooth developmental stage. When the results of the two examinations were compared, the differences between the first and the second evaluation regarding any given tooth never exceeded one developmental stage. A lower development stage was always chosen by consensus of two authors in an additional reading (AKR and IRK), whenever disparities occurred.

The chronological age (CA) of the patients was also registered based on the time from the child's birth to the day the panoramic radiograph was obtained. The obtained values were rounded down (i.e. a given patient on the day when the radiograph was obtained was of a certain CA and could not be in the next possible CA group) and noted in years and decimal places according to Demirjian's guidelines. This enabled comparison of the CA of a patient with the DA resulting from the standard tables. For that purpose, the difference between the DA obtained by means of Demirjian's method and the CA of each patient was calculated. A value below zero indicated slower dental development, a zero value meant that DA and CA were identical, while a value above zero indicated increased dental development when compared with Demirjian's standard. Furthermore, the difference between the total score obtained and that according to Demirjian was calculated.

Statistical analysis was performed using Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) and Statistica for Windows software (StatSoft Media, Tulsa, Oklahoma, USA). The Shapiro–Wilk test was used in order to determine normality of distribution of the results. The choice of the Mann–Whitney U or Student's t-test to study the significance of differences between the examined groups was based on the presence or absence of normality of distribution. Probability was set at $\alpha = 0.05$.

Results

DA in patients with impacted maxillary canines was significantly lower than in all control subjects ($P = 0.00$; Table 1 and Figure 1a). When the DA of the patients with palatally impacted canines was compared with the controls, a significant difference was found ($P = 0.00$)—DA was higher in the controls than in those with canine ectopia (Table 1 and Figure 1b). A significant difference ($P = 0.02$) was also noted when the DA of patients with buccally impacted maxillary canines was compared with estimations for the control group of healthy subjects—once again, the DA was higher in the control subjects (Table 1 and Figure 1c). On the other hand, patients with impacted canines, either with palatal or buccal displacement, did not differ significantly in DA ($P = 0.08$; Table 1 and Figure 1d).

Analysis of the difference between DA and CA for the total group of patients with impacted canines in comparison with all control subjects showed that this difference was significantly lower in patients with canine impaction. Statistical significance was very high ($P = 0.00$; Table 2). The differences between DA and CA were lower in patients with palatally impacted maxillary canines than in the corresponding control group ($P = 0.00$; Table 2). A similar situation was observed for the difference between DA and CA in patients with buccal displacement of the maxillary canines and the controls ($P = 0.00$; Table 2). The mean DA was lower than CA in patients with palatally impacted maxillary canines, while in those with canine buccal ectopia, a minor acceleration of mean DA was observed. This difference was also statistically significant ($P = 0.01$; Table 2).

Discussion

It was found in the present study that dental development was retarded in patients with both buccal and palatal impacted maxillary canines. This is contrary to the findings of Becker and Chaushu (2000). Those authors examined 55 patients with palatally displaced maxillary permanent canines, 47 with buccally ectopic maxillary permanent canines, and 57 with erupted or unerupted but undisplaced maxillary canines. Good quality panoramic radiographs were studied and DA was evaluated for each permanent tooth, erupted, and unerupted. The determination of DA was performed with an accuracy of 0.5 years by means of the system advocated by Becker (1998). This system is based on assessment of the completion of the crown and the advancing stages of root formation until closure of the root apex of the maxillary and mandibular teeth. The disappearance of the root-forming dental papilla is the most accurate to diagnose; therefore, it can be used as a baseline from which to begin the evaluation of a patient's DA. For example, when the roots of the mandibular central incisor are fully closed, it may be assumed that the patient has reached the DA baseline of 9 years. Each tooth with fully closed apices indicates increasing DA, e.g. 10 years for the maxillary central incisor, 11 years for the maxillary lateral incisor, 12–13 years for the mandibular canines, and first premolars until 15 years for the second permanent molars. A tentative DA is determined on the basis of the last tooth in the series to exhibit a closed apex. This method of evaluation of DA is more straightforward and less time consuming than that of Demirjian. On the other hand, the accuracy of

Table 1 Comparison of dental age (DA)—Mann–Whitney *U*-test results for the study and control groups.

Variable	*n*	SD	Mean	Mann–Whitney *U*-test	*P*
Patients with impacted maxillary canines (S) versus controls (C)					
DA	116	1.28	13.54		***
S				−4.05	
DA	116	1.48			
C			14.32		
Patients with palatally impacted canines (S–P) and controls (C–P)					
DA	54	1.32	13.76		***
S–P				−3.44	
DA	54	1.33			
C–P			14.73		
Patients with buccally impacted canines (S–B) and controls (C–B)					
DA	62	1.22	13.34		*
S–B				−2.44	
DA	62	1.52			
C–B			13.96		
Patients with palatally (S–P) and buccally (S–P) impacted maxillary canines					
DA	54	1.32	13.77		0.08
S–P				1.75	
DA	62	1.22			
S–B			13.34		

*$P < 0.05$; ***$P < 0.001$.

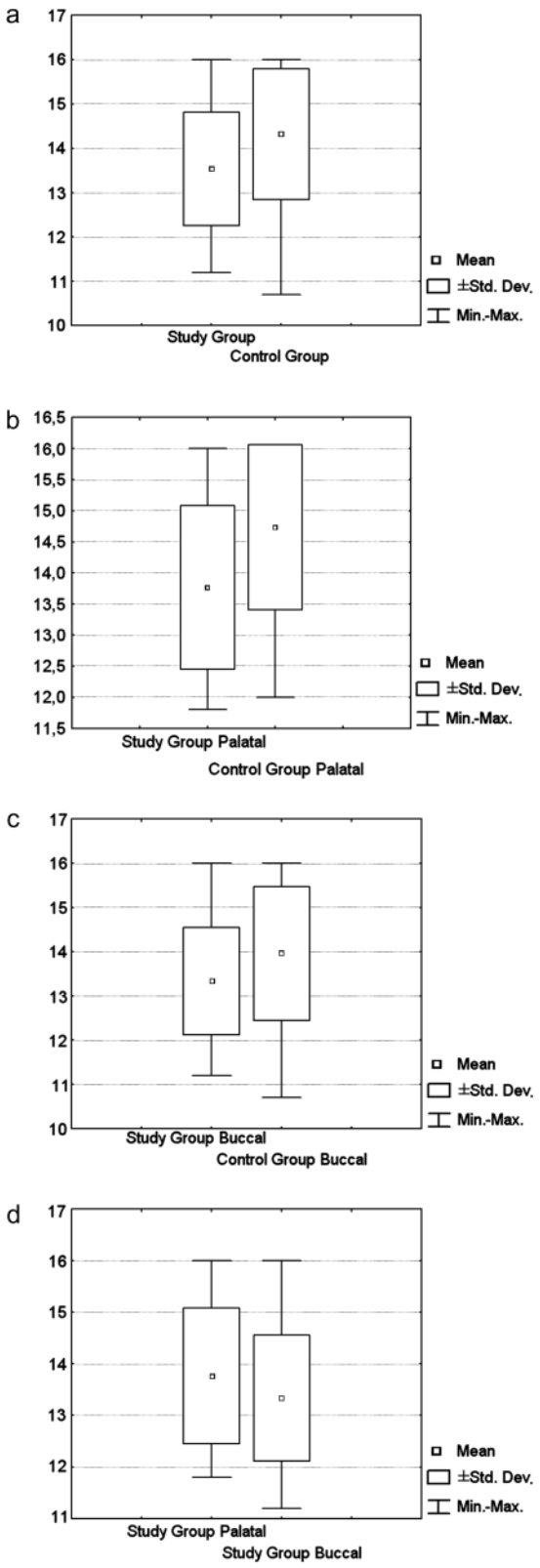

Figure 1 Dental age in patients with (a) impacted canines versus control group, (b) palatally impacted canines versus adequate control subgroup, (c) buccally impacted canines versus adequate control subgroup, and (d) palatally impacted canines versus buccally impacted canines.

the system allows a tolerance of 0.5 years, while DA according to Demirjian is estimated up to 0.1 years.

In the study by Becker and Chaushu (2000), the occurrence and range of DA values in the buccal canine group were close to those of the control group. Therefore, it was concluded that patients with buccally ectopic maxillary canines had a normal rate of dental development, contrary to the results of the present study.

With regard to palatally ectopic canines, Becker and Chaushu (2000) stated that their rate of development was abnormal. The patients in the palatal canine group showed a distinct tendency for delayed dental development with a high statistical significance ($P = 0.001$). Moreover, it was observed that approximately 50 per cent of the patients presented delay in development of the dentition by a mean of 1.5 years. The remaining 50 per cent had a normal DA. On this basis, they concluded that there existed two separate and distinct aetiological factors for palatal displacement of the canine.

In the present study, only patients with impacted canines were included. Although the incidence of palatal canine impaction is low, it exceeds that of buccal impaction. On the other hand, ectopic buccal eruption of the maxillary canines is one of the most frequently encountered conditions in orthodontic practice (Chaushu *et al.*, 2003). The difference in results in comparison with those of Becker and Chaushu (2000) may be due to the limitation of including only patients with unerupted canines and omitting those with ectopic eruption of these teeth in the present study. It might be assumed that maxillary canine impaction may be linked to a delay in the rate of their development, while in individuals with a normal rate of dental development, ectopic eruption of these teeth may be expected.

Demirjian's system is based on evaluation of the seven left mandibular teeth and also considers only these teeth when an anomaly exists in the maxillary arch. However, when using this system, it should be borne in mind that the results of DA estimation may be lower than expected in subjects with maxillary canine impaction as observed in the present study. It is likely that dental development is affected as a whole; however, it is also possible that the effects on the maxillary arch may be different. It should be underlined that in this study, patients with heritable dental anomalies were excluded.

A weakness of the current research may result from the choice of the control group. Due to ethical reasons, the control radiographs were chosen from the database of existing radiographs of patients undergoing orthodontic treatment or follow-up. According to the radiographic protection ALARA (As Low As Reasonably Achievable) rule, it is not possible to take radiographs of a random sample of patients in whom there are no diagnostic or therapeutic indications for this procedure involving harmful ionizing radiation. Nevertheless, all DA assessment studies suffer from the same potential

Table 2 Comparison of the differences between dental age (DA) and chronological age (CA) in study and control groups—Student's *t*-test results.

Variable	*n*	SD	Mean	Mean equality		SD equality	
				t	*P*	*F*	*P*
Patients with impacted maxillary canines (S) versus control group (C)							
DA-CA S	116	1.29	0.08	-4.83	***	1.21	0.31
DA-CA C	116	1.18	0.87				
Patients with palatally impacted canines (group S–P) and control subjects (group C–P)							
DA–CA S–P	54	1.29	−0.24	−4.00	***	1.11	0.70
DA–CA C–P	54	1.22	0.72				
Patients with buccally impacted canines (group S–B) and control subjects (group C–B)							
DA–CA S–B	62	1.24	0.37	−2.94	**	1.20	0.48
DA–CA C–B	62	1.13	0.99				
Patients with palatally (S–P) and buccally (S–B) impacted maxillary canines							
DA–CA S–P	54	1.29	−0.24	−2.60	*	1.08	0.77
DA–CA S–B	62	1.24	0.37				

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

weakness (Rozylo-Kalinowska *et al.*, 2011). Although none of the patients in the control group had maxillary canine impaction, both the study and the control groups were drawn from the sub-population of children requiring orthodontic assessment; therefore, the two groups were statistically appropriate for comparison.

The examined group consisted solely of patients of Caucasian origin. In other studies, it was demonstrated that an ethnic difference exists in the relative frequency of the prevalence of palatal versus buccal maxillary canine displacement (Takahama and Aiyama, 1982; Becker *et al.*, 1999).

It is known that the original standards of Demirjian and Goldstein (1976) for the French–Canadian population in the 1970s are mostly not suitable for other populations and require modifications due to, for example, secular trends in acceleration of dental development (Davis and Hägg, 1994; Rozylo-Kalinowska *et al.*, 2007). However, in this study, DA was determined using the same method in both the study and control groups and relative differences were taken into account therefore avoiding bias. Demirjian's system is more precise for estimation of DA than other methods used in previous studies for similar purpose, i.e. observation of dental eruption (Zilberman *et al.*, 1990) or assessment of dental development with an accuracy of 0.5 years (Becker and Chaushu, 2000).

The assumption that maxillary canine impaction may be linked to a slower rate of canine development, while in individuals with a normal rate of dental development, ectopic eruption of these teeth may be expected, requires further studies on a larger group of patients.

Conclusions

1. DA was significantly reduced in patients with impacted maxillary canines than in healthy controls, also when palatal or buccal type of ectopia was taken into account.
2. The dental development rate in patients with palatally impacted canines did not differ from that of subjects with buccal displacement of these teeth.
3. The differences between DA and CA were higher in the controls (faster DA) than in patients with impacted maxillary canines.
4. Maxillary canine impaction might be linked to a slower rate in their development.
5. DA estimation using Demirjian's method may be lower than expected in subjects with maxillary canine impaction.

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