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EVALUATION OF DENTAL DEVELOPMENT IN CHILDREN WITH PULPAL INFECTION DUE TO DENTAL CARIES IN IMMATURE PERMANENT FIRST MOLARS

Demir Seda Nur [1], Hazar Bodrumlu, Ebru [2]

1. Research Assistant, Zonguldak Bulent Ecevit University, Faculty of Dentistry, Department of Pediatric Dentistry, Zonguldak, Turkey.
2. Associate Professor, PhD, Zonguldak Bulent Ecevit University, Faculty of Dentistry, Department of Pediatric Dentistry, Zonguldak, Turkey.

CORRESPONDENCE: Ebru Hazar Bodrumlu, DDS, PHD. Postal Address: Zonguldak Bulent Ecevit Universty, Faculty of Dentistry, Department of Pediatric Dentistry, Zonguldak / Turkey.

EMAIL: hazarebru@yahoo.com

ABSTRACT

First permanent molars are particularly susceptible to caries. This study aimed to assess the impact of early tooth development on dental caries in children. A total of 220 patients (121 girls, 99 boys) with pulpal infection due to dental caries in immature permanent first molar teeth, aged between 6 and 10.5 years, were considered for inclusion in the study group. A control group of 220 healthy patients with matched age and gender was evaluated. The chronological age of the patients and information about the affected teeth were recorded. Dental ages were calculated using the Demirjian method. The obtained data were statistically analysed using the t-test, Mann Whitney U test, Wilcoxon test, Fisher Freeman

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Halton test, and Pearson Chi-square test ($p<0.05$). When comparing the differences between dental age and chronological age (DA-CA) averages between the study and control groups, DA-CA average was 0.16 in control group and 0.68 in study group, with the difference being statistically significant ($p<0.001$). Early eruption of permanent first molar teeth due to early dental development may increase the risk of decay in these teeth.

KEYWORDS: Demirjian method; dental age; dental caries.

EVALUACIÓN DEL DESARROLLO DENTAL EN NIÑOS CON INFECCIÓN PULPAR POR CARIES DENTAL EN PRIMEROS MOLARES PERMANENTES INMADUROS

RESUMEN

El objetivo de este estudio era evaluar el impacto del desarrollo temprano de los dientes en la caries dental infantil. Se incluyeron en el grupo de estudio 220 pacientes (121 niñas y 99 niños) con infección pulpar debida a caries dental en primeros molares permanentes inmaduros, con edades comprendidas entre los 6 y los 10,5 años. Se evaluó un grupo de control de 220 pacientes sanos de edad y sexo similares. Se registraron la edad cronológica de los pacientes y la información sobre los dientes afectados. La edad dental se calculó mediante el método de Demirjian. Los datos obtenidos se analizaron estadísticamente

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mediante la prueba t, la prueba U de Mann Whitney, la prueba de Wilcoxon, la prueba de Fisher Freeman Halton y la prueba Chi-cuadrado de Pearson ($p<0,05$). Al comparar las diferencias entre las medias de edad dental y edad cronológica (DA-CA) entre los grupos de estudio y control, la media de DA-CA fue de 0,16 en el grupo control y de 0,68 en el grupo de estudio, siendo la diferencia estadísticamente significativa ($p<0,001$). La erupción precoz de los primeros molares permanentes debido al desarrollo dental temprano puede aumentar el riesgo de caries en estos dientes.

KEYWORDS: Método Demirjian; edad dental; caries dental.

1. Introduction

Dental development is of great importance in anthropology, forensic medicine and dentistry, as well as in diagnosis and treatment planning for pedodontists, orthodontists and maxillofacial surgeons to determine the biological age of individuals (1, 2). While growth and development in the human body is the result of the continuous interaction of genetic and environmental factors, dental development is predominantly under the control of genetic factors (3). Early dental development can be observed in individuals with normal physical characteristics. Early dental development and subsequent early eruption may cause tooth and arch size incompatibilities, local eruption problems, crowding and malocclusions (4, 5). In addition, early development causes permanent teeth to be exposed to acid attacks in the oral environment for longer periods of time, significantly increasing their susceptibility to dental caries (6). It is known that different tooth surfaces and groups are at risk at different age periods

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depending on the developing dentition in children (7).

During the mixed dentition period, permanent first molars that erupt before they have completed their development have a certain sensitivity to caries. This sensitivity significantly increases the risk of caries in permanent first molars, especially in the first year after eruption (8). Other important factors that increase the risk of caries in permanent first molars are longer exposure to the oral environment due to the fact that it is the first permanent tooth to erupt, its posterior position in the mouth, the child's lack of brushing skills, wide occlusal surfaces with deep fissures, and parents not knowing that the erupting tooth is a permanent tooth (8, 9). The high risk of caries in immature permanent first molars that have not been intervened early for treatment may cause pulpal infection in these teeth before the root formation is completed (10).

This sensitivity of recently erupted immature permanent first molars to caries in the early period suggests that early dental development may have an effect on caries and caries-induced pulpal infections observed in immature teeth. In the literature, there are many studies investigating the causes of dental caries and pulpal infections in immature permanent first molars (9-11). However, there is no study evaluating the effect of dental development on caries formation in immature teeth leading to pulpal infections. Therefore, the aim of this study was to evaluate the dental development of children with immature permanent first molars whose pulp was affected by dental caries and to investigate the relationship between dental development and pulpal infections in immature teeth.

2. Methodology

Within the scope of the study, the examination forms of pediatric patients between the ages of 6-10.5 years who

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visited Zonguldak Bulent Ecevit University Faculty of Dentistry, Department of Pedodontics between November 2022 and November 2023 and whose immature permanent first molars were indicated for extraction, apexification or regenerative endodontic treatment due to pulpal infection were retrospectively analyzed. Ethics committee approval dated 05.10.2022 and numbered 2022-17 was obtained from Zonguldak Bulent Ecevit University Clinical Research Ethics Committee before the study. As a result of the analysis, the minimum sample size for each group that should be included in the study was calculated as 49 with 95% confidence power (1-a), 95% test power (1-ß) and effect size f=0.7425.

In order to determine the patients to be included in the study, examination forms of 2500 patients were evaluated. As a result of the evaluation of the examination forms, patients who met the study criteria were included in the study, while patients who did not were excluded from the study.

The inclusion criteria were as follows:

• The patient does not have any systemic disease and is not taking regular medication

• Panoramic radiography taken from the patient during routine examination should be diagnostically sufficient

• Patient has no dental anomaly and no dental trauma

• Not using an appliance for orthodontic treatment or placeholder purposes

• Permanent first molars erupted and the root tip is not closed

• Indication for extraction, apexification or regenerative endodontic treatment of any immature permanent first molar during the examination

The examination forms and panoramic radiographs of 220 patients who met the inclusion criteria were evaluated as the study group. In addition, 220 control group patients of the same age and gender as the patients in the study group were selected. Patients in the control group were selected among patients with caries-free immature healthy first molars,

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systemically healthy and without any syndromes, diagnostically adequate panoramic radiographs taken for dental reasons and without congenital dental deficiency. A total of 440 patients were evaluated in the study.

The chronologic age of the patients evaluated within the scope of the study was calculated with the data obtained from the examination records, and the dental age was calculated by evaluating the panoramic radiographs. The chronologic ages of the patients were calculated and recorded in the decimal system based on the date of birth and the date the panoramic radiographs were taken. In the study, dental age was calculated using the Demirjian method (12) on panoramic radiographs of 440 children. The developmental stages of the patients' left lower seven permanent teeth were determined by following the rules determined by Demirjian et al. (12) A total score was obtained using tables showing gender-specific weighted scores. Dental age was determined using gender-specific conversion tables.

Dental development of the children was calculated by the same investigator without knowing the age and gender of the patient. In order to determine the internal consistency of the investigator, 10% of the children were reassessed by the same investigator. The Kappa test of concordance was used on repeated measurements and a high reliability coefficient (0.999; p=0.001) was obtained. Since deep caries lesions can be easily identified from panoramic radiographs, it was not possible to blind dental age assessment to the presence of deep caries lesions.

Data were analyzed with IBM SPSS V23. The conformity of the data to normal distribution was examined by Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent samples t test was used for the comparison of normally distributed data according to paired groups and Mann Whitney U test was

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used for the comparison of non-normally distributed data. Wilcoxon test was used to compare non-normally distributed dependent samples. Fisher Freeman Halton test and Pearson Chi-square test were used for the relationships between categorical variables. Analysis results were presented as frequency (percentage) for categorical variables, mean ± standard deviation and median (minimum - maximum) for quantitative variables. Significance level was taken as $p<0.050$.

3. Results

Within the scope of the study, chronological age (CA), dental age (DA) calculated by Demirjian method (12), and the difference between dental age and chronological age (CA-DA) of 440 patients were compared to evaluate the dental development of the patients. Among the 121 female and 99 male patients evaluated in the study group, the mean chronological age was 8.29 ± 0.92 for females and 8.4 ± 0.92 for males. The patients in the control group were also comparable to the patients in the study group in terms of chronological age and gender. When the mean chronological age and mean dental age of the girls in the control group were compared, the difference between the values obtained was not statistically significant ($p=0.074$). However, when the mean chronological age and mean dental age of the girls in the study group were compared, dental age was found to be statistically significantly higher than chronological age ($p<0.001$). When the mean chronological age and mean dental age of all girls included in the study were compared, the difference was statistically significant ($p < 0.001$). When the mean chronological age and mean dental age of males in the control group, males in the study group, and all participants were compared, dental age was statistically significantly higher than chronological age ($p < 0.001$). When the mean dental age was compared between the study group and the control group in both girls and boys, this difference was found to be significantly higher in the study group than in the control group ($p<0.001$). When the mean dental age was

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compared between the study group and the control group in all patients included in the study, the values obtained were also significant (p<0.001) (Table 1).

Table 1. Comparison of dental ages.

		Control		Study		Total		Test statistics	p
		Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)		
Female	CA	8,29 ± 0,92	8,2 (6,4 - 10,5)	8,29 ± 0,92	8,2 (6,4 - 10,5)	8,29 ± 0,91	8,2 (6,4 - 10,5)	0,000	1,000*
	DA	8,41 ± 0,94	8,2 (6,4 - 10,8)	9,02 ± 0,83	9,2 (7,4 - 10,9)	8,71 ± 0,94	8,7 (6,4 - 10,9)	10185,000	**<0,001****
Test statistics		-1,790		-8,248***		-7,796***			
p		0,074***		**<0,001**		**<0,001**			
Male	CA	8,4 ± 0,92	8,3 (6 - 10,5)	8,4 ± 0,92	8,3 (6 - 10,5)	8,4 ± 0,92	8,3 (6 - 10,5)	-0,008	0,994*
	DA	8,61 ± 0,92	8,4 (7,2 - 11,1)	9,01 ± 0,85	9 (7,4 - 10,8)	8,81 ± 0,9	8,6 (7,2 - 11,1)	6251,000	**0,001****
Test statistics		-3,322		-6,979		-7,664			
p		**<0,001*** **		**<0,001*****		**<0,001*****			
Total	CA	8,34 ± 0,92	8,3 (6 - 10,5)	8,34 ± 0,92	8,3 (6 - 10,5)	8,34 ± 0,92	8,3 (6 - 10,5)	-0,005	0,996*
	DA	8,5 ± 0,93	8,2 (6,4 - 11,1)	9,02 ± 0,84	9 (7,4 - 10,9)	8,76 ± 0,92	8,6 (6,4 - 11,1)	32313,500	**<0,001****
Test statistics		-3,481		-10,793		-10,874			
p		**<0,001*****		**<0,001*****		**<0,001*****			

* T-Test, **Mann Whitney U Test, ***Wilcoxon Test. DA:Dental age; CA: Chronological age; SD: Standard deviation.

When the mean dental ages of girls and boys in the study and control groups were compared, the values obtained were not statistically significant (p<0.05). The

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mean dental ages of all girls and all boys included in the study did not differ according to sex (p=0.312) (Table 2).

Table 2. Comparison of dental ages between females and males.

		Female		Male		Test statistics	p
		Mean±SD	Median (min-max)	Mean±SD	Median (min-max)		
Control	CA	8,29 ± 0,92	8,2 (6,4 - 10,5)	8,4 ± 0,92	8,3 (6 - 10,5)	-0,930	0,353*
	DA	8,41 ± 0,94	8,2 (6,4 - 10,8)	8,61 ± 0,92	8,4 (7,2 - 11,1)	6746,500	0,107**
Study	CA	8,29 ± 0,92	8,2 (6,4 - 10,5)	8,4 ± 0,92	8,3 (6 - 10,5)	-0,938	0,349*
	DA	9,02 ± 0,83	9,2 (7,4 - 10,9)	9,01 ± 0,85	9 (7,4 - 10,8)	5910,000	0,865**
Total	CA	8,29 ± 0,91	8,2 (6,40 – 10,5)	8,40 ± 0,92	8,3 (6 – 10,5)	25717,000	0,185**
	DA	8,7 ± 0,9	8,7 (6,4 – 10,9)	8,8 ± 0,9	8,6 (7,2 – 11,1)	25298,000	0,312**

*T-Test, **Mann Whitney U Test. DA:Dental age; CA: Chronological age; SD: Standard deviation.

When the mean DA-CA of the girls in the study group and the control group were compared, this difference was found to be statistically significantly higher in the study group (p<0.001). When the mean DA-CA in males between the study group and the control group was compared, the difference in the study group was statistically significantly higher than in the control group (p<0.001). When the mean DA-CA in all patients between the study group and the control group was

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compared, this value was statistically significantly higher in the study group than in the control group (p<0.001).

When the mean DA-CA of the girls in the control group and the boys in the control group were compared, the values obtained were not statistically significant (p=0.275). When the mean DA-CA of the girls in the study group and the boys in the study group were compared, the values obtained were not statistically significant (p=0.157) (Table 3).

Table 3. Comparison between mean differences in dental age and chronological age.

		Control		Study		Total		Test statistics	p
		Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)		
Female	DA-CA	0,12 ± 0,72	0 (-1,5 - 2)	0,74 ± 0,69	0,7 (-1,7 - 2,2)	0,43 ± 0,77	0,4 (-1,7 - 2,2)	-6,777*	**<0,001**
Male	DA-CA	0,21 ± 0,56	0,2 (-0,9 - 1,4)	0,61 ± 0,66	0,6 (-1,2 - 2,4)	0,41 ± 0,64	0,4 (-1,2 - 2,4)	6675,5**	**<0,001**
Total	DA-CA	0,16 ± 0,65	0,2 (-1,5 - 2)	0,68 ± 0,68	0,6 (-1,7 - 2,4)	0,42 ± 0,71	0,4 (-1,7 - 2,4)	34636**	**<0,001**
Test statistics		6501,000**		1,419*		23532,5**			
p		0,275		0,157		0,748			

*T-Test, **Mann Whitney U Test. DA-CA: Dental age-chronological age; SD: Standard deviation.

In the control group, 100% of the patients had healthy immature permanent first molars. When the immature permanent first molars of the patients included in the study group were examined, it was found that 70.5% had pulpal infection in one tooth, 27.3% in two teeth, 1.4% in three teeth, and 0.9% in four teeth. In the study, a comparison was made between the DA-CA values of patients with one tooth affected and patients with more than one tooth affected. The obtained values were not statistically significant.

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4. Discussion

Dental age determination is a frequently used method to determine biological age. Age estimation is of particular interest for pediatric dentists, orthodontists and maxillofacial surgeons in addition to forensic medicine, pediatric endocrinology, and archaeology (1, 2). Dental age can be assessed by using eruption times and developmental stages of teeth. The eruption times of teeth can be affected by many factors such as systemic diseases, malnutrition, ankylosis, and space limitation. Developmental stages, which are relatively more reliable than eruption times, are frequently used when calculating dental age (13, 14). Therefore, in this study, dental age calculation was performed using the Demirjian method (12) using developmental stages.

The Demirjian method (12) has been reported to be highly correlated with chronological age and to have high accuracy. However, it has also been reported that each individual is different and there is no method that can determine the age with certainty (12, 15). The reason for this is that the differences between chronological age and dental age may be related to various factors such as the accuracy of the selected method, examination of the patient, experience of the investigator, sample size, and distribution. In addition, variation in growth and development can be observed among populations depending on ethnicity and environmental factors (16).

When the results of this study were evaluated, it was found that there was no significant difference between the dental age values of boys and girls, and dental development did not differ between genders. In addition to other studies reporting that the calculated dental age was higher in boys than in girls (17, 18), there are also studies reporting that dental age was higher in girls than in boys or that there was no difference between them, supporting the results of this study (19-21). This variation in the results of dental development assessments by sex may be due to varying environmental

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factors, socioeconomic level, and dietary habits, as well as cultural and ethnic differences between populations.

In this study, when chronological age and dental age were compared in the control and study groups, it was observed that dental age was significantly higher in both girls and boys. Additionally, when the DA-CA was analyzed, it was found that the DA-CA value of the study group was significantly higher in both girls and boys compared to the DA-CA value in the control group. There are many studies in the literature in which factors affecting dental development were evaluated by examining the DA-CA value (20-23). Although there are many studies evaluating dental development by examining the difference between detal age and chronological age and even evaluating the effect of caries on dental development (24, 25), there is no study evaluating the effect of dental development on caries in comparison to the control group. In this study, it was observed that the mean DA-CA value of children with caries-induced pulpal infection in immature permanent first molars was significantly higher than the mean DA-CA value of healthy children in the control group. In this study, it was thought that the patients in the study group had more advanced dental development. Dental development and dental eruption are mainly related to root development, and teeth erupt when the root length reaches two-thirds (26). A newly erupted immature tooth enamel calcifies only 70% of the time (9). During posteruptive enamel maturation, immature enamel tissue continues to develop and becomes more resistant to dental caries (9). As a result of this study, it is thought that the immature permanent first molars erupted earlier in the study group due to the fact that the dental development of the patients in the study group was more advanced compared to the patients in the control group, which may have increased the susceptibility of the immature permanent first molars to caries as a result of the increased

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exposure time of the teeth to the oral environment.

When teeth are newly erupted in the oral environment, they have not yet completed their maturation (9). Uysal et al. (27) compared the microhardness of the enamel structure of newly erupted immature teeth and mature teeth and reported that the microhardness of newly erupted teeth was lower and there was a strong correlation between the microhardness of the enamel and the percentage of mineral loss in caries lesions. Kotsanos and Darling (28) reported that immature teeth had a more porous and permeable enamel structure, were more susceptible to artificial caries formation, the porosities in caries lesions reached larger diameters, and the most caries occurred at the time of eruption and immediately after eruption. Schulte et al. (29) followed the electrical resistance of unerupted premolar teeth in three-month periods for 24 months and concluded that the electrical resistance of newly erupted teeth was low, similar to carious teeth, but increased with eruption. Enamel maturation led to an increase in electrical resistance. This result is proof that post-eruptive enamel maturation and permeability decrease in parallel with the time elapsed after eruption.

Considering the longer period of time in the mouth, early eruption of teeth into the oral environment due to early dental development may increase the risk of caries (30). Hedayati and Khalafinejad (19) reported that if permanent teeth erupt earlier due to an increase in body mass index, the incidence of caries in these teeth may increase. Lal et al. (5) reported that tooth eruption accelerates in children diagnosed with diabetes and this may cause gingival inflammation, tooth and arch size incompatibilities, local eruption problems, crowding, and malocclusions. All these conditions increase the risk of dental caries by causing long-term accumulation of bacterial plaque and food (31). The results of this study support the idea that the cause of caries in immature teeth with caries-related pulp infection

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may be earlier contact with the oral environment due to more advanced dental development.

5. Conclusions

As a result of the literature review, this study is thought to be the first to evaluate the effect of dental development level on the occurrence of pulpal infection due to caries in immature permanent first molars. Significantly more advanced dental development was observed in children with pulpal infection in their permanent first molars compared to those without pulpal infection. It is thought that early dental development, and consequently earlier-than-normal tooth eruption into the oral environment, is a risk factor for dental caries. Dentists should pay attention to treatment planning and timing in clinical practice, taking into account the fact that the dental development of these children is more advanced than that of normal children. In order to protect permanent first molars from cavities, it is necessary to raise awareness among both children and their families about oral care from an early age and to develop community-based preventive practices. However, it is believed that there is a need for studies to be conducted on a wider age range and a larger population.

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