DIFFERENT METHODS OF AGE ESTIMATION IN CHILDREN WITH MILD TO MODERATE HYPODONTIA

Muge Tokuc[1], Muge Bulut[1]

Department of Pediatric Dentistry,

Faculty of Dentistry,

Istanbul Okan University, Turkey

Abstract

Aim: The aim of this study was to determine the most reliable method to provide consistent results in age estimation in patients with mild-to-moderate hypodontia.

Material and Methods: A total of 126 patients (78 girls, 48 boys) with mild-to-moderate hypodontia were separated into 2 groups according to the severity of hypodontia considering similar age and sex distribution. A control group was formed of 126 age and sex-matched patients with complete dentition. The formation stages of permanent teeth on panoramic radiographs were evaluated according to the 12-stage classification of Haavikko, and the 8-stage classification of Demirjian et al. For dental age calculation, these stages were scored according to datasets provided by Haavikko, Demirjian et al. and Willems et al.

Results: Agreement between dental age and chronological age was examined using the Interclass correlation coefficient (ICC). Sex did not significantly affect the difference between the methods (p=0.435; p=0.591). Calculated dental age according to the different methods showed significantly differences according to the study groups (p (group*method) =0.003; p (group*method) =0.008). In all the groups, excellent agreement levels were obtained using the Haavikko method (ICC≥0.90).

Conclusions: The Haavikko method was detected as more reliable in healthy Turkish children and children with mild-to-moderate hypodontia than the Demirjian and Willems methods.
Keywords: Age estimation; Forensic odontology; Dental age; Hypodontia

How to cite this article: *Tokuc M, Bulut M. Different methods of age estimation in children with mild to moderate hypodontia. Int J Forensic Odontol. 2022;7;1:1-10*
Received on:6th April 2022 Accepted on:15th May 2022 Published on: 20th June 2022

INTRODUCTION

Dental age (DA) is an indicator of biological age and is determined by radiographic or clinical evaluation of the developing dentition.[1] There is generally accepted to be a good correlation between Chronological Age (CA) and Dental age (DA).[2] Several authors have reported that dental parameters are applicable for age estimation.[2,3] Dental age (DA) is used for age estimation in archaeological and forensic studies, criminal cases, or for patients lacking birth data. Various methods have been suggested to estimate age from dental development.[3,4]

Address for Correspondence:
Muge Tokuc, DDS
Assistant Professor, Department of Pediatric Dentistry
Faculty of Dentistry, Istanbul Okan University, Turkey
e- mail: *mugeyavas@outlook.com*

In literature, the most researched method in age estimation in different populations is the Demirjian method.[5] In this method, the of the 7 mandibular left-side teeth are evaluated radiographically based on an 8-stage classification. The stages determined for each tooth are converted into numerical values, and the total score provides DA according to age and sex-specific tables.[6,7] This method was introduced in 1973, and various modifications were subsequently made to increase its reliability.[8,9] Willems et al.[4] modified their dataset to provide a new method, since the Demirjian method was seen to overestimate results according to CA. In literature, another method recommended for use in age estimation from tooth formation is the Haavikko method.[10] This method is based on the radiographic evaluation of 4[11] or 7 [6] reference teeth according to a 12-stage classification. For DA calculation, these stages are converted to numerical values and DA is calculated by taking the average of the total score.[6] While DA can be calculated in healthy children with these methods, its reliability is not clear in children with dental anomalies.[12] Hypodontia is the most common dental anomaly, defined as the absence of at least one deciduous or permanent tooth excluding third molars. Hypodontia is classified as mild-to-severe according to severity (absence of 1-2 teeth as mild, 3-5 teeth as moderate, and >6 teeth as severe.[13,14] There are studies in literature which have reported that hypodontia is related to delayed dental development although a consensus has not yet been established.[15,16,17] In a case-control study by Daugaard et al.[19], it was reported that the absence of mandibular second premolars caused a delay in the development of canines and first premolars. Similarly, Medina et al.[18] determined a major delay in the formation of mandibular and maxillary second molars in patients with mild hypodontia. As patients with hypodontia are considered to have altered dental development patterns, [18-21] conventional methods for age estimation based on DA may not give reliable results for children with hypodontia. The aim of this study was to determine which of the Haavikko, Demirjian and Willems methods is most reliable in providing the most consistent results for age estimation in patients with mild-to-moderate hypodontia.

MATERIAL AND METHODS

This retrospective study was conducted in a university-based Pediatric Dentistry Clinic. The study protocol was approved by the university Ethics Committee (Decision No: 56665618-204.01.07). Patients aged 6-13 years were included in this study and patients with syndromic or systemic conditions that may be related to delayed dental development were excluded. All panoramic radiographs were taken with a Planmeca Promax 2D S2 device (Planmeca Oy, Helsinki, Finland) and transferred to the computer and archived. Image processing procedures such as adjustments to size, brightness or contrast, which facilitate evaluation of the tooth formation stages, could be easily implemented.

Following sample size calculation, a minimum of 53 patients were required for each group (power=0.80, α=0.05, nQuery Advisor Software Ver 7.0) for this study. A total of 126 patients with 1-5 absent permanent teeth were selected and separated into 2 groups according to the severity of hypodontia (mild and moderate) considering similar age and sex distribution. Permanent teeth without follicle formation or mineralization were considered to be absent. Third molars were excluded from the study, as there is wide variation in the development of these teeth. Patients lacking both symmetrical mandibular teeth were excluded. The control group was formed of 126 subjects by designating an age and sex-matched child with complete dentition for each patient in the hypodontia groups. The distribution of the groups according to CA and sex is presented in Table 1. The CA for each patient was determined by calculating the difference between the date when the panoramic radiograph was taken and the date of birth and then converting it to a decimal age.

Dental age assessment

The formation stages of permanent teeth were evaluated on 252 panoramic radiographs according to the 12-stage classification of Haavikko[6] and the 8-stage classification of Demirjian et al[3], as described below. In the Haavikko method, the formation stages of 4 reference teeth were evaluated using the 12-stage schematic images[11]. These reference teeth were the mandibular right second molar, first premolar, canine and maxillary right canine for children aged ≥10 years and the mandibular right second molar, first molar, first premolar and central incisor for children aged <10 years. In the Demirjian and Willems method, the formation stages of 7 mandibular left-side teeth were evaluated using the 8-stage schematic images of Demirjian et al[3] . If the corresponding tooth was absent, the mandibular symmetrical tooth was taken as reference. For DA calculation, these stages were scored according to datasets provided by Haavikko[6], Demirjian et al.[8] and Willems et al[4].

The staging of tooth formation on panoramic radiographs was done by an experienced and blinded examiner (MT). Before initiating the study, a pilot study was performed using both staging methods. All mandibular teeth in 45 randomly selected radiographs were examined by the examiner twice at a 3-week interval. Intra-observer agreement was evaluated with Cohen's Kappa analysis.

Statistical Analysis

Data obtained in the study were analyzed statistically using SPSS Statistics Software Ver. 14.0 software (IBM Co. NY, USA). To evaluate the effect of group and sex on differences between CA and DA calculated with the Haavikko, Demirjian and Willems methods, 3 way-mixed design ANOVA was applied using the linear models technique. The main effects of method, sex, and the double and triple interaction terms of

these effects were included in the model. When significance was determined, simple effects analysis was applied with Bonferroni Correction. A value of $p<0.05$ was set as statistical significance. The agreement between CA and DA calculated with the three different methods was examined using the Interclass correlation coefficient (ICC).

RESULTS

Intra-observer reliability was 0.89 for the 12-stage classification and 0.91 for the 8-stage classification. These results indicated an almost perfect agreement for both staging methods.

There was no statistical difference in the mean CA between the sexes ($p=0.592$) and study groups (control/hypodontia $p=0.898$; control/mild hypodontia/moderate hypodontia $p=0.988$). Differences between CA and DA calculated with the Haavikko, Demirjian and Willems methods were evaluated according to sex and study groups. The p values of the variation sources in the model are presented as footnotes in Tables 2 and 3. Sex did not significantly affect the difference between the methods ($p=0.435$; $p=0.591$). The calculated DA according to the methods showed significant differences according to the study groups (p (group*method) $=0.003$; p (group*method) $=0.008$). In the control group, DA calculated with the Haavikko method was significantly lower than CA ($p<0.001$). DA calculated with the Willems and Demirjian methods were significantly higher than CA ($p<0.001$) and there were no significant differences between the Willems and Demirjian methods ($p=0.998$) (Table 2).

In the hypodontia group, the Demirjian method showed the highest DA results significantly according to CA ($p<0.001$), Willems method ($p=0.004$) and Haavikko method ($p<0.001$). There were no significant differences between DA and CA in the Willems method ($p=0.186$). DA calculated with the Haavikko method was significantly lower than CA ($p<0.001$) (Table 2). In the mild hypodontia group, DA calculated with the Willems and Demirjian methods were higher than CA, with statistical significance only determined with the Demirjian method ($p=0.001$). DA calculated with the Haavikko method showed the lowest DA results according to CA ($p= 0.004$), Willems method ($p<0.001$) and Demirjian method ($p=0.001$) (Table 3).

In the moderate hypodontia group, there were no statistically significant differences between DA calculated with the Willems and Demirjian methods and CA ($p=0.875$; $p=0.352$). DA calculated with the Haavikko method showed the lowest DA results according to CA ($p=0.009$), Willems method ($p=0.002$) and Demirjian method ($p<0.001$) (Table 3). There was no statistical significance between the Demirjian and Willems methods ($p=0.698$).

The evaluation of the agreement between CA and calculated DA with the three different methods in

terms of groups are presented in Tables 4 and 5. In all groups, excellent agreements were obtained with the Haavikko method (ICC≥0.90).

incompatible in different ethnic and regional population.[7, 23-26] Reasons for preferring these methods for this study were that the Demirjian

Table 1: The distribution of the groups according to CA and sex

Groups		Sex		Age (year)	
		Girl	Boy	Mean±SD	Min-Max
Control		78	48	8.87±2.03	6.00-12.91
Hypodontia	Mild Hypodontia	40	24	8.81±2.09	6.08-12.66
	Moderate Hypodontia	38	24	8.87±2.08	6.00-12.33

DISCUSSION

It has been reported in literature that teeth provide reliable results in age estimation because of their resistance to environmental factors such as heat, humidity, mechanical forces and microbial activities, preserving their structure and morphologies for a long time.[2-4] Many researchers have reported that formation stages are more dependable, since tooth eruption is limited by a certain time and is affected by factors such as ankyloses, trauma, and infection.[8,17,22] Therefore, in this study, DA was calculated by evaluating the formation stages of teeth on panoramic radiographs as it is a non-invasive, simple, reproducible and reliable method. Haavikko, Demirjian and Willems datasets originate from populations living in a particular region. Therefore, the results of these methods for estimating age are

method is the most researched method in the literature and the Haavikko and Willems datasets have been reported to give consistent results in age estimation in different regions of Turkey [5,25] method. The Haavikko method showed the best agreement between CA and DA compared to the other methods with age underestimated by 0.18 years in girls and 0.41 years in boys. Similarly Kirzioglu et al.[10] determined that the Haavikko dataset is more suitable than the Demirjian dataset for Turkish children living in the southern region of Turkey.

The prevalence of hypodontia is reported at different rates depending on the population (7% in Europe, 6.3% in Asia and Australia, 4.4-5% in the USA and 6.2-8.7% in Turkey) Considering the prevalence of hypodontia in

Turkey, a large number of patients with mild-to-moderate hypodontia in a particular region were evaluated in this study[25].

There are conflicting results in the literature regarding the relationship between sexes and delay in the dental development in hypodontia patients [17,19]. In this study, consistent with previous studies reporting that sex has no discernible pattern on the delay of dental development in hypodontia patients[17] no significant difference was found between boys and girls in the hypodontia groups according to DA calculated with these three methods.

In the hypodontia groups, the Haavikko method provided consistent results with the control group in age estimation. DA was significantly underestimated with the Haavikko method in the hypodontia (0.44 years in girls, 0.45 years in boys), mild hypodontia (0.45 years in girls, 0.44 years in boys) and moderate hypodontia groups (0.4 years in girls, 0.5 years in boys). However, DA calculated with the Demirjian and Willems methods showed different deviations according to CA depending on hypodontia and its severity compared to the control group. In addition, the methods showed different agreement levels between CA and DA in the hypodontia groups, with the Haavikko method showing the best agreement compared to the other methods. The Demirjian and Willems methods are based on the assessment of the mineralization stages of 7 mandibular left-side teeth, which limits the utility of these methods especially in cases of missing teeth[35,37]. When calculating DA in the hypodontia groups with these methods in the current study, if the reference tooth was absent, the symmetrical mandibular tooth was taken as reference because of the high correlation reported between 7 teeth in the right and left mandible[3]. However, the Haavikko method was more easily applied in patients with hypodontia because the most frequently absent teeth (mandibular second premolars, maxillary lateral incisor [19,22,24] were not taken as reference. This utility of the Haavikko method in hypodontia patients may be the reason that it provided more reliable results compared to the Demirjian and Willems methods in age estimation in hypodontia groups. As a limitation of this study, a severe hypodontia group could not be included as the panoramic radiographs of that group did not meet the requirements of the study in terms of both quantity and image quality. Another limitation was that although this study was conducted in Turkey, the datasets used were not specific to the Turkish population. Factors such as geographic differences, climatic conditions and racial characteristics among populations may have an impact on growth and development [7,10], so it is recommended that datasets specific to each population are generated to achieve more consistent results in age estimation from dental development.

Table 2: The comparison of CA and DA calculated by different methods in control and hypodontia groups

Sex	Groups	Methods			
		CA	**DA^H**	**DA^w**	**DA^D**
		Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM
Girl	Control	8.97 ± 0.23^b	8.798 ± 0.246^c	10.11 ± 0,33^a	10.08 ± 0.33^a
	Hypodontia	8.9 ± 0.34^b	8.453 ± 0.369^c	9.24 ± 0,45^b	9.51 ± 0.45^a
Boy	Control	8.78 ± 0.3^b	8.363 ± 0.273^c	9.47 ± 0,32^a	9.78 ± 0.81^a
	Hypodontia	8.79 ± 0.43^b	8.332 ± 0.469^c	9.07 ± 0,52^b	9.23 ± 0.54^a

a,b,c: Different letters on the same line indicate a statistically significant difference ($p<0.05$)

DA^H: Dental age for the Haavikko method; DA^W: Dental age for the Willems method; DA^D: Dental age for the Demirjian method.

P values of the variation sources in the model: Group*Sex*Method p=0.454; **Group*Method p=0.003;** Sex*Method p=0.336; Group*Sex p=0.630; **Methods p<0.01**; Group p=0.449; Sex p=0.435

Table 3: The comparison of CA and DA calculated by different methods in control, mild and moderate hypodontia groups

Sex	Groups	Methods			
		CA	**DA^H**	**DA^w**	**DA^D**
		Mean±SEM	Mean±SEM	Mean±SEM	Mean±SEM
Girl	Control	8.97 ± 0.23^b	8.798 ± 0.246^c	10.11 ± 0.33^a	10.08 ± 0.33^a
	Mild Hypodontia	8.89 ± 0.49^b	8.44 ± 0.55^c	9,42 ± 0,65^{a,b}	9.52 ± 0.64^a
	Moderate Hypodontia	8.91 ± 0.49^a	8.467 ± 0.504^b	9,06 ± 0,63^a	9.49 ± 0.67^a
Boy	Control	8.78 ± 0.3^b	8.363 ± 0.273^c	9.47 ± 0.32^a	9.78 ± 0.81^a
	Mild Hypodontia	8.74 ± 0.6^b	8.335 ± 0.612^c	9.39 ± 0.81^{a,b}	9.45 ± 0.32^a
	Moderate Hypodontia	8.84 ± 0.65^a	8.33 ± 0.739^b	8.75 ± 0.67^a	9.02 ± 0.76^a

Table 4: The agreement between CA and DA calculated with different methods in control and hypodontia groups

Control	**ICC^{H} (95% CI)**	**ICC^{W} (95% CI)**	**ICC^{D} (95% CI)**
Girl	0.913 (0.866-0.944)	0.805 (0.319-0.921)	0.799 (0.369-0.914)
Boy	0.939 (0.784-0.975)	0.867 (0.570-0.945)	0.884 (0.569-0.954)
Hypodontia	**ICC^{H} (95% CI)**	**ICC^{W} (95% CI)**	**ICC^{D} (95% CI)**
Girl	0.929 (0.804-0.969)	0.880 (0.791-0.939)	0.857 (0.707-0.933)
Boy	0.906 (0.781-0.960)	0.885 (0.756-0.948)	0.876 (0.678-0.949)

ICC, interclass correlation coefficient; CI, confidence interval.

ICC$^{H:}$ Interclass correlation coefficient for the Haavikko method; **ICC$^{W:}$** Interclass correlation coefficient for the Willems method **ICC$^{D:}$** Interclass correlation coefficient for the Demirjian meth

CONCLUSIONS

The Haavikko method was determined to be more reliable than the Demirjian and Willems methods in age estimation of both healthy Turkish children and children with mild-to-moderate hypodontia. Using the Haavikko method with 4-referenced teeth, more consistent results can be obtained in mild-to-moderate hypodontia patients. It can be recommended that the suitability of this method is tested on patients with severe hypodontia.

Acknowledgments – No Acknowledgements

Conflict of interest statement: No conflict of interest.

Funding: No funding was received for this study.

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