Original Article

DOI: 10.7860/JCDR/2025/75693.20912

Dentistry Section

Dental Ages of Children with Attention Deficit Hyperactivity Disorder versus Healthy Children Measured using Different Dental Age Estimation Methods: A Retrospective Observational Study

MELEK BELEVCIKLI[1], DENIZ SILA ÖZDEMIR ÇELIK[2]

ABSTRACT

Introduction: Attention Deficit Hyperactivity Disorder (ADHD) is a neurobehavioural disorder that is common in childhood and can lead to serious impairment in quality of life if, not treated. The dental development of children with ADHD may also be affected due to the effects of the medications they use or as a result of delayed growth and deficient development caused by the disorder.

Aim: To evaluate the dental development of children with ADHD and healthy children using three different dental age estimation methods.

Materials and Methods: A retrospective observational study was conducted at Bolu Abant Izzet Baysal University Paediatric Dentistry Clinic, Turkey for 6 months. The records of patients with ADHD and healthy subjects were retrospectively reviewed between January 2017 and January 2021. Two clinicians evaluated radiographs of ADHD and healthy patients using three different dental age estimation methods. The Analysis of Variance (ANOVA) test assessed the difference between three or more independent groups with normal distribution. The Post-hoc Bonferroni test determined the group or groups that created the difference. A p-value of less than 0.05 was considered statistically significant.

Results: No statistically significant differences were obtained between the three different dental age calculation methods for the ADHD group and the control group (p>0.05).

Conclusion: The dental ages of patients with ADHD were similar to their chronological ages and there was no delay due to the effect of the disease or the medications used in treatment. Although there was no statistically significant difference between all three methods in the Turkish population, Cameriere's method underestimated chronological age, while Demirjian's method tends to overestimate it.

Keywords: Age determination, Forensic dentistry, Paediatric dentistry, Willems method

INTRODUCTION

The ADHD is a common neurobehavioural disorder in childhood that results in significant functional impairment and disabilities and can lead to serious impairment in quality of life if not adequately treated. ADHD is considered one of the most common psychiatric disorders of childhood and is among the most common chronic health problems affecting school-age children [1]. Eating and somatisation disorders are more common in girls with ADHD, while aggression-related and forensic problems are more common in boys [2]. Medication is the first line of treatment for ADHD. Drugs approved by the Food and Drug Administration (FDA) for the treatment of ADHD include stimulants such as methylphenidate and amphetamines (accepted first-line drugs), non-stimulants such as atomoxetine and extended-release alpha 2 agonists (accepted alternative drugs), tricyclic antidepressants, rapid-release alpha 2 agonists, and bupropion [3]. The most common side effects of ADHD medications reported in children and adolescents are decreased appetite, abdominal pain, vomiting, and dyspepsia [4]. Growth delay or failure to thrive is a common concern in the treatment of children with ADHD, whose growth percentiles may already be low, but the effects of medications on height and weight gain remain unclear [5].

The eruption of teeth and the degree of mineralisation can be affected by systemic conditions that affect bone development [6,7]. Dental development may also be affected as a result of the effect of the medications used by children with ADHD or by delayed and inadequate growth resulting from the disease [8]. Dental maturation indicators are mostly influenced by genetic char acteristics and are less affected by environmental factors than other developmental assessment methods. Therefore, they show less variation and are also an accepted method for age estimation by international forensic institutions [9,10]. Different methods defined for age estimation based on dental tissues include morphological (tooth wear rate, tooth discoloration), metric (carbon-14 analysis, histological analysis), radio-morphological (Demirjian's methods), and radiometric (Cameriere's methods, Mornstaad's methods) techniques [9-12]. In various methods used for dental age estimation, the degree of maturation, eruption, mineralisation and apical openings of the teeth are evaluated [12-14].

The present study aimed to evaluate the dental development of children with ADHD and healthy children using three different dental age estimation methods.

MATERIALS AND METHODS

A retrospective observational study was conducted at the Bolu Abant Izzet Baysal University Paediatric Dentistry Clinic, Turkey for 6 months. The panoramic radiographs of 37 patients with ADHD and 30 systemically healthy patients with ADHD in their anamnesis who reported to the Department between January 2017 and January 2021 were analysed. Ethical approval for conducting the study was obtained from Bolu Abant Izzet Baysal University Clinical Researches Ethic Committee (Ethics No: 2022/285).

Inclusion criteria:

Paediatric patients who:

- Were 4-15-year-old;
- Were of Turkish descent with parents of the same ethnicity;

- Had no chronic disease in addition to ADHD diagnosis;
- Had no congenital tooth deficiency;
- Good-quality panoramic radiographs were included.

Exclusion criteria:

- Blurred or distorted radiographs;
- Missing any of the left seven permanent mandibular teeth (agenesis or extraction);
- Having dental abnormalities (dilaceration, supernumerary teeth) and developmental disorders (cleft lip and palate);
- Patients with incomplete medical or dental history were excluded.

Sample size calculation: As a result of the analysis for the experimental-control groups, α=0.05, the standardised effect size was calculated as 0.9863 (8.6±0.7 and 9.5±0.5) from a similar study [15] and the minimum sample size was obtained as 36 with a theoretical power of 0.80.

Study Procedure

Radiographic evaluations were performed in a dimly lit, quiet environment under x150 magnification using the Image J program (Image J 1.46r, NIH, Maryland, MD, USA).

The Demirjian method involves the assessment of the radiographic mineralisation stages of seven teeth located in the lower left jaw. This assessment utilises tables designated A through H for each specific tooth, developed for various age groups and gender categories. The total dental scores for each individual are calculated, and the corresponding age is determined by aligning these scores with the relevant values presented on the chart [12].

In the Willems method, the same A-H mineralisation stages used in the Demirjian method are considered, but, the age values are calculated based on the gender-specific scoring tables created by Willems G et al., [13].

In the Cameriere method, root development and the degree of closure of the apical tip of seven teeth in the left mandible are evaluated. The apical openings of the teeth and the distances from the apex of the tubercle to the root tip are measured. These measurements are then converted to age using Cameriere's Excel formula [14].

All panoramic images utilised in the study were assessed independently by two clinicians (MB, DÖ) under the three aforementioned methods. Furthermore, the radiographs across all evaluated groups underwent a re-examination by the clinicians two weeks later.

STATISTICAL ANALYSIS

The International Business Machine (IBM) Statistical Packages of Social Sciences (SPSS) version 25.0 software was used for statistical analysis. The assumption of normal distribution was checked with the Shapiro-Wilk test. Independent Sample t-test was used to examine the differences between two independent groups with normal distribution. ANOVA test was applied to examine the differences between three or more independent groups with normal distribution. Post-hoc Bonferroni analysis was performed to determine the group or groups that created the difference. The correlations of the values obtained by the methods with the ages were analysed by Intraclass Correlation Coefficient (ICC) and the significance level was taken as p<0.05. The relationship between two categorical variables was investigated by Pearson's Chi-square analysis when the sample size assumption was met (n>5).

RESULTS

Six patients with ADHD and one patient in the healthy group were excluded from the study due to the poor quality of the panoramic radiographs.

Among the patients in the study, 31 (51.7%) were in the ADHD group and 29 (48.3%) were in the healthy group [Table/Fig-1]. No statistically significant relationship was found between gender and study groups (p=0.101). Thus, the gender distribution in the ADHD and control groups was determined to be homogeneous.

Groups	Gender	n (%)
ADHD	Girl	5 (16.1)
	Boy	26 (83.9)
Healthy	Girl	10 (34.5)
	Boy	19 (65.5)
p-value	0.101*	

[Table/Fig-1]: Distribution of sex by ADHD and healthy children.
p-value <0.05; *Chi-square test

Intraclass correlation was found to be high in both the healthy and ADHD groups. There was a high interobserver correlation in Demirjian, Willems, and Cameriere methods [Table/Fig-2].

Methods	Within		Between	
	Healthy	ADHD	Healthy	ADHD
Demirjian ICC (95% CI)	0.942	0.971	0.977	0.983
Willems ICC (95% CI)	0.960	0.971	0.985	0.978
Cameriere ICC (95% CI)	0.943	0.962	0.918	0.965

[Table/Fig-2]: Examination of the intra and interobserver agreement for Demirjian, Willems, and Cameriere's methods.
CI: Confidence interval

No statistically significant differences were obtained between the mean dental ages in three different dental age estimation methods for the ADHD group, healthy group and all participants (p>0.05) [Table/Fig-3].

Groups	Dental age estimation methods	n	Age (Mean±SD)	p-value
ADHD	Chronologic age	31	10.1374±2.80432	0.479
	Willems	31	10.3513±3.06501	
	Demirjian	31	10.9929±3.12629	
	Cameriere	31	9.8352±2.97148	
Healthy	Chronologic age	29	9.2138±2.21113	0.162
	Willems	29	9.7745±2.14264	
	Demirjian	29	10.1345±2.26452	
	Cameriere	29	9.0090±1.74996	
Total	Chronologic age	60	9.6910±2.55649	0.092
	Willems	60	10.0725±2.65329	
	Demirjian	60	10.5780±2.75508	
	Cameriere	60	9.4358±2.47313	

[Table/Fig-3]: Comparison of mean ages of ADHD and healthy groups for dental age estimation methods. The significance level was taken as p<0.05.
*ANOVA test, p-value <0.05

Similarly, no statistically significant differences were obtained between the means of different dental age estimation methods in both ADHD group and healthy children in girls and boys (p>0.05) [Table/Fig-4].

When analysing the mean difference between the chronological and dental ages of girls with ADHD, the Cameriere method estimated the dental age as statistically significantly younger and closer to the chronological age than the Demirjian method (p=0.005). There was a statistically significant difference (p=0.006) between the chronological ages of all the girls in the study and the mean differences of the dental ages obtained from the methods [Table/Fig-5].

DISCUSSION

The ADHD affects an estimated 5% of children worldwide [16]. The prevalence of ADHD in boys is reported to be 3 to 5 times higher than in girls [2]. The similar gender distribution of patients with ADHD in present study may be attributed to two factors: girls are

Gender	Groups	Dental age estimation methods	n	Age (Mean±SD)	p-value
Girl	ADHD	Chronologic age	5	10.2160±1.91955	0.640
		Wiellems	5	10.8700±1.91866	
		Demirjian	5	11.6100±2.20352	
		Cameriere	5	10.1820±1.87517	
	Healthy	Chronologic age	10	9.4600±2.27899	0.418
		Wiellems	10	10.3120±2.25370	
		Demirjian	10	10.7500±2.38665	
		Cameriere	10	9.3290±1.80289	
	Total	Chronologic age	15	9.7120±2.12784	0.206
		Wiellems	15	10.4980±2.09549	
		Demirjian	15	11.0367±2.28586	
		Cameriere	15	9.6133±1.80761	
Boy	ADHD	Chronologic age	26	10.1223±2.97423	0.650
		Wiellems	26	10.2515±3.25883	
		Demirjian	26	10.8742±3.29556	
		Cameriere	26	9.7685±3.16297	
	Healthy	Chronologic age	19	9.0842±2.22642	0.488
		Wiellems	19	9.4916±2.08730	
		Demirjian	19	9.8105±2.19264	
		Cameriere	19	8.8405±1.74688	
	Total	Chronologic age	45	9.6840±2.70608	0.332
		Wiellems	45	9.9307±2.82144	
		Demirjian	45	10.4251±2.90171	
		Cameriere	45	9.3767±2.67348	

[Table/Fig-4]: Comparison of mean ages calculated according to the dental age estimation methods of ADHD and healthy children by sex.
*ANOVA test, p-value <0.05

Sex	Groups	Chronologic age - dental age estimation methods	Age (Mean±SD)	p-value
Girl	ADHD	Chronologic age - Wiellems	-0.6540±0.59151	**0.005***
		Chronologic age - Demirjian	-1.3940±0.47679	
		Chronologic age - Cameriere	0.2340±0.21408	
	Healthy	Chronologic age - Wiellems	-1.0720±0.62610	0.143
		Chronologic age - Demirjian	-1.4700±0.83006	
		Chronologic age - Cameriere	0.7470±0.89306	
	Total	Chronologic age - Wiellems	-0.9327±0.62735	**0.006***
		Chronologic age - Demirjian	-1.4447±0.71362	
		Chronologic age - Cameriere	0.5760±0.76712	
Boy	ADHD	Chronologic age - Wiellems	-0.7285±0.78406	0.589
		Chronologic age - Demirjian	-0.9350±0.71931	
		Chronologic age - Cameriere	0.7723±0.77366	
	Healthy	Chronologic age - Wiellems	-0.6537±0.49639	0.432
		Chronologic age - Demirjian	-0.8842±0.61306	
		Chronologic age - Cameriere	0.7405±0.53275	
	Total	Chronologic age - Wiellems	-0.6969±0.67193	0.293
		Chronologic age - Demirjian	-0.9136±0.66961	
		Chronologic age - Cameriere	0.7589±0.67561	

[Table/Fig-5]: Comparison of the differences between the ages of children with ADHD and healthy children calculated by chronological and dental age estimation methods, according to sex.
*Bonferroni test ANOVA test, p-value <0.05

now diagnosed with ADHD at rates similar to boys, or hyperactivity in boys is often accepted as normal by families based on gender.

Differences in dental age and chronological age can be observed due to variations in gender. In most maturation events, girls tend to mature faster than boys [17]. This aligns with present study findings, which showed that girls had a more advanced dental age than boys. In present study, the dental ages of girls were consistently higher than those of boys by all three methods. This can be attributed to the fact that the mean age of the patients in this study was around nine years, coinciding with the onset of puberty in girls, while this period begins later in boys [18]. The Willems and Demirjian methods overestimated chronological age, while the Cameriere method underestimated it. However, the lack of statistically significant differences between chronological age, Willems age, Demirjian age, and Cameriere age indicates that these small deviations in dental age estimation can be considered negligible. Therefore, these three methods can be effectively used for dental age estimation in the Turkish subpopulation. The absence of a statistical difference between the dental ages of children in the ADHD and control groups, as estimated by the three different methods, suggests that the dental development of patients diagnosed with ADHD was not affected by the disorder or the medications used, and was similar to that of the control group. Consistent with present findings, Wadhwa P et al., reported no difference in dental ages between ADHD and control groups, noting that the dental ages of children using four types of medication for ADHD were similar [19]. Cameriere R et al., found that the Demirjian method overestimated chronological age, while the Cameriere method provided more accurate results for estimating chronological age in the Peruvian population [20].

In a study by Wolf TG et al., involving a German population, it was reported that the Demirjian method yielded results more closely aligned with chronological age than the Cameriere method [21]. Likewise, a study conducted in an Indian subpopulation found that the Cameriere method produced results closer to chronological age than the Demirjian method [22]. To our knowledge, the Willems and Cameriere methods are frequently compared in studies involving the Turkish population, while only two studies have compared the Demirjian method with the Cameriere method. One of these studies focused on Cameriere's method of age estimation from the third molar in 18-year-old patients, while the other used the open apex method, similar to present study [9,23]. In the present study, we found that the dental ages of children with ADHD were similar to those of the control group across all three dental age methods. Similar to present findings, several studies have reported comparable dental ages to those of healthy individuals in various systemic diseases and syndromes [7,24-27]. This suggests that dental maturation in syndromes and metabolic disorders is less vulnerable than skeletal maturation, indicating that the dental age methods employed are quite reliable.

Limitation(s)

One limitation of present study is that all participants with ADHD were taking medication, which suggests that a larger study is needed to determine whether the observed results are due to the medication or the disorder itself.

CONCLUSION(S)

It is important to demonstrate that various systemic diseases and the drugs used in their treatment may affect growth and development as well as dental development. The dental ages of patients diagnosed with ADHD are similar to their chronological ages, and no retardation in tooth development was observed due to the effect of the disease or the drugs used in its treatment. Although there was no statistically significant difference between all three methods in the Turkish population, Cameriere's method underestimates and Demirjian's method overestimates the chronological age.

Authors' contribution: Conceptualisation: MB, DSÖÇ; Data Curation: DSÖÇ; Investigation: MB, DSÖÇ; Formal Analysis: MB, DSÖÇ; Methodology: MB, DSÖÇ; Project Administration: MB, DSÖÇ; Supervision: MB; Software: MB, DSÖÇ; Resource: MB, DSÖÇ; Validation: MB, DSÖÇ; Visualisation: MB, DSÖÇ; Writing- Original Draft: MB, DSÖÇ; Writing- Review and Editing: MB, DSÖÇ.

REFERENCES

[1] Erşan EE, Doğan O, Doğan S, Sümer H. The distribution of symptoms of attention-deficit/hyperactivity disorder and oppositional defiant disorder in school age children in Turkey. Eur Child Adolesc Psychiatry. 2004;13(6):354-61.
[2] Skogli EW, Teicher MH, Andersen PN, Hovik KT, Øie M. ADHD in girls and boys--gender differences in co-existing symptoms and executive function measures. BMC Psychiatry. 2013;13:298. Doi: 10.1186/1471-244X-13-298. PMID: 24206839; PMCID: PMC3827008.
[3] Yılmaz KK. Effects of atomoxetine and omega 3 used in the treatment of attention deficit hyperactivity disorder, on growth and leptin, ghlerin and nesfatin levels in rats [Specialist]: Atatürk University, Faculty of Medicine 2014.
[4] Spencer T, Biederman J, Wilens T. Nonstimulant treatment of adult attention-deficit/hyperactivity disorder. The Psychiatric clinics of North America. 2004;27(2):373-83.
[5] Graham J, Banaschewski T, Buitelaar J, Coghill D, Danckaerts M, Dittmann RW, et al. European guidelines on managing adverse effects of medication for ADHD. Eur Child Adolesc Psychiatry. 2011;20(1):17-37.
[6] Papadopoulou CI, Sifakakis I, Tournis S. Metabolic bone diseases affecting tooth eruption: A narrative review. Children (Basel, Switzerland). 2024;11(6):748.
[7] Emeksiz C, Yilmaz N, Tüzüner T, Baygin O. Dental age estimation with two different methods in paediatric patients with hypothyroidism. Arch Oral Biol. 2022;139:105450.
[8] Poulton A, Cowell C. Slowing of growth in height and weight on stimulants: A characteristic pattern. J Paediatr Child Health. 2003;39(3):180-85.
[9] Apaydin B, Yasar F. Accuracy of the demirjian, willems and cameriere methods of estimating dental age on turkish children. Niger J Clin Pract. 2018;21(3):257-63.
[10] Ozveren N, Serindere G. Comparison of the applicability of Demirjian and Willems methods for dental age estimation in children from the Thrace region, Turkey. Forensic Sci Int. 2018;285:38-43.
[11] Altan HO, Altan A, Bilgiç F, Sözer ÖA, Damlar I. The applicability of Willems' method for age estimation in southern Turkish children: A preliminary study. J Forensic Leg Med. 2016;38:24-27.
[12] Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45(2):211-27.
[13] Willems G, Van Olmen A, Spiessens B, Carels C. Dental age estimation in Belgian children: Demirjian's technique revisited. J Forensic Sci. 2001;46(4):893-95.
[14] Cameriere R, Ferrante L, Cingolani M. Age estimation in children by measurement of open apices in teeth. Int J Legal Med. 2006;120(1):49-52.
[15] Vasconcelos NP, Caran EM, Lee ML, Lopes NN, Weiler RM. Dental maturity assessment in children with acute lymphoblastic leukemia after cancer therapy. Forensic Sci Int. 2009;184(1-3):10-14.
[16] Song P, Zha M, Yang Q, Zhang Y, Li X, Rudan I. The prevalence of adult attention-deficit hyperactivity disorder: A global systematic review and meta-analysis. J Glob Health. 2021;11:04009. Doi: 10.7189/jogh.11.04009. PMID: 33692893; PMCID: PMC7916320.
[17] Blankenship JA, Mincer HH, Anderson KM, Woods MA, Burton EL. Third molar development in the estimation of chronologic age in American blacks as compared with whites. J Forensic Sci. 2007;52(2):428-33.
[18] Celikoglu M, Cantekin K, Ceylan I. Dental age assessment: The applicability of Demirjian method in eastern Turkish children. J Forensic Sci. 2011;56:S220-S222.
[19] Wadhwa P, Yu Q, Zhu H, Townsend JA. Dental age difference in children with ADHD. J Clin Pediatr Dent. 2018;42(3):208-11.
[20] Cameriere R, Flores-Mir C, Mauricio F, Ferrante L. Effects of nutrition on timing of mineralization in teeth in a Peruvian sample by the Cameriere and Demirjian methods. Ann Hum Biol. 2007;34(5):547-56.
[21] Wolf TG, Briseño-Marroquín B, Callaway A, Patyna M, Müller VT, Willershausen I, et al. Dental age assessment in 6- to 14-year old German children: Comparison of Cameriere and Demirjian methods. BMC Oral Health. 2016;16(1):120.
[22] Babu E, Sajeev R, Kayalvizhi G, Ramesh V. Validity of Demirjian and Cameriere methods for dental age estimation of children aged 9–13 years in and around Puducherry–A comparative study. Journal of Scientific Dentistry. 2016;6(2):17-22.
[23] Akman H, Surme K, Cimen T, Ayyildiz H. Accuracy of different dental age estimation methods for determining the legal majority of 18 years in the Turkish population. Clin Oral Investig. 2022;26(6):4537-47.
[24] Mitsea A, Seremidi K, Tsiligianni A, Gizani S. Dental age estimation in children that have undergone antineoplastic treatment. Eur Arch Paediatr Dent. 2022;23(2):243-53.
[25] Jääsaari P, Visnapuu V, Nyström M, Peltonen S, Peltonen J, Happonen RP. Dental age in patients with neurofibromatosis 1. Eur J Oral Sci. 2012;120(6):549-52.
[26] Pinchi V, Bianchi I, Pradella F, Vitale G, Focardi M, Tonni I, et al. Dental age estimation in children affected by juvenile rheumatoid arthritis. Int J Legal Med. 2021;135(2):619-29.
[27] Condò R, Costacurta M, Maturo P, Docimo R. The dental age in the child with coeliac disease. Eur J Paediatr Dent. 2011;12(3):184-88.

PARTICULARS OF CONTRIBUTORS:
1. Department of Paediatric Dentistry, Zonguldak Bulent Ecevit University, Zonguldak, Kozlu, Turkey.
2. Department of Paediatric Dentistry, Bolu Abant Izzet Baysal University, Bolu, Centre, Turkey.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Melek Belevcikli,
Department of Paediatric Dentistry, Zonguldak Bulent Ecevit University, Faculty of Dentistry, Zonguldak, Kozlu, Turkey.
E-mail: mbelevcikli@hotmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 24, 2024
- Manual Googling: Jan 27, 2025
- iThenticate Software: Jan 29, 2025 (8%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Sep 18, 2024**
Date of Peer Review: **Nov 07, 2024**
Date of Acceptance: **Jan 31, 2025**
Date of Publishing: **Apr 01, 2025**