

Accuracy of the Chaillet's Method for Assessing the Age in Subadults. A Meta-Analysis

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ABSTRACT: Introduction Assessing the dental development plays a key role in forensic dentistry. Dental age based on stages of teeth mineralization can be assessed by using different methods, and is especially useful in subadults. Chaillet's method was developed based on the Demirjian's method. In this study, we aimed to study the applicability of Chaillet's method in subadults. Materials and methods: We performed systematic reviews and meta-analysis of observational studies published in English using the following databases Pubmed, Web of Science, Embase and Scopus, with a timeframe between 2013 and 2019. Results: The difference between chronological age and dental age was calculated separately, for each gender. In girls, the method underestimated the age with an average difference between dental and chronological of 0.83 years (CI= [-1.34; -0.31]), with significant heterogeneity and publication bias. In boys, the method underestimated the age with an average difference between dental and chronological of 0.64 years (CI= [-1.28; 0.01]), with significant heterogeneity and publication bias. Chaillet's method showed an advanced dental maturity in European boys by 0.35 years [-0.85; 1.55], while it underestimated the age in South Asian boys by -1.03 (CI= [-1.60; -0.46]). For girls this method showed a delayed dental development for both regions, with a rather smaller difference for Europeans of -0.06 years (CI= [0.91; 0.78]) compared to South Asian girls: -1.19 years (CI= [-1.86; -0.51]. Conclusion: Dental age estimation provided by the Chaillet's method showed an age overestimation in both genders, in most studies geographic groups.

KEYWORDS: Dental age, Chaillet's method, forensic dentistry, subadults, meta-analysis.

Introduction

Assessing the dental development plays a key role in forensic dentistry when chronological age is unknown. It is of use not only for living individuals, when the chronological age is debatable, especially in instances like illegal immigration or in people without identification documents, but also for forensic identification of unidentified deceased in crimes, natural disasters or war conflicts [1].

Dental age, together with skeletal age may be used to provide information about different stages of maturation in children and adolescents, with teeth being more reliable in this regard, given the decreased environmental and genetic influence on them [2,3].

One of the most used methods in estimating dental age is the Demirjian's method, developed on a French-Canadian population, using dental radiographs. For this method were used stages of development of the left side seven mandibular teeth, with 8 calcification stages in both genders. For each stage a score was given, and the sum of the scores was used to compute dental age [1,4].

With great reliability for the French-Canadian population, the Demirjian's method showed high a variability for other ethnic populations, and therefore the necessity for a more accurate estimation arose. Chaillet et al. developed a new method, based on Demirjian's, using new dental maturity scores from on cases

from eight countries with unknown ethnic origins [5].

The Chaillet-Demirjian's method has added the third molar in the original formula and two additional stages. With the third molar included in the new dental age formula, the dental age estimation for a chronological age beyond 16 years old became possible [6].

Having a detailed description of stages, with relative lengths of crown and root gave this formula a high reproducibility [5].

As that the Chaillet's method can be applied for unknown ethnic groups, it is less studied compared to other dental age methods like Demirjian, or Willems [7], due to its wider appeal, but decreased potential accuracy. The accuracy of this method is arguable, with a significant difference error between the estimated and actual age (>1 year is considered inaccurate) from authors that compared it to other methods. However, a systematic analysis of the studies performed using Chaillet's method has not yet been performed, as has been done for other highly used methods, such as Demirjian's and Willems's [8,9].

The aim of this study is to systematically assess the mean difference between dental and chronological age using the Chaillet's method, and to evaluate the method's accuracy for children of different age groups.

Materials and Methods

Our study was carried out according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and MOOSE guidelines for systematic reviews and meta-analyses of observational studies in epidemiology [10,11].

Search Method

We performed the analysis using articles published in English from Pubmed, Web of Science, Embase and Scopus databases, from a timeframe between 2013 and 2019. We used the following keywords “Chaillet”, “Chaillet” AND “dental age” or “Modified Demirijan”. We preferred not to use additional, restrictive criteria (e.g. article type) as other types, including letters, case presentations, reviews may allow us to identify other relevant articles that could be used either for adding them in the meta-analysis or for discussions. Additional articles were also identified by analyzing the reference lists of the already selected articles. Some specific journals like Forensic Science International, Journal of Forensic Odontostomatology, Journal of Forensic Sciences, International Journal of Pediatric Dentistry, International Journal of Legal Medicine, and Journal of Forensic Dental Sciences etc., were scrutinized. Relevant articles, its references, and the abstracts were imported in Mendeley.

Selection Criteria

Inclusion criteria: studies that contained data about mean and standard deviation and the total number for each chronological age and dental age in both genders separately.

Our focus for each study was the numeric results expressed in mean difference, exclusion criteria were mandatory: 1. studies without clear numeric data about mean or standard deviation, 2. no mention about the population type, 3. another dental age method calculation, other than Chaillet, 4. unhealthy children.

Quality Assessment and Risk of Bias

STROBE Statement Checklist for observational studies, with a 22-items checklist, was used in assessing the study quality of the included articles [10].

Two reviewers independently extracted, entered and evaluated data into a data table, using the included articles. The following data were evaluated: title with data about the used method, clearly stated purpose of the study, clear demographic criteria (race, location), number of the subjects clearly stated, inclusion and

exclusion criteria, number of the subjects excluded, clearly stated method used to assess dental age, with reference, clearly described Chaillet’s method, number of subjects presented on age groups and gender, statistical methods presented, results with values given overall per gender and per gender and age group with standard deviation for both chronological and dental age, discussion applied to the results, limits of the studies presented, conclusion supported by the results, at least 20 relevant and clear references to the methods from original sources.

Each criteria received a value of 0 (criteria not met), 1 (partially met) or 2 (fully met). If the sum was below 22, the studies were considered of low quality, between 23 and 29 they were considered average, and of high quality if the sum was above 30. Our analysis had an average score of 24.8, meaning an average quality.

Statistical Analysis

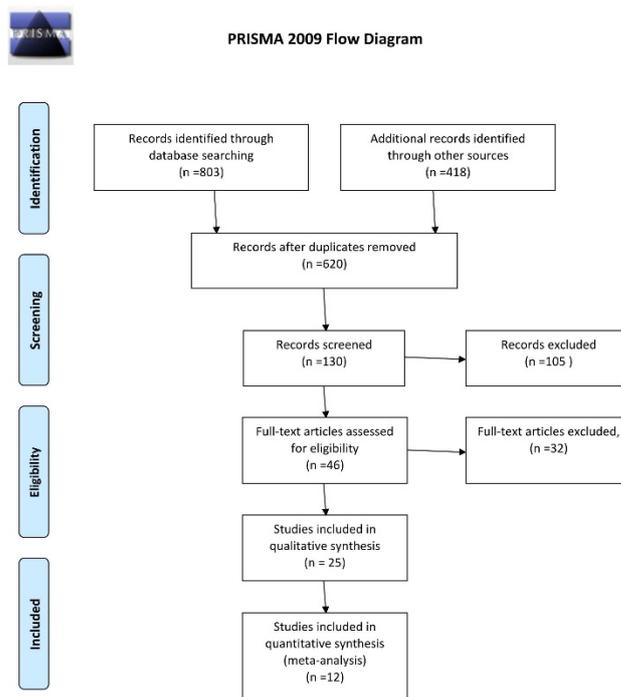
For statistical analysis we used Jamovi and Microsoft Excel 365 for Windows 10. Statistical significance was set at $p < 0.05$, using prediction intervals. DerSimonian-Laird estimator was used for the random effects model, and raw mean difference for effect size model measures. The difference between dental age and chronological age was evaluated statistically with prediction and confidence intervals at 95% for significant differences. For publication bias we used funnel plot and Egger’s regression test. To quantify the degree of heterogeneity among studies we used I^2 with the following intervals: 0-35%-most likely not important, 36-55%-moderate heterogeneity, 56-85%-most likely substantial heterogeneity, and 86-100%-important heterogeneity [12].

Results

Results of the Search Synthesis

During the initial database research, we obtained 803 articles from Pubmed, Scopus and Web of Science from which, after deleting duplicates and irrelevant studies we selected 30 to be further evaluated. By analyzing their references, we found another 6 potentially relevant articles that were also downloaded. From the 36 articles, 12 were included in the final analysis of prevalence. Details about the search synthesis are presented in Figure 1 [11].

We detailed the papers contained in the meta-analysis in Table 1.



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Figure 1. PRISMA 2009 Flow Diagram.

Quality assessment

Quality assessment scores were between 13.5 and 28.

The score for each study has been included in Table 1. No study showed significant bias.

Table 1. Studies included in the analysis.

Study	No. Subjects	Country	Age Range	Inclusion Criteria	Exclusion Criteria	Quality Score
Galic	1106	Bosnia Herzegovina	5 - 15	healthy children	diseases which can affect development of teeth, mandibular hypodontia except of third molars, low quality of radiographs and incomplete dental and medical history.	29.5
Urzel	743	France	4 - 15	high-quality radiographs	unclear orthopantomograms, the presence of systemic disease, age above 16 years, bilateral missing mandibular permanent teeth (with the exception of the third molar), and distinct retardation of dental development.	29
Gandhi	30	India	10 - 30	healthy children and adolescent of 10–30 years, full complement of teeth in mandibular left or right side	history of systemic disease that could affect the presence and development of wisdom tooth, history of serious illness or dental trauma and who had undergone any orthodontic treatment or permanent tooth extraction, mandibular hypodontia, low-quality radiographs and image deformity affecting third molar visualization and distortion and crowding of teeth.	27.5
Akhil	150	India	8 - 24	-	caries/periapical pathology, developmental anomalies, crowding of teeth where root structures of teeth were not clearly discernible, bilaterally missing mandibular teeth.	19.5
Sathawane	284	India	7 - 16	age group 7-16 years.	any congenital/developmental anomalies of jaws and teeth., history of craniofacial trauma, history of jaw lesion/disorder, endocranial/hereditary/nutritional disturbances, history of skeletal malocclusion, partial anodontia, orthodontic treatment, missing third molar tooth.	25

Mohanty	522	India	3 - 18	age group 3-18 years	developmental anomalies malnutrition and endocrine disorders prematurely born children; birth defects	23
Mohammed	660	India	6 - 16	patients of same ethnic origin	serious medical illness, history of extraction of permanent teeth, history of trauma to face, impacted or ankylosed teeth or transposition of teeth, congenital absence of third molars	28,5
Kelmendi	1022	Kosovo	9 - 14	Kosovo origin, age between 5 and 14 years, all permanent teeth in the left side of lower jaw present, no apparent dental pathology.	incomplete dental records, radiographs, agenesis of permanent teeth, extraction of permanent teeth from both jaws of one side of the face, recorded systemic diseases, premature birth, and congenital anomalies.	15
Agrawal	150	Nepal	8 - 19	orthopantomograms of orthodontic patients and good quality radiographs	gross pathology, radiographs of unknown age or sex or the absence of multiple teeth	28
Bijjaragi	300	Tibet	8 - 18	-	History of congenital/genetical abnormalities; endocrine, nutritional and degenerative disorders; developmental and acquired disorders affecting the teeth; orthodontic treatment or extraction; trauma to the head and neck region; previous prolonged illness; bilaterally missing teeth in the mandibular region; and poor quality images	26,5
Ortega-Pertuz	516	Venezuela	6 - 18	images with adequate contrast and density and minimal distortion, records, presence of the seven permanent mandibular teeth on the left side	-	27
Thetay	660	South India	6-16,99	unclear radiographs, presence of any systemic disease, missing teeth, distinct retardation of dental development.	unclear radiographs, presence of any systemic disease, missing teeth, distinct retardation of dental development.	20

Accuracy of Chaillet's formulas depending on the gender

Dental development was assessed separately depending on the subject's gender, because of hormonal influence on dental development.

Hence the difference between chronological age and dental age was calculated separately, for each gender.

In *girls*, the method overestimates the age with an average difference between dental and chronological of 0.83 years (CI=[-1.34; -0.31]) (Figure 2), with important heterogeneity ($I^2=94.36%$) and publication bias (Egger's Regression=-3.344, $p<0.001$) (Figure 3).

In *boys*, the method overestimates the age with an average difference between dental and chronological of 0.64 years (CI=[-1.28; 0.01]) (Figure 4), with significant heterogeneity ($I^2=95.77%$) and publication bias (Egger's Regression=-1.702, $p=0.089$) (Figure 5).

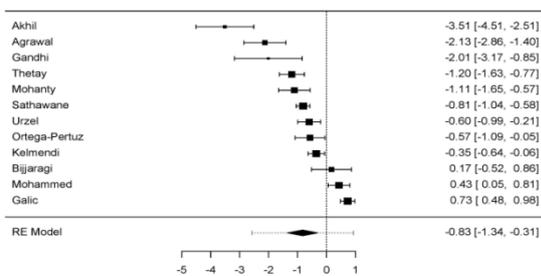


Figure 2. Forest plot, girls, overall.

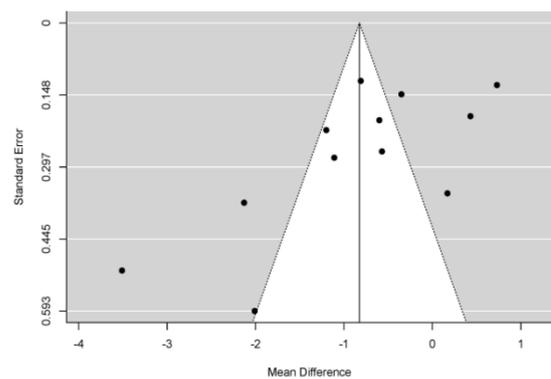


Figure 3. Funnel plot, girls, overall.

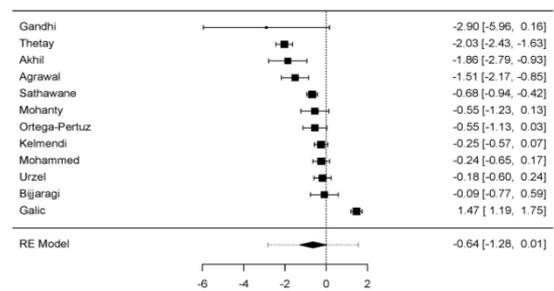


Figure 4. Forest plot, boys, overall.

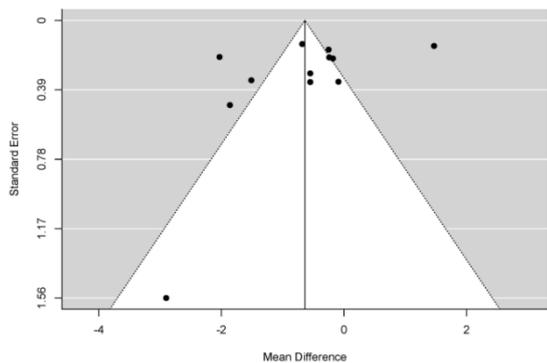


Figure 5. Funnel plot, boys, overall.

In Tables 2 and 3 are presented the accuracy of the Chaillet's methods depending on the age and gender.

Only four available studies for our meta-analysis estimated dental age for each age group in girls and also in boys. [1,13-15].

When comparing the male group with the female one, the difference between chronological age and Chaillet's estimation method was comparatively less than in boys. In assessing dental age in every age group, the standards of the Chaillet's method overestimates the age in girls by less than 0.3 years, respectively for 6-7, 9-10, 10-11 age groups. Outside these age groups the age underestimation is statistically significant (when taking into account the prediction interval), making the method unreliable.

In boys, there is an age overestimation in almost all age groups, except 11-13 age group. Publication bias and heterogeneity are, in most age groups, significant, suggesting a significant variability.

Table 2. Accuracy of Chaillet's method depending on the age in girls.

Age group	Mean difference in years (DA-CA)	LCI (95%)	HCI (95%)	No cases	I2%	Publication Bias Assessment-Egger's Regression	Publication Bias p	No. of studies
6-7	0.15	-0.22	0.51	50	81.82	-2.298	0.757	3
7-8	-0.06	-0.35	0.23	227	82.1	-2.986	0.003	3
8-9	-0.03	-0.46	-0.40	221	93.2	-5.360	<0.001	3
9-10	0.34	-1.01	1.7	334	99.53	-0.537	0.591	4
10-11	0.04	-0.86	0.95	240	98.32	-0.628	0.530	4
11-12	-0.09	-1.09	0.90	302	98.58	-0.873	0.383	4
12-13	-0.44	-1.45	0.57	265	98.53	-1.136	0.256	4
13-14	-0.39	-0.97	0.19	131	93.7	-0.508	0.611	4
14-15	-1.87	-2.95	0.80	112	92.14	-1.084	0.278	4

Table 3. Accuracy of Chaillet's method depending on the age in boys.

Age group	Mean difference in years (CA-DA)	LCI (95%)	HCI (95%)	No cases	I2%	Publication Bias Assessment-Egger's Regression	Publication Bias p	No. of studies
6-7	0.24	-0.10	0.58	127	79.56	1.212	0.226	4
7-8	0.17	-0.13	0.47	141	80.01	0.664	0.507	4
8-9	0.13	-0.26	0.52	187	89.71	0.832	1.089	4
9-10	0.22	-0.21	0.64	223	78.05	-1.046	0.296	4
10-11	0.25	0.01	0.49	255	20.51	0.560	0.575	4
11-12	-0.16	-0.65	0.32	246	94.54	0.084	0.933	4
12-13	-0.04	-0.37	0.29	219	76.9	-0.666	0.505	4
13-14	0.16	-0.11	0.44	145	58.43	-2.233	0.026	4
14-15	-0.31	-0.58	-0.05	115	33.64	1.287	0.195	4

Accuracy of Chaillet formulas depending on population subgroup

Differences in dental maturity were observed between South Asia and Europe. Chaillet's method showed an advanced dental maturity in European boys by 0.35 years (CI=[-0.85; 1.55],

while it underestimates the age in South Asian boys by -1.03 (CI=[-1.60; -0.46]).

For girls this method indicates a delayed dental development for both regions, with a difference in European girls of -0.06 years (CI=[-0.91; 0,78]) and -1.19 years (CI=[-1.86; -0.51]) in South Asian girls.

High heterogeneity and publication bias were significant for both regions (Figure 6 and 7).

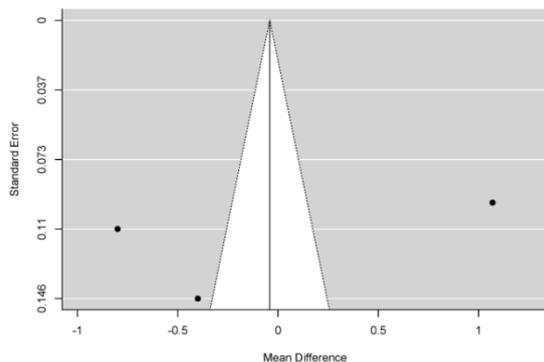


Figure 6. Funnel plot, Europe, overall.

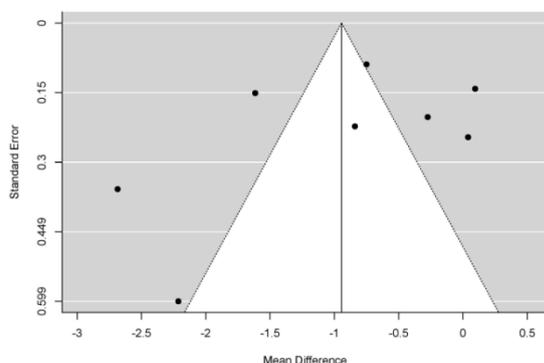


Figure 7. Funnel plot, South Asia, overall.

Discussion

The current study collected twelve studies from various populations with Chaillet's method [1,7,13-23].

While other dental age estimation methods have been widely researched, Chaillet's method remains less studied.

Chaillet *et al.* claimed their method to be more useful for unknown ethnicity, for example in natural disasters, airplane crashes, compared to Demirijan's method, having lower accuracy but higher reliability for dental age estimation [5].

Although skeletal age was widely used in the past decades, it was proved that it suffers more from environmental factors than dental age, hence the interest on the rise for the dental age assessment.

This study was designed to assess the accuracy of dental age estimation based on Chaillet's method, aiming for a lower difference between dental and chronological age.

A mean age difference of one year between DA and CA of 1 year is considered accurate, when assessing dental age [5].

Chaillet's method yielded a mean age difference of less than a year in both genders, which means that this method can predict dental age fairly accurately.

Our research shows that Chaillet's method tends to estimate dental age as more advanced than chronological age, with more than a half a year in both males and females, meaning an advanced dental development.

Galic *et al.* observed an overestimation in Bosnian-Herzegovinian girls (0.09 ± 0.83) and boys (0.28 ± 0.9), in every age group; similarly, Cruz-Landera *et al.* found on a Spanish Caucasian population an age overestimation for both genders (for girls 0.21 ± 1.07 and for boys 0.37 ± 1.04), results in compliance with our meta-analysis [14,19].

In contrast to these findings, an underestimation of the dental age estimation on Venezuelan, French, Indian, Tibetan Nepalese and Kosovar populations was found [1,13-15, 20,21].

The original study of Chaillet and Demirijan evaluated dental age from eight countries, showing an advanced dental development in Australian population, and also in French, French-Canadian and emphasizing an ethnical implication in dental development [5].

Apart from ethnicity, other factors may be involved, that can explain these differences: socioeconomic status or environmental factors.

In this regard Carneiro *et al.* studied on a Portuguese sample of children that those from a higher group of socioeconomic status showed an advancement in maturation of the third molar [24].

It was observed though that gender differences do exist.

Our meta-analysis showed that the difference between dental and chronological age in males versus females is rather small, with a lower overestimation in males and a higher one in females, being in agreement with the findings on the Spanish Caucasian and Bosnian-Herzegovinian population.

Chaillet's method is useful for both age groups, with no statistical significance, except between 14-15 years of age in girls and 11-12 years of age in boys, when taking into account the prediction interval.

A more researched dental age estimation method, the Cameriere Methods of Open Apices is accurate enough in the 7-14 age-interval [25], highlighting the usefulness of the Chaillet's method for a wider age range.

Study Limitations

Firstly, only 12 studies were included in our meta-analysis, showing a modest number of studies with a rather lower statistical significance.

Moreover, only 4 studies provided information about age groups.

Secondly, most of the included studies were carried out in India, without a broader spectrum of populations from different continents, which posed a limitation for a correct assessment based on the race/nationality profile; high heterogeneity of the method was observed ($I^2 > 96\%$).

Also, we preferred to use DerSimonian-Laird-a method for the random-effects model, which underestimates true heterogeneity, when the number of studies is small, but it allows to better compare the results with other meta-analyses using the same methodology.

Conclusion

Dental age estimation provided by the Chaillet's method showed an age overestimation in both genders as shown for the majority ethnic groups, with a delayed dental development in Asian population, in contrast to the European one.

As an average, this method shows an age overestimation by about half a year for both genders, hence being reliable but less accurate, with broader confidence intervals.

Conflict of interests

None to declare.

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