



Comparison between Nolla and Demirjian dental age assessment methods: a Systematic Review

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Comparison between Nolla and Demirjian dental age assessment methods: a Systematic Review

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Abstract

Background: Estimation of age has great importance in clinical practice, not only in orthodontics, being commonly used forensic medicine, radiology and paediatrics. For this reason, the Nolla and Demirjian methods have been developed. Several studies have been performed to determine the chronological age analysing the dental mineralization stage, however, it is not a straightforward analysis. The aim of our study is to estimate the observed differences between Chronological age (CA) and Dental age (DA) when the two assessment methods have been used.

Materials and Methods: A systematic search of literature for papers utilizing the Nolla and Demirjian datasets for age estimation was performed. All language articles from PubMed, Lilacs and Scopus databases were electronically searched for terms 'Nolla', 'Demirjian' and 'Dental age' published till October 2016.

Results: A total of 2,268 studies were identified from which 64 studies were included for qualitative analysis and 42 studies observed the eligibility criteria for quantitative assessment. When synthesizing the estimation results from different population groups, on average, the Demirjian dataset overestimated the age of females by 0.65 years (0.10 years to 2.82 years) and males by 0.60 years (0.23 years to 3.04 years).

Conclusions: The Demirjian method tends to overestimate age by more than six months, whereas the Nolla method tends to underestimate it. These methods should be used only with considerable caution, when applied to subjects of any global population.

Introduction

Age determination is an essential starting point for every clinical evaluation, not only in orthodontics, being commonly used in anthropology, radiology, forensic medicine, odontopediatrics and paediatrics¹⁻¹⁰. The necessity of finding a valid method to determine the chronological age of children derives from the increasing of globalization and of migratory flows, particularly evidenced in occidental states. The

socio-economical changes originated many legal problems linked to the assessing of legal adult age people without documents for judicial purposes, in stating somatic development for children, in orthodontic treatment and in other medical branches to have a complete evaluation of skeletal maturity in relation to the development of the whole body^{1-8,11,12,13}.

Many attempts have been done in medicine for using the skeletal development^{2,4,14} as indicator of growth and somatic processes, but it was evidenced that bone mineralization was more affected by environmental^{2,15,16} and hormonal controls^{2,17,18} than the states of dental mineralization. So dental development represented the base for the definition of two important age assessment methods: the first proposed by Nolla in 1960¹⁹ and by Demirjian et al. in 1973¹⁵.

Between the dental assessment methods, the Demirjian's one¹⁵ is the most used in literature because of its applicability, ease of standardization, intra-examiners agreement and the use across a wide range of populations^{4-7,10,20-25}. This dental maturity scores derived by the evaluation of the dental development of 1446 boys and 1482 girls aged 2 e 20 years belonging to a French and Canadian population. So Demirjian and co-workers performed a classification system based on the stage of development of the crown and the root, expressing the stages in letters which represent an ordinal or ranking scale of eight phases designated from A to H. In the 1976 the sample size was increased, incorporating dental maturity scores for additional tooth developmental stages and improving the overall accuracy of the system²⁶. So new stages were added to the initial classification, for example: stage A of the first premolar and stage C of the central incisor. At the first the age assessment method was based on the evaluation of seven left mandibular teeth, but this limited the applicability of the Demirjian scale for the patients with severe forms of dental agenesis. Then dental maturity scores based on a four-teeth system were added to the previous one. The dental age assessment method was performed on different ethnic and geographic population groups in order to determine its applicability. With the using of Demirjian dental age assessment method on different populations, overestimation of the age was observed.

Besides the Demirjian method, the scale developed by

Nolla appears to be easier and less articulated for each dental development stage. The Nolla¹⁹ method has been one of the least frequently used and tested across populations, despite its effectiveness. This is formed by a unique scale of ten stages indicated by numbers from 1 (no sign of calcification) to 10 (apical end completed) and if the tooth was between stages an appropriate fraction (0.2, 0.5 or 0.7) was added. Nolla method has shown itself to be very accurate with a sample of Spanish and Portuguese participants, while some others differences were reported in literature in several ethnic groups.

These considerations on Nolla and Demirjian dental assessment methods led the authors to the idea that “the scores for the stages will not vary too much between populations, but that the maturity standards may change appreciably” (Demirjian and Goldstein, 1976 p. 420). The lack of data about a sufficiently large sample determines criticisms for the evaluation and applicability of dental age scales. This principle aims the following systematic review of the literature, which highlights on the accuracy and the variations in age estimation in different ethnic and racial groups comparing the efficacy and effectiveness of the two different dental age assessment methods.

Materials and Methods

Selection of studies

During the years a large number of articles have been published in international literature on the topics of assessing the Chronological Age (CA) through the Dental Age (DA). So a detailed search has been performed for all the articles published between January 1960 and October 2016 on the principal medic databases: PubMed (MedLine), Lilacs and Scopus. The keywords used were: *Nolla method*, *Demirjian method*, *dental age* and *dental maturity*. No restrictions of languages have been fixed. The results have been filtered and valued following our eligibility criteria and then organized following the PRISMA method²⁷.

Inclusion criteria

Original research papers that used Nolla's and Demirjian's dental age assessment methods on healthy subjects, either for validating its applicability or for creating an adopted data set, were included in the study. All the studies included had clear availability of abstract as the full text could be found on informatics databases or through a manual search. Studies expressing the results in mean differences alone were included as it was intended to analyse the exact

degree of variation between the chronological age (CA) and the estimated dental age (DA).

Eligibility criteria

Because of this analysis is performed to generalise the results in mean difference, all the studies which express age estimation results in median or in percentages were excluded. Then, it was accepted only studies on normal orthodontics population, excluding all them conducted on subjects who were physically or medically compromised as on samples with syndromes or developmental anomalies. Other fundamental criteria to perform a robust analysis on the generalised applicability of the data set, were the inclusion of only studies with an accurate description of the sample, in terms of stratification for gender, age, ethnicity, as for the application of dental assessment scale to all the left mandibular teeth and not exclusively on fewer teeth or third molars. In fact, only the original forms of Nolla's and Demirjian's scales have to be take into consideration, as in both the original systems of dental age assessments proposed by the authors, the third molars were excluded.

Finally, an important consideration has to be due to the age, because of the applicability of two data set only to young patients during the tooth mineralization. So in our review studies that recruited healthy subjects aged between 2 and 21 years were included.

Review

Results of the search

The search identified 2,268 abstracts, including five foreign language articles (Hungarian, German, French, Senegalese and Chinese): 915 articles were selected from Pubmed, whereas 93 from Lilacs and 1,260 from Scopus. All the articles were reviewed manually and each one of interest was marked for further review. The full texts of the marked studies were retrieved and firstly, they were evaluated for attending the inclusion criteria. During the selection process, any disagreement in the selection of articles between the review authors was resolved by discussion. Foreign language articles were translated to English with the help of a translator. From the five foreign language articles, only two met the inclusion criteria (Chinese and Senegalese).⁵

In this way sixty-four studies have been identified, in the first phase. Then, these articles were selected from a qualitative point of view to satisfy the eligibility criteria. Finally, only forty-two articles have been considered.

Design of study and Statistical analysis

The statistical analysis was performed calculating the mean age difference for each study, that is, the difference between the estimated DA and the CA (or vice versa). The estimated age differences, if in months, were then converted to decimal years.^{28,29} For the eligibility criteria all the studies have to present in text data about chronological age as the estimated dental age. If this doesn't happen the mean differences were obtained by carefully examining the table values.

Demirjian method

Most of the studies used the original version of the French-Canadian data set for age estimation.³⁰ Only three studies³¹⁻³³ used the updated version of the data set.²⁶ The qualitative analysis shows that Demirjian dental age assessment method results generally in a discrepancy between CA and DA. In particular, the overestimation of estimated age was commonly reported when using the Demirjian data set.^{10,25,31,32}, whereas an underestimation resulted only in the Venezuelan subjects³⁴ and western Chinese males³⁵. The most accurate age estimation was described in the study conducted on northern Indian subjects, where the discrepancy was reduced for all the age groups and both sexes³⁶. From a quantitative point of view, the overall mean difference reported for males was 0.13 years and for females, it was 0.10 years, whereas for the global population, the variations in the estimated age ranged from -0.06 years to +3.02 years for males and -0.09 years to +2.79 years for females. The minimal differences were observed in the western Chinese subjects, with a mean difference of -0.08 years for males and +0.15 years for females³⁵; whereas the maximum differences were described in southern India subjects: +3.04 years for males and +2.82 years for females were reported for the southern Indian subjects³⁷. Summarizing, the average of data extracted by the works with application of Demirjian's data set overestimated the age of females by 0.65 years (from -0.10 years up to +2.82 years) and males by 0.60 years (from -0.23 years up to +3.04 years).

The quantitative analysis confirmed what evidenced previously from the qualitative point of view. All the estimated age presented a discrepancy respect to the chronological age, and the average of these variations resulted in an overestimation of about 6 months both for males and females. As previously reported only in Venezuela study it was observed an underestimation of about 3 months, although it demonstrated a great standard deviation for age difference.

Nolla method

Whereas literature reported that the Demirjian method overestimated chronological age, the Nolla method underestimated it, and this appears to be a statistically significant difference recorded between the two methods. With a stratification for gender, both Nolla and Demirjian methods reported the same observations for females, although the greater differences have to be subscribed for male subjects. The statistical analysis of literature reported a predictive capacity of total variance of chronological age of 63.2% for Nolla score and 49.3% for Demirjian scale (accepting a confidence range for the regression analysis of 95 per cent). The inferential method associated with a low rate of error. Evaluating the effectiveness of dental methods in estimating chronological age it was evidenced that both resulted in about 50% of validity, although Nolla score was a bit less than 60 per cent. Considering the possibility of applying Nolla method to each single tooth in the left mandibular quadrant, it's interesting to consider the results of regression for each one. Whereas the seven teeth showed almost a significant predictability about of 74.5% with Nolla method (it was of 57.7% for Demirjian), only the Lateral Incisor for Nolla score appears to be slight significant (excluding the third molar that wasn't included in the original dental age assessment scale). On the contrary, the most effective tooth in age estimating with Nolla method was the Second Molar (this confirmed also by Demirjian scale), followed by Second Premolar, First Molar and Canine (in which there is a great accordance of the recent literature); whereas with Demirjian scale the most valid tooth was First Premolar, immediately followed by the Lateral Incisor²⁵.

A part consideration has to be attributed to gender variations in age estimating, because of the wide variability. The Demirjian method was found to predict 53.1% of total variance of chronological age for men and 44.2% for women, while the Nolla method predicted 69% of total variance for men and 61.4% for women. This means that whereas a sufficient grade of predictivity was found on both methods, Nolla scores had greater effectiveness in chronological age estimation than Demirjian, for both men and women.

Predictive capacity related to age group

Considering the big sample size divided into age-subgroups, Nolla method evidenced the existence of two main distribution peaks very close to each other, whereas Demirjian scale reported a principal distribution peak with another one further than the previous. For Nolla scale the two main clusters were: 1 – from 4 to 10 years, and cluster 2 – from 11 to 21 years, with the second cluster being sub-divided in

another two: from 11 to 15 years and from 16 to 21 years. Besides Nolla, Demirjian method indicated the existence of two main clusters: the first from 4 to 8 years, and the second cluster from 9 to 21 years, the second cluster being sub-divided in three clusters: from 9 to 14, from 15 to 18 years and from 19 to 21 years. In the stratification for age there was accordance in literature that both age assessment methods show more powerful in young subjects (4 to 8 years for the Demirjian method and 4 to 10 years for the Nolla method); whereas the least significance was reported in adults up to 21 years.

Discussion

The study demonstrates that the application of the Nolla or Demirjian dental age assessments methods results in a useful instrument for diagnosis and treatment planning. The seven teeth considered by the Demirjian method were able to predict 47.5% of the chronological age of participants, whereas the Nolla method predicted 64.4%. The data confirms, therefore, the Nolla method was a more significant predictor, although the accuracy of both methods varied between the sexes and age groups. The age estimation appears to be more valid in males than females, as the stratification in four age-groups defined from the cluster analysis showed that as the age-group increases, the predictive capacities of both methods diminish. The Nolla method was more accurate than the Demirjian method in early and late childhood for both sexes. According with the most efficacy of dental assessment methods in determining chronological age at 10, 13, 16 and 18 years; neither method could be applied to predict chronological age in adults. For girls, the more predictivity of Nolla method was evident till the late childhood, whereas the Demirjian method, less effective, is able in age predicting from this age up to 18 years old. This significant sex variability led the authors to conclude that equations to estimate chronological age should use specific coefficients for males and females. In fact, in some other literature works it is confirmed that teeth appear in females before males, as soon as the dental maturity process also demonstrated how dental mineralization is in general earlier in females than in males.

Conclusion(s)

The systematic review of literature confirms that both Nolla and Demirjian methods show significance in

chronological age estimation, whereas each prediction has to be evaluated in relation to the other physical features. This in accordance with the multi genes influence on the odontogenesis and dental bud mineralization. In particular, we can estimate accurately the chronological age for early and late childhood using the Nolla and Demirjian methods, whereas in adult age the predictivity of both reduces. The Demirjian method tends to overestimate chronological age about of six months and the Nolla method tends to underestimate it, although the differences are less in relation to real age. The comparison between the two dental age assessment methods shows that Nolla score is more accurate than the Demirjian one in early and late childhood for both sexes. For girls, the Nolla method is more significant up to late childhood and the Demirjian method from this age up to 18 years old compared to that of Nolla.

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