COMPARATIVE ASSESSMENT OF THREE DENTAL AGE ESTIMATION METHODS - DEMIRIJANS, CAMERIERE AND WILLEMS METHODS

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ABSTRACT:

BACKGROUND: Objective assessment of maturation is important in pediatric dentistry in view of the importance of growth in treatment planning. And dental development has been found to be more reliable as an indicator of biological maturity in children that can be used from infancy to late adolescence.

AIMS AND OBJECTIVES: To assess and compare the accuracy of Demirjian’s, Willems and Cameriere’s methods of dental age estimation.

MATERIALS AND METHODS: The present study was a cross-sectional study undertaken of 140 children aged between 6-13 years comprising of both genders of District Durg of the state Chhattisgarh. After BMI assessment and oral screening, an OPG was taken.
to assess the dental age by all three dental age estimation methods mentioned above. The data obtained was recorded and sent for biostatistical analysis.

**RESULTS:** The results of this study conducted found Willem’s method to be the most accurate of the three methods analyzed, followed by Cameriere’s method and then Demirjian’s method respectively.

**CONCLUSION:** Amongst the age estimation methods used in this study, the Willem’s dental age estimation method was found to be the most accurate and consistent

**KEYWORDS:** Demirjian’s method, Willem’s method, Cameriere’s method

**INTRODUCTION:**

Growth and development are an extremely complex series of event that are best evaluated by careful examination at different stages. No one would disagree that it is more difficult to hit a moving target than a stationary one. This analog seems appropriate to apply to pediatric dentists who are working with growing children.¹

In view of the importance of growth in pediatric treatment planning, objective assessment of maturation is important. The chronological age based on the date of birth offers little insight in determining the developmental stage of a person. Thus maturity indicators provide an objective diagnostic evaluation of the stage of maturity in an individual.²

The dental development is more reliable as an indicator of biological maturity in children that can be used from infancy to late adolescence.³

Generally, the dental development can be assessed by either the phase of eruption or calcification, with the latter being more reliable.⁴

Extensive literature has been documented on Demirjian’s, Williem’s and various other age estimation methods in different countries. But there are limited studies to indicate the accuracy of these methods when applied to Indian children and thus there is still a need to apply and analyze their application in Indian children.
METHODOLOGY:

The present study was a cross-sectional study undertaken to assess and compare the accuracy of Demirjian’s, Willems and Cameriere’s methods of age estimation of 140 children aged between 6-13 years comprising of both genders of District Durg of the state Chhattisgarh. Subjects were selected randomly from patients visiting Outpatient Department of Pedodontics and Preventive Dentistry. The two groups comprising of 70 males and 70 females were further divided into 7 subgroups according to age comprising of 10 subjects in each subgroup.

SELECTION CRITERIA

Inclusion Criteria

1. Participants aged between 6 and 13 years
2. Participants who were Indian by nationality
3. Participants with known date of birth
4. Participants with no history of trauma or injury to the face
5. Participants with BMI (18.5-24.9 Kg/m²)
6. Participants with the presence of permanent teeth of third quadrant from central incisor to second molar (erupted or unerupted)

Exclusion Criteria

1. Participants with known congenital anomaly, developmental, and/or systemic disorders
2. Participants with history of prolonged illness
3. Participants with congenitally missing, impacted, or transposition of teeth
4. Participants with a history of extraction of any permanent tooth
5. Participants having caries, severe malocclusion, and any oral disease that could affect development of teeth
6. Participants undergoing orthodontic treatment

After obtaining informed from the accompanying parent/guardian the BMI was calculated by dividing the weight (in kg) by height (in m²), as recommended by the World Health Organization (WHO).
Then oral screening was done for the patients by seating them on the dental chair which was positioned to facilitate the examination using reflected light and a detailed case history was recorded.

Subsequently OPG’S were taken after instructing the subjects regarding the procedure (Thyroid collar and aprons were used to minimize the radiation exposure to the subject).

After tracing the opg’s dental age was estimated by all three methods mentioned above following the criteria described below:

A. **Demirjian’s method**

   In this method, tooth formation is divided into eight stages and criteria of these stages for each tooth are given separately. Each stage of the left mandibular seven teeth is rated in the following order: 2nd molar, 1st molar, 1st bicuspid, canine, lateral incisor, central incisor.

   **STAGE DESCRIPTION**

   A. In both uniradicular and multiradicular teeth, beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.
   
   B. Fusion of the calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface.
   
   C. a. Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen.
   
   b. The beginning of dentinal deposit is seen.
   
   c. The outline of pulp chamber has a curved shape at the occlusal border.
   
   D. a. The crown formation is completed down to cemento-enamel junction.
   
   b. The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave towards the cervical region. The projection of the pulp horns if present, gives an outline shaped like an umbrella top. In molars the pulp chamber has a trapezoidal form.
   
   c. Beginning of root formation is seen in the form of a spicule.
   
   E. Uniradicular teeth
   
   a. The walls of the pulp chamber now form a straight lines whose continuity is broken by the presence of the pulp horn, which is larger than the previous stage.
   
   b. The root length is less than the crown height.
Molars
a. Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semilunar shape.
b. The root length is still less than the crown height.

F. Uniradicular teeth
a. The walls of the pulp chamber form a more or less isosceles triangle. The apex ends in a funnel shape.
b. The root length is equal to or greater than the crown height.

Molars
a. The calcified region of the bifurcation has developed further down from its semilunar stage to give the roots a more definite and distinct outline with funnel shape endings.
b. The root length is equal to or greater than the crown height.

G. a. the walls of the root canal are now parallel and its apical end is still partially open.
H. a. the apical end of the root canal is completely closed.
   c. the periodontal membrane has a uniform width around the root and the apex.

Each stage is allocated a score and the sum of the scores give an evaluation of the subject’s dental maturity and the dental age is calculated using the sex specific tables. The above methodology was followed meticulously and the results tabulated.

B. Willems method
This method entails division of tooth formation into eight stages and the criteria for these stages for each tooth is described separately. After noting all the stages of tooth development from central incisor to the second molar, the developmental status of a particular tooth is scored and calculated in years on the basis of tables given by Willems.

Following the above mentioned criteria the results were obtained.

C. Cameriere method
Initially, the degree of apical closure and the root lengths of the seven left mandibular teeth are measured. The distance between the inner surfaces of the apex of the single rooted teeth are measured \((A_i, i=1,\ldots,5)\). The sum of the distances between the inner surfaces of the two apices of the teeth with two roots are measured \((A_i, i=6,7)\). To eliminate the possible effects of errors due to magnification and angulation due to X-rays, the measurements obtained above are divided by the tooth length. Thereby determining the \(X_i = A_i/L_i\). The data obtained
from this calculation is adapted with the following formula, wherein the regression analysis developed by Cameriere is used:

$$\text{Age} = 8.971 + 0.375g + 1.631x5 + 0.674N_0 - 1.034 s - 0.176 s. N_0$$

where,

(s): the sum of the $A_i/L_i$ of the open apices

($N_0$): the number of teeth with complete root development

(g): 1 for boys and 0 for girls

(x5) = $A_5/L_5$.

Data was obtained in the manner mentioned above and the regression analysis developed by Cameriere was used to obtain the results.

On the other hand, the chronological date of birth was recorded from the information given by parents/guardian.

The Chronological age for this study was calculated by subtracting the date of birth from the date on which the radiograph was exposed for that particular patient and was converted into the age of the patient in completed years and months.

The data thus collected was tabulated and sent for biostatistical analysis.

**RESULTS**

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronological Age</td>
<td>140</td>
<td>9.4537</td>
<td>2.04246</td>
<td>6.23</td>
<td>13.00</td>
</tr>
<tr>
<td>Demirijan Method</td>
<td>140</td>
<td>11.6158</td>
<td>2.23978</td>
<td>7.48</td>
<td>17.10</td>
</tr>
<tr>
<td>Willems Method</td>
<td>140</td>
<td>9.4953</td>
<td>2.68850</td>
<td>4.35</td>
<td>16.03</td>
</tr>
<tr>
<td>Cameriere Method</td>
<td>140</td>
<td>10.4816</td>
<td>2.05320</td>
<td>7.10</td>
<td>16.00</td>
</tr>
<tr>
<td>Total</td>
<td>560</td>
<td>10.2616</td>
<td>2.43151</td>
<td>4.35</td>
<td>17.10</td>
</tr>
</tbody>
</table>
### Compiled Tabulated Representation of Chronological Age, Demirijan, Willems and Cameriere Methods of Dental Age Estimation

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>437.097</td>
<td>3</td>
<td>145.699</td>
<td>28.247</td>
<td>.001*</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2867.838</td>
<td>556</td>
<td>5.158</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3304.935</td>
<td>559</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ANOVA**

<table>
<thead>
<tr>
<th>(I)</th>
<th>(J)</th>
<th>Mean Difference (I-J)</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Chronological Age</td>
<td>Demirijan Method</td>
<td><strong>-2.16207</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>.001*</td>
<td>-2.8616</td>
</tr>
<tr>
<td></td>
<td>Willems Method</td>
<td><strong>-0.04157</strong></td>
<td>.999</td>
<td>-.7411</td>
</tr>
<tr>
<td></td>
<td>Cameriere Method</td>
<td><strong>-1.02786</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>.001*</td>
<td>-1.7273</td>
</tr>
</tbody>
</table>

**TUKEY HSD**

- Negative sign in mean difference (mean prediction error) shows over-estimation with respect to chronological age and positive sign shows underestimation.
BAR GRAPH COMPARATIVE REPRESENTATION OF CHRONOLOGICAL AGE WITH DEMIRIJIAN, WILLEMS AND CAMERIERE METHODS OF DENTAL AGE ESTIMATION

For the total group, DM overestimated the children’s CA, and the mean prediction error was -2.16 years (for males = -2.18; females = -2.14). WM marginally overestimated the children’s CA and the mean prediction error was -0.04 years (for males = -0.19; females = 0.12). CM also overestimated the children’s CA and the mean prediction error was -1.02 years (for males = -0.99; females = -1.05). Only in case of WM (females) there was overestimation of age as compared to CA as the mean prediction error was 0.12.

Cross tabulation of age and sex groups was demonstrated in relation to real age. Amongst the age estimation methods used in this study, the Willem’s dental age estimation method proved to be the most accurate and consistent.

DISCUSSION

In recent years, age estimation has gained importance for a variety of reasons, like legal responsibility and social events etc. In India, legal requirements for age estimation include questions regarding criminal liability of an individual (a child <12 y is not liable, under certain circumstances), employability (work by children <14 y constitutes child labor), status of attaining majority for social issues like voting and for marriage.²⁻⁵

The term chronological age is used to refer to the actual age of an individual. Krogman defines chronological age as the ‘birthday – or calendric age of the child. It is based on sidereal time and is constant’.³⁻⁶

Often large differences are seen in growth and development rates among children of the same
chronological age. Hence, biological age is defined, and it marks different stages in a child’s development and maturity, whereas chronological age only roughly estimates a child’s maturity.\(^7\)

The concept of physiological age determination is based on the degree of maturation of different tissue systems. Several biological ages have been developed which include: skeletal age, morphological age, secondary sexual characters and dental age. These criteria can be applied individually or together to measure the degree of physiological maturity of a growing child.\(^8\)

The ability of an age estimation method to predict chronological ages (accuracy) closely and the extent to which estimated ages remain consistent over repeated measurements of the same individual (reproducibility) are basic characteristics for every practical purpose of the method.\(^9\) Dental age, refers to the morphological state of an individual’s dentition without reference to their actual age. Dental age estimation is more reliable than above methods described as it is less variable and genetically controlled. Saunders, a dentist, was the first to publish information regarding dental implications in age assessment by presenting a pamphlet entitled ‘Teeth A Test of Age’ to the English parliament in 1837.\(^10\)

Two different concepts of dental age estimation are present which include: (1) assessing eruption of teeth; (2) observing the mineralization of crowns and roots on radiographs of deciduous and permanent teeth.\(^11\) Most studies conducted after 1960 base dental age on the degree of development of the whole tooth and not on tooth eruption, and are thus considered reliable in determining dental age. The study of morphological parameters of teeth on dental X-ray of children is more reliable than most other methods for age estimation and is most commonly used to determine age. OPGs are considered the best tool for age estimation in children because intraoral radiography without image distortion is difficult to obtain in children.\(^7\)

Among many proposed methods, Demirjian's (1973) system of age assessment was widely accepted. The advantage of the Demirjian's method included the objective criteria describing stages of tooth development. Demirjian's method is related on evaluation of one from eight appropriate radiographic stages (A to H) of crown and root development on permanent teeth from left side of mandible excluding 3rd molar. Studies have proved that Demirjian's method tends to overestimate the dental age both in boys and girls. Hence, Demirjian's method needs an adaptation for every specific population.\(^8\)

Koshy S and Tendon S \(^12\) have done a study on the applicability of Demirjian's method in south Indian population in 184 children from 5 to 15 years of age and found an overestimation
of dental age.

As Demirjian’s method showed a significant over-estimation in other population, Willems (2001) modified the Demirjian’s technique by creating new tables from which a maturity score could be directly expressed in years. The tiresome step of converting maturity score to dental age was omitted making it simpler, yet retaining the advantages of Demirjian’s technique.

Cameriere R et al., took a completely different approach and published a mathematical formula for calculating dental age on teeth for some European countries. The method is based upon measuring the completeness of apical development via a computer method and all studies to date show a very strong correlation to chronological age. In the dental literature the existence of different patterns of dental maturation among different populations has been reported and hence, different standards were found in several countries.

The aim of the present study was to evaluate the accuracy of dental age estimation methods whilst comparing them with the chronological age among 6-13 year old children of Dist. Durg of state Chhattisgarh. The dental age was assessed from orthopantograms using Demirjian’s, Willems and Cameriere’s methods of dental age estimation.

The results of this study conducted found Willems’s method to be the most accurate of the three methods analyzed, followed by Cameriere’s method and then Demirjian’s method respectively. A research study evaluating the accuracy of the Demirjian’s, Willems and Cameriere methods of estimating dental age on the Turkish children showed similar results as the study conducted. And is highly supportive of the same.

Although another study assessing the accuracy of age estimation in children using radiographs of developing teeth by Cameriere R et al. where the same three methods were used to co-relate the dental age estimation with chronological age in white Italian, Spanish and Croatian children showed results where the Willems method was better than that of Demirjian thereby supporting the results of this study but on the other hand contradictory to the findings of the same Cameriere’s method was found to be more accurate than Willems method. But another study carried out by El-Bakary AA et al. conducted on Egyptian children found Willems method to be more accurate compared to Cameriere’s method which is similar to the findings of this study.

Various studies, namely those carried out by Ambarkova V. et al., Ye X. et al. and Manni SA. et al. where Demirjians and Willems methods were compared to assess the accuracy of the co-relation between dental age estimation and the chronological age deduced that Willems method was more accurate as compared to Demirjian’s which were in agreement with the result of the study conducted.
There was overestimation and underestimation of age in almost equal number of groups with Willem's method. However, these differences of chronological and dental age by Willem's method were consistently smaller than those between chronological age and dental age by Demirjian's method. This suggested that Willem's method is more accurate than the Demirjian's method for the population under study. This finding is supported by Mani et al., Maber et al., and Willems et al.

CONCLUSION

According to the results of this cross-sectional study, evaluating the accuracy of correlation between chronological age and dental age by comparatively analyzing Demirjians, Willems and Cameriere methods for dental age estimation.

The following conclusions were drawn within the limitations of this study:

- Results showed that all three age estimation method used overestimated the age of children.
- The Willems method slightly over estimated the real age of the children although on bio statistical analysis it was found to be non-significant.
- This was followed by cameriere’s method, where the over estimation was found to be bio-statistically significant.
- Demirjian’s method revealed maximum over estimation and the difference was found to be bio statistically significant.

Amongst the age estimation methods used in this study, the Willem's dental age estimation method was found to be the most accurate and consistent, although it would be pertinent to mention here that more research study needs to be conducted to authenticate the results of this study further.

Conflict of interest statement

Neither the author or any of the coauthors have any potential conflict of interests related to the publication of this paper.
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