Applicability of Modified Demirjian and Modified Fanning and Moores Method of Age Estimation in an Outpatient Population

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ABSTRACT

Introduction: Age estimation is one of the most important factors in forensic science, as it helps in solving criminal cases, and helps in identification of deceased persons. Predicting age is very crucial in the forensic context. The third molar is the only tooth developing during this chronological period and has been used to estimate minority/majority status (<≥18 years). It has a protracted time of development.

Materials and Methods: Demirjian’s grading has been used to assess third molar development although the method was not originally intended for evaluating this tooth. Demirjian incorporated a third molar assessment in a recent modification and replaced the alphabetical grading (A to H) with a numerical scale (0 to 9). Moore’s Fanning and Hunt method was also assessed; it was mainly based on 14 stages of tooth development, and the values were statistically analysed. Aim of the study is to compare and evaluate the accuracy of the Demirjian method and Moore’s and Fanning method of age estimation of lower 3rd molars (38) in an outpatient population. The study was conducted using 100 OPGs of 50 males and 50 females. The Method used for calculating the dental age was the Demirjian method and Modified Moore’s Fanning and Hunt methods.

Results: The values were statistically analysed, and polynomial regression graphs were added for accuracy of both methods.

Conclusion: The study shows that modified Fanning and Muoress methods and Demirjian methods show high accuracy in age estimation.

Keywords: Age determination, Moore’s Fanning and Hunt method, Demirjian method, Innovative Technique.

INTRODUCTION

Age estimation is a sub-discipline of forensic sciences and it is an important part of every identification process especially when information relating to the deceased is unavailable. Various radiographic methods are available depending on tooth calcification, among them the most accepted method of age estimation is based on developmental stages of seven left permanent Mandibular teeth.

Usage of mineralization of teeth calcification for age assessment is Moore’s method. The Demirjian method presents and assesses eight stages, which is frequently used for estimation of chronological age, due to its simplicity. Whether to check if the tooth is single rooted or multi rooted is the critical part in Moore’s method. (Moore’s et al, 1963) The main importance in age estimation lies in the assessment of criminal liability and protection of unaccompanied minor immigrants, when their age is unknown.

Age estimation is an important tool in forensic science, because it is correlated with crimes and accidents. Tooth development is an important measure of maturity, it represents a series of events that occur in the same sequence from initial event to end point. Moore’s method is the dental development which was studied in 14 stages of mineralization, the stages were assigned to each tooth according to Smith’s table. Considering that tooth mineralization is less affected

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based on environmental and hormonal variations that state bone mineralization, dental development is a more reliable indicator of chronological age and dental age than that of bone development.6 Various methods are available for age estimation in children - Atlas and Scoring; among these in the current study we have chosen 2 methods, 1. Demirjian 2. Moore’s fanning methods. The aim of our present study is to determine the dental age from a panoramic radiograph using Demirjian method and Moore’s method, to evaluate the techniques of both in an outpatient population. Usually, these methods are used to identify the dental age in deceased people, and to identify the similar morphology for further identification.7 This study fulfills the deficiency of finding the age for orphans using dental age as an indirect measure for the identification of chronological age. (Köhler S, Schmelzle R, Loitz C, Püschel K. Development of wisdom teeth).8 Several studies have been conducted to assess the applicability of these methods to subject the ethnic, socioeconomic and environmental characters different from those of samples used in their elaboration, bearing in mind that most have been conducted in European subjects; considering the fact that tooth maturation studies are scarce in Latin America, among various types of age estimation Dermerijian and Moore’s, methods divides the dental development in 11 stages. Therefore, in the current study, these two methods for age estimation have been evaluated in an outpatient population in a tertiary dental care hospital in South India. The aim of our study is to compare and evaluate the accuracy of Demirjian method and modified Moores and Fanning method of age estimation of lower 3rd molar [38] in a representative outpatient population of a tertiary dental care hospital of a major city in South India.

**MATERIALS AND METHODS**

The study was conducted in the department of Oral Pathology and Dental Anatomy, in Saveetha Dental College and Hospitals. A total of 100 subjects of both male [50] and female [50] of age group, from 10-19 years were included in the current study.

Radiographs of the outpatient population were collected and the age estimated on both Demirjian method and Moore’s method, based on Moores CFA, Fanning and Hunt, “Age variation of formation of tooth”. Modified Moore’s and fanning method in 1963 based on age estimation, were detected and used in our study. The chronological age range was from 10 to 19 years of both genders.

**Inclusion Criteria:**

The inclusion criteria consist of a complete set of both maxillary and Mandibular permanent teeth and radiographs of good diagnostic quality. For each and every individual included in the study, panoramic radiographs, which analysed the stages of development of teeth according to criteria given by both Demirjian and Moore’s method.

**Moores and Fanning Method**

MOORES METHOD: Dental development was studied in 14 stages of mineralization for the development of single and multi-rooted tooth of permanent Mandibular teeth. The age was determined from the date of birth and recorded as years. All the relevant data was entered in google sheets, and the correlation between male and female were checked. The data assessed were tabulated and statistically analysed.

The mean score for each method was calculated from the numerical values of the present third molars. These values were then plotted according to actual age. A trend line was applied to each figure using a polynomial regression formula. The polynomial regression trend line was utilized as it accounts for the most variance. The equation representing the polynomial trend line and the coefficient of determination ($R^2$) were then determined. Polynomial functions have been found to show a high reliability and accuracy in such studies, and both are desirable in forensic applications.

**RESULTS AND DISCUSSION**

**Age Estimation Methods:**

Accurate age estimation is considered to be of great importance in dental and medical practices.11 The aim of ideal age estimation method is to achieve an age that is as close as

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Gender N</th>
<th>Chi-square value ($\chi^2$)</th>
<th>Degree of freedom (df)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0-10.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.0-11.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.0-12.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.0-13.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.0-14.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.0-15.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.0-16.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.0-17.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.0-18.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.0-19.9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Demographic profile of study population by age and gender**

Interpretation: There is no significant difference in the gender distribution between the age groups.
possible to chronological age. One of the simplest and widely accepted age estimation is Demirjian method; Age was estimated with oral panoramic radiograph, standard deviation was calculated of both the methods, and mean value was calculated for both the methods, for both genders.

Variations have been recorded between different populations and between gender within populations on age estimation by different methods. This necessitated an evaluation between genders and population specific enquiry. Since documentation of age estimation methods in the South Indian population are not established, we evaluated modified Demirjian’s method and Modified Fanning and Hunt method in an outpatient population of a tertiary dental care hospital of Chennai.

**Demirjian Method:**
Demirjian’s method assigned alphabetical orders for third molars (A-H). This was converted to numerical numbers to aid in statistical evaluation similar to a study by Bassed et al. The current study revealed Demirjian’s method to have a strong positive correlation with the actual age. This holds good for both genders with males being more positively correlated.

**Moores Method:**
In a study done earlier, it was found that Moores method underestimated the age. (4,13) The present study showed

<table>
<thead>
<tr>
<th>Gender</th>
<th>Actual age and age estimation methods</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALE</td>
<td>Actual age</td>
<td>14.819</td>
<td>0.30561402824</td>
</tr>
<tr>
<td></td>
<td>Demerjian’s method</td>
<td>5.32</td>
<td>2.90259047355</td>
</tr>
<tr>
<td></td>
<td>Modified Flamming and Moores method</td>
<td>7.2</td>
<td>2.7663394829</td>
</tr>
<tr>
<td>FEMALE</td>
<td>Actual age</td>
<td>14.798</td>
<td>0.28077607384</td>
</tr>
<tr>
<td></td>
<td>Demerjian’s method</td>
<td>5.04</td>
<td>2.5565492053</td>
</tr>
<tr>
<td></td>
<td>Modified Flamming and Moores method</td>
<td>6.48</td>
<td>3.1764989506</td>
</tr>
</tbody>
</table>

In the current study, the standard deviation for the Demirjian method was 2.9025 for male, and for female it is 2.556, similarly modified Fanning and Moore’s method for male is 2.766 and for female it is 3.1764. Hence both methods were considered for calculating dental age.

**Table 2:** Mean, Standard Deviation for actual age, Demirjian method, and modified Moore’s and fanning method for both genders.

![Fig. 1: Moores and Fanning Method](image1)

![Fig. 2: Demirjian’s method](image2)

![Fig. 3: Orthopantomograph showing the lower left 3rd molar](image3)
Table 3: Correlation between actual age and Demirjian’s method of age estimation of third molars by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Correlation</th>
<th>Correlation coefficient (r)</th>
<th>p value</th>
<th>R square</th>
<th>Beta coefficient (β)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>Actual age vs Demirjian’s method</td>
<td>0.819</td>
<td>0.000#</td>
<td>0.659</td>
<td>0.440</td>
<td>0.000*</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>0.890</td>
<td>0.000#</td>
<td>0.741</td>
<td>0.508</td>
<td>0.000*</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>0.768</td>
<td>0.000#</td>
<td>0.534</td>
<td>0.370</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* Polynomial regression
# Spearman’s correlation

Interpretation: There is a positive strong correlation between the actual age and Demirjian’s method of age estimation (r=0.819). There is a positive strong correlation between the actual age and Demirjian’s methods of age estimation of males and females (r=0.890; 0.768).

Fig. 4: Scatterplot with polynomial regression line trends for actual age and Demirjian’s method
Table 4: Correlation between actual age and Moores, Fanning method of age estimation of third molars

<table>
<thead>
<tr>
<th>Gender</th>
<th>Correlation</th>
<th>Correlation coefficient (r)</th>
<th>p value</th>
<th>R square</th>
<th>Beta coefficient (β)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>Actual age vs Moorrees method</td>
<td>0.851</td>
<td>0.000#</td>
<td>0.730</td>
<td>0.893</td>
<td>0.000*</td>
</tr>
<tr>
<td>Male</td>
<td>0.884</td>
<td>0.000#</td>
<td>0.753</td>
<td>0.694</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.831</td>
<td>0.000#</td>
<td>0.707</td>
<td>0.817</td>
<td>0.001*</td>
<td></td>
</tr>
</tbody>
</table>

* Polynomial regression

# Spearman’s Correlation

**Interpretation:** There is a strong positive correlation between actual age and Moores method of age estimation (r=0.851). There is a strong positive correlation between actual age and Moores method of age estimation in males and females (r=0.884; 0.831).

Table 5: Polynomial regression equation and R square values of overall mean scores of third molars for each method

<table>
<thead>
<tr>
<th>Gender</th>
<th>Demirjian’s Method</th>
<th>Moores Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>(Y = -4.76 + 1.07x - 0.02x^2)</td>
<td>(Y = -16.94 + 2.48x - 0.05x^2)</td>
</tr>
<tr>
<td>Male</td>
<td>(Y = -3.41 + 0.81x - 0.01x^2)</td>
<td>(Y = -16.85 + 2.4x - 0.05x^2)</td>
</tr>
<tr>
<td>Female</td>
<td>(Y = -6.15 + 1.35x - 0.03x^2)</td>
<td>(Y = -16.71 + 2.52x - 0.06x^2)</td>
</tr>
</tbody>
</table>

Fig. 5: Scatterplot with polynomial regression line trends for actual age and Moores, Fanning and Hunt method
that the Moore's Fanning and Hunt method had a strong positive correlation with actual age. In another study where the correlation was checked for different ages among which positive correlation was found for younger ages, whereas when it was compared with adult ages, there is a low applicability with Demirjian.\textsuperscript{10}

A further study where a comparison of root maturation between 37 and 38 was evaluated, it was found that males have shown more accuracy than females in root maturation.\textsuperscript{10}

**Conclusion**

The current study concludes that both Modified Demirjian method and Modified Fanning and Moore's method can be used for age estimation. There was a definite strong positive correlation between these methods and actual age respectively. Males tended to have much more positive correlation than females though it was not significantly different among the genders. Therefore, among the outpatient population tested, both Modified Demerjian method and Modified Moores, Fanning and Hunt method showed positive predictability. This result necessitates wider testing on the differing South Indian populations to get an established documentation data.

**References**

14. Little TJ, O’Toole AN, Rambaut A, Chandra T, Marioni R, Pedersen AB. Methylation-Based Age Estimation in a Wild Mouse [Internet]. Available from: http://dx.doi.org/10.1101/2020.07.16.203687