

## Original Article

# Age Determination by Schour and Massler Method: A Forensic Study

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### INTRODUCTION

The development and eruption of teeth are useful dental events to assess age.<sup>[1]</sup> The tooth development process starts from the initiation of tooth bud formation from the embryonic cells and continues till complete root development.<sup>[2]</sup> When the root formation reaches three-fourth of the total root length, the tooth begins to erupt in the oral cavity. In a healthy individual, the development and eruption occur in a rhythmic pattern according to the age.<sup>[2,3]</sup> Hence, we can correlate the chronology of teeth eruption with the age of human being. Hence, it became an important tool for determining the biological age of human beings in forensic needs when the birth date is not known. Biological age may be expressed as either skeletal age (SA) or dental age (DA).<sup>[4]</sup> The methods which are related to teeth are highly reliable to determine the biological age of human beings because the teeth are highly mineralized and minimally affected by environmental and nutritional insult compared with other hard tissues of the body.<sup>[5]</sup>

Age estimation using dental methods are specifically based on age-related variables observed in teeth.<sup>[6]</sup> These methods are mostly based on the subjective prediction of radiological aspect of stages of dental development.<sup>[7]</sup> Practical experience is learned by observing and recording age-related features on collected radiograph and the obtained data are compared with the matching age estimation methods.<sup>[8]</sup> Hence, the

### ABSTRACT

**Introduction:** Age determination can be done by assessing the developmental and eruption status of dentition in the oral cavity. Schour and Massler studied the development of human dentition radiographically and histologically and put forward a chart explaining the stages of both deciduous and permanent teeth development in 21 stages. This chart is used in this study to estimate the age in the study population.

**Aim:** The aim of the study was to check the efficacy of Schour and Massler method in determining the age of the study population using Schour and Massler chart of teeth development.

**Methodology:** This study comprised of 62 panoramic images, taken from the department of oral medicine and radiology archives. Age was assessed by comparing the tooth developmental stages on panoramic radiographs with the standards using Schour and Massler chart. To check the accuracy of the present method, the actual age of the samples was matched with the dental age (DA) estimated by Schour and Massler method.

**Results:** Data were statistically analyzed using paired *t*-test and correlation was done. It showed a strong correlation between the actual age and DA by Schour and Massler method.

**Conclusion:** Schour and Massler method is a reliable method for age estimation in the study population.

**KEYWORDS:** Age determination, Schour and Massler method, teeth development

age may be expressed in terms of the time of emergence of teeth or the state of maturation of their mineralization and it is accepted that the process of mineralization is genetically determined.<sup>[9]</sup> The development of human dentition follows a reliable and predictable sequence, begins from the 4<sup>th</sup> month after conception, and continues to the beginning of the third decade of life.<sup>[10]</sup>

Each tooth passes through morphological stages such as initiation, bud, cap, and bell stages and the eruption process and well described in histological studies.<sup>[11]</sup> The eruption time coordinates with the osseous maturity in humans and this correlation is shown to be important to consider.<sup>[12]</sup> This can also be correlated with the physiological age. The radiographs are more definitive for age assessment during developmental stages such as appearance of tooth germs, earliest detectable trace of mineralization or beginning of mineralization, degree of crown completion, time of emergence of the tooth in the oral cavity, degree of root completion of erupted or unerupted teeth, degree of resorption of deciduous teeth, and measurement of open apices in teeth.<sup>[13]</sup>

Schour and Massler in 1941 introduced a chart explaining the development and eruption of human dentition.<sup>[14]</sup> They studied the development of deciduous and permanent teeth in seven

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stages, i.e., prenatal (4.5–5 months utero), neonatal (at birth), infancy (birth to 6 months), childhood (2–6 years), early grade school (6–10 years), prepubertal period (10–12 years), and adulthood (12–21 years) using histological and radiographical method.<sup>[14]</sup> They also compared the calcification stages of teeth on radiographs with the standards. The proposed numerical chart describes 21 chronological steps of teeth development ranging from 5 months *in utero* to 21 years of age. The American Dental Association (ADA) has periodically updated these charts and published them in 1982.<sup>[3]</sup>

The actual age of the individual is also known as chronological age (CA) and the documentation of birth is one of the most important factors determining CA. The actual age can be calculated by subtracting the date of birth from the date of assessment, if the date of birth is available. However, in forensics, it is not necessary that the date of birth should be available always to assess the actual age. In those conditions, the dental methods are helpful to determine the age.<sup>[4]</sup> Hence, the present study was performed to check the efficacy of Schour and Massler method in determining the age of the study population by comparing the DA estimated using Schour and Massler chart of teeth development with the actual age of the population.

### METHODOLOGY

The present study was conducted in the Department of Oral Medicine and Radiology, Yenepoya Dental College and Hospital, Mangalore. This retrospective study comprised of 62 panoramic images from the department archives which were taken for various diagnostic and therapeutic purposes. The images of the individuals within the age group of 5–16 years with equal numbers of males and females were selected for the study. Samples included healthy individuals' panoramic radiographic images with all complement set of teeth in complete or incomplete developmental stages. Only good quality radiographic images were taken for the study. Radiographic images with developmental anomalies, pathologies, and faulty images were excluded from the study.

A standard protocol was followed to examine the panoramic images. The panoramic images, stored in the computer with

Agfa NX Software, were retrieved and viewed on the screen. Age estimation was done by directly comparing the stages of tooth development on panoramic radiographs with the Schour and Massler chart [Figure 1].<sup>[14]</sup> The necessary details such as date of birth and date of radiograph taken were recorded for the calculation of chronological or the actual age. Once the DA was estimated using the present method, accuracy was checked by matching the DA with the actual age which was calculated using the formula,

$$\text{Actual/Chronological age} = (\text{date of radiograph taken} - \text{the date of birth})$$

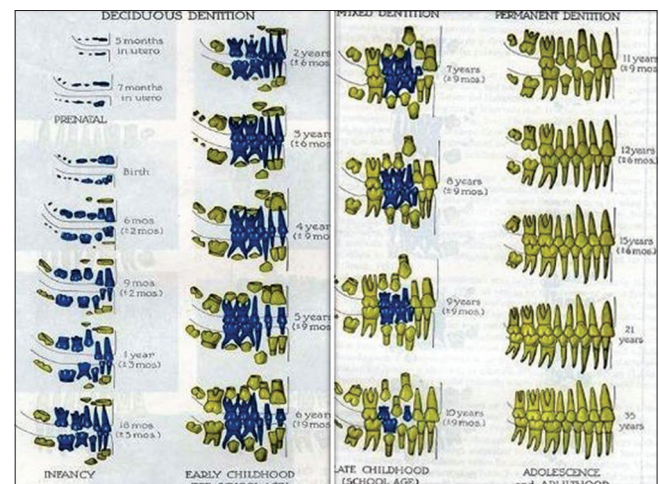
Parameters recorded were subjected to a descriptive statistical analysis and evaluated. The paired *t*-test and the correlation analysis were performed to compare the values obtained and to assess the relationship between them.

### RESULTS

In statistical analysis, the descriptive statistical analysis of data was done. To assess the relationship between the DA by Schour and Massler method and the actual age of the samples, correlation test was performed. This showed that statistically there was no significant difference between the two ages and exists a strong correlation between them [Table 1 and Figure 2], with a coefficient of 0.953 at  $P < 0.001$ . Since these showed a strong correlation, a regression analysis of the data was also performed to estimate the chronological/actual age using the age by Schour and Massler method [Table 2] and a formula is derived which can be used to determine the chronological or

**Table 1: Correlation between chronological age and age by Schour and Massler method**

	<i>n</i>	Correlation	<i>P</i>
Chronological age (years) and age by schour and massler method (years)	62	0.953	<0.001*



**Figure 1:** Dental development chart by Schour and Massler

**Table 2: Results of regression analysis - Estimation of chronological age by using the age by Schour and Massler method**

Model	Coefficients <sup>a</sup>						
	Unstandardized coefficients		Standardized coefficients	<i>t</i>	Sig.	95.0% Confidence Interval for <i>B</i>	
	<i>B</i>	Std. Error				Lower Bound	Upper Bound
(Constant)	-0.677	0.500		-1.354	0.181	-1.678	0.323
Age by schour and massler method (years)	1.105	0.046	0.953	24.252	0.000	1.014	1.197

<sup>a</sup>Dependent Variable: Chronological age (years)

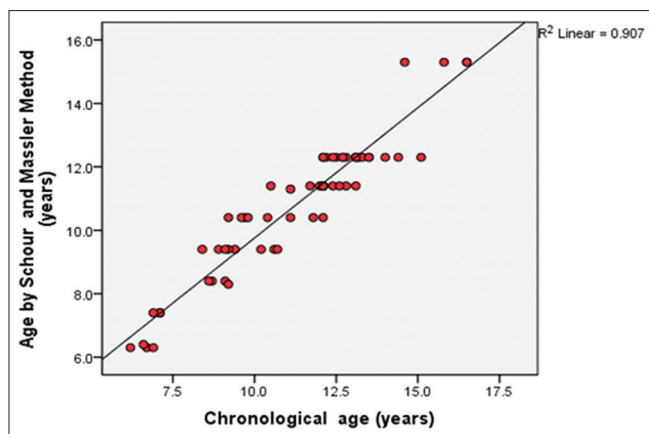


Figure 2: Graph representing correlation

actual age in the study population. The regression formula is as follows,

Chronological age =  $-0.677 + 1.105 \times$  (Estimated age by Schour and Massler Method)

## DISCUSSION

Schour and Massler<sup>[14]</sup> method is one among the oldest methods in age estimation. In this method, panoramic radiographs are used to determine the DA. Here, to estimate the DA, the development of teeth and state of eruption are taken into consideration. Schour and Massler chart of teeth development is used as a standard to compare the panoramic radiographs and was derived from the clinical status of 25 patients. It was originally intended just as a guide for dentists, but it is also widely used for the age estimation in archaeology.

The chart consists of a series of 21 drawings from *in utero* to adulthood. Each drawing shows one side of the jaws with outlines of developing teeth and eruption relative to the gingival line and corresponding age. The age categories are consecutive up to age 12 after which the next category is 15 years of age. At 21 and 35 years, the chart shows fully formed and erupted teeth. In this chart, the age is given in ranges and is applicable to both males and females. This chart was published in the Journal of the ADA as an attachment.

In the present study, 62 samples with an equal number of males and females within the age group of 5–16 were selected. In 30 patients below the age of 12 years, 14 patients (7 males and 7 females) showed approximately the same age as that of chronological age (CA). Eight patients (4 males and 4 females) showed an overestimation of  $\approx 1$  year  $\pm 6$  months and eight patients (6 males and 2 females) showed an underestimation of the age of  $\approx 1$  year  $\pm 6$  months. In 32 patients above the age of 12 years, nine (4 males and 5 females) showed approximately the same age as that of CA. One female patient showed an overestimation of  $\approx 1$  year  $\pm 6$  months and 20 patients (10 males and 10 females) showed an underestimation of  $\approx 1$  year  $\pm 6$  months. Two females showed an underestimation of  $\approx 2$  year  $\pm 6$  months which showed a considerable variation.

The present study shows that, up to the age of about 12 years, most estimates fall near the real age, and also some

showed the difference of more than a year. However, above the age of 12 years, there was a considerable difference of  $\approx 2$  year  $\pm 6$  months between the CA and the estimated age in some patients in this study. This is in agreement with a study conducted by A E Miles on 58 English children.<sup>[15]</sup> In his study above the age of 12 years, there was an increasing amount of variation and many were 2 years or more above or below the line. This is because of the interval in the sequence of age categories in the Schour and Massler chart. Schour and Massler omitted several age categories where tooth development is highly variable. Although the sample was too small for any definite conclusions to be drawn, Schour and Massler chart of age estimation was accurate for English children.

Ebrahim *et al.*<sup>[9]</sup> in 2014 conducted a study in 25 patients showed a strong correlation between the estimated and CA. In this study, five children showed overestimation, ten children showed approximately the same as that of the CA, and ten showed an underestimation of  $\approx 1$  year  $\pm 6$  months. Statistical analysis showed that there was no significant difference between chronological age and the age by Schour and Massler method ( $P < 0.1$ ). The regression formula derived had determinants which are variable for males and females. In the present study, 24 patients showed approximately the same age as that of CA. Nine patients showed overestimation and 27 patients showed an underestimation of  $\approx 1$  year  $\pm 6$  months. Two females showed an underestimation of  $\approx 2$  year  $\pm 6$  months. The statistical analysis of the present study showed that there was no significant difference between the CA and age by Schour and Massler method and had a strong correlation between them in the study population. The regression formula derived can be used for determining the CA in the study population.

Rai *et al.*<sup>[16]</sup> conducted a study in 2014 to investigate the relationship between the DA and SA of children and comparing it with the CA. In that study, they studied the efficacy of Schour and Massler method and compared with other methods using the orthopantomograms of 150 healthy subjects within the age range of 5–15 years and compared with the CA. Finally, the data collected were statistically analyzed using the SPSS version 15.0 statistical analysis software with  $P < 0.05$ . The result showed correlation between the dental and CA. This supported the results of the present study that showed a strong correlation between the DA and the CA.

Baylis and Bassed<sup>[17]</sup> in 2017 conducted a study to test the precision and accuracy of three dental development charts (Schour and Massler, Blenkin and Taylor, and the London Atlas) used to estimate DA of a sample of New Zealand juveniles between the ages of 5 and 18 years old ( $n = 875$ ). DA was calculated by comparing the developmental stages with the charts. CAs were compared to estimated DAs using a two-tailed paired *t*-test ( $P < 0.05$ ) for each of the three methods. The mean differences between two ages were calculated to determine bias and the absolute mean differences were calculated to indicate accuracy. The results of this study show that, while accuracy and precision were low for all charts tested against the New Zealand population

sample, however, the Blenkin and Taylor Australian charts performed best overall. This is due to the age gap in the Schour and Massler chart after the age of 12 as this study group contains samples of age up to 18 years. In the present study, most of the samples were around the age of 12 years, so the method became significant in the study population.

### LIMITATIONS

Even though it is a simple method to assess the age, there are limitations which affect the results of this method in determining the age. They include first the midpoint of age intervals differs by 6 months (year start or midyear). Second, Schour and Massler omit several age categories where tooth development is highly variable.<sup>[5]</sup> The chart does not have separate surveys for males and females.<sup>[18]</sup> Furthermore, the gaps in the sequence of age categories; for example, after 12 years the chart directly refers to 15 years that affects the accuracy of this method and also the age range is not mentioned when the third molar is in its various stages of root development.<sup>[5]</sup>

### CONCLUSION

The DA estimation by Schour and Massler method is more acceptable than other tooth specific methods. This is a simple and less time-consuming method. The present study showed the reliability of Schour and Massler method in estimating the age in the study population. However, more studies are required with large sample size to strengthen the efficacy of this method and there need a modification in Schour and Massler chart to overcome the limitations in future.

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### CONFLICTS OF INTEREST

There are no conflicts of interest.

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