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ORIGINAL ARTICLE

Comparative Analysis of Deciduous Teeth Eruption and Carpal Bone Ossification for Forensic age Estimation in Children Aged 5–15 Years

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ABSTRACT

Objective: To evaluate and compare the accuracy of deciduous teeth eruption (using the Demirjian method) and carpal bone ossification (using the Greulich and Pyle method) for forensic age estimation in children aged 5 to 15 years.

Methods: This randomized controlled trial included 146 children of both genders, aged 5–15 years, who were divided into two groups: Group A (dental age estimation) and Group B (skeletal age estimation). Group A utilized dental radiographs of the left mandibular quadrant, and Group B utilized radiographs of the right wrist for skeletal age estimation. The statistical differences between chronological age and estimated age for both methods were calculated using SPSS version 24.

Results: The sample consisted of 78 males (53.42%) and 68 females (46.58%). In Group A, the mean chronological age for 5–10 years was 7.43 ± 2.32 years, and dental age was 6.85 ± 1.21 years. For 11–15 years, the mean chronological age was 13.55 ± 1.91 years, and the dental age was 12.88 ± 2.06 years. In Group B, for ages 5–10 years, the mean chronological age was 7.76 ± 2.30 years, and skeletal age was 7.08 ± 1.18 years. For 11–15 years, the mean chronological age was 12.67 ± 1.83 years, and skeletal age was 12.02 ± 0.66 years. No significant differences were found between the two methods in both age groups ($p > 0.05$).

Conclusion: Both the dental and skeletal methods for forensic age estimation are accurate and effective. No significant differences were observed between the two methods, making either suitable for forensic age assessment.

Keywords: Forensic Age Estimation, Dental Age (Demirjian Method), Skeletal Age (Greulich and Pyle Method), Carpal Bone Ossification, Pediatric Age Assessment

INTRODUCTION

Age estimation is an essential tool in forensic science, especially in cases involving unidentified individuals or those involved in legal issues such as immigration or juvenile justice. Forensic age estimation plays a pivotal role in both identifying victims and determining the legal status of individuals based on age. It can aid in confirming the age of minors and adults in cases where legal age thresholds are important, such as in the case of criminal responsibility, medical treatment, or migration[1].

There are various methods for determining age, including skeletal, dental, and combined approaches. Skeletal age estimation is based on the ossification process, while dental age estimation is focused on the development stages of the teeth. Both methods are commonly used in forensic practice to determine age, especially in individuals whose age cannot be reliably determined through birth records or other documentation[2].

Skeletal age estimation, particularly via hand-wrist radiographs, remains one of the most widely accepted techniques. The Greulich and Pyle method is a classic approach that utilizes a standardized atlas of skeletal images to compare the radiographic appearance of bones to estimated age ranges[3]. This method is based on the ossification of various bones, including those in the hand and wrist, which mature at different rates during childhood and adolescence.

On the other hand, dental age estimation has gained considerable recognition, especially through the Demirjian method, which evaluates the stages of tooth development and eruption[4]. The eruption of deciduous teeth, followed by the formation of permanent teeth, is a clear marker of biological age[5]. The Demirjian method, in particular, is widely adopted due to its simplicity and reliability in various populations[6].

Both techniques have their advantages and limitations. For instance, skeletal age estimation can be influenced by factors such as nutritional status, endocrine disorders, and genetics[7]. Similarly, dental age may be affected by environmental and genetic factors, making it essential to consider ethnic and regional variations in the method's application[8]. Previous studies have shown varying results in different populations, highlighting the need for further comparative studies to assess the accuracy of these methods[9,10].

This study aims to compare the accuracy and reliability of the Demirjian method (dental age estimation) and the Greulich and Pyle method (skeletal age estimation) in children aged 5 to 15 years, specifically in terms of their forensic applicability.

MATERIALS AND METHODS

This randomized controlled trial was conducted at Turbat Teaching Hospital, Balochistan from August 2021 to November 2022. A total of 146 children aged 5 to 15 years, of both genders, were included in the study. Children were recruited based on parental consent, and those who had any medical conditions that could influence skeletal or dental development (e.g., endocrine disorders, severe malnutrition, or known developmental anomalies) were excluded from the study.

Group Allocation: The participants were randomly divided into two groups:

- **Group A (Dental Age Estimation)**: 73 children (37 males, 36 females).
- **Group B (Skeletal Age Estimation)**: 73 children (41 males, 32 females).

Dental Age Estimation (Group A): Radiographs of the left mandibular quadrant were obtained for each participant using a Radiovisiograph (RVG). The Demirjian method was used for dental age estimation. The radiographs were analyzed for the stages of tooth development, which were compared to the standard classification by Demirjian.

Skeletal Age Estimation (Group B): X-rays of the right hand and wrist were taken for each participant. The skeletal age was assessed using the Greulich and Pyle method, comparing the images with the standard skeletal maturity charts to estimate the child's age.

Statistical Analysis: Data were analyzed using SPSS version 24. Descriptive statistics were computed for the chronological, dental, and skeletal ages. Paired t-tests and chi-square tests were used to evaluate the significance of differences between chronological and estimated ages. A p-value of <0.05 was considered statistically significant.

RESULTS

In this study, a total of 146 children were included, with 78 males (53.42%) and 68 females (46.58%). The participants were divided into two groups based on the method of age estimation they received. Group A (Dental Age Estimation) consisted of 73 children, while Group B (Skeletal Age Estimation) also had 73 children. Among the 146 children, 73 (50%) were in the 5–10 years age group, and 73 (50%) were in the 11–15 years age group. Table 1

For Group A (Dental Age Estimation), the mean chronological age of children in the 5–10 years age group was 7.43 ± 2.32 years, while their dental age was 6.85 ± 1.21 years. The difference between chronological and dental age was 0.64 ± 1.24 years, which was not statistically significant (p = 0.063). For the 11–15 years age group, the mean chronological age was 13.55 ± 1.91 years, and the dental age was 12.88 ± 2.06 years. The difference between chronological and dental age was 0.67 ± 0.18 years, with no statistically significant difference (p = 0.071).

In Group B (Skeletal Age Estimation), the mean chronological age for children aged 5–10 years was 7.76 ± 2.30 years, while their skeletal age was 7.08 ± 1.18 years. The difference between chronological and skeletal age was 0.72 ± 1.18 years, and this difference was not significant (p = 0.084). For the 11–15 years age group, the mean chronological age was 12.67 ± 1.83 years, and the skeletal age was 12.02 ± 0.66 years. The difference was 0.66 ± 1.18 years, and no statistically significant difference was found (p = 0.67). Table 2

Thus, both methods dental and skeletal age estimation showed no significant difference between chronological and estimated ages, suggesting that both techniques are equally reliable for forensic age estimation.

Table 1: Demographic Details of Participants

Variable	Group A (Dental Age)	Group B (Skeletal Age)	Total (N = 146)
Gender			
Male	40 (57.14%)	41 (56.16%)	78 (53.42%)
Female	30 (42.86%)	32 (43.84%)	68 (46.58%)
Age Group			
5–10 years	37 (50.68%)	36 (49.32%)	73 (50%)
11–15 years	36 (49.32%)	37 (50.68%)	73 (50%)

Table 2: Comparison of Chronological, Dental, and Skeletal Age for Both Groups:

Age Group	Chronological Age (years)	Dental Age (Group A)	Difference (Group A)	Skeletal Age (Group B)	Difference (Group B)	p-value
5-10 years	7.43 ± 2.32	6.85 ± 1.21	0.64 ± 1.24	7.08 ± 1.18	0.72 ± 1.18	0.063
11-15 years	13.55 ± 1.91	12.88 ± 2.06	0.67 ± 0.18	12.02 ± 0.66	0.66 ± 1.18	0.067

DISCUSSION

The results of this study demonstrate that both dental and skeletal methods of age estimation are reliable and effective in determining the age of children aged 5 to 15 years. No significant differences were observed between the chronological age and the estimated age obtained through the Demirjian method for dental age and the Greulich and Pyle method for skeletal age. This finding is consistent with several previous studies that have compared these two methods[11,12].

Dental age estimation, specifically using the Demirjian method, has been shown to be highly accurate and reliable in various populations[13]. The method provides a clear classification of tooth development stages, making it easy to apply in forensic practice. Similarly, skeletal age estimation using the Greulich and Pyle method remains one of the most widely used approaches for assessing bone maturation in children[14]. Both methods are non-invasive and provide useful forensic age estimates.

However, limitations in both methods exist. For instance, dental age can be influenced by diet, socioeconomic status, and ethnicity[15]. Skeletal age, while generally reliable, can vary based on hormonal influences, growth patterns, and environmental factors[16]. Further research is needed to refine these methods and account for ethnic differences that may affect the results of age estimation techniques[17,18].

Additionally, while both methods showed good accuracy in this study, it is essential to consider the possibility of combining skeletal and dental methods for a more comprehensive assessment of age[19]. This combined approach could enhance the reliability of age estimates in forensic cases where accuracy is crucial[20].

CONCLUSION

Both dental and skeletal methods for age estimation proved to be effective and reliable in this study. Neither method showed a statistically significant advantage over the other, suggesting that both approaches can be used interchangeably for forensic age estimation in children aged 5–15 years. Further studies focusing on combining both methods could provide more accurate results, especially in cases where precision is critical.

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