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Comparison Of Dental And Skeletal Age Determination In Adolescents At A Dental Hospital In Rajasthan: A Retrospective Study To Determine Impact Of Changing Puberty Trends.

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Abstract
Background*: Over the last decade, a global trend has been documented indicating an earlier onset of puberty. Ergo, it would be considered unwise to rely solely on chronological age as a definitive indicator for assessing a child's maturity status. Deception may occur in various cases especially if forensic identification of a deceased is concerned. In this regard, a retrospective study was conducted on adolescents of age group 10 - 16 years in a Dental Hospital in Rajasthan to gain a better understanding of the impact of changing trends and individual differences in the timing of pubertal growth spurts. The study, comprised of 30 participants, evaluated the impact of changing trends of puberty on the competence of different age estimation methods. It reviewed dental and skeletal methods by assessing the stages of dental calcification and hand-wrist maturation during the pre- and post-pubertal growth phases. Björk, Grave and Brown method was employed to determine the maturation stages of the wrists and the dental maturation status was estimated according to the Demirjian's method by using orthopantomograms.*
Results*: A comparison of chronological age with dental and skeletal age was performed using the Wilcoxon Signed Rank Test. In both the pre pubertal (males 60%, females 63%) and post pubertal populations (males 83%, females 85%), dental age (DA) was found to be more reliable in relation to chronological age as compared to the skeletal age (SA) in both sexes, and this difference was found to be statistically significant ($p < 0.05$).*
Conclusions*: This discrepancy between chronological age and skeletal age might be due to a significant change in the trend towards earlier onset of puberty, suggesting greater reliability of dental age estimation and the need for changes in the method of determining skeletal age.*
Keywords*: skeletal age; puberty; age determination; panoramic radiography; forensic dentistry*

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I. Introduction

Change and growth are integral elements of the evolutionary process, intertwining seamlessly to propel the continual development and progression of life forms and systems. Over time, these significant changes become crucial milestones in the journey of development, serving as guiding markers that inspire ongoing exploration and research efforts. Puberty is one such period of rapid increase in body size, transformation in body shape and composition, the development of the gonads and the characteristics that indicate sexual maturity [1]. For many young individuals, the period between the ages of ten and sixteen is significant for their growth and development as noteworthy change in growth rate takes place during puberty.

Over the past decade, a possible shift in the onset of puberty has been documented around the world, leading to an earlier onset of puberty. Increased incidence of sexual precocity, particularly in girls, has been observed internationally. Possible mechanisms for this global shift in the timing of puberty include lifestyle changes, genetic factors, diet and work culture, intrauterine conditions, stress, light-dark cycle, climatic conditions, and exposure to endocrine-disrupting chemicals [2]. There is a need for further research on variations and secular trends in the initiation of puberty in relation to ethnic, geographical and socioeconomic parameters.

Major studies on pubertal timing have reported changes in age of menarche in girls, while there is little data on pubertal timing in boys [3]. A study found that pubertal milestones in boys were being reached at a younger age than previously reported, while in girls, menarche was seen to occur 3.6 months earlier in daughters than in their mothers [4].

When it comes to estimating the maturity of a child, it can be misleading to rely on chronological age alone, so more accurate methods of age estimation are required [5]. The accuracy of age assessment is of great importance in forensic dentistry and in the medico-legal context, particularly considering the rising incidence of juvenile delinquency [6]. This critical assessment also extends to orthodontics, where understanding the complex interplay between chronological age (CA), dental age (DA) and skeletal age (SA) is essential for accurate diagnosis and treatment planning [7]. Furthermore, cases of deliberate age manipulation in sports selections at the national level demonstrate the need for more advanced methods of age verification, as birth certificates may be tempered in such cases [8] Age estimation, whether applied to cadavers, human remains or living individuals, has profound legal and societal implications for individuals and communities [9].

Age estimation methods can vary depending on the context, such as biological age, chronological age, or age estimation in forensic anthropology. Some common methods used in different fields are DA estimation, SA estimation, anthropometric measurements and biological markers [5] In this subject, the classic and widely accepted method of assessing SA involves analyzing wrist bones using radiographs [10]. This involves assessing the secondary ossification centers that mineralize during maturation and result in characteristic changes in bone structures that correspond to the patient's different growth phases [11]. Dental development appears to be under stronger genetic control and is less influenced by environmental factors such as biomechanics, physiological stress and nutrition [12]. It depends primarily on the rate of development and calcification of the tooth buds and on the orderly sequence of tooth eruptions in the oral cavity. Several methods have been developed to measure DA based on the extent of calcification of the permanent teeth.

This paper examines the impact of changing trends in puberty on the efficacy of age estimation by dental and skeletal methods and evaluates whether existing theories need to accommodate these changes or be modified accordingly.

II. Materials And Method

Study design: This study is collaboration between the Department of Orthodontics and the Department of Radiology. The research included participants who were enrolled in the Outpatient Department of Orthodontics in May 2022. Thirty individuals, who participated in the study, were chronologically aged 10 to 16 years. They met the following inclusion criteria: presence of fully or partially erupted teeth and an undamaged left hand and wrist. Exclusion criteria were certain dental characteristics such as missing, impacted, embedded or trans-positioned teeth, ongoing or previous orthodontic treatment, presence of dental disease, a history of extractions or restorations, and a history of trauma to the face or hand. Due to the retrospective nature of the study, unnecessary exposure to radiation was avoided. Participants were contacted and consent was obtained for the use of their data such as date of birth, gender, pubertal status and X-ray images. After selecting participants with the above specifications, details from the records were tabulated to ensure accurate calculation of CA, which emphasizes the accuracy and reliability of the research results presented in this article. CA was calculated based on the participants' date of birth in months. Participants were also categorized into pre-pubertal and post-pubertal groups based on their pubertal status, considering the progression of menarche in females and the onset of voice break in males.

Methodology: The assessment of the maturation stages of the hand and wrist was performed using a method defined by Björk, Grave and Brown [13]. In this method, the bone maturity of the hand and wrist was divided into nine developmental stages. Each of these stages was assigned a corresponding skeletal age by Schopf (1978), which corresponds to a specific phase along the curve of the pubertal growth spurt [14]. The second stage marks the beginning of the growth spurt, while the fourth and fifth stages mark a period characterized by a rapid growth rate. The sixth stage symbolizes a phase that is characterized by a deceleration in growth rate and applies to both sexes. The maturation of hand-wrist bones was assessed by viewing the hand-wrist radiographs under an x-ray viewer. The maturation of the wrist bones, which corresponds to the developmental stage of the method, was considered as the developmental stage of an individual's skeleton. The age was recorded for this skeletal development and noted as the bone age of an individual.

In parallel, the assessment of dental maturity was conducted using the method of Demirjian et al. The permanent mandibular second molars on the left side were selected as focal points for the assessment. This choice was guided by the fact that apices of the incisors and first molars had already reached a state of closure [15]. The third molars were excluded due to uncertainties regarding their formation and their limited correlation with skeletal maturity. In addition, the maxillary teeth were excluded due to potential overlapping of roots with calcified structures in the region of interest, leading to a complex interpretation. In this method, teeth are graded on a scale from stage A to H, with scoring based on the presence of apex closure . The DA detection process involved viewing orthopantomograms (OPG) on a radiographic viewer, identifying the calcification stage of each tooth, from the central incisor to the second permanent molar, based on the Demirjian method and assigning a score for the developmental stage of each tooth using a predetermined scoring table and then summing the developmental score values for all seven teeth. The total score obtained was considered as the total score for tooth maturation and converted into dental age.

Statistical analysis: The analysis was performed using the Wilcoxon signed-rank test in Microsoft Excel. For small sample sizes, the Wilcoxon signed-rank test evaluates the differences in the medians and can provide more accurate results compared to parametric tests where the evaluation of differences is a main objective. [Table 2]

III. Result

30 adolescents (17 males and 13 females) who met the inclusion criteria were divided into a pre-pubertal and a post-pubertal group. The pre-pubertal group comprised 10 males and 6 females, while the post-pubertal group comprised 7 males and 7 females.

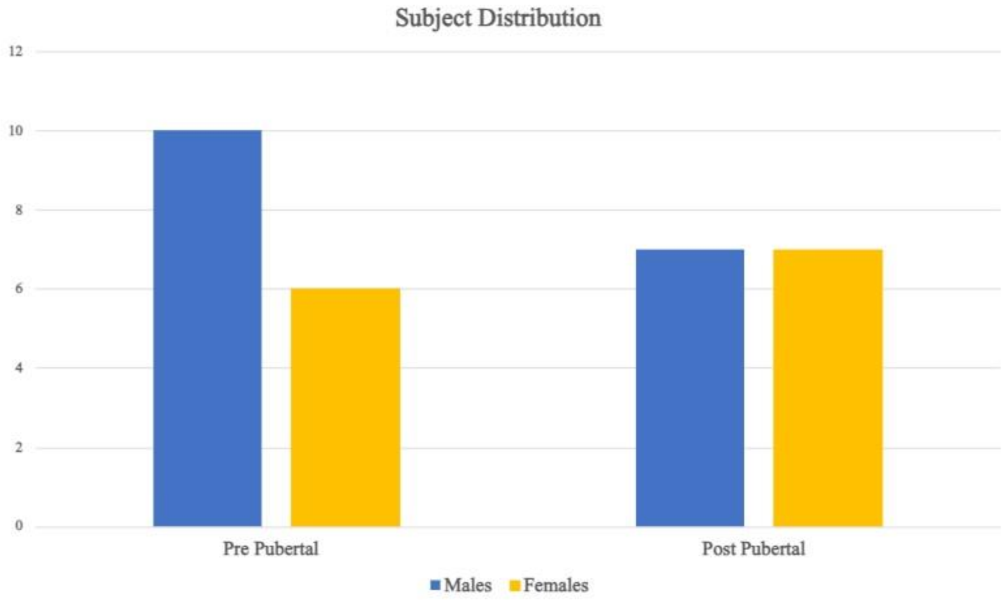

Figure 1: Gender wise distribution of subjects in pre and post pubertal groups.

Results from the pre-pubertal group revealed that, among males, dental age (DA) was more accurate in 6 out of 10 cases than skeletal age (SA), with an average chronological age (CA) leading DA by 0.27 years and lagging behind SA by 0.7 years [Table1]. A more positive and significant correlation was observed between CA and DA (r = 0.97) than CA and SA (r = 0.56) suggested dental age (DA) estimation to be more reliable than skeletal age (SA) [Table 2]. In females, average CA lagged DA by 0.48 years and led SA by 0.1 years [Table1]. A higher positive and significant correlation noted between CA and DA (r = 0.90) than CA and SA (r = 0.48) suggest more reliability of DA with more accuracy in 4 out of 6 cases [Table 2] [Figure2].

Table 1: Descriptive statistics for chronological age, dental age and skeletal age in pre and post pubertal group as determined (in years). . List of abbreviations: CA: Chronological Age DA: Dental Age SA: Skeletal Age

GROUPS	GENDER	AGE	AVG	STD DEV	MEDIAN
PRE PUBERTAL	MALE (n= 10)	CA	11.78	1.50	11.75
		DA	11.51	1.51	11.3
		SA	12.48	1.37	12.3
	FEMALE (n = 6)	CA	11.02	0.97	10.8
		DA	11.50	0.98	11.1
		SA	10.92	2.75	10.6
POST PUBERTAL	MALE (n= 7)	CA	15.17	0.79	15
		DA	15.40	0	15.4

		SA	15.64	0.44	15.9
	FEMALE (n = 7)	CA	14.80	0.84	15
		DA	14.94	0.87	15.6
		SA	15.57	1.13	16

In the post-pubertal group, among males, mean CA lagged DA by 0.23 years and SA by 0.47 years, while SA was ahead of DA by 0.24 years. [Table1] A higher significant positive correlation was observed between CA and DA (r = 0.73) and a negative correlation between CA and SA (r = -0.28). [Table 2] In females, average CA lagged DA by 0.14 years and SA by 0.77 years, with SA ahead of DA by 0.63 years. [Table1] A positive and significant correlation was observed between CA and DA (r = 0.87) and CA and SA (r = 0.41) [Table 2] [Figure2]. Correlation in both male and female groups suggested DA to be more reliable as compared to SA.

Table 2 Correlation between Chronological Age with Dental Age (DA) and Skeletal Age (SA) in Pre- and Post-Pubertal groups. List of abbreviations: CA: Chronological Age DA: Dental Age SA: Skeletal Age

GROUP	GENDER	AGE	MEAN ± STD DEV	CORELATION CO-EFFICIENT	INFERENCE
PRE PUBERTAL	MALES (n = 10)	DA	11.51 ± 1.51	0.978040104	Significant
		SA	12.48 ± 1.37	0.56732755	Significant
	FEMALES (n = 6)	DA	11.50 ± 0.98	0.902223032	Significant
		SA	10.92 ± 2.75	0.482944107	Significant
POST PUBERTAL	MALES (n = 7)	DA	15.40 ± 0	0.731831715	Significant
		SA	15.64 ± 0.44	-0.284514916	Significant
	FEMALES (n = 7)	DA	14.94 ± 0.87	0.873795107	Significant
		SA	15.57 ± 1. 13	0.418657217	Significant

IV. Discussion

The notion of physiological age emerged to address variations in the development of individuals sharing the same chronological age [16]. While chronological age signifies the actual time a person has been alive, physiological age takes into account biological and functional characteristics, including physical fitness, organ function, and overall health. It is relevant in assessing children and adolescents, acknowledging the potential differences in their growth and development despite being of the same chronological age. This disparity in chronological and physiological age of an individual emphasized the need for accurate age estimation techniques. It limits the search for an individual of unknown age and thus it should be as accurate as possible as it allows for a more efficient and time-saving approach [17]. The present study was one of its kinds with an attempt to determine the accuracy of dental age (DA) and skeletal age (SA) estimation during puberty. The results provided valuable insights into the intricate relationships between puberty and the reliability of age estimates.

In the pre pubertal group, DA showed a higher accuracy rate of 60% in males and 66% in females, surpassing the reliability of SA. In both the male and female groups, the *p*-value was less than 0.05. In both males and females, DA showed a stronger positive association with ca than with SA.

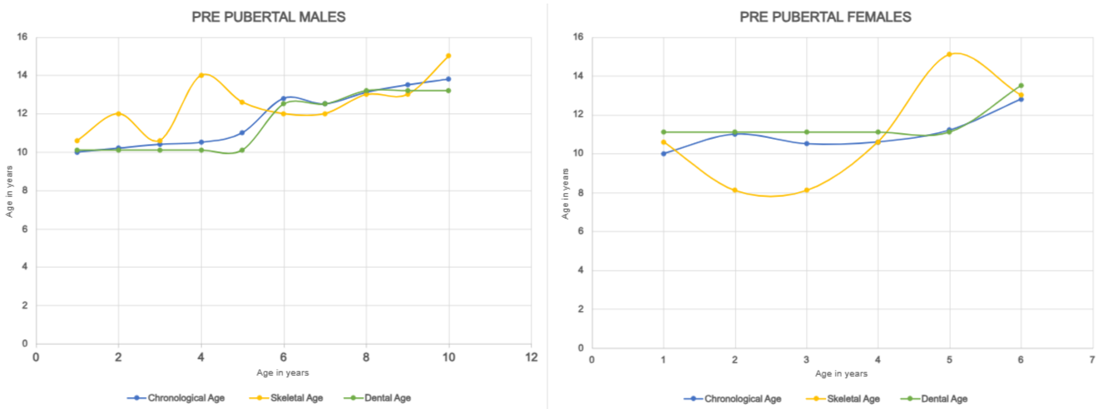

Figure 2: Correlation between CA, DA and SA in pre-pubertal males and females

In the post-pubertal phase, DA estimation proves to be a reliable predictor of age in about 83% of males and 85% of females with a *p*-value of < 0.05 in both cases. DA shows a higher positive correlation with ca compared to SA in both males ($r = 0.73$) and females ($r = 0.87$)[Table 1]. Here the contrast between DA and SA diminished as compared to pre pubertal group, indicating greater consistency in age estimation as one attains puberty [figure 3].

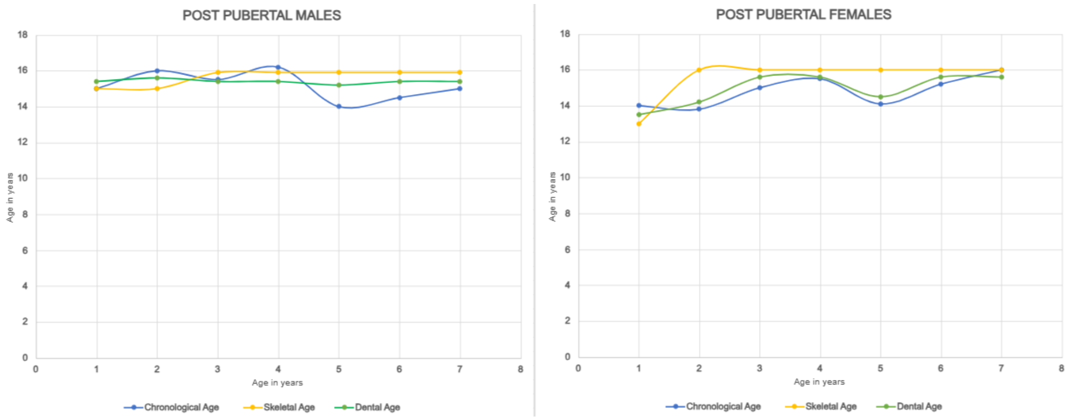

Figure 3: Correlation between CA, DA and SA in post-pubertal males and females

These results are consistent with the findings of Patel PS et al. who studied two dental and one skeletal age determination in children from Gujarat [17]. These results are also in line with the results of studies conducted by Palanisamy V et al. [18] and Kullman L et al. [19] in a variety of populations. Comparable results were also obtained by Hegde RJ in the Karnataka community [16].

In pre pubertal and post pubertal age groups, a stronger significant association was found between chronological age and dental age as compared to skeletal age in both the genders [Table1]. Before hitting puberty, the development and assessment of dental characteristics are found to be consistent than relying on skeletal indicators. In pre pubertal group, difference between DA and SA is larger while this gap narrows in the post pubertal group. This might be due to the reason that after attainment of puberty, an individual reaches its maximum potential growth leading to fewer discrepancies between the two methods. We believe that this may be caused by shifting patterns in the onset of puberty and that a small corrective element may be appropriate. While the observed trends are intriguing, they require further investigation to support their validity and applicability. Larger sample sizes and different demographic representations are essential to draw comprehensive conclusions.

V. Conclusion

This study examines the accuracy of estimating dental age and skeletal age in relation to chronological age during puberty. The results show a stronger positive correlation between DA and CA in both males and females, with DA having a higher accuracy than SA in both pre and post pubertal groups.

In the post-pubertal phase, the gap between DA and SA decreases, indicating greater consistency in age estimation. The study also highlights a decline in the average age for attaining puberty, raising questions about the implications for skeletal development and the accuracy of age estimation methods in forensic and medical sciences. However, the observed trends require further research with larger samples and different demographic characteristics to draw comprehensive and valid conclusions.

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