

## Estimation of Dental and Bone Age in Obese Children of South India

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### ABSTRACT

**Aim:** Determination of skeletal and dental age is very essential for Pediatric dentist and orthodontist to formulate a treatment plan, and it is a source of supplemental information for Pediatrics, Orthopedics, and Forensics. There are no available studies in the literature about the comparison of dental and bone age with chronological age in obese children of south India. Accordingly, the aim of this study was to evaluate and compare dental age, bone age, and chronological age in obese children of south India.

**Materials and Methods:** Ethical approval was obtained from the ethical committee of college, and informed consent was obtained from parents of the study participants. A total of 100 obese study participants were selected between 8 to 14 years age group. Date of birth was considered to obtain chronological age. Demirjian's method was used to assess dental age. Bjork, Grave, and Brown's method was followed to detect bone age using hand-wrist radiograph. The comparison of three ages was done using the unpaired Student's *t*-test and Pearson's correlation coefficient.

**Results:** Dental age and bone age were advanced in comparison to chronological age in both sexes and its statistically significant ( $P < 0.001$ ). There was a positive relationship between three ages in both sexes.

**Conclusion:** As per our study, dental age and bone age were advanced in obese children, but dental age was more advanced. Dental age and bone age can be considered as variables for diagnosing the impact of growth in obese children. In the future, further studies are required to support our findings.

**KEYWORDS:** Bone age, Demirjian's method, dental age

### INTRODUCTION

Growth is an important phase in the childhood which separates him or her from the adult. Growth begins from birth till child matures into adulthood.<sup>[1]</sup>

Various factors are responsible for growth such as genetics, nutrition, environment, gender, social, emotional, and culture.<sup>[2]</sup> The prevalence of overweight and obesity has been increasing markedly in recent years in developing and developed nations. It may influence growth in prepubertal children.<sup>[3]</sup>

Obesity and underweight are calculated using the body mass index (BMI). BMI is calculated dividing weight in kg by the square of height in meters.  $BMI = \text{weight in kg}/(\text{height in meters})^2$ . A BMI  $< 5^{\text{th}}$  percentile is

considered as underweight and above the 95<sup>th</sup> percentile is considered as obese.<sup>[4,5]</sup>

Bone age is different from chronological age, and its a measure of the physiological development of an individual.<sup>[1]</sup>

The appearance and union of the various skeletal ossification centers follows a fairly orderly pattern and time schedule from birth to maturity. A roentgenographic study of these skeletal maturational processes provides a valuable criterion of the child's level of osseous maturation. Maturation of skeletal centers of the individual is recognized as bone age.<sup>[2]</sup>

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Teeth development and eruption are part of the total development of the child and its useful count of maturity. Dental age depends on the amount of tooth bud development and mineralization and their pattern of the proper eruption as per eruption schedule. Tooth mineralization is a better evaluation of physiologic maturity of an individual compare to tooth eruption, and tooth mineralization is an uninterrupted process of development. Many methods are in use to evaluate dental age based on calcification rate of permanent teeth. Demirjian, Goldstein, and Tanner method is extensively used to assess dental age.<sup>[6]</sup>

An accurate understanding of skeletal growth pattern of maxilla and mandible is essential for the timely intervention of growth deformities in craniofacial complex.

Dental maturation broadens the thinking related to clinical judgment in treatment planning for dental deformities and orthodontic problems.<sup>[7]</sup>

Detection of dental and bone age is valuable for the dentist to formulate a proper treatment plan and its also useful as supplemental information for the pediatricians, hematology, forensics, and anthropology.<sup>[8]</sup>

There is paucity in the dental literature about the impact of obesity on bone and dental maturation in children of South India.

Hence, this research was undertaken to detect and compare bone age, dental age and chronological age in South Indian obese children.

## MATERIALS AND METHODS

This was a cross-sectional study. The study period was from July 12, 2017 to December 12, 2017. The source of data was from the out patients of the department of Pedodontics and Preventive Dentistry. The children were randomly selected according to the inclusion criteria based on international standards. The children who are obese irrespective of any disease associated with obesity were selected for the study. The study sample included 100 obese children out of that 63 were males, and 37 were females between the ages of 8–14 years.

Ethical clearance was obtained from the Institutional Ethical Committee (Letter No: NDC/RCR-IEC/2017-18/080/1). Written informed consent was acquired from the parent of study participants and study objective was explained to parents of the study participants.

Armamentarium included as follows: orthopantomograms (OPG), hand-wrist radiographs, X-ray viewer, Stadiometer, weighing machine, and BMI percentile charts.

Selection of the study subject: height of the child was measured using stadiometer to the nearest of 0.1cm, and the height in centimeter was converted into meters. Weight was measured using the weighing machine to the nearest of 0.1 kg. The BMI of the child was calculated using the formula  $BMI = \text{Weight in Kgs}/(\text{height in meters})^2$ .

The obtained BMI was compared with BMI percentile charts for particular age and sex. If the BMI of particular child based on age and sex was more than 95<sup>th</sup> percentile than he/she was considered as an obese child and such child was included in the study.<sup>[4,5]</sup>

Chronological age was detected using school birth date records or statement obtained from parents regarding the date of birth of their child.

Hand-wrist radiographs and OPG was obtained from the study participants to detect dental and bone age. Interpretation of the radiograph was done using X-ray viewer.

## DENTAL AGE ESTIMATION

Dental age was evaluated depending on the amount of tooth calcification. As per Demirjian's method, total 7 mandibular left permanent teeth (excluding the 3<sup>rd</sup> molar) was examined to know their rate of calcification. If any tooth was missing out of 7 teeth than contralateral tooth was taken into consideration.

Tooth mineralization was split into eight stages by Demirjian<sup>[9,10]</sup> and the stages are as follows [Figure 1]: stage A-start of mineralization on cusp tips, stage B-union of mineralized cusps, stage C-appearance of dentinal deposits, stage D-crown, is formed up to cemento-enamel junction, stage E-root formed but less than crown, stage F-root formed but equal or more than crown, stage G-root completely formed but apical foramen is open, stage H-root fully formed and apical foramen is closed.

Among 7 mandibular left permanent teeth, each tooth has been designated with fixed score depending on its calcification stage [Tables 1 and 2]. The total scores of 7 teeth were taken as maturity score, which will be transformed into dental age following conversion chart [Tables 3 and 4].

The procedure of dental age detection:

- OPG [Figure 2] was observed in X-ray viewer, and calcification stage of each tooth from central incisor to permanent 2<sup>nd</sup> molar were determined as per Demirjian's method [Figure 1]
- After determining the developmental stage of each tooth, the score for that particular development stage was obtained using the score table [Tables 1 and 2].

All developmental score values of 7 teeth were added and total score value thus obtained was recognized as complete dental maturation score which was transformed into dental age following conversion chart [Tables 3 and 4].

Maturity score = developmental scores of 31 + 32 + 33 + 34 + 35 + 36 + 37

- 31: Left Mandibular central incisor
- 32: Left Mandibular lateral incisor
- 33: Left Mandibular canine
- 34: Left Mandibular 1 premolar
- 35: Left Mandibular 2<sup>nd</sup> premolar
- 36: Left Mandibular 1<sup>st</sup> molar
- 37: Left Mandibular 2<sup>nd</sup> molar.

**BONE AGE ASSESSMENT**

Bjork, Grave, and Brown’s method was considered in our study to determine bone age using hand-wrist radiograph.<sup>[11]</sup> In this method, hand-wrist bone maturity was split into 9 developmental stages. Each of the stage has been given an appropriate skeletal age by Schopf in 1978.

**METHOD OF BONE AGE ASSESSMENT**

Maturation of hand-wrist bones was assessed observing hand-wrist radiographs under X-ray viewer [Figure 3]. The hand-wrist bones maturity which matches with the particular developmental stage of Bjork, Grave, and Brown’s method was considered as skeletal development

stage of an individual. The particular age was recorded for that skeletal development which was noted as the bone age of an individual.

Unpaired Student’s *t*-test and Pearson’s correlation were done to compare three ages.

**RESULTS**

The results observed in the study sample are as follows:

Males:

Comparison of three ages [Tables 5 and 6]

- Chronological age was decreased in relation to dental age by 1.46 years

**Table 1: Self-weighted scores of dental stages of 7 teeth (mandibular left side) in boys**

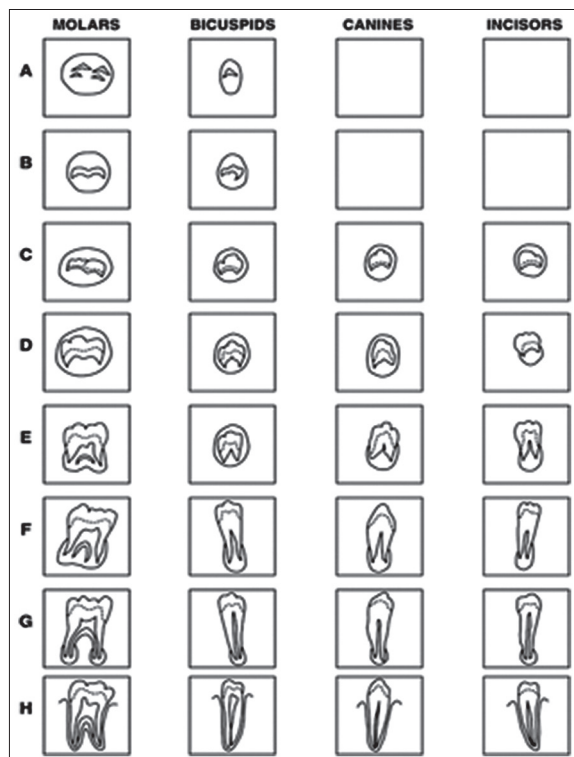
Tooth	Stages							
	A	B	C	D	E	F	G	H
M2	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4
M1			0.0	8.0	9.6	12.3	17.0	19.3
PM2	1.7	3.1	5.4	9.7	12.0	12.8	13.2	14.4
PM1		0.0	3.4	7.0	11.0	12.3	12.7	13.5
C			0.0	3.5	7.9	10.0	11.0	11.9
LI				3.2	5.2	7.8	11.7	13.7
CI				0.0	1.9	4.1	8.2	11.8

M2=Permanent second molar, M1=Permanent first molar, PM2=Second premolar, PM1=First premolar, C=Canine, LI=Lateral incisor, CI=Central incisor

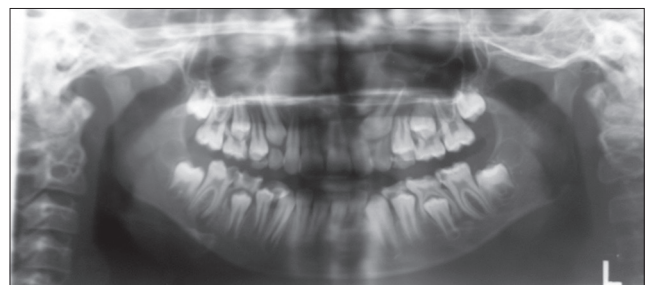
**Table 2: Self-weighted scores of dental stages of 7 teeth (mandibular left side) in girls**

Tooth	Stages							
	A	B	C	D	E	F	G	H
M2	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6
M1			0.0	4.5	6.2	9.0	14.0	16.2
PM2	1.8	3.4	6.5	10.6	12.7	13.5	13.8	14.6
PM1		0.0	3.7	7.5	11.8	13.1	13.4	14.1
C			0.0	3.8	5.6	10.3	11.6	12.4
LI			0.0	3.2	5.6	8.0	12.2	14.2
CI				0.0	2.4	5.1	9.3	12.9

M2=Permanent second molar, M1=Permanent first molar, PM2=Second premolar, PM1=First premolar, C=Canine, LI=Lateral incisor, CI=Central incisor



**Figure 1: Demirjians tooth calcification stages**



**Figure 2: Orthopantomogram**

**Table 3: Conversion chart for boys to convert maturity score into dental age**

Age	Score	Age	Score	Age	Score	Age	Score
3.0	12.4	7.0	46.7	11.0	92.0	15.0	97.6
0.1	12.9	0.1	48.3	0.1	92.2	0.1	97.7
0.2	13.5	0.2	50.0	0.2	92.5	0.2	97.8
0.3	14.0	0.3	52.0	0.3	92.7	0.3	97.8
0.4	14.5	0.4	54.3	0.4	92.9	0.4	97.9
0.5	15.0	0.5	56.8	0.5	93.1	0.5	98.0
0.6	15.6	0.6	59.6	0.6	93.3	0.6	98.1
0.7	16.2	0.7	62.5	0.7	93.5	0.7	98.2
0.8	17.0	0.8	66.0	0.8	93.7	0.8	98.2
0.9	17.6	0.9	69.0	0.9	93.9	0.9	98.3
4.0	18.2	8.0	71.6	12.0	94.0	16.0	98.4
0.1	18.9	0.1	73.5	0.1	94.0		
0.2	19.7	0.2	75.1	0.2	94.4		
0.3	20.4	0.3	76.4	0.3	94.5		
0.4	21.0	0.4	77.7	0.4	94.6		
0.5	21.7	0.5	79.0	0.5	94.8		
0.6	22.4	0.6	80.2	0.6	95.0		
0.7	23.1	0.7	81.2	0.7	95.1		
0.8	23.8	0.8	82.0	0.8	95.2		
0.9	24.6	0.9	82.8	0.9	95.4		
5.0	25.4	9.0	83.6	13.0	95.6		
0.1	26.2	0.1	84.3	0.1	95.7		
0.2	27.0	0.2	85.0	0.2	95.8		
0.3	27.4	0.3	85.6	0.3	95.9		
0.4	28.6	0.4	86.2	0.4	96.0		
0.5	29.5	0.5	86.7	0.5	96.1		
0.6	30.3	0.6	87.2	0.6	96.2		
0.7	31.1	0.7	87.7	0.7	96.3		
0.8	31.8	0.8	88.2	0.8	96.4		
0.9	32.6	0.9	88.6	0.9	96.5		
6.0	33.6	10.0	89.0	14.0	96.6		
0.1	34.7	0.1	89.3	0.1	96.7		
0.2	35.8	0.2	89.7	0.2	96.8		
0.3	36.9	0.3	90.0	0.3	96.9		
0.4	38.0	0.4	90.3	0.4	97.0		
0.5	39.2	0.5	90.6	0.5	97.1		
0.7	42.0	0.6	91.3	0.6	97.3		
0.8	43.6	0.7	91.6	0.7	97.4		
0.9	45.1	0.8	91.8	0.8	97.5		

**Table 4: Conversion chart for Girls to convert maturity score into dental age**

Age	Score	Age	Score	Age	Score	Age	Score
3.0	13.7	7.0	51.0	11.0	94.5	15.0	99.2
0.1	14.4	0.1	52.9	0.1	94.7	0.1	99.3
0.2	15.1	0.2	55.5	0.2	94.9	0.2	99.4
0.3	15.8	0.3	57.8	0.3	95.1	0.3	99.4
0.4	16.6	0.4	61.0	0.4	95.3	0.4	99.5
0.5	17.3	0.5	65.0	0.5	95.4	0.5	99.6
0.6	18.0	0.6	68.0	0.6	95.6	0.6	99.6
0.7	18.8	0.7	71.0	0.7	95.8	0.7	99.7
0.8	19.5	0.8	75.0	0.8	96.0	0.8	99.8
0.9	20.3	0.9	77.0	0.9	96.2	0.9	99.9
4.0	21.0	8.0	78.8	12.0	96.3	16.0	100.0
0.1	21.8	0.1	80.2	0.1	96.4		
0.2	22.8	0.2	81.2	0.2	96.5		
0.3	22.5	0.3	82.2	0.3	96.6		
0.4	23.2	0.4	83.1	0.4	96.7		
0.5	24.0	0.5	84.8	0.5	96.8		
0.6	24.8	0.6	84.8	0.6	96.9		
0.7	25.6	0.7	85.3	0.7	97.0		
0.8	26.4	0.8	86.1	0.8	97.1		
0.9	27.2	0.9	86.7	0.9	97.2		
5.0	28.0	9.0	87.2	13.0	97.3		
0.1	28.9	0.1	87.8	0.1	97.4		
0.2	29.7	0.2	88.3	0.2	97.5		
0.3	30.5	0.3	88.8	0.3	97.6		
0.4	31.3	0.4	89.3	0.4	97.7		
0.5	32.1	0.5	89.8	0.5	97.8		
0.6	33.0	0.6	90.2	0.6	98.0		
0.7	34.0	0.7	90.7	0.7	98.1		
0.8	35.1	0.8	91.1	0.8	98.2		
0.9	36.8	0.9	91.4	0.9	98.3		
6.0	37.0	10.0	91.8	14.0	98.3		
0.1	38.0	0.1	92.1	0.1	98.4		
0.2	39.1	0.2	92.3	0.2	98.5		
0.3	40.2	0.3	92.6	0.3	98.6		
0.4	41.3	0.4	92.9	0.4	98.7		
0.5	42.5	0.5	93.2	0.5	98.8		
0.6	43.9	0.6	93.5	0.6	98.9		
0.7	46.7	0.7	93.7	0.7	99.0		
0.8	48.0	0.8	94.0	0.8	99.1		
0.9	49.5	0.9	94.2	0.9	99.1		

- Chronological age was lagging beyond bone age by 0.76 years.
- Dental age was ahead of bone age by 0.70 years [Tables 5 and 6].

Correlation between 3 ages [Table 7]

- The positive correlation was observed between chronological and dental age which was significant. ( $r = 0.597$ )
- The positive correlation was obtained between chronological and bone age which was significant. ( $r = 0.511$ )
- The positive correlation was found between dental

age and bone age which was significant. ( $r = 0.522$ ) [Table 7].

In females:

Comparison of 3 ages [Tables 5 and 8]

- Chronological age was behind dental age by 1.61 years
- Bone age was ahead of Chronological age by 0.99 years
- Bone age was reduced compare to dental age by 0.62 years.

Correlation between 3 ages [Table 9]



- There was a positive correlation between chronological and dental age which was significant ( $r = 0.635$ )
- Significant positive correlation was found between chronological and bone age ( $r = 0.614$ )
- Our observation revealed a positive correlation between dental and bone age which was significant ( $r = 0.568$ ).

**DISCUSSION**

Obesity in childhood is increasing at an alarming rate. Obesity has emerged as one of the global health problems with 200 million school children worldwide categorized as being overweight/obese, of which 40–50 million are obese.<sup>[12]</sup> Various studies



**Figure 3:** Hand-wrist radiograph

carried out in India from 2002 to 2012 indicate a rising trend in the prevalence of overweight and obesity in children and adolescents.<sup>[13-17]</sup> Ranjani *et al.* reviewed the data about the childhood obesity reported in India from 1981 to 2013. The review included 52 studies done in 16 states of India. As per the data reviewed, they found that the prevalence of childhood obesity was more after 2010 onward which was 19.3% compared to 16.3% reported from 2001 to 2005.<sup>[18]</sup>

Dental age estimation and bone age estimation are useful to compare with chronological age to assess the overall growth of various tissue systems, especially in children with underweight, normal weight, and obesity. Various studies have been carried out to assess the determination of bone and dental maturation. Many procedures are in use to detect bone and dental age. In our study, hand-wrist radiograph was used to study bone maturation. Greulich and Pyle<sup>[19]</sup> have expressed that hand wrist radiographic study is the convenient method to detect bone age.

Bjork, Grave, and Brown method was used in our study to determine bone maturation.

Iguma and Tavano compared Bjork, Grave, and Brown method and Martins and Sakima methods, they found that both methods are valuable in the study of a hand-wrist radiograph for the detection of bone age.<sup>[20]</sup>

Demirjian’s method was applied to assess dental age in our study. Three separate procedures have been evaluated by Hagg and Matsson for determination of dental age, and they found that Demirjian’s procedure affords a high degree of reliability and precision.<sup>[21]</sup>

Wolf *et al.* proved that Demirjian’s method is appropriate for dental age estimation.<sup>[22]</sup> Demirjian’s method offers accurate dental age estimation on Indian people as per the research findings of the Nanda and Chawla<sup>[23]</sup> and Hegde and Sood.<sup>[7]</sup>

Our study findings confirmed that chronological age was lagging behind the bone age and dental age in a sample of 100 obese children. In this study, dental and bone maturation was advanced with respect to the chronological age in 100 obese children. Mack *et al.* investigated about the relationship between

**Table 5: Mean chronological age, dental age and bone age of females and males**

Sex	Mean (years)	SD
Males		
Chronological age	10.32	0.76
Dental age	11.78	1.78
Bone age	11.08	0.79
Females		
Chronological age	10.13	0.79
Dental age	11.74	1.61
Bone age	11.12	0.89

SD=Standard deviation

**Table 6: Comparison of chronological age, dental age and bone age in males**

	Mean difference (Years)	95% confidence interval for mean difference	t	P	Inference
Chronological Age	-1.46	1.27-2.14	6.71	$P < 0.001$	Significant
Dental Age					
Chronological Age	-0.76	0.53-1.41	4.23	$P < 0.001$	Significant
Bone Age					
Dental Age	0.70	0.49-1.36	4.11	$P < 0.001$	Significant
Bone Age					

BMI percentile and skeletal and dental maturity in adolescent orthodontic patients between the ages of 8–17 years and found that skeletal and dental ages were ahead of chronological age in obese children.<sup>[24]</sup>

Hedayati and Khalafinejad studied about the association of BMI percentile with skeletal and dental maturation in 6–15-year-old orthodontic patients and they found that obese children had accelerated dental and skeletal development and dental development was statistically significant compared to skeletal development.<sup>[3]</sup>

Hilgers *et al.* carried out research to detect dental maturation with 63 normal weight children, 23 overweight children and 18 obese children and they observed that dental development was advanced in obese children compared to normal and overweight children.<sup>[25]</sup>

Chehab *et al.* studied dental age in 265 average weight, overweight, and obese children between 6 and 12 years age group of Hispanic children and they found that children with overweight and obesity had a statistically significant increase in dental development compared to average weight children.<sup>[26]</sup>

Guica *et al.* compared skeletal development in 25 obese and 25 normal children and observed that obese children exhibited significantly higher skeletal maturation compared to normal children.<sup>[27]</sup>

Moreover, in our findings, girls exhibited a statistically more significant increase in dental and bone development. Moreover, in our findings, dental

maturation was faster than bone maturation in both sexes. These findings are in agreement with the Hedayati, and Khalafinejad who have shown that girls exhibited higher advancement in dental and bone development and dental maturation was much faster when compared to bone maturation.<sup>[3]</sup> Akridge *et al.*<sup>[28]</sup> and Basaran *et al.*<sup>[29]</sup> also revealed that girls exhibited higher bone maturation compared to boys. Yadav *et al.* evaluated dental calcification stages and skeletal maturity in 120 participants and he found that skeletal age in females was advanced compared to males.<sup>[30]</sup> Macha *et al.* also found that females attained dental and bone maturation faster than males.<sup>[31]</sup>

As per our findings in both the sexes, the three ages are positively correlated. The positive correlations have also been found in the studies done by Vallejo-Bolanos and Espana-Lopez,<sup>[8]</sup> Green,<sup>[2]</sup> Hedge and Sood,<sup>[7]</sup> Prabhakar *et al.*,<sup>[6]</sup> Litsas and Lucchese,<sup>[32]</sup> Palaniswamy *et al.*,<sup>[33]</sup> and Nagaraju *et al.*<sup>[34]</sup>

Similarly, numerous investigations carried out in the past have established the positive correlation ship between various maturity indicators of the body.

Limitations of the study:

- Uneven distribution of sample
- Limited size of sample
- Geographical variation with previous studies.

## CONCLUSION

An important observation in the present research was the accelerated bone and dental maturation with respect to chronological age in 100 study participants with obesity. Dental age and bone age estimation as against chronological age was significant to know the overall maturation of various tissues in a body of an individual and its important in Orthodontics and Pedodontics to formulate treatment plan and its supplemental information in the field of Orthopedics, Forensics, Hematology, Pediatrics, and Anthropology.

## FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

**Table 7: Correlation between chronological age, dental age and bone age in males**

	Correlation coefficient (value)	Inference
Chronological Age Dental Age	0.597	Significant
Chronological Age Bone Age	0.511	Significant
Dental Age Bone Age	0.522	Significant

**Table 8: Comparison of chronological, dental age and bone age in females**

	Mean difference (years)	95% confidence interval for mean difference	t	P	Inference
Chronological Age Dental Age	-1.61	1.50-2.88	7.12	P<0.001	Significant
Chronological Age Bone Age	-0.99	0.72-1.79	5.61	P<0.001	Significant
Dental Age Bone Age	0.62	0.77-1.32	4.01	P<0.001	Significant

**Table 9: Correlation between chronological age, dental age and bone age in females**

	Correlation coefficient (value)	Inference
Chronological Age Dental Age	0.635	Significant
Chronological Age Bone Age	0.614	Significant
Dental Age Bone Age	0.568	Significant

**CONFLICTS OF INTEREST**

There are no conflicts of interest.

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