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Original Research Article

# An analysis of correspondence in between body mass index (BMI) and dental developmental age in 4-10 years old children in north Indian population – A cross-sectional study

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ABSTRACT

**Aim:** The study aims to assess the relationship between body mass index (BMI) and dental developmental age in 4-10-year-old age group subjects.
**Materials and Methods:** 74 subjects were selected between the age range of 4-10 years. Height and weight were recorded for the determination of BMI. IOPA radiographs of the mandibular right first permanent molar were taken for estimation of dental age using Nolla's method.
**Results:** The correlation between BMI and dental developmental age was statistically significant with boys showing greater advancement than girls. A strong positive correlation between dental developmental age and chronological age was found among the total study population. A statistically significant difference was observed in the mean difference between dental age and chronological age, which was higher in girls than in boys and higher among obese than in non-obese.
**Conclusion:** Obese children have a higher rate of dental development compared to normal children. Hence, orthodontic treatment planning should be meticulously chalked out as obese children have accelerated dental growth and maturation.



## 1. Introduction

Age determination with dental maturity indicators is a more reliable and useful index of maturation as they show less variability than other skeletal tissues, which are more susceptible to external factors.[1] Childhood obesity is an escalating problem worldwide that can result in cardiovascular problems, endocrine problems, early onset of puberty, increased risk of breast cancer, polycystic ovary disease, asthma, obstructive sleep apnea, Pickwickian syndrome, orthopedic, gastrointestinal, psychological problems, and many more.[2,3]

Body Mass Index (BMI) is a method to measure adiposity and it also affects teeth development.[4] According to BMI curves provided by the Center for Disease Control and Prevention (CDC), children are divided into four categories: underweight, normal, overweight, and obese.[5]The rate of growth and development and length of craniofacial structures are increased in obese individuals. These cases need special consideration during orthodontic treatment as their development and growth speed are more than in normal individuals.[6]The prevalence of overweight in India increased from 9.7% before 2001 to 13.9% after 2010. The combined overweight/obesity trend increased from 15.9% before 2001 to 17.4% in the 2006-2010 period and 19.3% after 2010.[7]

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Among the various radiographic methods for determining dental age, one of the methods for assessing dental calcification in subjects of a wider age range is the Nolla's technique given by C.M. Nolla in 1960. It utilizes the amount of maturation of teeth for age assessment. The study aims to assess the relationship between body mass index (BMI) and dental developmental age in 4-10-year-old age group subjects and to compare the difference between dental developmental age and chronological age according to BMI.

## 2. Materials and Methods

This study is a cross-sectional, epidemiological study on selected patients. Subjects were selected over a 12-month period. A total of 74 subjects (31 boys and 43 girls) all of whom were aged between 4-10 years were selected for the study according to the following predetermined selection criteria.

### *2.1. Inclusion criteria*

Chronological age greater than or equal to 4 years and less than or equal to 10 years, Indian by nationality, known date of birth, no history of trauma or injury to the face, visibility of lower right permanent first molar in participant's IOPA radiograph.

### *2.2. Exclusion criteria*

Any congenital tooth anomaly, any systemic disease that could affect growth (such as nutritional disturbance, endocrine disorders, syndromes, and long-term consumption of medication), decayed or exfoliated/extracted permanent mandibular first molars.

The BMI of each patient was calculated as mass (kg) / height (m).[2] The chronological age for each subject was noted as specified by their parents/guardians. The BMI score, age, and gender were used to obtain the BMI percentile value for each subject with age and gender-specific growth charts from the Center for Disease Control and Prevention (CDC).[8] The subjects were categorized into two groups according to their BMI percentile obtained. The two groups were Group A: Obese (comprised of overweight and obese subjects), Group B: Non-obese (comprised of normal and underweight subjects).

The subject's IOPA radiographs were obtained using the conventional radiographic method. A size 2 E-speed Carestream radiographic film and dental radiograph machine (GOMAX), pre-set at 60KV and 10mA as recommended by the manufacturer to provide optimal brightness and contrast, were used. Dental age was determined using Nolla's method. Each radiograph was evaluated by the primary investigator and graded accordingly. The dental age differences of the subjects were calculated by subtracting the calculated dental age from chronological age. Positive differences reflected a delay in dental development (negative dental age) and negative differences reflected an acceleration in dental development (positive dental age).

The data was subjected to statistical evaluation, in which Pearson's Correlation test and Paired sample t-test were applied to assess the correlation and the mean difference between chronological age and dental developmental age among children.

NORMS FOR THE MATURATION OF PERMANENT TEETH FOR BOYS

| Age | Mandibular Teeth (Growth Stage) | | | | | | | | Maxillary Teeth (Growth Stage) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Yrs.) | 1\|1 | 2\|2 | 3\|3 | 4\|4 | 5\|5 | 6\|6 | 7\|7 | 8\|8 | 1\|1 | 2\|2 | 3\|3 | 4\|4 | 5\|5 | 6\|6 | 7\|7 | 8\|8 |
| 3 | 5.2 | 4.5 | 3.2 | 2.6 | 1.1 | 5.0 | .7 | | 4.3 | 3.4 | 3.0 | 2.0 | 1.0 | 4.2 | 1.0 | |
| 4 | 6.5 | 5.7 | 4.2 | 3.5 | 2.2 | 6.2 | 2.0 | | 5.4 | 4.5 | 3.9 | 3.0 | 2.0 | 5.3 | 2.0 | |
| 5 | 7.5 | 6.8 | 5.1 | 4.4 | 3.3 | 7.0 | 3.0 | | 6.4 | 5.5 | 4.8 | 4.0 | 3.0 | 6.4 | 3.0 | |
| 6 | 8.2 | 7.7 | 5.9 | 5.2 | 4.3 | 7.7 | 4.0 | | 7.3 | 6.4 | 5.6 | 4.9 | 4.0 | 7.4 | 4.0 | |
| 7 | 8.8 | 8.5 | 6.7 | 6.0 | 5.3 | 8.4 | 5.0 | .8 | 8.2 | 7.2 | 6.3 | 5.7 | 4.9 | 8.2 | 5.0 | |
| 8 | 9.3 | 9.1 | 7.4 | 6.8 | 6.2 | 9.0 | 5.9 | 1.4 | 8.8 | 8.0 | 7.0 | 6.5 | 5.8 | 8.9 | 5.8 | 1.0 |
| 9 | 9.7 | 9.5 | 8.0 | 7.5 | 7.0 | 9.5 | 6.7 | 1.8 | 9.4 | 8.7 | 7.7 | 7.2 | 6.6 | 9.4 | 6.5 | 1.8 |
| 10 | 10.0 | 9.8 | 8.6 | 8.2 | 7.7 | 9.8 | 7.4 | 2.0 | 9.7 | 9.3 | 8.4 | 7.9 | 7.3 | 9.7 | 7.2 | 2.3 |
| 11 | | | 9.1 | 8.8 | 8.3 | 9.9 | 7.9 | 2.7 | 9.95 | 9.7 | 8.8 | 8.6 | 8.0 | 9.8 | 7.8 | 3.0 |
| 12 | | | 9.6 | 9.4 | 8.9 | | 8.4 | 3.5 | | 9.95 | 9.2 | 9.2 | 8.7 | | 8.3 | 4. |
| 13 | | | 9.8 | 9.7 | 9.4 | | 8.9 | 4.5 | | | 9.6 | 9.6 | 9.3 | | 8.8 | 4.9 |
| 14 | | | | 10.0 | 9.7 | | 9.3 | 5.3 | | | 9.8 | 9.8 | 9.6 | | 9.3 | 5.9 |
| 15 | | | | | 10.0 | | 9.7 | 6.2 | | | 9.9 | 9.9 | 9.9 | | 9.6 | 6.6 |
| 16 | | | | | | | 10.0 | 7.3 | | | | | | | 10.0 | 7.7 |
| 17 | | | | | | | | 7.6 | | | | | | | | 8.0 |

**Figure 1:** Normsfor permanent teeth maturation (boys)

NORMS FOR THE MATURATION OF PERMANENT TEETH FOR GIRLS

| Age | Mandibular Teeth (Growth Stage) | | | | | | | | Maxillary Teeth (Growth Stage) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Yrs.) | 1\|1 | 2\|2 | 3\|3 | 4\|4 | 5\|5 | 6\|6 | 7\|7 | 8\|8 | 1\|1 | 2\|2 | 3\|3 | 4\|4 | 5\|5 | 6\|6 | 7\|7 | 8\|8 |
| 3 | 5.3 | 4.7 | 3.4 | 2.9 | 1.7 | 5.0 | 1.6 | | 4.3 | 3.7 | 3.3 | 2.6 | 2.0 | 4.5 | 1.8 | |
| 4 | 6.6 | 6.0 | 4.4 | 3.9 | 2.8 | 6.2 | 2.8 | | 5.4 | 4.8 | 4.3 | 3.6 | 3.0 | 5.7 | 2.8 | |
| 5 | 7.6 | 7.2 | 5.4 | 4.9 | 3.8 | 7.3 | 3.9 | | 6.5 | 5.8 | 5.3 | 4.6 | 4.0 | 6.9 | 3.8 | |
| 6 | 8.5 | 8.1 | 6.3 | 5.8 | 4.8 | 8.1 | 5.0 | | 7.4 | 6.7 | 6.2 | 5.6 | 4.9 | 7.9 | 4.7 | |
| 7 | 9.3 | 8.9 | 7.2 | 6.7 | 5.7 | 8.7 | 5.9 | 1.8 | 8.3 | 7.6 | 7.0 | 6.5 | 5.8 | 8.7 | 5.6 | |
| 8 | 9.8 | 9.5 | 8.0 | 7.5 | 6.6 | 9.3 | 6.7 | 2.1 | 9.0 | 8.4 | 7.8 | 7.3 | 6.6 | 9.3 | 6.5 | 2.1 |
| 9 | 10.0 | 9.9 | 8.7 | 8.3 | 7.4 | 9.7 | 7.4 | 2.3 | 9.6 | 9.1 | 8.5 | 8.1 | 7.4 | 9.7 | 7.2 | 2.4 |
| 10 | | 10.0 | 9.2 | 8.9 | 8.1 | 10.0 | 8.1 | 3.2 | 10.0 | 9.6 | 9.1 | 8.7 | 8.1 | 10.0 | 7.9 | 3.2 |
| 11 | | | 9.7 | 9.4 | 8.6 | | 8.6 | 3.7 | | 10.0 | 9.5 | 9.3 | 8.7 | | 8.5 | 4.3 |
| 12 | | | 10.0 | 9.7 | 9.1 | | 9.1 | 4.7 | | | 9.8 | 9.7 | 9.3 | | 9.0 | 5.4 |
| 13 | | | | 10.0 | 9.4 | | 9.5 | 5.8 | | | 10.0 | 10.0 | 9.7 | | 9.5 | 6.2 |
| 14 | | | | | 9.7 | | 9.7 | 6.5 | | | | | 10.0 | | 9.7 | 6.8 |
| 15 | | | | | 10.0 | | 9.8 | 6.9 | | | | | | | 9.8 | 7.3 |
| 16 | | | | | | | 10.0 | 7.5 | | | | | | | 10.0 | 8.0 |
| 17 | | | | | | | | 8.0 | | | | | | | | 8.7 |

**Figure 2:** Norms for permanent teeth maturation (girls)

**Table 1:** Socio-demographic features

| Variables (N= 74) | Category | Frequency | Percentage |
|---|---|---|---|
| Gender | Male | 31 | 41.9 |
| | Female | 43 | 58.1 |
| Age | 4-6 | 27 | 36.5 |
| | 7-8 | 28 | 37.8 |
| | 9-10 | 19 | 25.7 |

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## 3. Results

Among the study population, 31 (41.9%) were boys and 43 (58.1%) were girls "(Table 1). The mean age of boys was

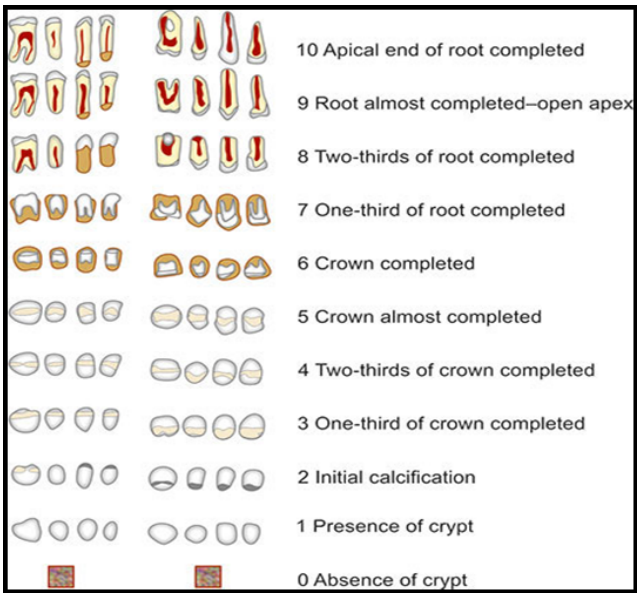
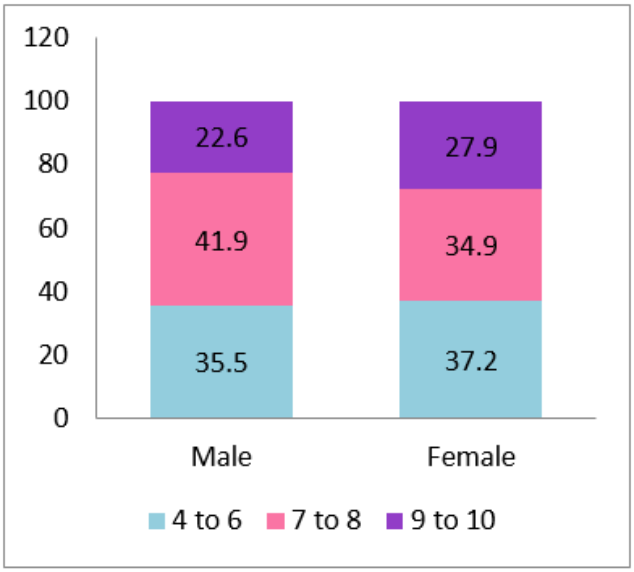


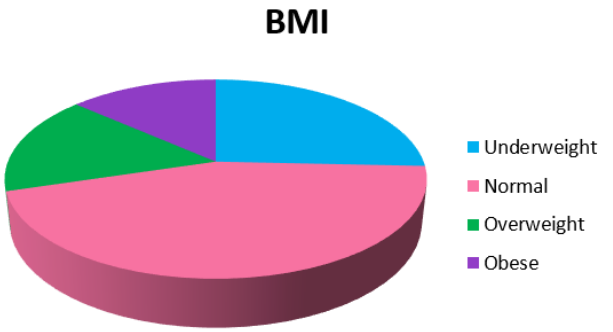

**Figure 3:** Stages of teeth development




Graph 1: Gender-wise distribution of age groups among the study population

**Table 2:** Gender-wise distribution of BMI

| Variables | Male N= 31 (%) | Female N= 43 (%) | Total N= (%) |
|---|---|---|---|
| Underweight | 7 (22.6%) | 12 (27.9%) | 19 (25.7%) |
| Normal | 13 (41.9%) | 20 (46.5%) | 33 (44.6%) |
| Overweight | 6 (19.4%) | 6 (14%) | 12 (16.2%) |
| Obese | 5 (16.1%) | 5 (11.6%) | 10 (13.5%) |




Graph 2: Distribution of BMI among the study population

**Table 3:** Correlation of BMI and dental developmental age

| | r | P value |
|---|---|---|
| Total Study Population (n=74) | 0.395 | 0.000* |
| Age group | | |
| 4-6(n=27) | 0.364 | 0.062 |
| 7-8(n=28) | 0.435 | 0.021* |
| 9-10(n=19) | 0.143 | 0.559 |
| Gender | | |
| Male(n=31) | 0.472 | 0.007* |
| Female(n=43) | 0.389 | 0.01* |
| BMI Percentile | | |
| Obese (Overweight/ Obese) (n=22) | 0.429 | 0.046* |
| Non-obese (Underweight/ Normal) (n=52) | 0.465 | 0.001* |

*Statistically significant at p-value < 0.05

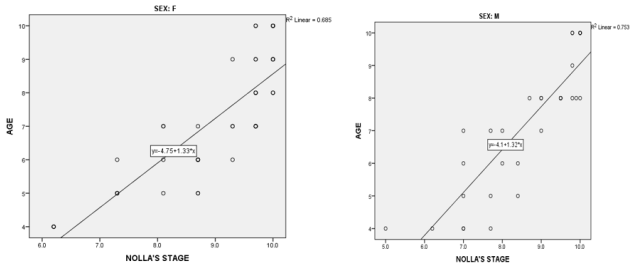
**Table 4:** Correlation between chronological age and dental developmental age

| | r | P value |
|---|---|---|
| Total Study Population (n=74) | 0.837 | 0.000* |
| Age group | | |
| 4-6(n=27) | 0.719 | 0.000* |
| 7-8(n=28) | 0.477 | 0.000* |
| 9-10(n=19) | 0.344 | 0.149 |
| Gender | | |
| Male(n=31) | 0.868 | 0.000* |
| Female(n=43) | 0.828 | 0.000* |
| BMI Percentile | | |
| Obese (Overweight/ Obese) (n=22) | 0.874 | 0.000* |
| Non-obese (Underweight/ Normal) (n=52) | 0.834 | 0.000* |

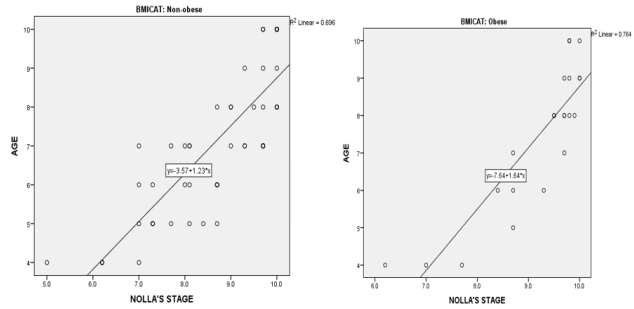
*Statistically significant at p-value < 0.05

**Table 5:** Comparison of means of the chronological age, BMI and dental age among boys and girls (Independent sample t test)

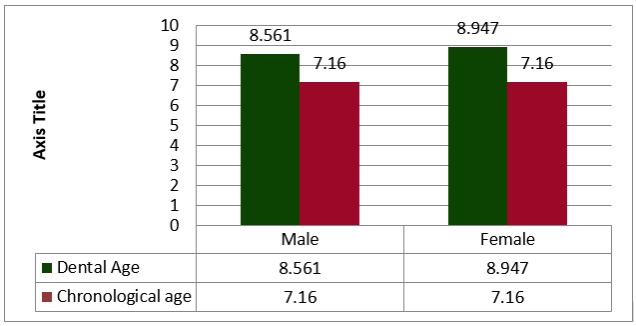
| Variables | Male | | Female | | P value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Age | 7.16 | 2.051 | 7.16 | 1.825 | 0.997 |
| BMI | 16.781 | 3.63 | 15.709 | 2.92 | 0.164 |
| Nolla'S Stage | 8.561 | 1.3524 | 8.947 | 1.1346 | 0.188 |



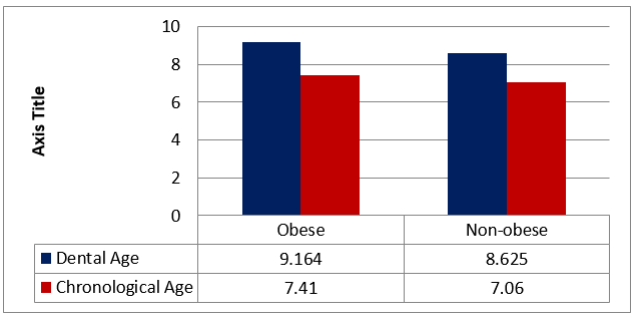

Graph 3: Gender-wise comparison of correlation between chronological age and dental age




Graph 4: Comparison of correlation between chronological age and dental age according to BMI




Graph 5: Gender-wise comparison of means between dental age and chronological age




Graph 6: Comparison of means between dental age and chronological age according to BMI

**Table 6:** Comparison of means between dental age and chronological age (Paired t Test)

| | Chronological age | | Dental developmental age | | Mean difference (95% CI) | Paired t test p value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Total Study Population (n=74) | 7.16 | 1.909 | 8.785 | 1.23 | -1.623 (-1.87, -1.36) | 0.000* |
| Gender | | | | | | |
| Male (n=31) | 7.16 | 2.051 | 8.561 | 1.35 | -1.4 (-1.8, -0.99) | 0.000* |
| Female(n=43) | 7.16 | 1.825 | 8.947 | 1.1346 | -1.78 (-2.12, -1.44) | 0.000* |
| BMI Percentile | | | | | | |
| Obese (Overweight/ Obese) (n=22) | 7.41 | 1.943 | 9.164 | 1.0349 | -1.754 (-2.26, -1.24) | 0.000* |
| Non-obese (Underweight/ Normal) (n=52) | 7.06 | 1.904 | 8.625 | 1.288 | -1.56 (-1.87, -1.26) | 0.000* |

*Statistically significant at p-value < 0.05

7.16 (2.051) and girls were7.16 (1.82). Among the boys, 35.5% belong to the 4-6 age group, 41.9% belong to the 7-8 age group and 22.6% belong to the 9-10 age group [Graph 1]. Among the girls, 37.2% belong to the 4-6 age group, 34.9% belong to the 7-8 age group and 27.9% belong to the 9-10 age group. In the study population, 7 boys (22.6%) and 12 girls (27.9%) were under-weight while 13 (41.9%) boys and 20 (46.5%) girls were found to have normal BMI. Result showed, 6 (19.4%) boys and 6 (14%) girls were overweight, and 5 (16.1%) boys and 5 (11.6%) girls were obese (Table 2). Overall, there was a weak positive correlation (r = 0.395) between the calculated dental age and BMI which was statistically significant. There is a positive correlation between the BMI and dental developmental age among the age group 7-8 (r = 0.435) which was statistically significant (Table 3).

Among both males (r = 0.472) and females (r = 0.389), there is a positive correlation between BMI and dental developmental age which was statistically significant. Among both obese (r = 0.429) and non-obese (r = 0.465), there is a positive correlation between BMI and dental developmental age which was statistically significant. There was a strong positive correlation (r = 0.837) between the calculated dental age and chronological age which was statistically significant (Table 4).

There is a strong positive correlation between the chronological age and dental developmental age among the age group 4-6 (r = 0.719) which was statistically significant and there is a weak positive correlation between the chronological age and dental developmental age among the age group 7-8 (r = 0.477) which was statistically significant.

Among both males (r = 0.868) and females (r = 0.828), there is a strong positive correlation between chronological age and dental developmental age which was statistically significant. Among both obese (r = 0.874) and non-obese (r = 0.834), there is a strong positive correlation between chronological age and dental developmental age which was statistically significant.

There were no statistically significant differences in mean values between boys and girls in their chronological age, dental developmental age, and BMI (p=0.997, p = 0.188, p = 0.164) (Table 5). It was found that the mean difference between the dental age and chronological age was higher in the case of females (-1.7837) than in males (-1.4). The mean difference between the dental age and chronological age among the obese patients (-1.754) was more than that among the non-obese patients (-1.567) (Table 6).

## 4. Discussion

The BMI of this study population shows the unique problem of double burden wherein there is obesity at one end and underweight at the other end.[7] In this study, the correlation between BMI and dental developmental age was statistically significant with a weak positive correlation among the total sample population (r = 0.395) (Table 3). Hegde et al (2018)[9] found similar results in their study where there was a positive correlation (r = 0.1739) between BMI and calculated dental age. Weddell et al (2011)[10] also observed similar results in their study.

When a correlation between BMI and dental development age among males and females was seen, boys (r = 0.472) showed greater advancement than girls (r = 0.389) (Table 3). Booshehri et al (2011)[2] also found a stronger coefficient ratio between increased BMI in boys and increased rate of eruption of teeth. Our study is also in accordance with Mack et al (2013)[11] who found that there was a greater average advancement in boys than in girls. Hedayati et al (2014)[12]and Hilgers et al (2006)[13] found girls to have more advanced dental age in their study, which is not in accordance with our results. Our findings are different from the above studies which could be due to the difference in race, diet, and socioeconomic conditions.

The positive correlation between BMI and dental developmental age agrees and supports the study of Eid et al (2002)[14] where they found a lack of significant association between the category of BMI and variation in dental age.

In this study, a strong positive correlation (r = 0.837) between dental developmental age and chronological age was found among the total study population which agrees and support with the findings of Hedayati et al (2014)[12] where there was a direct relationship between dental age and chronological age (r = 0.841, $p \leq 0.001$). Hegde et al (2018)[9] (r = 0.967) and Chaudhry et al (2010)[15] (r = 0.650) also found similar results between calculated dental age and chronological age in their studies on the Indian population. Booshehri et al (2011)[2] also found a high level of relationship between chronological age and dental age (r = 0.784) in their study on the Iranian population. Chehab et al (2017)[16] also reported similar findings from their study on Hispanic children. However, both boys (r = 0.868) and girls (r = 0.828) [Table 4] [Graph 3] showed a strong positive correlation between chronological age and dental developmental age which was in accordance with the study of Hegde et al (2018)[9] (r = 0.9699 for boys and r = 0.9652 for girls). Similar results were observed in the studies of Mack et al (2013)[11] and Yassin et al (2020).[17] However, Hilgers et al (2006)[13] found dental age acceleration was significantly greater for females than males.

Both obese (r = 0.874) and non-obese (r = 0.834) (Table 4 ) (Graph 4) had a strong positive correlation between dental developmental age and chronological age which was statistically significant. Hegde et al (2018)[9] reported similar findings in their study where both underweight (r = 0.9538) and normal weight (r = 0.9866) had a strong positive correlation.

In this study, there were no statistically significant differences in the mean values between boys and girls in their chronological age (p = 0.997), dental developmental age (p = 0.188), and BMI (p = 0.164) (Table 5) similar to Hedayati et al (2014).[12] In this study, a statistically significant difference was observed between the dental age and chronological age (-1.623) among the total study population (Table 6). Similar results were observed by Yassin et al (2020)[17] in their study.

It was found that the mean difference between the dental age and chronological age was higher in girls (-1.7837) than in boys (-1.4) (Table 6) (Graph 5). This is in accordance with that of Khoja et al (2015)[18] who reported mean age difference was greater in females than in males. However, Nur et al (2012)[19] observed that the mean difference between dental age and chronological age was higher in males (0.27 to 1.60 years) than in females (0.15 to 1.24 years). The mean difference between dental age and chronological age among obese (-1.754) was more than in non-obese (-1.567) (Table 6) (Graph 6). This is in accordance with the findings of Hedayati et al (2014)[12] who reported the mean difference between dental age and chronological age to be 1.8±1.08 for overweight and obese while 0.73±1.3 for underweight and normal-weight children. Hilgers et al (2006)[13] also reported the same.

The present study concluded that obese children have a higher rate of dental development compared to normal children. This is an important variable to be considered when planning for dental and orthodontic treatments in obese children. Orthodontic treatment usually lasts 1 to 2 years or more. Therefore, an orthodontist has the opportunity to impact the general health status of children and adolescents. As childhood obesity is related to many different diseases and malfunctions like hypertension, type II diabetes, and dyslipidemia, it is the orthodontist's responsibility to orient patients about their health status and its risk factors and refer these obese patients for medical consultations when necessary.

Future studies with larger sample sizes are warranted to determine if different chronologic age groups, ethnicity, and socioeconomic condition in coordination with obesity would have an effect on dental development. Moreover, the study was conducted on children from a single site; hence the observations cannot be generalized to the Indian population. Further studies with larger samples from various regions of India are required to be carried out.

## 5. Conclusion

Based on this study's results, the following conclusions can be drawn:

1. There is a positive correlation between the calculated dental age and BMI which is statistically significant. There is a positive correlation between the BMI and dental developmental age among the age group 7-8 which is statistically significant. Among both males and females, there is a positive correlation between BMI and dental developmental age which is statistically significant. Among both obese and non-obese there is a positive correlation between BMI and dental developmental age which was statistically significant. Children who are overweight or obese have accelerated dental development.
2. There is a statistically significant difference between dental age and chronological age. It was found that the mean difference between the dental age and chronological age was higher in the case of females than in males. The mean difference between the dental age and chronological age among the obese patients were more than that among the non-obese patients.
3. There are no statistically significant differences in mean values between boys and girls in their chronological age, dental developmental age, and BMI.

Hence, orthodontic treatment planning should be meticulously chalked out by orthodontists for overweight and obese children keeping in mind that these children have accelerated dental growth and maturation in comparison to children with a normal build. They should also educate these children and their parents about the probable obesity-related disorders and keep an eye on the children's general health and well-being.

## 6. Statement of Informed Consent and Ethical Approval

Necessary ethical clearances and informed consent were received and obtained respectively before initiating the study from all participants.

## 7. Source of Funding

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## 8. Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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