**Research Article**

## ASSESSMENT OF DENTAL MATURITY OF CHILDREN AGED 6-14 YEARS USING DEMIRJIAN'S AND NOLLA METHODS

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**A B S T R A C T**

**Introduction:** Growth is a physiochemical process found in living beings, which manifests itself in the structure, composition and size of an organism. The degree of skeletal development is reflection of the degree of physiological maturation of a subject. While dental maturity can be determined by stages of tooth formation. Chronological age is important for school attendance, employment and social benefits. Therefore, dental age, chronological age and skeletal age are all essential parameters that help to assess the growth and development in children.

**Aim:** To assess the dental maturity of children aged 6-14 years using Demirjian's and Nolla methods in Patiala city.

**Method:** The study included hand wrist radiograph of left hand and an Orthopantomogram on the same day. Chronological age was assessed from the date of birth of the child. The radiographs of hand and wrist were taken and skeletal age was determined using atlas of Greulich and Pyle. Dental age was assessed from OPG by using Demirjian's method and Nolla's calcification stages.

**Result:** The skeletal age was found to be more significantly correlated to chronological age followed by Dental age according to Nolla's method and Dental age according to method.

**Conclusion:** Skeletal age was found to be more reliable than dental age. Among dental age estimation methods Nolla method gave relatively closer age estimation than Demirjian's method in population of Patiala district.

## INTRODUCTION

Growing individuals not only differ in the timing of the maturational events, but also in the sequence of these events. Developmental status can have considerable influence on diagnosis and treatment planning of an indvidual. The developmental status of a child can be accessed from various parameters as height, weight, chronological age, secondary sexual characteristics, skeletal age and dental age.

Importance of age has been emphasized in various fields such as school attendance, child adoption, in forensic medicine, age assessment for sports, immigration details and particular interest in orthodontic and pedodontic practice and forensic sciences. However there are instances where date of birth might not be known due to missing documents. Thus, estimation of age and reliability of methods to assess the age of a child is very important to study and it has got a lot of importance.

Several methods have been developed in order to assess the dental age according to the degree of calcification observed in permanent teeth eg.

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Nolla and Demirjian's method. However, reliability of dental age is dependent on a number of factors like the population group on which it is to be tested, nutritional status of a child, race, genetic factors etc. The difference in overall dental maturity not only exist among nations but also among groups of children in a nation or community.

## MATERIALS AND METHODS

The present study was conducted on 252 healthy children in age group of 6-14 years. The children were selected from various schools of Patiala city. Brief history of each child including name, age, sex, date of birth, name of the school and address was recorded. Consent was obtained from the parents and school teachers. Approval was taken from ethical committee. Dental examination was done under good illumination to check status of teeth. Mandibular left quadrant was examined.

### Inclusion Criteria

1. Healthy children in age group of 6 to14 years.
2. Children with no caries on left mandibular quadrant were selected for the study.
3. Children with no serious illness, developmental skeletal abnormality or any dental pathology.

4. Children with no history of trauma to hand -wrist and facial skeleton.

## Method of collection of data: The study included

1. Hand wrist radiographs of left hand using 8"x 10" films.
2. Orthopantamographs using 8"x 10" films.

All the radiographs for each child were taken on the same day.

## Assesment of Chronological Age

Chronologic age of each child was calculated from the date of birth of the child to the date when radiographs were taken.

## Assesment of Skeletal Age

Skeletal age was assessed using hand wrist radiographs using the standards given in the 'Radiographic Atlas of Greulich and Pyle". In this method by merely comparing the patient's hand wrist radiographs with standard radiographs that represent different skeletal ages, skeletal maturation status of that individual can be determined. It is quick and relatively easy to learn and perform.



**Fig 1** shows the anatomy of hand and wrist radiograph

1. capitate
2. hamate
3. distal epiphysis of the radius
4. epiphysis of proximal phalanx of the third digit
5. epiphysis of proximal phalanx of the second digit
6. epiphysis of proximal phalanx of the fourth digit
7. epiphysis of the second metacarpal
8. epiphysis of distal phalanx of the first digit
9. epiphysis of the third meta- carpal
10. epiphysis of the fourth metacarpal
11. epiphysis of proximal phalanx of the fifth digit
12. epiphysis of middle phalanx of the third digit

13. epiphysis of middle phalanx of the fourth digit
14. epiphysis of the fifth metacarpal
15. epiphysis of middle phalanx of the second digit
16. triquetral
17. epiphysis of distal phalanx of the third digit
18. epiphysis of distal phalanx of the fourth digit
19. epiphysis of the first metacarpal
20. epiphysis of proximal phalanx of the first digit
21. epiphysis of distal phalanx of the fifth digit
22. epiphysis of distal phalanx of the second digit
23. epiphysis of middle phalanx of the fifth digit
24. lunate
25. trapezium
26. trapezoid
27. scaphoid
28. distal epiphysis of the ulna
29. pisiform
30. sesamoid of adductor pollicis (the sesamoid of flexor pollicis brevis is visible through the head of the first metacarpal, just below the numeral 2 on the epiphysis of the proximal phalanx of the thumb).

## Assesment of Dental Age

The dental age was determined from the Orthopantomographs by following ways: -

Nolla method − For dental age, stage of calcification of permanent left mandibular canine was assessed. The maturation status of permanent left mandibular canine was analyzed and then compared to a series of standardized drawings depicting , (0-10) stages of tooth calcification for each gender. This stage was given a score according to norms for maturation of permanent teeth given by Nolla. This stage was reffered for age, to the tables given by Nolla for boys and girls**.**
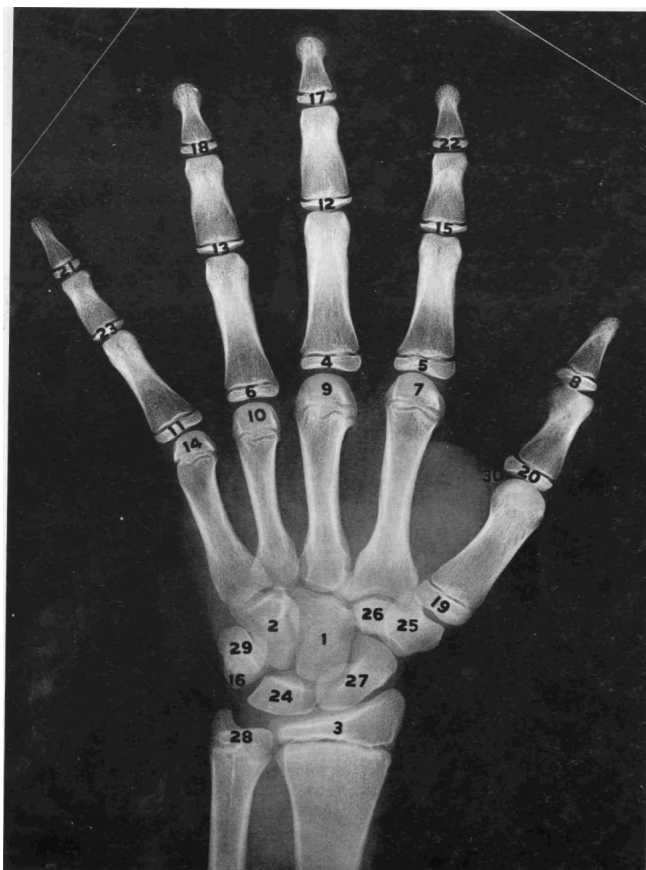


Stage 0: Absence of crypt
Stage 1: Presence of crypt
Stage 2: Initial calcification
Stage 3: 1/3rd crown completed
Stage 4: 2/3rd crown completed
Stage 5: Crown almost completed
Stage 6: Crown completed
Stage 7: 1/3rd root completed
Stage 8: 2/3rds root completed
Stage 9: Root completed, apex open
Stage 10: Apical foramen closed
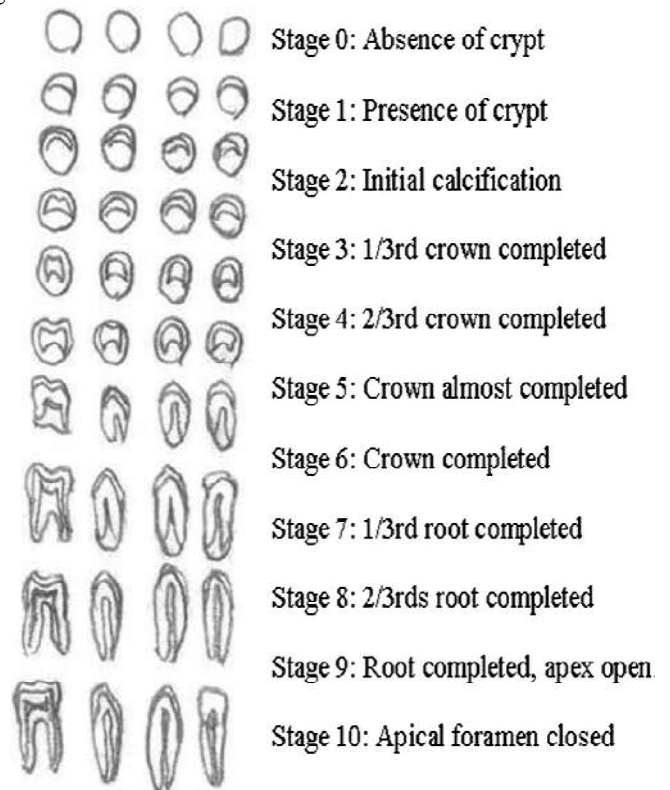
**Fig 2** Ten stages of tooth formation with description.

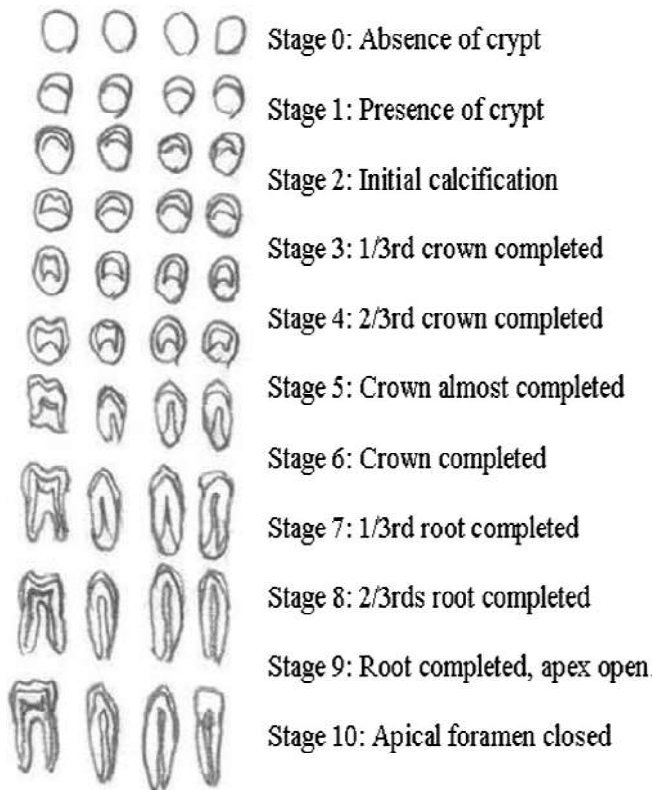| Age (years) | Mandibular teeth (growth stage) Mandibular right canine | Maxillary teeth (growth stage) Maxillary right canine |
|---|---|---|
| 3 | 3.4 | 3.3 |
| 4 | 4.4 | 4.3 |
| 5 | 5.4 | 5.3 |
| 6 | 6.3 | 6.2 |
| 7 | 7.2 | 7.0 |
| 8 | 8.0 | 7.8 |
| 9 | 8.7 | 8.5 |
| 10 | 9.2 | 9.1 |
| 11 | 9.7 | 9.5 |
| 12 | 10.0 | 9.8 |
| 13 | | 10.0 |

**Norms for maturation of permanent teeth for girls (Nolla Method)**

| Age (years) | Mandibular teeth (growth stage) Mandibular right canine | Maxillary teeth (growth stage) Maxillary right canine |
|---|---|---|
| 3 | 3.2 | 3.0 |
| 4 | 4.2 | 3.9 |
| 5 | 5.1 | 4.8 |
| 6 | 5.9 | 5.6 |
| 7 | 6.7 | 6.3 |
| 8 | 7.4 | 7.0 |
| 9 | 8.0 | 7.7 |
| 10 | 8.6 | 8.4 |
| 11 | 9.1 | 8.8 |
| 12 | 9.6 | 9.2 |
| 13 | 9.8 | 9.6 |

**Norms for maturation of Permanent teeth for boys (Nolla method)**

Demirijian method – For dental age, the calcification stages (A- H) of seven permanent teeth on the left side of mandible from central incisor to second molar were assessed. The development stage of each tooth was converted into a score using the conversion table given by Demirjian's. The score of all seven teeth were added together to get a maturity score. After the maturity score was calculated, it was converted to dental age by referring to the table given by Demirjian's for boys and girls.
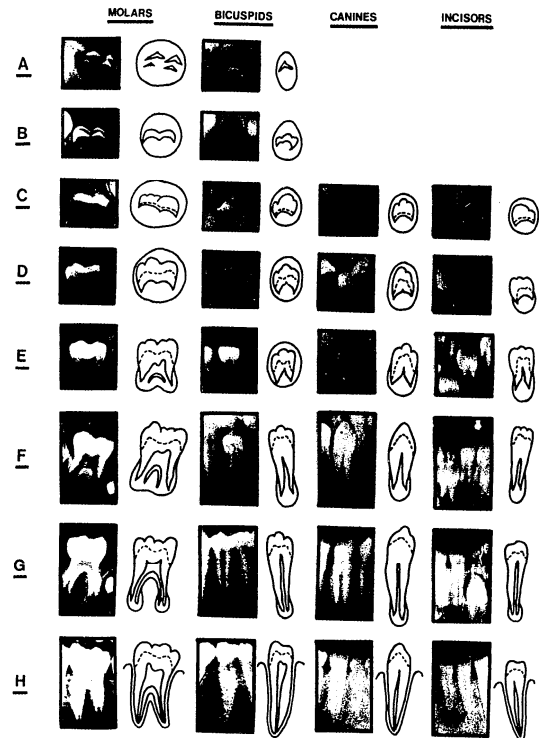


**Fig 3** Developmental stages of tooth formation
DESCRIPTION OF VARIOUS STAGES OF DEMIRJIAN (A-H)

In both uniradicular and multiradicular teeth, a beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.

Fusion of the calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface.

  a. Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen.
  b. The beginning of a dentinal deposit is seen.
  c. The outline of the pulp chamber has a curved shape at the occlusal border.

  a. The crown formation is completed down to the cemento-enamel junction.
  b. The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave towards the cervical region. The projection of the pulp horns if present, gives an outline shaped like an umbrella top. In molars the pulp chamber has a trapezoidal form.
  c. Beginning of root formation is seen in the form of a spicule.

### Uniradicular teeth

  a. The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage.
  b. The root length is less than the crown height.

## Molars

a. Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi-lunar shape.
b. The root length is still less than the crown height.

Uniradicular teeth

a. The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape.
b. The root length is equal to or greater than the crown height.

## Molars

a. The calcified region of the bifurcation has developed down further from its semi-lunar stage to give the roots a more definite and distinct outline with funnel shaped endings.
b. The root length is equal to or greater than the crown height.

The walls of the root canal are now parallel and its apical end is still partially open (Distal root on molars).

a. The apical end of the root canal is completely closed (Distal root on molars).
b. The periodontal membrane has a uniform width around the root and the apex.

*Self-Weighted Scores for Dental Stages*
*7 Teeth (Mandibular Left Side)*

### Boys

| Tooth | Stage 0 | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| M₂ | 0.0 | 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 | 0.0 | 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 |
| I₂ | | | | 0.0 | 3.2 | 5.2 | 7.8 | 11.7 | 13.7 |
| I₁ | | | | | 0.0 | 1.9 | 4.1 | 8.2 | 11.8 |

### Girls

| Tooth | Stage 0 | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| M₂ | 0.0 | 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 | 0.0 | 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 | 7.3 | 10.3 | 11.6 | 12.4 |
| I₂ | | | | 0.0 | 3.2 | 5.6 | 8.0 | 12.2 | 14.2 |
| I₁ | | | | | 0.0 | 2.4 | 5.1 | 9.3 | 12.9 |

NB: Stage 0 is no calcification

*Self weighted score for dental age (Demirjian's method)*

*Conversion of Maturity Score to Dental Age 7 Teeth (Mandibular Left Side)*

### Girls

| Age | Score | Age | Score | Age | Score | Age | Score |
|---|---|---|---|---|---|---|---|
| 3.0 | 13.7 | 7.0 | 51.0 | 11.0 | 94.5 | 15.0 | 99.2 |
| .1 | 14.4 | .1 | 52.9 | .1 | 94.7 | .1 | 99.3 |
| .2 | 15.1 | .2 | 55.5 | .2 | 94.9 | .2 | 99.4 |
| .3 | 15.8 | .3 | 57.8 | .3 | 95.1 | .3 | 99.4 |
| .4 | 16.6 | .4 | 61.0 | .4 | 95.3 | .4 | 99.5 |
| .5 | 17.3 | .5 | 65.0 | .5 | 95.4 | .5 | 99.6 |
| .6 | 18.0 | .6 | 68.0 | .6 | 95.6 | .6 | 99.6 |
| .7 | 18.8 | .7 | 71.8 | .7 | 95.8 | .7 | 99.7 |
| .8 | 19.5 | .8 | 75.0 | .8 | 96.0 | .8 | 99.8 |
| .9 | 20.3 | .9 | 77.0 | .9 | 96.2 | .9 | 99.9 |
| 4.0 | 21.0 | 8.0 | 78.8 | 12.0 | 96.3 | 16.0 | 100.0 |
| .1 | 21.8 | .1 | 80.2 | .1 | 96.4 | | |
| .2 | 22.5 | .2 | 81.2 | .2 | 96.5 | | |
| .3 | 23.2 | .3 | 82.2 | .3 | 96.6 | | |
| .4 | 24.0 | .4 | 83.1 | .4 | 96.7 | | |
| .5 | 24.8 | .5 | 84.0 | .5 | 96.8 | | |
| .6 | 25.6 | .6 | 84.8 | .6 | 06.9 | | |
| .7 | 26.4 | .7 | 85.3 | .7 | 97.0 | | |
| .8 | 27.2 | .8 | 86.1 | .8 | 97.1 | | |
| .9 | 28.0 | .9 | 86.7 | .9 | 97.2 | | |
| 5.0 | 28.9 | 9.0 | 87.2 | 13.0 | 97.3 | | |
| .1 | 29.7 | .1 | 87.8 | .1 | 97.4 | | |
| .2 | 30.5 | .2 | 88.3 | .2 | 97.5 | | |
| .3 | 31.3 | .3 | 88.8 | .3 | 97.6 | | |
| .4 | 32.1 | .4 | 89.3 | .4 | 97.7 | | |
| .5 | 33.0 | .5 | 89.8 | .5 | 97.8 | | |
| .6 | 34.0 | .6 | 90.2 | .6 | 98.0 | | |
| .7 | 35.0 | .7 | 90.7 | .7 | 98.1 | | |
| .8 | 36.0 | .8 | 91.1 | .8 | 98.2 | | |
| .9 | 37.0 | .9 | 91.4 | .9 | 98.3 | | |
| 6.0 | 38.0 | 10.0 | 91.8 | 14.0 | 98.3 | | |
| .1 | 39.1 | .1 | 92.1 | .1 | 98.4 | | |
| .2 | 40.2 | .2 | 92.3 | .2 | 98.5 | | |
| .3 | 41.3 | .3 | 92.6 | .3 | 98.6 | | |
| .4 | 42.5 | .4 | 92.9 | .4 | 98.7 | | |
| .5 | 43.9 | .5 | 93.2 | .5 | 98.8 | | |
| .6 | 45.2 | .6 | 93.5 | .6 | 98.9 | | |
| .7 | 46.7 | .7 | 93.7 | .7 | 99.0 | | |
| .8 | 48.0 | .8 | 94.0 | .8 | 99.1 | | |
| .9 | 49.5 | .9 | 94.2 | .9 | 99.1 | | |

*Conversion of Maturity Score to Dental Age (7 Teeth)*

### Boys

| Age | Score | Age | Score | Age | Score | Age | Score |
|---|---|---|---|---|---|---|---|
| 3.0 | 12.4 | 7.0 | 46.7 | 11.0 | 92.0 | 15.0 | 97.6 |
| .1 | 12.9 | .1 | 48.3 | .1 | 92.2 | .1 | 97.7 |
| .2 | 13.5 | .2 | 50.0 | .2 | 92.5 | .2 | 97.8 |
| .3 | 14.0 | .3 | 52.0 | .3 | 92.7 | .3 | 97.8 |
| .4 | 14.5 | .4 | 54.3 | .4 | 92.9 | .4 | 97.9 |
| .5 | 15.0 | .5 | 56.8 | .5 | 93.1 | .5 | 98.0 |
| .6 | 15.6 | .6 | 59.6 | .6 | 93.3 | .6 | 98.1 |
| .7 | 16.2 | .7 | 62.5 | .7 | 93.5 | .7 | 98.2 |
| .8 | 17.0 | .8 | 66.0 | .8 | 93.7 | .8 | 98.2 |
| .9 | 17.6 | .9 | 69.0 | .9 | 93.9 | .9 | 98.3 |
| 4.0 | 18.2 | 8.0 | 71.6 | 12.0 | 94.0 | 16.0 | 98.4 |
| .1 | 18.9 | .1 | 73.5 | .1 | 94.2 | | |
| .2 | 19.7 | .2 | 75.1 | .2 | 94.4 | | |
| .3 | 20.4 | .3 | 76.4 | .3 | 94.5 | | |
| .4 | 21.0 | .4 | 77.7 | .4 | 94.6 | | |
| .5 | 21.7 | .5 | 79.0 | .5 | 94.8 | | |
| .6 | 22.4 | .6 | 80.2 | .6 | 95.0 | | |
| .7 | 23.1 | .7 | 81.2 | .7 | 95.1 | | |
| .8 | 23.8 | .8 | 82.0 | .8 | 95.2 | | |
| .9 | 24.6 | .9 | 82.8 | .9 | 95.4 | | |
| 5.0 | 25.4 | 9.0 | 83.6 | 13.0 | 95.6 | | |
| .1 | 26.2 | .1 | 84.3 | .1 | 95.7 | | |
| .2 | 27.0 | .2 | 85.0 | .2 | 95.8 | | |
| .3 | 27.8 | .3 | 85.6 | .3 | 95.9 | | |
| .4 | 28.6 | .4 | 86.2 | .4 | 96.0 | | |
| .5 | 29.5 | .5 | 86.7 | .5 | 96.1 | | |
| .6 | 30.3 | .6 | 87.2 | .6 | 96.2 | | |
| .7 | 31.1 | .7 | 87.7 | .7 | 96.3 | | |
| .8 | 31.8 | .8 | 88.2 | .8 | 96.4 | | |
| .9 | 32.6 | .9 | 88.6 | .9 | 96.5 | | |
| 6.0 | 33.6 | 10.0 | 89.0 | 14.0 | 96.6 | | |
| .1 | 34.7 | .1 | 89.3 | .1 | 96.7 | | |
| .2 | 35.8 | .2 | 89.7 | .2 | 96.8 | | |
| .3 | 36.9 | .3 | 90.0 | .3 | 96.9 | | |
| .4 | 38.0 | .4 | 90.3 | .4 | 97.0 | | |
| .5 | 39.2 | .5 | 90.6 | .5 | 97.1 | | |
| .6 | 40.6 | .6 | 91.0 | .6 | 97.2 | | |
| .7 | 42.0 | .7 | 91.3 | .7 | 97.3 | | |
| .8 | 43.6 | .8 | 91.6 | .8 | 97.4 | | |
| .9 | 45.1 | .9 | 91.8 | .9 | 97.5 | | |

**Table 1** Distribution And Mean Chronological Age, Skeletal Age, Dentalage(Nolla And Demirjian's Method) In Total Males And Females From 6-14 Year

| S.no. | Age group(in years) | N M | N F | Chronological age(in years) | Skeletal age(in years) | Dental age(in years) Nolla method | Dental age(in years) Demirjian's method |
|---|---|---|---|---|---|---|---|
| 1 | 6-7 | 15 | 15 | 6.53 ± 0.24 | 6.48 ± 0.32 | 6.46±0.50 | 6.71 ± 0.33 |
| 2 | 7-8 | 15 | 15 | 7.443 ± 0.26 | 7.440±0.37 | 7.70±0.46 | 7.63 ± 0.35 |
| 3 | 8-9 | 16 | 16 | 8.45 ± 0.27 | 8.40 ± 0.38 | 8.56±0.50 | 8.54 ± 0.41 |
| 4 | 9-10 | 16 | 16 | 9.48 ± 0.24 | 9.42 ± 0.25 | 9.62±0.49 | 9.64 ± 0.63 |
| 5 | 10-11 | 16 | 16 | 10.43 ± 0.25 | 10.37±0.41 | 10.46±0.50 | 10.80± 0.59 |
| 6 | 11-12 | 16 | 16 | 11.54 ± 0.25 | 11.62±0.41 | 11.65±0.48 | 12.06±0.35 |
| 7 | 12-13 | 16 | 16 | 12.40 ± 0.23 | 12.44±0.40 | 12.46±0.50 | 12.68 ±0.41 |
| 8 | 13-14 | 16 | 16 | 13.41 ± 0.19 | 13.44±0.23 | 13.37±0.49 | 13.92 ±0.60 |

**Table 2** correlation co-efficents between skeletal age and chronological age, nolla age and chronological age, demirjian's age and chronological age in males and females from 6- 14 years.

| Age (years) | Skeletal age (r-value) Male | Skeletal age (r-value) Female | Nolla age (r-value) Male | Nolla age (r-value) Female | Demirjian 's age (r-value) Male | Demirjian 's age (r-value) Female |
|---|---|---|---|---|---|---|
| 6-7 | 0.96 | 0.91 | 0.34 | 0.21 | 0.13 | 0.48 |
| 7-8 | 0.77 | 0.75 | 0.47 | 0.00 | 0.34 | 0.58 |
| 8-9 | 0.61 | 0.89 | 0.41 | 0.34 | 0.65 | 0.55 |
| 9-10 | O.53 | 0.53 | -0.35 | 0.34 | -0.08 | -0.09 |
| 10-11 | 0.76 | 0.67 | 0.21 | 0.26 | 0.29 | -0.37 |
| 11-12 | 0.65 | 0.81 | 0.41 | -0.32 | 0.19 | 0.05 |
| 12-13 | 0.84 | 0.83 | 0.68 | 0.76 | 0.12 | 0.53 |
| 13-14 | 0.77 | 0.67 | 0.65 | 0.65 | 0.18 | 0.34 |

## RESULTS

252 healthy children comprising of equal number of male and female children were selected in the age group of 6-14 years . Mean chronological age, skeletal age, dental age according to Nolla method and Demirjia n's method was obtained for each age group (Table 1). Intragroup comparisons were done and the relationship among various parameters viz. chronological age, skeletal age, dental age according to Nolla method and Demirjian's method was obtained by applying the Pearson's

Correlation Coefficient.Data was tabulated and put to statistical analysis.

The results showed correlation co-efficients (r-value) between chronological age and skeletal age in males and females from 6-14 years was a significant for both the males and females in all age groups.

The correlation co-efficients (r-value) between chronological age and dental age (Nolla method) in males and females showed that there was a significant correlation between chronological age and dental age(Nolla method) for both the males and females in the age group of 12-13 and 13-14 years and it showed non significant results in age group of 6-12 years of age.

The correlation co-efficients (r-value) between chronological age and dental age (Demirjian's method) in males and females showed that there was a significant correlation between chronological age and dental age for 8-9 years in males and 7-8 years in females and non significant relation in all other groups.

## DISCUSSION

The present study was conducted on 252 healthy children to assess and evaluate the dental maturity using Demirjian's and Nolla Methods and to correlate skeletal age, dental age with chronological age in children aged 6-14 years. The hand- wrist radiograph is used for skeletal developmental assessment as it is easily accessible, easy to restrict radiation exposure and it has many ossification centers which ossify at separate times which is standardized.

Mandibular region was assessed since there is no overlapping of structure in mandible as compared to maxilla, which might lead to any aberration in image hence making it difficult to assess the apices of teeth. Since in Demirjian's method, left side of the mandible has been standardized, thus assessment of dental age by Nolla method and skeletal age assessment by hand wrist radiograph was also assessed for left hand to minimize any asymmetry of left and right side. No difference in the age estimated by using left or right canine was observed by Sierra *et al* [11]. The mandibular canine was used as it showed a strong relation between stages of eruption of mandibular canine and pubertal growth (Bala M *et al* ) [2].

Table 2 shows correlation co-efficents between skeletal age and chronological age, nolla age and chronological age, demirjian's age and chronological age in males and females from 6- 14 years.

The correlation co-efficients (r- value) between chronological age and skeletal age in males and females from 6-14 years showed that there was a significant correlation between chronological age and skeletal age for both the males and females in all age groups. This result is in concordance with the study of Engstrom *et al*[6] who evaluated the relation of dental development, skeletal maturation and chronological age. They concluded that there was a strong correlation between chronological and skeletal age which is similar to the studies done by Cole AJL *et al* in 1988 [3]

The correlation co efficients (r- value) between chronological age and dental age according to Nolla's method in males and females from 6-14 years was found to be highest at 12- 13 and 13-14 years of age. This can be attributed to the fact that at ages 12-14 years the root development of all the teeth is almost complete and the Nolla stage of the teeth is either 9 or 10. Thus this represents a period of growth completion in both males and females which coincides with chronological age, hence giving greater r value for this age groups. However, this was lower than skeletal age at all age groups. However for all other age groups results were non significant . The lower precision seen in the Nolla method may be due to more number of stages. The method allows the observer to choose between 10 stages but also gives 3 interstage options for each stage, increasing the possible stage to 40. Increasing the number of stages has been shown to decrease precision [7].

The correlation co - efficients (r- value) between chronological age and dental age according to Demirijian method in males and females from 6-14 years showed less correlation between chronological age and dental age according to Demirijian method for both males and females as compared to skeletal age and dental age estimation by Nolla's method. These results are in concordance with study of Maber *et al*. [8] Similar results were obtained by Chaillet *et al* [4] . Demirijian method involves calculating dental age by adding up a score for each stage of each tooth .Towards the end of dental maturation, fewer stages contribute more so that a single stage change can lead to large jump in dental age. eg. A difference for one stage for girl with stage G with a dental age 14.6 years, jumps to dental age 16 for a girl with dental stage of H. The correlation co-efficients (r-value) between chronological age and dental age (Demirjian's method) in males and females showed that there was a significant correlation between chronological age and dental age for 8-9 years in males and 7-8 years in females and non significant relation in all other groups. This can be attributed to the fact that this period is stable period when minimal changes take place.

In this present study, correlation with chronological age was found to be in following order:- Skeletal age > Dental age according to Nolla's method > Dental age according to Demirjian's method. However, more studies should be attempted over a larger range of population to assess the correction factor required to create a more accurate and standardised reference charts most suitable for application in North Indian population.

### *Summary and conclusion*

### *In our study we have found*

- Skeletal age was found to be more reliable than dental age.
- Among dental age estimation methods Nolla method gave relatively closer age estimation than Demirjian's method in population of Patiala district.

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