ORIGINAL RESEARCH PAPER

Volume-6 | Issue-10 | October-2017 | ISSN No 2277 - 8179 | IF : 4.176 | IC Value : 78.46

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

AN EVALUATION OF SKELETAL MATURATION IN CHILD PATIENTS AT A TERTIARY HEALTH CENTRE IN LUCKNOW, INDIA

Dental Science

***Dr Vivek Mehta** Assistant Professor, Deptt of Pediatric Dentistry, Jamia Millia Islamia, New Delhi-110025. *Corresponding Author

Dr R K Pandey Deptt of Pediatric Dentistry, Professor and Head, Faculty of Dental Sciences, KGMC Lucknow.

ABSTRACT

OBJECTIVE: The purpose of the study was to assess skeletal maturation in children with generalized decreased skeletal age and compare it with the children having normal skeletal age.

MATERIALS AND METHODS: Hand wrist radiographs of 37 child patients (age group 3-14 years) were taken and skeletal age assessment was done with hand wrist radiograph of the left hand according to Greulich and Pyle method, based on which two groups were made, Group A - Control group (normal skeletal age) and Group B - study group (decreased skeletal age). Group A had a sample size of 20 and Group B, a sample size of 17. These were further divided into subgroups according to age: subgroup (A) - 3 to 6 years, subgroup (B) - 7 to 11 years and subgroup (C) - 12 to 14 years. Difference in the state of skeletal maturation in chronological age and estimated bone age of both the normal and diseased subjects were compared together with the help of one way Analysis of Variance (ANOVA) and their significance by Tukey's post hoc test, separately for each age group. Before analyzing the data by ANOVA, the homogeneity of variance was first tested by Bartlett's test.

RESULTS: On comparing mean, chronological age and bone age of normal and diseased show no significant ($p>0.05$) change in age Group A and B, while Group C these differs significantly ($p<0.01$) and bone age of diseased were found significantly ($p<0.01$) lower than the Normal-CA, Normal-BA and Diseased-CA. It was noticed that chronological age and bone age of both the normal and diseased subjects increase as age increases, but the growth increments were found to be higher in normal than diseased children.

CONCLUSION: The present study led to the conclusion that general skeletal growth was retarded in children with generalized decreased skeletal age in comparison to healthy child patients.

KEYWORDS

Skeletal maturation, Hand-wrist radiograph, Greulich and Pyle method.

INTRODUCTION

Growth is a combination of morphogenetic and histogenetic changes occurring continuously over a period of time in response to genetic, hormonal, socio-economic and environmental influences. Human growth is characterized by substantial variation in the rate of progress of different persons toward physiologic maturity. Knowledge of growth status of a child patient is vital and fundamental for diagnosis, treatment planning and outcomes of orthodontic treatment and also plays an important role in the etiology of malocclusion.

The developmental status of a child is usually assessed in relation to events that take place during the progress of growth. Biological indicators that have been used frequently to identify stages of growth are chronological age, dental development, height and weight measurements, sexual maturation characteristics and skeletal age. It is imperative to assess the patient's biological age as chronological age alone cannot be considered as a reliable parameter in evaluating the skeletal maturation stage.

Skeletal maturation refers to the degree of development of bone ossification [1] Skeletal maturation is marked by an orderly and reproducible sequence of recognizable changes in the appearance of the skeleton during childhood. The degree of skeletal development shows the degree of physiological management which is evident on the basis of bone ossification.[2] The assessment of skeletal maturity can be useful in the evaluation and management of child patients with various endocrinopathies and having malformation syndromes. Skeletal maturity assessment might be a part of the evaluation of child patients who are either too tall or too short for that chronologic age and can be used to predict height at maturity. Skeletal maturity is also closely related to the craniofacial growth. The skeletal assessment can also be useful in planning procedures in which the outcome may be influenced by subsequent growth of the child.

The concept of skeletal maturation was first introduced by Crampton [3] followed by Todd [4] and Greulich and Pyle [5] with the use of hand-wrist radiographs. Hand wrist analysis using hand wrist radiographs is a reliable and widely used method of skeletal age estimation. [6] The skeletal maturation assessed on hand-wrist radiographs are classically considered as the best indicator of maturity and have a close relation with growth spurt [7-9] .Skeletal age can be derived from examining the successive stages of skeletal development after viewing the hand-wrist radiographs.

The present study was undertaken to evaluate skeletal maturity through hand-wrist radiographs in healthy and diseased child patient groups with the objective to ensure better treatment planning and eventual outcome of orthodontic procedures.

MATERIAL & METHODS

The present study was conducted on 37 healthy and diseased children, 25 males and 12 females in the age group from 3-14 years. The ages were so selected since this was the age group in which most of the children reported in the outpatient department. The children were selected from the Outpatient Department of Pediatrics and Outpatient Department of Pedodontics and Preventive Dentistry, C.S.M. Medical University, Lucknow, India.

Healthy children (control group) were selected according to Indian weight standards established by Aggarwal et al.[10] The normal variation range in weight was taken between 3rd and 97th percentile curves for a particular age. The child patients beyond this range were not included in the study. The diseased child patient group comprised of children with generalized decreased skeletal age according to criteria for selection prescribed by Caffey's. [11]

The study was carried out during post-graduation thesis of author, Dr Vivek Mehta. The patients admitted in the Department of Pediatrics, at a tertiary center at a given point of time were enrolled in the present study. Since there was no provision of ethical clearance during the time period of present study .i.e. January 2006 to October 2006, ethical clearance for the study was not taken.

A brief history of each child including name, age, sex, date of birth, name of the school and address was recorded. The informed consent was obtained from the parents and school teachers. Hand-wrist radiographs was used in the present study as per criteria of Greulich and Pyle. The study included radiographs of hand-wrist of the left hand. Since the patient number was less, so the study was carried out irrespective of age and sex.

The child patients with following characteristics were excluded from the present study.

1. Child patients with history of orthodontic treatment.
2. Child patients with history of trauma in face and neck region.

3. Child patients with abnormal dental conditions such as congenitally missing teeth, transposition.
4. Child patients who were not natives of North India.

The state of skeletal maturation for each patient was evaluated by recording radiographs of left hand-wrist. The assessment of bone age was carried out by comparing the radiographs of subject with the standards established by "Radiographic Atlas of Greulich and Pyle".[5] The Chronological Age and estimated bone age of normal and diseased subject were presented in Annexure-I.

STATISTICAL ANALYSIS:
The statistical methods used in the present study were Mean and standard deviation, Analysis of variance (ANOVA) test, Tukey's post-hoc test, Bartlett's test and Regression analysis.

After using the statistical analysis following results were drawn.

RESULTS:
The hand wrist radiographs of all the 37 subjects were recorded for healthy and diseased groups. The child patients were divided in three subgroups according to age. The subgroup A consisting of child patient in range of 3-6 years, the subgroup B comprised of child patients in the rage of 7-11 years, while the subgroup C contains child patients in the age group of 12-16 years.

Observed Chronological Age (CA) and estimated Bone Age (BA) of Normal and Diseased for three sub groups were summarized in Table 1 and shown graphically by Fig. 1. Mean comparison for Group A, Group B and Group C were presented in Table 2, 3 and 4 respectively.

Chronological age and bone age of both the normal and diseased increases as age increases, but the increment were higher in normal than the diseased (Table 1). On comparing mean, chronological age and bone age of normal and diseased show no significant ($p>0.05$) change in age Group A and B (Table 2-3), while Group C these differs significantly ($p<0.01$) (Table 4) and bone age of diseased were found significantly ($p<0.01$) lower than the Normal-CA, Normal-BA and Diseased-CA.

Correlation coefficient (r) between chronological age and bone age of all the normal and diseased subjects were found positive and significant ($p<0.01$) suggest these are linearly dependent on each other (Table 6) and thus, bone age of normal and diseased subjects can be estimated by their respective chronological age *i.e.* without taking the radiographs. For this, considering chronological age an independent variable (X) and bone age the dependent variable (Y), a simple linear regression approach was performed which estimates 99.5% and 89.2% of total variation of bone age for normal (R^2=0.995) and diseased (R^2=1.262) respectively with 0.305 and 1.262 respective standard error of estimates (Table 5). The following two mathematical equation were formulated for calculation of bone age of normal and diseased individual for planning dental procedures in which outcome may be influenced with subsequent growth of individual and shown graphically by Fig. 2 and Fig. 3.

Bone Age (Y) = -0.078 + 1.020∗CA (X) + 0.305 …… NORMAL
Bone Age (Y) = -0.334 + 0.850CA (X) + 1.262 …… DISEASED

Table 1. Summary-statistics of Chronological Age and Bone Age for Normal and Diseased subjects

Age groups	Statistic	Normal-CA	Normal-BA	Diseased-CA	Diseased-BA
Group A (3-6 years)	N	6	6	6	6
	Mean ± SD	4.00 ± 0.89	4.00 ± 0.89	4.00 ± 0.89	3.07 ± 0.80
	Min-Max	3-5	3-5	3-5	2-4
Group B (7-11 years)	N	7	7	5	5
	Mean ± SD	8.71 ± 1.38	8.86 ± 1.57	10.40 ± 0.55	8.20 ± 1.92
	Min-Max	7-10	7-11	10-11	5-10
Group C (12-16 years)	N	7	7	6	6
	Mean ± SD	13.43 ± 0.79	13.57 ± 0.98	13.17 ± 0.98	11.10 ± 1.05
	Min-Max	12-14	12-15	12-14	10-12

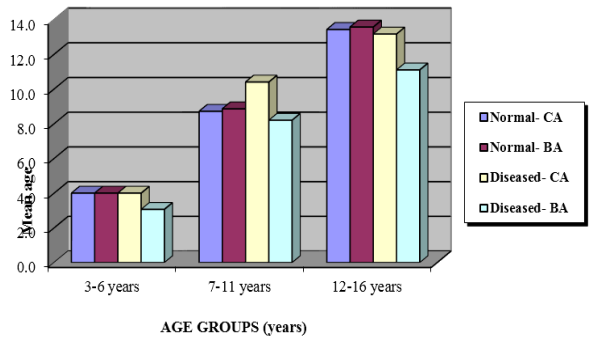


Fig. 1. Chronological and Bone Age of Normal and Diseased subjects in three different age groups.

Bartlett's statistic (corrected) B_c=0.0892^{ns}, DF=3

Source of variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Groups	3.92	3	1.31	1.72^{ns}
Residual	15.17	20	0.76	
Total	19.09	23		

ns = not significant ($p>0.05$)

Table 2. One Way Analysis of Variance Summary for Group A (3-6 years)

Bartlett's statistic (corrected) B_c=4.830^{ns}, DF=3

Source of variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Groups	13.71	3	4.57	2.16^{ns}
Residual	42.29	20	2.11	
Total	56.00	23		

ns = not significant ($p>0.05$)

Table 3. One Way Analysis of Variance Summary for Group B (7-11 years)

Bartlett's statistic (corrected) B_c=0.467^{ns}, DF=3

Source of variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Groups	24.95	3	8.32	9.26**
Residual	19.76	22	0.90	
Total	44.72	25		

ns = not significant ($p>0.05$)
** = highly significant ($p<0.01$)

Table 4. One Way Analysis of Variance Summary for Group C (12-16 years)

Comparisons	Group A (3-6 years)	Group B (7-11 years)	Group C (12-16 years)
Normal CA vs. Normal BA	0.00^{ns}	0.26^{ns}	0.40^{ns}
Normal CA vs. Diseased CA	0.00^{ns}	2.80^{ns}	0.70^{ns}
Normal CA vs. Diseased BA	2.63^{ns}	0.85^{ns}	6.25**
Normal BA vs. Diseased CA	0.00^{ns}	2.56^{ns}	1.09^{ns}
Normal BA vs. Diseased BA	2.63^{ns}	1.09^{ns}	6.63**
Diseased CA vs. Diseased BA	2.63^{ns}	3.38^{ns}	5.34**

ns = not significant ($p>0.05$)
** = highly significant ($p<0.01$)

Table 5. Simple correlation and linear regression between Chronological Age and Bone Age of Normal and Diseased subjects.

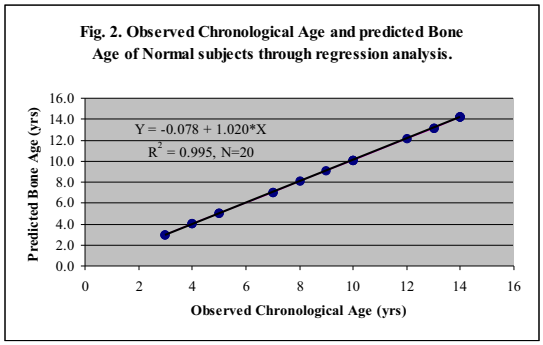


Fig. 2. Observed Chronological Age and predicted Bone Age of Normal subjects through regression analysis.

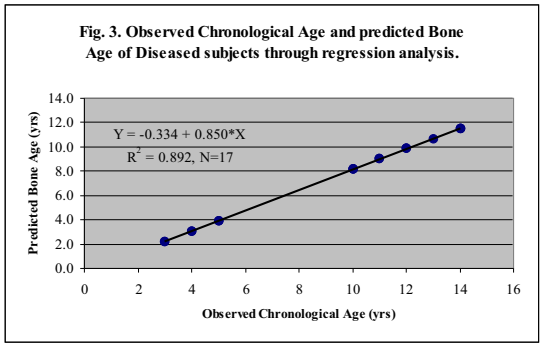


Fig. 3. Observed Chronological Age and predicted Bone Age of Diseased subjects through regression analysis.

DISCUSSION

Growth and development can be regarded as a kind of energy which can be best utilized if it can be delivered during proper timing of orthodontic and orthopedic treatment in children and guide the development of dentoalveolar and skeletal structures. Prevention of undesirable growth-related changes and allowing desirable ones constitutes the general principle of orthodontic principle in children. It is important to understand the uncertain variations in growth for correct diagnosis and treatment planning.[12]

Bone age is an important parameter when children with growth disorders are investigated, and it is the basis for calculation of height prediction. Hand-wrist radiographs have been used for determination of maturation and subsequent evaluation of growth potential during preadolescence and adolescence. Thus in our study, assessment of bone age was done with the help of left hand wrist radiographs as recommended by Greulich and Pyle [5] and substantiated as an accurate indicator of skeletal age as proven in various previous studies.[13–16]

In the present study hand-wrist radiograph of the left hand was used. The reason being that the number of right handed persons in most populations is much larger than the number of left-handed ones and that, consequently, the left hand is somewhat less likely to be maimed or otherwise injured than the one which is used more frequently. [5]

Even though the standards in this atlas have been prepared by using children of American origin, they have been employed in the present study due to the absence of any such standards published exclusively for Indian children as evidenced by Shah et al.[17]

The Greulich and Pyle standards were found to be reliable in assessing age in children of South Indian origin. [18]

In the present study a delay in maturation rates was found when compared with skeletal age assessment. Before 4–5 years of age, the rates are nearly normal but they are slower as age increases. Our findings are in agreement with the results of Johnston et al. [19]

Protein energy malnutrition formed the second major group in the present study.

Malnutrition is one of the major health problems in developing country. Bone age of diseased subjects was found to be delayed. Craniofacial morphology was not altered much. The results of the study corroborated with the findings of Steward et al [20] and Garn et al [21]

The analysis of the chronological age and bone age revealed that bone age in diseased individuals is found less than their chronological age and bone age due to alteration in calcium phosphorus metabolism. Highly significant relationship of diseased chronological age and bone age which is evidenced by Steward et al[20] and Garn et al.[21] who affirmed that malnutrition might be a cause of delayed skeletal age.

Thalessemia subjects showed a delay of the bone maturation as reaffirmed by Johnston et al.[19] and Adelman et al.[22] reviewed that orthodontic treatment has to be initiated in thalessemia patients since cephalofacial deformity increased with age and the disease process did not interfere with the bone activity associated with orthodontic tooth movement.

Bone age was delayed in protein energy malabsorption and males were affected more than females in accordance with studies of Tanner et al.[23] and Frisancho et al.[24]

Malnutrition affected the maturation of the skeleton more than the teeth as confirmed by Steward et al [20]and Garn et al. [21]

According to a recent study conducted by Mohammed et al [25] digital radiographic assessment of hand-wrist skeletal maturation can become a better choice predictor for average bone age of an individual because of its simplicity, reliability and lesser patient exposure.

Thus this study supports the fact that the skeletal maturation in children with decreased skeletal age as a result of various diseases is different from healthy children and the timing for treatment and its direction is of paramount importance in imparting favourable results to the patients.

We agree that the sample size is small and insignificant in formulating a hypothesis but it is still valuable in forming a basis for the thought process of studying diseased children with decreased skeletal age which may be done in further studies.

CONCLUSION :

The present study concluded that bone age of diseased subjects especially in age sub Group C (12-16 years) differs significantly and exhibited lower values than the normal chronological age, normal bone age, and disease chronological age. So the orthodontic treatment must be exercised after careful evaluation of patient and postponed with history of generalized systemic malformation in developing child patients. The present study opens scope for further research with a larger sample size to establish hand wrist skeletal maturation as a valuable tool for skeletal age determination.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil

CONFLICTS OF INTEREST

The authors have none to declare.

REFERENCES

1. Rajagopal R, Kansal S. A comparison of modified MP3 stages and the cervical vertebrae as growth indicators. J Clin Orthod 2002; 36: 398-406.
2. Hassel B, Farman AG. Skeletal maturation evaluation using cervical vertebrae. Am J Orthod Dentofacial Orthop 1995;107: 58-66.
3. Crampton C.W. Physiological age, a fundamental principle. Amer Phys. Educ. Rev,13: 3-6:1903, reprinted Child Dev., 15:1-52,1944.
4. Todd TW. Atlas of skeletal maturation. St Louis: CV Mosby; 1937.
5. Greulich WW, Pyle SI. Radiographic atlas of skeletal development of the hand and wrist. Stanford: Stanford University Press; 1984.
6. Jurca A. Dental age assessment using Demirjian′s method - A radiographic study. Eur Sci J 2014; 10: 51-60.
7. Bjork A, Helm S. Prediction of the age of maximum pubertal growth in body height. Angle Orthod. 1967; 37:134–43.
8. Bowden BD. Epiphyseal changes in the hand/wrist area as indicators of adolescent stage. Aust. Orthod. J. 1976;4:87–104
9. Houston WJ, Miller JC, Tanner JM. Prediction of the timing of the adolescent growth spurt from ossification events in hand-wrist films. Br J Orthod. 1979;6:145–52
10. Ghai OP. Textbook of Essential Pediatrics. 5th ed. Vol.6. 1996.
11. Caffey's Pediatric Diagnostic Imaging. 10th ed. Vol.2 pg. 2436.
12. Gupta M, Divyashree R, Abhilash P, A Bijle MN, Murali K. Correlation between chronological age, dental age and skeletal age among monozygoyic and dizygotic twins. J Int Oral Health 2013; 5:16-22.
13. Mora S et al. Skeletal age determinations in children of African and European descent: applicability of Greulich and Pyle standards. Pediatr Res. 2001;50 : 624-628.
14. Varkkola O, Ranta H, Metsaniitty M, Sajantila A. Age assessment by the Greulich and Pyle method compared to other skeletal X-ray and dental methods in data from Finnish child victims of the South East Asian Tsunami. Forensic Sci Med Pathol. 2011; 7 December (4):311-316.
15. Kucukkeles N, Acar A, Biren S, Arun TJ. Comparison between cervical vertebrae and hand-wrist maturation for the assessment of skeletal maturity. J Clin Pediatr Dent. 1999; 24:47-52.
16. Pechnikova M, Gibeli D, De Angelis D, De Santis F, Cattaneo C. The "blind age

assessment": applicability of Greulich and Pyle, Demirjian and Mincer aging methods to population of unknown ethnic origin. Radiol. Med. 2011; 116(7): 1105-1114.
17. Shah PN, Joshi MR, Daruwala NR. The interrelationship between facial areas and other body dimensions.Angle Orthod. 1980; 50(1): 45-53.
18. Rezwana Begum Mohammed, Dola Srinivasa Rao, Alampur Srinivas Goud, S. Sailaja, Anshuj Ajay Rao Thetay, Meera Gopalakrishnan. Is Greulich and Pyle standards of skeletal maturation applicable for age estimation in South Indian Andhra children. J Pharm Bioallied Sci. 2015 Jul-Sep; 7(3): 218–225.
19. Johnston FE, Hertzog KP, Malina RM. Longitudinal growth in thalessemia major. Am J Dis Child, 1966; 112:396-401.
20. Steward TD. New developments in evaluating in evidence from the skeleton. J Dent Res 1963; 42: 264-273.
21. Garn SM, Lewis AB, Kerewsky RS. Genetic, nutritional and maturational correlates of dental development. J Dent Res. 1965, 44(Supplement 1); 228-242.
22. Adelman AB. Cooley's anemia from an orthodontic viewpoint. N Y State Dent J. 1965; 31:405-408.
23. Tanner JM. Growth at adolescence. 2nd Edition Oxford: Blackwell Scientific publications. 1962; 34-43.
24. Frisancho, Sanchez, Pallardel, Yanez I. Adaptive significance of small body size under poor socio-economic conditions in Southern Peru. Am J Phy Anthrop 1973; 39:255-262.
25. Mohammed RB, Reddy MA, Jain M, Singh JR, Sanghvi P, Thetay AA. Digital radiographic evaluation of hand- wrist bone maturation and prediction of age in South Indian adolescents. Hand (N.Y.) 2014 Sep; 9(3):375-83