Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/10972
DOI URL: http://dx.doi.org/10.21474/IJAR01/10972

RESEARCH ARTICLE

ASSESSMENT OF SKELETAL AGE USING MIDDLE PHALANX, DENTAL AGE USING NOLLA'S CLASSIFICATION & THEIR CORRELATION WITH CHRONOLOGICAL AGE IN CHILDREN

Dr. Monalisa Das[1], Dr. Gautam Kundu[2] and Dr. R.R Paul[3]

1. PhD Scholar, Department of Oral and Dental Sciences, JIS University, Kolkata.
2. Professor and HOD, Department of Pedodontics & Preventive Dentistry, Guru Nanak Institute of Dental Science & Research, Kolkata.
3. Professor & HOD, Department of Oral and Dental Sciences, JIS University, Kolkata.

……………………………………………………………………………………………………....

Manuscript Info

……………………….

Manuscript History
Received: 14 March 2020
Final Accepted: 16 April 2020
Published: May 2020

Key words:-
Dental, Maturity, Radiograph, Skeletal

Abstract

………………………………………………………………………

Introduction: The assessment of growth and development is an integral part of diagnosis & treatment planning in clinical pediatric dentistry. It is often necessary to know the correlation between the chronological age and maturation. The purpose of our study was to find out the interrelationship among chronological, skeletal and dental age.

Materials and Methods: This cross sectional study included 202 healthy Bengali patients (7-14 years, 101 males and 101 females) who visited the outpatient department of Pedodontics for regular dental check up. Date of birth of the children was documented along with radiovisiographs of middle phalanx and maxillary canines (right and left). Evaluation was done using Greulich & Pyle (1959) atlas and Nolla's classification (1960) methods.

Results: One way Analysis of Variance showed that there were no significant differences in mean ages between chronological, dental age and skeletal age in males and females ($p>0.05$). Skeletal age and dental age have a significant correlation with chronological age. A significant correlation was found between dental age right and left irrespective of sex.

Conclusion: Middle phalanx of third finger of left hand can be used as a maturity indicator in Bengali population. Both the maxillary canine calcifications show positive interrelationship suggestive of its role in assessment of dental development. The higher association found between chronological age and skeletal age than with the dental ages, also suggests skeletal age to be a better indicator of actual age of a child.

……………………………………………………………………………………………………....

Introduction:-

In normal child, growth and development proceed concomitantly & they are to some degree potentially independent processes [1]. General growth and developmental status of child can be obtained by developmental anatomic variations (e.g. height and weight); but these parameters provide inadequate information due to genetic diversity and nutritional differences among the population [2,3]. Thus there was always a search for a suitable method to determine the actual age of a developing child.

Corresponding Author:- Dr. Monalisa Das
Address**:-** Assistant Professor, Pedodontics and Preventive Dentistry, Dr. R Ahmed Dental College and Hospital, Kolkata.

The need for age assessment is based not only for medical purpose but also identification of an individual. Only half of the children under five years old in the developing world have their births registered. Their official ‘invisibility’ increases their vulnerability and the risk that violations of their rights will go unnoticed. For a juvenile to be wrongly identified as an adult can have life-changing consequences. To be processed as an adult puts the child at increased risk of abuse in a system that makes no consideration for the child’s situation, age or maturity. Some countries, such as Afghanistan and Bangladesh, have successfully created their first government birth registration systems ever, while India and Pakistan have played leadership roles in promoting birth registration across Asia [4,5].

Considering this background, the aim and objectives of the present study was to assess skeletal age from middle phalanx of third finger of left hand and dental age from both the maxillary canines. An attempt was made to find out correlation between dental ages of right and left maxillary canines i.e. dental age of right maxillary canine (DR), dental age of left maxillary canine (DL), skeletal age (SA), and chronological age (CA).

Materials and Methods:-

The present study was conducted after obtaining permission of the institutional ethical committee. 202 healthy children from mixed socio-economic society, between age group 7 – 14 years were selected randomly from the outpatient department of Pedodontics and Preventive Dentistry. Children, whose family were residing in west Bengal since two prior generations, were selected according to Indian weight standards. Children with developmental anomalies, gross malocclusion, history of systemic illness and/or maxillofacial trauma, were excluded from the study.

Study Technique:

Brief clinical history was taken including general physical, extra oral and intra oral examination. The measurement of height and weight were done with the help of weigh machine and height measuring scale respectively. Children with appropriate height-weight (as per Agarwal et al.), [6] were selected for radiovisiographic (RVG) examination.

The radiographic examination was done in the radiology room of the Department of Pedodontics. Radiographs were taken using X-Mind (Satelec) X-ray machine with total filtration 2mm at 70 KV, 8 Amp & nominal voltage 230 V ± 15%. Sopix 2 digital dental X-ray imaging system with 0.040 sec exposure time was used. Type I RVG sensor was used for acquisition of images. RVG of middle phalanx of third finger of left hand, maxillary right and left canines were taken. All the images for a specified child were taken on the same day.

Evaluation and Assessment:

All the RVG images were stored in size of 31× 41mm of each. Tracing of printed radiographs were then done with the A4 size tracing paper and lead pencil following the identification code. The interpretations were based on comparative measurements on mm graphs with the help of particular standards.

Chronological age was calculated in years from the date of birth to date of examination of child. Assessment of skeletal age was done by matching the traced radiographs of MP3 of left hand to the standard given by Greulich & Pyle (1959). The width of the epiphysis of MP3 in traced RVG was compared with its closest standard of maturation of middle phalanx depicted in the atlas. The interpretation of dental age was done with Nolla’s stages of tooth development (1960).

All the data obtained were subjected to statistical analysis with help of Epi Info (TM) 3.5.3. The descriptive statistical analysis was performed to prepare different frequency tables and to calculate the means with corresponding standard deviations. One Way Analysis of variance (ANOVA) followed by Tukey’s Test was performed with the help of Critical Difference (CD). Pearson Correlation Co-efficient (r) was calculated to find the correlations between CA, DR, LR and SA. Significance level was considered at 0.05.

Results:-

In the present observational study, 202 Bengali children (power 92%) of 7-14 years of age (101 males and 101 females) were selected from the outpatient department of Pedodontics & Preventive Dentistry during the period March 2012 to May 2013. The samples were divided into eight age groups and each age group contained equal number of samples of both sexes.

The mean, standard deviation and F value of CA, DR and DL, SA of males and females of 7-14 years are listed in **Table 1 and 2**. There were no significant differences in mean ages between CA, DA and SA in males and females (p>0.05). Females were skeletally advanced than males in 11 to 14 years. Females and males did not differ in dental development. There was no statistical difference between DR and LR. SA and DA had a significant correlation in children of 11 to 14 yrs. SA was better correlated with the CA rather than with DA. Significant correlation was also noted in dental age right and left irrespective of sex. **[Table 3, 4, 5 and 6]**

Discussion:-

The assessment of growth status, timing of maximum growth period and direction of growth are the important criteria in diagnosis and treatment planning of paediatric patients. Early treatment is extremely important to attain a satisfactory outcome in specific types of dental deformity. Previous research demonstrated, 42% of the patients who received early treatment did not require phase II treatments [5].

Usually we determine age of an individual by examination of height and weight in regular clinical practice. Studies suggested that normal growth & development has an intimate relationship with the height & weight. Thus, an Indian standard protocol given by Agarwal et al. was used in this research [6]. Baldwin (1928) reported high correlation between ossification, height and weight [7]. Flory (1936) suggested the appearance of the adductor sesamoid has been highly correlated to peak height velocity and the start of the adolescent growth spurt [8]. Minkoff (1959) found statistically significant correlation between condylar growth and height, and metacarpal and condylar growth [7]. Bjork and Helm (1967) found that there was close association between the age at maximum pubertal growth in body height [9]. Hunter C J et al. (1966) reported statural height and hand wrist skeletal maturation in both sexes are significantly related [10]. Study done by Simmons and Greulich (1943) concluded that skeletal age was better correlated to menarcheal age than the standing height, weight or annual increments in standing height [7].

There are several methods of age determination but no method is universal or reliable due to varying differences in varying ethnic population groups. In clinical pedodontics, it requires a proper method with well defined and easily identifiable stages which could be interpreted in a cross-sectional study without requiring long observation period. The study was designed with a purpose to equip the Pedodontist with a standard age determination technique which enables him to accurately evaluate the amount of maturation along with proper planning of treatment.

In this study, two methods used for skeletal age determination was Greulich and Pyle method and Nolla's classification for dental age estimation. There are several studies regarding the skeletal age determination using the hand-wrist region in the field of dentistry. The Greulich and Pyle (GP) atlas, 2nd edition (1959) was used to evaluate the epiphyseal changes in middle phalanx of third finger. The middle phalanx of third finger of left hand (MP3) has been used as maturity indicator in the current study. At the age of 4.6 years in boys and 4.2 years in girls, the epiphysis become thickest centrally and the shape of its angular articular surface become visible. By 11.6 years (boys) and 7.10 years (girls) age, the epiphysis becomes as wide as diaphysis. The epiphysis caps the diaphysis at around 13.6 years in boys and 10 years in girls. The epiphysis begins to fuse with its shaft at 15.6 years and 13.6 years in boys and girls respectively. Lastly the evidence of completion of fusion was found at around 16 years in boys and 14 years in girls [1]. It was clearly evident that girls are ahead in all the stages of middle phalanx maturation. As the age range in this study was 7-14 years, the radiographic images from the GP atlas considered from 4years 6 months to 16 years for boys and in case of girls it was 4 years 2 months to 15 years. Olli Verkkola et al. (2010) evaluated the validity of this age assessment method in forty seven Finnish children of known ages below 16 years and concluded that in adolescence, the validity of skeletal methods improves considerably [11].

MP3 of left hand was used in the present study as the indicator of maturity. Todd and some of the other early workers in this field were probably influenced by a number of considerations. First of all, the International Agreement for the Unification of Anthropometric Measurements to be made on living subjects drawn up at the Monaco and Geneva conferences of physical anthropologists in 1906 and 1912, respectively, specified that measurements be made of the left rather than the right side of the body and of the left extremities. Another consideration was the fact 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 [1].

Nolla's classification (1960) was used to calculate the dental age for boys & girls separately. In this study, only the Nolla's 6th stage (crown completion stage) to 10th stage (root completion stage) was considered. These stage ranges were taken in consideration to include the maximum variation to be expected in males and females. In order to obtain an appraisal of the development of a particular tooth, the radiograph was matched as closely as possible with the comparative figure. When the radiographic readings lay between two grades, 0.5 should be added to the lower developmental stage. When the radiograph showed a reading that was slightly greater than the illustrated grade, but not as much as half way between that stage and the next, the value 0.2 was added. If the development were slightly less than the grade indicated the value 0.7 was added [12].

In this present study, dental age was estimated from maxillary canines of both sides to find out the correlation. The dental age from right and left maxillary canines showed no statistical difference. There were several studies which show the sexual dimorphism regarding the canine maturation but no studies are available suggesting the relation between these teeth of both sides. Chertkow (1980) investigated the relationship between the stages of maxillary and mandibular canines and concluded that significant differences in maturity between the sexes of all teeth except for mandibular canines [13]. Morgan J (2011) suggested there was insignificant difference in sexual dimorphism in all human permanent canines [14]. In the present study, it was found that the difference in dental maturation in males and females were not statistically significant.

There was a significant correlation ($p<0.05$) of skeletal age from MP3 and dental age was found in 11-14 years of age. M Bala et al (2010) found maxillary canine maturation is closely associated with MP3 and hand-wrist development in the age group of 12-14 years [15]. R. Modassir Shamsher Khan et al (2011) studied 200 children of 8-16 years and concluded that a strong correlation present between canine calcification and skeletal maturity [16].

The present study showed no statistical difference in dental age of males and females suggesting no influence on dental maturation with sexual variation. Nolla C.M (1960) found insignificant difference in the rate of dental development in males and females [12]. M Bala et al. (2010) suggested that females and males did not differ in dental maturation [15].

Conclusion:-

For clinicians, in regular practice, continuous monitoring of hand-wrist radiographs may not be practically feasible. However, they can monitor the changes in radiographs for shape and size of the epiphysis of the individual bones which could be more easily interpreted and readily available and acceptable. In this context middle phalanx of third finger of left hand can be used as a maturity indicator in Bengali population. Both the maxillary canine calcifications show positive interrelationship and thus it is suggestive of maxillary canines also can be used to assess the dental development in the same population. This study suggested there was positive correlation between the chronological, skeletal and dental ages. The higher association found between chronological age and skeletal age than with the dental ages, suggestive of skeletal age as a better indicator of actual age of a child. There was no significant difference between dental age of males and females whereas females were ahead in skeletal development than males. The dental ages showed significant association with the skeletal maturation during pre-pubertal growth spurt.

Table 1:- Mean chronological age, dental age (right), dental age (left) and skeletal age (MP_3 radiographs) in males of 7-14 years.

Sl. No.	Age (in years)	No. of children (n)	Chronological age (mean±s.d.)	Dental age (right) (mean±s.d.)	Dental age (left) (mean±s.d.)	Skeletal age (MP_3 radiographs) (mean±s.d.)	F-values with p
1	7	18	7.41±0.25	7.12±0.67	7.24±0.69	7.12±0.67	$F_{3,68}=1.71;p>0.05$ $CD_5=1.17;$ $CD_1=2.13$
2	8	15	8.56±0.29	8.05±0.73	8.18±0.77	8.89±1.04	$F_{3,56}=1.84;p>0.05$ $CD_5=1.02;$ $CD_1=1.81$
3	9	14	9.41±0.27	8.56±0.68	8.57±0.66	9.35±0.47	$F_{3,52}=2.02;p>0.05$ $CD_5=0.76;$ $CD_1=0.98$
4	10	12	10.40±0.30	8.81±0.82	8.98±0.79	10.16±0.44	$F_{3,44}=1.62;p>0.05$ $CD_5=1.01;$

							CD_1=1.77
5	11	10	11.50±0.28	12.51±1.67	12.88±1.73	11.85±1.18	$F_{3,36}$=2.11;p>0.05 CD_5=1.07; CD_1=1.92
6	12	12	12.34±0.26	13.71±0.63	13.44±0.51	14.10±1.34	$F_{3,44}$=2.13;p>0.05 CD_5=0.83; CD_1=1.17
7	13	10	13.34±0.30	13.94±0.93	13.83±1.12	15.00±0.84	$F_{3,36}$=2.21;p>0.05 CD_5=1.17; CD_1=1.33
8	14	10	14.50±0.36	15.02±0.40	14.54±0.68	14.37±1.28	$F_{3,36}$=1.17;p>0.05 CD_5=0.72; CD_1=0.98

Table 2:- Mean chronological age, dental age (right), dental age (left) and skeletal age (MP_3 radiographs) in females of 7-14 years.

Sl. No.	Age (in years)	No. of children (n)	Chronological age (mean±s.d.)	Dental age (right) (mean±s.d.)	Dental age (left) (mean±s.d.)	Skeletal age (MP_3 radiographs) (mean±s.d.)	F-values with p
1	7	18	7.41±0.32	7.25±0.98	7.19±0.82	8.01±1.46	$F_{3,68}$=2.14;p>0.05 CD_5=1.12; CD_1=2.06
2	8	15	8.40±0.31	7.47±0.82	7.37±0.60	8.95±0.77	$F_{3,56}$=1.97;p>0.05 CD_5=1.22; CD_1=2.24
3	9	14	9.58±0.27	8.20±1.04	8.29±1.29	10.10±0.70	$F_{3,52}$=1.92;p>0.05 CD_5=1.07; CD_1=1.51
4	10	12	10.45±0.33	8.75±0.95	8.64±0.99	10.41±0.46	$F_{3,44}$=1.54;p>0.05 CD_5=0.87; CD_1=1.17
5	11	10	11.61±0.22	10.46±0.99	10.44±1.01	12.60±1.71	$F_{3,36}$=1.78;p>0.05 CD_5=1.21; CD_1=1.77
6	12	12	12.57±0.31	11.31±1.60	11.29±1.62	14.13±1.41	$F_{3,44}$=2.17;p>0.05 CD_5=0.98; CD_1=1.87
7	13	10	13.42±0.28	13.94±0.93	11.70±0.79	15.20±1.01	$F_{3,36}$=2.13;p>0.05 CD_5=0.93; CD_1=1.41
8	14	10	14.52±0.24	13.00±0.00	13.00±0.00	15.25±1.20	$F_{3,36}$=1.29;p>0.05 CD_5=1.06; CD_1=2.01

Table 3:- Correlation Co-efficient between chronological age and dental age (right) in males and females.

		Male			Female		
Sl. No.	**Age (in years)**	**r-value**	**p-value**	**Significant**	**r-value**	**p-value**	**Significant**
1	7	0.158	0.53	NS	0.005	0.98	NS
2	8	0.795	0.04	S	0.014	0.96	NS
3	9	0.143	0.62	NS	0.768	0.01	S
4	10	0.846	0.03	S	0.207	0.51	NS
5	11	0.862	0.04	S	0.759	0.05	S
6	12	0.988	0.03	S	0.856	0.04	S

7	13	0.758	0.03	S	0.791	0.06	S
8	14	0.816	0.03	S	0.812	0.02	S

Table 4:- Correlation Co-efficient between chronological age and dental age (left) in males and females.

		Male			Female		
Sl. No.	**Age (in years)**	**r-value**	**p-value**	**Significant**	**r-value**	**p-value**	**Significant**
1	7	0.346	0.11	NS	0.066	0.794	NS
2	8	0.844	0.01	S	0.068	0.810	NS
3	9	0.260	0.36	NS	0.778	0.03	S
4	10	0.991	0.001	S	0.226	0.04	NS
5	11	0.769	0.05	S	0.872	0.04	S
6	12	0.847	0.03	S	0.729	0.02	S
7	13	0.811	0.02	S	0.887	0.01	S
8	14	0.778	0.03	S	0.789	0.02	S

Table 5:- Correlation Co-efficient between chronological age and skeletal in males and females.

		Male			Female		
Sl. No.	**Age (in years)**	**r-value**	**p-value**	**Significant**	**r-value**	**p-value**	**Significant**
1	7	0.895	0.03	S	0.765	0.03	S
2	8	0.745	0.04	S	0.815	0.02	S
3	9	0.805	0.03	S	0.836	0.01	S
4	10	0.872	0.03	S	0.789	0.03	S
5	11	0.898	0.01	S	0.822	0.01	S
6	12	0.773	0.02	S	0.860	0.01	S
7	13	0.825	0.01	S	0.869	0.01	S
8	14	0.887	0.01	S	0.972	0.01	S

Table 6:- Correlation Co-efficient between dental age (right) and dental age (left).

		Male			Female		
Sl. No.	**Age (in years)**	**r-value**	**p-value**	**Significant**	**r-value**	**p-value**	**Significant**
1	7	0.828	0.0001	S	0.959	0.0001	S
2	8	0.858	0.0001	S	0.887	0.0001	S
3	9	0.873	0.0001	S	0.966	0.0001	S
4	10	0.955	0.0001	S	0.966	0.0001	S
5	11	0.989	0.0001	S	0.998	0.0001	S
6	12	0.275	0.388	NS	0.555	0.061	NS
7	13	0.958	0.0001	S	0.077	0.832	NS
8	14	0.335	0.347	NS	0.878	0.001	S

References:-

1. Greulich WW, Pyle SI. Radiographic atlas of skeletal development of the hand and wrist. In: Todd TW, editor. Brush foundation study of human growth and development initiated. California: Stanford University, Stanford University press:1959:25-28.
2. Balwant Rai & S.C. Anand. Tooth development: An Accuracy of Age Estimation of Radiographic Methods. World J. Med. Sci.2006;1(2):130-2.
3. Carlos Flores-Mir, Brian Nebbe, Paul W. Major. Use of Skeletal Maturation Based on Hand-Wrist Radiographic Analysis as a Predictor of Facial Growth: A Systematic Review. Angle Orthodontist 2004;74(1).
4. Terry Smith, Laura Brownlees. Age assessment practices: a literature review & annotated bibliography. United Nations's Children's Fund (UNICEF). New York April 2001; part I:5-73.
5. Dugoni S, Aubert M, Baumrind S. Differential diagnosis and treatment planning for early mixed dentition malocclusions. Am J Orthod Dentofacial Orthop 2006;129:80-81.

6. Agarwal KN, Agarwal DK, Bansal AK for the Indian Academy of Pediatrics and adopted from V.V. Khadilkar et al. IAP Growth Monitoring Guidelines for Children from Birth to 18 Years. Indian Pediatrics 2007; 44:187-197.
7. Joseph C Konie. Comparative value of X- rays of the spheno-occipital synchondrosis and of the wrist for skeletal age assessment. Angel Orthod. 1964. 34(4): 303-13.
8. Hassel B, Farman A G. - Skeletal maturation evaluation using cervical vertebrae. Am J Orthod,1995; 107:58-61.
9. Bjork A, Helm S. Prediction of the age of maximum pubertal growth in body height. Angle Orthod.1967;37:134-43.
10. Hunter CJ. The Correlation of Facial Growth with Body Height and Skeletal Maturation at Adolescence. Angle Orthod. 1966;36:44–54.
11. Olli Varkkola, Helena Ranta, Mari Metsa¨niitty, Antti Sajantila. 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 Southeast Asian Tsunami. Forensic Sci Med Pathol 2011; 10:24-33.
12. Nolla CM. The development of permanent teeth. J Dent Child 1960;27: 254–66.
13. Chertkow S. Tooth mineralization as an indicator of the pubertal growth spurt. Am J Orthod Dentofacial Orthop 1980;77:79-91.
14. Morgan J. Metric Sexual Dimorphism in Permanent Canines. Bull Int Assoc Paleodont. 2011;5(1):4-12.
15. M Bala, A Pathak, R L Jain. Assessment of skeletal age using MP3 and Hand-wrist radiographs & its correlation with dental & chronological ages in children. J Indian Soc Pedod Prev Dent 2010;28:95-9.
16. R. Modassir Shamsher Khan, Abida Ijaz. Correlation of Dental Calcification and Skeletal Maturity Indicators 2011;17:22-6.