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Original article

Dentistry Section

Evaluation of Skeletal Maturation in Children of Azamgarh

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ABSTRACT

Introduction: Orthodontics includes the study of the growth and development of the dentofacial complex particularly and the growth and development of the body generally. Overall growth and development is recognized as one of the most important factors in Orthodontics. The early prevention and interception of dentofacial deformities is dependent upon the accurate interception of the inherent facio-skeletal pattern and overall growth and development.

Material and Methods: Skeletal maturity was asessed by Tanner-Whitehouse and Healy method TW2 on110 Boys and 110 Girls of prepubertal age (11-13 years). Mean skeletal age was estimated and standards of skeletal age,height and weight were computed and given for every six months of chronological age.

Discussion: Skeletal maturity in Boys at pre pubertal age can be accurately assessed by RUS (TW2) method. Skeletal maturity in Girls at prepubertal age can be accurately assessed by 20 bone TW2 method The mean skeletal age is 12.10±1.60 at mean chronological age of 11.94±0.71 in Boys (RUS).

The mean skeletal age is 13.62±0.99 at mean chronological age of 12.10±0.64 in Girls. (20-B) Both Azamgarh Boys and Girls TW2 show advanced skeletal age than the chronological age.

Conclusion: Both Azamgarh Boys and Girls are 11 months more matured than the British population(TW2 standards). Azamgarh Boys are 6 months and Girls are 12 months more matured than the Australian population.

Azamgarh Girls had a mean of 4 months advanced skeletal age then the Boys.

Keywords: Skeletal maturity, Radiographs, Skeletal age, Chronological age, Growth

INTRODUCTION

In orthodontics the maturity stage of an individual is also of great importance for the treatment of certain malocclusions. Certain aspects of orthodontic treatment can readily be achieved when dento facial complex is still growing and treatment designed to influence facial growth can be successful only during periods of rapid growth. During the pubertal spurt,the velocity of growth is greater than at any other time at which orthodontic treatment might be undertaken. Obvious benefits are gained if the aspects of treatment that depends on growth can be undertaken during this period.

Though the various areas in human skeleton to assess skeletal maturation include knee, foot and cervical vertebrae. The hand (including the wrist) has received most attention in the literature, both because it is easy to radiograph, and because it includes a wide range of bones suitable for the study. The work of Rotch [1] and Greulich and Pyle [2] suggests that this region offers a fair index of the maturity of the entire skeleton of the healthy child.

Skeletal age derived from hand and wrist films is well established as a method of estimating physical maturity and its value has been demonstrated, particularly at about the time of puberty when the greatest variations in maturation are found among children of the same chronological age. This was advocated by Tanner [3]. He stated that in the same ethnic group, skeletal maturation varied from one person to another person because each person has his or her own biological clock. In a heterogenous society(india)which we belong, it is impractical to compare the skeletal maturity of our population to the skeletal maturation standards of other population. Therefore, standards have to be developed for each relevant population. In different ethnic groups differences have been found in the onset of the various skeletal maturation stages. In the same ethnic group, skeletal maturation varies from one person to another person because of each person has his or her own biologic clock. In a heterogenous society like INDIA which we belong, it is impractical to compare the skeletal maturity of our population to the skeletal maturation standards of other population. Therefore standards have to be developed for each relevant population.

Orthodontists in our country are using separate Indian cephalometric norms, however, western standards are used in assessing skeletal maturation due to unavailability of Indian skeletal maturation norms. In an attempt to provide with more dependable maturity pattern to allow more timely intervention of orthodontic therapy, we have tried to establish norms for children inhabiting in Azamgarh, India.

This study was conducted in children schools of Azamgarh, India with consent of Students, Parents, and respective Managements of the schools. The main objectives were:

1. To know the radiological standard of physical maturity in children of azamgarh.
2. To evaluate norms of skeletal maturation for azamgarh children in hand and wrist radiographs
3. To compare azamgarh norms of with other population.
4. To give the standards of skeletal age compared to chronological age.

MATERIAL AND METHODS

The sample in this study consists of 110 boys and 110 girls of children school Azamgarh, India, aged between 11 to 13 years. Hand wrist radiographs of left hand was obtained as advocated by TW 2 method. Chronological age, height, weight and date of onset of menarche were recorded.

The selection of subjects was based on the following criteria:

1. All subjects selected were in the age group of 11-13 years
2. All participants were well nourished and free of any serious illness and of good socio-economic status.
3. Samples were in active growth phase.
4. There was no gross deformity of the left hand and wrist.
5. There was no history of trauma to the left hand and wrist in the past

Left hand radiographs of 220 children in standing position with palm on the cassette was taken using "(Sirona Orthophos XG5/CEPH)" Cephalometric X-Ray machine [Table/Fig-1] Kodak film size 8"x10" were exposed at 60 kvp, 5Ma, with 5ft.2" film focus distance and exposed for 1.5 seconds.

The method of skeletal maturity assessment is based on changes in the developing skeleton which can be easily viewed and evaluated on x-ray films of selected body areas. The most commonly used area for maturity assessment is the hand wrist complex, which comprises almost 28-30 separate centres of bone growth and maturation. The hand wrist area is fairly typical of the reminder of the skeleton, although variation relative to other anatomic areas are apparent. Nevertheless, for all practical purposes, X-ray films of the hand and wrist have been used most widely and are the major source of skeletal maturity data.

The radiographs of left hand and wrist were taken with palm facing downwards [Table/Fig-2], in contrast with cassette and with the axis of the middle finger in direct line with the axis of the forearm. Upper arm and forearm should be in the same horizontal plane. Palm is placed in such a way that the fingers do not touch each other and the thumb was placed in the comfortable, natural degree of rotation with its axis making an angle of about 30 degrees with forefinger. The palm was pressed lightly downwards on the film cassette by the subject. The tube was centred above the head of the 3rd metacarpal. All radiographs taken in this study were exposed, developed and fixed under similar conditions to achieve uniformity in results. The collection of data included estimation of chronological age, date of onset of menarche and measuring height and weight.

Height was measured without shoes, the child standing straight against an accurately calibrated vertical pole. The held in Frankfurt plane. Weight was measured with child standing on krups weigh machine, without shoes (with head held in frankfurft plane). Female sample were asked whether meanstrual cycle had started and date of onset of menarche was noted (if the answer was positive).

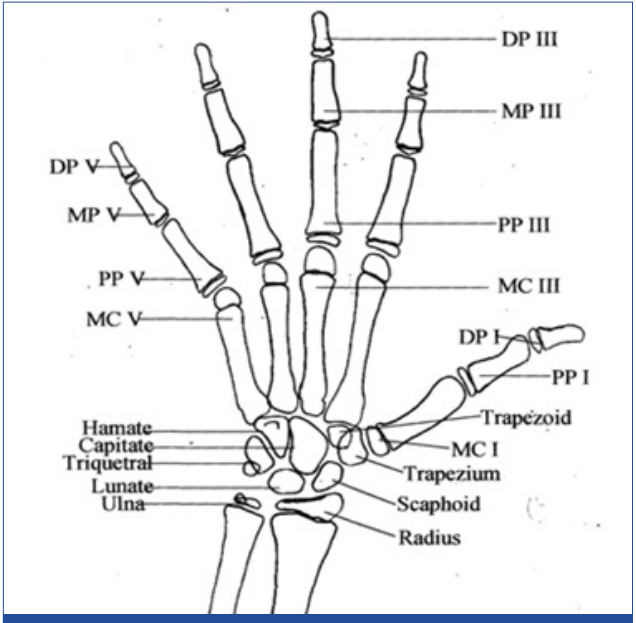
Left hand and wrist radiographs were assessed for skeletal age by TW2 method. Tanner and white house method is a matching method, but entails matching individual bones on a given film to a series of written criteria for standard stages through which each bone passes in its progress to the mature scale. Each stage is assigned a specific point score which has different scores for male and female.The result i.e. the sum of all the point scores gives the skeletal maturity score.Skeletal maturity score is matched in the tables given to obtain the skeletal ages of the individual.

Three separate scoring systems were derived in which one concerns radius, ulna and finger bones (RUS), another the carpals only and third is the combinaton of above two.

[Table/Fig-1]: Cephalometric machine

The bones examined in TW2 method were [Table/Fig-2]

- Radius, Ulna
- Metacarpals 1,2,5
- proximal phalanges 3 and 5
- middle pahalanges
- capitates, hamate, triquetral, lunate, scaphoid
- Trapezium and trapezoid



[Table/Fig-2]: Bones examined

RESULTS

[Table/Fig-3-10]

Comparison	Mean ± SD	Difference
20-B-SA chronological age	10.98 ± 1.31 11.94 ± 0.71	-0.96 ± 1.17 P<0.001
RUS-SA Chronological age	12.10 ± 1.60 11.94 ± 0.71	0.16 ± 1.47 NS
Car-SA Chronological age	10.15 ± 1.12 11.94 ± 0.71	-1.79 ±1.02 P<0.001

[Table/Fig-3]: Comparison of mean chronological age with the mean Skeletal ages of 20-b, rus and carpal in boys

Comparison	Mean ± SD	Difference
2 0-B-SA chronological age	12.20 ± 1.00 12.01 ±0.64	0.19 ± 1.08 NS
RUS-SA Chronological age	13.62 ± 0.99 12.01 ± 0.64	1.61 ± 1.10 P<0.001
Car-SA Chronological age	11.04 ± 0.88 12.01 ± 0.64	-0.97 ± 1.00 P<0.001

[Table/Fig-4]: Comparison of mean chronological age with the mean skeletal ages of 20-b, rus and carpal in girls

Chronological Age	Boys		Girls	
	20-B-SA	95% CI (Norms)	20-B-SA	95% CI (Norms)
11	10.17	8.7-11.6	11.90	10.9-13.1
$11^{1/2}$	10.60	9.2-12.0	12.05	10.7-13.3
12	11.02	9.6-12.5	12.30	11.0-13.5
$12^{1/2}$	11.45	10.0-12.9	12.75	11.4-14.0
13	11.87	10.4-13.3	13.50	12.2-14.7

[Table/Fig-5]: 20-b-skeletal age and 95% confidence intervals Forcorresponding chronological age

Chronological Age	Boys		Girls	
	RUS-SA	95% CI (norms)	RUS-SA	95% CI (norms)
11	11.25	9.8-12.6	13.45	12.2-14.7
$11^{1/2}$	11.70	10.3-13.1	13.56	12.3-14.8
12	12.15	10.7-13.5	13.67	12.4-15
$12^{1/2}$	12.60	11.2-14	13.78	12.5-15
13	13.05	11.6-14.4	13.89	12.6-15.2

[Table/Fig-6]: Rus-skeletal age and 95% confidence intervals for u corresponding chronological age

Chronological age	Boys		Girls	
	CAR-SA	95% CI (norms)	CAR-SA	95% CI (norms)
11	9.48	8-10.9	10.59	9.3-11.9
$11^{1/2}$	9.83	8.4-11.2	10.82	9.5-12.1
12	10.19	8.8-11.6	11.04	9.7-12.3
$12^{1/2}$	10.55	9.1-11.9	11.26	9.9-12.5
13	10.90	9.5-12.3	11.49	10.2-12.7

[Table/Fig-7]: Rus-skeletal age and 95% confidence intervals for u corresponding chronological age

Chronological age	Height	Weight
11	4.51	27.81
$11^{1/2}$	4.56	29.61
12	4.60	31.40
$12^{1/2}$	4.64	33.20
13	4.69	34.99

[Table/Fig-8]: (Boys) height and weight with corresponding Chronological age

Chronological age	Height	Weight
11	4.36	31.88
$11^{1/2}$	4.49	32.42
12	4.63	32.96
$12^{1/2}$	4.76	33.50
13	4.90	34.04

[Table/Fig-9]: (Girls) height and weight with corresponding Chronological age

Chronological age	Australian		Present Study	
	Bone Weight	Estimated Chr. Age (Br.Std)	Bone Weight	Estimated Chr. Age (Br.Std)
11	838	11.0	930.2	12.6
$11^{1/2}$			940.5	12.8
12	898	11.11	950.0	12.10
$12^{1/2}$			955.2	13.0
13	960	13.2	980.7	13.9

[Table/Fig-10]: Comparison of chronological age between (azamgarh), australian and british norms (girls)

DISCUSSION

Skeletal development is divisible into two components,increase in size and increase in maturity. Although closely integrated in the healthy child,each follows its own individual pattern. Increase in size is relatively easy to assess, but it is difficult to compare with other individuals due to genetic difference.

Skeletal maturity,however is not a static concept, rather it is dynamic indicating the progress that an individual is making towards attainment of biological maturity as was stated by Robert M [4]. It is usually accepted as being the metamorphosis of the cartilaginous and membraneous skeleton of the fetus to the fully ossified bones of the adult. Skeletal maturation gives an objective record of the maturity status of the skeleton at a single point of time. It, of course, represents the sum of all events prior to the time radiograph was taken.

In the present study to assess the skeletal maturity of azamgarh children we chose the bone specific approach (TW2 method) because in atlas method (GREULICH-PYLE method), the skeletal age is estimated by matching a given radiograph with set of standard radiographs. As hand – wrist radiographs maintains both round bones (Carpal bones) and Tubular bones(phalanges) which does not show same maturation. Ossification of bones appear at different intervals in different populations.Whereas bones specific approach (TW2 method) is based on matching of individual bone to a series of standard stages for each bone. Bone stages and their individual sequences are the same in all populations and are unaffected even by starvation as reported by Tanner et al., [5].

Radiographs of 20 males and 20 females randomly selected were reassessed by the same observer after 3 months to calculate method error in assessing maturity stages.

Wenzel and Melsen [6] mentioned that the deviations in stages lead to deviation in skeletal ages. Deviation of one score of one stage result in much larger differences in skeletal age. Hagg and Taranger et al., [7] reported 80.6, 78.7 and 83.5 percent of agreement respectively. In our study we found 80% agreement.

Wenzel and Melsen [6] advised blind assessment, otherwise the knowledge of diagnosis or age is shown to influence the observer. In present study to assess intraobserver error, radiographs were randomly selected without the knowledge of age to the observer.

In [Table/Fig-3 and 4] mean of 20-bone-skeletal age (20-B-SA), RUS skeletal age (RUS-SA) and Carpal skeletal age (CAR-SA) were compared with mean chronological age. In TW2 method, the stage which changes quickly were given more weight score. Spurts in RUS bones occur at puberty,show acceleration in boys at age of 11 or 12 and 7 to 8 years in girls ([Table/Fig-5-7], TW2 method). As our sample were prepubertal (11-13 years) RUS-SA did not show significant difference with chronological age in boys [Table/Fig-6], but showed significant difference ($p<0.001$) with chronological age in girls [Table/Fig-7] due to early acceleration. Our results coincided with a study done by Prakash and Cameron [8].

Carpal–SA showed significant difference ($p<0.001$) with chronological age both in boys and girls. This difference is due to carpal bones which reach maximum velocity by 10-11 years in boys and 8-10 years in girls. Due to this early maturation of carpal bones, stages lasts for long time, so they are given lower weight [Table/Fig-8 and 9]. CAR-SA results of our sample show less skeletal maturation. In this age range in azamgarh population carpal bone should not be considered (for both boys and girls) in assessing skeletal maturity. This finding is in agreement with other investigations, Garn, Rohmann and Silverman [9]. 20-B-SA showed significant difference ($p<0.001$) with chronological age in boys [Table/Fig-3] and no significant difference in girls [Table/Fig-4]. In TW2 method, 20-B-SA in bone score is one half of the RUS plus one half of the carpal weights. This may be the reason 20-B-SA showed significant difference due to under rating of the skeletal maturity of carpal bones in boys. In girls there was no significant difference,this could be due to more rating of skeletal age for RUS-SA and less rating of skeletal age in Carpal-SA. Our results coincide with Beunen [10] et al.

Kimura K [11], advised that skeletal maturity scores should be used rather than the skeletal ages for comparing the skeletal maturity between different ethnic population. Chronological age of Azamgarh standards, Australian standards (Rochie AF) are compared with British standards in for boys and for girls with the help of bone weight scores [Table/Fig-10]. Austarlian standards showed close relation with British standards. This finding coincides with Tanner et al., [3]. Azamgarh children showed 6 months more skeletal maturation in boys and 12 months more skeletal maturation in girls than Australian population and 11 months more skeletal maturation with

British population. On an average Azamgarh girls are 4 months more mature than boys. Our results coincide with the results of Prakash and Cameron [8] which was done on Chandigarh, India population by TW2 method.

In our study, date of birth was collected from school records and some parents may record less age during admission. This could be the reason why four girls and one boy showed adult maturity score.

CONCLUSION

As our study is cross sectional and consists of age group only 11 to 13 years, it is difficult to conclude the onset,peak and end of pubertal growth spurt. To know exactly where the skeletal maturity of Azamgarh population stands to know the onset, peak height velocity (PHV) and end of pubertal growth spurt, longitudinal studies to establish standards of skeletal maturity are highly desirable.

REFERENCES

[1] Rotch TM. Chronologic and anatomic age in early life. *J Amer Med Ass.* 1908; 51, 1197-1205.
[2] Greulich WW & Pyle SI. Atlas of Skeletal Development of the Hand and Wrist. Stanford University Press, 1950.
[3] Tanner JM, White House. RH Takaishi M. Standards from birth to maturity for height,weight,height velocity and weight velocity:British children Part-1. *Arch Dis Childh.* 1966; 41: 454.
[4] Divakar HS, Shama Patil, Jayade VP. Interpretation of hand and wrist radiographs in estimating skeletal maturational status. *J Indian Dent Assoc.* 2000; 71: 122-25.
[5] Tanner JM, White House RH, Takaishi M. Standards from birth to maturity for height,weight,height velocity and weight velocity: British children Part-2. *Arch Dis Childh.* 1966; 41: 613.
[6] Wenzel A, Melsen B Skeletal maturity in 6-16 year old danish children assessed by the Tanner-Whitehouse 2. Method. *Ann Hum Biol.* 1982 May-Jun 9(3) 277-81.
[7] Hägg U, Taranger J. Dental emergence stages and the pubertal growth spurt. *Acta Odontol Scand.* 1981; 39:298-306.
[8] Prakash S and Cameron N. Skeletal maturity of well off children in Chandigarh North india. *Ann Hum Biol.* 1981 Mar-Apr; 8(2): 175-80.
[9] Garn SM, FN Silvermann and CG Rohmann. A rational approach to the assessment of skeletal maturation. *Ann Radiol.* 1964.7,297-307.
[10] Beunen G, Lefevre J. Skeletal maturity in Belgian youths assessed by Tanner-Whitehouse method. *Ann Hum Biol.* 1990; 17(5); 355-376.
[11] Kimura K. Skeletal maturation of children in Okinawa. *Ann Hum Biol.* 1976; 3(2): 149-55.

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