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Correlation between skeletal maturation and dental calcification stages

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Abstract

Introduction: Assessing skeletal maturity and dental development is very common in clinical practice, especially for the purpose of provision of growth modification treatment and age estimation in forensic sciences. Hence the purpose of the present study was to determine the correlation between skeletal maturity and dental calcification stages.

Material & Methods: A total of 103 consecutive patients in age group of 9-16 years were included in the study. Patients with obvious dental pathology or previous history of orthodontic treatment were not included in the study. Lateral cephalometric and panoramic radiographs were taken on the same day. Cervical stages (CS) and Demirjian index (DI) were recorded.

Results: The results showed a positive and strong correlation between skeletal maturity and dental calcification.

Conclusions: Mandibular second molar DI stages are a reliable indicator of skeletal maturity. DI stage E corresponded to cervical stage 2 (pre peak of pubertal growth spurt) and DI stages F and G corresponded to cervical stages 3 and 4 (peak of pubertal growth spurt). DI stage H was associated with cervical stage 6 (end of pubertal growth spurt).

Keywords: Growth spurt; growth modification; skeletal maturity; dental age

Introduction

It is becoming increasingly evident that the timing of treatment onset may be as crucial as the selection of a specific treatment protocol, because in the organisation, differentiation, development and growth of any somatic structure, time plays a vital role in determining the final morphologic and dimensional results.[1] The issue of optimal timing for dentofacial orthopaedics is linked to the identification of a period of accelerated or intense growth that can contribute significantly to the correction of skeletal imbalance in a patient.[2,3] The timing of growth of facial bones and the periods of accelerated and intense physiologic growth must be individualized to better exploit bone remodeling for correcting skeletal discrepancies in orthodontic patients.[4] The rate of facial growth is correlated with both statural growth and skeletal maturation. During growth, every bone goes through a series of changes that can be seen radiographically. The sequence of changes is relatively constant for a given bone in every person but the timing of changes varies because each individual has his/her own biological clock.[5] Developmental age is used to express the stage of development of a child as a proportion of the chronologic age.[6] Chronologic age is not a valid instrument to calculate the speed of growth and skeletal maturation.[7] Although chronologic age is commonly used to gauge a patients position on his/her growth trajectory, but it does not address the difference in timing, duration and extent of adolescence between the sexes and among individuals within the same sex. When physiologic age is used instead of chronologic age, the prediction of growth potential of the patient becomes more individualised.[8] Physiologic age is the rate of

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progress toward maturity that can be estimated by somatic, sexual, skeletal and dental maturity.[9]

An important objective of orthodontic treatment during adolescence is to take advantage of growth in patients with skeletal discrepancies.[10] Maturational status can have considerable influence on diagnosis, treatment goals, treatment planning and the eventual outcome of orthodontic treatment. Clinical decisions regarding growth modification with functional appliances or orthognathic surgeries are modulated by the patient's degree of physiologic maturity, which is why prediction of the time and the amount of active growth is an important issue.

The evaluation of changes in size and shape of the cervical vertebrae in growing subjects as a biologic indicator of individual skeletal maturity have gained increased interest mainly because the analysis of cervical vertebral maturation is performed on a lateral cephalogram of a patient, a type of film routinely used in orthodontic diagnosis. It is well known that the morphology of the cervical vertebral bodies change with growth, as seen in the lateral cephalogram.[11] Skeletal maturity can be evaluated in a detailed and objective manner on the cephalometric radiograph by determining the cervical vertebral bone age.[12]

Dental age or dental development can be assessed by either the phase of tooth eruption or the stage of tooth calcification, with the latter being more reliable.[13] The method of Demirjian et al.[14] is useful in estimating the dental age of the patient. The advantage of Demirjian's technique is that the predicted dental age is relatively accurate since it is not based on the eruption process of teeth and this is confirmed by its use in so many studies throughout the world. Tooth eruption has some limitations in evaluating dental age since it is heavily influenced by environmental factors such as available space, extraction of deciduous predecessors, tipping or impaction of teeth. Therefore, dental age estimation using calcification or developmental stages of teeth is more useful since tooth development is less influenced by environmental factors.[15]

The ability to assess skeletal maturity by stages of dental calcification using a panoramic radiograph (which is a routine initial radiograph for orthodontic treatment), reduces the radiation exposure to the patient. Additional radiation exposure to assess skeletal maturity would then not be necessary if assessment were performed through routine radiographs, keeping in mind the ALARA (As Low As Reasonably Achievable) principle.[16] Investigating the correlation between dental calcification (Demirjian's method) and skeletal maturity (by Cervical Vertebral Maturation method) will be the first study of its kind in our local population as no literature has yet been published all over Pakistan. This study will provide us with local statistics about correlation between these two variables and the results of the study will be compared with already published international data. The results can also be used as an objective evidence for recommendation on future research over similar context before concluding the usefulness of dental calcification in assessing skeletal maturity. Hence the objective of this study was to determine the correlation between skeletal maturity and dental calcification stages.

Material and Methods

This descriptive (Cross sectional) study was conducted at the Department of Orthodontics, Khyber College of Dentistry, Peshawar. Sample size was 103, using correlation coefficient of +0.2772 between dental calcification stages and skeletal maturity, 95% confidence interval and 80% power of test.

The sampling was done using Consecutive (Non-probability) sampling technique. The chronological age ranging from 9-16 years of either gender, having no history of extraction of the permanent teeth and patients visiting OPD for malocclusion treatment were included. Radiographs showing obvious dental pathology e.g. Impactions, transpositions, congenitally missing teeth, previous history of trauma or disease to the face and neck, abnormal cervical vertebral anatomy, history of orthodontic treatment were excluded from the sample. The above mentioned conditions act as confounders and if included would have introduced bias in the study results.

Approval of the Hospital's ethical committee was taken. Informed consent was taken from all patients. Complete history was taken. Clinical examination including inspection, palpation and percussion, performed on all teeth present in the mouth. The patients were then sent to the Radiology Department to get panoramic and lateral cephalometric radiographs to identify the stages of dental calcification and skeletal maturity. The two radiographs were taken on the same day for each patient. All the radiographs were reported and assessed by single experienced Orthodontist having minimum of three years of experience. Strict exclusion criteria were followed to control confounders and bias in the study results.

Tooth calcification was rated according to Demirjian et al,[14] using the panoramic radiograph. One of eight stages of calcification, A to H, were assigned to the permanent left mandibular 2nd molar. In case of a missing left mandibular 2nd molar or any rotations, the corresponding right tooth was examined. The lateral profile changes of the 2nd, 3rd, 4th cervical vertebrae were assessed using the lateral cephalometric radiograph and assigned the cervical stage using the improved version of Cervical Vertebral Maturation given by Baccetti, Franchi and McNamara. Data was entered and analyzed by SPSS version 20.0. Frequencies and percentages were calculated for qualitative variables like gender, dental calcification stages and skeletal maturity stages. Mean and standard deviation of quantitative variable like age were ascertained. Spearman's Rank correlation test was applied to see the relationship between dental calcification stages and skeletal maturity stages. P value of $\leq$ 0.05 was considered significant.

Results

The study group consisted of 103 subjects with chronological age range of 9 to 16 years with a mean age of 13.04 ± 2.06 years. Fifteen years was the predominant (n=23, 22.3%) age group of the patients. The least number of patients 6 (5.8%) were 9 year olds. There were 11 (10.7%) patients who were 10 years old, 7 (6.8%) patients were 11 years old, 15 (14.6%) were 12 years of age, 17 (16.5%) were 13 years of age, 14 (13.6%) were 14 years old and 10 (9.7%) were the age of 16 (Table I). Of the 103 patients, 50 (48.54%) were females whereas 53 (51.46%) were males, which formed the predominant gender. The mean age for males was 12.77 ± 2.05 and the mean age for females was 13.32 ± 2.13 years. Based on the skeletal age of the 103 subjects, the maximum number of patients were in CS4 (37) and the minimum number were in CS3 (7). 16 patients were in CS1, 13 patients were in CS2, 22 were in CS5 and 8 were in CS6 (Table II). Skeletal maturational stage in different chronological ages of the patients is given in Table III. Of the 16 patients in CS1, 6 were 9 and 10 year olds respectively, 1 was 11 and 3 were of 12-year age. Of the 13 patients in CS2, 5 were 13 year olds, 4 were 10 years of age and 2 each were 11 and 12 years of age. Of the 7 patients in CS3, 3 were 12 year olds, 1 each were 10 and 11 years of age and 2 were 13 years of age. Of the 37 patients in CS4, 11 were 14 years of age whereas 3, 6, 9, 5 and 3 patients were 11, 12, 13, 15 and 16 years of age respectively. Of the 22 patients in CS5, 12 were 15 year olds, 1 each were 12 and 13 years of age whereas 3 and 5 were 14 and 16 years of age respectively. Of the 8 patients in

CS6, 6 were 15 years of age and 2 were 16 years old.

Based on dental age of the 103 subjects, the maximum number of patients were in Demirjian stage G (42) whereas, there were no patients in Demirjian stages A and B. There were only 2 patients in Demirjian stage C, 11 in stage D, 12 in stage E, 25 in stage F and 11 in stage H (Table II).

The correspondence of skeletal age with dental calcification stages was ascertained (Table II). Of the total number of 16 patients in CS1, the maximum number of patients (9) corresponded to Demirjian stage D and the minimum number of patients (1) were in Demirjian stage G whereas there were no patients in stages A, B and H. Of the total number of 13 patients in CS2, the maximum number of patients (8) corresponded to Demirjian stage E and the minimum number of patients were in stage D whereas there were no patients in stages A, B, C, G and H. Of the total number of 7 patients in CS3, the maximum number of patients (4) corresponded to Demirjian stage F and the minimum number of patients (1) were in stage G whereas there were no patients in stages A, B, C, D and H. Of the total number of 37 patients in CS4, the maximum number of patients (20) corresponded to Demirjian stage G and the minimum number of patients (2) were in stage H whereas there were no patients in stages A, B, C, D and E. Of the total number of 22 patients in CS5, the maximum number of patients (17) corresponded to Demirjian stage G and the minimum number of patients (1) were in stage F whereas there were no patients in stages A, B, C, D and E. Of the total number of 8 patients in CS6, the maximum number of patients (5) corresponded to Demirjian stage H and the minimum number of patients (3) were in stage G whereas there were no patients in stages A, B, C, D, E and F.

Table I: Age distribution of the sample

Age group	Frequency	Percent
9	6	5.8
10	11	10.7
11	7	6.8
12	15	14.6
13	17	16.5
14	14	13.6
15	23	22.3
16	10	9.7
Total	103	100.0

Table II: Frequencies of Demirjian's stages by skeletal age of patients

Dental	Skeletal age (N)						Total N
	CS_1	CS_2	CS_3	CS_4	CS_5	CS_6	
C	2	0	0	0	0	0	2
D	9	2	0	0	0	0	11
E	2	8	2	0	0	0	12
F	2	3	4	15	1	0	25
G	1	0	1	20	17	3	42
H	0	0	0	2	4	5	11
Total N	16	13	7	37	22	8	103

Table III: Skeletal age of patients by chronological age

	Frequencies of ages (years)							
Skeletal age	9 yr	10 yr	11 yr	12 yr	13 yr	14 yr	15 yr	16 yr
CS_1	6	6	1	3	0	0	0	0
CS_2	0	4	2	2	5	0	0	0
CS_3	0	1	1	3	2	0	0	0
CS_4	0	0	3	6	9	11	5	3

	Frequencies of ages (years)							
Skeletal age	9 yr	10 yr	11 yr	12 yr	13 yr	14 yr	15 yr	16 yr
CS_1	6	6	1	3	0	0	0	0
CS_2	0	4	2	2	5	0	0	0
CS_3	0	1	1	3	2	0	0	0
CS_5	0	0	0	1	1	3	12	5
CS_6	0	0	0	0	0	0	6	2

Table IV: Association between dental and skeletal age

Variable	**T**	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
Dental age	51.414	102	0.000	6.23301	5.9925	6.4735
Skeletal age	23.750	102	0.000	3.58252	3.2833	3.8817

Table V: Correlation between skeletal maturation and dental calcification stages.

		r (correlation value)	Asymp. Std. Error[a]	Approx. T[b]	p-value
Spearman Correlation		0.817	0.038	14.249	0.000[c]
N of Cases		103			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					
c. Based on normal approximation.					

Table VI: Gender wise correlation between skeletal maturation and dental calcification stages

Gender			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Male	Ordinal by Ordinal	Spearman Correlation	.815	.055	10.031	.000[c]
	N of Valid Cases		53			
Female	Ordinal by Ordinal	Spearman Correlation	.811	.045	9.599	.000[c]
	N of Valid Cases		50			
a. Not assuming the null hypothesis.						
b. Using the asymptotic standard error assuming the null hypothesis.						
c. Based on normal approximation.						

Table IV shows statistically significant association between dental and skeletal age. Table V shows correlation between skeletal maturity and dental calcification with r = 0.817. The correlation between skeletal maturation and dental calcification is slightly more in males with r = 0.815 than in females with r = 0.811 (Table VI). This shows a positive and strong correlation between skeletal maturity and dental calcification.

Discussion

In dento-facial orthopedics, each patient's skeletal maturity is important to better exploit the growth potential by using functional appliances. The issue of optimal timing for dento-facial orthopedics is linked to the identification of a period of accelerated or intense growth that can contribute significantly to the correction of skeletal imbalance in a patient. The rate of facial growth is correlated with both statural growth and skeletal maturation. Chronological age is not a valid predictor of skeletal growth velocity or skeletal maturity.[17] Skeletal maturity is the most commonly used index in routine clinical work and is closely related to sexual and somatic maturity. Hand and wrist radiographs were widely used previously for skeletal age assessment however skeletal maturity is now most frequently assessed using cervical vertebral maturation. Hence the purpose of this investigation was to provide the Orthodontist with an additional tool (other than a hand-wrist radiograph or a lateral cephalogram) to help determine the growth potential of an adolescent patient. This was to be accomplished by utilizing the dental calcification stages using a panoramic radiograph which is a routine radiograph done for orthodontic patients. Many methods for precise prediction of growth have been suggested. Dental maturity, in particular, has the advantage of easy evaluation during routine dental treatment. Radiation exposure time and dose are high when specialised radiographs are used (hand-wrist radiographs or lateral cephalograms), making their use questionable according to the ALARA principle. The ALARA principle is especially important for children and young adults, hence high-radiation methods should not be used frequently to assess growth. The ease of recognising the stages of dental development and the availability of panoramic radiographs are practical reasons for attempting to assess physiologic maturity without resorting to hand-wrist or lateral cephalometric radiographs. Others have questioned these latter approaches from the radiation safety point of view. In addition, the cost of the equipment that is required for these radiographs is high, making them expensive.[16] Conventional prediction schemes of maturation indicators would overestimate the developmental stage of the child and consequently underestimate the growth potential.[18] Conversely, comparisons of a child's status against published standards from other countries may overestimate a patient's degree of developmental delay or the precocity. Racial variations in the relationships between the calcification stages of individual teeth and skeletal maturity have been reported previously.[19]

In the present study, calcification stages of teeth instead of eruption were preferred because tooth formation is proposed as a more reliable criterion for determining dental maturation.[20] Therefore, the dental maturity assessment stages of Demirjian et al[14] were used. This method's criterion consists of distinct details based on shape criteria and proportion of root length, using the relative value to crown height, rather than on absolute length. Therefore, foreshortened or elongated projections of developing teeth will not affect the reliability of assessment.

Krailassiri et al[21] and Coutinho et al.[22] reported that the associations between the tooth calcification stages and the skeletal maturity indicators probably allow the clinician to more easily identify the stages of the pubertal growth period from the panoramic radiograph. From this study, ease of recognition of the stage of development of the tooth, together with the free availability of intra-oral or panoramic radiographs in an orthodontic or paedodontic practice, would make the assessment of onset of puberty possible in children of Turkish origin without resorting to the use of hand-wrist radiographs or serial recordings of annual increases in stature.

Many studies have attempted to determine whether there is a relationship between the level of skeletal maturity and the maturation of the permanent dentition. Demisch and Wartmann[23] reported a high correlation between dental and skeletal ages, Chertkow,[24] Coutinho et al,[22] and Krailassiri et al,[21] reported similar high correlations. On the other hand, Lewis and Garn,[25] Garn et al,[26] and Tanner[27] have reported low or insignificant correlations between the level of skeletal and dental maturation. The lack of concordance among the results of previous studies may be attributed, at least in part to the different methods used for assessing skeletal and dental maturity. Because the same methods were used, the authors compared most of their results with the findings of Krailassiri et al.[21] Statistically significant correlations were found between dental calcification stages and skeletal maturity indicators in Turkish subjects, similar to Thai individuals.

Most studies of the dentition have used either mandibular canines [22, 24, 28] or third molars [26, 29] for dental age assessment, but these two parameters exhibit some drawbacks. Root formation and apex closure of mandibular canines are completed by the age of 13 years, but most children exhibit active growth up to the age of 16 to 17 years. Third molars, on the other hand, are the most commonly missing teeth in the human dentition, making them unreliable for age assessment. The present radiographic study was therefore taken up to assess the reliability of using the developmental stages of mandibular second molars as an indicator of maturity. This tooth offers an advantage over other teeth because its development tends to continue over a longer period and until a later age. Apex closure generally extends up to the age of 16 years in normal children. We used the mandibular second molar as a sample because estimation errors occur more frequently in calculating the maturation of maxillary molars than that of mandibular molars. Sometimes the maxillary molar roots overlap with anatomic structures such as the palate, the inferior border of the zygomatic arch, or the maxillary sinus septum. This makes it difficult to observe the roots.[29] The current study showed that statistically significant correlation between dental and skeletal age (r = 0.817). Krailassiri et al[21] carried out a study to investigate the relationship between the stages of calcification of various teeth and skeletal maturity stages among Thai individuals. The Spearman rank order correlation coefficient revealed significant relationships (r = 0.31–0.69, P < .01) between dental calcification stages and skeletal maturity stages. Uysal et al.[30] investigated the relationships between the stages of calcification of various teeth and skeletal maturity stages among Turkish subjects. Correlations between dental development and skeletal maturity (hand wrist) ranged from .490 to 0.826 for females and 0.414 to 0.706 for males (P < .01). Kumar et al.[16] investigated the relationships between the stages of mandibular second molar calcification and skeletal maturity and whether second molar calcification stages can be used as a reliable diagnostic tool to determine skeletal maturity. Therefore, a highly significant association exists between DI and CVM and mandibular second molar DI stages are reliable indicators of skeletal maturity. The previous studies are in consistent with the current study.

Conclusions

A high correlation was found between skeletal maturation and dental calcification stages in Pakistani subjects according to the statistical evaluation. The correlation between skeletal maturation and dental calcification stages was almost equal for both genders. The results showed a statistically significant association between dental and skeletal age. A wide variation in chronological age for different maturity levels suggests that chronological age is a poor indicator of skeletal maturity. Mandibular second molar DI stages are a reliable indicator of skeletal maturity. DI stage E corresponded to cervical stage 2 (pre peak of pubertal growth spurt) and DI stages F and G corresponded to cervical stages 3 and 4 (peak of pubertal growth spurt). DI stage H was associated with cervical stage 6 (end of pubertal growth spurt).

References

1. Cericato GO, Bittencourt M, Paranhos L. Validity of the assessment method of skeletal maturation by cervical vertebrae: a systematic review and meta-analysis. Dentomaxillofac Radiol 2015;44(4):20140270

2. Baccetti T, Franchi L, McNamara JA. An improved version of the Cervical Vertebral Maturation (CVM) method for the assessment of mandibular growth. Angle Orthod 2002;72:316-23
3. Pichai S, Rajesh M, Reddy N, Adusumilli G, Reddy J, Joshi B. A comparison of hand wrist bone analysis with two different cervical vertebral analysis in measuring skeletal maturation. J Int Oral Health 2014;6(5):36
4. Mellion ZJ, Behrents RG, Johnston LE. The pattern of facial skeletal growth and its relationship to various common indexes of maturation. Am J Orthod Dentofacial Orthod 2013;143(6):845-54
5. Zelazo PD, Carlson SM. Hot and cool executive function in childhood and adolescence: Development and plasticity. Child Dev Persp 2012;6(4):354-60
6. Kalinowska I R, Raczka A K and Kalinowski P. Relationship between dental age according to Demirjian and cervical vertebrae maturity in Polish children. Eur J Orthod 2011; 33:75-83
7. Shamsher RM, Ijaz A. Age of high growth rate in adolescent period of development. Pak Oral Dent J 2005; 25:53-8
8. Basaran G, Ozer T, Hamamci. Cervical vertebral and dental maturity in Turkish subjects. Am J Orthod Dentofac Orthop 2007; 131:447 e13-20
9. . Cho S M, Hwang C Skeletal maturation evaluation using mandibular third molar development in adolescents Korean J Orthod 2009; 39(2):120-29
10. Ochoa KB, Nanda RS. Comparison of maxillary and mandibular growth. Am J Orthod Dentofac Orthop 2004; 125:148-59
11. Mito T SK, Mitani H. Predicting mandibular growth potential with cervical vertebral bone age. Am J Orthod Dentofac Orthop 2003; 124:173-7
12. Mito T, Sato K, Mitani H. Cervical vertebral bone age in girls. Am J Orthod Dentofac Orthop 2002; 122:380-5
13. Al-Hadlaq A M, Hashim H A, Al-Dosari M A and Al-Hamad A. Interrelationship betweendental development, skeletal maturity and chronologiacal age in Saudi male children. Egypt Dent J 2008 ; 54:55-65
14. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol 1973 ; 45:211-27
15. Al-Emran S. Dental age assessment of 8.5 to 17 year old Saudi children using Demirjian's method. J Contemp Dent Pract 2008; 9(3):1-10
16. Kumar S, Singla A, Sharma R, Virdi M S, Anupam A, Mittal B. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod 2012; 82(3):501-6
17. Hagg U, Taranger J. Maturation indicators and the pubertal growth spurt. Am J Orthod Dentofac Orthop 1982; 82:299-309
18. Harris EF, Weinstein S, Weinstein L, Poole AE. Predicting adult stature: a comparison ofmethodologies. Ann Hum Biol 1980; 7:225–34
19. Beckwith JB. Macroglossia, omphalocele, adrenal cytomegaly, gigantism, and hyperplastic visceromegaly. Birth Defects 1969; 5:188–96
20. Nolla CM. The development of the permanent teeth. J Dent Child 1960; 27:254–63
21. Krailassiri S, Anuwongnukroh N, Dechkunakorn S. Relationships between dental calcification stages and skeletal maturity indicators in Thai individuals. Angle orthod 2002;72:155-66
22. Coutinho S, Buschang PH, Miranda F. Relationship between mandibular canine calcification stages and skeletal maturity. Am J Orthod Dentofacial Orthop 1993; 104:262–68
23. Demisch S, Wartmann C. Calcification of mandibular third molar and its relationship to skeletal and chronological age in children. Child Dev 1956; 27:459–73
24. Chertkow S. Tooth mineralization as an indicator of the pubertal growth spurt. Am J Orthod 1980; 77:79–91
25. Lewis AB, Garn SM. The relationship between tooth formation and other maturational factors. Angle Orthod 1960; 30:70–77
26. Garn SM, Lewis AB, Bonne B. Third molar formation and its developmental course. Angle Orthod 1962; 44:270–76
27. Tanner JM. Growth at Adolescence. 2nd ed. Oxford, UK: Blackwell Scientific Publications; 1962:55–93
28. Hareesha KB, Babu NC. Co-relation between mandibular canine calcification stages and skeletal maturity. J Int Oral Health 2013; 2(3):41–47
29. Cho SM, Hwang CJ. Skeletal maturation evaluation using mandibular third molar. Korean J Orthod 2009; 39(2):120–29
30. Uysal T, Sari Z, Ramoglu SI, Basciftci FA. Relationships between dental and skeletal maturity in Turkish subjects. AngleOrthod 2004; 74:657–64