CORRELATION OF CERVICAL VERTEBRAL MATURATION AND TOOTH MINERALIZATION OF MANDIBULAR SECOND MOLAR

Muhammad Kamran[1] , Gulsana Hashmi[2] , Muhammad Noman[3] , Umar Hussain[4]

Correspondence

[4]Umar Hussain, BDS, FCPS, Orthodontics, MS(Biostatistics and Epidemiology), Lecturer, Saidu College of Dentistry, Swat

: +92-345-4500578

: drumarhussain@gmail.com

[1]Assistant Professor, Department of Orthodontics, Saidu College of Dentistry, Swat

[2]Senior Registrar, University College of Dentistry, University of Lahore, Lahore

[3]Senior Registrar, Department of Orthodontics, Sharif Medical and Dental College, Lahore

How to cite this article

Kamran M, Hashmi G, Noman M, Hussain U. Correlation of Cervical Vertebral Maturation and Tooth Mineralization of Mandibular Second Molar. J Gandhara Med Dent Sci. 2023;10(3): 3-7
https://doi.org/10.37762/jgmds.10-3.470

ABSTRACT

OBJECTIVES

To determine the correlation between skeletal maturity and mandibular second molar calcification.

METHODOLOGY

A descriptive cross-sectional study was conducted at the Saidu College of Dentistry from 15th January to 30th October 2022. One hundred participants of Pakistani descent, aged 8-16 years (both genders), with ANB greater than 5^0 and presence of all permanent teeth excluding 3rd molars, were included. Medically compromised, syndromic patients, those who had undergone previous orthodontic treatment, and cases with extracted permanent teeth were excluded. Skeletal maturity was determined by analyzing the cervical vertebrae maturation index (CVMI) on lateral cephalogram according to Baccetti et al. and mandibular second molar calcification according to the Demijian Index from panoramic radiographs. The Spearman correlation test was run for correlation assessment.

RESULTS

The mean age was 11.81±1.62 years. There were 49 (49%) males and 51 (51%) females. A perfect correlation (100%) was found between CVM stage I and dental stage C. The concordance between CVM stage II and dental stage D was found in 21 (91.30%). The correlation between tooth mineralization and CVM stages was very high and statistically significant (r=0.97, p<0.001). Similarly, the correlation between CVM and chronological age was also high and statistically significant (r=0.8, p<0.001). The correlation was also significantly increased in males and females (r=0.97, p<0.001).

CONCLUSION

The tooth mineralization stages of the mandibular second molar can be used to assess growth as an alternative to cervical maturation staging.

KEYWORDS: *Tooth Mineralization, Demirjian's stages, Cervical Vertebral Maturation, Growth Assessment*

INTRODUCTION

Understanding or knowledge of growth events in orthodontics is crucial in practice because these events can influence diagnosis, treatment planning, appliance selection, and treatment outcome.[1] Therefore, identifying the maturation stage of a patient, particularly during the pubertal growth spurt, is especially important when treating a patient with dentoskeletal disharmony.[2] Every individual's skeletal osseous structures undergo serial changes visible on radiographs.[3] The timeframe of these changes varies between individuals because everyone has their biological clock. Some exceptions exist, but the events are reproducible, providing a basis for individual comparison.[4] Many biological indicators of skeletal maturity, such as chronologic age, dental development, height and width measurement, sexual maturation, and bone ossifications, have been reported in the literature.[5] The validity of hand-wrist radiographs in determining skeletal maturation has also been demonstrated in the literature. However, the complete hand-wrist radiograph has 30 bones, and assessing these bones can be difficult, requiring knowledge of anatomy and exposing patients to extra radiation.[4] The cervical vertebrae maturation (CVM) method is reliable for assessing the growth spurt of the whole body and mandible. This method can be easily evaluated from a lateral cephalogram, with no extra radiation to the patient, available as part of the diagnostic records.[6] Dental maturity can be determined by tooth calcification stages, which can be used as a skeletal maturity indicator.[7] Due to the high correlation between skeletal maturity indicators such as CVM and tooth calcification stages, tooth calcification stages can be a valid alternative for determining the pubertal growth spurt.[8] The researchers have suggested that racial variation, nutrition, socioeconomic levels, and urbanization are causative factors for the differences in this correlation.[9] Therefore, the rationale for the current

study was to determine whether a significant correlation exists between mandibular second molar calcification and the skeletal maturity indicator, i.e., cervical vertebrae maturation stages, for this sample of Pakistani subjects. No study in this population has reported this correlation in individuals with skeletal class II due to mandibular deficiency. This might help use second molar calcification stages as an alternative to cervical vertebrae maturation stages to assess skeletal maturity and to plan growth modification in patients with skeletal disproportion. This study aimed to determine the correlation between skeletal maturity and mandibular second molar calcification in individuals with skeletal class II.

METHODOLOGY

This cross-sectional descriptive study was conducted at the Department of Orthodontics, Saidu College of Dentistry, Swat, from 15th January 2022 to 30th October 2022. The sample size was calculated as 100 cases using a 5% Type 1 error and 10% Type II error, taking an expected correlation coefficient r=0.63 between skeletal maturity and mandibular second molar calcification. The sample was selected using a non-probability consecutive sampling technique. The inclusion criteria were patients of Pakistani descent with an age range of 8-16 years (both genders), ANB greater than 5^0, and intact dentition from 2^{nd} to 2^{nd} molar. Medically compromised/syndromic patients, previous orthodontic treatment, and extracted permanent teeth were excluded. Skeletal maturity was determined by analyzing the cervical vertebrae maturation index (CVMI) on a lateral cephalogram according to Baccetti et al. and mandibular second molar calcification according to Demijian Index from a panoramic radiograph.[10] The machine used for acquiring OPG and lateral cephalogram images is the Dentsply Sirona Orthopos XG 3D. It is a floor-mounted machine with a tube current ranging from 3 to 16 mA. The operation mode was set to automatic, providing convenience and efficiency in image acquisition. The data were analyzed using R programming version 4.12. Descriptive statistics were obtained by calculating the means and standard deviations of the age. To study the relationships between the stage of mineralization of the teeth and the stage of skeletal maturation, the percentage distribution of the calcification stages for molar was calculated. Spearman's correlation test was applied to determine the relationships between Demirjian's and CVM stages. The correlation was stratified among genders to control confounders. The significance level for correlation was $P < 0.01$.

RESULTS

The mean age was 11.81 ± 1.62 years, ranging from 9 to 15 years. There were 49 males (49%) and 51 females (51%). Sixty-three participants belonged to the age group of 9-11 years, while 37 (37%) belonged to 13-15 years. The most common stage of tooth mineralization in the lower second molar was F (n=32, 32%), followed by stage G (n=28, 28%) (Table I). The distribution of cervical vertebral maturation (CVM) stages shows that the most common stage was E (33%), followed by IV (27%), and the least was stage V (7%) (Fig 1). A perfect correlation (100%) was found between CVM stage 1 and dental stage C. The concordance between CVM stage 2 and dental stage D was found in 21 (91.30%). The rest of the details are shown in Table 3. The correlation between tooth mineralization and CVM stages was very high and statistically significant (r=0.97, p<0.001). Similarly, the correlation between CVM and chronological age was also high and statistically significant (r=0.8, p<0.001) (Fig 2). Fig 3 shows the correlation between CVM and dental maturation in both genders. The correlation was similar between males and females (r=0.97, p<0.001).

Table 1: Frequency of Gender, Age Groups and Tooth Mineralization Stages

Variable	Characteristic	n (%)
Gender	Female	51(51.00)
	Male	49(49.00)
Age Group(years)	9-11	63(63.00)
	13-15	37(37.00)
Tooth Mineralization Stages	C	10(10.00)
	D	23(23.00)
	E	32(32.00)
	F	28(28.00)
	G	07(7.00)

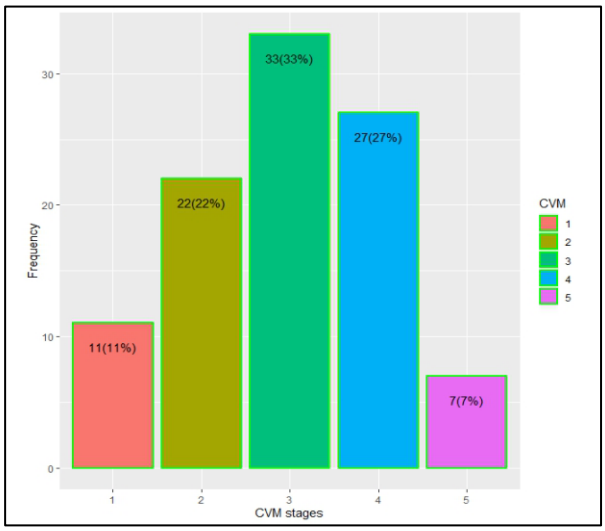

Fig 1: Distribution of Cervical Vertebral Maturation Stages

Table 2: Association of Chronological Age and CVM Stages

CVM Stages	Age(Years) Mean±SD	P-Value*
I	9.55±0.69	<0.001
II	10.32±0.95	
III	12.18±1.13	
IV	13±0.83	
V	15.71±0.95	

*One-way ANOVA test

Table 3: Cross Tabulation of CVM Stages and Tooth Mineralization Stages

CVM Stage	Tooth Mineralization Stages				
	C, n=10	D, n=23	E, n=32	F, n=28	G, n= 7
I	10(100.0)	01(4.35)	0(0.00)	0(0.00)	0(0.00)
II	0(0.00)	21(91.30	01(3.12)	0(0.00)	0(0.00)
III	0(0.00)	01(4.35)	30(93.75	02(7.14)	0(0.00)
IV	0(0.00)	0(0.00)	01(3.12)	25(89.29	01(14.29)
V	0(0.00)	0(0.00)	0(0.00)	01(3.57)	06(85.71)

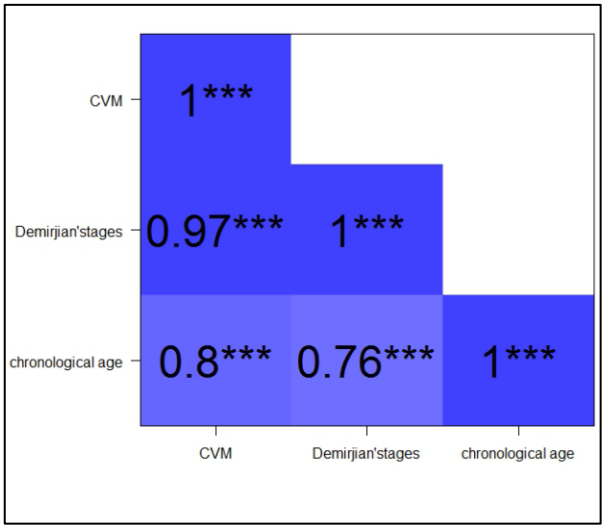

Fig 2: Correlation of CVM with Chronological Age and Demirjian's Stages

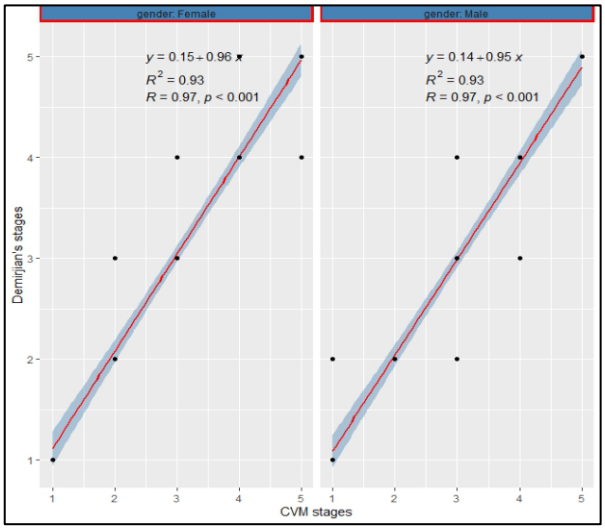

Fig 3: Correlation between CVM and Dental Maturation in both Genders

(Codes for Demirjian's stage: 1-stage C, 2-stage-D, 3-stage-E, 4-stage-F, and 5-stage-G)

DISCUSSION

This study aimed to determine the correlation between mandibular second molar maturation stages and CVM. Our findings showed a very high correlation between dental maturation and CVM stages. In 93% of cases, we can predict the CVM staging from mandibular second molar calcification stages. In our investigation, the mandibular second molar was selected because of the estimating error, which may occur in maxillary molars because, in some cases, the maxillary molar roots may overlap with adjacent structures like the palate, zygomatic buttress, and maxillary sinus, thus making it difficult to observe the root morphology.[11] Treatment planning in orthodontics requires information gained from a history, clinical, and radiographic examination. With the introduction of cephalometry in 1940, orthodontists became more aware of the aetiology of jaw disproportion for malocclusion. Using functional jaw orthopaedics at the correct time during growth can achieve a better smile, good profile, and functional occlusion for patients with skeletal disproportion.[12] The utilization of the Demirjian system in OPG imaging enables standardized dental development assessment, aiding in age estimation and treatment planning with improved reliability and consistency. This method's justification lies in its established validity, widespread acceptance, and useful application in pediatric and orthodontic dentistry.[7] In the present study, males were 49%, and females were 51%, which agreed with the sample size of Goya et al. in their study on the correlation of dental calcification stages and skeletal maturity.[13] Mital S conducted a study on 100 patients (46 males & 54 females), and the present study mirrors the same sample size.[14] The same sample percentage was also shown by Vijayashree et al. The male ratio also agrees with the study conducted by Mustafa, but the female sample size (16) is not in agreement. This could be because of their study's low sample size (60).[15],[16] The sample selection criteria based on age were 8 to 16 years with a mean age of 12.11±1.64, which is close to the mean sample age of the study conducted by Goyal et al. (13.27±2. in males & 12.89±2.26 females).[12] The percentage distribution of age concerning CVM stages shows that the mean age at CVM 3 was 12 years, which reflects the same observation made by many authors.[2,4] The sample selection criteria based on age was 8 to 16 years with a mean age of 12.11±1.64 which is close to the mean sample age of studied conducted by Goyal et al. (13.27±2. in males & 12.89±2.26 females).[13] The percentage distribution of age regarding CVM stages shows that the mean age at CVM 3 was 12 years which

reflects the same observation made by many authors.[14,17] Studies have been conducted on other populations on the correlation of dental calcification stages and skeletal maturity using CVM methods. Their findings show a high correlation.[2,4] Our findings showed that the Spearman correlation test showed a highly significant correlation between skeletal maturity and mandibular second molar calcification stages with r=.97 (p=0.000), and mandibular second molar calcification stage G is significantly correlated with skeletal maturity (CVM 3). The same finding has been observed by Mittal S in his study on 100 patients (46 males & 54 females).[14] Kumar et al., in their study on 300 patients, reported that dental maturation stages showed a highly significant correlation with skeletal maturity (r=0.854 for males and 0.866 for females).[18] These results are in agreement with our findings. The little difference might be linked to the ethnic differences in the calcification stages of individual teeth. Similar effects of this study are reflected in a survey by Mitta et al. conducted on 100 (46 males and 54 females), which concluded that the mandibular second molar strongly correlates with skeletal maturity.[14] A study conducted by Ara et al. on 50 patients connecting skeletal maturity with calcification stages concluded that mandibular second molar calcification stages show a higher and statistically significant correlation.[17] The unique feature of this study is that the correlation between skeletal maturity and second molar calcification stages has been conducted in patients with skeletal Class II based on <ANB. The literature is deficient in this regard, and almost all studies are general without considering the skeletal relationship. This study's mean <ANB angle showed that the maximum number of patients had a mild skeletal Class II relationship. Only one study by Gupta et al. divided the patients based on Angle's molar relationship into Class I, II, and III.[19] They concluded that females attain maturity earlier than males, which agrees with our findings. Also, patients with Class II malocclusion showed little advancement in skeletal maturity in males. However, this finding cannot be applied to the general population because the relationship was based on Angle's molar relationship, not a skeletal discrepancy. Further studies are encouraged to check the correlation in patients, including the severity of skeletal discrepancy based on <ANB, like in our research, and consider skeletal Class I as a control group to check the findings of the mentioned study. Another limitation of this research is the relatively small number of participants, which may restrict the generalizability of the findings. Additionally, the study was conducted within a single hospital environment, which could limit the applicability of the results to other settings or populations.

LIMITATIONS

Our study focused primarily on skeletal class II cases, as they represent a significant portion of our treatment group and require growth assessment and treatment interventions. We suggest for the future researchers to include other skeletal classes for a comprehensive analysis.

CONCLUSIONS

This study concludes that, within its limitations, there is a high degree of predictability (93%) in determining cervical vertebral maturation stages from mandibular second molar calcification stages.

CONFLICT OF INTEREST: None

FUNDING SOURCES: None

REFERENCES

1. Hou D, Capote R, Bayirli B, Chan DC, Huang G. The effect of digital diagnostic setups on orthodontic treatment planning. Am J Orthod Dentofacial Orthop. 2020;157(4):542-9.
2. Helal NM, Basri OA, Baeshen HA. Significance of cephalometric radiograph in orthodontic treatment plan decision. J Contemp Dent Pract. 2019;20(7):789-7793.
3. Ferrillo M, Curci C, Roccuzzo A, Migliario M, Invernizzi M, de Sire A. Reliability of cervical vertebral maturation compared to hand-wrist for skeletal maturation assessment in growing subjects: A systematic review. J Back Musculoskelet Rehabil. 2021;34(6):925-36.
4. Prokop-Piotrkowska M, Marszałek-Dziuba K, Moszczyńska E, Szalecki M, Jurkiewicz E. Traditional and new methods of bone age assessment-an overview. J Clin Res Pediatr Endocrinol. 2021;13(3):251-8.
5. Carelli J, Mattos C, Morais ND, Scariot R, Brancher JA, Baratto-Filho F, et al. Correlation between Insulin-Like Growth Factor I and Skeletal Maturity Indicators. Glob Pediatr Health. 2021;8:233.
6. Amasya H, Cesur E, Yıldırım D, Orhan K. Validation of cervical vertebral maturation stages: Artificial intelligence vs human observer visual analysis. Am J Orthod Dentofacial Orthop. 2020;158(6):e173-e9.
7. Lecca-Morales RM, Carruitero MJ. Relationship between dental calcification and skeletal maturation in a Peruvian sample. Dent Press J Orthod. 2017;22:89-96.
8. Kamal AT, Shaikh A, Fida M. Assessment of skeletal maturity using the calcification stages of permanent mandibular teeth. Dent Press J Orthod. 2018;23:44. e1-. e8.
9. Mauricio-Vilchez C, Mauricio F, Vilchez L, Cadenillas A, Medina J, Mayta-Tovalino F. Radiographic correlation of skeletal maturation using the stages of dental calcification in a Peruvian population. Sci. 2020;2020:1-5.
10. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthodontic. 2002 Aug; 72(4): 316-23.
11. Motghare PC, Bedia AS, Degwekar SS, Indurkar AD, Bedia S. Correlation of calcification of permanent mandibular canine, mandibular premolars, and permanent mandibular first and second molars with skeletal maturity in Indian population. J Forens Dent Sci. 2016;8(2):67-71.

12. Durão AR, Pittayapat P, Rockenbach MIB, Olszewski R, Ng S, Ferreira AP, et al. Validity of 2D lateral cephalometry in orthodontics: a systematic review. Prog Orthod. 2013;14(1):1-11.
13. Goyal S, Goyal S, Gugnani N. Assessment of skeletal maturity using the permanent mandibular canine calcification stages. J Orthod Res. 2014;2(1):11-20.
14. Mittal S, Singla A, Virdi M, Sharma R, Mittal B. Co-relation between determination of skeletal maturation using cervical vertebrae and dental calcification stages. Internet J Forensic Sci. 2009;4(2):1-9.
15. Vijayashree UH, Pai V, Naik VR. Second molar calcification stages to evaluate skeletal maturation: A cross-sectional radiographic study. APOS Trends Orthod 2014;4:156-61.
16. Mustafa S. Evaluation of dental and skeletal maturity using digital panoramic radiographs and digital cephalograms. Asian Biomed. 2015;23:9:335.
17. Ara SA, Arora V, Ullah SZ. Relationship between dental maturity and cervical vertebral maturity in North Karnataka (India) children: a hospital-based retrospective study. J Orofac Res. 2014:35-40.
18. Kumar S, Singla A, Sharma R, Virdi MS, Anupam A, Mittal B. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod. 2012;82:501-6.
19. Gupta KP, Garg S, Grewal PS. Establishing a diagnostic tool for assessing optimal treatment timing in Indian children with developing malocclusions. J Clin Exp Dent. 2011;3:e18-24.

CONTRIBUTORS

1. ***Muhammad Kamran -*** *Concept & Design; Data Acquisition; Critical Revision*
2. ***Gulsana Hashmi -*** *Drafting Manuscript; Final Approval*
3. ***Muhammad Noman -*** *Drafting Manuscript; Critical Revision; Final Approval*
4. ***Umar Hussain -*** *Data Analysis/Interpretation; Drafting Manuscript; Supervision*