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Diagnostic accuracy of tooth mineralization in growth spurt determination using modified middle phalanx (MP3) as a gold standard

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Abstract

Introduction: was to determine diagnostic accuracy of tooth mineralization in growth spurt determination using modified middle phalanx (MP3) as a gold standard.

Material and Methods: This cross sectional (Diagnostic) study was conducted on 150 cases. Panoramic radiographs were assessed according to the Dermirjian's stages of dental calcification of mandibular second molar of right side. Digital radiographs of the middle phalanx (MP3) were taken using the procedure described by Abdel-Kader. The inclusion criteria were age from 8 to 16 years, Pakistani national, and both genders. Children with previous history of orthodontics treatment, Systemic disease, congenital anomalies of teeth, history of trauma or surgery in the neck or dentofacial region were excluded. Intra and inter-observer reliability was assessed through Cohen's Kappa statistics. Sensitivity, specificity positive predictive value, and negative predictive value were calculated. P ≤ 0.05 was considered significant.

Results: The age range was 8 to 16 years with a mean of 11.56±2.26 year. The correlation between tooth calcification and MP3 stages was high (r=0.705) and very highly statistically significant (P<0.001). Most of the stages of mandibular second molar mineralization had low diagnostic accuracy but only stage F show high diagnostic accuracy (80.67%; 95% CI=73.43, 86.65).

Conclusions: The Stage F of second molar has relatively high diagnostic accuracy for detecting growth spurt.

Keywords: Growth spurt; mandibular second molar calcification; modified middle phalanx

Introduction

For growing patients in orthodontics and dentofacial orthopedics the timing of treatment is very important for correcting dento-skeletal imbalances.[1] Advance knowledge in growth determination is very essential for growth modification therapy to be successful.[2] Different sort of malocclusions need functional appliance treatment at different time.[3] Treatment started before the adolescent growth spurt to enhance or restrain maxillary growth is more effective, whereas therapy for enhancing or restraining mandibular growth give better response when carried out during the circumpubertal growth spurt period.[4]

Due to low correlation of chronological age with skeletal maturation especially during circumpubertal growth stages, this indicator is known not to be reliable for treatment timing detection.[5] Same is the case with tooth eruption or emergence.[6, 7] Nevertheless, tooth mineralization stages assessed through radiographs seem to have high correlation with skeletal maturation. Panoramic radiographs are used to assess dental maturity, which are available routinely for diagnosis in Orthodontics with minimal

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irradiation hazards to the subjects.[8] In pediatric patient, the use of a thyroid collar is mandatory in taking cephalometric radiographs while no need for Panoramic radiographs. But according to Wiechmann et al.[9] and Sansare et al[10] the thyroid collar conceals landmarks required for skeletal maturity assessment.

A method of dental maturity, which can be easily accessed through the assessment of tooth mineralization, and which could performed on panoramic radiographs that are used on routine basis for various purposes, and with minimal irradiation to the patient.[11] The degree of crown and root formation is not affected by magnification error of radiation can be seen on panoramic radiographs.[6] Previous investigations have concluded that the dental maturation staging is a reliable indicator for skeletal maturity in growing cases, which has major diagnostic implications.[12, 13]

Rajagopal and Kansal.[14] and Ozer et al.[15] determined the relation of cervical vertebral maturation stages with modified middle phalanx (MP-3) stages of third finger and concluded that the MP3 method is a reliable tool for assessment of subject's skeletal maturation. The MP3 method utilized a periapical x-ray films and could be simple, accurate, practical, and economical as a growth spurt detection tool to make decisions regarding treatment planning. Surendran et al.[16] conducted a study to determine diagnostic accuracy of tooth mineralization in growth determination using modified middle phalanx (MP3) as gold standard. Their correlation coefficient for tooth mineralization stages of mandibular second molar and MP-3 was 0.703. They concluded that dental maturation assessment is only useful for diagnosis of the prepubertal and post-pubertal growth phases.

The rationale of this study is, as most of growing patients have dental malocclusion (crowding) without skeletal problems for that patients it would be inappropriate to advice lateral cephalograms because of increased radiation dose and cost. Digital radiograph for MP-3 have much less radiation dose. Mp-3 method as described by investigators[13,14] is a good alternative of cervical vertebral maturation staging (CVM). So in this study MP-3 was used as gold standard to determine the diagnostic value of mandibular second molar mineralization stages for growth determination.

The objective of this study was to determine diagnostic accuracy of tooth mineralization in growth determination using modified middle phalanx (MP3) as a gold standard.

Material and Methods

This observational study (diagnostic accuracy) was performed at department of Orthodontics, Khyber College of Dentistry Peshawar from March 2015 to July 2018. Approval of the hospital ethical committee was taken. Subjects fulfilling the inclusion criteria were invited to take part in the study after verbal informed from parents.

The Sample Size was calculated to be 99 by using EpiTools epidemiological calculator (http://epitools.ausvet.com.au/content.php?page=FreedomSS&Prevalence=0.106&Sens=0.43&seh=0.97&Population) keeping the prevalence of 10.6% for stage H of mandibular second molar, sensitivity of 43%[16] for test and required population sensitivity of 99%, however, we have taken 150 cases for making subcategories analysis easy.

The inclusion criteria were panoramic radiographs available with high clarity and good contrast, age from 8 to 16 years, Pakistani national assessed on the basis of NIC, both genders, and patient coming for orthodontic treatment. Children with previous history of orthodontics treatment, systemic disease that could affect general development like hormonal diseases, congenital anomalies of teeth, history of trauma or surgery in the neck or dentofacial region were excluded.

Panoramic radiographs (OPGs) of the patient were taken and assessed according to the

Dermirjian's stages of dental calcification of mandibular second molar.[32] From several investigations, the tooth calcification of homologous teeth was found to be symmetrical; therefore, only right mandibular teeth were examined in this study.[65]

Digital radiographs of the MP3 region was taken using the procedure described by Abdel-Kader.[64] The subject were instructed to place the right hand with the palm downward on a flat table. The middle finger of left hand was centered on a 31 × 41 mm periapical dental X-ray film, parallel with the long axis of the film. The cone of the dental X-ray machine (70 kVp and 8 mA) was positioned in slight contact with the middle phalanx, perpendicular to the film. Exposure time was 0.4 second. Stage G and H of MP3 stages were considered as growth spurt stage. The two radiographs (OPG and MP3) were taken on the same day for each patient. All radiographs were assessed by two examiners (UH and AA).

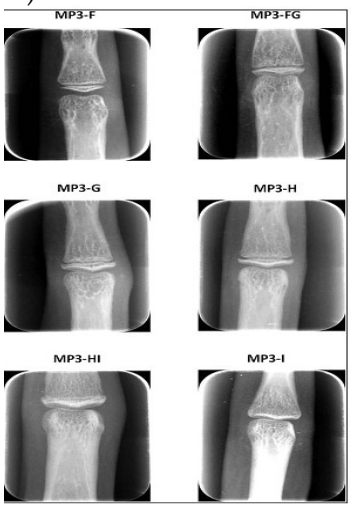

Figure 1: MP3 radiographs

A set of 10 randomly chosen OPGs, used to assess inter- and intra-rater agreement in grading of MP3 and tooth mineralization stages. Two raters were used to assess inter-rater agreement; the time interval between the two 'blind' assessments for intra-rater agreement was one week. The degree of agreement was calculated using Cohen's Kappa statistics. The agreement was high (k=0.92).

Data were analyzed using SPSS version 20.0 and Medcalc software. Mean and standard deviation was calculated for numerical variable like age. Frequency & percentage were calculated for qualitative variable like gender, MP-3 and tooth mineralization stages. Sensitivity, specificity, positive likelihood ratio, negative likelihood ratios, positive predictive values, and negative predictive values were calculated. P≤0.05 was considered significant.

Results

The age range was 8 to 16 years with a mean 11.56±2.26 year. Descriptive statistics are presented in **table I**. The most common age category was 11 to 13 years (n=69, 46%). Male were the predominant gender (n=85, 56.7%). The most common mandibular second mineralization stages were stage 'G" (n=58, 38.7%) and 'H" (n=30, 20%). The most common MP3 stages were stage 'FG" (n=44, 29.3%) and 'F" (n=42, 28%). Most of the participants were belonged to pre-pubertal stage (n=81, 54%).

The correlation between tooth calcification and MP3 stages was high (r=0.705) and very highly statistically significant (P<0.001). **(Table II)**

Most of the stages of mandibular second molar mineralization had low diagnostic accuracy but only stage F show high diagnostic accuracy (80.67%; 95% CI=73.43, 86.65). **(Table III)**

Table I: Descriptive statistics of the study

	Category	Frequency	Percent
Age	08-10	54	36
	11-13	69	46
	14-16	27	18
Gender	Male	85	56.7
	Female	65	43.3
Mandibular second mineralization stages	D	19	12.7
	E	26	17.3
	F	17	11.3
	G	58	38.7
	H	30	20

MP3 stages	F	42	28
	FG	44	29.3
	G	27	18
	H	6	4
	HI	7	4.7
	I	24	16
MP3 categories	Pre-pubertal stage	81	54
	Pubertal stage	38	25.3
	Post-pubertal	31	20.7

Table II: Correlation between Modified middle phalanx and second molar tooth mineralization

Variables	Correlation coefficient	P-value
Modified middle phalanx (MP3)	0.705	<0.001
second molar tooth mineralization		

**. Correlation is significant at the 0.01 level (2-tailed)

Table III: Diagnostic accuracy of tooth mineralization in determination of growth spurt

	Tooth stages in growth spurt determination				
	Stage D (95% CI)	**Stage E (95% CI)**	**Stage F (95% CI)**	**Stage G (95% CI)**	**Stage H (95% CI)**
Sensitivity	2.63% (0.07-13.81)	13.16% (4.41-28.09)	34.21 (19.62-51.35)	47.37% (30.9-64.2)	2.63% (0.07-13.8)
Specificity	83.93% (75.79-90.19)	81.25% (72.78-88)	96.43% (91.11-99)	64.29% (54.7-73.2	74.11% (64.9-81.9)
PLR	0.16 (0.02-1.19)	0.70 (0.28-1.73)	9.58 (3.32-27.61)	1.33 (0.87-2.21)	0.1 (0.01-0.72)
NLR	1.16 (1.05-1.28)	1.07 (0.92-1.24)	0.68 (0.54-.86)	0.83 (0.59-1.14)	1.31 (1.16-1.48)
PPV	5.26% (0.76-28.69)	19.23% (8.8-37.01)	76.46% (53-90.35)	31.03% (22.9-40.6)	25.33% (0.48-19.65)
NPV	71.76 (69.76-73.67)	73.39% (70.31-76.26)	81.2% (77.4-84.49)	78.26% (72.1-83.3)	69.17% (66.52-71.69)
D. Accuracy	63.33 (55.08-71.04)	64% (55.7-71.2)	80.67% (73.43-86.65)	60% (51.69-67.9)	56% (47.67-64.09)

*PLR, positive likelihood ratio; NLR, Negative likelihood ratio; PPV, positive predictive value; negative predictive value; D. accuracy, Diagnostic accuracy

Discussion

The diagnostic ability of the circumpubertal maturation stages of the mandibular second molar's various stages were investigated in this study. Most of the stages of second molar were having less accurate in diagnosing the pubertal growth spurt. Only stage F of second molar in overall sample showed high diagnostic accuracy (80.67%; 95% CI=73.43, 86.65) and PLR (9.5; 95% CI= 3.3, 27.6) in detecting growth spurt.

We used demirjian's method in our study which has the advantage of not being affected by magnification error. This method is based on crown and root stages rather than millimetric length of the tooth. The tooth radiograph used in this method is easily avialble in each dental setting. Many studies had utilized this methodologies.[11, 16, 17]

We used modified middle phalanx (MP3) as gold standard. According to Rajagopal and Kansal, this method has high inter-observer reliability and accuracy in diagnosing growth sput.[14] We considered stage G and H of MP3 stages as growth spurt stage. This fact is well established in literature. [18, 19]

Treatment timing is very important for the outcomes of all orthopedic treatments for dentoskeletal imbalances in growing patients. Prior knowledge to quantify the remaining growth would be extremely useful for predicting treatment results. For growth modification to be successful, it is absolutely essential that it starts at the right time. Optimal timing for treatment is different in various malocclusions.[3]

Due to low correlation of chronological age with skeletal maturation especially during circumpubertal growth stages, this indicator is known not to be reliable for treatment timing detection.[5] Same is the case with tooth eruption or emergence.[6,7] Nevertheless, tooth mineralization stages assessed through

radiographs seem to have high correlation with skeletal maturation. Panoramic radiographs are used to assess dental maturity, which are available routinely for diagnosis in Orthodontics with minimal irradiation hazards to the subjects.[8]

In spite of the high correlations between the dental and skeletal maturation stages, the overall diagnostic ability of the former for the identification of the pubertal growth spurt is generally low according to the positive likelihood ratios. Even combinations of dental maturation stages used for diagnostic performance of the pubertal growth spurt were limited. Similar result were reported by previous study conducted in Indian population.[16]

This single center and hospital-based study. Further large sample and community-based studies are recommended to further explore this area.

Conclusions

Within the limitations of this study, it can be concluded that the Stage F of mandibular second molar has relatively high diagnostic accuracy for detecting growth spurt.

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