Diagnostic Potential of Mandibular Second Premolar and its Relation to Physiological and Skeletal Maturity in Girls

Research Article

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Abstract

Aims and objectives: 1). To estimate the association between mandibular second premolar calcification stages and cervical vertebrae maturation 2). To estimate relationship of dental maturation and sexual maturation in female subjects 3). To analyse discriminatory ability of premolar calcification in assessing subjects having potential growth.

Materials and Methods: Panaromic radiographs and lateral cephalograms of 90 girls subjects (before menarche) were selected for the study. Mandibular second premolar calcification stage was estimated according to Demirjian index-DI and cervical vertebrae maturation index (CVMI) was estimated using Hassel and Farman index.

Results: Highly significant statistical correlation(C= 0.603) was found between DI and CVMI stages in girls.CVMI-2 correlated with stage DI-E, CVMI-3 correlated with stage DI-F, CVMI-4 and 5 correlated with stage DI-G. Dental maturation preceeded sexual maturation and 7.8% of the sample population showed completion before attaining sexual or skeletal maturity.

Conclusion: Mandibular second premolar can be used as a preliminary method of estimating skeletal maturity. Calcification stage DI–F of premolar corresponds to peak growth in females.However, completion of calcification may be misleading, therefore other diagnostic methods should be considered for confirming the growth status of an individual.

Keywords: Skeletal Maturation; Dental Maturation; Demirjian Index; Tooth Calcification; Cervical Vertebrae Maturation; Mandibular Second Premolar; Menarche.

Introduction

Physiological maturity shows considerable variation among different persons. Orthodontic treatment planning involves anticipation of future growth potential of facial skeleton [1]. Few clinical considerations such as use of functional appliances, extra-oral traction etc.are strongly related to rates of craniofacial growth. Therefore, it is essential to establish whether pubertal growth spurt of the patient has been reached or completed.

Rate of progress towards maturity can be estimated by various indicators such as somatic, sexual, skeletal and dental, which are explained below.

Somatic: Annual growth increments in height to estimate growth velocity are valid means determine spurt. Maximum growth in height coincides with maximum facial growth in majority of subjects [2]. However , this method is of little value to orthodontists as identification of spurt is retrospective.

Sexual: Development of secondary sexual characters was related to growth spurt in several studies. It was estimated that peak height velocity precedes menarche by approximately 2 year in female subjects [3], while voice change may be related to growth spurt. Beginning of voice change marks the most intense phase of spurt and transformation to adult relates to deceleration of growth [4].

Skeletal: Hand wrist radiographs [5-7] and cervical vertebrae maturation [8, 9] were proposed as best indicators to assess growth by many scientists. Ossification time of hook of the hamate, adductor sesamoid [10] and capping of epiphysis of middle phalynx of third finger [11, 12] were strongly correlated with peak height velocity in many previous studies [13].

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Dental: Dental maturity in subjects can be estimated by using either dental emergence stages or dental calcification stages. Estimation of these dental indicators is relatively simple, requiring a routine diagnostic panaromic or a periapical radiograph [14]. Dental emergence stages (DES) were previously identified as not so useful in indicating pubertal growth [15]. Dental calcification stages of various teeth has been widely studied to estimate its correlation with skeletal maturity. Few studies reported no correlation between development of lower premolars, second molars and the maturational state of the patient [16]. Green et al suggested that skeletal age, height, weight are possibly controlled to some degree by the same forces of growth and development, which is unrelated to dental development [13]. However, several other studies recognized dental indicators to reliably estimate skeletal maturity. Mandibular canine calcification stage G was found to coincide with various skeletal indicators of the pubertal growth spurt [6-8]. A recent report on relation between calcification stages of various teeth to skeletal maturation reported that mandibular second premolar showed highest correlation among all the teeth in Thai subjects [17], another report suggested second mandibular molar showed high correlation with CVMI [18]. Some studies show that dental maturity may vary with gender and racial factors [1, 19, 20], suggesting a caution for applying these results universally. The present study attempts to establish a correlation between mandibular second premolar calcification stages and other indicators of growth among Indian females to check its validity in estimating growth.

The aims of this study were:

1. To estimate the association between mandibular second premolar calcification stages and cervical vertebrae maturation
2. To estimate relationship of dental maturation and sexual maturation in female subjects
3. To analyse discriminatory ability of premolar calcification in assessing subjects having potential growth.

Materials and Methods

The study followed a cross sectional design. 90 pre pubertal girls with age ranging from 10-13 years were selected from out patients reporting to SVS institute of dental sciences Mahabubnagar. In-

formed consent was obtained from their guardians, dental check-up was supplemented with radiographic analyses for diagnosing overall dental condition of the patient. This radiation dosage was within the levels permitted for routine diagnostic purpose. High quality digital images and adequate use of radiation shields (thyroid collar and lead apron) was used for the exposing the subjects. Radiographic exposure for lateral cephalogram and orthopanto-mogram was done on the same day.

- Inclusion criteria
- 1) Chronological age between 10-13 years.
- 2) Moderately built girls who haven't reached menarche.
- 3) Good general health with absence of any nutritional problems.
- 4) No use of any anti-inflammatory agents or antibiotics.
- 5) No active orthodontic treatment

All the radiographs were exposed by a single radiologist.

Evaluation of Skeletal Maturity According to Hassel And Farman Method

Cervical vertebral maturation was analysed based of index proposed by Hassel and Farman [21] ranging from CVM I TO CVM VI as shown in Table 1.

Evaluation of Dental Maturity of Mandibualr Second Premolar According to Demirjian Index

Mandibular left second premolar calcification stage was assessed according to Demirjian index [22] ranging from DI-A TO DI-H as shown in Table 2.

Comparison between skeletal maturity and dental maturity was carried out to estimate the potential of second premolar in assessing skeletal growth.

Statistics

We performed statistical analysis using SPSS software version 17.0. Two observers were blinded to asses all the radiographs according to the indices. Inter observer agreement and variability

Table 1. Cervical Vertebrae Maturation Index(CVMI).

Stage Characteristics

Stage 1 (Initiation): Very significant amount of adolescent growth expected (80% to 100%). C2, C3, and C4 inferior vertebral body borders are flat. Vertebrae are wedge-shaped. Superior vertebral borders are tapered posterior to anterior.

Stage 2 (Acceleration): Significant amount of adolescent growth expected (65% to 85%). Concavities are developing in the inferior borders of C2 and C3. The inferior border of C4 is flat. The bodies of C3 and C4 are nearly rectangular in shape.

Stage 3 (Transition): Moderate amount of adolescent growth expected (25% to 65%). Distinct concavities are seen in the inferior borders of C2 and C3. A concavity is beginning to develop in the inferior border of C4. The bodies of C3 and C4 are rectangular in shape.

Stage 4 (Deceleration): Deceleration of adolescent growth spurt. Small amount of adolescent growth expected (10% to 25%). Distinct concavities in the inferior borders of C2, C3, and C4. C3 and C4 are nearly square in shape.

Stage 5 (Maturation): Final maturation of the vertebrae takes place during this stage. Insignificant amount of adolescent growth expected (5% to 10%). Accentuated concavities of inferior vertebral body borders of C2, C3, and C4. C3 and C4 are square in shape.

Stage 6 (Completion): Adolescent growth is completed (little or no growth expected). Deep concavities are seen in inferior border of C2, C3, and C4. C3 and C4 heights are greater than widths.

Table 2. Calcification stages of tooth according to Demirjian.

Stage A: Beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.

Stage B: Fusion of calcified points forming one or several cusps.

Stage C: Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen. Beginning of a dentinal deposit is seen .The outline of the pulp chamber has a curved shape at the occlusal border.

Stage D: The crown formation is completed till the cement-enamel junction. The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, with concavity towards the cervical region. The projection of pulp horns if present, gives an outline shape like an umbrella top. In molars the pulp chamber has a trapezoidal form. Beginning of root formation is seen in the form of a spicule.

Stage E: The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger compared to the previous stage. The root length is less than the crown height. For molars, initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi lunar shape. The root length is still less than the crown height.

Stage F: Uniradicular teeth: The walls of the pulp chamber now form a more or less isosceles triangle, the apex ends in a funnel shape. The root length is equal to or greater than the crown height. For molars, the calcified region of the bifurcation has developed further down from its semilunar stage to give the roots a more definite and distinct outline with funnel shaped endings. The root length is equal to or greater than the crown height.

Stage G: The walls of the root canal are now parallel and its apical end is still partially open (distal root in molars).

Stage H: The apical end of the root canal is completely closed (distal root in molars)
The periodontal membrane has a uniform width around the root and the apex.

was estimated using Cronbach's alpha value. To estimate relationship between DI and CVMI Spearman's rho correlation coefficient and Pearson contingency coefficient were estimated.

Results

Table 3 shows highly significant inter observer agreement (p=0.001) in estimating calcification stages and cervical vertebrae maturation stages. Cronbachs alpha value was 0.872 showing relatively high internal consistency. Table 4 shows distribution of pre pubertal sample population among various stages of premolar calcification and cervical vertebrae stages. Complete calcification of the tooth with DI-H was noticed in 8 girls of the pre pubertal sample population. While, CVMI-VI was not noticed in the sample and CVMI-V was evident in 5 subjects. Correlation between calcification stages and cervical vertebrae maturation stages was positive. Spearman's rho Correlation Coefficient was 0.465 with high significance (p < 0.001). Pearson contingency coefficient was 0.603 (p < 0.001; Highly Significant). CVMI-2 correlated with stage DI-E, CVMI-3 correlated with DI-stage F, CVMI-4 and 5 correlated with stage G.

Discussion

Cervical vertebrae maturation was suggested as a reliable indicator for estimating skeletal maturity [13, 23]. CVMI as given by Hassel and Farman was used to analyse the lateral cephalograms obtained from sample population. The variability and repeatability of this method was previously questioned in a study by Gabriel et al., [24]. However, our study showed good interobserver agreement (Cronbachs alpha=0.872) which was statistically significant (p<0.001), Table 3 also shows good inter-observer agreement in estimating Demirjian index.

Age of second premolar calcification and eruption coincides with the age of circumpubertal growth spurt in females, which make its correlation to skeletal maturity skeptical. Few studies suggested tooth calcification showed correlation with chronological age and

was independent of skeletal maturity [13] while, few other studies reported good correlation between calcification stages and skeletal maturity. Table 4 reported correlation with high statistical significance between stages of CVMI and stages of 2nd premolar calcification. Spearman correlation coefficient of value 0.465 and Pearson contingency coefficient of value 0.603 was recorded in this study, suggesting second mandibular premolar calcification stages can be reliably used to asses skeletal maturity [25]. Stage E of second premolar calcification corresponded to pre pubertal growth phase as reported in previous study [26]. Stage F of premolar calcification correlated with stage III (transition) phase of CVMI and therefore can be used to estimate peak growth spurt in female subjects.

Sexual maturity was taken as an additional guide to ensure that the sample population had significant growth potential. of second premolar calcification stages in assessing growth. In girls the menarche provides a stage of maturation recordable around puberty, menarche did not occur before peak pubertal skeletal growth and is recorded up till few years later [27]. All girls had the menarche before the end of the spurt [28]. Association between sexual maturity, dental maturity and peak height velocity has been previously reported in study by Demirjian, according to which 90% dental maturity occurred approximately 2 years before sexual maturity. Subjects chosen for the study haven't attained sexual maturity(menarche).Assuming active growth is remaining in all the subjects, distribution of CVM stages and DI stages in the sample population was determined to check the ability of these indices in discriminating individuals who had growth remaining and who have minimal growth potential. CVMI reported to have good discriminatory ability [21] as it was observed that of the total 90 sample population CVM –stage –VI was not identified, CVM–V was noticed in 5 subjects. This confirms the reliability of CVM index in assessing skeletal maturity as suggested by previous studies [29]. Calcification stages of second premolar showed distribution among all stages ranging from D-H. Stage H was noticed in 7 subjects. Completion of tooth calcification when skeletal growth is still active indicates premolar calcification stages

Table 3. Inter operator reliability analysis.

CVM Stage	Operator 1		Operator 2		Inter-operator Reliability Analysis
	No.	% age	No.	% age	
Stage 1	1	1.1	1	1.1	Cronbach's Alpha = 0.872; F value = 7.800; p<0.001; Highly significant correlation
Stage 2	32	35.6	34	37.8	
Stage 3	37	41.1	29	32.2	
Stage 4	15	16.7	21	23.3	
Stage 5	5	5.6	5	5.6	
Total	90	100.0	90	100.0	

Table 4. Association between CVM Stage and Calcification Stage.

CVM Stage	Calcification Stage					Total
	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	
Stage 1	1 (100%)					1 (100%)
Stage 2	1 (2.9%)	17 (50%)	13 (38.2%)	3 (8.8%)		34 (100%)
Stage 3	1 (3.4%)	9 (31.0%)	10 (34.5%)	5 (17.2%)	4 (13.8%)	29 (100%)
Stage 4		3 (14.3%)	8 (38.1%)	8 (38.1%)	2 (9.5%)	21 (100%)
Stage 5			1 (20%)	3 (60%)	1 (20%)	5 (100%)
Total	3 (3.3%)	29 (32.2%)	32 (35.6%)	19 (21.1%)	7 (7.8%)	90

x^2 (16) = 51.520; Contingency Coefficient = 0.603; p < 0.001; Highly Significant
Spearman's rho Correlation Coefficient = 0.465; p < 0.001; Highly Significant

cannot discriminate individuals having active growth from those having minimal growth.

Conclusions

1. Mandibular second premolar calcification stages correlates positively to cervical vertebrae maturation stages
2. Mandibular second premolar calcification stages can be used as indicator of skeletal maturity
3. Peak pubertal growth may be noticeable during stage F of premolar calcification stages.
4. Initial and peak phases of pubertal spurt can be estimated by second premolar calcification stages. However, growth completion cannot be estimated using this method.

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