ASSOCIATION OF CERVICAL VERTEBRAE MATURITY INDICATORS AND THIRD MOLAR CALCIFICATION STAGES FOR ASSESSMENT OF GROWTH STATUS

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Running Title - CVMI and third molar calcification stages for assessment of growth status.

ABSTRACT

Skeletal maturation assessment has a great role in many health professions especially in Orthodontics & Dentofacial Orthopedics. Functional appliances have proved to be more effective when used at the peak of mandibular growth, rather than before. The purpose of this study was to assess the correlation between the third molar development stages and cervical vertebrae maturity index. Lateral cephalograms and orthopantomogram (OPG) of the subjects who reported to the Department of Orthodontics and Orthopaedics at Saveetha Dental College, Chennai were taken for this study. Third molar developmental stages were assessed using Demirjian index (DI) and Cervical vertebrae maturation indicators (CVMI) was evaluated using the classification given by Hassel and Farman. To assess the association between the two, Pearson Chi square association test was done using IBM SPSS software separately for both males(p>.001) and females(p>.001). Results of this study showed that there is no significant association between the cervical vertebrae maturity indicators and development of third molars stages in both males and females. Limitation of our study was that the study sample was small. With more samples and records, the association results would have been increased considerably.

Keywords: Cervical vertebrae maturation indicators (CVMI), Demirjian index(DI), Lateral cephalogram, Molar development stages, Orthopantomogram
INTRODUCTION

In clinical orthodontics, an understanding of the growth events is of prime importance. Knowledge of the pubertal growth spurt status of the individual is important for a clinician, as it influences diagnosis, treatment planning, outcome of orthodontic treatment (Krailassiri, Anuwongnukroh and Dechkunakorn, 2002). As the age of the patient plays a major role in the diagnosis and treatment planning and outcome of an orthodontic treatment, so is the growth status of the individual. Growth modulation procedures such as the use of extraoral orthopedic forces or functional appliances, are better to be initiated during active growth periods. These active growth periods have to be objectively assessed for both the timing and amount of active growth vector or direction of growth. Cervical vertebrae maturity indicator uses the 2nd, 3rd, and 4th cervical vertebrae to assess the growth status of the individual. Hassel and Farman observed the cervical vertebrae (C2, C3, and C4) to evaluate skeletal maturity (Hassel and Farman, 1995; Rubika, Sumathi Felicita and Sivambiga, 2015)). Dental maturity is assessed using radiological appearances of the mandibular teeth, method developed by Demerjian. Each tooth was rated according to the developmental criteria (amount of dentinal deposit, shape changes of pulp chamber, etc). Eight stages ie, from A to H are defined from first appearance of calcification points to the closure of apex.

This study was conducted to evaluate the relationship between the third molar developmental stages and cervical vertebrae in determination of growth status of an individual in subjects reporting to the Department of Orthodontics, Saveetha Dental College, Chennai.

MATERIALS AND METHODS

The inclusion criteria of the study were; age of the subjects in the range of 9-18 years, subjects with normal growth and development, no skeletal deformities, absence of developmental and skeletal disorders, presence of third molars. Orthopantomogram (OPG) and lateral cephalograms of patients who reported to the Department of Orthodontics at Saveetha Dental College Chennai were taken for this study. Group A had 8 radiographs of male patients and group B had 8 radiographs of female patients.

OPGs were assessed for the development stages using the Demirjian index (DI) (Demirjian, Goldstein and Tanner, 1973). In the current study, the lower 3rd molar was used to assess the developmental stages of the tooth. Lateral Cephalogram was evaluated for assessing the cervical vertebrae maturity indicator stages. The stages were divided into six stages as done by Hassel and Farman (Hassel and Farman, 1995). Table 1 gives the CVMI stages and table 2 gives DI stages.

The CVMI stages were classified as initiation, acceleration, transition, deceleration, completion, and maturation and the coding was given from 1 to 6. Third molar developmental stages were scored according to the method described by Demirjian A et al., (Demirjian Index [DI]), in which one of eight stages of calcification (A to H) was assigned to the tooth and coding was given from 1 to 8.

Statistical analysis

All data collected were entered into an excel sheet (Microsoft Excel 2007)(Table 3) and statistical analysis done using IBM SPSS software version 23.0. The Pearson’s Chi square association test was done to assess the relation between DI and cervical vertebrae maturity indicator stage in both genders. (Figure 1 and 2)

RESULTS AND DISCUSSION

The results of the present study conclude that there is no statistically significant association between the cervical vertebrae maturity indicator stages and development of third molar stages in both females (p value - 0.59)(fig 1) and males (p value - 0.233)(fig 2).
The findings of Kumar S et al. (Kumar et al., 2012), Srkoc T et al., Krailassiri S et al., signifies that DI stages in male subjects tend to be ahead when compared with female subjects in relation to cervical stages (Krailassiri, Anuwongnukroh and Dechkunakorn, 2002; Srkoc et al., 2015). In the present study, we also observed that at the same cervical stage, males had a more advanced trend in DI, as compared to female subjects.

In a similar study done by Krailassiri et al. the relationship between the calcification stages of the mandibular canines, premolars, second, third molars, and skeletal maturity stages among Thai individuals was investigated. The third molar demonstrated the poorest correlation (Krailassiri, Anuwongnukroh and Dechkunakorn, 2002). Uysal et al. in a study had approved that the calcification stage of the second molar had the highest correlation with the skeletal maturity stage. In Turkish subjects, the tooth sequence in order of the lowest to the highest correlation was: third molar, canine, first premolar, second premolar, and second molar (Uysal et al., 2006).

With the above result, it is very clear that growth status cannot be evaluated from OPG, which is frequently used in orthodontic treatment planning and evaluation. The results of the present study showed no significant relationship between the 3rd molar developmental stages and cervical vertebrae maturity indicator. But the studies performed by Engström et al. (Engström, Engström and Sagne, 1983) and Krailassiri et al. (Krailassiri, Anuwongnukroh and Dechkunakorn, 2002) suggested a strong relationship between dental maturity and skeletal maturity. The probable reasons for this could be the small sample of the present study and an unequal distribution of subjects in various stages of CVMI stages and DI stages. Chertkow (Chertkow, 1980) indicated that mandibular canine root before apical closure can be used as a maturity indicator with pubertal growth spurts with same accuracy as that of hand-wrist radiographs in Caucasian children. A study by Bolanos et al. (Bolanos et al., 2003) showed that root formation of the third molar is almost completed around the age of 18–19 years. The third molar has a unique feature of the development over a long period of time when compared to other teeth. In the current study, there was no association between the cervical vertebrae maturity indicator and third molar development stages in males and females.

Previously our team had conducted numerous clinical trials (Kamisetty, 2015; Krishnan, Pandian and Kumar S, 2015; Viswanath et al., 2015; Sivamurthy and Sundari, 2016; Felicita, 2017b; Samantha et al., 2017; Vikram et al., 2017) and lab animal studies (Ramesh Kumar et al., 2011; Jain, Kumar and Manjula, 2014; Rubika, SumathiFelicita and Sivambiga, 2015; Felicita, 2017a; Pandian, Krishnan and Kumar, 2018) and in-vitro students (Felicita, Chandrasekar and Shanthasundari, 2012; Dinesh et al., 2013; Felicita, 2018) over the past 5 years. Now we are focussing on epidemiological surveys. The idea for this survey stemmed from the current interest in self ligating brackets and the rise in their usage in many practises.

In orthodontic practice, dental maturity is usually evaluated from either the tooth eruption or stages of tooth development. The main disadvantage of the study was that the patient was exposed to X-ray radiation twice and the sample size taken was less which reflected on the association result. With more samples, the association would have been significant.

This was conducted to evaluate whether an association existed between the third molar developmental stages and cervical vertebrae maturity indicators helping in age estimation in the patients seeking orthodontic treatment.

CONCLUSION

Within the limitation of this study it was concluded that the mandibular third molar calcification stages could not be used as an indicator of skeletal growth. Therefore this method cannot be used in clinical practice to determine the growth status of the individual unlike hand wrist radiographs and cervical vertebrae maturity indicators.

AUTHOR CONTRIBUTIONS

There was equal contribution from all the authors.

CONFLICT OF INTEREST

There is no conflict of interest.
REFERENCES


Ramesh Kumar, K. R. et al. (2011) ‘Depth of resin penetration into enamel with 3 types of enamel conditioning


<table>
<thead>
<tr>
<th>Stages</th>
<th>Amount of growth expected</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 (Initiation)</td>
<td>80-100%</td>
<td>C2, C3, and C4 inferior vertebral body borders are flat. Vertebrae are wedge-shaped.</td>
</tr>
<tr>
<td>Stage 2 (Acceleration)</td>
<td>65-85%</td>
<td>Concavities are developing in the inferior borders of C2 and C3. The inferior border of C4 is flat. C3 and C4 are nearly rectangular in shape</td>
</tr>
<tr>
<td>Stage 3 (Transition)</td>
<td>25-65%</td>
<td>Distinct concavities are seen in the inferior borders of C2 and C3, C4 developing concavity in the inferior border of the body. The bodies of C3 and C4 are rectangular in shape</td>
</tr>
</tbody>
</table>
Table 1: The table depicts Cervical vertebrae maturation stages (CVMI, Hassel and Farman, 1995). Hassel and Farman observed the cervical vertebrae (C2, C3, and C4) to evaluate skeletal maturity.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 5 (Maturation)</td>
<td>5-10%  Insignificant amount of adolescent growth is expected. Accentuated concavities of the inferior vertebral body borders of C2, C3, and C4. C3 and C4 are square in shape.</td>
</tr>
<tr>
<td>Stage 6 (Completion)</td>
<td>Little or no growth Adolescent growth is completed. Deep concavities are seen in the inferior borders of C2, C3, and C4. C3 and C4 heights are greater than widths</td>
</tr>
</tbody>
</table>

Table 1: The table depicts Cervical vertebrae maturation stages (CVMI, Hassel and Farman, 1995). Hassel and Farman observed the cervical vertebrae (C2, C3, and C4) to evaluate skeletal maturity.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Calcification of single occlusal points without fusion of different calcifications</td>
</tr>
<tr>
<td>B</td>
<td>Fusion of mineralization points; the contour of the occlusal surface is recognizable</td>
</tr>
<tr>
<td>C</td>
<td>Enamel formation has been completed at the occlusal surface, and dentin formation has commenced. The pulp chamber is curved, and no pulp horns are visible</td>
</tr>
<tr>
<td>D</td>
<td>Crown formation has been completed to the level of the cementoenamel junction. Root formation has commenced. The pulp horns are beginning to differentiate, but the walls of the pulp chamber remain curved.</td>
</tr>
<tr>
<td>E</td>
<td>The root length remains shorter than the crown height. The walls of the pulp chambers are straight, and the pulp horns have become more differentiated than in the previous stage. In molars, the radicular bifurcation has started to calcify.</td>
</tr>
</tbody>
</table>
The walls of the pulp chamber now form an isosceles triangle, and the root length is equal to or greater than the crown height. In molars, the bifurcation has developed sufficiently to give the roots a distinct form.

The walls of the root canal are now parallel, but the apical end is partially open. In molars, only the distal root is rated.

The root apex is completely closed (distal root in molars). The periodontal membrane surrounding the root and apex is uniform in width throughout.

Table 2: Dental calcification stages using the Demirjian index (DI) (Demirjian, Goldstein and Tanner, 1973). Demirjian developed a method for estimating dental maturity or dental age using radiological appearances of the mandibular teeth, that is, from incisors to molars. Each tooth was rated according to the developmental criteria (amount of dentinal deposit, shape changes of pulpal chamber, etc.).

<table>
<thead>
<tr>
<th>Age/ sex</th>
<th>Molar stage</th>
<th>Coding</th>
<th>CVMI stage</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>11/M</td>
<td>E</td>
<td>5</td>
<td>Deceleration</td>
</tr>
</tbody>
</table>

Table 3: Data collection format in Excel.
Figure 1. Bar graph represents the association between the third molar developmental stages and CVMI stages in females. Blue colour represents acceleration stage, green colour- transition stage and orange colour represents deceleration stage. X axis represents the third molar developmental stages and Y axis represents the CVMI stages. No significant association was found between third molar developmental stages and CVMI stages in females using Pearson’s Chi-square association test (Chi-square value=2.77; df=4; p value =0.596, >0.05) hence statistically not significant). It can be inferred from the above result that most of the females in the study population were in the transition stage of CVMI stage and stage E of DI stage.
Figure 2. Bar graph depicts association between 3rd molar developmental stages and CVMI stages in males. X axis represents the third molar developmental stages and Y axis represents the CVMI stages. Blue colour represents acceleration stage, green colour - transition stage and orange colour represents deceleration stage. No significant association was found between third molar developmental stages and CVMI stages in males using Pearson’s Chi-square association test (Chi square value = 2.91; df=2; p value=0.233, > 0.05), hence statistically not significant. It can be inferred from the above result that most of the males in the study population were in the acceleration and transition stages of CVMI stage and stage D of DI stage.