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# Skeletal Maturity Assessment using Mandibular Canine Calcification Stages

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## ABSTRACT

***Objective:*** To determine the correlation between cervical vertebral maturation stages on a lateral cephalo-gram and Dimerijan canine calcification stages on an Orthopan-tomogram for assessment of skeletal maturity

***Study Design:*** Cross-sectional study.

***Place and Duration of Study:*** Orthodontics Department, Armed Forces Institute of Dentistry (AFID), Rawalpindi Pakistan, from Dec 2021 to Apr 2022.

***Methodology:*** The subjects of either gender, aged 9 to 16 years, in good physical, mental and oral health were included in the study. Two radiographs, a lateral cephalogram and Orthopantomogram, were taken for each patient. Hassel and Farman and Demirjian stages were used to asses skeletal maturity and canine classification, respectively.

***Results:*** The mean age of the sample was 13.29±1.86 years. The Hassel and Farman CVM stages on a lateral cephalometric radiograph and Dimerijan canine calcification stages on a panoramic radiograph showed a significant positive correlation (r= 0.785, *p*= 0.000)

***Conclusion:*** There is a high correlation between CVM stages by Hassel and Farman and Dimerijan canine calcification stages to assess skeletal maturity. Therefore, any of these radiographs can be employed to assess the skeletal maturity status of the patient without exposing the patient to additional radiographic radiation.

**Keywords:** Cervical vertebral maturation (CVM) stages, Canine calcification stages, Dental maturity, Skeletal maturity.

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## INTRODUCTION

Skeletal maturity is the "Complete fusion of epiphyseal plates of bone". Dental maturity refers to the "Completion of teeth calcification or mineralisation".[1] Growth can be defined as an "Increase in size", and development is an "increase in complexity of cells and tissues into organs and systems".[2] Assessment of skeletal maturity is vital in developing patients when growth modification therapy is necessary to address a skeletal disparity because the success of such a treatment modality can be assured only before the patient enters the pubertal growth spurt.[3,4] This growth spurt can be determined using skeletal maturity indicators such as ossification and shape of bones like those of hands and wrists and cervical vertebrae and also by the stages of development of dentition.[5] The goal of growth modification is to maximise skeletal changes and minimise dental changes.[6]

Various methods are used to assess the skeletal maturity of a growing patient. The use of an Orthopantomogram, which is often used in routine orthodontic investigations, can also be used to assess skeletal maturation from phases of calcification of various teeth like premolars, molars and canines.[7,8] Cervical vertebral maturation stages by Hassel and Farman are considered the gold standard in determining the skele-tal maturity status of a growing child. This requires an assessment of the shape and concavity of the lower border of the first four cervical vertebras on a lateral cephalometric radiograph.[9,10]

This study aims to correlate cervical vertebral maturation and canine calcification stages to assess skeletal maturity.

## METHODOLOGY

The cross-sectional study was conducted at the Orthodontics Department of Armed Forces Institute of Dentistry, Rawalpindi, Pakistan, from December 2021 to April 2022. Prior approval from the Institutional Ethical Committee Board was taken (Ref letter number: 918/Trg-AB1K2). In addition, their parents confirmed the chronologic age of the patients. The sample size estimated by the Stats Direct software was 108.[11]

**Inclusion Criteria:** The subjects aged 9 to 16 years, in good physical, mental and oral health were included in the study.

**Exclusion Criteria:** Subjects with a history of dental injury, congenital tooth anomaly, and hormonal,

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nutritional and any other chronic illness were excluded from the study.

Using a convenient sampling technique, the study recruited 117 participants from the Out-Patients Department of the Orthodontics department. Two radiographs were taken for each subject, a digital panoramic radiograph for assessing the Demirjian method and a lateral cephalometric radiograph for assessing CVM stages which are already a part of routine ortho examination. Sirona Dental System Orthopentomogram machine D-64625 (64kV, 8mA) model was used. A single radiographer took all the OPG. The lateral cephalogram machine Sirona Dental system D-64625 (73kV, 15mA) model was used.

Permanent mandibular left canine calcification stages were evaluated by the method described by Demirjian *et al*.[6] Panoramic radiograph was used to assess stages from E to H. These are as follows: Stage E: The walls of the pulp chamber are perfectly straight. The horns of the pulp are more pronounced. The length of the roots is shorter than the height of a crown; stage F: The pulp chamber walls form an equilateral triangle. The tip is funnel-shaped. The crown's height is equal to slightly more than the root length; Stage G**:**The root canal walls are straight, with a partially open terminal portion; Stage H: The root canal's terminal end is entirely sealed. The periodontal membrane has the same diameter around the root and top.[12]

A lateral cephalogram was used to assess the maturation of cervical vertebras following Hassel and Farman's method. Cervical vertebrae (C2, C3, C4) were assessed and then classified into different stages according to changes in their shape. Sirona Dental System lateral ceph machine model D-64625 was used. A single radiographer took all lateral cephalograms. CVM Stage 1 (Initiation): All three vertebras (C2, C3, and C4) have straight lower margins. C3 and C4 have trapezoidal bodies with superior edges that taper from posterior to anterior; CVM Stage 2 (Acceleration): On the bottom edges of C2 and C3 have curvature. Curvature on the bottom margins of C2 is more significant than C3. C4's lower border is still flat. C3 and C4 bodies are still trapezoidal; CVM Stage 3 (Transition): C2 and C3 have curvature at their bottom margins. C3 and C4 bodies can be trapezoidal, rectangular or horizontal in shape; CVM Stage 4 (Deceleration): Concavities are now found at the bottom margin of C2, C3 and C4. Both C3 and C4 have rectangular horizontal bodies. Concavity at the bottom margin of C4 and the peak interval terminates or has terminated at this level, CVM Stage 5 (Maturation): Curvature at the bottom margins of C2, C3 and C4 remains. At least one of C3 and C4's bodies are squared, whereas the others are horizontally rectangular; CVM Stage-6 (Completion): Curvature at the bottom margins of C2, C3 and C4 still are discernible. C3 and C4's bodies are rectangular and vertical, whereas the others are squared.[13,14]

The data were analysed using for Windows SPSS version 23.0. The Spearman's correlation coefficient was calculated to assess the correlation between dental and cervical maturation stages by Demirjian and CVM stages. The *p*-value of ≤0.05 was set as the cut-off value for significance.

## RESULTS

The sample comprised 117 individuals, including 70 females (59.8%) and 47 males (40.1%). The age range of patients varied from 9-16 years (mean age: 13.29± 1.86 years).

The sample frequency distribution based on CVM staging and Left Mandibular Canine Calcification staging are presented in Tables-I and II, respectively.

**Table I: Frequency Distribution of Sample based on Cervical Vertebral Maturation (CVM) staging (n=117)**

| CVM Stages | Frequency (Percentage) |
|---|---|
| 1 | 17(14.5%) |
| 2 | 14(12.0%) |
| 3 | 13(11.1%) |
| 4 | 19(16.2%) |
| 5 | 28(23.9%) |
| 6 | 26(22.2%) |
| Total | 117(100.0%) |

**Table II: Frequency Distribution of Sample based on of Left Mandibular Canine Calcification staging (n=117)**

| Canine calcification stages | Frequency (Percentage) |
|---|---|
| E | 8(6.8%) |
| F | 16(13.7%) |
| G | 39(33.3%) |
| H | 54(46.2%) |
| Total | 117(100.0%) |

Finally, the correlation between CVM stages and left mandibular canine calcification stages was correlated using Spearman's correlation, which yielded significant results. The two measures of skeletal maturity were strongly positively correlated with a correlation coefficient of 0.785 (0=0.001). (Table-III).

**Table III: Correlation between Cervical Vertebral Maturation (CVM) stages and Left Mandibular Canine Calcification stages (n=117)**

| Variables | | Results |
|---|---|---|
| CVM Staging | Spearman Correlation Coefficient | 0.785 |
| Left mandibular canine calcification stage | *p*-value | 0.001* |

## DISCUSSION

This study aims to correlate cervical vertebral maturation and canine calcification stages to assess skeletal maturity. Orthodontic treatment options vary depending on the patient's remaining growth potential. The lateral cephalogram is still a routine diagnostic radiograph despite the advent of three-dimensional imaging techniques that enhance diagnosis and treatment planning due to its easy availability and less radiation exposure.[13,14] Lateral cephalogram is used in routine ortho procedures or during treatment planning to assess the skeletal age of a patient.[15] A lateral cephalogram assesses a child's peak pubertal growth status, which is critical for an orthodontist, especially when transitioning from mixed to permanent dentition. In many cases, chronological age does not always correlate with skeletal age due to various factors such as genetic predisposition, environmental factors, syndromes, malnutrition, chronic illness, ethnic background, active or sedentary lifestyle, and ethnic background. Because tooth maturation and tooth calcification are more reliable in determining skeletal maturity than tooth eruption, an orthopantomogram is used.[16]

In some studies, second premolar and second and third molar calcification stages correlate with CVM stages.[16,17] This study assessed the association between left mandibular canine calcification stages and CVM. A canine has a rare incidence of permanent canine hypoplasia 0.07% to 0.13%, and root variations in mandibular canines are rare, 1% to 5%. However, the clinician should always be aware of unpredictable root canal morphologies. Third molar development and eruption status are highly controversial.[17]

Peak pubertal growth spurt or secondary sexual characteristics in males and females is achieved at different ages. Maximum skeletal maturity in females is attained early as compared to males. Evaluation of cervical vertebral maturation stages is done as suggested by Hassel and Farman on lateral ceph.[5] According to the literature, CVM stages strongly correlate with skeletal maturity but some studies show a weak correlation.[11,18] The relation between left mandibular canine and skeletal maturation in the Pakistani population was 0.787 in this study. As a result, it may be concluded that the mandibular canine is an important factor in determining skeletal maturity.[19] Hence, for evaluating the child's skeletal age, a single radiograph, either lateral cephalogram or Orthopantomogram, is enough.[20]

Further research on the correlation of the rest of the dentition with CVM stages needs to be carried out, especially in patients with canine agenesis, syndromic patients and missing or impacted canines.

## CONCLUSION

Cervical vertebral maturation stages correlate highly with left mandibular canine calcification stages. So, to minimise radiation exposure in children evaluating only one radiograph, either lateral cephalogram or orthopantomogram, is enough for diagnosis.

**Conflict of Interest:** None.

**Authors' Contribution**

Following authors have made substantial contributions to the manuscript as under:

ZBN: Study design, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

AJ: Critical review, approval of the final version to be published.

ZK: Data acquisition, interpretation of data, approval of the final version to be published.

QUAT: Critical review, drafting the manuscript, approval of the final version to be published.

RZ: & NA: Study design, Drafting the manuscript, interpretation of data, approval of the final version to be published.

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