

Evaluating the Accuracy of App-based Assessment of Cervical Vertebral Maturation Stages: A Comparative Study

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ABSTRACT

Context: Cervical vertebral maturation (CVM) assessment is an important tool for evaluating skeletal maturity and assessing the growth and development of children. It is commonly used to predict the timing of pubertal growth spurts and to monitor the effects of treatment on growth. **Aims and Objective:** The aims of this study were to compare the accuracy of app-based versus manual methods for assessing CVM stages in growing children. **Materials and Methods:** Seventy-two lateral cephalograms of children aged 9–16, with a balanced representation of boys and girls were included in the study. CVM stages were assessed using “CVM Stage Guide app” as well as manual methods by three experienced orthodontists, and the results were compared using Mann–Whitney U-test. **Results:** Statistical analysis was conducted using the Statistical Package for the Social Sciences to compare the groups represented by CVM Stage determined manually and with the app. A Mann–Whitney U-test was used for pairwise comparisons. No statistically significant differences were found ($P < 0.05$). **Conclusion:** The app-based method for assessing CVM Stages using “CVM Stage Guide” app is as accurate as the manual method and may be conveniently used as a learning tool by the orthodontic students.

Key words: Cervical vertebral maturation, CVM stage guide, skeletal age, smartphone app

INTRODUCTION


Cervical vertebral maturation (CVM) assessment is an important tool for evaluating skeletal maturity and assessing the growth and development of children. It is commonly used to predict the timing of pubertal growth spurts and to monitor the effects of treatment on growth.^[1]

Conventionally, CVM assessment has been performed manually, using visual inspection and measurement of the cervical vertebrae. The CVM method, developed by Baccetti *et al.*, which uses

the geometry of the second, third, and fourth cervical vertebrae to identify six stages of CVM, is widely regarded as a reliable and straightforward method.^[2] There is a considerable learning curve involved for the orthodontic students in accurately applying the guidelines in determining the CVM stages.

To make the identification of these stages even easier, an app called “CVM Stage (CVMS) GUIDE” has been developed and is available on the Google Play store.^[3] This app offers a user-friendly interface that guides users through the process of identifying the CVM stage. Since there is a need to verify the reliability of this app, we aim to evaluate the accuracy of the “CVMS GUIDE” app in correctly identifying the CVMS.

The null hypothesis for this study is that there is no significant difference between the CVM stages determined using the CVMS Guide app and the manual method. The alternative hypothesis is that

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there is a significant difference between the two methods.

MATERIALS AND METHODS

The sample for this study included 72 lateral cephalograms of children aged 9–16, with a balanced representation of boys and girls, obtained from the archives of the Department of Orthodontics at the Kamineni Institute of Dental Sciences.

The app, called “CVMS GUIDE,” uses a wizard-like guided interface to help users determine the CVM stage.

The app’s main screen [Figure 1a] offers the option to “Begin Wizard,” which initiates a five-step process for identifying cervical stages. Steps 1–5 involve selecting the shape that best matches the lower borders of C2, C3, and C4 and bodies of C3 and C4 [Figure 1b]. Navigating through these steps is made easy with the option to use the “Back” button to return to previous steps or the “Restart” button to start over.

Once all steps are completed, the app will use the guidelines established by Baccetti *et al.* to determine the cervical stage, as illustrated in a final screen displaying an inference of peak mandibular growth [Figure 1c].

Three experienced professors in the Department of Orthodontics used the CVM method to identify the CVMS depicted in each cephalogram. By examining the cephalograms

and applying the CVM method, the professors determined the stage of CVM present in each cephalogram using both the app-based method and a manual method, which involves visual inspection of the cervical vertebrae.

Statistical Analysis

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS), version 20 (SPSS Inc., Chicago, IL, USA) to compare the groups represented by CVMS determined manually and with the app. A Mann–Whitney U-test was used for pairwise comparisons. The significance level for the analysis was set at $P < 0.05$.

The CVM stages assessed manually and using the app were tabulated as sample 1 and sample 2, respectively, for the 72 cephalograms.

RESULTS

The data showed a Z-score of 0.10588 (Table 1) which means that the data point is slightly below the mean. P -value was .4562 indicating that there is a 45.6% chance that the difference in the CVMS results obtained using the two methods could have occurred by chance alone. Therefore, based on this P -value, we would fail to reject the null hypothesis, meaning that we do not have enough evidence to suggest that there is a significant difference between the CVMS results obtained using the app and the manual method. This means that the CVMS Guide app can be considered as reliable and accurate as the manual method in determining the CVMS.

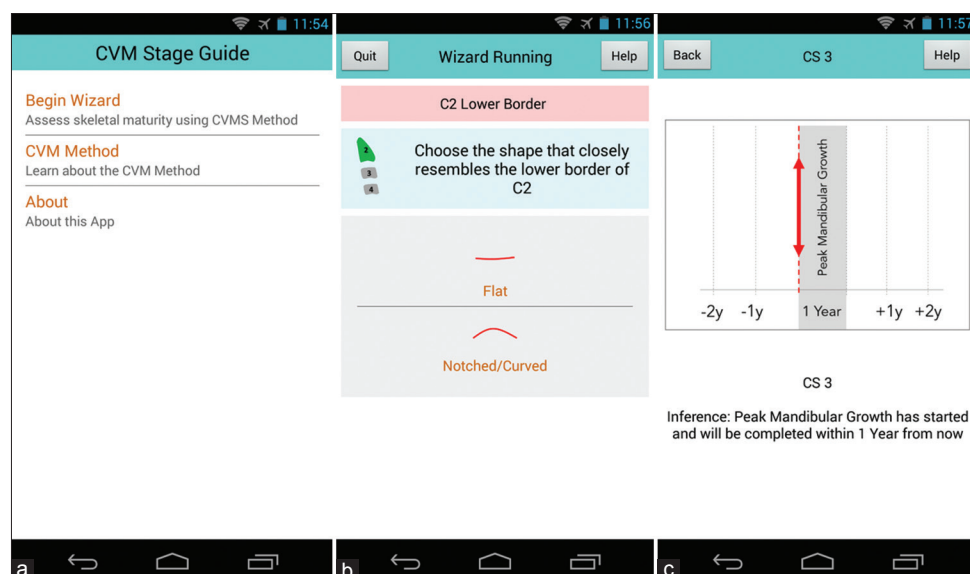


Figure 1: (a-c) The screenshots of the CVM Stage Guide App

Table 1: Comparison of Sample 1 (Manual) and Sample 2 (App-based) CVMS

Parameter	Sample 1 (Manual)	Sample 2 (App-based)
Sum of ranks	5193	5247
Mean of ranks	72.12	72.88
Expected sum of ranks	5220	5220
Expected mean of ranks	72.5	72.5
U-value	2619	2565
Expected U-value	2592	2592
Samples 1 and 2 combined		
Sum of ranks		10440
Mean of ranks		72.5
Standard deviation		250.2798
U value		2565
Z-score		0.10588
P-value		0.4562

DISCUSSION

Timing is of utmost importance when it comes to treatments that involve modifying growth.^[1] One reliable way to determine skeletal maturity is by analyzing the cervical vertebrae on a lateral cephalogram. The CVM method, developed by Baccetti *et al.*, uses the shape of the second, third, and fourth cervical vertebrae (C2, C3, and C4) to identify six cervical stages.^[2] These stages can be used to determine the most appropriate time to perform treatment for various dentoskeletal issues in growing children.

The CVM method, while reliable, can be difficult for beginners to learn due to its steep learning curve. To help overcome this challenge, the authors of the Smartphone App titled CVMS Guide have designed an easy-to-use, step-by-step wizard that guides users through the process,

making it more accessible, and less intimidating for beginners.

The results of the experiment comparing the CVMS determined by the CVMS Guide app and the manual method showed a high level of agreement between the two methods. Specifically, there was an almost 99% match between the two samples, with only two cases, where the app-based stages were reported as Stage 6 instead of Stage 5 as determined manually. Since *P*-value was 0.4562, we do not have enough evidence to suggest that there is a significant difference between the CVMS results obtained using the app and the manual method. This suggests that the CVMS Guide app is a reliable and accurate tool for determining CVMS, and that the results obtained using the app are highly comparable to those obtained through manual methods.

Using the app, learners can take an objective approach to the steps involved in CVMS assessment, making the method more engaging, and helping them to gain a deeper understanding of the process.

CONCLUSION

The findings of the present study indicate that the CVMS Guide app provides an accurate and reliable method for assessing CVMS, which can be used as an effective learning tool for orthodontic students and novice clinicians.

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