Comparison of statural height growth velocity at different cervical vertebral maturation stages

Sara Hosni,[a] Girvan Burnside,[b] Simon Watkinson,[c] and Jayne E. Harrison[a]
Liverpool and Blackburn, United Kingdom

Introduction: Knowledge of a patient's stage of growth and development plays a vital role in diagnosis, treatment planning, results, and stability of the outcome. Cervical vertebral maturation (CVM) predicts the stage of growth and development, but its validity has only been investigated restrospectively, using historic samples. Our objective was to assess prospectively whether a correlation exists between CVM stage and statural height growth velocity. **Methods:** Participants were aged between 8 and 18 years and of both sexes. Standing height was measured every 6 weeks with participants barefoot and in natural head position. CVM stage was assessed from lateral cephalograms taken at the start of treatment. Intraobserver and interobserver reliability of CVM staging and statural height measurements were assessed using the Cohen weighted kappa, percentage of agreement, intraclass correlation coefficient, and Bland-Altman plots, respectively. Analysis of variance was used to test for statistically significant differences between growth velocities at the CVM stages. **Results:** We analyzed 108 participants. The peak in statural height growth velocity occurred at CVM stage 3 ($P = 0.001$). There was a statistically significant difference in the mean annualized growth velocity between all CVM stages except stages 2 and 4. Girls had their peak pubertal growth spurt an average of 1.2 years earlier than did boys. **Conclusions:** This study suggests that there is a significant relationship between CVM stage and statural height velocity. (Am J Orthod Dentofacial Orthop 2018;154:545-53)

Knowledge regarding the timing and extent of growth for orthodontic patients is essential for managing them optimally and successfully, particularly in those with skeletal discrepancies.[1] Such knowledge plays a vital role in the diagnosis, treatment planning, results, and overall stability of the patients' outcomes.[1] Depending on the stage of development and growth velocity expected for a patient, different treatment modalities may be considered more appropriate than others.[2-5] For orthodontists, it therefore is crucial to be able to assess the growth potential of a patient and, when orthognathic surgery or implants are required, to know when growth has ceased (Fig 1).

Numerous methods have been investigated to identify the stage of growth and development and predict both the timing and potential of this growth.[6-17] These include chronologic age, dental age,[6-8] menarche and voice changes,[9,10] standing height,[11,12] skeletal maturation of the hand and wrist,[6,7,10,13] and cervical vertebral maturation (CVM).[14-17]

None of these methods has demonstrated a strong enough correlation to growth with the exception of skeletal age of hand-wrist radiographs and CVM.[5,6,18-23] The principle of using skeletal maturity to determine the most appropriate time for orthodontic treatment has varied in popularity but has always required additional radiation exposure and additional skills for the orthodontist to interpret the hand-wrist radiographs.[24] As a result, alternatives to hand-wrist radiographs were sought using investigations that were more commonplace in orthodontics and more familiar to the orthodontist to facilitate interpretation.[25]

CVM is an alternative method to hand-wrist radiographs that has been shown to be reliable[18,19,26-29] and does not require additional radiation for patients

[a]Liverpool University Dental Hospital and School of Dentistry, Liverpool, United Kingdom.
[b]Department of Biostatistics, University of Liverpool, Liverpool, United Kingdom.
[c]Orthodontic Department, Royal Blackburn Hospital, Blackburn, United Kingdom.
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Address correspondence to: Jayne Harrison, Orthodontic Department, Liverpool University Dental Hospital, Pembroke Place, Liverpool, United Kingdom L3 5PS; e-mail, Jayne.Harrison@rlbuht.nhs.uk.
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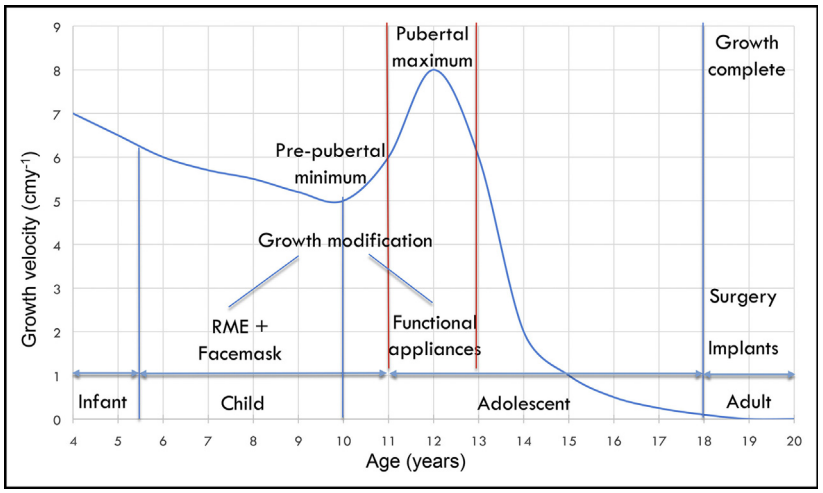

Fig 1. Changes in height growth velocity from infancy to adulthood (modified from McNamara[47]).

undergoing orthodontic treatment.[19] The CVM index[14] assesses the shape of the cervical vertebrae visible on a standard lateral cephalogram and uses this approach to predict the patient's stage of growth and development.

Although many studies have looked into the validity of this index, all have used historical samples and have been retrospective.[14-16,18,23,30-36] Methodologic flaws, as well as sampling issues, mean that the validity of the CVM method is yet to be shown in a contemporary population sample in a prospective manner.

For the CVM method to be of use clinically today, it must not only be reliable but also be valid with respect to its predictability of growth in a contemporary sample. The aim of this study was therefore to address the concerns raised in previous research[19] and to determine the validity of the CVM stage as a predictor for growth using an appropriately sized, contemporaneous sample of children and adolescents, in a prospective manner. The objective of this study was to assess whether a correlation exists between CVM stage and statural height growth velocity. Phase II of this study will assess the relationship between CVM stage and facial (mandibular) growth.

MATERIAL AND METHODS

Routine orthodontic clinical records were collected from all patients according to the departmental protocol of Liverpool University Dental Hospital, United Kingdom, for use in treatment planning. These records included the patient's initial standing height, a lateral cephalogram radiograph, intraoral and extraoral photographs, and other radiographs as indicated clinically. After this, the patients started orthodontic treatment, as appropriate, to correct their malocclusion. Routine care was provided per the consultant's treatment plan. Interim and final records were obtained as clinically necessary. In addition to this routinely acquired information, the clinicians undertaking the patients' treatment took a measurement of standing height at each visit and recorded it in the clinical records.

Participants receiving orthodontic treatment at Liverpool University Dental Hospital in the academic years 2012-2013 and 2013-2014 were eligible to participate in this study. At their first appointment, routine history, examination, and special investigations were undertaken; then the patient and parent or guardian were informed about the study and invited to participate if the inclusion criteria were fulfilled.

Participants were included if they were 18 years or younger, were of either sex, had not received previous orthodontic treatment, and had given informed consent or assent to participate in the study.

Patients diagnosed with any congenital clefts of the lip or palate, or known or suspected craniofacial syndromes or growth-related conditions, were excluded.

Standing height was measured with the patients barefoot, feet together with their heels against the wall and in natural head position (Frankfort horizontal plane parallel to the floor), using a wall-mounted height measure, at every visit. Taking the standing height at each visit (every 6 weeks) was the only intervention that was in addition to routine clinical practice. It was carried out in a designated area by the treating clinician and recorded on a data sheet in the patients' notes. The height was measured at the same time of the day on each occasion. An annualized growth rate was calculated to allow comparison of growth rates over the same time period. This was also because there were small fluctuations in