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Research

Evaluation of Ricketts' and Bolton's growth prediction algorithms embedded in two diagnostic imaging and cephalometric software

Matthew Sagun [a], Budi Kusnoto [b,*], Carla A Evans [c], Maria Therese Galang-Boquiren [d], Grace Viana [e], Ales Obrez [f]

[a] Private practitioner, Chicago, IL
[b] Department of Orthodontics, Clinic director and Associate Professor, University of Illinois at Chicago, Chicago, IL
[c] Department of Orthodontics, Professor and Department Head, University of Illinois at Chicago, Chicago, IL
[d] Department of Orthodontics, Assistant Professor and Director of Predoctoral Orthodontics, University of Illinois at Chicago, Chicago, IL
[e] Department of Orthodontics, Statistician, University of Illinois at Chicago, Chicago, IL
[f] Department of Restorative Dentistry, Associate Professor, University of Illinois at Chicago, Chicago, IL

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A B S T R A C T

Background: Accurate assessment and prediction of skeletal and dentofacial growth are very important for planning orthodontic treatment and achieving stable and esthetic outcomes. Several algorithms (e.g. Bolton and Ricketts) for predicting craniofacial growth using lateral cephalograms are available to clinicians in commercial computer software packages.
Methods: This retrospective study compares the reliability of craniofacial growth of three growth prediction algorithms currently available in Dolphin Imaging™ 11.0 and RMODS-JOE CEPH® programs. Lateral cephalograms of skeletal normal class I of 56 untreated children obtained from the Craniofacial Growth Legacy Collection of the American Association of Orthodontists Foundation (AAOF) were used to evaluate the Ricketts and Bolton growth prediction algorithms in Dolphin Imaging™ 11.0 as well as the Ricketts growth prediction algorithm in RMODS-JOE CEPH®. The groups were subdivided by growth prediction algorithm, gender, chronological age, developmental age and length of rediction. Student t-tests were used to compare the mean differences of the growth predictions tested.
Results and discussions: This study showed no differences with respect to developmental age and gender, but the two-year predictions appear to be more valid than the four-year predictions. The Bolton growth prediction algorithm in Dolphin Imaging 11.0 and the Ricketts growth prediction algorithm in RMODS-JOE CEPH® were more alike among the three.
Conclusions: The three growth prediction algorithms tested indicated to be within a 1.5 mm clinical reference when compared with the actual growth of the same subject studied for the majority of the landmarks assessed, indicating their clinically reference acceptability specially for a two year prediction.

1. Background

In its early years, cephalometric radiograph was primarily a research tool for studying the development of craniofacial components over time using measurements of dental and facial changes derived from serial records [1]. The longitudinal data of the Bolton Study in particular helped form many of the principles of craniofacial growth and developmental [2]. During this research movement, the investigator proposed the idea of downward and forward face development and the establishment of the pattern of the head and face at an early age [3]. Eventually, those that thought they had a mastery of growth also believed they could wield this knowledge and apply it to the prediction of growth.

In 1971, Ricketts described the breakthroughs that led to greater understanding of mandibular growth and eventually his theory of forecasting. His ideas and methods of forecasting went through scrutiny and many stages of development in the 1950s and 1960s [4–7].

A study by Johnston in 1975 introduced a simplified approach to prediction in the form of a "forecast grid," which shows average

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* Corresponding author: University of Illinois at Chicago, Department of Orthodontics, 801 S. Paulina St., Room 131, Chicago, IL 60612.
E-mail addresses: bkusno1@uic.edu, bkusno1@gmail.com (B. Kusnoto).

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increments of growth per year for the points nasion, A, B, nose, posterior nasal spine, and maxillary first molar [8]. The author stated, “the grid did not perform too badly,” explaining that the predictions were not much worse than would be expected from an analysis of cephalometric error.

The Johnston grid system and the Ricketts computerized forecasting techniques were compared in a study by Schulhof and Bagha [9]. They evaluated the ability of the Ricketts long-term forecast, the Ricketts short-range predictions, and the Johnston grid system using average increments from Sella-Nasion to accurately predict the growth at A point, pogonion, Ricketts Xi point, tip of the nose, and mandibular molar position. The computerized Ricketts short-range prediction method showed a 10–20% improvement over the average increments, and finally, the computerized Ricketts long-term forecast was found to be the most accurate, being 21% more accurate than the Ricketts short-range method and 56% more accurate than the Johnston grid system.

In another study, Greenberg and Johnston evaluated the accuracy of Ricketts computerized long-term arcial forecast [10]. The authors found no significant difference between the computerized method of prediction and the average changes in the study population. They concluded that this sophisticated method was unable to individualize the subjects and that more simplistic methods would prove equally satisfactory.

In a more recent study, Kocadereli and Telli [11] studied the Ricketts long-range growth prediction in Turkish children. “Predicted” and “actual” measurements were evaluated. Of the 21 parameters studied, showed a high correlation between “predicted” and “actual” for girls (14 measurements) and boys (nine measurements).

In 2007, Turchetta et al. [12] evaluated three prediction systems: the Ricketts analysis, the Johnston grid system, and the Fishman system of skeletal maturation assessment. They found that the Fishman system was the most accurate for predicting short- and long-term growth but stated that the Ricketts and Johnston systems might have greater predictive accuracy if they were based on maturational age, eliminating unwanted developmental variables.

As part of their study to evaluate the treatment effects of the variable anchorage straightwire technique in Angle Class II patients, Parikakis et al. [13] evaluated a control group of 30 untreated Class II Swedish individual (20 girls, 10 boys). To ensure the validity of the Ricketts Visual Treatment Objectives (VTO) method, they tested an untreated sample. They concluded that the growth prediction method according to Ricketts VTOs was valid for skeletal and dentoalveolar variables in a sample of Swedish post-normal children.

Some software manufacturers have adapted or created algorithms based on the above-mentioned growth prediction techniques. The objective of this study was to evaluate and compare the relative accuracies of three computerized growth prediction methods based on lateral cephalograms, namely the Ricketts and Bolton growth prediction algorithms embedded in Dolphin Imaging™ 11.0 (Alg 1 and Alg 2, respectively) and the Ricketts algorithm (Alg 3) in RMODS® (Rocky Mountain Orthodontics Data Services) JOE CEPH® software. This study tested the hypothesis that three algorithms (Ricketts [Alg 1] and Bolton [Alg 2] in Dolphin Imaging™ 11.0 and Ricketts in RMODS-JOE CEPH® [Alg 3]) provide accurate growth predictions when compared with the actual observed growth of untreated children.

2. Methods

Radiographs from 56 subjects (28 males and 28 females) with relative normal craniofacial with no skeletal deformities (ANB of 3.0 ± 2.0°; FMA of 23.0 ± 5.0°) were obtained from the AAOF Craniofacial Growth Legacy Collection. The AAOF craniofacial growth legacy collection website classified 39 of the subjects as Class I and 17 subjects as Class II, showing that majority of the subjects had relatively normal facial patterns [14,20]. Collection of radiographs obtained must have clearly defined fiducial to correct for magnification, good quality for landmark identification, and follow-up time points at 2 and 4 years with no treatment. Three lateral cephalograms at three different time points were used for each subject. The first time point (T1) for males was approximately between 9 and 11 years of age, and that for females was between 8 and 10 years of age. The second (T2) and third (T3) time points were 2 and 4 years after T1 respectively. The study was approved by the University of Illinois at Chicago Institutional Review Board (No. 2007-0831).

Each cephalogram was traced by the same investigator. Nineteen skeletal cephalometric landmarks were traced (Table 1).

Table 1
Cephalometric landmarks studied

Variables
1. A point
2. ANS (anterior nasal spine)
3. Anatomic gnathion
4. B point
5. Basion
6. Condylion
7. Gonion
8. L1 tip (lower central incisor tip)
9. L6 occlusal (lower 1st molar occlusal)
10. Menton
11. Nasion
12. Orbitale
13. PNS (posterior nasal spine)
14. PT point
15. Pogonion
16. Porion
17. Sella
18. U1 tip
19. U6 occlusal

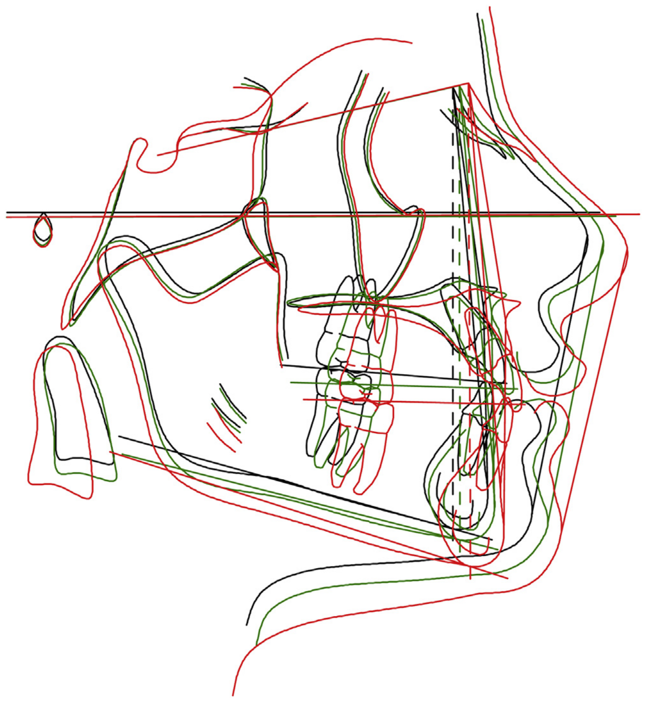

Fig. 1. Superimposition of T1, T2, and T3 of one subject.