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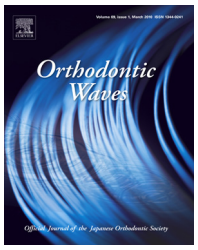

Original article

# Mathematical modeling for explanation and prediction of treatment outcome in growing patients with anterior open bite malocclusion treated with rapid molar intruder and posterior bite blocks

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ABSTRACT

*Purpose:* Rapid molar intruder (RMI) is a non-compliant treatment modality for correction of anterior open bite (AOB) in growing patients. The aim of this study is to explain the main treatment outcome (increase in overbite) by the other morphological changes after treatment with RMI and posterior bite blocks (PBBs). We also investigated the baseline characteristics that may help predict the treatment outcome.

*Subjects and methods:* Fourteen patients (mean age ± SD = 10.7 ± 1.7 year) with AOB malocclusion were treated with RMI springs and PBBs fixed on posterior teeth for 4 months. Patients were assessed before and after treatment using cephalometric radiographs. Multivariable regression model was developed to explain overbite change by the other morphological components. Single regressions of overbite change on baseline variables were conducted to determine best predictor of treatment outcome.

*Results:* Treatment produced significant increase in overbite. The change in overbite was best explained by the changes in facial axis angle, upper anterior dental heights and upper posterior dental heights. The best predictor for treatment outcome was the facial axis angle before treatment.

*Conclusion:* The correction of AOB by the RMI may be explained by orthopedic and dental changes resulting from growth and treatment. The orthopedic changes consisting of counterclockwise mandibular true rotation is the strongest contributor to overbite increase. Patients with severe vertical growth pattern tend to have greater closure rate of open bite.



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## 1. Introduction

Early treatment of skeletal anterior open bite (AOB) is advocated for its several advantages. May be the most important advantage is that it could avoid the patient more aggressive treatment options in the future [1,2]. The keystone in the treatment of this kind of malocclusion is the modification of prominent vertical growth so that true forward mandibular rotation is achieved. The forward mandibular rotation would not only contribute to the correction of the AOB, but also improve vertical facial proportions and advance chin [3–5].

Several techniques for correction of AOB have been proposed to achieve these above mentioned treatment objectives with varying efficacy [6]. The available techniques also vary in terms of patient compliance and treatment time, which both consist a main concern when treating growing patients. Rapid molar intruder (RMI), a noncompliant treatment modality, has been reported to effectively correct AOB within 4–5 months [7,8]. It consists of flexible springs that are applied to the bands on first permanent molars. When this technique is used in mixed dentition, primary molars would be left without intrusion and would interfere with correction of open bite. Previous reports solved this problem by extraction of the primary molars after intrusion of first permanent molars [7] or applying the elastic springs to posterior bite blocks (PBBs) [9].

Closure of open bite after treatment with RMI has been attributed to several morphological changes that simultaneously presented, but a description of the relationships between these changes and overbite increase has not been introduced yet. Dental and skeletal changes previously proposed to contribute to the closure of open bite after treatment with RMI were counterclockwise rotation of the mandible as a result of redirecting growth, and intrusion of posterior teeth [8].

Understanding the relationships between the morphological changes and closure of open bite after treatment with different modalities is crucial for choosing the appropriate treatment modality that fits best the needs of each patient according to his morphological characteristics. In the current study, we used multivariable linear regression modeling to describe the relationship between the morphological changes and the increase of overbite in growing patients treated with RMI and PBBs. We also investigated the baseline morphological predictors that may help expect the treatment outcome.

## 2. Material and methods

### 2.1. Subjects

A sample size of 14 was necessary to have a 80% of power to detect a 0.8 standardized difference in overbite (OB) assuming that standard deviation of OB is 1.5 mm [10]. Fourteen consecutive patients with AOB malocclusion (mean age ±SD=10.7±1.7 year) were selected according to inclusion and exclusion criteria. The inclusion criteria were that the patient should have no anterior contact (OB<0), class I or II molar relationship, and the mandibular plane angle (MPA) should be more than 36°. Patients who had systemic diseases, syndromes or oral habits were excluded. The sample consisted of 4 males and 10 females. ANB angle ranged between 0.4 and 8.2° (mean±SD=5.3±2). For each patient the treatment plan was explained to his/her parents and an informed consent was obtained. The study was approved by the academic ethics committee in the Faculty of Dental Medicine Damascus University.

### 2.2. Treatment procedures

Posterior bite blocks were constructed and lingual and transpalatal 1 mm-diameter arches were attached to the bite blocks to restrict the buccal rotations of the posterior teeth (Fig. 1A). Tubes were added on the buccal sides of bite blocks to attach the RMI modules (American Orthodontics, Sheboygan, WI, USA) as illustrated in Fig. 1B. The RMI modules apply a force of 800 g on each side but the force gradually decrease to reach 250 g by the end of second week [7]. The bite blocks were cemented to the posterior teeth, and kept in place for 4 months with RMI springs attached to the buccal tubes (Fig. 1C). Patients were instructed to wear a vertical band around the head during sleeping to prevent the mandible from opening. Patients were examined each 4 weeks, and the lingual arch was adjusted when needed so that it keeps distant from gingiva. Cephalometric measurements were obtained before and after 4 months of treatment as defined in Fig. 2. Patients who still present anterior open bite after 4 months continued the treatment with the same appliance. Patients who achieved positive overbite received removable bite blocks for retention period of 4 months.

### 2.3. Method error

Twenty cephalograms were traced again by the same author to evaluate the reliability of tracing process. The method error was calculated using Dahlberg formula [11]; ($\delta = \sqrt{\Sigma d^2/2n}$): d=the difference between the two measurements, n=the number of retraced cephalograms. The method error was less than 0.4 for linear measurements, and less than 0.6 for angular measurements.

### 2.4. Statistical analysis

All cephalometric parameters fitted to normal distribution according to Shapiro–Wilk tests, therefore parametric tests were used. Significance of overbite change was assessed using t-test. A multivariable linear regression model that explains the change in overbite over treatment using changes in cephalometric parameters as predictors was developed. The model was adjusted for age and gender. To investigate the trends among the patients in terms of AOB closure rate, single regressions of overbite changes on baseline measurements were assessed. Recursive partitioning analysis was conducted on the cephalometric parameter that showed the strongest relationship to overbite change. Partitioning analysis helped determine the border value between patients with high or low

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