

## How to predict the timing of eruption of mandibular second premolars

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### ABSTRACT

**Objective:** To evaluate the relationship between the stages of dental formation and the timing of eruption of mandibular second premolars.

**Materials and Methods:** The sample comprised panoramic radiographs of 25 children, 7 to 12 years old, observed by space supervision during development of dentition. The initial radiograph (T1) was taken in the mixed dentition period and the progress radiograph (T2) close to the eruption of mandibular second premolars. The stages of dental formation were determined by the proportion between crown length and total length (CL/TL) as well by the Simpson and Kunos index. Average values between right and left sides (35, 45) were correlated to the time elapsed until dental eruption (T2-T1). Statistical analysis was performed by Pearson correlation analysis.

**Results:** The proportion CL/TL presented higher correlation index with time to eruption than the Simpson and Kunos index. The linear regression equation for prediction of timing of eruption showed high coefficient of determination, low deviation, and good accuracy. According to survival analysis, mean deviation at 95% confidence level was between 3.6 and 6.4 months. There was no difference in contralateral measurements, with high intraclass correlation coefficient for both CL/TL proportion and Simpson and Kunos index.

**Conclusions:** More advanced stages of dental formation indicate less time until dental eruption. The strong correlation with crown length/total length proportion (CL/TL) provides a linear regression equation for prediction of the timing of eruption of mandibular second premolars. (*Angle Orthod.* 0000;00:1–4.)

**KEY WORDS:** Premolars; Tooth eruption; Mixed dentition

### INTRODUCTION

Dental eruption is defined as a continuous process driving teeth from the dental crypts to the line of occlusion, keeping them in occlusion afterwards.<sup>1,2</sup> Osseous resorption and apposition, periodontal vascular characteristics, and root development are highlighted as direct causes related to the phenomenon of dental eruption.<sup>3–6</sup> Dale highlighted that teeth tend to erupt only after half of the root formation.<sup>1</sup>

Dental development can be divided into morphologic stages.<sup>7</sup> Simpson and Kunos<sup>8</sup> suggested a method based on a centesimal scale to represent the morphologic increments and anatomic changes observed during dental development. Teeth are scored from 0 to 2, where 0 represents no radiographic evidence of dental crown, 1 represents total crown development, and 2 represents complete root development.

The permanent teeth tend to erupt in groups, varying sequence and chronologic order.<sup>9,10</sup> The wide individual variation in the chronologic age of dental eruption makes population averages unreliable to individual prediction.<sup>11</sup> Growth index also varies in different

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Accepted: February 2012. Submitted: September 2011.

Published Online: April 3, 2012

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populations, since genetics and environment can influence the timing of dental calcification. However, chronologic tables of dental mineralization cannot be indiscriminately applied for different populations.<sup>12,13</sup>

The prediction of timing of dental eruption is useful in interceptive guidance of occlusion, especially to determine eventual extractions of deciduous teeth and timing of orthodontic treatment.<sup>6</sup> The eruption of mandibular second premolars is of special interest. At first, the exfoliation of the second deciduous molars provides the leeway space, which is of major importance in the diagnosis of arch length. Another point is that mandibular second premolars are usually the last successor teeth to erupt in the mandible and can determine the beginning of full orthodontic treatment.<sup>14</sup>

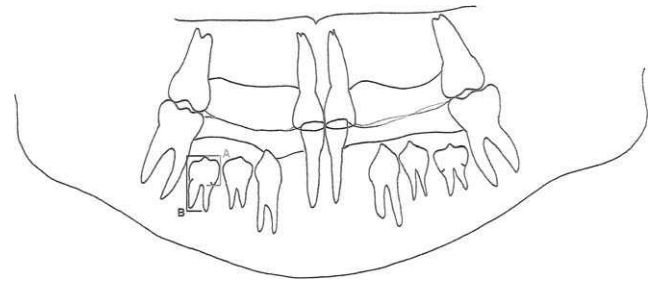
From the standpoint of the clinician orthodontist, the prediction of the timing of eruption of mandibular second premolars can determine when to install a lingual arch and can decrease the number of appointments before full orthodontic treatment. In this way, the aim of this study was to investigate the relationship between the stages of dental development and the time elapsed until eruption of mandibular second premolars. Indeed, it intends to formulate a method to predict the eruption of mandibular second premolars.

## MATERIALS AND METHODS

The sample was obtained from private office files of an orthodontist certified by the Brazilian Board of Orthodontics and Dentofacial Orthopedics in Porto Alegre, Brazil. From 1200 records, 25 healthy individuals (12 girls and 13 boys) were selected, 7 to 12 years old, without syndromes or lip/palate clefts. All of them were in mixed dentition period and had undergone only space maintaining or space supervision during dentition development. Selection criteria required the presence of all teeth mesial to the second molars, no abscesses, cysts, or premature loss of deciduous teeth and less than 3 mm of crowding in the mandible.<sup>15</sup> The research was approved by the Committee of Ethics and Research.

All individuals had two panoramic radiographs, one at the early mixed dentition period (T1) and another close to the eruption of the mandibular second premolars (T2), with a maximum of two thirds of dental crown eruption. The mean time between T1 and T2 was 17 months (minimum interval was 7 months).

Panoramic radiographs were traced by the same investigator on acetate paper over a light box with a standard light. The diagram copied the palate process, the mandible, central and lateral permanent incisors, permanent first molars, mandibular second premolars, alveolar processes, and occlusal plane (Figure 1).



**Figure 1.** Diagram illustrating panoramic radiograph tracing. (A) Crown length. (B) Total length.

Measurements of the crown length and the total length (crown + root) of the mandibular second premolars (35, 45) were obtained in the initial panoramic radiographs (T1) with a digital caliper (Mitutoyo, São Paulo, Brazil). Crown length was considered the distance from the most coronal point to the cementum/enamel junction. Total length was the distance between the most coronal and the most apical points (Figure 1).

The proportions between coronal length and total length (CL/TL) of the right and left mandibular second premolars (35, 45) were averaged. Dental development was also classified according to the Simpson and Kunos index.<sup>8</sup> Both the Simpson and Kunos index and dental length proportion were correlated to the time elapsed until the eruption of the second premolars (T2-T1). A linear regression equation based on CL/TL proportion was applied to predict the timing of eruption of the mandibular second premolars.

## Statistical Analysis

The Simpson and Kunos index and CL/TL proportion were correlated to the time elapsed until eruption with Pearson correlation analysis ( $r$ ). Gender comparison was performed by Student's  $t$ -test for independent samples. Contralateral measurements were compared with paired  $t$ -test and with intraclass correlation coefficient (ICC).<sup>16,17</sup>

A linear regression equation derived from analysis of correlation between CL/TL proportion and time to eruption was applied in the same data source to determine mean deviation, accuracy coefficient,<sup>18</sup> and error band with 95% confidence level (Kaplan/Mayer survival analysis). The agreement-survival graphic related agreement levels to clinical tolerance limits.

## RESULTS

The proportion CL/TL presented a higher correlation index with time to eruption than the Simpson and Kunos index. Correlation of CL/TL proportion and time to eruption was stronger for girls than for boys (Table 1). The linear regression equation for prediction

**Table 1.** Gender Dimorphism in Months of Eruption, Crown Length and Total Length (CL/TL) Proportion, and Simpson and Kunos Index

	Months for Eruption		CL/TL Proportion		Simpson and Kunos Index	
	Mean ± SD	Mean ± SD	Correlation to Months	Mean ± SD	Correlation to Months	
Male	14 ± 5.8	0.43 ± 0.05	-0.049	1.40 ± 0.13	-0.061	
Female	21.1 ± 12.1	0.50 ± 0.11	0.882	1.33 ± 0.12	-0.638	
<i>P</i> Value*	.036	.778		1		
Total	17.4 ± 9.8	0.47 ± 0.09	0.74	1.37 ± 0.13	-0.468	

\* *t*-test for independent samples.

of timing of eruption showed a high coefficient of determination, low deviation, and good accuracy (Table 2). According to survival analysis, the minimum and maximum values at mean deviation at 95% confidence level were between 3.6 and 6.4 months (Figure 2). There was no difference in contralateral measurements, with high intraclass correlation coefficient for both CL/TL proportion and Simpson and Kunos index (Table 3).

## DISCUSSION

In the present study, a correlation of 0.74 between CL/TL proportion and time to eruption (Table 1) provided a linear regression equation to predict eruption of the mandibular second premolars (Table 2). Tooth size predictions, widely used in diagnosis at the mixed dentition period, are based on lower correlation coefficients. The size predictions of unerupted premolars and permanent canines proposed by Moyers<sup>19</sup> and by Tanaka-Johnston<sup>20</sup> considered correlation coefficients between 0.58 and 0.66.<sup>18</sup> The Knot and Meredith study<sup>21</sup> found correlation from 0.49 to 0.70 in eruption prediction.

There was a direct correlation between CL/TL proportion and time to eruption. Small rates (higher root growth) were related to less time until eruption. On the other hand, there was an inverse correlation between the Simpson and Kunos index and time to eruption: high indexes indicated less time until eruption (Table 1). This pattern was followed especially by girls. Boys presented low correlations for both CL/TL and the Simpson and Kunos index. One can consider that in further studies an increase in the sample size would provide better correlation coefficients for boys.

Despite slower dental eruption for girls, there was no gender dimorphism in the correlation of CL/TL proportion and Simpson and Kunos index (Table 1). Demir-

jian and Levesque<sup>3</sup> found sex differences in the timing of eruption of mandibular second premolars. However, Nolla<sup>22</sup> showed no gender differences in dental development indexes.

The prediction equation (Table 2) seems reliable to estimate the timing of eruption of mandibular second premolars in girls. It presented low mean deviation error (3.6 to 6.4 months) at 95% confidence level. The cumulative deviation error in 75% of cases was 6.5 months (Figure 2). For example, if an 8-year-old girl has second premolars with half of the root formation (CL/TL = 0.4), premolar eruption is expected to occur in approximately 12 months (6 to 18 months, considering the deviation error) (months to eruption = 78.7 [0.4]–19.2). If patient is under space supervision, a new appointment should be rescheduled in 6 months.

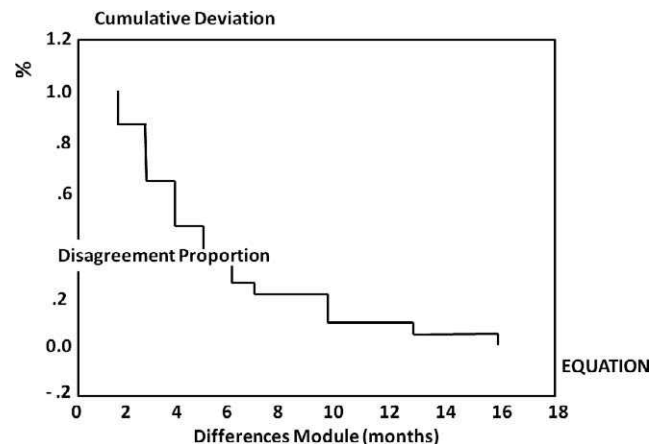
The high value of ICC and the *P* value in the contralateral measurements suggest similarity between the right and left sides.<sup>17</sup> Nolla<sup>22</sup> also found small differences between the right and left counterpart teeth. However, the graphics of dental emergency proposed by Hurme<sup>11</sup> showed high variability in the timing of eruption of mandibular second premolars.

Moyers<sup>19</sup> said in 1971 that predictions are not statements, but hypotheses. Lima and Monnerat<sup>23</sup> highlighted that, despite the prediction methods, it is difficult to identify which dentition will develop favorably. Nevertheless, predictions of timing of eruption can provide useful information for diagnosis and plan

**Table 2.** Correlation Derived Equation, Explanation Coefficient, Mean Deviation, and Accuracy Coefficient

Equation <sup>a</sup>	<i>R</i> <sup>2</sup>	Mean Deviation, mo	Accuracy Coefficient
$y = 78.7x - 19.2$	0.547	-0.0003 ± 6.6	0.38

<sup>a</sup> *y* indicates months for eruption; *x*, crown length and total length proportion.

**Figure 2.** Survival – accordance graph: proportion of disagreement between prediction and months to eruption.

**Table 3.** Contralateral Measurement<sup>a</sup>

	Mean Difference (R and L) <sup>b</sup>	P Value <sup>c</sup>	ICC
CL/TL proportion	0 ± 0.07	.778	0.835
Simpson and Kunos index	0	1	1

<sup>a</sup> CL/TL indicates crown length and total length; ICC, intraclass correlation coefficient.

<sup>b</sup> Mean difference between measurements of teeth on both right and left sides.

<sup>c</sup> Paired t-test.

of treatment, especially in cases of interceptive guidance of occlusion.

Early orthodontic treatment during the mixed dentition period is often necessary. Gianelly<sup>23</sup> concluded that 68% of mild to moderate lower incisor crowding could be treated by arch length preservation with Nance's lingual arch installed in late mixed dentition, before exfoliation of second deciduous molars.

The transition from mixed dentition to permanent dentition usually is completed after the eruption of mandibular second premolars. Thus, prediction of second premolar eruption is useful in determining the timing for lingual arch cementation and the expected time until its removal. Despite the recognized effectiveness of this treatment strategy, it would be appropriate to install the lingual arch close to mandibular second premolar eruption, respecting a safety margin of 3 to 6 months, according to the present study.

Clinically, the present study showed that mandibular second premolars with half of their roots formed (Simpson and Kunos index 1.5) erupted after a mean period of 12.7 months. Premolars with one fourth root formation (Simpson and Kunos index 1.25) erupted after 21.7 months (Table 4). Hypothetically and based on our results, individuals under space supervision should be reviewed in 6 months if mandibular second premolars have already half of the root formed and after 1 year if they have one fourth of the root formed. Rowlands et al.<sup>14</sup> showed that a strategy to predict the timing of eruption can reduce the number of appointments before full orthodontic treatment.

## CONCLUSIONS

- More advanced stages of development of mandibular second premolars are related to shorter periods of time until eruption.
- It is possible to predict the timing of eruption of mandibular second premolars, respecting a safety margin.

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