Relationship between inter-molar, inter-canine, and inter-gonion widths in children aged 6–9 years

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Abstract. The mixed dentition stage of tooth development is critical as it often involves changes in the inter-molar and inter-canine widths of the dental arch, which may affect the inter-gonion width. It was hypothesized that the relationship between the inter-molar, inter-canine, and inter-gonion widths could be used to estimate the width of the dental arch, thus allowing better treatment planning. This research aimed to determine the relationship between the inter-molar, inter-canine, and inter-gonion widths in children aged 6–9 years old. This cross-sectional study used 30 study models and panoramic radiographic images of pediatric patients in Teaching Dental Hospital, Faculty of Dentistry, Universitas Indonesia. The results showed that the inter-molar and inter-gonion widths and the inter-canine and inter-gonion widths exhibited weak correlations that were not statistically significant (r = 0.277, r = 0.032, respectively). However, the inter-molar and inter-canine widths demonstrated a strong, statistically significant correlation (r = 0.580).

1. Introduction
The dental arch is made up of tooth crowns and is largely influence by the position and inclination of the teeth, lips, cheeks and tongue, [1] while the line of occlusion is a smooth, unbroken, symmetrical line along which the teeth in the two dental arches meet. The dental arches themselves can be classified into alveolar and basal arches.

Progression through the various stages of tooth development, including the deciduous, mixed dentition, and permanent stages, can bring about considerable changes in the width and length of the dental arches, although the changes in length are usually less noticeable [2]. The mixed dentition period is critical for the growth and development of the child's teeth given that malocclusions may occur at this stage [3]. The width of the dental arch is defined as the space between the two canines and the permanent first and second molars, [4] and is seen to increase between the ages of 4 and 17 [5]. In the mixed dentition period shows a considerable change and mean on the size of the dental arch [5,6]. The inter-canine and inter-molar widths determine the growth pattern of the dental arch, although no definite factors have been found to affect either of the sizes as yet [7]. Typically, the width of the dental arch is determined by measuring the horizontal distance between the left and right canine peaks and the distance between the central fossae of the first permanent molars on each side [3,6].
The high prevalence of malocclusion necessitates precautionary measures in the growth and development stage, when there is a discrepancy between the inter-canine and inter-molar widths of the dental arch, making it essential for dentists to develop a clear understanding of the changes that occur in the dental arch during this stage [8].

Researchers have previously traced radiographic images of the patient’s skull, mandible, and tooth models, and these are known as skeletal or dental tracings [9]. Over time, development of a variety of equipment and techniques have reduced or eliminated distortions in photographs of panoramic radiographs. The size of the gonial or mandibular angle can be determined depending on the method used, i.e., whether the horizontal line from the angle of the mandible is formed by the tangent line of the mandibular border line or with a straight line through gnation. Both of these methods can be performed using a lateral cephalogram, although the gnation cannot be accurately determined from photographs of panoramic radiographs [10].

2. Methods
This cross-sectional study used secondary data from panoramic radiographs and dental study models of thirty male and female patients aged 6–9 years. The data were collected between 2010 and 2013 from medical records held at Teaching Dental Hospital, Faculty of Dentistry, Universitas Indonesia. The inter-molar and inter-canine widths were measured using Moyers method and a Nankai digital caliper at a precision of two decimal points. The inter-gonion measurements were made by tracing photographs of panoramic radiographs on tracing paper, and then measuring the angle formed between the two lines tangent to the inferior outer edge of the mandible and the outer border of the posterior side of the ramus and condyle on either side and dividing them by two. The gonion point was determined from the line and measured using an iron rule.

Only 5 pairs of data (5 photos of panoramic radiographs and 5 study models) were collected each day to avoid straining the examiners responsible for reading the scales contained in the digital calipers and iron rulers. To ensure validity, the examiner was first asked to measure 5 study model 3 times, and the consistency between the measurements was checked. If the results of the first measurement did not differ from that of the second, the examiner was considered to be eligible to collect the data. While to measure inter-gonion was done 1 time.

The relationship between the inter-molar, inter-canine, and inter-gonion widths were statistically analyzed. In case of normal distribution, the parametric Pearson’s correlation coefficient would be used for analysis, while the non-parametric Spearman’s test would be used if the data were not normally distributed. Here the data were found to be normally distributed using the Kolmogorov–Smirnov test (p > 0.05) and the parametric Pearson’s correlation test was used to examine the relationship between the three variables. This was followed by regression analysis to allow prediction of the inter-molar and inter-canine widths (with 95% confidence intervals) and based on the inter-gonion width (a = 0.05).

3. Results
The results showed that there was a weak correlation between the inter-molar and inter-gonion widths (r = 0.277), as well as between the inter-canine and inter-gonion widths (r = 0.32). The results of the t-test showed that the relationship between the inter-molar and inter-gonion widths were not statistically significant (p = 0.138), and this was also true for the association between the inter-canine and inter-gonion widths (p-value = 0.868). However, the inter-canine and inter-molar widths exhibited a strong correlation (r = 0.580), and the t-test showed a statistically significant relationship between the two variables (p = 0.001).

The linear regression analysis yielded an $R^2$ value of 0.077 (7.7%), suggesting that the inter-gonion width could explain only 7.7% of the variability in the inter-molar width. The remaining 92.3% was influenced by other variables not included in the current model. The standard error estimate of the number of errors in the inter-molar prediction was 2.32219 mm. The simple linear regression analysis resulted in a constant (a) of 30.976 and regression coefficient of 0.061, and the following formula could be used to predict the inter-molar width ($Y^*$) $Y^* = 30.976 + 0.061X$. 


Therefore, upon using this formula and assuming inter-gonion width values from 150 mm to 248 mm (2 mm range), approximately 100 different prediction values of the inter-molar width were obtained (Figure 1).

![Intermolar Width Predictions](image1)

**Figure 1.** Graph showing inter-molar widths predicted using the inter-gonion width

The second linear regression analysis yielded an $R^2$ value of 0.001 (0.1%), suggesting that the inter-gonion width only explained 0.1% of the variability in the inter-canine width. The remaining 99.9% was influenced or explained by other variables not included in the current model. The standard error estimate of the number of errors in the prediction of inter-canine width was 2.33940 mm. In addition, the constant (a) value was 24.220 and the regression coefficient was 0.007, and these values were used to construct a regression estimation model to predict the inter-canine width ($Y''$) $Y'' = 24.220 + 0.007X$.

Therefore, upon using this formula and assuming inter-gonion width values from 150 mm to 248 mm (2 mm range), approximately 100 different prediction values of inter-canine width were obtained (Figure 2).

![Intercanine Width Predictions](image2)

**Figure 2.** Graph showing inter-canine width predicted using the inter-gonion width

4. Discussion
The mixed dentition period usually begins at the age of 6 and is characterized by the eruption of the permanent first molars. The Moyers method was used to measure the inter-molar and inter-canine widths due to the following advantages: a) minimal systematic error, b) can be performed quickly, c) does not require any special tools or radiography, and d) can be performed by beginners. Although the measurements and calculations are typically performed on a model, this method also yields a high
degree of accuracy when carried out inside the mouth. This method can also be performed to analyze the state on both jaw arches.

Panoramic radiographs were used to determine the inter-gonial width as it was easier to perform and yielded more precise results compared to lateral or postero-anterior cephalometric radiographs [10]. In addition other advantages of the panoramic radiograph are the received radiation dose is not too large and equivalent to four times the periapical radiograph of the photograph. Panoramic radiographs can also be performed in patients with oral disorders [11]. In this study the researcher also required the impression of the dental arch, but the impression could not be performed in the patient with such limitations. Therefore, the researcher expected that the photo utilizing Panoramic radiographs are not only for initial treatment or preliminary treatment but also for diagnosing abnormalities in patients.

Several studies that examined growth changes in curved widths in the transverse direction reported that the inter-canine and inter-molar widths did not change after the age of 13 in females and 16 in males [12]. However, this study included boys and girls aged 6–9 years when the dental arches were still growing, suggesting that the inter-molar and inter-canine values obtained were accurate.

Although the inter-canine width has been extensively examined in previous studies, the results obtained have been inconsistent. This may be attributed to differences in the ages of the patients included and the severity of malocclusion observed. This study also found a lack of consistency in the inter-canine measurements, and this could be a result of the small sample size included. Further studies utilizing a larger number of patients are recommended.

The Kolmogorov–Smirnov (Z) test for normality yielded coefficient values of 0.088, 0.098, and 0.117 for the inter-molar, inter-canine, and inter-gonion widths, respectively. As these values were >0.05, it was assumed that the data were normally distributed and the parametric Pearson’s correlation test was used for analysis.

The correlation between the inter-molar and inter-gonion widths was found to be weak and not statistically significant \(r = 0.277, p\text{-value} = 0.138\), and this was in accordance with previous studies. Although this previous study also compared the inter-molar and inter-gonial widths in children, their methodology differed from ours in that they used postero-anterior cephalogram tracings for measurement of the inter-gonial width. However, they did use Moyers method to measure the intermolar width and defined it as the distance between the central fossae of the first left and right permanent molars of the lower jaw [13].

Previous literature suggested that the inter-canine width was an indicator of the width of the lower dental arch [6]. In this study, the width of the lower jaw was defined as the inter-gonion width. A weak correlation was observed between the inter-canine and inter-gonion widths, and this could be explained by the fact that the former directly affected the width of the dental arch itself and had little effect on the inter-gonion width [2,4].

A previous study including a sample of 100 patients (72 females and 28 males) with a mean age of 18.7 years reported that the inter-molar and inter-canine widths were strongly correlated in the upper and lower jaws [14]. In accordance with this, the results of the current study also showed a strong relationship between the inter-molar and inter-canine widths \(r = 0.580\).

The inter-gonion width was seen to affect 7.7% of the variability in the inter-molar width and only 0.1% of the inter-canine width. Several factors may affect the width of the dental arch, including environmental factors, nutrition, genetics, race, and gender [2]. Other factors influencing the characteristics of the dental arches include the function of the oral cavity, oral habits, and the muscles of the oral cavity, while premature loss of deciduous teeth, race, and gender may affect the growth and development of the arches [15].

This study also carried out regression analysis to predict the inter-molar and inter-canine widths using the inter-gonion width. The regression estimation model \(Y’ = 30.976 + 0.061 X\) (where \(Y’\): predicted inter-molar width, X: inter-gonion value) was used to predict the inter-molar width, while \(Y'' = 24.220 + 0.007 X\) (where \(Y''\): predicted inter-canine width, X: inter-gonion value) was used to predict the inter-canine width. These regression estimation models could therefore be used to predict
the inter-molar and inter-canine widths in some pediatric patients as they did not require study models and could be calculated from a panoramic radiograph.

5. Conclusions
In conclusion, the inter-canine and inter-molar widths exhibited a strong, statistically significant relationship, while the inter-canine and inter-gonion widths were weakly correlated. The inter-molar and inter-gonion widths also exhibited a weak association that was not statistically significant.

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