Correlation of Maxillary and Mandibular Arch form and Tooth Size Ratio in Ethnic Javanese Malocclusion Patient

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Original Research

Correlation of Maxillary and Mandibular Arch form and Tooth Size Ratio in Ethnic Javanese Malocclusion Patient

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Abstract

Aims: Arch form is one of the important components that can relapse after orthodontic treatment. The relationship is between arch form and tooth size ratio (TSR) need to be evaluated that could help to determine extraction or nonextraction treatment in malocclusion. The aim of this study was to analyze the correlation of maxillary and mandibular arch forms with TSR in ethnic Javanese Malocclusion Patient at Airlangga University Dental Hospital. **Materials and Methods:** This study was an observational, analytical study with cross-sectional and total sampling method. The samples consisted of 135 model study were chosen according to the inclusion criteria and distributed into malocclusion Class I, Class II, and Class III Angle's classification. All the samples were analyzed using Bolton's anterior and overall ratio, and the maxillary and mandibular arch forms were detected using mathematical ratio using (canine depth/molar depth (MD))/(canine width [CW]/molar width [MW]). **Statistical Analysis:** The correlation of maxillary and mandibular arch form with clinically significant TSR using Bolton's analysis is interpreted using Pearson correlation test ($P < 0.05$). **Results:** No significant correlation of maxillary and mandibular arch forms with TSR using Bolton's analysis among malocclusion of Angle Class I, Class II, and Class III in ethnic Javanese ($P > 0.05$) was found. While the anterior TSR in Class I Angle's malocclusion has a significant correlation with inter-CW in mandibular arch ($P < 0.05$). **Conclusions:** TSR was not affected by types of arch form either in maxillary or mandibular while the anterior TSR in Class I Angle's malocclusion did.

Keywords: Arch form shape, Bolton's analysis, ethnic Javanese, malocclusion, tooth size ratio

Introduction

Analysis of the study model is one of the undeniable procedures in orthodontic to interpret diagnosis and treatment planning for patients with different malocclusion. The analysis of study model has been used for three-dimensional evaluation in the upper and lower arch forms with the relationship of occlusal which can be calculated by mean of analysis using arch length, arch form dimension, and mesiodistal tooth size.[1,2] Malocclusion can be diagnosed if there is a discrepancy or surplus of tooth material either in maxillary arch form or mandibular arch form.[3,4]

According to Bolton, tooth size ratio (TSR) estimation is crucial for treatment planning in orthodontics.[5] Many investigators found that Bolton's ideal TSR is varied and affected by different population, genetic, malocclusion, and gender.[6-9] Shahab *et al.* found that Bolton's TSR varied among the Turkish population and the most difference was found on the first molar size.[10]

Smith *et al.* found that there was significantly different overall TSR among three different populations which are Hispanics (93.1%), Asian (92.3%), and African (93.4%) that showed interarch tooth size relationships are population specific.[11,12] Kusnoto found that there was difference in the overall and anterior TSR among the Indonesian population and Caucasian population. He found that among the Indonesian population, the Bolton TSR value of 89.7 ± 2.05 for overall ratio and 76.4 ± 2.76 for the anterior ratio is more suitable.[13]

The arch form before the treatment is fundamental in orthodontic treatment planning. The pretreatment adjusted through the skeletal base and soft tissues which might be determined by genetic and environmental factors.[14] All the changes during pretreatment should be assessed as amending in

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arch form during treatment as a whole estimated as potentially unstable and quantized.[15] Tooth size shows a substantial relation with inheritance, and in the study of Harris found that the contribution of genetic component to mesiodistal and buccolingual crown circumference is >80%.[11] The study of Cassidy found that the influence of genetic on the dental arch form from 320 orthodontic patients and found that the size of arch and arch shape (length-width ratio) possess an average genetic component.[16]

So far, the correlation between the dimensions of the anterior teeth and their corresponding arch forms has only been evaluated in one study. A statistically significant relation between broad and sharp or tapered maxillary arch forms with smaller tooth sizes was detected among 200 Greek individuals seeking orthodontic treatment, but this was more commanding among male samples. In Addition, a statistically significant relationship was found between tappered maxilla arch forms and smaller teeth in female patient. Nevertheless, tooth size discrepancy was found in previous study.[9] Therefore, the relationship between tooth size discrepancy (TSD) and arch form has not been studied as yet. This study hypothesis was no correlation exists between maxillary and mandibular arch form and TSR using Bolton's analysis in patients with malocclusion Class I, Class II, and Class III. Furthermore, the objective of this study was to evaluate the correlation of upper and lower arch forms with TSR in ethnic Javanese Patient Malocclusion Patient at Airlangga University Dental Hospital.

Materials and Methods

This study was an observational analytical retrospective study with cross-sectional and total sampling method. A total of 135 study models from ethnic Javanese with the age range of 12–26 were selected from Orthodontic Clinic Department, Faculty of Dental Medicine, Airlangga University, according to the inclusion and exclusion criteria of the study. The study models divided into three major Angle's classifications of malocclusion as follows: Group 1 (Class I malocclusion), Group II (Class II malocclusion), and Group III (Class III malocclusion). Each class of malocclusion was analyzed equally using Bolton's overall and anterior ratio, and maxillary and mandibular arch forms were interpreted using mathematical method.

The width of mesiodistal of each tooth is measured using digital Vernier caliper with 0.01 least count (Gauge Block No. 020048) [Figure 1]. Anterior TSR was calculated using total of mesiodistal (MD) width of six anterior teeth using the formula:

$$\text{Anterior ratio} = \frac{\text{Total MD width of mandibular 6 teeth}}{\text{Total MD width of maxillary 6 teeth}} \times 100$$

$$\text{Overall ratio} = \frac{\text{Total MD width of mandibular 12 teeth}}{\text{Total MD width of maxillary 12 teeth}} \times 100$$

Dimension of arch form, which is intercanine width (ICW), interpremolar width (IPW), intermolar width (IMW), intercanine depth (CD), interpremolar depth (PD), and intermolar depth, was calculated using the Vernier caliper according to the anatomy landmark marked at the study model [Figure 2].[17]

The calculated arch form dimension was used to interpret the shape of the arch form using a mathematical formula (canine depth/Molar Depth (MD))/(CW/MW) [Figure 3].[17]

1. ICW – The interspace between the cusp tips of right and left canines
2. IPW – The interspace between the right and left first premolars, measured from the tip of the first premolar tooth
3. IMW – The interspace between the highest point on the mesiobuccal cusp tips of the right and left first molars
4. CD – The interspace from a line adjoining the canines to the midpoint between the central incisors
5. PD – The interspace from a line adjoining the first premolars to the midpoint between the central incisors
6. Molar depth (MD): The interspace from a line adjoining the first molars to the midpoint between the central incisors.

All data were analyzed statistically using the Statistical Package for the Social Sciences (SPSS) software version 25 (IBM Coporation, Illinois, Chicago, USA). The distribution of data was tested using the One-Sample Kolmogorov–Smirnov test ($P > 0.05$). The correlation of arch form dimensions and Bolton's TSR was analyzed using Pearson Correlation test ($P < 0.05$). In addition, one-way analysis of variance ($P < 0.05$) was used for the comparisons between different types of arch form and the Bolton's TSR.

Results

Class 1 malocclusion was the most prevalent in our study [Table 1]. The most prevalent arch form in maxilla was tapered while in mandibular was square [Table 2]. Differences in the mean value of Bolton's TSR according to arch form in the maxilla and mandibular in all three major Angle's malocclusions are shown in Table 3. There was no statistically significant correlation between arch form and TSR (anterior and overall) in the maxilla and mandibular among Class II and Class III malocclusions. However, this study found that there were inadequate correlation between TSR and arch form in maxilla among Malocclusion Class I.

Figure 1: Digital vernier caliper with 0.01 least count (Gauge Block No. 020048)

Discussion

In the present study, there was no significant correlation between TSR and arch form in Ethnic Javanese maloclussion patient. Nevertheless, there was weak correlation between anterior TSR and arch form in maxilla among malocclusion Class I. The same result was found with the recent study of O'Mahony *et al*., about the relationship between TSD and arch form among different types of malocclusions.[18]

In this study, we classified the malocclusion according to angle, but this study did not take the consideration of Class II Division I, Division II, subdivision and Class III pseudo, true, and subdivision. This is because there is lack of samples in each subdivision to get a significant result.

Among Ethnic Javanese, we found that the most common maxillary arch form was square in malocclusion Class I, tapered in Class II and Class III, whereas in the mandibular arch form, the most common arch form found is square in all three classes of malocclusion Class I, Class II, and Class III. The most common maxillary tapered arch form among malocclusion Class II has the same result as in the study of Olmez *et al*., and the most common mandibular square arch form among Class III has the same result as Slaj study.[18,19]

In the recent study by Omar among a Saudi samples in Class I, Class II, and Class III cases, the most prevalent arch form was narrow tapered, followed by narrow ovoid and the upper arch form did not match the lower arch form, especially in Class II and Class III cases.[20]

Tubercle sharp end and incisal edges are used as landmarks in most of the conventional studies, in identifying the arch form. In our study, we used the same technique to determine the anatomy landmarks on study models.[21] In this study, we used mathematical formula to interpret the shape of the arch from which is square, ovoid, and tapered which is the form of human dental arch has been used traditionally as in the study. According to McLaughlin and Bennet, relative ratios of the canine and MW along with their relative arch depth were used to relate the arch form. When the CW/MW ratio increases and the CD/MD ratio decreases, the arch becomes squarer.[22] However, when the CW/MW ratio decreases and CD/MD ratio increases, the arch gets a more pointed form according to Budiman's study.[21] When compare the Bolton's TSR among the three classes, Class I and Class III are showing bigger mean value of Bolton's TSR. The same result was found with the study of Wedrychowska where the anterior TSR in Class I was 79.1 ± 2.2 while 80.1 ± 3.0 in Class III.[23] In the present study found that Malocclusion Class I has greater anterior TSR mean than another malocclusion types, meanwhile overall TSR mean was still in normal range. It can be explained that, in Class I, the anterior tooth material is greater in mandibular anterior or there was a discrepancy in the tooth size material in maxilla anterior teeth.[5] Whereas in the study of Abdul Jamih *et al*, among South indian population found that the total anterior tooth ratio was greater than the Bolton's tooth ratio for all angles malocclusions among and the results exhibited there is total increased mandibular tooth excess.[24]

In Class III, the anterior and overall TSR showed a bigger value than normal may assure the results from the study of

Table 1: The distribution of total samples into respective malocclusion classification

Angle's classification of malocclusion	Study samples
Class I	54
Class II	24
Class II subdivision	25
Class III	22
Class III subdivision	10
Total Sampels	135

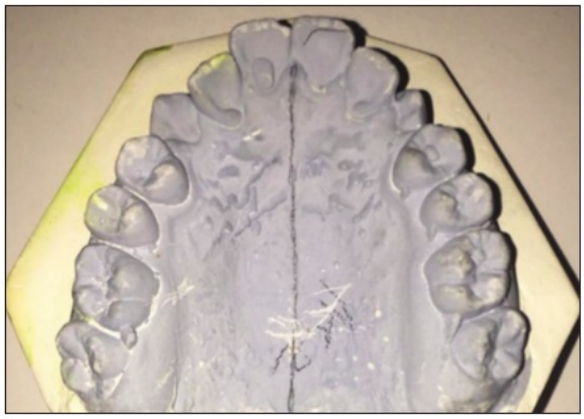

Figure 2: The linear width and depth measurements of arch dimensions

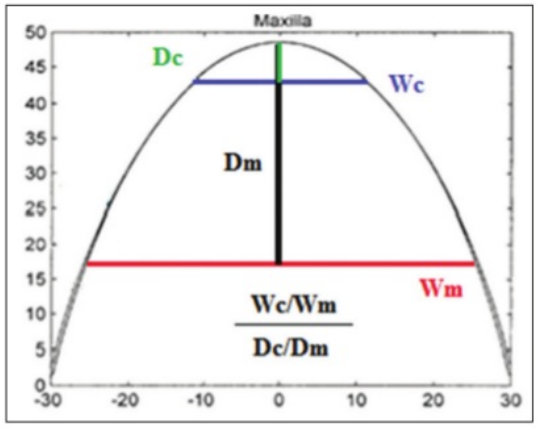

Figure 3: The calculated arch form dimension was used to interpret the shape of arch form by using a mathematical formula (CD/MD)/(CW/MW).[17] CD: Canine depth, MD: Molar depth, CW: Canine Width, and MW: Molar Width. When the Wc/Wm ratio increases of the Dc/Dm ratio decreases, the arch becomes squarer. On the contrary, when Wc/Wm ratio decreases or Dc/Dm ratio increases, the arch gets a more tapered form. Therefore, the formula is used to describe the arch form

Table 2: Differences in the mean value of Bolton's TSR according to arch form in maxilla and mandibular in all three major Angle's malocclusions (Descriptive One-way ANOVA test

Maxilla					Mandibular				
Malocclusion	**Bolton's TSR**	**Arch form**	***n***	**Mean value**	**Malocclusion**	**Bolton's TSR**	**Arch form**	***n***	**Mean value**
Class I	Anterior	square	22	80.1682			square	33	78.6970
		ovoid	17	76.6471		Anterior	ovoid	11	794364
		tapered	15	80.8933	Class I		tapered	10	80.9300
		Total	54	79.2611			Total	54	79.2611
	Overall	square	22	91.6136			square	33	91.2091
		ovoid	17	91.1665			ovoid	11	93.4300
		tapered	15	93.1480		Overall	tapered	10	92.4920
		Total	54	91.8991			Total	49	90.7592
Class II	Anterior	square	11	78.2818			square	21	77.9810
		ovoid	9	76.4889		Anterior	ovoid	8	78.2250
		tapered	29	79.3241			tapered	20	79.3250
		Total	49	78.5694	Class II		Total	49	78.5694
	Overall	square	11	91.9455			square	21	91.8190
		ovoid	9	92.1667		Overall	ovoid	8	91.1750
		tapered	29	89.8724			tapered	20	89.4800
		Total	49	90.7592			Total	49	90.7592
		square	6	77.9900			square	16	78.7400
		ovoid	10	80.6600		Anterior	ovoid	8	83.2875
	Anterior	tapered	16	81.7688			tapered	8	82.0875
Class III		Total	32	80.7138			Total	32	80.7138
		square	6	94.5167	Class III		square	16	93.4187
		ovoid	10	93.6700		Overall	ovoid	8	96.3625
	Overall	tapered	16	95.9563			tapered	8	96.6875
		Total	32	94.9719			Total	32	94.9719

Table 3: Differences in TSR between different types of arch form among 3 major malocclusions in maxilla

Malocclusion	TSR	Comparison	Sum of Squares	df	Mean Square	*F*	*P*
Class I	Anterior	Between Groups	174.229	2	87.114	3.617	0.034*
		Within Groups	1228.359	51	24.085		
		Total	1402.588	53			
	Overall	Between Groups	34.314	2	17.157	1.340	0.271
		Within Groups	652.866	51	12.801		
		Total	687.179	53			
Class II	Anterior	Between Groups	56.386	2	28.193	0.827	0.444
		Within Groups	1568.738	46	34.103		
		Total	1625.124	48			
	Overall	Between Groups	56.113	2	28.057	0.563	0.573
		Within Groups	2292.085	46	49.828		
		Total	2348.198	48			
Class III	Anterior	Between Groups	62.350	2	31.175	1.038	0.367
		Within Groups	870.749	29	30.026		
		Total	933.100	31			
	Overall	Between Groups	33.696	2	16.848	0.774	0.471
		Within Groups	631.609	29	21.780		
		Total	665.305	31			

Lavelle (1972) that Class III individuals patient have irregular smaller upper teeth than Class I and Class II patient, and from the value, it can be interpreted either there was significant bigger tooth size material in mandibular or severe discrepancy in tooth size in maxilla.[23] In our study, malocclusion Class II showed a normal range value of anterior and overall TSR. The higher value of anterior and overall TSR among Class III malocclusion can be correlated by a gradual increase in the width of the anterior upper teeth or the cumulative of minor discrepancies of individual teeth.[5,22]

There was significant negative correlation between anterior TSR from Bolton analysis and mandibular ICW in malocclusion Class I. This showed that if mandibular ICW increases, anterior Bolton's TSR decreases. This indicated that, if the mandibular intercanine expands, there will be high changes of higher tooth material in maxillary anterior teeth or discrepancy in the anterior mandibular teeth.[5,22,25]

The study of Al-Khateeb *et al.* and O'Mahony *et al*. found that there was no any significant correlation between arch form and TSD.[6,18] There was indirect relationship between arch form and TSD which was validated in the study of Gaidyte and Baubiniene where found that arch form dimension influenced by Bolton's index.[26]

The current study was carried out among orthodontic patients, hence the distribution of malocclusion are not representative of general population characteristics. Patient's ethnicity was recognized on their self-reporting during questionnaire section and not tracing the ancestry or genealogical pool. We also categorized malocclusion based only molar relationship which is according to Angle's classification of malocclusion and it could be different from the underlying skeletal relationship which we did not take heed in our study. Upcoming studies may consider these limitations in mind and handle them while designing their research methodology.

Conclusions

There was no significant correlation between maxillary and mandibular arch form and TSR using Bolton's analysis among three major malocclusions, while there was a negative correlation between anterior TSR from Bolton's analysis and mandibular ICW in malocclusion Class I that can be used to interpret the orthodontic treatment plan in ethnic Javanese malocclusion patient.

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Conflicts of interest

There are no conflicts of interest.

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