# The Difference of Mesiodistal Tooth Size Ratio Using Bolton Analysis for Palembang and Toba Batak Ethnicities

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### Abstract

**Introduction**. Bolton's analysis is often used to determine discrepancy in tooth size. Mesiodistal size of teeth in each race & ethnicity is different, resulting in a different ratio of mesiodistal teeth size. The mesiodistal tooth size ratio is very important in determining the orthodontic treatment plan so that a good occlusion can be achieved as the end result of treatment. The purpose of this study was to determine the difference in the ratio of mesiodistal teeth size between Palembang and Batak Toba ethnic according to Bolton's analysis.
**Methods.** This is a cross-sectional analytic study. The number of participants was 60 subjects divided into 2 groups, Palembang and Batak Toba ethnicity (n=30). All samples consisting of the maxilla and mandible study cast from each participant then were measured the mesiodistal size ratio of the teeth using Bolton's analysis with Sliding Caliper. The data were analyzed using an independent T-test. **Results.** The results of this study indicate that there is no significant difference between the ratio of mesiodistal tooth size according to Bolton's analysis of the ethnic Palembang and Batak Toba both in the anterior ratio and the overall ratio. Only the anterior ratio of the Toba Batak ethnic group has a significant difference with the Bolton anterior ratio.
**Conclusion**. The Bolton overall ratio (91.3) can be used for the Palembang and Toba Batak ethnic groups in Palembang, while the Bolton anterior ratio (77.2) can only be used for the Palembang ethnic group and cannot be used for the Toba Batak ethnic group in Palembang.
**Keywords:** *Mesiodistal tooth size ratio, Bolton's analysis, Palembang ethnicity, Toba Batak ethnicity*

## Introduction

The success of an orthodontic treatment begins with establishing a correct diagnosis that involves anamnesis, clinical examination and investigations tailored to the patient's needs.[1] Clinical examination consists of extraoral examination and intraoral examination. Some of the intraoral examinations such as examination of the jaw arch, and examination of arch occlusion require orthodontic calculation analysis. One analysis of orthodontic calculations that is often used is the Bolton analysis.[2]

Bolton's analysis was introduced by Dr. Wayne Bolton in 1958. He studied 55 people of Caucasoid race who had perfect occlusion and normal overjet and overbite values.[5] Bolton compared the total mesiodistal sizes of the maxillary and mandibular teeth and obtain two ratios, the overall ratio was 91.3 and the anterior ratio was 77.2.[3,4] The purpose of this analysis is to help determine the disproportion between maxillary and mandibular tooth size which is

important for determining good occlusion. This analysis is considered practical and easy, so this method is used as an orthodontic guide that is useful in determining tooth size discrepancies.[5,6]

Indonesia is divided into two main races, the Mongoloid race and the Melanesoid race. The Mongoloid race occupies almost all parts of western Indonesia. According to Fisher, the Mongoloid race in Indonesia is divided into two sub-racial groups based on physical characteristics / racial stock, namely Deutro-Malay and Proto-Malay. Deutro-Malay includes ethnic Aceh, Minangkabau, Coastal Sumatra, Rejang Lebong, Palembang, Lampung, etc. Proto-Malay includes ethnic Batak, Gayo, Sasak and Toraja.[7,8]

Some studies suggest that the ratio of tooth size for each ethnicity, race and gender is specific, whereas Bolton's analysis has a constant ideal ratio for measuring jaw relationships.[9] Aida Nur (2012) stated that of the three main ethnicities in Malaysia, Bolton's analysis can only be applied to Chinese and Indian ethnicities, while the ratio of mesiodistal tooth size of Malaysian ethnic groups is significantly different from the Bolton's ratio.[10] Research in Indonesia has also been carried out on several ethnicities. The results of research conducted by Euis Sugiarti (2013) show that the overall ratio and the anterior ratio of Bolton in Javanese ethnicity is greater than that of Chinese. Another study conducted by Lasse (2015) showed that the overall Bolton ratio to ethnic Papuans was greater than ethnic Chinese.[11,12]

The ratio of the mesiodistal tooth size is very important in determining the orthodontic treatment plan. The ratio of mesiodistal teeth size in the Mongoloid race still needs to be further investigated considering that in his study Bolton only assessed the ratio of mesiodistal teeth size in one race, namely the Caucasoid race, while the mesiodistal size of the teeth in each race varied. Mesiodistal tooth size ratios in the Mongoloid race, especially the Proto-Malay and Deutro-Malay sub race have never been studied. This study aimed to examine the differences in the mesiodistal tooth size ratios using Bolton's analysis on the Deutro-Malay sub-race represented by Palembang ethnicity and the Proto-Malay sub-race represented by the Toba Batak ethnicity.

**Methods**

This is analytic research with cross-sectional design. The subjects in this study were students of Universitas Sriwijaya class of 2011-2016 that are coming from Palembang and

Batak Toba ethnic groups. Each group consisted of 30 subjects that meet the inclusion and exclusion criteria. The sampling technique used in this study was purposive sampling.

Inclusion criteria were male and female aged 17-25 years, individuals who came from at least three pure lineages, Class I Angle Malocclusion (Normal), had complete fully erupted maxilla and mandibular teeth from the right to the left first molar with normal overjet and overbite, signed the informed consent. The exclusion criteria were individuals who had a history of orthodontics or were undergoing orthodontic treatment, teeth with moderate and severe crowding, presence of proximal caries, congenital abnormalities, systemic disease.

The independent variable is Palembang and Toba Batak ethnicity. The dependent variable is the ratio of mesiodistal tooth size using Bolton analysis, controlled variable is age, congenital abnormalities, systemic diseases, uncontrolled variables are genetic factors, bad habits.

The statistical analysis in this study was carried out with the SPSS version 24 program with bivariate analysis. Bivariate analysis was performed to test the hypothesis with the parametric Independent Sample T-test.

## Results

The data in Table 1 shows that the research sample of the Palembang ethnic group and the Toba Batak ethnic group has the same number.

Table 1. The number of samples in the Palembang ethnic group and the Toba Batak ethnic group

| Ethnic | Gender | | Total |
|---|---|---|---|
| | Male (N) | Female (N) | |
| Palembang | 15 | 15 | 30 |
| Batak Toba | 15 | 15 | 30 |
| Total | 30 | 30 | 60 |

Table 2. Results of the Kolmogorov-Smirnov normality test on the Palembang ethnic and the Toba Batak ethnicity

| | Anterior Ratio | | Overall Ratio | |
|---|---|---|---|---|
| Ethnic | Palembang | Batak Toba | Palembang | Batak Toba |
| P-value | 0.200 | | 0.200 | |

Based on Table 2, it can be seen that the research data were normally distributed (p> 0.05), thus data analysis could be continued using the independent T test.

Table 3. Differences in the Bolton ratio of the Palembang ethnic and the Toba Batak ethnicity

| Variable | Palembang Ethnic (N= 30) | Batak Toba Ethnic (N=30) | p-*value* |
|---|---|---|---|
| Anterior Ratio (SD) | 77.58 (3.76) | 78.77 (2.68) | 0.163 |
| Overall Ratio (SD) | 90.55 (2.59) | 91.25 (2.77) | 0.320 |

Table 3 showed that the mean value of the anterior ratio and the mean value of the overall ratio between the Palembang and Toba Batak ethnic group did not have a statistically significant difference, this is indicated by a p-value > 0.05.

Table 4. The difference between the Bolton ratio and the ethnic Palembang and Batak Toba ethnic ratios

| Ethnic | Anterior Ratio | | Overall Ratio | |
|---|---|---|---|---|
| | Palembang | Batak Toba | Palembang | Batak Toba |
| Average | 77.58 | 78.77 | 90.55 | 91.25 |
| Rasio Bolton | 77.20 | | 91.3 | |
| p-*value* | 0.588 | 0.003* | 0.125 | 0.918 |

Table 4 shows the comparison between Bolton's ratio and the ratio of each ethnic group. The anterior ratio of the Toba Batak ethnic group has a statistically significant difference to the Bolton anterior ratio, this is indicated by a p-value <0.05. It means that the Bolton anterior ratio cannot be used for the Toba Batak ethnicity. The anterior ratio and the overall ratio of Palembang ethnic group as well as the overall ratio of Batak Toba have insignificant differences to the anterior ratio and overall Bolton ratio (p-value> 0.05). This indicates that the overall Bolton ratio can be used for both Palembang and Batak Toba ethnic groups, while the anterior ratio can only be used for Palembang ethnic group.

**Discussions**

Ethnicity has a close relationship with genetic and hereditary factors, so there is no doubt that ethnicity can affect the mesio-distal size of teeth in different populations and ethnicities.[13]

Palembang ethnic is a sub-race of Deutro Malay, while the Batak Toba ethnic group is a sub-race of Proto Malay. Based on *the Two Layer Theory*, the two races that migrated to Indonesia, the Mongoloid race and the Melanesoid sub-race, experienced a mixture. The first mixing of the two was called the Proto Melayu (Old Malay) sub-race. Migration continued to develop, especially the migration of the Mongoloid race, so there was a mixture of the Mongoloid race and the Proto Melayu sub-race which was later called the Deutro Melayu (Young Malay) sub-race.[14,15,16] When viewed from this theory, the two Proto Malay and Deutro Malay sub-races will of course have several differences in physical characteristics because when compared to the Deutro Malay sub-race, the Proto Malay sub-race still has a closer lineage with the Melanesoid sub-race (including the Negroid). The differences in physical characteristics can be seen, especially in the shape of the jaw arch, tooth arch and the mesiodistal size of the teeth of the Proto Malay sub-race, which is bigger than the Deutro Malay sub-race.[17,18,19]

Based on the results of this study, the anterior ratio and overall ratio of the Toba Batak are greater than the Palembang ethnic group but statistically insignificant. This may occurdue to the relationship between the Palembang and the Toba Batak ethnicity is still close because they are still in one race, namely the Mongoloid race. Aida Nur in 2012 examined the comparison of Bolton's analysis ratios on three ethnic groups in Malaysia (Malay, Chinese and Indian) and found no significant differences among those groups. [20,21,22.23] This proves that the ratio of the mesiodistal tooth size of Malay and Chinese, both are Mongoloid races, have no significant difference.

The suitability of Bolton's analysis ratio for various races, ethnicities and populations is still considered interesting to be researched. In the various studies, the ratios obtained varied, even most of them had ratios that were not similar to those obtained by Bolton, although the difference was not statistically significant. This indicates that there are many factors that can affect the calculation of the mesiodistal size ratio of teeth.

Based on this study, the anterior ratio of Palembang ethnicity (77.58) is greater than Bolton's anterior ratio (77.20) but it was statistically insignificant so it can still be used for Palembang ethnic group. Palembang's overall ethnic ratio (90.55) is smaller than Bolton's anterior ratio (91.30) but these two values were statistically insignificant hence it can still be used for Palembang ethnicity.

This is the first research using Bolton's analysis on Palembang ethnic group. Previously Andrew et al. conducted research using Bolton's analysis on the Deutro-Malay sub-race in

general involving students at the University of North Sumatra. The results obtained were the anterior ratio 77.91 and the overall ratio 90.91, and the two ratios of Bolton's analysis do not have a significant difference hence it can be applied to the Deutro Melayu sub-race.24 Andrew's research is in line with the results obtained in this study because Palembang ethnicity belongs to the Deutro Melayu sub-race and both can use the anterior ratio and the overall Bolton ratio.

Mesiodistal size of teeth is influenced by several factors, including genetics, environment,[25,26] sex, race and ethnicity. Mesiodistal size of teeth for each race is specific and dissimilar. Lavelle examined the differences in the mesiodistal size of teeth in white, yellow, and black races. The results showed that the mesiodistal size of the teeth of black races was greater than yellow races, and yellow races were greater than those of white races.[27,28] This proves that the mesiodistal size of the teeth is different for each race. Bolton calculated the ratio of tooth mesiodistal size, which means that the mesiodistal value of the tooth has been converted into a ratio. Thais Maria et al. examined Bolton's analysis ratio of white, black, Afromeditary, and Japanese race. The researchers stated that the Bolton's analysis can be applied to all races except Japanese. [29,30] It can be concluded that although the mesiodistal size of the teeth is different for each race, the Bolton ratio can still be applied in various different races.

The anterior ratio of the Toba Batak ethnicity (78.77) is greater than the Bolton analysis ratio (77.20) and statistically significant, so that the Bolton analysis ratio cannot be used for the Toba Batak ethnicity. However, the overall ratio between the Toba Batak ethnicity (91.25) was not statistically significant hence it can be used for the Toba Batak ethnicity. The Bolton anterior ratio cannot be applied to the Toba Batak ethnic group because relationship between the size of the maxillary and mandibular teeth is influenced by population, sex and length of the arch segment.[31,32] The longer the maxillary segment, the greater the ratio of mesiodistal tooth size obtained. This is in line with research by Isnanie, that the Batak ethnic group has greater jaw and dental arches than the Deutro Melayu sub-race.[33]

The suitability of Bolton's analysis on the Batak ethnicity has been studied by Budi who examined the validity of Bolton's analysis on the Batak people in North Sumatra in 2012 and obtained an anterior ratio of 79.24. This shows that both the ratio of the anterior ratio and the overall ratio of Bolton's analysis cannot be used for the Bataks.[56] The research stated that the overall ratio and the anterior ratio of Bolton's analysis cannot be used for the Toba Batak

ethnicity. It is in contrast with this study. This may related to the authenticity of the research samples. The subjects in this study were students of Universitas Sriwijaya class of 2011-2016 who were descendants of the Toba Batak ethnicity. Some of these students were born and lived in Palembang, and some were born in Medan and recently migrated to Palembang. Environmental factors may influence tooth size around 10-20%, therefore there may be a difference in the ratio of mesiodistal teeth size between the Batak Toba ethnic group in Palembang and the ones who were originally born in Medan.

Bolton's analysis has an ideal ratio of 77.2 for the anterior ratio and 91.3 for the overall ratio. If the value is greater than Bolton's ideal ratio, the mesiodistal number of mandibular anterior teeth will be excessive. It means that the mandibular tooth size is relatively large, causing a discrepancy in mandibular tooth size. If the value is less than Bolton's ideal ratio, the total number of maxillary teeth is excessive. It means that the maxillary tooth size is relatively large, causing a discrepancy in maxillary tooth size.[34] The larger maxillary teeth size usually causes large overjet and overbite, maxillary crowding, mandibular spacing, palatoversion of the maxillary incisors, or labioversion of the mandibular incisors. The size of the teeth in the larger mandible usually causes small overjet and overbite, crowding of the mandible, spacing of the maxilla, linguoversion of the mandibular incisors or labioversion of the maxillary incisors. Various treatment plans can be undertaken to overcome this discrepancy in tooth size, such as reduction of tooth enamel (strippling, grinding or slandering), prosthetic restorations, tooth extraction, and arch expansion of the jaw.[35] The interpretation of Bolton's analysis aims to make it easier for dentists to make a diagnosis, determine a treatment plan, and determine the functional esthetic results of orthodontic treatment. Therefore, Bolton's analysis is one of the orthodontic calculation analysis required by dentists before performing orthodontic treatment.

**Conclusion**

Based on the research that has been done, it can be concluded that there is no difference between the anterior and overall Bolton ratios of the Palembang and Toba Batak ethnic groups. Bolton's overall ratio (91.3) and Bolton's anterior ratio (77.2) can be used in Palembang ethnic patients, whereas for Batak Toba patients, Bolton's overall ratio (91.3) can be used but Bolton's anterior ratio (77.2) cannot.

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