# Relationship between Arch Base Length and Dental Crowding in Different Skeletal Patterns

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**Abstract**

This study aimed to assess the maxillary and mandibular effective arch lengths in a Malaysian population sample and to verify the relationship between effective arch length and dental crowding in patients with different skeletal patterns.

A sample of 96 subjects was divided into three groups according to skeletal pattern (I,II and III), each group was further divided into 2 sub-groups (based on the amount of maxillary and mandibular arch crowding) sub-group1(≤4mm) and sub-group2 (>4mm). The maxillary and mandibular effective arch lengths were measured on cephalometric radiographs. Descriptive statistics and Analysis of Variance (ANOVA) were used for analysis. The results showed that this Malaysian sample have smaller mean values of effective arch length compared with other populations. Maxillary base length was highest in Class I, followed by Class II and Class III. Mandibular base length was highest in Class III, followed by Class I and Class II. No statistically significant differences were found in maxillary and mandibular base length between the 2 sub-groups of crowding in all skeletal patterns. Further analysis for the 2 crowding sub-groups in the maxilla showed no statistically significant differences in base length for the maxilla (P=0.132) and mandible (P=0.215). Similarly, in subjects with mandibular crowding, no statistically significant differences in base length were detected in the maxilla (P=0.359) and mandible (P=0.948). A baseline data for maxillary and mandibular effective arch lengths for Malaysian population was established in this study. Arch base length and crowding need to be further investigated.

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## Introduction

Dental crowding is one of the most common problems that lead patients to seek orthodontic treatment. Crowding is defined as the difference between the arch perimeter and the sum of mesiodistal width of teeth (in millimeter) that lead to the malalignment[1-3]. Crowding is not only treated for esthetic reasons but also for function and periodontal health[4].

The evaluation of the relation between the skeletal pattern and the dental characteristics could assist in revealing the complexity of a malocclusion[5].

Many previous studies have been carried out to identify the etiological and contributing factors of dental crowding; however, it is still an ongoing subject of debate[1,2,6-11]. Dental crowding could be caused by skeletal, dental, or soft tissue factors or a combination of them. Examples of the factors include tooth size, tooth shape, oral and perioral musculature and dental arch dimensions[12,13]. The correlation of tooth size and arch dimension with dental crowding was previously reported [11]. Arch base length which is referred to as effective arch length is not the actual anatomic length but rather a line measured on the cephalograms. Figure 1 illustrates that the maxillary effective length, which is the effective midfacial length, is determined by measuring a line from condylion (the most posterosuperior point on the outline of the mandibular condyle) to point A (Co-A)[14], while mandibular effective length is measured by constructing a line from condylion to anatomic gnathion (Co-Gn)[15].

Few studies investigated the relation between effective arch length and dental crowding, however, conclusions remain inconsistent. Sakuda et al.[13] found that patients

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with crowding in the permanent dentition had a smaller mandibular body length. Similarly, Janson G et al.[11] verified the relationship between maxillary and mandibular effective lengths and dental crowding in patients with Class II malocclusion and concluded that decreased maxillary and mandibular effective lengths was associated with dental crowding in patients with complete Class II malocclusion. Conversely, Khoja A et al.[6], in a study that considered different skeletal patterns, concluded that an increase in amount of dental crowding was weakly associated with smaller skeletal base lengths. To date their study is the only one to consider different skeletal patterns, moreover, no baseline data is available on effective arch length in a Malaysia population. Thus the aim of this study was to assess the effective arch length of maxilla and mandible in a Malaysian population sample and to investigate the relation between effective arch length and dental crowding in different skeletal patterns. This knowledge could provide guidance during orthodontic treatment planning to help the orthodontist in determining the treatment plan for patients with different types of skeletal relationship that have crowding and whether extraction is needed to fulfill the treatment aims. This would affect the long term stability and relapse after fixed orthodontic treatment.

## Materials and methods

The study sample was retrospectively selected from data base of orthodontic department, Faculty of Dentistry,Universiti Teknologi Mara (UiTM). Ethical approval was applied for and obtained from the ethics committee of Faculty of Dentistry, UiTM. After screening of 600 patients' data, from the orthodontic database for patients with cephalometric records, we selected 96 patients' records that fit our inclusive criteria. The sample only includes patients who were suitable for fixed appliance orthodontic treatment.

The inclusion criteria were as follows[13].

- Class I, Class II or Class III skeletal pattern
- age range from 18-45 years old
- fully erupted permanent teeth except the third molar
- normal vertical relationship and no open bite
- absence of dental anomalies of number, size and form
- diagnostically acceptable lateral cephalograms
- Malay ethnic subjects.

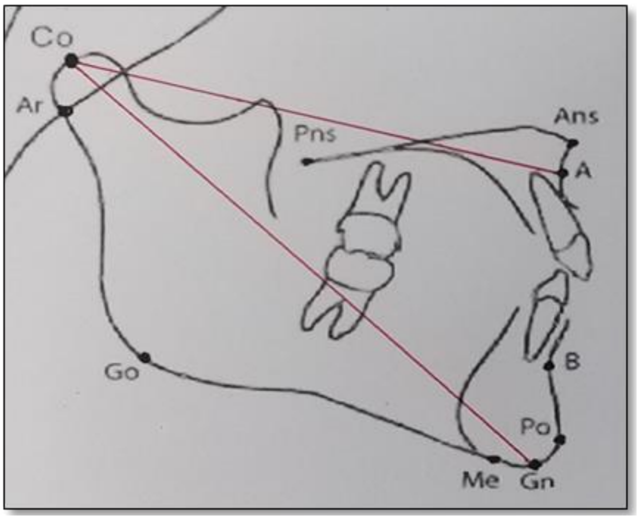


**Figure 1.** Arch Base Length Measurement.

The subjects were classified according to their skeletal relationship into Class 1, Class II and III (31, 30 and 35 respectively). The ANB was set at 2°-4° for Class I, >4° for Class II and <2° for Class III. Each skeletal class was subdivided into two subgroups according to their degree of crowding. Subjects with maxillary or mandibular arch crowding of ≤4mm were placed in sub-group 1 and those with maxillary or mandibular arch crowding of >4 mm were placed in sub-group 2. The amounts of crowding on the labial segment for both maxilla and mandible were obtained from the patients' dental records. Cephalometric tracings and location of dentoskeletal landmarks were conducted manually [13]. The following points and lines as illustrated in Figures 1 and 2 were traced [6,16]:

- Sella (S): the midpoint of the sella turcica
- Nasion (N): the most anterior point on the frontonasal suture
- A point (A): deepest concavity on the anterior profile of the maxilla
- B point (B): the deepest concavity on the anterior surface of mandibular symphysis
- Condylion (Co): the most posterosuperior point on the outline of the mandibular condyle
- Gnathion (Gn): the most anteroinferior aspect of the mandibular symphysis
- SN: the line connecting sella and nasion

- Maxillary effective length: determined by measuring a line from condylion to point A (Co-A)
- Mandibular effective length: determined by measuring a line from condylion to anatomic gnathion (Co-Gn)

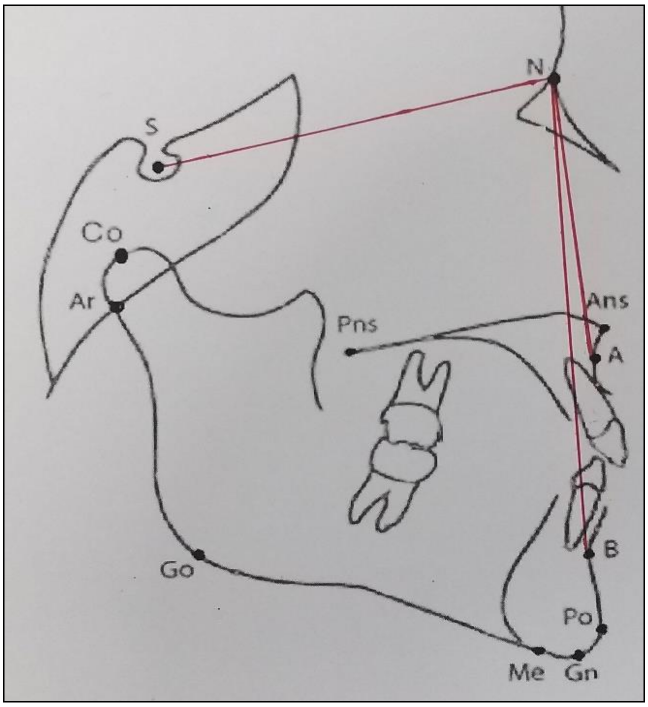


**Figure 2.** ANB Angle Measurement.

The skeletal relationship was determined on pre-treatment lateral cephalograms by measuring ANB angle (Figure 2). The maxillary and mandibular effective lengths (Co-A and Co-Gn) were observed based on McNamara Cephalometric Analysis [12]. Inter-examiner calibration and intra-examiner calibration was conducted using Kappa test. There was strong correlation between both values in the inter-examiner (r=0.925) and intra-examiner calibration (r =0.942). The cephalometric variables were compared between the groups with t-test and Analysis of variance (ANOVA).

### Results

In this study sample of 96 subjects, 24% were males and 76% were females. The skeletal pattern distribution was 32.3%, 31.3% and 36.4% for Class I, II and III respectivly. For the maxillary crowding, Tables 1 and 2 show that 46% had crowding ≤4 mm (sub-group1) and 54% of the subjects had crowding >4mm (sub-group2), whereas for mandibular crowding, 43% had crowding ≤4 mm (sub-group1) and 57.3% of the subjects had crowding >4mm (sub-group2). The results of independent samples t-test for sub-groups1 and 2 of maxillary crowding (Table 1) showed that sub-group 1 had slightly higher mean value of maxillary base length compared to sub-group 2, but the difference was not statistically significant (*P*=0.132). Similarly, the mean value of mandibular base length in sub-group 1 of maxillary crowding was slightly higher than the mean value of sub-group2, however, the difference was not statistically significant (*P*=0.215).

Table 2 shows the results of independent samples t-test for sub-groups1 and 2 of mandibular crowding where sub-group1 had slightly higher mean value of maxillary base length compared to the sub-group 2. Conversely, the mean value of mandibular base length in sub-group 1 of mandibular crowding was slightly lower than the mean value of sub-group 2. Nevertheless, these differences were not statistically significant for maxillary and mandibular effective length (*P*=0.359 and *P*=0.948 respectively). Maxillary base length was highest in Class I, followed by Class II and Class III. Mandibular base length was highest in Class III, followed by Class I and Class II (Table 3). One Way ANOVA test of all three skeletal patterns showed no significant difference between the skeletal groups in the mean value of maxillary base lengths (*P*= 0.166). Similarly, the mean value of mandibular base length was not significantly different between the three skeletal patterns (*P* = 0.151) as shown in Table 4.

### Discussion

In this study, subjects within each skeletal pattern were divided into 2 sub-groups according to the severity of the crowding of the maxilla and mandible. Crowding of 4mm was set as the splitting limit between the two groups. Few studies used 3mm crowding as the splitting limit. Janson et al.[11], divided the sample into two groups according to the severity of pretreatment mandibular anterior crowding where group 1 consisted of patients with crowding 3 mm and above whereas group 2 had patients with crowding of less than 3 mm [11]. However, in this study, 4 mm was chosen as the splitting limit following the dental crowding classification suggested by Proffit [16]. Initially, in this study, data analysis was performed on pooled female and male samples. There was no significant difference found in comparison between the arch base lengths for groups with different severity of crowding in the three skeletal patterns. Due to this result, the analysis was conducted again, with the same objectives, while only including female subjects data. Despite of that, the results also showed no significant difference in the relationship of arch base length in different severity of crowding for all the skeletal patterns. Therefore, the results presented in this study were the analysis performed for the pooled male and female subjects.

The effective maxillary and mandibular length for the Malay population was established in this study where the mean value for maxillary base length was highest in Class I followed by Class II and Class III, whereas mandibular base length was highest in Class III and shortest in Class II (Table 3). These results are similar to previous studies by Dhophatkar et al.[9] and Khoja et al.[6] where they found the same trend for the mandible in being longest in skeletal Class III. However, in the results reported by Khoja et al.[6] the differences in mean values of effective arch length of the maxilla and mandible showed significant differences between the skeletal patterns while in this study the differences were not significant. While in a previous study by Ramezanzadeh et al.[17] the results were in concordance with our study where they reported a higher mean value for mandibular effective length of Class III subjects but no statistically significant difference between Class I and III. The other aim of this study was to assess the relationship of maxillary and mandibular base length with the severity of dental crowding among different skeletal patterns. The results of this study revealed that maxillary and mandibular base length for sub-group1 with crowding ≤4mm is higher than maxillary and mandibular base length for sub-group2 with crowding >4mm for all skeletal classes. However, this difference was not statistically significant. These results corroborate the findings of a previous work by Khoja et al.[6] in which they reported that although, generally the group with less crowding demonstrated higher arch length, no significant differences between effective arch lengths in different groups of crowding could be detected. These discrepant results from various studies warrant further investigation and assessment of other possible etiological factors associated with dental crowding such as oral and peri-oral musculature and incisors inclination [17-21].

The etiology of crowding needs to be thoroughly considered especially where there are inconsistencies of study results which indicate the need to examine multiple factors which could aid the orthodontist in determining the best treatment plan for the patient with crowding especially when deciding on the need for extraction [6,17].

One of our study objectives was to establish a baseline for the arch base length in a Malay population. To date, no study has evaluated the effective arch base length in a Malay sample. Table 5 shows the mean values of arch base length from previous studies and the Malay population mean values obtained in the present study. The lower mean values for the Malay sample could be attributed to ethic factors. The mean values reported by McNamara[12] were based on a Caucasian population. The variations in mean values between different populations, as highlighted in Table 5, necessitate the need for each population to conduct their treatment planning based on data obtained from their own population rather than trying to fit their patients to standards and values derived from different ethnic group which might negatively impact the treatment plan and stability.

## Conclusions

Ethnic factors could influence arch base length. The maxillary and mandibular base lengths showed different patterns in different skeletal relationship. The effect of arch base length on dental crowding needs to be further investigated and other possible crowding etiological factors need to be considered.

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## Declaration of Interest

The authors report no conflict of interest and this study was not funded or supported by any research grant.

| Maxillary Crowding Sub-groups | | Maxillary Effective Length | Mandibular Effective Length |
|---|---|---|---|
| ≤4 mm (n=44) | | 80.625±7.5175 | 107.034±10.0848 |
| >4mm (n=52) | | 77.962±9.3425 | 104.077±12.6640 |
| Mean Difference (Δ) | | 2.6635±1.7526 | 2.9572±2.3670 |
| T-test | *P*- value | 0.132 | 0.215 |
| | Significant Difference | No | No |

**Table 1.** Independent Samples T-test of Maxillary Crowding Sub-groups.

| Mandibular Crowding Sub-groups | | Maxillary Effective Length | Mandibular Effective Length |
|---|---|---|---|
| ≤4 mm (n=41) | | 80.122±8.7227 | 105.341±11.4807 |
| >4mm (n=55) | | 78.482±8.5462 | 105.500±11.7757 |
| Mean Difference (Δ) | | 1.6401±1.7789 | -.1585±2.4040 |
| T-test | *P*-value | 0.359 | 0.948 |
| | Significant Difference | No | No |

**Table 2.** Independent Samples T-test of Mandibular Crowding Sub-groups.

| Skeletal Class | Maxillary Effective Length(mm) | | Mandibular Effective Length(mm) | |
|---|---|---|---|---|
| | Sub-group1 (≤4 mm) | Sub-group2 (>4mm) | Sub-group1 (≤4 mm) | Sub-group2 (>4mm) |
| **Class I** | 82.4460±7.1676 | 80.6111±7.5936 | 106.3182±11.9358 | 107.275±9.9174 |
| **Class II** | 82.2857±9.7126 | 76.9375±7.6569 | 102.3611±13.0009 | 101.5±9.7863 |
| **Class III** | 78.8438±4.5743 | 75.7894±11.6861 | 108.9167±7.6895 | 106.0435±13.9869 |

**Table 3.** Mean Values of Maxillary and Mandibular Effective Length in Different Skeletal Patterns.

| Variable | F | df | *P* value | Significant Difference |
|---|---|---|---|---|
| Maxillary Effective Length | 1.829 | 95 | 0.166 | No |
| Mandibular Effective Length | 1.933 | 95 | 0.151 | No |

**Table 4.** One Way ANOVA Test for Effective Length Between Class I, II and III.

| Author | Year | Country | Maxillary Effective Length (mm) | | Mandibular Effective Length (mm) | |
|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female |
| **McNamara**[12] | 1986 | USA | 99.80 | 91.00 | 134.30 | 120.20 |
| **Miyajima et al.** [22] | 1996 | Japan | 91.40 | 86.30 | 125.50 | 118.80 |
| **Wu et al.** [23] | 2007 | China | 87.90 | 85.93 | 113.95 | 113.32 |
| **Al-Barakati and Talic** [7] | 2007 | Saudi Arabia | 101.70 | 98.20 | 133.40 | 124.90 |
| **Nahidh M** [24] | 2010 | Iraq | 93.22 | 85.50 | 121.37 | 111.00 |
| **Poosti M et al.** [25] | 2013 | Iran | 94.72 | 91.12 | 119.00 | 96.36 |
| **Present study** | 2019 | Malaysia | 82.96 | 77.99 | 110.60 | 103.80 |

**Table 5.** Mean Values of Arch Base Length in Present Study and Other Countries.

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