# Arch Dimension and Tooth Size in Class I Malocclusion Patients with Anterior Crossbite

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## Abstract

The objective of this study was to determine the differences of dental arch dimensions and tooth sizes between Class I malocclusion patients with and without anterior crossbite and also between the crossbite and non-crossbite side among Class I unilateral anterior crossbite patients. Arch widths, arch heights, and anterior tooth size ratios of 62 dental models of Class I malocclusion patients with anterior crossbite were compared with the other 62 Class I malocclusion models controlled for age, sex and amount of tooth size - arch length discrepancy, but without anterior crossbite. Independent t-tests were used to determine the differences. Moreover, arch widths and tooth sizes of 39 models of Class I unilateral anterior crossbite patients were compared between the crossbite and non-crossbite sides. Paired t-tests were used to analyze the differences.The results of this study demonstrated that patients with anterior crossbite had significantly shorter maxillary arch height than those without anterior crossbite ($p < 0.001$). Apart from that, none of the arch dimension or tooth size parameters were significantly different ($p > 0.05$). Among the unilateral crossbite patients, arch widths and tooth sizes were similar between the crossbite and non-crossbite side ($p > 0.05$). In conclusion, maxillary arch height was significantly shorter in anterior crossbite patients. Neither arch dimensions nor tooth sizes were found to be the influential factors.

**Key words:** Anterior crossbite; Arch height; Arch width; Class I malocclusion; Tooth size

# มิติส่วนโค้งแนวฟันและอัตราส่วนขนาดฟันหน้าในผู้ป่วยภาคใต้กลุ่มหนึ่งที่สบฟันผิดปรกติประเภทที่ 1 ร่วมกับฟันหน้าสบไขว้

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## บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบความแตกต่างของมิติส่วนโค้งแนวฟันและขนาดฟันระหว่าง  ผู้ป่วยสบฟันผิดปรกติประเภทที่ 1 ที่มีและไม่มีฟันหน้าสบไขว้ และด้านที่มีและไม่มีฟันหน้าสบไขว้ในผู้ป่วยสบฟันผิดปรกติประเภทที่ 1 ที่มีฟันหน้าสบไขว้ข้างเดียว โดยการเปรียบเทียบความกว้างและความสูงของส่วนโค้งแนวฟัน และอัตราส่วนขนาดฟันหน้าในแบบจำลองฟันของผู้ป่วยที่มีการสบฟันผิดปรกติประเภทที่ 1 ร่วมกับฟันหน้าสบไขว้ 62 คู่ และที่ไม่มีฟันหน้าสบไขว้ 62 คู่ โดยควบคุมเพศ อายุ และปริมาณขนาดฟัน-ความยาวส่วนโค้งแนวฟันเคลื่อนคลาด ใช้การทดสอบทีชนิดที่เป็นอิสระต่อกันเพื่อเปรียบเทียบความแตกต่างนี้และเปรียบเทียบความกว้างของส่วนโค้งแนวฟันและขนาดฟันของด้านที่มีและไม่มีฟันหน้าสบไขว้ในแบบจำลองฟัน 39 คู่ของผู้ป่วยสบฟันผิดปรกติประเภทที่ 1 ร่วมกับฟันหน้าสบไขว้ข้างเดียวโดยใช้การทดสอบทีแบบจับคู่เปรียบเทียบความแตกต่าง จากการศึกษาพบว่าผู้ป่วยที่มีฟันหน้าสบไขว้มีความสูงของส่วนโค้งแนวฟันบนที่สั้นกว่ากลุ่มที่ไม่มีฟันหน้าสบไขว้อย่างมีนัยสำคัญทางสถิติ ($p < 0.001$) ในขณะที่ตัวแปรอื่น ๆ ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p > 0.05$) ในกลุ่มผู้ป่วยที่มีฟันหน้าสบไขว้ข้างเดียว ขนาดของความกว้างส่วนโค้งแนวฟันและขนาดฟันไม่มีความแตกต่างกันระหว่างข้างที่มีและไม่มีการสบไขว้ ($p > 0.05$) ผลการศึกษาสรุปว่าผู้ป่วยสบฟันผิดปรกติประเภทที่ 1 ที่มีฟันหน้าสบไขว้มีความสูงของส่วนโค้งแนวฟันบนสั้นกว่าอย่างมีนัยสำคัญ ในขณะที่มิติส่วนโค้งแนวฟันอื่น ๆ รวมทั้งขนาดฟันอาจไม่มีอิทธิพลต่อการเกิดภาวะฟันหน้าสบไขว้

**คำสำคัญ:** ฟันหน้าสบไขว้; ความสูงส่วนโค้งแนวฟัน; ความกว้างส่วนโค้งแนวฟัน; การสบฟันผิดปรกติประเภทที่ 1; ขนาดฟัน

## Introduction

Anterior crossbite is commonly found in Class III patients, however, it is not uncommon among other classes.[1,2] The presence of anterior crossbite may lead to several complications, such as, tooth wear, lowered masticatory efficiency,[3] gingival margin discrepancy,[4] form deviation of the articular eminence,[5] and adverse growth of the alveolar process and jaws.[6] Prevalence of anterior crossbite has ranged from 4 - 10% among studied populations.[7-9] The etiologic factors of anterior crossbite, besides skeletal discrepancy, could be early loss or prolonged retention of anterior deciduous teeth, and abnormal tooth bud position, leading to atypical eruption path of the permanent incisors.[10] Also, premature loss of posterior support during childhood and occlusal interference may induce abnormal chewing behavior which subsequently establishes an anterior crossbite occlusion.[11] Regarding Class I malocclusion, a number of studies have reported the difference of arch dimensions and tooth sizes between normal and crowded groups. The Class I subjects with more than 5 mm of space deficiency had a significantly smaller maxillary arch width and larger tooth size when compared with the uncrowded subjects.[12] The other study found that Class I crowded group had maxillary and mandibular intermolar and alveolar arch widths significantly smaller than the non-crowded group.[13] Nevertheless, up to these days, the contributions of arch dimension and tooth size on the development of anterior crossbite in skeletal Class I patients are not known. In this study, we posed two hypotheses; first, the dental arch dimensions and tooth sizes are not different between Class I malocclusion patients with and without anterior crossbite. Second, among Class I patients with unilateral anterior crossbite, the arch dimensions and tooth sizes are not different between crossbite and non-crossbite side.

## Materials and Methods

This study was conducted at the Faculty of Dentistry, Prince of Songkla University and was approved by the faculty's ethical committee. The study protocol was also conformed to the provisions of the Declaration of Helsinki. Sixty-two pre-treatment orthodontic models of permanent dentition patients (25 males and 37 females; age 11 - 25 years old) with skeletal and dental Class I malocclusion were selected (ANB angle = 0 - 5 degrees, The mesiobuccal cusp of both maxillary first molars occluded in the buccal groove of the mandibular first molars in the sagittal plane). All patients presented at least one anterior crossbite (incisal overjet ≤ 0 mm). The other 62 models of skeletal and dental Class I non-crossbite patients matched for age, sex and amount of tooth size arch length deficiency (TSALD) were selected as control group. The matching was performed to eliminate the confounding effects from these three factors on arch dimensions and tooth sizes.

All subjects must have a fully erupted permanent dentition from right first molars to left first molars. Subjects with major dental destruction or restoration which may deviate the genuine mesio-distal tooth width were excluded from the study. Additionally, patients with history of ortho dontic treatment, significant craniofacial deformities, posterior crossbite, and functional crossbite were excluded. Poor quality of dental models were also discarded.

For the first part of the study, all models were measured for anterior, posterior arch widths, and arch height (Fig. 1). Collective mesiodistal tooth width from right to left second premolar was also measured. To avoid underestimation of arch height measurement, subjects with bilateral anterior crossbite of the central incisors were excluded, Hence, only 50 subjects were left for arch height measurement. All maxillary and mandibular models were

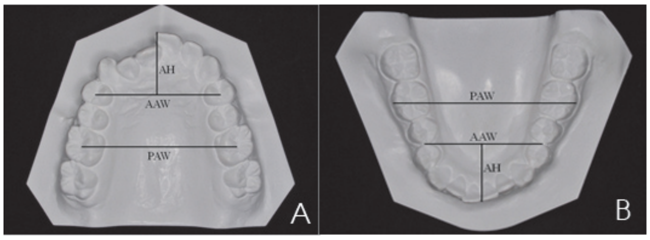


*Figure 1* *Arch dimension parameters for A) maxillary arch and B) mandibular arch. AAW = anterior arch width, PAW = posterior arch width, and AH = arch height.*

separated and randomly measured by an investigator. All measurements were made with a digital caliper which can be measured to the nearest 0.01 mm. Anterior tooth size ratio was later calculated.

To test the second hypothesis, 39 models with unilateral anterior crossbite were examined. Using median palatine raphe to divide the maxillary arch into two halves, unilateral maxillary anterior and posterior arch widths were measured (Fig. 2). The mandibular arch dimension was not evaluated in this part, due to the difficulty in identifying the coronal midline of this arch. Maxillary and mandibular collective mesiodistal tooth widths on the crossbite and non-crossbite sides were measured.

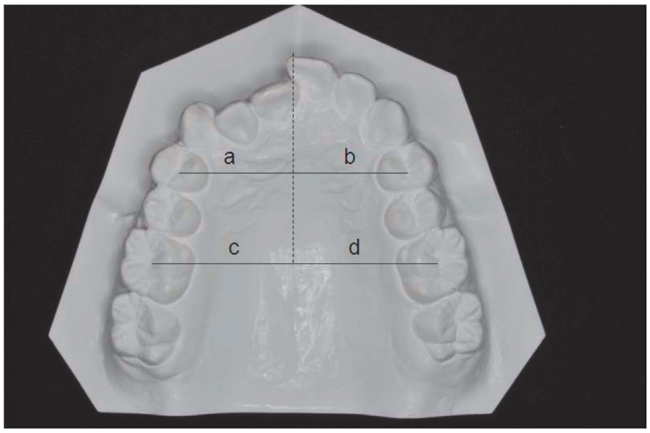


*Figure 2* *Maxillary arch dimension parameters for unilateral anterior crossbite subjects. a = anterior arch width on crossbite side, b = anterior arch width on non-crossbite side, c = posterior arch width on crossbite side, and d = posterior arch width on non-crossbite side.*

## Arch dimension and tooth size measurements

Maxillary anterior arch width = Distance between the lower-most point of the transverse fissure of the first premolars

Maxillary unilateral anterior arch width = Distance from the lower-most point of the transverse fissure of the first premolar to the median palatine raphe. The line is perpendicular to the palatal midline.

Maxillary posterior arch width = Distance between the point of intersection of the transverse fissure with the buccal fissure of the first permanent molars

Maxillary unilateral posterior arch width = Distance from the point of intersection of the transverse fissure with the buccal fissure of the first permanent molar to the median palatine raphe. The line is perpendicular to the palatal midline.

Mandibular anterior arch width = Distance between the buccal contact point between first and second pre-molars

Mandibular posterior arch width = Distance between the tip of the mesio-buccal cusp of the mandibular first permanent molars

Arch height = Distance perpendicular to the line connecting the reference points of anterior arch width in the midsagittal plane. It is measured from the intersection of the two lines to the labial surface of the most anterior positioned central incisor.

5 - 5 tooth width = Sum of mesio-distal tooth width from right second premolar to left second premolar.

Anterior tooth size ratio = sum of mesio-distal tooth width of six mandibular anterior teeth x 100 / sum of mesio-distal tooth width of six maxillary anterior teeth.

## Data analysis

Independent t-tests were used to examine the within group difference between genders as well as the differences between crossbite and non-crossbite groups. Paired t-tests were used to determine the differences between the crossbite and non-crossbite sides. The level of significance was established as $p < 0.05$. Intra-examiner's reliability was assessed by measuring 25 models twice at 4-week interval. More than 96% of the measurements were within the limit of agreement (mean difference $\pm$ $2SD_{diff}$) indicating marked reliability.

## Result

All within-group parameters were equivalent between genders ($p > 0.05$) (data not shown). As a consequence, both sexes were pooled for further analysis. Neither the age nor

TSALD was significantly different between the crossbite and non-crossbite groups ($p > 0.05$) (Table 1). Skeletally, sagittal maxillo-mandibular relationship (ANB angle) was almost identical between two groups ($p = 0.99$) (Table 1). Table 2 compares the means ± SD of maxillary and mandibular arch dimensions and anterior tooth size ratios of the crossbite and non-crossbite groups. The only parameter that was significantly different between groups was maxillary arch height. Patients with anterior crossbite had shorter arch height than those without anterior crossbite (17.2 ± 2.2 mm vs. 19.1 ± 2.4 mm, $p < 0.001$). Among the unilateral anterior crossbite patients, none of the arch parameters exhibited significant difference between crossbite and non-crossbite side ($p > 0.05$) (Table 3).

*Table 1 The mean ± standard deviation of age and tooth size arch length discrepancy*

| Parameters | Non-crossbite Group (n = 62) | Crossbite Group (n = 62) | *p*-value† |
|---|---|---|---|
| Age (years) | 17.4 ± 4.9 | 18.7 ± 5.0 | ($p = 0.38$) |
| Maxillary TSALD (mm) | -6.5 ± 1.6 | -7.3 ± 5.1 | ($p = 0.50$) |
| Mandibular TSALD (mm) | -4.8 ± 2.0 | -4.4 ± 2.7 | ($p = 0.66$) |
| ANB (degree) | 2.5 ± 1.5 | 2.5 ± 1.2 | ($p = 0.99$) |

(TSALD) of the non-crossbite and crossbite groups

†Independent t-test

*Table 2 Comparisons of dental arch dimension and tooth size between non-crossbite and crossbite groups (n = 62 for all parameters except for arch height measurements which n = 50)*

| Parameters | Non-crossbite Group | Crossbite Group | *p*-value† |
|---|---|---|---|
| Maxillary dental arch | | | |
| Anterior arch width (mm) | 36.4 ± 1.9 | 35.3 ± 2.7 | ($p = 0.09$) |
| Posterior arch width (mm) | 46.8 ± 2.2 | 45.4 ± 2.6 | ($p = 0.13$) |
| Arch height (mm)‡ | 19.1 ± 2.4 | 17.2 ± 2.2 | ($p = < 0.001$*) |
| 5-5 tooth width (mm) | 79.3 ± 2.1 | 78.6 ± 2.4 | ($p = 0.48$) |
| Mandibular dental arch | | | |
| Anterior arch width (mm) | 36.2 ± 2.1 | 35.4 ± 2.6 | ($p = 0.53$) |
| Posterior arch width (mm) | 45.7 ± 2.2 | 44.6 ± 2.8 | ($p = 0.26$) |
| Arch height (mm)‡ | 17.3 ± 2.3 | 16.6 ± 2.5 | ($p = 0.42$) |
| 5-5 tooth width (mm) | 69.2 ± 1.8 | 69.1 ± 2.4 | ($p = 0.68$) |
| Anterior tooth size ratio | 77.9 ± 2.6 | 78.8 ± 2.6 | ($p = 0.22$) |

†Independent t-test,‡ n=50,* statistical significant at $p < 0.05$

*Table 3* *Comparisons of unilateral measurements of arch dimensions and tooth sizes on non-crossbite and crossbite sides (n = 39).*

| Unilateral parameters | Non-crossbite side | Crossbite side | *p*-value† |
|---|---|---|---|
| Maxillary anterior arch width (mm) | 17.8 ± 1.6 | 17.6 ± 1.6 | ($p$ = 0.49) |
| Maxillary posterior arch width (mm) | 22.2 ± 1.5 | 22.4 ± 1.6 | ($p$ = 0.53) |
| Maxillary 5-5 tooth width (mm) | 39.2 ± 2.2 | 38.6 ± 4.3 | ($p$ = 0.31) |
| Mandibular 5-5 tooth width (mm) | 35.1 ± 1.8 | 34.6 ± 2.4 | ($p$ = 0.46) |

†Paired t-test

## Discussion

Comparing between Class I with and without anterior crossbite subjects, the null hypotheses for arch dimensions and anterior tooth size ratios were accepted, except for maxillary arch height difference. The null hypotheses for arch dimensions and tooth sizes comparisons between crossbite and non-crossbite sides among Class I unilateral anterior crossbite subjects were accepted.

The absence of gender dimorphism of arch dimensions within either Class I with or without anterior crossbite is in line with the report of Chang et al.[14] They found no gender difference of intercanine and intermolar widths in both maxillary and mandibular arch of the Class I crowded subjects. However, there have been other studies reporting that males had larger arch dimensions than females.[15,16] Differences between the results probably signify population diversity.

Reports about gender dimorphism of intermaxillary tooth size ratios are also controversial. Recent studies reported that males have larger mesio-distal tooth widths than females.[17,18] However, Endo et al[19] found no gender differences in anterior or overall ratio in any malocclusion group. Oktay and Ulukaya[20] reported gender difference for posterior ratio, but not for anterior ratio. On the other hand, Basaran et al[21] found no gender dimorphism of neither tooth sizes nor intermaxillary tooth size ratios in the same type of malocclusion. Again, different races may be accountable for the different results.

Providing that the amount of maxillary and mandibular TSALD, and ANB angle were carefully matched, the absence of difference of variables other than arch height between crossbite and non-crossbite subjects, in conjunction with the indifference of arch widths and tooth sizes between the crossbite side and non-crossbite side among unilateral anterior crossbite subjects imply that arch height was the only contributor to the occurrence of anterior crossbite.

The development of arch height, similar to the other arch dimensions, is partly under genetic influence. A high heritability estimate for dental arch dimensions has been reported.[22,23] A twin study on genetic and environmental contributions to dental arch dimensions using a model incorporating additive genetic and unique environmental variation found that the estimates of heritability for arch height ranged from 0.86 - 0.94, whereas those for arch width were 0.49 - 0.92 and those for palatal height were 0.80 - 0.81, indicating a higher genetic contribution for arch height than arch width and palatal height.[24]

On the other aspect, other studies have emphasized the importance of environmental influence on the variation of occlusion over the genetic influence.[10,25] A recent study on 164 pairs of twin found that as high as 5% of monozygotic male twins and 20% of dizygotic male twins had within-pair difference in crossbite. The differences were statistical significant.[26] The authors concluded that environmental factors may account for more malocclusions than previously believed.

Therefore, the combination of hereditary and environ mental influence possibly plays a role on the establishment of arch height which may subsequently be responsible for the occurrence of anterior crossbite among Class I patients. The marked increase of arch height between 7 and 13 years of age is mainly due to the eruption of permanent central incisors in a proclined position.[27] It is possible that some environmental factors may impede the permanent central incisors from erupting in the normal range of inclination which could subsequently impair the normal development of arch height. The examples of such obstacle factors are the abnormal tooth bud position, the lack of eruptive guidance due to early loss of deciduous central incisors, or any interferences causing delayed eruption of permanent central incisors may impair the normal development of arch height.[10] In a worse situation, short arch height may be hereditarily transferred and some environmental factors may additively worsen the situation and subsequently cause anterior crossbite.

The strength of the study is the large sample size. In addition, this is the first study done in southern Thai population. However, since this study was cross-sectional, it is not possible to determine a cause-effect relationship between tested variables. Nevertheless, since the arch height was measured from the most-anterior and non-crossbite maxillary incisor, the environmental influence from abnormal inclination or path of eruption of permanent central incisors was thus eliminated. Moreover, all subjects had fully erupted permanent teeth. Hence, the uncertainty from remaining arch growth was avoided.

A longitudinal observational study would give a more insight into the contribution of arch dimension on the occurrence of anterior crossbite. Also, a combination of dental model and cephalometric study may provide more information about the effect of dental and skeletal interaction on anterior crossbite. Moreover, the addition of other parameters, such as intercanine widths and tooth thickness may improve the strength of the study.

While the genetic influence cannot be altered, the results of this study encourage the early intervention to intercept, disrupt, and diminish the effects of malocclusion from the environmental influences. Observation of parents' occlusion; early detection of abnormal tooth bud position, path of eruption, and noticeable short maxillary anterior arch height; and the surveillance of chewing habit may prevent the occurrence of subsequent anterior crossbite. Also, preventive measures of dental caries and early loss of deciduous teeth, especially in the maxillary anterior region, may be the other way to avert the occurrence of anterior crossbite.

## Conclusion

Class I malocclusion patients with anterior crossbite had significantly shorter maxillary arch height than those without anterior crossbite. Among the unilateral crossbite samples, arch widths and tooth size of the crossbite and non-crossbite side were not different.

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