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# Arch Length and Tooth Size Relationship and Its Role in Predicting Crowding and Spacing

**Yahya Baradaran Nakhjavani[1], Azam Nahvi[2], Mohsen Izadfar[3], Farid Baradaran Nakhjavani[3], Ahmad Jafari[1,*]**

[1]Associate Professor, Dept. of Pediatric Dentistry, Faculty of Dentistry, Tehran University of Medical Sciences. Tehran, Iran
[2]Postgraduate Student, Dept. of Pediatric Dentistry, Faculty of Dentistry, Tehran University of Medical Sciences. Tehran, Iran
[3]Dentist, Tehran Faculty of Dentistry, Karegar-Hakim Cross, Tehran, Iran

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## ABSTRACT

**Aim:** This study aimed to analyze the relationship between arch length and incisor teeth size in prediction of crowding or spacing.
**Materials and Methods:** A cross-sectional design was carried out on study casts of the jaws of 62 children. Mesiodistal widths of the four anterior teeth were measured along with arch length and inter-canine width on plaster casts. Available space of the anterior teeth was predicted along with the ratio of the arch length to total mesiodistal width of the four incisor teeth. Collected data were analyzed using the Kolmogorov-Smirnov test, analysis of variance (ANOVA) and the Kruskal-Wallis test.
**Results:** Arch length markedly increased as well as its ratio to the sum of mesiodistal widths of the incisors resulting in a change from crowding to spacing. Furthermore, the mean ratio of the arch length to the total mesiodistal width of the four incisor teeth was 2.97±0.04 for the lower jaw and 2.48±0.03 for the upper jaw.
**Conclusion:** With early prediction of crowding or spacing of teeth at the onset of the mixed dentition period, we may be able to come up with a suitable treatment plan for resolving these problems more efficiently.

**KEYWORDS:** Mesiodistal width, crowded arch, space prediction, intercanine width, mixed dentition.

## INTRODUCTION

Teeth crowding is considered a common health issue observed among various races and in both genders. This problem directly affects the occlusion and aesthetics; it also causes inability to maintain good oral hygiene. Periodontal disease secondary to crowding may manifest in older ages. Discrepancy between tooth size and arch length is known as the primary cause of malocclusion. Crowding or spacing may occur when the permanent teeth size and arch length do not match,. [1] Tooth size is dictated by genetic factors, and does not change after the formation of the tooth crown unless it is influenced by environmental factors such as tooth decay. Therefore, the mesial-distal dimension of tooth crown is a fixed value influencing the ratio of tooth size to arch length.[1] Arch length can be reduced and crowding may occur as the result of environmental factors including early loss of deciduous teeth, inter-dental caries, pathological issues, ankylosis of the primary teeth, oral habits, trauma, and early eruption of the permanent second molars.[2] Tooth size and arch length are affected by genetic factors as well.[3] If crowding is diagnosed early after the eruption of permanent teeth, available space in the posterior region can be used to mitigate the problem because premolars and canines erupt later. However, this does not resolve the crowding and only transfers the problem to another area; thus, healthy premolar teeth are inevitably extracted in certain severe cases lacking eruption space.

Evidence suggests that if the arch length is increased or decreased in the initial stages of tooth eruption, orthodontic intervention may considerably increase the chances for managing crowding or spacing. Hence, it is necessary to diagnose crowding or spacing in early stages of tooth eruption.[1] In order to diagnose crowding or spacing, an initial evaluation of the size of the unerupted permanent canines and premolars is necessary. Several analyzing techniques are currently used for such calculations including Moyers' table, Tanaka- Johnston analysis and the use of radiographs.[4] In Moyers' table, the mesiodistal widths of the four mandibular incisor teeth are measured followed by the calculation of the sum of sizes required for the eruption of the canines and premolars. In Tanka- Johnston analysis, however, the mesiodistal widths of the four mandibular incisor teeth are measured, summed up and divided by 2. Obtained values for the lower and upper jaws are increased by 10.5 and 11 milimeters, respectively. The sum of mesiodistal widths of the premolars and canines is also calculated in each quadrant. [4]

This study was designed to assess the possibility of early prediction of crowding or spacing of teeth through an initial evaluation of the mixed dentition system based on the size of the anterior teeth and arch length.

***Corresponding Author:** Associate Professor, Dept. of Pediatric Dentistry, Faculty of Dentistry, Tehran University of Medical Sciences. Tehran, Iran. Email: ajafari@tums.ac.ir Tel: +98 2188015960

## MATERIALS AND METHODS

This cross-sectional descriptive-analytical study was conducted on a population of children referred to the Department of Pediatric Dentistry at Tehran University of Medical Sciences. An initial pilot study was carried out on 16 samples. The ratio of the arch length to total mesiodistal width of the four incisor teeth was calculated in order to determine the samples size. Twenty samples were included in each group of normal, crowding and spacing of anterior teeth. Based on the Bonferroni method, sample size was calculated equal to 62 jaws.

The selected patients aged 7 to 10 years and were examined for the following criteria: 1) Being at the beginning of the mixed dentition with four fully erupted permanent incisors and primary canines and molars still present; 2) No extracted or lost teeth; 3) No tooth decay or marginal ridge involvement; 4) No disorders affecting tooth size or number including macrodontia, microdontia, hyperdontia, hypodontia, or morphological disorders such as taurodontism, additional cusps, gemination or fusion; 5) No erosion or fracture; and 6) No previous orthodontic treatment.

Impressions were made from all the 62 jaws (29 upper and 33 lower) using alginate and were poured using dental stone. Plaster casts were trimmed according to their occlusal level (parallel to the horizon). The arch length of each cast was measured from the mesial surface of the permanent first molar of one side to that of the other side. An orthodontic wire was used for this measurement connected to a meter. Inter-canine length was measured on each cast from the mesial surface of the primary canine of one side to that of the other side. The highest mesiodistal width of each incisor tooth was measured using a compass along with the total mesiodistal width of the four anterior teeth. Subtracting the total mesiodistal width of the four incisor teeth from the intercanine length yields the degree of crowding or spacing and determines the leveling of the anterior teeth. The relationship of arch length with tooth size was assessed. This ratio was obtained by dividing the arch length to the total mesiodistal width of the four incisor teeth. Total mesiodistal width of the four incisor teeth in each jaw can also be multiplied by the result of the mean ratio of the arch length to total mesiodistal width of the four incisor teeth in each jaw of the normal group for the individual's specific arch length. Available arch length was measured from the mesial surface of the first molar in one side to that of the other side. Comparison of the available arch length with the required arch length for each case can show the degree of crowding or spacing. The spaces between the anterior teeth fell into the following categories: A) Normal group: $-1<\text{space}<+1$; B) Crowding group: space $\leq -1$; or C) Spacing group: space $\geq \pm 1$. Collected data were analyzed using Kolmogorov-Smirnov test, ANOVA, and the Kruskal-Wallis test. P-values equal or less than 0.05 were considered significant.

## RESULTS

From 62 plaster casts, 29 were upper jaw and 33 were lower jaw models. Of the maxillary models, 9 were normal, 9 had crowding and 11 had spacing. Of the mandibular models, 9 were normal, 13 had crowding, and 10 had spacing. Study subjects included 40 girls and 22 boys. A total of 19 maxillary and 21 mandibular casts belonged to girls and 10 maxillary and 12 mandibular casts belonged to boys.

Kolmogorov-Smirnov test showed normal distribution of data for the upper and lower jaws of girls and boys. ANOVA revealed a statistically significant difference in the mean value of arch length between the maxillary and mandibular jaws in the three groups ($P<0.001$). The mean value of the maxillary arch length was greater than that of the mandibular arch. However, there was no significant difference in the mean value of total mesiodistal width of the four incisor teeth between the upper and lower jaws in the three groups ($P>0.05$).

The Kruskal-Wallis test revealed a statistically significant difference in the mean ratio of the arch length to total mesiodistal width of the four incisor teeth in the mandible among the three groups ($P<0.001$). The mean value of this variable in the spacing group was greater than that in the other two groups.

ANOVA indicated that the mean arch length in the maxilla and mandible was not equal in the three groups in girls and boys (Table 1). The mean arch length in the spacing group was greater than that in the other two groups. The mean values of total mesiodistal width of the incisors in the upper and lower jaws were the same in the three groups. The mean ratio of the arch length to total mesiodistal width of incisors was not equal in the maxilla or mandible among the three groups. The mean ratio in the spacing group was greater than that of other groups.

The mean ratio of the arch length to total mesiodistal width of incisors with 95% confidence interval (95% CI) was 2.97±0.04 in the mandible and 2.48±0.03 in the maxilla. This ratio in the maxilla and mandible of the three groups was 2.46 -2.50 and 2.94-3.00 in the normal group, 2.19-2.40 and 2.68-2.84 in the crowding group and 2.66 -2.82 and 3.18-3.48 in the spacing group, respectively (Table 2).

## DISCUSSION

Discrepancy between tooth size and arch length may affect the arrangement of the permanent teeth in dental arch leading to teeth crowding or spacing. Crowding is one of the most acknowledged embodiments of malocclusion in dental arches. In an ideal dental arch, the total sum of the mesiodistal dimensions of permanent

teeth equals the length of the alveolar arch. [1] According to our results, data analyzing and ratio of tooth size to arch length showed that arch length clearly increases as crowding changes to spacing. In addition, the relationship between crowding or spacing and the arch length is quite significant. However, normal, crowding and spacing cases did not significantly differ in the total mesiodistal width of the four incisors. Moreover, the ratio of arch length to total mesiodistal width of the four incisors increased as crowding changed to spacing. Our findings support those of Howe et al,[5] Tsai,[6] Melo et al,[7] Randzic,[8] and Facal-Garcia et al,[9] regarding arch length. However, these results contradicted the findings of Chang, [10] Turkkahroman, [11] Melo et al, [7] and Tsai, [6] regarding tooth size.

In our study, the main cause of crowding or spacing of teeth appeared to be due to the arch length; and total mesiodistal width of the four incisor teeth did not contribute to the crowding or spacing. In order to resolve or prevent crowding or spacing, it is best to use methods that add to the arch length in case of crowding or reduce the arch length in case of spacing. Since crowding or spacing is significantly related to the ratio of the arch length to total mesiodistal width of the four incisors, this ratio can be used to predict the arch length required for the mixed dentition system.

To compare these methods, the required arch length was calculated based on total mesiodistal width of the four incisor teeth in the lower jaw (Table3). Comparison of the three methods revealed that the arch lengths calculated were very similar with less than 1 mm discrepancy. Moreover, the arch length calculated based on the ratio of the arch length to total mesiodistal width of the four incisor teeth fell into the range of 1-3 mm, and was therefore more than the arch lengths obtained by the other two methods.

One possibility suggests that the differences seen could be due to the tooth type or race of the patients. Both Moyers' table and Tanaka- Johnston analysis were used for samples that had permanent dentition. Both methods provide the arch length required for the permanent dentition while the current method uses the mixed dentition system to calculate the arch length required for the mixed dentition. Furthermore, Moyers' table and Tanaka- Johnston analysis are implemented on Caucasians of northern European origin while our method was implemented on an Iranian population.

Table 1: Comparison of arch length, total mesiodistal width, and ratio of arch length to total mesiodistal width between girls and boys using ANOVA

| | Jaw | Variables | F | P. Value | P. Value * |
|---|---|---|---|---|---|
| Girls | Upper jaw | Arch length | 17.881 | .000 | .304 |
| | | Total mesiodistal width | 1.571 | .238 | .286 |
| | | Ratio of arch length to total mesiodistal width | 31.179 | .000 | .078 |
| | Lower jaw | Arch length | 17.618 | .000 | .396 |
| | | Total mesiodistal width | 2.368 | .122 | .855 |
| | | Ratio of arch length to total mesiodistal width | 52.647 | .000 | .16 |
| Boys | Upper jaws | Arch length | 10.271 | .008 | .643 |
| | | Total mesiodistal width | .609 | .570 | .264 |
| | | Ratio of arch length to total mesiodistal width | 14.895 | .003 | .066 |
| | Lower jaw | Arch length | 4.727 | .040 | .133 |
| | | Total mesiodistal width | .685 | .529 | .30 |
| | | Ratio of arch length to total mesiodistal width | 6.948 | .015 | .226 |

* Levene's test

Table 2: The 95% CI of arch length, total mesiodistal width and ratio of arch length to total mesiodistal width

| Jaw | Spaces between the anterior teeth | Variables | 95% CI (mm) |
|---|---|---|---|
| Maxilla | Normal | Arch length (mm) | 76.4- 81.1 |
| | | Total mesiodistal width (mm) | 30.65- 32.7 |
| | | Ratio of arch length to total mesiodistal width | 2.46- 2.50 |
| | Crowding | Arch length (mm) | 70.2- 77 |
| | | Total mesiodistal width (mm) | 31.23- 32.76 |
| | | Ratio of arch length to total mesiodistal width | 2.19- 2.40 |
| | Spacing | Arch length (mm) | 83.25- 88 |
| | | Total mesiodistal width (mm) | 30.15- 32 |
| | | Ratio of arch length to total mesiodistal width | 2.66- 2.82 |
| Mandible | Normal | Arch length (mm) | 69.4- 74.59 |
| | | Total mesiodistal width (mm) | 23.32- 25.08 |
| | | Ratio of arch length to total mesiodistal width | 2.94-3.00 |
| | Crowding | Arch length (mm) | 65.13- 69.02 |
| | | Total mesiodistal width (mm) | 23.68- 24.93 |
| | | Ratio of arch length to total mesiodistal width | 2.68- 2.84 |
| | Spacing | Arch length (mm) | 74.44- 79.96 |
| | | Total mesiodistal width (mm) | 22.28- 24.08 |
| | | Ratio of arch length to total mesiodistal width | 3.18- 3.48 |

Table 3: Comparative analysis of the arch length required based on Moyers' table, Tanaka- Johnston analysis and our suggested approach (mm)

| **Total mesiodistal width of the four mandibular incisors** | **20** | **20.5** | **21** | **21.5** | **22** | **22.5** | **23** | **23.5** | **24** | **24.5** | **25** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Arch length required based on the Tanaka- Johnston analysis | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | **71** |
| Arc length required based on the Moyers' table | 60.8 | 61.9 | 63 | 64.1 | 65.2 | 66.3 | 67.4 | 68.5 | 69.6 | 70.7 | **71.8** |
| Arch length required based on our approach | 59.4 | 60.88 | 62.37 | 63.85 | 65.34 | 66.82 | 68.31 | 69.79 | 71.28 | 72.76 | **74.2** |

## Conclusion

Arch length is one of the major factors responsible for the occurrence of crowding or spacing because reduction in arch length causes crowding and increase in arch length leads to spacing. The sum of mesiodistal widths of the four incisor teeth does not influence crowding or spacing of the anterior teeth.

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