Relationship among Lower Arch Length, Arch Width and Arch Perimeter in Crowding and Non-Crowding Groups

SUMMARY
Crowding is one of the causes of class I malocclusion. The purpose of the present study was to examine the relationship between arch length, arch width and arch perimeter in crowded and non-crowded arches, as well as to make comparison of the right and left sides between them and to find out the contributing factor in lower arch crowding. The study groups consisted of 60 subjects aged 16 to 21 years. First group consisted of 30 pairs of dental study models with class I normal occlusion. The second group consisted of 30 pairs of study models with class I crowding. Measurements of arch length and width were made as defined by Lavelle and Foster, using Korkhaus callipers. Arch perimeter was measured by Lundstrom method's using manual calliper with sharp points. Differences between these measurements were made by Mann-Whitney U test (Z/U).

According to our study, the arch length and arch perimeter were not associated factors in contribution to lower arch crowding. In association of contributed factors on the lower arch crowding, we could mention the width of the arch, because the differences between the two groups was significantly different.

Key words: Arch Length; Arch Width; Arch Perimeter; Crowding

Introduction
Crowding of teeth is considered as the most common type of malocclusion7. The relationship between arch dimensions and crowding has become subject of interest to many investigators which has lead to many conflicting and contradictory views. Arch dimension is explained by arch width, arch length and arch perimeter. An investigation performed by Howe et al13 compared crowded and non-crowded groups using study models. They indicated that arch dimension made a greater contribution to dental crowding than tooth size. Other investigators found the same correlation between arch dimensions and dental crowding8,10,21.

Bishara et al2-5 in the longitudinal study of the changes in dental arches and dentition between early childhood to adulthood, 25-45 years, and 6 weeks to 45 years, observed the increased late incisor crowding in both arches, which was more pronounced in the mandibular anterior segment. Similar findings have been observed in untreated subjects by Lundstrom15, Sinclair23 and Little14. Hamid and Rahbar12 found significant relationship between arch dimensions and crowding rather than to tooth size in a Pakistani sample. Carter and McNamara8 also reported significant reduction in the upper and lower arch lengths with time. Nimkarn et al18, while studying records of 20 males and 20 females at the University of Pittsburgh by using their study casts, found that only males demonstrated significant correlation between intermolar arch width discrepancy and crowding.

Crowding may occur due to different reasons, for example growth, decrease in dental arch length, maturation, aging of dentition, mesial drift, soft tissue pressures and tooth morphology24. Sanin and Savara22 evaluated 150 children and reported that children without crowding in the
permanent dentition had larger anterior and posterior widths of the mandibular dental arch. Nordeval et al.\(^2\) compared 27 adults with ideal occlusion with slight mandibular crowding and reported no differences in inter-canine width between the groups. The objective of present study was to examine the relationship between arch length, arch width and arch perimeter in crowded and non-crowded arches, to compare right and left side of the lower arch on crowded and non-crowded groups and to define possible contributing factor in lower arch crowding.

### Subjects and Methods

The study groups consisted of 60 dental study models of the subjects aged 16 to 21 years. First group consisted of 30 pairs of dental study models with class I (normal) occlusion, selected from students the Dental Faculty Pristine, and they had a complete set of permanent teeth in both jaws (including erupted third molars) with normal occlusion, which had not undergone orthodontic treatment. The second group consisted of 30 pairs of study models with class I crowding, selected from patients seen at the Department of Orthodontics, Dental Faculty Clinical Centre in Pristine.

The inclusion criteria were:
1. complete lower dental arch
2. Angle Class I molar relationship
3. no artificial dental crowns and no anomalies of crown morphology
4. no orthodontics treatment in maxillary and mandibular arch.

All the measurements were made by a single investigator to eliminate inter-examiner variability, and were assessed at least twice.

The following lower arch dimensions were measured on the study models (Fig. 1):

1. **Length** - Measurements of arch length were made as defined by Lavelle and Foster, using Korkhaus callipers. These measurements were made in segments (anterior and posterior for right and left sides) and represented:
   a. distance between the mesial edge point of the medial incisor, and the middle point of the mesial surface of the lower first molar;
   b. distance between the mesial edge point of the medial incisor and the middle point of the canine distal surface;
   c. distance between the middle point of the mesial surface of the canine and the middle point of the distal surface of the lower first molar;
   d. distance between the mesial edge point of the lateral incisor and the middle point of the distal surface of the first premolar.

2. **Width** - Measurements of arch width were also made as defined by Lavelle and Foster, using Korkhaus callipers.
   a. distance between the canine cusps (inter-canine width);
   b. distance between the second premolars measured in the middle of the intercuspal fissure (inter-premolar width);
   c. distance between the buccal surfaces of the lower second molars + distance between the lingual second molar surfaces, divided by two (inter-molar width).

3. **Arch perimeter** was measured by Lundstrom method on the right and left side, using manual calliper with sharp points.

   S1 arch segment: first molar and second premolar of the right dental quadrant.
   S2 arch segment: first premolar and the canine of the right quadrant;
   S3 arch segment: lateral and medial right incisors;
   S4 arch segment: medial and lateral left incisors;
   S5 arch segments: canine and first premolar in the left quadrant;
   S6 arch segment: second premolar and first molar in the left quadrant.

### Statistical Analysis

Differences between these measurements of the lower arch “crowded” and “non-crowding” (right and left side) groups were made by Mann-Whitney U test (Z/U). Significance was determined by p<0.05.

### Results

Results related to differences in the measurements of the lower arch length between crowded and non-crowded groups, right and left sides, are shown in table 1. Values of arch length (a-d) on the right and left side were greater in non-crowded group; however, differences were significant for a on the right side and for b on the both sides.
Table 1. Differences of the measurements of lower arch length between crowding and non-crowding groups, right and left side

| Parameter | Right | Left |
|-----------|-------|------|
| a         | 736.50| 812.00| 793.00| 918.00|
| b         | 689.50| 1108.00| 658.50| 897.50|
| c         | 897.50| 1108.00| 884.00| 918.00|
| d         | 884.00| 918.00| 884.00| 918.00|

Differences of analyzed parameters for lower arch width between crowded and non-crowded groups are shown in table 2. As it can be seen, a significant difference was found for all 3 measured widths - inter-canine (a), inter-premolar (b) and inter-molar (c).

Table 2. Differences of the measurements of the lower arch width between crowded and non-crowded groups in the mandible

| Parameter | Crowded | Non-crowded |
|-----------|---------|-------------|
| a         | 546.00  | 1284.00     |
| b         | 660.50  | 1169.50     |
| c         | 581.00  | 1249.00     |

Differences of arch perimeters on the right and left sides (S1-S6) between crowded and non-crowded group are shown in table 3. Values of these segments were greater in crowded group in all relationships, but differences for segments S1, S2, S3, and S4 were not statistically significant. Segment S5 of the crowded group was significantly greater compared to non-crowded group, and segment S6 in the lower arch of the crowded group was significantly greater compared to the non-crowded group.

Table 3. Differences of the measurements of the lower arch perimeter between crowding and non-crowding groups (S1-S6)

| Parameter | Crowded | Non-crowded |
|-----------|---------|-------------|
| S1        | 1038.00 | 792.00      |
| S2        | 1026.50 | 803.50      |
| S3        | 957.00  | 873.00      |
| S4        | 1028.50 | 801.50      |
| S5        | 1044.00 | 786.00      |
| S6        | 1133.50 | 699.50      |

Table 4. Differences between measurements of the lower arch length and arch perimeter in the crowding group on the right and left side

| Parameters | Right | Left |
|------------|-------|------|
| a          | 823.00| 1007.00|
| b          | 940.00| 890.00|
| c          | 847.00| 983.00|
| d          | 850.50| 979.50|
| S1/ S6     | 793.00| 1037.00|
| S2/ S5     | 886.00| 944.00|
| S3/ S4     | 836.00| 994.00|
Differences between measurements of the lower arch length on the right and left side are presented in table 4. There were not significant differences between right and left side when the arch length and arch perimeter were measured in the crowding group.

Differences between measurements of the lower arch length and arch perimeter in non-crowding group on the right and left side are shown in table 5. Also, in non-crowding group, we could not find significant differences between these measurements between right and left side.

Table 5. Differences between measurements of the lower arch length and arch perimeter in the non-crowding group on the right and left side

| Parameters | Rank Sum right side | Rank Sum left side | U   | Z       | p       | Valid N right side | Valid N left side |
|------------|---------------------|--------------------|------|---------|---------|--------------------|-------------------|
| a          | 912.00              | 918.00             | 447.00 | -0.04   | 0.96    | 30                 | 30                |
| b          | 921.50              | 908.50             | 443.50 | 0.10    | 0.92    | 30                 | 30                |
| c          | 918.50              | 911.50             | 446.50 | 0.05    | 0.96    | 30                 | 30                |
| d          | 838.00              | 992.00             | 373.00 | -1.14   | 0.25    | 30                 | 30                |
| S1/ S6     | 908.00              | 922.00             | 443.00 | -0.10   | 0.92    | 30                 | 30                |
| S2/ S5     | 907.50              | 922.00             | 442.50 | -0.11   | 0.91    | 30                 | 30                |
| S3/ S4     | 915.00              | 915.00             | 450.00 | 0.00    | 1.00    | 30                 | 30                |

Discussion

Crowding is one of the causes of class I malocclusion. Arch form and arch dimensions are 2 important factors in case assessment, diagnosis and treatment planning. Forsberg\(^9\) found that the arch dimensions were more important factor for crowding than the tooth dimensions. Mills\(^17\) in a study of 230 males between 17 and 21 years of age, found a significant association between crowding of teeth and arch width. Furthermore, he stated that little variation existed between crown diameters of persons with and without mal-alignment. In investigations performed by Howe et al\(^13\) comparisons were made between crowded and non-crowded groups using study models. They indicated that arch dimension made a greater contribution to dental crowding than tooth size. McKeown\(^16\) in a study of 65 dental casts collected from subjects between 18 and 25 years of age, found that arch width and crowding were strongly correlated and that a narrow arch predisposed to crowding of teeth. This is an agreement with our study because in that age lower arch width in crowded group was narrow compared with non-crowded group, the difference being significant. It seems, therefore, that narrow arch predisposes to crowding of teeth.

Since the lower arch represents the basic foundation on which the occlusion would be built\(^14\), announcement about the form of the lower dental arch is of at most importance for orthodontists, even more than the maxillary one. Therefore in our study, all the parameters were measured and analyzed in the lower arch, especially when it comes to the importance of orthodontics treatment.

Some investigators\(^6,11\) suggest that other morphological characteristics, such as tooth shape and arch dimensions, play an important role in space discrepancies and these parameters have great implications in orthodontic diagnosis and treatment planning. In our study, we aimed to determine differences in non-crowded and crowded lower arches in terms of arch dimensions to better understand the morphological relationships of these variables with dental crowding.

Previous studies\(^13\) verified that arches with crowding were shorter than those without crowding, which was confirmed in our study where we observed that the arches of the crowded group were shorter in relation with non-crowded arches, but not significantly in all of the analyzed parameters of the arch length. According to Hamid and Rahbar\(^12\), arch length was found greater in non-crowded arches compared to crowded arches, and the differences were statistically significant (p<0.05). This is compatible with our findings, because in the non-crowding group the lower arch length was significantly greater than in the crowding group only for some of the analyzed parameters.

Furthermore, we have the arch perimeter greater in crowded group in relation to non-crowded group, but differences between the groups were not significant, except for segments S4 and S5 of the lower arch; therefore, according to our study, the arch length and arch perimeter of the lower arch are not dominant factors that contribute to lower arch crowding. It seems that the width of the lower arch contributes to crowding more as the differences between the 2 groups were significant.

In all the undertaken measurements, when we compared the right and left side of the arch length and arch perimeter of the crowding and non-crowding groups, we did not find significant differences between them.

The findings of our study may be important for orthodontic treatment planning of lower arch crowding correction, as it may have several possibly helpful points to overcome difficulties in orthodontics treatment.
Conclusions

Based on the results of our study, the following conclusions might be drawn:

A significantly greater difference was found between the crowded and non-crowded groups for inter-canine, inter-premolar, and inter-molar widths of the lower arch;

Arch length was greater in non-crowded arches as compared to crowded, but differences were not significant for all of the analyzed parameters;

Arch perimeter was greater in crowded group in relation to non-crowded group, but differences were not significant;

Non significant association was found between crowded and non-crowded arches when the right and left sides were compared.

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