Original Article

Correlation Between Dental Arch Width and Sagittal Dento-Skeletal Morphology in Untreated Adults

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Abstract
Objective: Dental arch form is one of the most important characteristics of dentition. However, this dimension usually receives less attention in diagnosis or treatment planning and orthodontic patients are traditionally classified with regard to their sagittal characteristics. The objectives of this study were to investigate if a relationship exists between the dental arch width (transverse dimension) and sagittal skeletal and dental parameters in orthodontic patients.
Materials and Methods: Dental casts and lateral cephalograms of 108 consecutive untreated Iranian patients (47 males and 61 females) between 16 and 31 years of age were evaluated. Arch width (AW) parameters including upper and lower inter-molar width (UIMW and LIMW) and upper and lower inter-canine width (UICW and LICW) were measured by a digital caliper. Sagittal parameters included SNA and SNB angle and Wits' appraisal obtained from lateral cephalograms in addition to upper and lower arch length (UAL and LAL) obtained from dental casts. The correlation between the aforementioned parameters was evaluated applying Pearson correlation coefficients. Molar and canine relationship according to Angle's classification was also recorded and the means of all parameters were compared between three occlusal relationship classes and two gender groups by means of two-way ANOVA.
Results: According to statistical analysis a significant positive correlation between sagittal parameters and arch width measures exists between SNA and UICW and between LICW and LAL. Upper and lower ICW were significantly correlated, the relationship between upper and lower IMW and between UAL and LAL were significant. Among sagittal measures, both UAL and LAL were correlated with the ANB angle. The means of arch width parameters in three occlusal classes were not significantly different.
Conclusion: The only significant correlation between arch width and sagittal parameters existed between UICW and SNA angle and between LICW and LAL. No significant difference of the arch width parameter was observed between the three occlusal classes.
Key Words: Dental Arch; Morphology; Correlation Study

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INTRODUCTION

Dental arch form is one of the most important aspects of dentition and understanding its descriptive characteristic is essential for orthodontists. Dental arches are dynamic and they undergo changes due to treatment intervention as well as growth and development [1,2]. Adequate knowledge of the factors affecting the shape and dimension of the dental arch is helpful in planning the treatment of malocclusion to achieve more successful results with regard to esthetics, function and stability [3]. By introduction of straight wire system and wide application of prefabricated arch wires, the importance of influencing factors on arch shape and dimension have become more crucial for both orthodontics and orthodontic appliance manufacturers. Several studies have addressed the relationship of arch form and dimension with other dentoskeletal features. Basically, the anterior cranial base may affect the form and position of the jaws and the dentoalveolar complex. According to Enlow and Hans, class II patients have a long narrow cranial base. This fact influences the form of the nasomaxillary complex that in turn results in long, narrow palates and dental arch of the upper jaw [4]. It is also believed that vertical growers have a narrower transverse dimension and horizontal growers have a wider one [5]. However, the results of investigations on more detailed characteristics of the dental arch are not conclusive. Considering the sagittal dimension, the reported results are more conflicting. Frohlich [6] and Shu et al. [7] found no significant difference in the absolute arch width of class II patients and normal class I children. However, Staly et al. [8] and Uysal et al. [9] compared adults with class II division 1 occlusion with normal class I patients and concluded that maxillary intercanine width, intermolar width and alveolar width were narrower in Class II division 1 patients than normal adults. In contrast with class II, few studies have addressed class III malocclusion. Kuntz et al. [10] reported no difference between the maxillary and mandibular intercanine width of class III and class I patients; 535 the maxillary intermolar width and alveolar arch width were narrower in class III patients. The same results were reported by two other studies, but their findings about mandibular intercanine and intermolar width were conflicting [11,12]. The majority of arch width studies that surveyed the relationship between arch dimension and types of malocclusion, applied angle classification by means of dental casts that may not be representative of the real skeletal malocclusion. Few investigations applied the patients' cephalometric radiographs to measure some skeletal parameters [13,14]. Moreover, most of the aforementioned researches presented a limited sample size that may be a causative factor for the discrepancy of reported results and also the applied landmarks for measuring arch width parameters were not identical. Although many studies compared maxillary and mandibular arch width parameters of different malocclusions with normal control groups, the correlation of maxillary arch width parameters and mandibular parameters within each group has not received much attention in the literature. This study was performed to evaluate the relationship between dental arch width parameters and sagittal skeletal and dental parameters in pretreatment records of orthodontic patients and to compare different malocclusion classes according to dental arch parameters.

MATERIALS AND METHODS

In this study with a descriptive design, the pretreatment study casts of 108 patients (47 males and 61 females with the mean age of 17.8 ± 3.8 and 18.2 ± 3.8 years, respectively) were selected from the Department of Orthodontics, Tehran University of Medical Sciences. All patients had lateral cephalometric radiographs.

The inclusion criteria for choosing dental casts were that all the permanent teeth should have been fully erupted (except the third molars), without any missing or supernumerary teeth, without any dento-facial deformities including alveolar cleft, no crowding in the posterior dental segment and no abrasion or defect on the buccal cusps of the first molars and tips of canines. The following measurements were taken from the casts by applying a digital caliper with the accuracy of 0.01 mm (Figure 1).

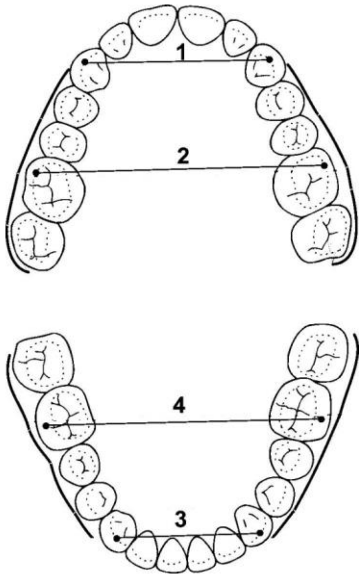

Fig1. 1: Upper intercanine width, 2: Upper intermolar width, 3: Lower intercanine width, 4: Lower intermolar width

- Upper intermolar width (UIMW): the distance between the tip of the mesiobuccal cusp of the right and left first maxillary molars
- Upper intercanine width (UICW): the distance between the tip of the right and left first maxillary canines
- Lower intermolar width (LIMW): the distance between the buccal fossa of the right and left first mandibular molars
- Lower intercanine width (LICW): the distance between the tip of the right and left first mandibular canines
- Upper arch lengh (UAL): the distance between the line that connects the mesial contacts of the maxillary first molars and the upper central incisors
- Lower arch lengh (LAL): the distance between the line that connects the mesial contacts of the mandibular first molars and the upper central incisors

In addition to dental cast measurement, cephalometric analyses were also performed. Cephalometric parameters comprised Sella-Nasion-A (SNA) angle, Sella-Nasion-B (SNB) angle and ANB angle. It was done by hand tracing. Measuring the arch width parameters and cephalometric angles was done by two examiners that were calibrated beforehand.

Twenty randomly selected dental casts and radiographs were examined by both examiners and the Cronbakh alpha for inter-examiner reliability was 0.81 for dental casts and 0.77 for cephalometric analysis. The correlation between arch-width measures (including LIMW, UIMW, LICW and UICW) and sagittal dental arch measures (UAL and LAL) and sagittal skeletal measures (SNA, SNB and ANB) was evaluated applying Pearson correlation coefficients (since the data were distributed normally). Then, patients were classified to Angles' class I, class II and class III classification according to the following criteria [15]:

Class I: bilateral class I molars and canines in centric occlusion relationship and class I skeletal relationship with ANB angle between 0 and 5° in cephalometric analysis Class II: bilateral class II molar relationship in centric occlusion (the mesial cusps of bilateral maxillary first molars were mesial to the centric groove of the corresponding mandibular first molars) and class II skeletal relationship with ANB angle > 5° in cephalometric analysis Class III: bilateral class III molar relationship in centric occlusion (the mesial cusps of bilateral maxillary first molars were distal to the centric groove of the corresponding mandibular first molars) and class III skeletal relationship with ANB angle < 0° in cephalometric analysis Subdivision casts (those in which the molar relationship was not identical on the right and left side) or the casts in which molar relationship was in contrast with ANB angle were excluded from this part of study. The means of all parameters of arch-width and arch-length that were considered in this study were compared in three occlusal relationship classes by means of two-way ANOVA test. All aforementioned parameters were also compared in males and females by two-way ANOVA.

RESULTS

One hundred and eight dental casts and cephalograms were evaluated. The mean, maximum, minimum and standard deviation of arch width parameters including LIMW, UIMW, LICW and UICW are demonstrated in Table 1. The sagittal parameters of dental arch including LAL and UAL in addition to skeletal sagittal parameters including SNB and SNA are also reported in Table 1.

According to Pearson correlation coefficients (ρ), among the measures of arch width, upper intermolar width had no significant correlation with UAL and SNA. No significant correlation was also found between LIMW and LAL (ρ =-0.022; p-value=0.818) and SNB (ρ =0.169; p-value=0.082).

The upper intercanine width was significantly correlated with SNA and SNB. Although UICW did not correlate with AL, the lower intercanine width correlated with LAL and UAL (Table 2).

Within the measures of arch width, UIMW was significantly correlated with LIMW (ρ = 0.562; p-value=0.00), UICW (ρ = 0.327; p-value =0.001) and LICW (ρ = 0.353; p-value =0.000). Similarly, LIMW was significantly correlated with LICW (ρ = 0.267; p-value =0.005) and UICW (ρ = 0.306; p-value =0.001) (Table 3).

Within the measures of sagittal dimension, SNA was not correlated with UAL (ρ = -0.054p-value = 0.581) and SNB was not correlated with LAL too (ρ =- 0.007; p-value = 0.942). However, SNB and ANB was significantly correlated with UAL (ρ = -0.300 and 0.369; p-value = 0.002 and 0.000, respectively) and LAL was correlated with ANB (p-value=0.033). The correlation between SNA and SNB was also significant (ρ = 0.702; p-value = 0.000) (Table 4).

When the patients were classified according to Angle’s classification, 50 patients were class I, 46 were class II and 12 were class III. The arch width parameters of each class are given in Table 5.

The mean of the upper arch length was 26.28, 27.02 and 24.88 in class I, II and III patients, respectively. The values of the lower arch length were 21.14, 22.63 and 20.79 in the same order. Since the interaction between gender and occlusal classes was not significant (Tables 5 and 6), the differences between arch parameters in three occlusal classes and two genders were analyzed by two-way ANOVA. No significant difference was seen between arch-width and arch-length parameters in each class; while the sagittal skeletal factors of SNB and ANB were significantly different. According to post-hoc analysis, there was significant difference regarding SNB between class III patients and the other two groups and ANB was different in all three groups (Tables 5 and 6). Comparing the results between male and female subjects, it was determined that 47 patients were male (mean age = 17.82 ± 3.8) and 61 were female (mean age = 18.21±3.7). The mean and standard deviation of transverse and sagittal parameters are given in Tables 5 and 6. All values of arch width and AL were relatively similar in both groups. The only significant difference between two genders was LIMW with higher values in males (p-value= 0.016). The skeletal sagittal parameters were also not different between the two genders.

DISCUSSION

The mean UICW observed in this study (34.08) was relatively similar to the results of some other studies that used cusp tip as landmark [5, 10, 16]. However, LICW (26.43) was larger [5,16]. LIMW and UIMW (Table 1) were a little less than previous reports [7, 16]. Comparison with many studies was not possible since they applied other landmarks to measure UIMW or LIMW. Our results indicated that the only correlation that existed between the arch width parameters and sagittal arch parameters were between UICW and SNA angle and between LICW and LAL (Table 2).

Table 1. Arch Width and Sagittal Parameters of the Patients

	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation (mm)
LIMW	34.9	61.58	47.73	4.87
UIMW	37.39	58.3	49.63	3.88
LICW	19.66	37.41	26.43	2.56
UICW	27.45	42.74	34.08	2.92
LAL	13.95	33.10	22.72	2.92
UAL	16.67	37.13	26.40	3.00
SNB	69.00	93.00	77.01	3.86
SNA	74.00	87.00	80.48	3.23

N=108

Table 2. Corelation Between Transverse and Sagittal Parameters According to Pearson Correlation Coefficients

	LAL	UAL	SNB	SNA	ANB
LIMW	-0.022	-0.056	0.169	0.053	-.160
UIMW	0.024	0.082	0.071	0.091	0.020
LICW	0.227*	0.256**	-0.021	0.078	0.145
UICW	0.158	0.072	0.221*	0.257**	0.015

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 3. Correlation Between Transverse Parameters According to Pearson Correlation Coefficients

	LIMW	UIMW	LICW	UICW
LIMW	1.000	0.562**	0.267**	0.306**
UIMW	0.562**	1.000	0.353**	0.327**
LICW	0.267**	0.353**	1.000	0.390**
UICW	0.306**	0.327**	0.390**	1.000

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation Between Sagittal Parameters According to Pearson Correlation Coefficients

	LAL	UAL	SNB	SNA	ANB
LAL	1	0.602**	-0.007	0.149	0.205*
UAL	0.602**	1	-0.300**	-0.054	0.369**
SNB	-0.007	-0.300**	1	0.702	-0.569
SNA	0.149	-0.054	0.702**	1	0.186
ANB	0.205*	0.369**	-0.569**	0.186	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 5. Comparison of Means of Arch Width and Arch Length Parameters of Patients Classified According to Angles' Classification Analyzed by One Way ANOVA

Gender	Class	LIMW Mean(SD) in mm	UIMW Mean(SD) in mm	LICW Mean(SD) in mm	UICW Mean(SD) in mm
male	I	49.25(4.01)	4985(3.88)	26.49(2.22)	33.98(2.94)
	II	49.20(4.17)	51.32(3.48)	27.07(2.47)	34.78(3.42)
	III	50.00(6.48)	49.61(6.65)	26.86(2.12)	36.04(3.22)
female	I	46.51(4.40)	49.21(2.94)	26.11(5.45)	33.35(2.63)
	II	46.41(5.45)	48.50(4.08)	26.21(1.83)	34.11(2.42)
	III	46.35(4.53)	51.27(1.14)	25.46(0.71)	33.36(099)
Gender (p value)*		0.016*	0.615	0.197	0.080
Class (p value)*		0.977	0.690	0.772	0.354
Interaction (p value)*		0.965	0.161	0.829	0.595

mm: millimeter, SD: standard deviation
*The mean difference is significant at the 0.05 level.

Table 6. Transverse and Sagittal Measures of the Dental Arch in Females and Males

Gender	LIMW Mean (SD) (mm)	UIMW Mean (SD) (mm)	LICW Mean (SD) (mm)	UICW Mean (SD) (mm)	LAL Mean (SD) (mm)	UAL Mean (SD) (mm)
male	I	21.47(2.28)	26.81(2.73)	76.76(3.83)	79.93(3.43)	3.17(1.32)
	II	23.29(3.25)	28.18(3.13)	75.89(2.58)	80.95(3.10)	4.83(2.41)
	III	20.30(1.64)	24.30(2.40)	81.18(3.23)	81.00(2.17)	-0.18(2.22)
female	I	21.01(3.06)	26.05(3.61)	77.27(3.03)	79.88(2.78)	2.52(2.05)
	II	21.96(2.80)	26.14(2.67)	75.42(3.31)	80.77(3.66)	5.35(3.69)
	III	22.10(1.64)	26.83(1.44)	83.86(10.06	82.66(6.65)	-1.00(4.35)
Gender (p value)		0.998	0.904	0.355	0.576	0.575
Class (p value)		0.056	0.285	0.000*+	0.178	0.000* ++
Interaction(p value)		0.304	0.121	0.472	0.732	0.372

mm: millimeter, SD: standard deviation
*The mean difference is significant at the 0.05 level.
+: According to Tukey Post hoc test, the difference between class I and III and between class II and III was significant (p=0.000) while the difference between class I and II was not (p=0.099)
++: According to Tukey Post hoc test, the difference between all three classes was significant (p=0.000)

This means that in the maxilla, arch length cannot be a predictive factor for arch width. Paulino et al. [17] found a very high correlation between ICW and arch length both for upper and lower arches and for males and females. However, they described arch length as the ideal line between every mesial and distal contact point of each permanent tooth from the mesial of the first molar to the same point on the opposite side. This definition was similar to arch perimeter.

Lower and upper IMW were also not correlated with sagittal skeletal parameters (SNA and SNB angle). This means that patients with a protruded maxilla or an upper jaw with a larger antero-posterior length do not necessarily have a wider dental arch in the molar region. Although the correlation between LICW and SNA and SNB was not significant, a significant correlation existed between UICW and SNA and SNB. In other words people with a larger SNA angle had a wider inter canine width, while people with a larger SNB do not necessarily have a wider mandibular dental arch. SNA is representative of the position and dimension of the maxilla in the antero-posterior direction and it is a part of the naso-maxillary complex that is directly influenced by the anterior cranial base [18]. However, SNB is an indicator of the mandible in the AP direction and it is affected by the dimension and position of the mandible. Thus, it is affected by the rotation of the mandible in relation to the anterior cranial base [19]. Rotation of the mandible is more variable and largely influenced by external factors such as environmental effects, breathing pattern, molar extrusion and rotation of the maxilla [20]. This fact is prominent in Table 5; ANOVA showed a significant difference between SNB angle in class I, II and III patients, while, SNA was almost similar in the three groups. Analysis of variance demonstrated no difference in any of the arch width measures between the three classes of occlusion. Arch length, either upper or lower, was also not significantly different. Our results were in consistent with Frohlich [6] and Al-Khateeb [21] who reported no significant difference between the arch width of class II children and normal class I. A very recent study conducted by Shu et al. [7] also found no significant difference in the maxillary and mandibular arch width and alveolar width between class II division 1 malocclusion and class I occlusion. However, they reported that the maxillary premolar and first molar were significantly more lingually tilted in class II division 1 than in class I, but they did not measure ICW in their study. Bishara et al. [22] compared the alveolar width in a study on growth trend and reported no differences in maxillary and mandibular ICW between samples with class II division 1 and normal subjects. On the other hand, Ball et al. [13] reported a significantly larger FA point intercanine width in class II division 1 samples compared with the class I samples, while the basal arch form that was measured by WALA ridge did not differ in the two groups. The same result was reported by Sayin and Turkhahraman [23]; whereas, Staley et al. [8] and Uysal et al. [9] and Huth et al. [16] stated that patients with class II division 1 malocclusion had a narrower maxillary ICW, IMW and alveolar width and mentioned the necessity of maxillary expansion therapy in the treatment of patients with class II malocclusion.

Regarding class III malocclusion, Kuntz et al. [10] compared the arch width of class III patients with that of class I patients with and without crowding. Maxillary and mandibular ICW were similar in the three groups, while maxillary IMW and alveolar arch width were narrower in class III and class I with crowding than normal class I patients who had no crowding. However, mandibular IMW was the same as in the two class I groups and larger than the class III group. Two other studies compared arch width of class III and normal occlusion.

They agreed that UIMW is narrower in class III group and UICW was similar in the two groups [11,12], although their results on the comparison of mandibular ICW and IMW were conflicting. Another study reported no significant difference in the upper and lower ICW and IMW among class III and normal patients [21].

In the current study, the correlation among various transverse parameters was assessed. As it is illustrated in Table 3, a relatively high correlation was found between UIMW and LIMW and between UICW and LICW. This finding emphasizes on the importance of coordination of the upper and lower arches in the molar region. An optimum buccal overjet should be maintained in the posterior segments too [24] and this should be taken into consideration while choosing prefabricated orthodontic archwires. A significant correlation between IMW and ICW was also found that confirms the literature that the human dental arch form follows a mathematical function [25, 26], although the exact formula is still open to dispute. About the relationship between sagittal parameters, the values of Table 4 indicated that the upper arch length was significantly correlated with the lower AL. meaning that the antero-posterior dimension of the upper and lower dental arches are correlated. Similarly, the antero-posterior skeletal dimension of the maxilla and the mandible were highly correlated with regard to the significant correlation between SNB and SNA (Table 4). Generally, this study could not find a significant relationship between all aspects of transverse and sagittal dimension. The relationship between the transverse dimension of the dental arch and the vertical dimension of craniofacial was not assessed in this study. Forster et al. in a study on 185 patients found a trend that the angle between the mandibular plane (MP) and anterior cranial base (SN) increased as the arch width decreased [5]. The correlation between arch width and other parameters such as crowding and divisions of class II has been investigated vastly; nevertheless, the results are not conclusive.

The reason for these controversies may arise by using different landmarks for measuring arch width, mismatching the surveyed population and other interfering factors.

For example about LIMW, we measured the distance between the buccal fossa of the right and left first mandibular molars similar to Huth et al. [16] and Sayin [23]; while, some investigators applied FA point [17], WALA point [7] or central pit [27] of the first molar.

Accordingly, further studies should be set up with harmonious designs in order to achieve a definite result about factors affecting the transverse dimension of the dental arch by considering the fact that transverse discrepancies are one of the major challenges that orthodontists face.

CONCLUSION

Within the limitation of this study we concluded that:

- A positive strong correlation existed between SNA angle and UICW but not UIMW. This means that patients with a higher SNA angle had a wider dental arch in the canine area, but not necessarily in the posterior area.
- In the mandible, LICW had a significant positive correlation with LAL, but not with SNB angle. LIMW was not correlated with any sagittal parameters.
- ICW may be a predictive factor for some sagittal parameters, but IMW cannot.
- There was no significant difference in arch width parameters between the three occlusal classes.
- No significant difference was detected between two gender groups except for LIMW.

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