Evaluation of the dental arch asymmetry in natural normal occlusion and Class II malocclusion individuals

Paulo Estevão Scanavini*, Luiz Renato Paranhos**, Fernando César Torres**, Maria Helena Ferreira Vasconcelos**, Renata Pilli Jóias*, Marco Antonio Scanavini***

Abstract

Objective: To verify the presence and degree of asymmetry of dental arches in Brazilian individuals with natural normal occlusion and Class II, Divisions 1 and 2 malocclusions. **Methods:** The study evaluated the symmetry of the maxillary and mandibular dental arches of 180 pairs of dental casts, divided into: Group I = 60 pairs of natural normal occlusion individuals; Group II = 60 pairs of Class II, Division 1 malocclusion individuals; and Group III = 60 pairs of Class II, Division 2 malocclusion individuals. A device was used to measure dental midline deviation and the canine tip in the dental arches (in degrees). It was also verified the distance of the upper canines from the palatal suture, intercanine distance, and anteroposterior upper and lower first molar position. **Results:** Dental arches of individuals from all groups presented asymmetry, regardless of the presence of malocclusion. Group I showed a lower asymmetry degree in relation to Groups II and III. The asymmetry in Groups II and III was similar. **Conclusion:** The dental arches of individuals with natural normal occlusion and with Class II, Division 1 and Division 2 malocclusions showed asymmetry. The asymmetry degree was higher in the mandibular dental arches than in the maxillary dental arches in all 3 evaluated groups.

Keywords: Dental arch. Abnormalities. Growth and development. Anatomy and histology. Malocclusion.

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* MSc in Orthodontics, Methodist University of São Paulo (UMESP).
** Professor, Orthodontics Graduate Program, UMESP.
*** PhD in Orthodontics, School of Dentistry, University of São Paulo (USP). Head of the Orthodontics Graduate Program, UMESP.

INTRODUCTION

The study of form and transverse dimensions of dental arches is of great relevance to orthodontists. Correcting skeletal and dental midlines, as well as coordinating the position of teeth in each side of the arch, lead to maximum intercuspation, correct function, stability of achieved results, anterior and facial dental aesthetics and reduced potential for temporomandibular joint dysfunction.[1]

The midpalatal suture and the center of the maxillary dental arch are almost coincident, validating the use of the suture as a symmetry axis.[2,3] Dental arch asymmetry can be caused by a combination of genetic[3,4] and environmental[3] factors, with skeletal, dental or functional repercussions.[4] In individuals with symmetric development, the slight differences between the right and left sides may be due to external environmental factors, such as: Thumb sucking, unilateral chewing, loss of contact due to cavities, extraction or trauma.[3] Children can also feature asymmetric dental arches,[5] and older individuals tend to have greater arch asymmetry, resulting from lifelong external environmental factors.[6]

Even symmetrical faces feature skeletal asymmetry, suggesting that soft tissues minimize the existing asymmetry. Dentoalveolar regions feature symmetry between the right and left sides, probably due to muscle balance of lingual and labial forces.[7]

It is rare to find a totally symmetric individual. Therefore, small asymmetries are regarded as normal.[8] Most individuals with normal occlusion may show almost coinciding midlines (deviation smaller than 1 mm), and many can have molar asymmetry greater than 1 mm in transversal and anteroposterior directions.[9] Dental midline deviations greater than 2 mm are easily detected by lay persons, and should therefore be considered when planning orthodontic treatments.[10]

Dental asymmetries and a variety of functional deviations can be treated with orthodontics, but significant asymmetries of facial structures may require orthopedic correction during growth period and/or later surgical treatment.[4]

Some authors have observed skeletal asymmetries both in normal occlusion and malocclusion groups,[2,11] with pre-orthodontic treatment patients showing more symmetrical arches.[2] Conversely, other authors revealed a tendency for posterior crossbite in individuals with malocclusion,[12] and a greater tendency towards dental arch asymmetries in individuals with Angle Class II and/or Class III malocclusions.[13,14] Other studies showed asymmetries in the dental arches of individuals with normal occlusion, in the passage from adolescence to adult age, further questioning the possibility of achieving post-treatment stability.[5]

The verification of dental arch asymmetries during diagnosis makes it possible to choose the appropriate mechanics for orthodontic treatment—for instance, whether to recommend extractions. When opting for tooth extractions, arch symmetry should be controlled throughout orthodontic movement.

In cases of dental arch asymmetry, therapy with asymmetric extractions can reduce complications resulting from patient compliance to the use of elastic bands, as well as reducing the length of orthodontic treatment. Atypical extractions can also benefit pre-surgery orthodontic preparation.[16]

Caution must be taken when planning orthodontic treatments, as there are cases when transversal asymmetry of dental arches is not corrected after orthodontic treatment, and orthodontic cases originate dental arches that are larger than those without extraction.[17]

There is great ethnic diversity among the Brazilian population, raising questions on the applicability of standards and measurements previously established in more homogenous populations. Based on that premise, the objective of this study was to evaluate the presence and degree of asymmetry of the maxillary and mandibular dental arches in Brazilian individuals with normal occlusion or Angle Class II, Divisions 1 and 2 malocclusion.

MATERIAL AND METHODS

Material

The experimental group consisted of plaster cast models of mandibular and maxillary dental arches from 80 patients with ages varying between 12 and 21 years. The experimental group was composed using the following selection criteria: a) Permanent dentition, with exception of third molars; b) Brazilian ethnicity; c) Not subjected to any orthodontic intervention. They were then divided into three groups:

» Group 1: 60 pairs of models from individuals with natural normal occlusion, featuring at least 4 of Andrews' 6 keys to occlusion.
» Group 2: 60 pairs of models from individuals with Angle Class II, Division 1 malocclusion.
» Group 3: 60 pairs of models from individuals with Angle Class II, Division 2 malocclusion.

The plaster models are part of the collection belonging to the Orthodontics Graduate Program of the Methodist University of São Paulo (UMESP), São Bernardo do Campo/SP, Brazil.

Methods

Model measurements were obtained from an original device, developed specifically to analyze dental arch asymmetries. It was conceived and designed at UMESP, in the Orthodontics Department, manufactured in steel and aluminum. A millimeter ruler and metallic protractor were adapted to obtain measurements. The models were positioned in a delineator base (used in the manufacture of removable partial prostheses) fixed in the base of the appliance using a screw manufactured specifically for that purpose (Fig 1).

The maxillary model midline was determined by marking points over the midpalatal suture, from the incisive papilla to the most visible posterior landmark.[5,18] By connecting these points, the symmetry axis is obtained, which if prolonged anteriorly up to the incisal edge of the maxillary incisor determined point As (anterior-superior), and posteriorly, up to the posterior surface of the maxillary model, determining point Ps (posterior-superior), as shown in Figure 2.

To determine the mandibular midline, the midline projection obtained in the maxillary dental arch was used, according to Alavi.[19] The maxillary midline was transferred to the mandibular model, using the As and Ps reference points.

The models, properly cropped, were placed in occlusion, so that their posterior surfaces coincided in the same place. Landmark Ps of the maxillary model was transferred onto the mandibular model using a squared ruler, positioned perpendicular to the base of the mandibular model. This defined landmark Pi (posterior-inferior) in the mandibular model (Fig 3).

Next, using the squared ruler equally positioned anteriorly to the models, coinciding with point As of the maxillary model, landmark Ai (anterior-inferior) was marked in the mandibular model (Fig 4). The assessment of points Ai and Pi made it possible to determine the mandibular midline (Fig 5). Thus, two angular measurements and three linear measurements were made in each of the plaster cast models.

To assess the reliability of the obtained measurements, they were repeated in 20 pairs of models selected at random. These measurements were made 15 days after obtaining the initial data.

Angular measurements performed

» Midline deviation, in degrees (MD): The reference used to position the models on the device was the midpalatal suture. The positioning, in degrees, of the maxillary and mandibular midline in relation to the midpalatal suture was measured using the protractor in the device, as shown in Figures 6 and 7.
» Positioning of canines in the dental arches, in degrees (PC): The reference point in the

FIGURE 1 - Measuring device with models in position: frontal view (**A**), posterior view (**B**).

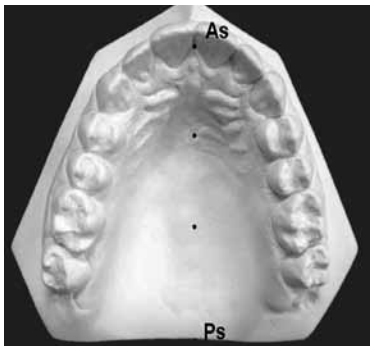


FIGURE 2 - Determining the maxillary midline (points As and Ps).

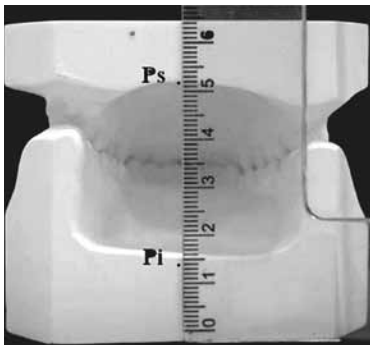


FIGURE 3 - Transferring point Ps to the mandibular model (obtaining point Pi).

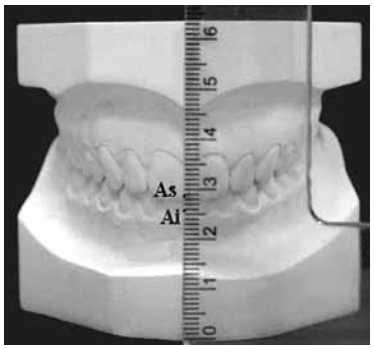


FIGURE 4 - Transferring point As to the mandibular model (obtaining point Ai).

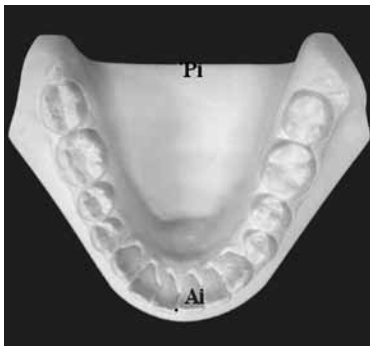
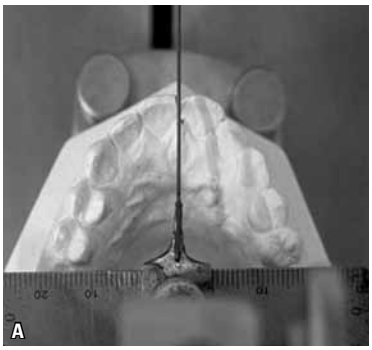


FIGURE 5 - Determining the mandibular midline (points Ai e Pi).

canines was the cusp tip. The positioning, in degrees, of right and left maxillary and mandibular canines in relation to the midpalatal suture, was measured using the protractor in the device (Fig 8).

Linear measurements performed

» Distance of right and left canines in relation to the midpalatal suture (DC): The cusp tip was used as reference to measure the distance from the maxillary and mandibular



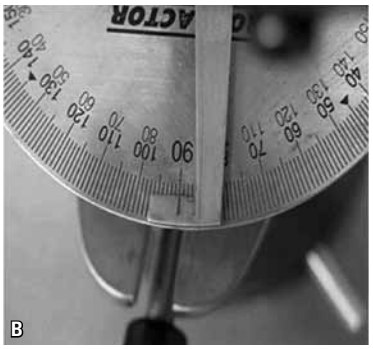


FIGURE 6 - Model positioned with the protractor in the zero position over the palatine raphe (**A**); protractor in the 90º position – initial position (**B**).

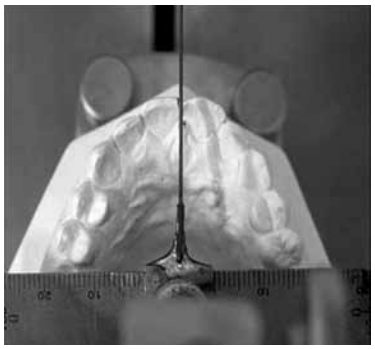
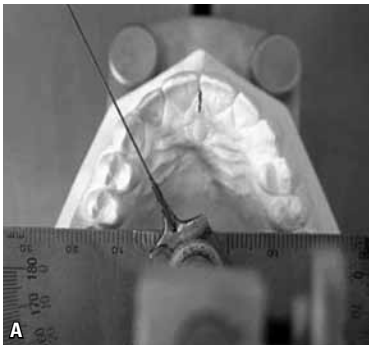


FIGURE 7 - Model positioned with the hand over the dental midline.



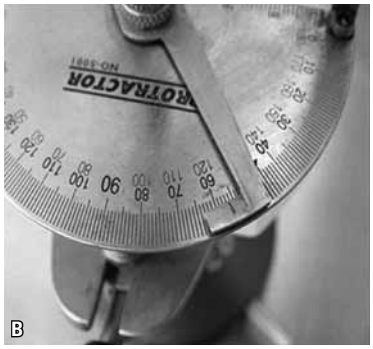
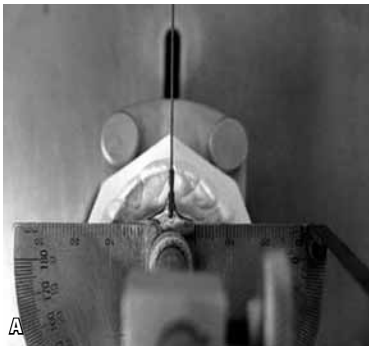


FIGURE 8 - Model positioned with the hand over the cusp of the right maxillary canine (**A**); protractor pointing the position of the right maxillary canine at 33.5º (**B**).



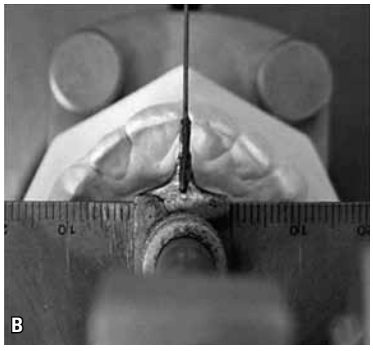


FIGURE 9 - Model positioned for measurement of DC (right and left) and ICD (**A**); close-up view of the model and ruler used to measure DC and IDC (**B**).

canines to the midpalatal suture (Fig 9).

» Intercanine distance (ICD): The cusp tip of canines was used as reference point to measure intercanine distance, in the maxillary and mandibular models (Fig 9).

» Position of the maxillary and mandibular first molars, in anteroposterior direction (PM): The distance was measured longitudinally from the mesial marginal crest of the molar positioned more distally to the mesial marginal crest of opposite side molar, as shown in Figures 10 and 11.

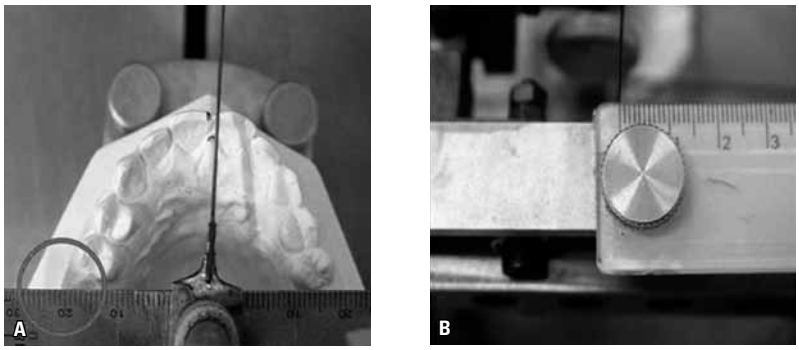


FIGURE 10 - Model positioned evidencing a more mesial positioning of the right-side maxillary first molar, in relation to its left-side counterpart (**A**); ruler recording the positioning of the right-side maxillary first molar at the zero position (**B**).

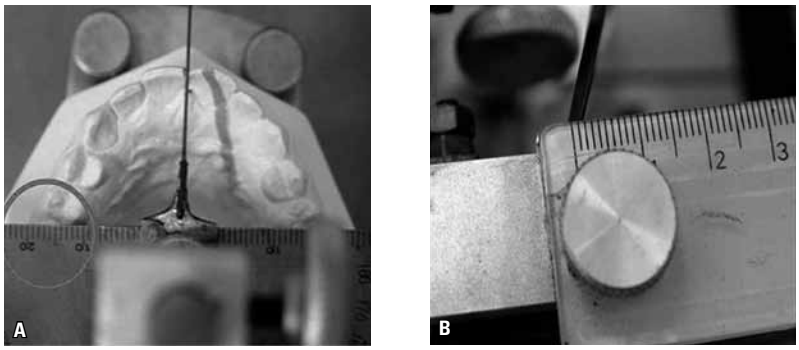


FIGURE 11 - Device positioned at the level of the mesial marginal crest of the right-side maxillary first molar (**A**); ruler recording a more mesial positioning of the right-side maxillary first molar by 1.5 mm, in relation to its left-side counterpart (**B**).

RESULTS

In order to verify intra-examiner systematic error, the paired t-test was used; to determine casual error, Dahlberg's error formula was applied. The comparison of studied measurements among groups was done using ANOVA. Whenever it indicated a statistically significant difference, Tukey's test was applied for multiple comparisons. For statistical calculations of measurements MD and PM, left-side deviations were recorded as negative and right-side deviations as positive. The measurements marked as "_dif" refer to the difference between right and left sides. Measurements marked as "_abs" refer to the absolute value (positive) of measurements, which can oscillate between negative and positive, in order to analyze the level of deviation, regardless of direction (Tables 1 to 4). To verify the correlations between measurement MD and PC_dif, DC_dif and PM, Pearson's correlation coefficient was used (Table 5). Tests were executed in Statistica for Windows 5.1 software, with significance level of 5%.

DISCUSSION

In evaluating dental midline deviation on the maxillary arch, a lower value was observed for group 1, followed by groups 2 and 3. There was a statistically significant difference between groups 1 x 2 and 2 x 3 for MD; and 1 x 3 for MD_abs. In the mandibular arch, group 1 continued to show lower values, but group 2 showed higher values than group 3. There was a statistically significant difference between groups 1 x 2 and 1 x 3 for MD_abs, with no statistically significant difference be-

TABLE 1 - Mean, standard deviation and Analysis of Variance, for comparison of measurements among the three groups, regardless of gender (n=180).

Arch	Measurement	Normal occlusion		Class II-1		Class II-2		F	p
		mean	SD	mean	SD	mean	SD		
Maxillary	MD	-0.24	0.88	-0.28	1.49	0.53	1.70	6.46	0.002*
	MD_abs	0.43	0.80	0.92	1.21	1.10	1.40	5.40	0.005*
	PC_right	34.11	1.48	32.26	2.15	33.61	2.15	14.46	0.000*
	PC_left	34.57	1.49	33.07	2.43	33.91	2.13	8.03	0.000*
	PC_dif	-0.46	1.67	-0.81	2.42	-0.30	2.99	0.69	0.502
	PC_dif_abs	1.01	1.40	1.99	1.58	1.92	2.31	5.51	0.005*
	DC_right	17.54	1.09	17.13	1.61	17.91	1.80	3.94	0.021*
	DC_left	17.19	1.04	16.64	1.50	16.82	1.24	2.99	0.053
	DC_dif	0.35	1.20	0.49	1.62	1.09	1.95	3.57	0.030*
	DC_dif_abs	0.78	0.97	1.07	1.30	1.41	1.73	3.14	0.046*
	ICD	34.73	1.76	33.76	2.65	34.72	2.40	3.55	0.031*
	PM	-0.20	1.18	-0.27	1.14	-0.18	1.86	0.06	0.945
	PM_abs	0.87	0.81	0.78	0.87	1.32	1.32	4.70	0.010*
Mandibular	MD	-0.13	1.38	0.81	2.55	0.32	2.47	2.70	0.070
	MD_abs	0.96	0.99	1.94	1.82	1.70	1.81	6.23	0.002*
	PC_right	28.66	1.57	28.63	4.14	28.98	2.75	0.25	0.781
	PC_left	28.49	1.87	27.37	2.67	27.71	2.02	4.07	0.019*
	PC_dif	0.17	2.30	1.26	5.30	1.27	3.80	1.51	0.225
	PC_dif_abs	1.77 a	1.46	4.24 b	3.38	3.12 c	2.49	13.98	0.000*
	DC_right	12.88	0.80	13.05	1.81	12.73	1.38	0.78	0.462
	DC_left	13.50	0.97	13.27	1.52	13.25	1.45	0.64	0.529
	DC_dif	-0.62	1.11	-0.22	2.58	-0.52	2.01	0.63	0.536
	DC_dif_abs	1.00	0.78	1.89	1.75	1.52	1.40	6.40	0.002*
	ICD	26.38	1.39	26.33	2.12	25.98	1.99	0.81	0.448
	PM	-0.02	1.38	-0.20	1.84	0.20	1.97	0.79	0.456
	PM_abs	1.12	0.79	1.37	1.23	1.57	1.19	2.57	0.080

* statistically significant difference (p<0.05).

tween MD averages. With regard to MD_abs, it was noticed that dental midline deviation values were higher for the left side in groups 1 and 2, represented by the negative sign, and higher for the right side in group 3, represented without any sign for positive value. In the mandibular arch, the average of values for the left side was higher only in group 1. These negative values for MD mean that the average for left-side midline deviation values was higher than the average deviation values for the right side, which in the final average show as negative, representing a greater frequency of deviation to the left side.

With regard to the positioning of canines, in degrees, group 1 showed a smaller difference between the right and left sides than the other groups, representing a lower degree of asymmetry in both arches. In the maxillary arch, group 2 showed higher values for PC_dif and PC_dif_abs; statistically significant values were found only for

TABLE 2 - Mean, standard deviation and Tukey's test for comparison of measurements between groups 1 and 2, regardless of gender (n=180).

Arch	Measurement	Normal occlusion		Class II-1		
		mean	SD	mean	SD	p
Maxillary	MD	-0.24	0.88	-0.28	1.49	>0.05
	MD_abs	0.43	0.80	0.92	1.21	>0.05
	PC_right	34.11	1.48	32.26	2.15	<0.05*
	PC_left	34.57	1.49	33.07	2.43	<0.05*
	PC_dif	-0.46	1.67	-0.81	2.42	>0.05
	PC_dif_abs	1.01	1.40	1.99	1.58	<0.05*
	DC_right	17.54	1.09	17.13	1.61	>0.05
	DC_left	17.19	1.04	16.64	1.50	>0.05
	DC_dif	0.35	1.20	0.49	1.62	>0.05
	DC_dif_abs	0.78	0.97	1.07	1.30	>0.05
	ICD	34.73	1.76	33.76	2.65	<0.05*
	PM	-0.20	1.18	-0.27	1.14	>0.05
	PM_abs	0.87	0.81	0.78	0.87	>0.05
Mandibular	MD	-0.13	1.38	0.81	2.55	>0.05
	MD_abs	0.96	0.99	1.94	1.82	<0.05*
	PC_right	28.66	1.57	28.63	4.14	>0.05
	PC_left	28.49	1.87	27.37	2.67	>0.05
	PC_dif	0.17	2.30	1.26	5.30	>0.05
	PC_dif_abs	1.77	1.46	4.24	3.38	<0.05*
	DC_right	12.88	0.80	13.05	1.81	>0.05
	DC_left	13.50	0.97	13.27	1.52	>0.05
	DC_dif	-0.62	1.11	-0.22	2.58	>0.05
	DC_dif_abs	1.00	0.78	1.89	1.75	<0.05*
	ICD	26.38	1.39	26.33	2.12	>0.05
	PM	-0.02	1.38	-0.20	1.84	>0.05
	PM_abs	1.12	0.79	1.37	1.23	>0.05

* statistically significant difference (p<0.05).

PC_dif_abs between groups 1 x 2 and 1 x 3. The average of PC_dif values was higher for the left side than for the right. In the mandibular arch, groups 2 and 3 showed almost similar values for PC_dif. For PC_dif_abs, however, group 2 showed higher values; statistically significant values among the three groups were found only for PC_dif_abs. The average for PC_dif values was higher for the right side than for the left. Regardless of malocclusion, the values for differences between the positioning of right- and left-side canines were higher in the mandibular than in the maxillary arch, with exception of PC_dif for group 1. As with the analysis of midline deviation, the mandibular arch showed a higher degree of asymmetry than its maxillary counterpart.

The distances from the right and left canines to the palatine raphe, in millimeters, were measured as well. Group 1 showed lower values for that difference, between the right and left sides,

TABLE 3 - Mean, standard deviation and Tukey's test for comparison of measurements between groups 1 and 3, regardless of gender (n=180).

Arch	Measurement	Normal occlusion		Class II-2		p
		mean	SD	mean	SD	
Maxillary	MD	-0.24	0.88	0.53	1.70	<0.05*
	MD_abs	0.43	0.80	1.10	1.40	<0.05*
	PC_right	34.11	1.48	33.61	2.15	>0.05
	PC_left	34.57	1.49	33.91	2.13	>0.05
	PC_dif	-0.46	1.67	-0.30	2.99	>0.05
	PC_dif_abs	1.01	1.40	1.92	2.31	<0.05*
	DC_right	17.54	1.09	17.91	1.80	>0.05
	DC_left	17.19	1.04	16.82	1.24	>0.05
	DC_dif	0.35	1.20	1.09	1.95	<0.05*
	DC_dif_abs	0.78	0.97	1.41	1.73	<0.05*
	ICD	34.73	1.76	34.72	2.40	>0.05
	PM	-0.20	1.18	-0.18	1.86	>0.05
	PM_abs	0.87	0.81	1.32	1.32	<0.05*
Mandibular	MD	-0.13	1.38	0.32	2.47	>0.05
	MD_abs	0.96	0.99	1.70	1.81	<0.05*
	PC_right	28.66	1.57	28.98	2.75	>0.05
	PC_left	28.49	1.87	27.71	2.02	>0.05
	PC_dif	0.17	2.30	1.27	3.80	>0.05
	PC_dif_abs	1.77	1.46	3.12	2.49	<0.05*
	DC_right	12.88	0.80	12.73	1.38	>0.05
	DC_left	13.50	0.97	13.25	1.45	>0.05
	DC_dif	-0.62	1.11	-0.52	2.01	>0.05
	DC_dif_abs	1.00	0.78	1.52	1.40	>0.05
	ICD	26.38	1.39	25.98	1.99	>0.05
	PM	-0.02	1.38	0.20	1.97	>0.05
	PM_abs	1.12	0.79	1.57	1.19	>0.05

* statistically significant difference (p<0.05).

than the other groups, with exception of DC_dif, which represented the highest value for the average of group 1. Even so, this group again showed a lesser degree of asymmetry of dental arches. In the maxillary arch, group 3 featured higher averages for both DC_dif and DC_dif_abs, with statistically significant values between groups 1 x 3 and 2 x 3 for both variables. And, contrary to PC_dif, the values of averages for DC_dif were higher for the right side as compared to the left in this arch.

In the mandibular arch, group 1 showed higher values for DC_dif, followed by group 3, with group 2 featuring the lowest averages, with no statistically significant difference among groups for this variable. Averages were higher for the left side than for the right in this arch. For DC_dif_abs, the highest values were obtained by group 2, and the lowest by group 1; statistically significant differences were found only between groups 1 x 2, in this arch.

TABLE 4 - Mean, standard deviation and Tukey's test for comparison of measurements between groups 2 and 3, regardless of gender (n=180).

Arch	Measurement	Class II-1		Class II-2		p
		mean	SD	mean	SD	
Maxillary	MD	-0.28	1.49	0.53	1.70	<0.05*
	MD_abs	0.92	1.21	1.10	1.40	>0.05
	PC_right	32.26	2.15	33.61	2.15	<0.05*
	PC_left	33.07	2.43	33.91	2.13	>0.05
	PC_dif	-0.81	2.42	-0.30	2.99	>0.05
	PC_dif_abs	1.99	1.58	1.92	2.31	>0.05
	DC_right	17.13	1.61	17.91	1.80	<0.05*
	DC_left	16.64	1.50	16.82	1.24	>0.05
	DC_dif	0.49	1.62	1.09	1.95	>0.05
	DC_dif_abs	1.07	1.30	1.41	1.73	>0.05
	ICD	33.76	2.65	34.72	2.40	>0.05
	PM	-0.27	1.14	-0.18	1.86	>0.05
	PM_abs	0.78	0.87	1.32	1.32	<0.05*
Mandibular	MD	0.81	2.55	0.32	2.47	>0.05
	MD_abs	1.94	1.82	1.70	1.81	>0.05
	PC_right	28.63	4.14	28.98	2.75	>0.05
	PC_left	27.37	2.67	27.71	2.02	>0.05
	PC_dif	1.26	5.30	1.27	3.80	>0.05
	PC_dif_abs	4.24	3.38	3.12	2.49	<0.05*
	DC_right	13.05	1.81	12.73	1.38	>0.05
	DC_left	13.27	1.52	13.25	1.45	>0.05
	DC_dif	-0.22	2.58	-0.52	2.01	>0.05
	DC_dif_abs	1.89	1.75	1.52	1.40	>0.05
	ICD	26.33	2.12	25.98	1.99	>0.05
	PM	-0.20	1.84	0.20	1.97	>0.05
	PM_abs	1.37	1.23	1.57	1.19	>0.05

* statistically significant difference (p<0.05).

With regard to intercanine distance, a statistically significant difference was observed only in the maxillary arch, between groups 1 x 2. This difference is not relevant from a clinical standpoint. As shown in another work,[12] intercanine distance in the maxillary arch showed higher values in group 1 than in the other groups, while in the mandibular arch the groups showed similar values.

Molar position, in the anteroposterior direction, was evaluated comparing the molar from one side to its opposite side counterpart. In the maxillary arch, the averages of variation in position of these teeth were higher for left-side molars in the three groups, and there was no statistically significant difference in PM among the groups. For PM_abs, there were statistically significant differences among groups 1 x 3 and 2 x 3. In the mandibular arch, there was

TABLE 5 - Pearson's correlation coefficient between MD and measurements PC_dif, DC_dif and PM.

Group	Arch	Measurement	r	p
Normal	Maxillary	PC_dif	0.58	0.000*
		DC_dif	0.35	0.006*
		PM	-0.29	0.022*
	Mandibular	PC_dif	0.71	0.000*
		DC_dif	0.78	0.000*
		PM	-0.60	0.000*
Class II-1	Maxillary	PC_dif	0.46	0.000*
		DC_dif	0.43	0.001*
		PM	0.13	0.328
	Mandibular	PC_dif	0.84	0.000*
		DC_dif	0.67	0.000*
		PM	-0.55	0.000*
Class II-2	Maxillary	PC_dif	0.27	0.037*
		DC_dif	0.54	0.000*
		PM	-0.34	0.008*
	Mandibular	PC_dif	0.82	0.000*
		DC_dif	0.77	0.000*
		PM	-0.61	0.000*

* statistically significant correlation (p<0.05).

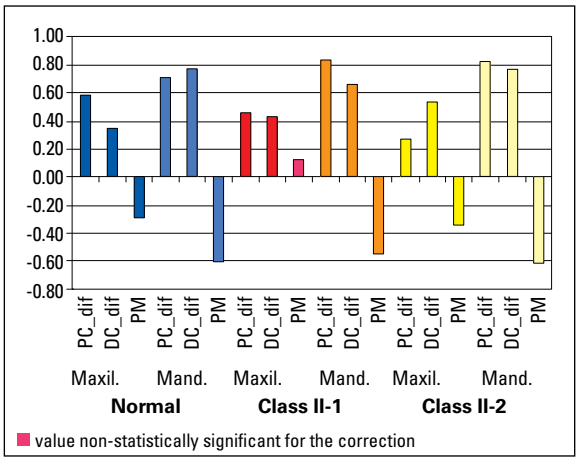


FIGURE 12 - Pearson's correlation between MD and measurements PC_dif, DC_dif and PM, in all three studied groups.

no statistically significant difference among the three groups, either for PM or PM_abs. In groups 1 and 2, PM values were higher for left-side molars, while in group 3 they were higher for the right side.

Corroborating the works of other authors,[2-5,8,9] individuals with natural normal occlusion (group 1) showed dental arch asymmetry, even if in a lesser degree than individuals with Angle Class II, Division 1 malocclusion (group 2) and Angle Class II, Division 2 malocclusion (group 3).

Although group 1 showed a smaller degree of asymmetry than the other two groups, a small difference was noticed between the degrees of asymmetry shown by groups 2 and 3; in other words, the results do not show an expressive difference, clinically speaking, among the measured variables, when comparing only groups 2 and 3. This indicates a greater degree of asymmetry for groups with malocclusion, in agreement with other authors.[13]

As in other research studies,[9,11,13,14] the degree of asymmetry of the mandibular dental arch was greater than its maxillary counterpart, for all three groups, regardless of the presence or not of malocclusion.[12]

To facilitate the interpretation of the analysis of asymmetry degree of dental arches, Pearson's correlation test was also performed to evaluate the MD ratio and measurements for PC_dif, DC_dif and PM.

Pearson's correlation was statistically significant among the 3 measurements (PC_dif, DC_dif and PM) and MD in all groups and arches, except for measurement PM in Angle Class II, Division 1 malocclusion for the maxillary arch (Fig 12).

The significant correlations were directly proportional for measurements PC_dif and DC_dif and inversely proportional for measurement PM. A higher correlation value could also be observed in the mandibular arch, when compared to the correlation in the maxillary arch.

The results of Pearson's correlation analysis revealed that the occurrences of MD, PC_dif and DC_dif were in the same direction, whereas for MD and PM, they were in opposite directions. This means that whenever the midline deviation

was towards the right side, the left-side molar was more mesial in relation to the right-side molar and vice-versa, in both arches.

With regard to the maxillary arch of group 2, factors such as tooth rotation and more severe crowding, found in the entire group, can explain the fact that this correlation is different than the other groups only in this arch of this group.

Dental arch asymmetry is a widely discussed subject in orthodontic literature, from its possible causes (such as heredity,[3] chewing[3,6,7] and posture[3,6] habits, early tooth loss and agenesis with resulting movement of adjacent teeth[3,4,17]) to the several different diagnostic resources[4,10,16,17] and treatment possibilities[1,10,16,17] in the first phases of orthodontic mechanics, aiming for a successful orthodontic treatment resulting in an occlusion with better post-treatment stability. This stability also deserves special attention, because it is questioned over time, as individuals reach adult age.[1,2,6,15,16,17]

This study introduced a new methodology, with measurements in plaster cast models, to analyze the asymmetry of dental arches. The obtained results will provide important data that can be used by clinical professionals and researchers in orthodontics, both in the diagnosis and planning or new cases to be treated, as in devising new research studies.

CONCLUSIONS

After a judicious analysis of the applied methodology and the results obtained in this study, it can be concluded that:

1) Asymmetry in the dental arches was found in all individuals, regardless of the presence of malocclusion.
2) Individuals with natural normal occlusion showed a smaller degree of asymmetry than individuals with Angle Class II, Division 1 and Angle Class II, Division 2 malocclusions, and the latter two featured similar degrees of asymmetry.
3) The degree of asymmetry in mandibular dental arches was greater than in maxillary dental arches for all 3 evaluated groups.
4) The direction of midline deviation showed a correlation directly proportional to the difference in position of the canines and to the difference in the distances from the canines to the palatine raphe.
5) The direction of midline deviation showed a correlation inversely proportional to the side of the molar positioned most mesially, in both arches of all three groups, with exception of the maxillary arch in group 2 (Angle Class II, Division 1).

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Contact address
Paulo Estevão Scanavini
Rua Antonio Pereira de Camargo, 129 – Centro
Zip code: 13.800-033 – Sumaré/SP, Brazil
E-mail: pauloscana@yahoo.com.br