Longitudinal evaluation of dental arches individualized by the WALA ridge method

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Abstract

Introduction: The mandibular arch form is considered one of the main references among the diagnostic tools because the maintenance of this arch form and dimension is an important factor for stability of orthodontic treatment. **Objectives:** to evaluate the changes in mandibular intercanine and intermolar widths during orthodontic treatment and 3 years of post treatment, in which the WALA ridge was used for individualization of the mandibular arch form. **Methods:** The sample comprised 20 patients (12 women and 8 men), with a mean age of 20.88 years. The dental casts of the initial, final and post-treatment evaluations were used for measurement of the intercanine and intermolar distances in the center of the facial surface of the clinical crown and in the width of the WALA ridge. Data were analyzed by means of ANOVA test followed by Tukey test (p<0.05). **Results:** There was a statistically significant difference in intercanine and intermolar distances among the three stages evaluated. These distances increased significantly with treatment, and presented a reduction in the post-treatment period, however not reaching the initial values. **Conclusions:** the WALA ridge method used in this study for construction of the individualized diagrams and for measurement of the intercanine and intermolar distances was shown to be valuable, allowing the individualization of the dental arches and favoring the post-treatment stability.

Keywords: Malocclusion. Angle Class I. Orthodontics. Relapse.

INTRODUCTION AND LITERATURE REVIEW

The purpose of orthodontics is to correct malocclusions, and place the teeth in their ideal positions and in equilibrium with their bony bases. Esthetics and function is enhanced provided that the periodontal tissues and support structures remain healthy. Furthermore, the long term success and stability will depend on precise diagnosis and planning and well used mechanics. During preparation of the treatment plan it is important to observe the morphology of the dental arch of each patient, since respect for its individuality

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will avoid periodontal problems, such as gingival retractions, instability and deficiencies in the esthetic results.[11] The form of the mandibular dental arch is considered one of the main references during treatment, as its maintenance is an important factor for the stability of orthodontic treatment.[20]

In an ideal occlusion, the teeth are positioned in the greatest possible degree of harmony with their bony bases and with the surrounding tissues. Thus, preservation of the form and dimensions of the dental arches must be one of the first objects of orthodontic treatment. Various factors may influence the morphology of the dental arches, such as the facial type, genetics, type of occlusion, musculature and ethnicity. The mandibular canines and molars are considered determinant factors in the arch width and movements of incisors in the buccal direction should be avoided.[18]

Dental arch form studies began in 1889 with Bonwill,[6] who developed the first diagram which was used in orthodontics by other researchers. On the basis of his postulations, Hawley[13] constructed a diagram denominated Bonwill-Hawley, for orthodontic purposes. From then onwards, various diagrams were drawn with the aim of helping in the construction of metal arches used during treatment. In addition to form, the dimension of the dental arch was also a reason for concern.[8,11,16] It is known that when alterations are made in the distance between the canines and molars during treatment, there is a great tendency towards relapse.[19,25]

Andrews and Andrews[2] suggested the use of an anatomic reference such as a parameter with the object of centralizing the roots of teeth in the basal bone, which they denominated the WALA ridge, of which the initials mean Will Andrews + Lawrence Andrews. The WALA ridge is the strip of soft tissue immediately above the mucogingival junction of the mandible, at the level of the line that passes through the centers of rotation of the teeth or close to it, and is exclusive to the mandible. The mandibular dental arch will present this

requirement and will be with the ideal form when the midpoint of the vertical axes of the facial surfaces ("FA" points) of the central and lateral incisors, canines, 1st premolars, 2nd premolars, 1st and 2nd molars are 0.1 mm; 0.3 mm; 0.6 mm; 0.8 mm; 1.3 mm; 2.0 mm and 2.2 mm, respectively, from the WALA ridge. In the authors' perception, after eruption the crowns of the permanent teeth are subject to alterations as a result of "environmental" forces. These forces may tip the teeth around their centers of rotation. Hypothetically, when this occurs, the centers of rotation of the mandibular teeth, which remain in the center of the basal bone, do not alter, however, the crowns and root apexes may be altered. Therefore, the center line of rotation (hypothetical line that passes through the horizontal center of rotation of each tooth) would be the line that best conserves the original and supposedly ideal form of the dental arch. Thus, the ideal form of the maxillary and mandibular dental arches would be dictated by the form of the basal bone of the mandible. When the form of the mandibular dental arch is correct, the wire that unites the bracket slots of "straight-wire" brackets should have the same shape as that of the WALA ridge.[17]

By means of the "Six Elements of Facial Harmony", defined as a classification of the objectives and goals of orthodontic treatment, Andrews and Andrews[3] determined that Element 1 referred to the form and length of the dental arches. Based on the premise that the form and length of the dental arches should be individual for each patient, the goals established for a correct dental arch would be: The root apex of the long axis of each tooth should be centralized on the basal bone and the crown should present the correct inclination; the distance from point FA to the WALA ridge, within the nominative values; the central line of the dental arch is equal to the sum of the mesiodistal diameters of the crowns at the contact points and the depth of the central line of the mandibular arch should be between 0 and 2.5 mm.

The WALA ridge concept would keep a close relationship with the "Six Keys of Perfect Occlusion"[1] and was consolidated as a real and true reference for determining the individual morphology of the dental arches.

PROPOSITION

To perform a longitudinal evaluation of dental casts of patients submitted to orthodontic treatment, who had their dental arches individualized by the WALA ridge method with regard to the following aspects:

- alterations in the mandibular intercanine distance and between the mandibular molars;
- transversal alterations in the WALA ridge, in the region contiguous to the mandibular intercanine and intermolar distances;
- reliability of the method for the individualization of dental arches.

MATERIAL AND METHODS
Material

The materials were used in accordance with the regulations of the National Council of Health, No. 196/1996, Ministry of Health, and this study was approved by the Research Ethics Committee of UNIARARAS Protocol No. 219/2007.

The sample was obtained from the files of patients who received orthodontic treatment at a private clinic in Curitiba/ PR, Brazil. It was composed of 20 plaster models, obtained from the same clinic, taken at the stages of pre-treatment (T1), post-treatment (T2) and 3 years after the end of treatment (T3) of patients ranging between the ages of 13 years and 11 months and 39 years and 1 month, among whom 8 were men and 12 women.

For selecting the T1 sample, the following factors were evaluated:
- Presence of complete permanent dentition, except third molars.
- Class I malocclusion, determined by the relationship of the first molars and premolars.

- Absence of diastemas.
- Teeth and alveolar ridge visible in plaster models, the latter being compatible and checked against the morphology of the WALA ridge clinically presented by the patient.
- Slight mandibular crowding (-1 mm to -4 mm).

For selecting the T2 sample, the following factors were evaluated:
- Class I, determined by the relationship of the canines, premolars and first molars; correct intercuspation provided by the first molar cusp-sulcus relationship and premolar cusp imbrasure relationship, evaluated from the lingual perspective.
- Overjet of 0 to 2 mm and overbite of 1 to 2 mm.
- Angulation and inclination of the crowns according to Andrews method of Keys II and III, respectively.[1]
- Absence of diastemas.
- Curve of Spee depth of 0 to 2.5 mm.
- Teeth and alveolar ridge visible in plaster models, the latter being compatible and checked against the morphology of the WALA ridge clinically presented by the patient.

The corrective orthodontic treatment was performed according to the following protocol: without extractions; finishing objectives in accordance with Andrews' six keys method;[1] straight-wire technique, Andrews standard prescription ("A" Company, California, USA) with slot 0.022 x 0.028-in; wire contour individualization for leveling and alignment defined by the WALA ridge form, observed from the occlusal perspective of the mandibular plaster model and adapted to a diagram recommended by Andrews and Andrews.[2]

The notes made on the clinical charts about the clinical procedures were analyzed, showing that 8 cases were submitted to rapid maxillary expansion before orthodontic treatment; 5 used Class II intermaxillary elastics with an upper reverse curve; 7 used Class III intermaxillary elastics; 7 were submitted to interproximal wear of the mandibular

incisors, as 3 cases presented Bolton's discrepancy due to excess maxillary tooth size.

Plaster models of patients that presented the following anomalies were excluded from the sample: Dental agenesis; supernumerary and extranumerary teeth; teeth with alterations in shape, dental mutilations and bony bases compromised in the sagittal direction.

Methods

To mark the axes, points and reference ridges and to obtain dimensions on the plaster models, the following equipment was used: Black pencil (model t5.5v Regent 1250 6B, Faber Castell, SP) and a digital caliper with a resolution of 0.01 mm and exactness of approximately 0.02 mm (Mitutoyo Sul Americana Ltda., Brazil). The measurements were made exclusively by the researcher.

Axis, WALA ridge, points and their demarcations

A single examiner, using a pencil, marked the axes, points and WALA ridge on the maxillary plaster models for T1, T2 and T3, by the visual method, according to the following description:
a) Facial-Axis of the Clinical Crown (FACC): The most prominent portion of the central lobe of the facial surface of all teeth crowns, except for the molars, which corresponds to the sulcus that separates the two large facial cusps. Demarcation was done with a graphite on the crowns of mandibular canine and first molar teeth.

b) WALA Ridge: Soft tissue ridge located below the gingival margins of mandibular tooth crowns and immediately above the mucogingival junction.
c) Facial-Axis Point (FA point): Point on FACC that separates the gingival half of the clinical crown from the occlusal half. Demarcation was done with a graphite tip on the crowns of mandibular canine and first molar teeth (Fig 1).
d) WALA Ridge Point (point WR): Demarcation of the WALA ridge was made with the graphite surface (Fig 2); the most prominent point on the curve of the WALA ridge adjacent to each tooth was denominated Point WR (Fig 3). Demarcation was done with a graphite tip contiguous to the mandibular canine and first molar teeth.

Measurement of the linear variables (mm)

These were made with the use of a digital caliper directly on the mandibular plaster models and noted on a specific chart.
a) Mandibular intercanine distance (IC): distance between the mandibular right and left canines, on the respective FA points (Fig 4).
b) Mandibular intermolar distance (IM): distance between the mandibular right and left canines, on the respective FA points (Fig 4).
c) Intercanine distance at the width of the WALA ridge (IC WR): transversal dimension between the points of the WALA ridge of the mandibular canines (Fig 6).

FIGURE 1 - Delimitation of Points FA with a graphite tip.

FIGURE 2 - Demarcation of the WALA ridge made with a graphite surface.

FIGURE 3 - Delimitation of Points WR with a graphite tip.

d) Intermolar distance at the width of the WALA ridge (IM WR): transversal dimension between the points of the WALA ridge of the mandibular molars (Fig 7).

After every measurement taken, the caliper was reset in the initial position (zero), in order to avoid an erroneous readout. The caliper was placed on the reference points, using the tips of the measurement probes, taking care to keep it parallel to the occlusal plane during each measurement to ensure the recordings were made only in the horizontal direction.

Statistical Analysis
Method Error

To calculate the intra-examiner error, 7 pairs of models for each evaluated stage (T_1, T_2 and T_3) were randomly selected, for a second demarcation of the points and linear variable measurements, totaling 21 pairs of plaster models. The approximate interval between the first and second measurement was 15 days.

The formula proposed by Dahlberg[9] ($Se^2 = \sum d^2/2n$) was applied to estimate the order of variables of the casual errors, while the

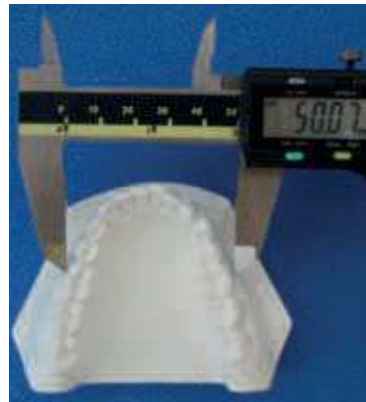FIGURE 4 - IC distance at the respective FA points.

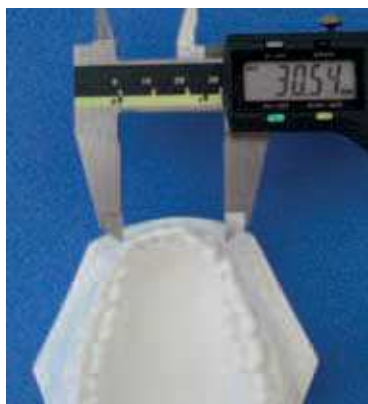FIGURE 5 - IM distance at the respective FA points.

FIGURE 6 - IC WR distance at the respective WR points.

FIGURE 7 - IM WR distance at the respective WR points.

systematic errors were analyzed by the application of the paired "t" test, according to Houston[14]. The level of significance was established at 5% (p<0.05).

Statistical Method

Descriptive statistics were performed of all the data obtained from the sample: age at the beginning of treatment (T1); treatment time (T2-T1); post-treatment evaluation time (T3-T2), as well as for the studied variables (IC, IM, IC WR and IM WR), in all the stages and periods studied: T_1, T_2, T_3, T_2-T_1, T_3-T_2 and T_3-T_1.

The dependent ANOVA test was used, and when there was a significant result, the Tukey test was performed to observe whether there was significant alteration in the studied variables between the initial, final and post-treatment stages. The level of significance was established at 5% (p<0.05).

RESULTS

Table 1 presents the descriptive statistics (mean, standard deviation, minimum and maximum) initial age, treatment time and post-treatment evaluation time.

Table 2 presents the results of the systematic and casual and error evaluations by means of the paired t test and the Dahlberg formula,[9] applied to the studied variables. There were no systematic errors and the casual errors were considered acceptable, and it could be affirmed that the WALA ridge method was an easily reproducible method, since there was no difference between the two measurements of the variables IC WR and IM WR performed by the same examiner at two different times.

The results of the descriptive statistical analysis for the variables IC, IM, IC WR and IM WR are shown in Tables 3, 4, 5 and 6, respectively, in all the studied times: T_1, T_2, T_3, T_2-T_1, T_3-T_2 and total

TABLE 1 - Descriptive statistics of initial age, time of treatment and post-treatment evaluation time (mm).

Variables	Mean	s.d.	Minimum	Maximum
Initial age	20.88	7.86	13.91	39.08
Time of treatment	2.47	0.57	1.36	3.17
Post-treatment evaluation time	3.20	0.32	3.05	4.17

TABLE 2 - Results of the estimate of systematic and casual errors applied to the variables IC, IM, IC WR and IM WR.

Variables	1st Measurement		2nd Measurement		N	Dahlberg	P
	Mean	s.d.	Mean	s.d.			
IC	28.95	1.59	28.90	1.60	21	0.09	0.059
IM	49.50	1.65	49.54	1.65	21	0.10	0.134
IC WR	30.65	2.55	30.10	2.58	21	1.21	0.138
IM WR	54.44	2.37	54.47	2.33	21	0.11	0.339

TABLE 3 - Descriptive statistics of the variable IC (mm).

Variables	Mean	s.d.	Minimum	Maximum
IC T1	29.29	1.62	25.70	31.80
IC T2	30.42	1.57	27.60	33.30
IC T3	29.79	1.68	26.10	32.50
IC T2-T1	1.12	1.06	-0.70	3.10
IC T3-T2	-0.62	0.69	-2.30	0.20
IC T3-T1	0.50	0.65	-0.70	1.80

TABLE 4 - Descriptive statistics of the variable IM (mm).

Variables	Mean	s.d.	Minimum	Maximum
IM T1	48.07	2.14	44.00	52.20
IM T2	50.30	1.77	47.20	53.70
IM T3	49.30	2.08	44.00	52.90
IM T2-T1	2.22	1.73	-0.90	5.30
IM T3-T2	-0.99	1.15	-4.60	0.60
IM T3-T1	1.23	1.13	-0.50	3.50

TABLE 5 - Descriptive statistics of the variable IC WR (mm).

Variables	Mean	s.d.	Minimum	Maximum
IC WR T1	30.06	2.23	25.30	33.20
IC WR T2	30.82	1.60	26.90	33.40
IC WR T3	30.39	1.88	26.00	33.30
IC WR T2-1	0.76	0.90	-1.60	1.90
IC WR T3-2	-0.43	0.52	-1.60	0.50
IC WR T3-1	0.33	0.56	-1.10	1.70

TABLE 6 - Descriptive statistics of the variable IM WR (mm).

Variables	Mean	s.d.	Minimum	Maximum
IM WR T1	54.18	1.94	50.50	57.30
IM WR T2	54.79	1.97	51.10	58.40
IM WR T3	54.51	1.90	50.70	57.50
IM WR T2-1	0.61	1.08	-2.40	2.50
IM WR T3-2	-0.28	0.75	-1.50	2.50
IM WR T3-1	0.32	0.72	-1.50	2.10

TABLE 7 - Results of the ANOVA test and Tukey test for the variables IC, IM, IC WR and IM WR, among the 3 evaluation times T1, T2 and T3.

Variables	Initial (T1) Mean (s.d.)	Final (T2) Mean (s.d.)	Post-treatment (T3) Mean (s.d.)	P
IC	29.29 (1.62)A	30.42 (1.57)B	29.79 (1.68)C	0.000*
IM	48.07 (2.14)A	50.30 (1.77)B	49.30 (2.08)C	0.000*
IC WR	30.06 (2.23)A	30.82 (1.60)B	30.39 (1.88)A	0.004*
IM WR	54.18 (1.94)A	54.79 (1.97)A	54.51 (1.90)A	0.074

Different letters indicate statistically significant differences (p<0.05).

alteration between the initial stage and the post-treatment evaluation stage (T_3-T_1).

Table 7 demonstrates the results of the dependent ANOVA test and Tukey test for the variables IC, IM, IC WR and IM WR, among the 3 evaluation times.

The results of the dependent ANOVA test for the variables IC and IM indicated that there was statistically significant difference among the three studied stages. This demonstrates that these variables increased significantly with the treatment (T_2-T_1), and presented a reduction in the post-treatment period (T_3-T_2); that is, a return to the pre-treatment values, however, not attaining the initial values.

The variable IC WR presented an increase during treatment, and also presented a significant relapse post-treatment, returning to the initial values. The variable IM WR did not change significantly with the treatment or during the post-treatment period.

DISCUSSION

According to Houston,[14] in order for the precision of a methodology to be adequately analyzed, a minimum of 20-30% of the sample must be re-evaluated. Therefore, for the intra-examiner error evaluation, new measurements of the four studied variables were taken in 7 randomly selected study models, totaling 21 pairs of models, measured about 15 days after the first measurements were taken. The results of the two measurements were then submitted to the formula proposed by Dahlberg,[9] to obtain the casual errors. To obtain the systematic errors the paired t test was applied. Some degree of judgment and subjectivity on the part of the examiner may occur during measurement of the plaster models,[24] which emphasizes the importance of the methodological error analysis in the case of measurements taken from plaster models.

The results demonstrated the absence of systematic errors, and the casual errors were minimal and acceptable (Table 2). The major casual error occurred in the measurement IC WR, with a value of 1.21. The absence of significant systematic errors and the reduced values of the casual errors observed in this study may have occurred both from the standardization and precision of the measurements, as well as from the simplicity

and objectivity of the measurements of the study models, making the WALA ridge diagram method extremely reliable and easily reproducible.

Of the evaluated sample, 17 patients presented an increase in IC during the treatment and 3 presented a slight reduction. On an average, the increase was 1.12±1.06 mm (Table 3). IC showed a slight but statistically significant increase during treatment, perhaps due to the fact that 8 patients were treated by having rapid maxillary expansion performed. The change in the post-treatment period—hat is, between the final and the post-treatment evaluation stages—also referred to as relapse, was slight, but statistically significant (Table 7). This change in IC in the post-treatment period occurred in the direction of the initial position occupied by the canines; that is, there was a reduction of –0.62±0.69 mm in this distance after the conclusion of treatment (Table 3). This reduction was shown to be significant, however, it did not attain the values obtained at the beginning of treatment (Table 7).

These results may support the concept of maintenance of the original intercanine distance in orthodontic treatment, as it tends to return to the initial values, as has been described in the literature[9,19]. Some authors[17,21,26] have also concluded that the increase in IC could lead to a deficiency in the results. However, it is difficult to distinguish between what is relapse or what is a natural reduction in this distance as the years pass.[4,5,22,23]

As regards IC WR, this presented a significant alteration during treatment, as well as a significant relapse in the post-retention period (Tables 5 and 7). Nevertheless, these alterations were well reduced, representing an increase of 0.76±0.90 mm during treatment and a reduction of only -0.43±0.52 mm in the post-treatment period (Table 5). Clinically, these alterations may be considered insignificant. Moreover, these alterations in IC WR were shown to be smaller than the alterations of IC measured at the FA points; that is, in the center of the facial surface of the clinical crown of the mandibular canines.

There was a slight increase in IM during the treatment stage, and a relapse tending to a reduction in this distance in the post-treatment period. Only 2 patients presented a reduction in IM during the treatment. The mean increase during treatment was 2.22±1.73 mm. The relapse was small, a mean of -0.99±1.15 mm, however, it was significant since the alteration in the treatment was also shown to be significant, and it occurred in the direction of the initial position occupied by the mandibular molars but did not attain the pre-treatment values (Tables 4 and 7). The variable IM presented greater differences between the beginning and end of treatment than between the final and post-treatment evaluation stages, which demonstrated that this dimension presented a relative longitudinal stability.[22,23] The relapse found in the post-retention stage for the intermolar distance was small, similar to that found in some studies.[12,21]

The variable IM WR presented no significant alteration during treatment and in the post-treatment period (Tables 6 and 7). Due to the non-significant results, one could consider that IM WR was not altered during the treatment and remained stable during the post-retention period. The alterations in IM WR were shown to be more stable than the alterations in the intermolar distance measured in the FA points.

Before examining the models of dental arches with the objective of evaluating their form, specifically for determining the diagram, it is necessary to have a dagnosis and the general treatment goal defined. On this point, the dental arches had probably been examined and influenced the diagnosis and treatment plan. Only after this is it possible to have parameters for judging the mandibular arch, and evaluating its form.[7,11]

The major concern of researchers has always been to obtain a simplified method that would allow an analysis of the position of the teeth in the dental arches that could be performed by the clinician in a simple and objective manner. The

other question would be the standardization of the method of evaluating the position of the teeth in the dental arch.

During orthodontic treatment, the intercanine distance can be increased,[15] but many authors have observed that any alteration in the mandibular intercanine width was unstable.[19,25] Therefore, the original width needs to be maintained to increase the long term stability. According to the results obtained, it can be affirmed that the WALA ridge method[2,10] was shown to be valid and allowed the individualization of dental arches in order to favor post-treatment stability.

Consequently, evaluating the form of dental arches with the object of defining the form of the arches to be used in dental treatment in an individualized manner is a mandatory procedure. This study, therefore, supports the affirmation that there is true individualization only when it allows treatment intentions, interacting with the anatomic characteristics, to define the form of the arches.[7]

CONCLUSIONS

It was concluded that:

» IC and IM increased with treatment and underwent a statistically significant reduction in the post-treatment period, although they did not return to the initial values. The alterations were small and clinically insignificant.

» IC WR increased with treatment and underwent a reduction in the post-treatment period, although the alterations were clinically insignificant. IM WR were not altered during treatment and remained stable during the post-retention period.

» Clinically, the WALA ridge method used in this study for making the individualized diagrams and for measuring the intercanine and intermolar distances was shown to be valid, allowing individualization of the dental arches and favoring post-treatment stability.

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