Original Article

Changes in Dental Arch Measurements of Young Adults with Normal Occlusion—A Longitudinal Study

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Abstract: This study evaluates the longitudinal changes in occlusal dimensions in young adults. The sample was composed of 27 individuals (13 male and 14 female individuals) who presented dental Class I and normal occlusion, according to the inclusion protocol. All teeth were present except for the third molars. The mean age of the subjects was 21 years and two months initially and 28 years and four months at the end of the observation period. The measurements collected in both arches were overbite, overjet, intercanine and intermolar distances, irregularity index, and perimeter. All measurements were taken from study dental casts by a calibrated operator, using a digital caliper. The paired *t*-test was used to evaluate the changes, using the difference between the initial and final mean measurements. Data indicated that the overbite increased 0.39 mm, the incisor irregularity increased 0.38 mm in the upper arch and 0.54 mm in the lower arch, and the arch perimeter decreased 0.67 mm in the upper arch and 0.71 mm in the lower arch ($P > .05$). The other measurements did not show significant changes. No sexual dimorphism was observed. It could be concluded that occlusal dimensions change throughout adult life. In the sample studied, changes were statistically significant for overbite, incisors irregularity, and arch perimeter after a mean period of seven years and two months. These changes can be observed in both sexes. (*Angle Orthod* 2004;74:618–623.)

Key Words: Adult; Normal occlusion; Study dental casts

INTRODUCTION

It is of particular interest for orthodontists to understand how occlusion changes during all stages of human development. Graber[1] stated that a balanced, healthy, and stable occlusion could be considered normal, even if small tooth rotations and small tooth size–arch length discrepancies are present. However, if orthodontists observe dental crowding, increased overjet, open bite, or any other characteristics not desirable for a patient in the posttreatment stage, they tend to search for causes of failure.

Sometimes a perspective for high standards of excellence in orthodontics seems distant. Will the finished case with excellent occlusion really be stable? Could the physiology of the masticatory system lead to certain occlusion modifications, changing the pattern obtained at the end of the orthodontic treatment? Would this actually be an unacceptable relapse? Are the nongrowing patients also subject to these changes? Such questions deserve to be answered and should be made clear. Initially, an evaluation of adaptive longitudinal changes in occlusion in individuals with normal occlusion who have not undergone previous orthodontic treatment should be done. These observations could then be used to determine changes that could occur in the posttreatment period.

The vertical and horizontal relationships between the upper and lower incisors were investigated through all periods of facial development. Bishara et al[2] reported that they observed insignificant changes in overjet when they evaluated individuals from five to 15 years, and Bishara et al[3] confirmed the same finding in a posterior study, with a sample evaluated from 25 to 45 years. They did report, however, a one-mm mean overbite increase in the women studied from 25 to 45 years.

Sinclair and Little[4] studied individuals in the 13- to 20-year age group who had not undergone orthodontic treatment and observed a small decrease in overbite (0.59 mm) and overjet (0.48 mm) in the postpubertal period. On the basis of the supposition that a patient with a normal occlu-

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sion that remained stable from the complete eruption of the permanent dentition to a more advanced adult age and maintained the transversal dimensions of the dental arches, authors, such as Knott,[5] Rossouw et al,[6] Proffit,[7] Melrose and Millet,[8] and Little,[9] stated that the maintenance of these dimensions during a well-conducted orthodontic treatment would be a factor of stability for a satisfactory final occlusal result.

Sinclair and Little[4] described a decrease of 0.75 mm in the intercanine dimension, especially for women, in the 13- to 20-year age group. Bishara et al[10] found a significant decrease in the upper and lower intercanine dimensions of female individuals above 25 years. In male individuals, only the inferior intercanine dimension showed reduction. While evaluating adult dental arch dimension changes, Carter and McNamara[11] found a reduction in the upper and lower intercanine dimensions.

Regarding the distance between molars, Sillman[12] did not observe any changes in male individuals 14 years and older but showed an insignificant reduction for female individuals even after 16 years. Bishara et al[3] demonstrated that the upper intermolar distance underwent an increase in adults 25 to 45 years, whereas the intermolar distance in the mandible did not undergo the same changes.

After observing upper and lower incisor crowding, Bishara et al[13] reported a significant clinical increase in crowding as patients with normal occlusion grew older. The authors considered this part of the natural maturation process of the dentition. The same findings were observed by Little[9,14] in the lower incisors. When evaluating upper incisors irregularity, Bishara et al[3] and Carter and McNamara[11] stated that a tooth malalignment increase during maturation of the dentition does exist, but it is much more discrete than that in the case of the lower incisors. Moorrees and Chadha[15] showed constant values for dental arch length in individuals more than 14 years old. However, several studies have indicated a reduction in arch length through time.[4,10,11,16]

The population in Brazil, which has quite a rich ethnic diversity, can present different characteristics from those observed through studies carried out with Caucasian samples, in the eastern countries or other countries. It is even possible that these dental occlusion maturation characteristics could be influenced by this ethnic diversity pattern. Based on the principle that occlusal changes can occur even in patients with normal occlusion, as well as in the absence of active growth, the objective of this study is to qualify and quantify these possible changes, aiming to contribute to the increase in knowledge about the development of the human occlusion over time.

MATERIALS AND METHODS

A longitudinal study was composed of 27 Caucasian Brazilian adults (14 female and 13 male adults). A minimum age of 18 years for the male individuals and 17 years for the female individuals was established to minimize any residual growth effect that could still occur. The mean age at T1 was 21 years and two months (range, 17 years and 11 month to 27 years). The individuals participating in the sample presented dental and skeletal Class I occlusion and had a satisfactory clinical occlusion. Thus, they represented normal occlusion cases and not excellent or ideal occlusion. A complete permanent dentition, with the exception of the third molars, was required. At T1, radiographs and impressions were obtained from the selected sample.

At T2, the 27 individuals of the initial sample were contacted by phone or e-mail and asked to return to the orthodontic clinic. The mean age at T2 was 28 years and four months (varying from 24 years to 35 years and three months). At this time, radiographs and impressions were obtained for new measurements. The mean time between T1 and T2 was seven years and two months (range, five years and eight months to eight years and four months).

The 54 plaster casts were examined to ensure that there was no dental loss in the fillings placed that could have led to important alterations between T1 and T2. No changes were observed. Cast measurements (of T1 and T2) were taken by a unique calibrated operator using a digital caliper (Starret Tools, Itu, Brazil, Electronic Caliper), with a 0.01-mm precision and a steel ruler (Endo Keiki, Tokyo, Japan) graduated in 0.5 mm. The caliper was modified to facilitate narrower and more accurate ends that could touch precisely on teeth surfaces such as grooves and proximal contact points. Each cast was measured on three different occasions and the mean value recorded.

Cast measurements used in this study were based on those of Little,[17] Sinclair and Little,[4] and Bishara et al[13] as follows—overbite, overjet, upper intercanine width, lower intercanine width, upper intermolar width, lower intermolar width, and irregularity of the upper incisors; adapted from Little[17]—irregularity of the lower incisors and upper arch perimeter; and adapted from Sinclair and Little[4]—lower arch perimeter.

RESULTS

The measurements and the descriptive statistics of the casts of the 27 individuals according to time and variation between T2 − T1 are presented in Table 1. The paired *t*-test was used to verify the significance of the values ($P < .05$).

The values for overbite and irregularity of the upper and lower incisors showed a statistically significant increase ($P < .001$), and the values for upper and lower arch perimeters presented significant reductions ($P < .001$). The lower intercanine widths showed a significant decrease ($P = .001$), and the lower intermolar widths also demonstrated significant reduction ($P = .033$). The overjet, upper intercanine

TABLE 1. Descriptive Statistics and *t*-Test of the Measurements Taken from Casts (n = 27), in T1 and T2 and the Change Between T1 and T2

Measurements Taken from Casts[a]	Times									
	Baseline (T1)			Observation (T2)			Change (T2 − T1)			
	M	SD	VF (%)	M	SD	VF (%)	M	SD	SE	P
Overbite	2.87	0.95	33.1	3.26	0.97	29.8	0.39	0.45	0.09	<.001*
Overjet	2.08	0.69	32.9	2.06	0.72	34.7	−0.02	0.36	0.07	.791
Upper canine width	34.47	1.82	5.3	34.27	1.77	5.2	−0.21	0.68	0.13	.127
Upper molar width	48.00	2.30	4.8	47.82	2.44	5.1	−0.18	0.68	0.13	.185
Upper incisors irregularity	4.36	1.99	45.5	4.75	2.24	47.3	0.38	0.50	0.10	<.001*
Upper arch perimeter	71.02	3.28	4.6	70.35	3.35	4.8	−0.67	0.80	0.15	<.001*
Lower canine width	25.97	1.69	6.5	25.58	1.69	6.6	−0.39	0.55	0.11	.001*
Lower molar width	47.91	2.49	5.2	47.66	2.49	5.2	−0.25	0.58	0.11	.033*
Lower incisors irregularity	3.75	1.85	49.3	4.29	1.88	43.9	0.54	0.43	0.08	<.001*
Lower arch perimeter	60.76	2.97	4.9	60.05	3.01	5.0	−0.71	0.88	0.17	<.001*

[a] Abbreviations: M, mean; SD, standard deviation; SE, standard error; VF, variation factor = SD/M.
* $P < .05$

TABLE 2. Descriptive Statistics and *t*-Test of the Variations of the Measurements Taken from Casts According to Sex

Measurements Taken from Casts[a]	Change According to Sex (mm)				
	Male Subjects (n = 13)		Female Subjects (n = 14)		
	M	SE	M	SE	P
Overbite	0.32	0.08	0.46	0.15	.407
Overjet	0.00	0.11	−0.04	0.09	.802
Upper canine width	−0.14	0.20	−0.27	0.17	.611
Upper molar width	−0.22	0.12	−0.14	0.23	.765
Upper incisors irregularity	0.35	0.17	0.42	0.09	.713
Upper arch perimeter	−0.64	0.26	−0.70	0.18	.841
Lower canine width	−0.42	0.15	−0.37	0.16	.813
Lower molar width	−0.13	0.19	−0.37	0.13	.295
Lower incisors irregularity	0.51	0.10	0.56	0.14	.776
Lower arch perimeter	−0.75	0.25	−0.67	0.24	.812

[a] Abbreviations: M, mean; SE, standard error.

width, and upper intermolar width values did not show significant variation between T1 and T2.

No sexual dimorphism was observed in the changes between T1 and T2 (Table 2). The Pearson correlation coefficient for the variations between the evaluated cast measurements was used in this study and is presented in Table 3. Positive significant correlations between the variations were observed in the upper intercanine width and the upper and lower arch perimeter values. On the other hand, there were significant inverse correlations between the upper intercanine width and the irregularity values of the upper incisor index.

DISCUSSION

Overbite

In this study, a significant increase occurred in the amount of overbite in a group of young adults with normal occlusion after a mean period of seven years and two months (Table 1). This increase in overbite differs from the values found by Sinclair and Little,[4] who demonstrated a decrease of 0.59 mm in a similar sample observed from 13 to 20 years. The discrepancy in this finding could lie on the fact that our study did not include individuals of younger ages (less than 17 years old) and also of the higher final mean age (28 years and four months) in this study. This difference in the initial and final mean ages can represent stages in which the overbite presented reductions or increases that modified the average value of the total change. Studies carried out by Carter and Mcnamara[11] and Forsberg[18] represent this dissimilarity where significant differences for overbite were not found in individuals observed from adolescence until adulthood. The reason for this might be that they registered a period of decrease followed by a period of increase in the overbite that would in the end nullify each other.

Overjet

The values for overjet did not demonstrate significant changes during the evaluation period (Table 1) and are in agreement with those of Bishara et al,[2,3] Carter and Mc-

TABLE 3. Pearson Correlation Coefficient for the Changes in the Measurements Taken from Casts (n = 27)[a]

		Changes in Millimeters								
		OB	OJ	UCW	UMW	IUI	UAP	LCW	LMW	ILI
OB	Correlation	1								
	P									
OJ	Correlation	0.216	1							
	P	.279								
UCW	Correlation	−0.152	0.070	1						
	P	.448	.730							
UMW	Correlation	−0.137	−0.057	−0.093	1					
	P	.494	.779	.645						
IUI	Correlation	0.099	0.006	−.439*	−0.034	1				
	P	.624	.977	.022	.866					
UAP	Correlation	−0.175	0.369	0.361	0.140	−0.131	1			
	P	.383	.058	.065	.485	.516				
LCW	Correlation	−0.014	−0.007	0.086	0.364	−0.122	0.206	1		
	P	.945	.973	.671	.062	.543	.303			
LMW	Correlation	0.148	0.161	0.024	−0.073	−0.348	0.136	0.330	1	
	P	.461	.424	.906	.716	.076	.497	.092		
ILI	Correlation	−0.226	−0.116	0.171	−0.176	0.238	−0.273	0.007	−0.270	1
	P	.257	.565	.395	.380	.231	.168	.972	.174	
LAP	Correlation	0.049	0.157	0.387*	−0.017	−0.316	0.568*	−0.084	0.353	−0.124
	P	.809	.434	.046	.934	.109	.002	.677	.071	.539

* Statistically significant value ($P < .05$).

[a] Abbreviations: OB, overbite; OJ, overjet; UCW, upper canine width; UMW, upper molar width; IUI, irregularity of the upper incisors; UAP, upper arch perimeter; LCW, lower canine width; LMW, lower molar width; ILI, irregularity of the lower incisors; LAP, lower arch perimeter.

Namara,[11] and Forsberg,[18] who also stated that no significant change in the overjet was observed after 17 years. However, the reduction found by these authors in the overjet for male individuals between 13 and 17 years is close to the values obtained by Sinclair and Little,[4] with a sample ranging from 13 to 20 years. Consequently, it seems evident that a reduction of approximately 0.5 mm occurs until 17 years. All studies that pointed out a small but significant decrease in the overjet until around 17 years[4,11,19,20] have clearly demonstrated that mandibular residual growth is a factor highly associated with this result.

Intercanine width

In the upper arch, the intercanine width did not show significant change in the evaluated sample. The lower intercanine width demonstrated a small but significant reduction of 0.39 mm (Table 1). Other authors,[5,12,21] while examining the modifications in the intercanine widths during dentition maturation, observed constancy for these values. However, Sinclair and Little[4] have stated that there are significant changes in this factor because they reported a 0.75-mm decrease in the intercanine distance, especially for women, from 13 to 20 years. Bishara et al[3] verified a reduction of 0.4 and 0.6 mm in the upper and lower intercanine widths, respectively, for female individuals and 0.4 mm in the lower intercanine distance for male individuals, but only after 25 years. Likewise, Carter and McNamara[11] found a decrease of 0.65 and 0.58 mm in the upper and lower intercanine distances, respectively, when they evaluated adult individuals.

Intermolar width

No significant change was observed for the upper intermolar width, whereas the lower arch showed a reduction of 0.25 mm with a 0.58-mm standard deviation (Table 1). Constant values for upper and lower intermolar widths have also been found after 14 years.[12] Bishara et al[3] demonstrated a mean increase of 0.2 mm in the upper intermolar width, but they were observing individuals between 25 and 45 years, which could be a reflection of the predisposition for this age group. This difference in findings does not seem to result in a contradiction because the studies that found alterations for intercanine and intermolar widths demonstrated very discrete values, not much different from the ones that showed unaltered distances in this study.

Irregularity of the incisors

The computation of Little's irregularity index for the lower incisors revealed that during the observation period of this study, these teeth presented a significant ($P < .001$) increase of 0.54 mm in their malalignment, similar to other studies[9,13,14,21] (Table 1). Although this increase in the crowding of lower incisors could be related to other parameters, such as an increased overbite, a decreased overjet, a reduction in the intercanine and intermolar distances, a decrease in the arch perimeter, or even these parameters measured in the upper arch, no significant correlation was demonstrated between the increase in the irregularity for the lower incisors and any other parameter. These findings are in agreement with observations made by many authors[4,16,22–24] who reported that a highly complex interaction of the craniofacial and dental matrix is probably involved with the increase in the crowding of lower incisors and that not only obvious characteristics, such as a decrease in the arch perimeter and intercanine distance, would represent the factors responsible for this malalignment. Sampson[23] reported local factors, such as oral breathing, caries, and extractions, as the cause for incisor crowding. Extractions and extensive caries that could result in this type of modification were not observed in the sample because the presence of caries or fillings that could compromise the occlusion and extractions, except for the third molars, would exclude the individuals from the study. Considering oral breathing, the arch atresia caused by this parafunction seriously affects the components of the stomatognathic system, but an evaluation of the respiratory function would be necessary to verify this correlation, and this was not included in the methodology of this study. This would be an interesting proposal to be answered in future research.

The significant value found for the alteration in the irregularity index for the upper incisors (Table 1) (mean increase of 0.38 mm) was inversely correlated to the upper intercanine width; therefore, the reduction in this width was associated with an increase in the maxillary incisor crowding. Some studies[3,11,25] support this study by confirming that the increase in the upper incisor crowding in this period of human development is much more discrete than the increase in the lower incisor crowding.

Arch perimeter

The upper and lower arch perimeters showed significant reductions of 0.67 and 0.71 mm, respectively, bringing up an issue discussed in other studies,[6,23] the anterior component of occlusion force. Sinclair and Little[4] and Carter and McNamara[11] also reported significant reduction in the upper and lower arch lengths with time. On the other hand, the classical study of Moorrees and Chadha[15] showed constant values for these factors after 14 years unlike that indicated by most of the orthodontic literature. The upper arch perimeter showed a mean reduction of 0.67 mm, and the lower arch perimeter showed a mean reduction of 0.71 mm.

Sexual dimorphism

Although several authors[4,9,11–16,21,25] have described differences according to sex, none of the variables studied here demonstrated significant sexual dimorphism.

Considerations

While searching for the understanding of the correlations that were significant or not, some results seemed to be incoherent, such as the fact that the increase in the lower irregularity index did not show a significant correlation with the reduction of the lower intercanine width. This is because the individual correlations are limited and have little meaning because changes are relative and depend on many parameters. The significant increase in overbite and the constancy in the mean overjet value could be related to other factors, such as intercanine and intermolar widths, incisors irregularity, or arch perimeter, or could even be correlated between themselves, but these associations could not be observed in this study. Thus, the cause/effect relation is difficult to understand because of the high number of variables.

The results in this study give evidence of some occlusal maturation patterns, but mainly they encourage us to continue investigation in this subject. Larger sample sizes could show different changes and maybe more significant results. The comparison of these developmental values with the values demonstrated by patients that underwent orthodontic treatment could bring valuable observations related to orthodontic finalization, relapse, and occlusal stability patterns. A follow-up study of the present sample during a longer period of time will certainly bring more important information to orthodontic studies and practices to establish an ideal and stable occlusal pattern.

CONCLUSIONS

After the longitudinal occlusal changes in 27 young adults with normal occlusion had been evaluated after a period of seven years and two months, it could be concluded that:

- A significant overbite increase was found, as well as increases in the irregularities of the upper and lower incisors. A significant decrease was observed in the upper and lower arch perimeters and in the lower intercanine and intermolar widths. These changes were statistically significant, although none showed variation greater than 0.71 mm.
- Positive correlations were found between the upper intercanine width and the lower arch perimeter and between the upper and lower arch perimeters. A significant inverse correlation was observed between the upper intercanine width and the irregularity index for the upper incisors.
- None of the variables showed significant sexual dimorphism.

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