Original Article

Evaluation of transverse changes in the dental arches according to growth pattern: a longitudinal study

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Abstract

Objective: To evaluate changes in intercanine (LICW and UICW) and intermolar (LIMW and UIMW) widths on the dental arches of subjects with normal occlusion and Angle Class I malocclusion during the transition to permanent dentition, and evaluate whether or not facial pattern influences on the normal development of the dentition and occlusion. **Methods:** Nineteen Caucasian Brazilian children were selected, with ages ranging from 6 to 8.6 years at T1 and from 10.10 to 14.2 years at T2. Their second records consisted of study dental casts and a lateral cephalometric radiograph. To obtain intermolar and intercanine widths a three-dimensional scanner unit (digitizer MicroScribe 3DX) was used connected to a microcomputer. To analyze changes at T1 and T2 Student's paired t-test was applied, whereas Spearman's correlation analysis was used to assess the relationship between measurements obtained at T1 and T2 and the facial pattern, both at 95% level of confidence. **Results:** The mean values found on each assessment time (T1 and T2) were statistically different (p=0.000 for LICW, p=0.001 for UICW, p=0.000 for UIMW, and p=0.046 for LIMW), regardless of the facial pattern. The anterior dimensions, UICW and LICW, increased by 3.21 mm and 1.52 mm, respectively. And the posterior dimensions, UIMW and LIMW, increased by 2.16 mm and 0.50 mm, respectively. Only UIMW showed a significant correlation with the facial pattern ($p<0.01$). **Conclusion:** There was an increase in dental arch width during the transition period from primary or mixed dentition to permanent dentition irrespective of facial pattern. Only the changes observed in the maxillary intermolar width were associated with the facial pattern.

Keywords: Transverse changes. Intercanine width. Intermolar width. Facial pattern.

How to cite this article: Ribeiro JS, Ambrosio AR, Santos-Pinto A, Shimizu IA, Shimizu RH. Evaluation of transverse changes in the dental arches according to growth pattern: a longitudinal study. Dental Press J Orthod. 2012 Jan-Feb;17(1):66-73.

» The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

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INTRODUCTION

Dimensional changes in dental arches are compensatory mechanisms that occur as a result of growth and are required in order to maintain a balance between the functional and structural needs of the face and dentition.[4,18] The dimensions of the dental arches change systematically during growth and development period, even if no treatment is administered.[8]

The dimensions and morphology of the dental arches have considerable impact on orthodontic diagnosis and treatment planning, affecting space availability, dental esthetics, dentition stability and the prospects for a favorable development.[11,15]

Changes in the dimensions of the dental arches have been studied since 1890, when Zsigmondy,[29] using three sets of dental casts from an individual sample of children between the ages of 6 and 17 years, measured for the first time the length of the dental arches. Clinch[10] and Sillman[23] however, were the first to present the development process of the dentition since birth.

Many authors have investigated the transverse changes that occur during the development of dentition and occlusion, which consist mainly of the intercanine and the intermolar widths.[2,3,7,14,22,25]

By studying the development of dental arches in children aged 5 to 8 or 9 years a rapid increase in intercanine width was observed (4 mm in the maxilla and 3 mm in the mandible). The cusp tips of canines were used as reference points for the measurements.[2]

Another assessment that has been performed in longitudinal studies is related to the occlusion type, that can be established early in life. In other words, based on the characteristics of the occlusion of deciduous teeth it is possible to predict the occlusion of permanent teeth.[1,7,22,24] By observing the maxillary and mandibular intercanine width from birth to adulthood in a longitudinal study, the behavior of these dimension in the different stages of dentition were reported. It was found that from birth to 13 years of age a continuous increase in the maxillary and mandibular intercanine width occurred, whereas no significant changes were detected after that age.[25]

A study that sought to correlate the facial pattern with the dental arches' width found some relatively weak correlations in non-growing individuals.[12] Studies that subdivided the sample by gender found that, in women, the correlation was only identified in the region of maxillary second premolars, with no correlation in the mandible. In men, correlations were found in maxillary and mandibular intercanine and inter-first premolar width and maxillary inter-second premolars and first molars.[12]

In general, studies available in the literature describe the changes in the dental arches by attempting to correlate them with the type of occlusion, individual growth pattern,[12,20] gender,[12] existence of crowding or spaces,[12] among others.

Correlation studies have only addressed growth pattern on specific occasions, both with growing and non-growing subjects. These studies are essential for planning preventive actions or treatment, for which successful outcomes depend, in part, on changes in the teeth and facial growth[18]. Therefore, identifying any potential relationship between growth pattern and dimensional changes in the dental arches caused by normal growth could alter prospects, orthodontic planning and treatment.

OBJECTIVE

The aim of this longitudinal study was to evaluate transverse changes in the dental arches of individuals with normal occlusion or Angle Class I malocclusion during mixed dentition and to assess whether these changes correlate with the growth pattern of the individuals.

MATERIAL AND METHODS

Sample selection

This research project was approved by the Ethics in Research Committee of the Center of

Biological and Health Sciences (CEP-CCBS) at the Catholic University of Paraná, identified by file number 111.

To obtain the initial complementary exams of the subjects, the 1998 records archived at the Graduate Dentistry Program department, Orthodontics concentration area, were utilized. Selection of the initial sample was intentional and convenient, comprising 19 Caucasian Brazilian children (7 males and 12 females) aged between 6 and 8.5 years, displaying normal occlusion or Angle Class I malocclusion.

From these individuals, dental casts and lateral cephalometric radiographs were obtained in the year 2003, when they were aged between 10 years and 10 months and 14 years and 2 months old.

Obtaining and evaluating lateral cephalograms

Lateral cephalograms were obtained in the Radiology Clinic of Dentistry, Pontifical Catholic University of Paraná, according to the technique standardized by Broadbent.[5]

All cephalometric tracings were performed twice by a single operator, three months apart. The angular measurements were taken with the aid of a protractor with 0.5 degree accuracy, with values being rounded up to the highest degree. The linear measures were determined with a digital caliper with 1/10 mm accuracy.

The measures considered for this purpose were FMA, SN.GoGn and the PFH/AFH Index. Individuals with FMA values lower than 21°, SN.GoGn lower than 30° and Index greater than 0.75 were classified as brachyfacial, whereas individuals with FMA between 21° and 29° (inclusive), SN.GoGn between 30° and 34° (inclusive) and index between 0.65 and 0.75 (inclusive) were classified as mesofacial and finally those with FMA angular values over 29°, SN.GoGn higher than 34° and Index values lower than 0.65 were classified as dolichofacial. When all measures were considered, only those individuals who remained in the same facial pattern group from beginning to end were included in the sample. No subject was excluded due to changes in facial pattern.

Study dental casts fabrication

Study dental casts were made from alginate impressions obtained with sterile trays and wax bite registration of dental occlusion in habitual maximum intercuspation. These casts were used to obtain measurements of the upper and lower dental arches.

Measurement of digitized dimensions

For landmark demarcation, pre-determined points were used on the upper and lower study dental casts according to the method described by Moyers.[19]

After proper calibration of the device and operator the data gathering process was initiated using a three-dimensional scanner unit, Digitizer MicroScribe 3DX (Fig 1) (Immersion, California, USA) connected to a computer as a measuring instrument.

The points shown in Figures 2 and 3 were scanned into an Excel spreadsheet (Microsoft, Redmond, USA), where the study measurements were calculated.

All dental casts were scanned at two different times to control error. Therefore, the values used in the study were the arithmetic means between these two assessments.

» Intercanine width – The distance between the cusps of the upper canines were measured to obtain the upper intercanine width (UICW) and similarly, the distance between the cusps of the lower canines were measured to obtain the lower intercanine width (LICW) (Figs 2 and 3).

» Intermolar width – The distance between the midpoint of the mesiopalatal, distopalatal, mesiobuccal and distobuccal cusps of the maxillary first molars were calculated to determine the upper intermolar width (UIMW). In the case of

FIGURE 1 - Digitizer MicroScribe 3DX.

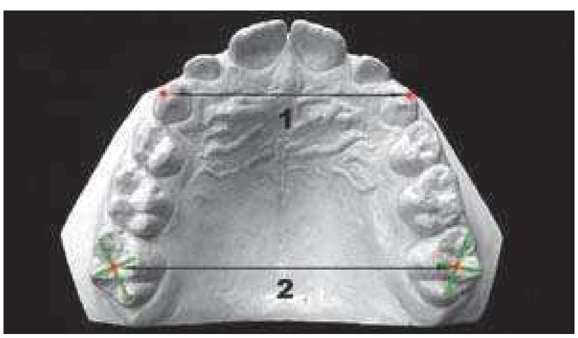

FIGURE 2 - Upper intercanine width (1), Upper intermolar width (2).

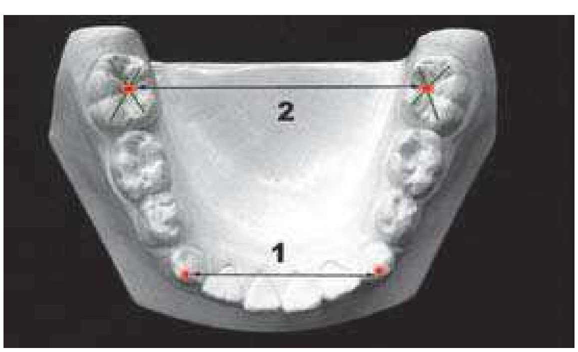

FIGURE 3 - Lower intercanine width (1), Lower intermolar width (2).

the lower intermolar width (LIMW) the distances between the midpoint of the mesiolingual, distolingual, mesiobuccal and distobuccal cusps (Figs 2 and 3) were measured.

When a tooth was missing at the time of final evaluation due to the physiological replacement of a deciduous tooth by a permanent tooth, this measure could not be determined and therefore the data were excluded from the sample. Due to this fact, in those cases the sample consisted of only 18 individuals instead of 19.

METHOD ERROR

Reproducibility of all data was confirmed by Dahlberg's Formula. The paired t-test (Table 1) was applied to test for systematic error. The test confirms that the measurements obtained were not statistically different at a significance level of 5% for n–1 degrees of freedom, since the t values were lower than 2.03, confirming that the data are reliable.

STATISTICAL ANALYSIS

All dimensions presented a normal distribution when analyzed by the Kolmogorov-Smirnov test at 5% alpha level. Therefore, a paired Student's t-test was applied to check for differences between T1 and T2 for all arch widths examined, initially disregarding the facial pattern.

TABLE 1 - Paired t-test to evaluate systematic error.

Variable	n	Difference between means	s^2	t
UICW	36	0.1288	0.15177	1.9850
LICW	38	0.1289	0.20444	1.7580
UIMW	36	-0.0563	0.11815	0.9842
LIMW	36	-0.0719	0.12124	1.2396

Note: t values according to n–1 degrees of freedom, lower than 2.0301 for n = 36 and lower than 2.0262 for n = 38, indicating that there is no difference at a significance level of 5%.

The descriptive analysis of the variables was performed according to facial pattern, regardless of the assessed moment. The Spearman correlation test with a confidence level of 95% was used to verify whether there was any correlation between the facial pattern and variations in the transverse dimensions of the dental arches.

RESULTS

The descriptive statistics of the variables revealed higher mean values at T2 than those found at T1. Thus, after an interval of five years all the variables analyzed showed some increase, and this difference was statistically significant at a level of $p \leq 0.05$ for all variables studied (UICW, LICW, UIMW and LIMW) (Table 2).

The variable that showed the greatest variation was upper intercanine width, and the lowest variation was found between the lower molars (Fig 4). Descriptive statistics (Fig 5) and Spearman correlation test (Table 3) revealed that UIMW was the only variable that correlated with the facial pattern.

DISCUSSION

The longitudinal observation of how the set of features characterizing the dental arches evolves and interrelates is a reliable method to explain its normal development. The advantages are: the fact that variability between individuals is put into proper perspective; serial comparisons are enabled; temporary problems are suppressed over time; and any extraordinary events or errors in the measurements are more easily detected and corrected.

Despite substantial advantages, longitudinal studies are not so common due to certain hurdles that hinder or discourage researchers.[21] Among the disadvantages are the longer time that is required to complete the studies, higher cost and reduced sample size over time.[19,21] However, these limiting factors do not outweigh the excellent results obtained by the longitudinal studies.

In order to deal with some of the shortcomings of this longitudinal study, it is important above all to analyze results with caution.

TABLE 2 - Descriptive statistics of variables analyzed and Student's t-test for mean differences between the two observation times (T1 and T2).

Variable	Statistics	Time		Difference	t	p
		initial	final			
Upper Intercanine Width (UICW)	mean	30.94	34.15	3.283	-7.025	**0.000**
	standard deviation	1.90	2.49	__		
	minimum	28.70	29.69	__		
	maximum	34.82	38.35	__		
Lower Intercanine Width (LICW)	mean	25.38	26.90	3.238	-3.967	**0.001**
	standard deviation	2.17	1.61	__		
	minimum	21.15	23.71	__		
	maximum	28.13	29.28	__		
Upper Intermolar Width (UIMW)	mean	46.15	48.31	1.893	-6.149	**0.000**
	standard deviation	2.78	2.47	__		
	minimum	41.64	44.84	__		
	maximum	50.48	52.04	__		
Lower Intermolar Width (LIMW)	mean	42.53	43.03	0.527	-2.154	**0.046**
	standard deviation	2.23	2.79	__		
	minimum	39.95	38.23	__		
	maximum	45.83	46.53	__		

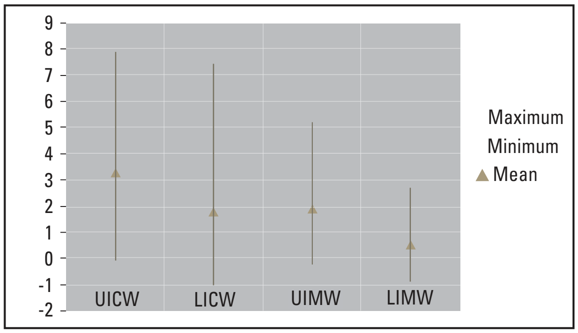

FIGURE 4 - Variation of the dimensions evaluated between T1 and T2 showing maximum and minimum variations found.

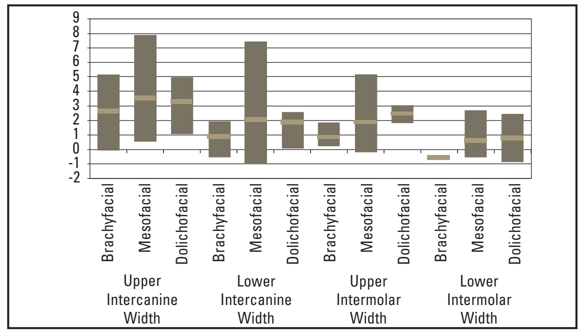

FIGURE 5 - Descriptive statistics of the changes observed between T1 and T2 for each facial pattern, showing means, maximum and minimum limits.

TABLE 3 - Spearman correlation test.

Variable	Spearman Coefficient (R)	t	p
UICW	0.05	0.19	0.850
LICW	0.31	13.23	0.203
UIMW	0.61	30.48	**0.008***
LIMW	0.29	12.06	0.245

*p<0.001.

The number of subjects (n) diminished considerably in some groups, making the sample of brachyfacial patients become greatly reduced. Therefore interpretation of the results according to the facial pattern should be carefully used.

Intercanine width

Final values of upper and lower intercanine widths in relation to initial values showed statistically significant increases of 3.21 mm and 1.52 mm (p=0.000 and p=0.001), respectively, for the upper and lower arches. Several other studies that examined samples in a similar age range yielded results that are close to those observed in the present study.[14,25] However, Sinclair and Little[26] found a decrease of 0.75 mm when analyzing orthodontically untreated individuals aged from 7 to 17 years. This decrease can be explained by the age range differences between the samples, since, after the complete eruption of permanent teeth, a decrease in intercanine width occurs.[2,25]

The clinical applicability of this outcome, considering the gradual increase in intercanine distances during the transition from deciduous to permanent dentition, can prove very helpful, confirming some treatment approaches which suggest the correction of crowding at a later stage.[27]

Intermolar width

The values found for upper and lower intermolar width in this study revealed a statistically significant increase from T1 to T2 (p=0.000 for UIMW and p=0.046 for LIMW). Regarding the upper intermolar width the increase reached 2.16 mm and as to the mandibular intermolar width it increased 0.50 mm. These values are similar to those observed in the literature.[2,16,25] However, Moorrees[17] and Brown[6] found stable intermolar widths in longitudinal studies involving subjects without prior orthodontic treatment.

Relationship with the facial pattern

In the present study, the analysis of variations in the intercanine and intermolar widths showed that only the upper intermolar width correlated significantly with the growth pattern (p=0.008) as the value of the correlation coefficient (R) was greater than 0.6. The value of R^2 (0.3721) shows that just over 37% of LIMW variations are explained by the facial pattern, while almost 63% of the changes are determined by other variables which were not the focus of this study.

In another study, which also did not take into account the gender and ethnicity of the evaluated patients, but only the relationship with the facial pattern, the lower intermolar widths were greater in individuals with a more horizontal pattern when compared to vertical ones.[20]

However, despite some studies concluding that there was no relationship between the transverse dimensions of the arches and the facial pattern[9,12,20] there are others showing that it depends on the individual's gender, i.e., other determinant variables were identified.[12]

The literature shows that brachyfacial men tend to have larger maxillary and mandibular widths than mesofacial men.[9] However, no significant differences were found when comparing the arch widths in brachyfacial versus mesofacial[9] women.

In any case, studies that found relationships between facial pattern and transverse dimensions show increases in these dimension as the facial pattern becomes more horizontal. The findings were attributed to the muscle pattern of these patients.[13,28]

In the present study, although the Spearman's correlation test pointed to a relationship between facial pattern and variations in the transverse dimensions of the dental arches in only one of the variables studied (UIMW), decrease of the sample according to facial pattern may have generated a false negative.

However, it would be adequate to pursue longitudinal studies with a representative sample size of individuals during growth period, in a way that the subdivision into different facial patterns, as well as gender and race, could be made without drastically reducing the sample size. This type of study would also allow professionals — above and beyond the mere identification of correlations between facial patterns and dental arch dimensions — to verify whether variations between dolichofacial, mesofacial and brachyfacial individuals become increasingly apparent as the individual grows or if such variations are already present at an early age.

CONCLUSIONS

Given the nature of this longitudinal study, the sample studied and the results achieved, the following conclusions could be drawn:

- There were increases in maxillary and mandibular intercanine widths.
- There were increases in maxillary and mandibular intermolar widths.
- A correlation was found between maxillary intermolar widths and facial pattern.

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Submitted: February 18, 2009
Revised and accepted: June 15, 2010

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