Prediction of arch length based on intercanine width

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SUMMARY Arch length (AL), intercanine width (ICW), and intermolar width (IMW) are essential for diagnosis and treatment planning and are closely related factors in orthodontics. The aim of the present study was to determine correlations between these measurements and to predict some of these measurements based on others.

The dental casts of 197 Spanish patients (119 females and 78 males) with a mean age of 18 years (11–26 years) in the permanent dentition attending the Orthodontic Department of the University of Valencia, Spain, were selected. ICW, IMW, and AL on each dental cast were measured using a previously tested digital method. Correlation between variables was determined using Pearson's correlation coefficient. Linear regression analysis was applied and the 95 per cent confidence intervals (CIs) for slope and intercept were determined.

The data showed very high correlations between ICW and AL, both for the upper and lower arches and for males and females, r=0.925. This coefficient was very close to 1, indicating a linear relationship. The regression equation for AL and ICW was AL=1.36 ICW+29.39 for both arches. There was very high correlations between AL and ICW for the upper and lower arches and a regression equation between both magnitudes was established indicating that the size of one factor can be predicted by knowing the other. For an increase of 1 mm in ICW, the AL increases approximately 1.36 mm with a 95 per cent Cl (1.30–1.42).

Introduction

The study of the relationship between several arch measurements is important in orthodontics. Prediction of the change in arch length (AL) as a consequence of transvers expansion could be helpful in orthodontic treatment planning as reported by some authors.

Ricketts *et al.* (1982) stated that, for each millimetre of arch width increase at the canines and molars, AL increased by 1 and 0.25 mm, respectively. However, they did not include the method used to obtain these values.

Adkins *et al.* (1990) showed that rapid palatal expansion with a Hyrax appliance produced an increase in the maxillary arch perimeter of approximately 0.7 mm.

Using a mathematical model for quantitative comparison of the effects of various types of orthodontic expansion of the mandibular arch perimeter, Germane *et al.* (1991) found that incisor advancement was responsible for the greatest increase in arch perimeter for each millimetre of expansion, followed by canine expansion. On the other hand, molar expansion was the least effective for increasing the dental arch perimeter.

Hnat *et al.* (2000) combined two mathematical functions, the hyperbolic cosine and beta functions, to study the relationship between AL and alterations in dental arch width, the former for the six anterior teeth and the latter for the remaining dentition posterior to the canines. They stated that, from a clinical point of view, most of the AL increase occurred in the anterior segment for all alterations in arch width.

Motoyoshi *et al.* (2002), in a study that attempted to estimate the increase in arch perimeter associated with mandibular lateral expansion using a three-dimensional model for simulating mandibular expansion, showed that a 1 mm increase in intermolar width (IMW) resulted in an increase in arch perimeter of 0.37 mm.

Therefore, the aim of the present study was to determine the relationship between intercanine width (ICW), IMW, and AL in both treated and untreated subjects.

Materials and methods

The upper and lower dental casts of subjects attending the Orthodontic Department of the University of Valencia, Spain, were randomly selected. The sample included 119 females and 78 males, with a mean age of 18 years (11–26 years). All of them were Spanish and lived in the city of Valencia. Eighty-three had received orthodontic treatment with fixed appliances without any tooth reduction or extractions, while 114 subjects had not undergone orthodontic treatment.

The inclusion criteria of the casts (Paulino, 2005) were permanent dentition from first molar to first molar; upper and lower first molar fully erupted without the gingiva overlapping the distal surface of the tooth; good-quality casts; no tooth agenesis or extractions; and no large restorations or teeth with different shapes that could change the mesiodistal diameter of the tooth.

A digital method developed at the University of Valencia was used for arch measurement. The method has previously been tested for accuracy and reliability in determining mesiodistal tooth diameters (Paredes, 2003; Paredes *et al.*, 2006).

The study casts were digitized with a conventional Hewlett Packard Scan Jet II Cx/T scanner using an accurate and easy calibration system to obtain dental cast dimensions in millimetres. This calibration system consisted of surrounding the dental stone casts with a millimetric paper sheet and digitizing the arches. When the magnification of the millimetric paper in the two axes is known, the dental cast magnification can be determined (Paredes *et al.*, 2005).

Following digitation and calibration of the dental casts, with the aid of the mouse as a user interface for the digital method, the points of the ICW and IMW and the AL of each image of the casts were marked by two trained operators. The software designed for this purpose automatically determines these measurements in millimetres (Figure 1).

The following linear measurements were performed.

- 1. Upper and lower intercanine widths (UICW and LICW, respectively)—maximum linear width between the canines.
- 2. Upper and lower intermolar widths (UIMW and LIMW, respectively)—maximum linear width between molars at their buccal surface.
- 3. Upper and lower arch lengths (UAL and LAL, respectively)—ideal line between every mesial and distal contact point of each permanent tooth from the mesial of the first molar to the mesial of the first molar of the opposite side. AL was considered to be equal to arch perimeter.

Statistical method

The Statistical Package for Social Sciences (SPSS Inc., v.11.5[®], Chicago, Illinois, USA) was used to compare paired

measurement means and to determine the correlation between variables calculated by the analysis of linear regression and correlation coefficients. Correlation between variables was determined using Pearson's correlation coefficient. Linear regression analysis was applied and the 95 per cent confidence intervals (CIs) for slope and intercept were determined.

The reproducibility of the digital method was analysed by determining intra- and inter-examiner measurement errors in turn, calculated by the coefficients of variation (CVs). These CVs (CV = standard deviation \times 100/mean) are expressed as a percentage.

Twenty dental casts from the present study were randomly selected. The measurements were again determined by the same (intra-examiner error) and by two different examiners (inter-examiner error) in order to obtain the CV. All CVs were very low (below 5.8 per cent) and similar between examiners. The digital method CVs were 0.05–2.88 and 0.16–5.70 per cent for intra- and inter-examiner calibrations, respectively (Paredes, 2003).

Results

A high correlation was observed between UAL and UICW as well as between LAL and LICW, while a weak correlation was found between UAL and UIMW and LAL and LIMW. The scatter plot of UAL versus UICW and LAL versus LICW (Figure 2) showed the same dependence between these variables for the upper and lower arch, which is the regression line of AL versus ICW with no difference between the upper and lower arch.

The regression parameters are shown in Table 1. The correlation coefficient between AL and ICW, r = 0.925,



Figure 1 Measurements using the digital method: lower intercanine width, intermolar width, and arch length of a randomly selected subject.



Figure 2 Scatter plot and fitted regression line of data for arch length versus intercanine width for upper, lower, and both arches (total).

Table 1Linear regression parameters for arch length (AL) versusintercanine width (ICW) (upper and lower).

| Variables | Regression parameters | Values | Standard error | 95 per cent confidence interval | | Pearson's coefficient |
|------------------|-----------------------|-----------------|-------------------|---------------------------------------|-----------------|-----------------------|
| | | | | Lower limit | Upper limit | |
| AL versus ICW | Intercept Slope | 29.386 1.360 | 0.869 0.028 | 27.679 1.305 | 31.094 1.416 | 0.925 |

showed a very good linear relationship between variables, making it possible to establish the following regression equation for UAL and LAL and UICW and LICW:

$$AL = 1.36 \times ICW + 29.39.$$
 (1)

The 95 per cent CI for the slope (1.30–1.41) means that for each millimetre of ICW increase, the AL would increase between 1.30 and 1.41 mm.

The interpretation of the Pearson's coefficient (Adkins *et al.*, 1990) as the variation percentage of a variable that is explained by the variation of the other variable means that 85.5 per cent of AL variation is explained by an ICW variation.

A low correlation between UAL and UIMW (r = 0.474) and between LAL and LIMW (r = 0.426) was found, indicating that there was no linear correlation (Figure 3).

Discussion

Even though digitizing dental casts is a laborious process and time-consuming, the use of digital methods, as used in this study to measure digital dental casts, has a number of advantages such as storage; immediate data transmission to a colleague; and measurements that can be made in an easy, accurate, and automated manner.

Several correlations were found between the widths measured on the dental casts. The highest correlation was between AL and ICW in both arches, indicating that changes in one magnitude may be directly related to the other. It is not usual to find such a high correlation between two variables as that found between AL and ICW.

The present findings cannot be compared with those of Germane et al. (1991), since those authors found a correlation in patients after treatment and not in patients who had not undergone any orthodontic treatment. They found a correlation between AL and ICW using a mathematical model of the dental arch. They reported that arch perimeter increases due to intercanine expansion were intermediate between those of the incisors and molars, the first millimetre of expansion causing a 0.73 mm increase in the perimeter. Tibana et al. (2004) also found significant correlations between UICW and LAL, but only weak correlations between ICW and AL within the same arch. Adkins et al. (1990), when studying 21 consecutively treated orthodontic patients (11.5-17 years of age) who required the use of a rapid palatal expansion device, found that the premolar width increase



Figure 3 Scatter plot and fitted regression line of data for arch length versus intermolar width for upper, lower, and both arches (total).

was the best predictor of the increase in arch perimeter as a result of a stepwise multiple linear regression analysis of the three independent variables studied (molar, premolar, and canine width increase). The correlations found between AL and IMW were less significant.

Motoyoshi *et al.* (2002) also reported small values for arch perimeter increase as a consequence of intermolar mandibular expansion of the order of 0.37 mm, but greater than the values of Germane *et al.* (1991) and Ricketts *et al.* (1982) of 0.27 and 0.25 mm, respectively.

In present study, it must be emphasized that a regression equation could be established between AL and ICW, which could predict the value of one of these magnitudes when knowing the value of the other. Equation 1 gives the value of UAL or LAL from the value of UICW or LICW, respectively. It is, of course, possible to make the prediction the other way round. In this case, the corresponding equation would be

$$ICW = 0.629 \times AL - 14.090, \tag{2}$$

where ICW is the UICW or LICW, respectively, if AL is the value of UAL or LAL.

Conclusions

A high correlation coefficient between AL and ICW was found for both arches, and a regression equation was established between both magnitudes. Correlation makes it possible to predict the size of one of the variables by knowing the size of the other. The correlations between IMW and AL were lower and with a differing variation between the upper and the lower arch.

For an increase of 1 mm of ICW, the AL increases approximately 1.36 mm with 95 per cent CI (1.30–1.42).

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