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LETTER TO THE EDITOR

MIXED DENTITION SPACE ANALYSIS OF A SOUTHERN ITALIAN POPULATION: NEW REGRESSION EQUATIONS FOR UNERUPTED TEETH

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Mixed dentition analysis forms a critical aspect of early orthodontic treatment. In fact an accurate space analysis is one of the important criteria in determining whether the treatment plan may involve serial extraction, guidance of eruption, space maintenance, space regaining or just periodic observation of the patients. The aim of the present study was to calculate linear regression equations in mixed dentition space analysis, measuring 230 dental casts mesiodistal tooth widths, obtained from southern Italian patients (118 females, 112 males, mean age 15±3 years). Student's *t*-test or Wilcoxon test for independent and paired samples were used to determine right/left side and male/female differences. On the basis of the sum of the mesiodistal diameters of the 4 mandibular incisors as predictors for the sum of the widths of the canines and premolars in the mandibular mixed dentition, a new linear regression equation was found: $y = 0.613x+7.294$ ($r= 0.701$) for both genders in a southern Italian population. To better estimate the size of leeway space, a new regression equation was found to calculate the mesiodistal size of the second premolar using the sum of the four mandibular incisors, canine and first premolar as a predictor. The equation is $y = 0.241x+1.224$ ($r= 0.732$). In conclusion, new regression equations were derived for a southern Italian population.

The amount of discrepancy between the total tooth material (mesiodistal width) present and the dental arch perimeter available to contain the teeth is probably the most critical estimate of any in the orthodontic diagnostic procedure (1, 2). Nowadays, three main approaches have been used to estimate the mesiodistal crown widths of permanent canines and premolars in mixed dentition patients: measurement of the unerupted teeth using radiographs (3, 4), the application of regression equations that relate the mesiodistal widths of erupted teeth to those of unerupted teeth (5, 6) and combination of measurements from erupted teeth and radiographs of unerupted teeth (7, 8).

The approach by Moyer proposed a very simple and easy way to use regression scheme to predict

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mesiodistal widths of permanent canines and premolars on the basis of mandibular incisors widths using a statistical coefficient (r), called correlation coefficient (5). Coefficients of determination (r^2) are indicators of predictive accuracy of the regression equations for y (the sum of mesiodistal widths of canine and premolars) based on values of x (the corresponding sum of mesiodistal widths of four mandibular incisors), that is, the proportion of the total variance of y, which is determined then value of x for each regression equation (6). Although a regression equation must have an r^2-value of at least 0.5 to be clinically useful (7), the r^2 tends to overestimate the true reliability (8).

This method was developed on a Caucasian population, therefore the applicability of this method to populations of other ethnic groups has been studied and doubted (9-12). In addition, there has been some evidence of secular trends of changing dimensions of teeth, which may require progressive modification of mixed dentition analysis for different populations (13).

The aim of the present study was to calculate a regression equation, suitable for southern Italians which predicts the sum of the canine, first and second premolars using the sum of the four mandibular incisors as the predictor. To better estimate the width of the leeway space, another regression equation was found to predict the second premolar width, using the sum of the four mandibular incisors, the canine and first premolar as a predictor.r.

MATERIALS AND METHODS

By using methodology from a previous similar experience (14), we collected the dental cast models of 230 consecutive subjects (118 females and 112 males, mean age 15±3 years) between 2006 and 2014, from a private practice in the city of Bari (Centri Odontoiatrici Specialistici).

This work was carried out according to the recommendations of the Declaration of Helsinki, and all patients and parents gave informed consent. Patients were included in the study according to the following criteria :

- fully erupted permanent teeth in the mandibular jaw (except the third molar);
- absence of alterations in form, size and number;
- absence of inter-proximal restorations, fracture and caries, or age-related attrition in the measured teeth;
- no fractures or bubbles on the analyzed casts;
- no orthodontically treated patients;
- all Italian subjects, born and still resident in Puglia (southern Italy) for at least one previous generation.

All impressions and study casts were obtained with alginate and plaster models for high quality (orthodontic extra strong white stone 164-450-89 Orthosnow,

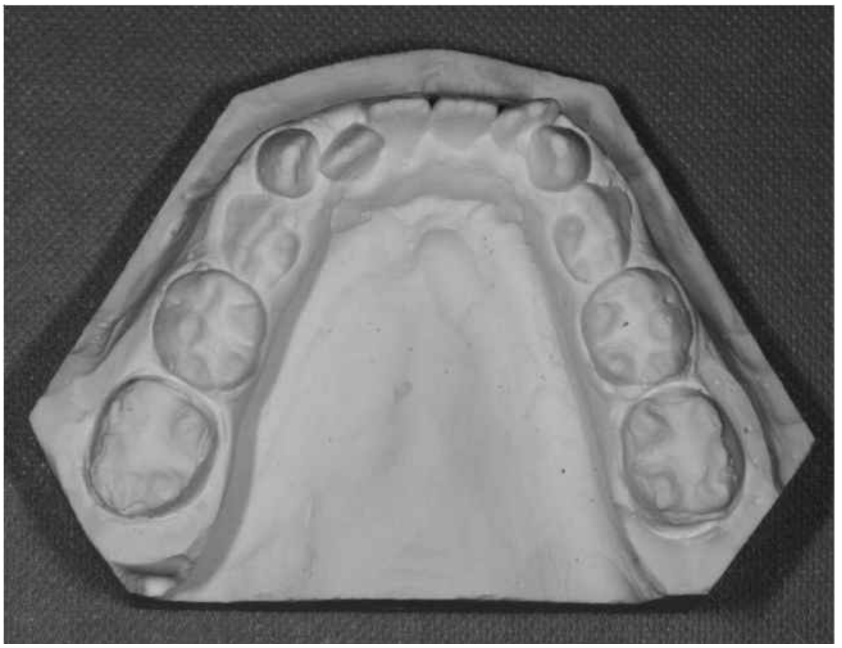

Fig. 1. *Study cast model of mixed dentition.*

Dentaurum, Italy) which had been shaped using the Tweed technique (Fig. 1). A digital caliper (Mauser® A/08 10825 Pforzheim, Germany) with an accuracy of 0.01 mm was used to measure each tooth (15), and to better adapt to the interdental space, the measuring tips were also narrowed. The mesiodistal widths of all the mandibular incisors, canines and premolars were measured, and the caliper was adjusted to the greatest mesiodistal diameter (contact point) of the teeth, parallel to the occlusal surface and perpendicular to the longitudinal axis (15, 16). Duplicate measurements were made 2 weeks later by a single investigator on 15 randomly selected dental casts.

Statistical analysis

On the basis of the study conducted on a northern Italian population (14) and hypothesizing a normal distribution of the predictor (sum of widths of the four mandibular incisors), with a precision of 0.15 mm in the estimate of such sum, a standard deviation of 1.16 mm and a confidence level of 95%, a number of at least 230 casts was defined. All statistical analyses were performed using the SPSS software package (SPSS for Windows 98, release 16.0, SPSS Inc., Chicago, Illinois, USA).

Descriptive statistics (mean, standard deviation, minimum and maximum values) were computed; normality of the distribution of the variables was assessed using the Shapiro-Wilk test. None of the *p*-values was greater than 0.05, for all the parameters except for the sum of the width of the incisors, and for the mean between the sum of the width of canine and first and second premolar of right and left arch. For these parameters, comparisons between genderes and arches were carried out by using *t*-test for independent and paired samples and for the other parameters comparisons between the genderes and arches were carried using Mann-Whitney U-test for independent samples or Wilcoxon test for paired samples.

Correlation coefficients (r) and linear regression equations were constructed to evaluate the relationship between the sum of widths of the four mandibular incisors (independent variable) and the sum of the widths of the canine and first and second premolars (dependent variable).

The constants of the models, the coefficients of linear determination (r^2) and the standard error of the estimated (SEE) were computed and the significance of the difference between the correlation coefficients was computed by using Z- transformation of the coefficients.

Significance value was *a priori* set at 0.05; accuracy of measurements was tested using Dahlberg's formula (17), and the method error for the measurement of individual permanent teeth ranged from 0.01 to 0.03 mm with a mean of 0.004 mm (standard deviation=0.02 mm).

For the intra-examiner calibration, intra-class correlation coefficient (ICC) was used to determine measurement consistency.

The values for each type of tooth were high (ICC=0.995, p=0.001 for incisors; ICC=0.958, p=0.001 for canines; ICC=0.969, p=0.001 for premolars) indicating high measurement reliability and consequently all tooth measurements for the remaining 215 dental casts were performed only once.

RESULTS

Statistically significant differences were observed in the sums of both the mandibular canine and premolar diameters (p=0.001) and in the widths of incisors (p=0.006) by gender, resulting that males seem to have teeth slightly larger (Table I).

No statistically significant difference was observed between the left and right side in either gender, so the results of right and left summations were averaged.

Table II presents the linear regression equation, the standard error of the estimate and correlation coefficients between the mandibular incisors and the mandibular lateral segments. Residual plots showed fairly even distribution of the residuals above and below zero, and the normal plots of the residuals were fairly straight.

The predictive accuracy of the regression equation of the sums of the widths of the canine and premolars based on the values of the sums of the widths of the four mandibular incisors was better in females than in males.

Analysis of variance (ANOVA) (F = 217.28 with 1 and 229 degrees of freedom, with all statistically significant P values equal to 0.001) demonstrate that all variances due to regression were highly significant, so that it is unlikely that the relationship between the sums of widths of the four mandibular incisors and the sums of widths of the canine and first and second premolars in the linear model was due to chance.

The percentage of observations having an absolute error (computed as the difference between observed and predicted values) greater than 1 mm was 13.00% (29/230), greater in males (17/112=15%) than in females (12/118=10%). The regression equation for the total sample is: $y = 0.613x+7.294$ (r= 0.701)

No statistically significant difference in the second premolar of the two sides was observed

Table I. *Descriptive values for the sums of the four mandibular incisors and the mandibular canine and premolar segments.*

GROUP	N	Summation	Mean (mm)	SD (mm)	Min (mm)	Max (mm)
Combined	230	Mandibular incisors Mandibular canine and premolars	23.55 21.72	1.59 1.39	18.90 17.85	28.40 27.10
Females	118	Mandibular incisors * Mandibular canine and premolars **	23.27 21.34	1.44 1.06	19.60 17.85	28.40 25.35
Males	112	Mandibular incisors* Mandibular canine and premolars**	23.84 22.13	0.16 1.41	19.60 18.85	28.40 27.10

*SD: standard deviation; *t-test=2.75, p=0.006, males vs females;*
*** Mann-Whitney U-test=4187, p=0.001, males versus females.*

Table II. *Regression parameters for prediction of summation of mesiodistal widths of the canine and second premolars in mandible.*

Group	Arch	r	a (mm)	b	SEE(mm)	r^2
Combined	Mandible	0.701	7.294*	0.613*	0.991	0.491
Females	Mandible	0.713	6.874*	0.621*	0.884	0.508
Males	Mandible	0.670	8.773*	0.560*	1.053	0.449

*SEE: standard error of estimates; *Significant at p=0.001*

by gender or between the sums of the mandibular incisors, canines and first premolar segments of the two sides, therefore the results of the right and left sides were averaged. Statistically significant differences in these mean values were observed by gender (respectively p=0.005 and p=0.001) (Table III), with the result that the males' teeth are slightly larger than those of the females.

Table IV shows the linear regression equation, the standard error of the estimate and the correlation coefficients between the mandibular second premolar and the sum of mandibular incisors, canine and first premolar for each gender. Residual plots showed a fairly even distribution of the residuals above and below zero, and the normal plots of the residuals were fairly straight.

The correlation coefficients were not significantly different between males and females.

The predictive accuracy of the regression equation of the sums of widths of the incisors, canine and first premolar based on the values of the sums of widths of the second mandibular premolar was better in females than in males. Analysis of variance (ANOVA) (F = 260.33 with 1 and 229 degrees of freedom, and all statistically significant p = 0.001) indicated that all variances due to regression were highly significant, so that it is unlikely that the relationship between the sums of widths of the second mandibular premolar and the sums of widths of the incisors, canine and first premolar in the linear model was due to chance.

The percentage of observations having absolute error greater than 0.5 mm was 6.09% (14/230), and was smaller among females (6/112=5.35%) than among males (8/118=6.78%). The regression equation for the total sample is: y=1.224+0.241x (r=

Table III. *Descriptive values for the sums of the four mandibular incisors canine and first premolar and the mandibular second premolar.*

Group	N	Summation	Mean (mm)	SD (mm)	Min (mm)	Max (mm)
Combined	230	Mandibular incisors canine and I premolar	26.00	1.61	21.25	31.75
		Mandibular II premolars	7.50	0.53	6.05	9.55
Females	118	Mandibular incisors canine and I premolar	25.57	1.45	21.25	30.30
		Mandibular II premolars	7.40	0.50	6.05	8.65
Males	112	Mandibular incisors canine and I premolar	26.46	1.64	22.70	31.75
		Mandibular II premolars	7.59	0.54	6.45	9.55

Table IV. *Regression parameters for prediction of summation of mesiodistal widths of the incisors, canines and first premolar in mandible.*

Group	Arch	r	a (mm)	b	SEE	r^2
Combined	Mandible	0.732	1.224	0.241***	0.361	0.535
Females	Mandible	0.704	1.206	0.242***	0.356	0.496
Males	Mandible	0.735	1.712	0.244***	0.370	0.541

*SEE: standard error of estimates; ***Significant at p = 0.001*

0.732).

DISCUSSION

During the mixed dentition period, the mesiodistal dimensions of unerupted canines and premolars were extrapolated from measurements of the erupted permanent mandibular incisors using the Tanaka and Johnston prediction equations (5) or calculated using Moyers probability tables (6). It is essential to remember that tooth size varies in different ethnic groups and among genders, so prediction equations and tables specific to each population for both males and females must be made (14, 18). Consequentially, the different methods proposed for mixed dentition space analysis are relevant only for the population from which it was developed (13, 16).

As previously reported, only Caucasian-born subjects were evaluated who had been residents in Puglia (southern Italy) at least from one generation and referring to the Dr. Cirulli private practice in Bari. Obviously, the data collected in the present study do not represent the southern Italian population in general, but can be considered representative of a certain population of southern Italy. In fact, as reported by Rickards et al. in 1995 (19), southern and central Italian populations, Greek and Aegean populations appeared very homogeneous and quite differentiated from the rest of Europe, both continental (including northern Italy) and south-eastern, stressing the major impact of the heavy Greek colonization on the genetic pools of the circum-Mediterranean people.

Certainly, according to evidence-based dentistry (20), further investigation with a larger sample size is required to collect more representative odontometric data for southern Italians.

In conclusion, the findings of this study provide southern Italian odontometric data which were previously unavailable. Validating studies need to be carried out to confirm the applicability and precision of the new regression equations proposed.

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