

Relationship between Vertical Facial Pattern and Dental Arch Forms in Skeletal Class II Malocclusion

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Abstract

Introduction: The purpose of this study was to investigate the relationship between vertical facial pattern and dental arch forms in class II skeletal malocclusion. **Materials and Methods:** The study comprised of 60 pretreatment (lateral cephalogram, dental cast and photographs) aged between 11-38 years full permanent dentition without agenesis and/or tooth loss except third molar. The evaluation of the dental arch form was performed using a computer analysis (AutoCad). **Results:** Assessment of interexaminer reliability analysis was performed using Kappa statistic. Pearson correlation was used to analyze the dental arch form and facial vertical dimensions. **Conclusion:** As the form of dental arches is associated with the vertical growth patterns, it would be desirable to use individualized arches for each patient.

Key words: Reliability, AutoCad, Photographs.

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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 [1]. The dimensions of the dental arches change systematically during growth and development period, even if no treatment is administered [2]. 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 [3]. Soft tissues relating to the bones play an important role in the remodeling process. The factors that affect a patient's arch form and dimensions are dental perimeter, arch width, and arch depth.

One of the purposes of orthodontics is to correct malocclusion and position the teeth in ideal equilibrium with their bony bases. In an ideal occlusion the teeth are positioned in the greatest possible degree of harmony with their bony bases and surrounding

tissues. Thus, during treatment planning it is important to observe the morphology of dental arch of each patient, since respect of its individuality will avoid periodontal problems, instability and deficiencies in the esthetic results. Hence preservation of form and dimensions of dental arches must be one of the first objectives of orthodontic problem. Arch dimensions are determined by arch width, arch length and arch depth. Arch width is measured as intercanine width, interpremolar width and intermolar width. Transverse expansion can change the arch perimeter along with increase in intercanine and intermolar width [2]. Arch form tends to return to its original form so the patient's existing arch form appears to be the best guide to the future arch form and stability [3].

Arch wires are the vital components of fixed orthodontic treatment [3]. Improper shaped archwires create many post treatment problems such as relapse or iatrogenic damage to teeth moved beyond their bony edges [4]. It can be accepted that in at least half of the patients the preformed arch wires don't seem to be functional. Because of these reasons, the routinely used superelastic preformed arch wires have to be in

various forms with individual malocclusion adaptations. The fabrication of arch form in the canine and molar region should be planned in the proper way so as to prevent the instability of arch form [5,6]. Orthodontic archwires are manufactured in different forms of dental arch in order to choose the most suitable ones for each patient. Therefore, orthodontic manufacturer produce different arch forms as archwires and it is difficult to choose the most suitable for our patients [7, 8].

Isaacson *et al.* reported that subjects with long faces showed decreased maxillary intermolar width [15]. The jaw transverse dimensions are also related to the vertical growth patterns. Long-face individuals have small skeletal transversal dimensions and individuals featuring short face have increased cross-sectional dimensions [1].

Clinicians often pay much attention to the inclination of the mandibular plane, because it is a major determinant of the vertical dimension of a face. A person with a steeper mandibular plane to cranial base often has a long anterior facial height, a smaller ratio of posterior to anterior facial height, and a short mandibular ramus height. Conversely, a person with a flat mandibular plane has a short anterior facial height, a larger ratio of posterior to anterior facial height, and a long mandibular ramus height [11, 12]. The purpose of this study was to evaluate the relationship between vertical facial patterns and dental arch forms in skeletal class I malocclusions.

MATERIALS AND METHOD

The present study was carried out in the department of Orthodontics and Dentofacial Orthopaedics of Himachal Dental College and Hospital, Sundernagar (H.P). The sample consisted of 60 pretreatment records (lateral cephalogram, dental cast and photographs) aged between 11-38 years and the subjects were included in the study as per the following inclusion and exclusion criteria.

INCLUSION CRITERIA

- Full dentition except third molars.
- Pre-treatment lateral cephalogram, dental casts and digital photographs of dental cast.
- Individuals between 11-38 years of age.

EXCLUSION CRITERIA

- Previous orthodontic treatment
- Edentulous spaces
- Malformation

MATERIALS USED FOR THE STUDY

- Radiographs- Lateral Cephalogram.
- Dental casts and photographs
- AutoCad Software

Method of tracing

The radiographic films were covered on one side with the transparent cellulose acetate sheet. The tracings of the films were done using 3H lead pencil. In the lateral cephalograms, the ANB angle was measured according to the Steiner's [11]. ANB angle (Class II-ANB $>4^\circ$). The subjects were further divided into three subgroups according to the values of angle SN-MP according to Schudy [12]: (1) low angle (MP-SN $< 27^\circ$), (2) average angle (MP-SN $> 27^\circ$ and $< 36^\circ$), and (3) high angle (MP-SN $> 36^\circ$).

DENTAL CAST ANALYSIS

Shape of dental arch measurements was performed on digital photographs of patient plaster model. All the photos were taken by a single operator based on American Board of Orthodontics instructions with and the distance from the camera lens to the dental cast was recorded 20-25cm for each cast.

The photo files were sent to AutoCad 2013 software. The evaluation of the dental arch form was performed using a computer analysis. The AutoCad software was used to draw a pentagon inscribed inside the arches as shown in figure I for maxilla and figure II for mandible.

The following dental cast landmarks were used

- Incisal point: The point in the midway between the incisal edges of two central incisors.
- Canine point: The cusp tip of right and left permanent canines.
- Mid central points of first permanent molars: by joining a line diagonally from cusp tip of mesiobuccal cusp to distopalatal cusp and a line from mesiopalatal cusp to distobuccal cusp and mid central point was made at the intersection of these two lines according to author Jucienne Salgado Ribeiro [13].

The following linear measurements were performed on maxillary and mandibular dental casts using computer analysis:

- Intercanine width the linear distance from cusp tip of one canine to the cusp tip of the other.
- Intermolar width the linear distance from mid central point of one permanent molar to the mid central point of other permanent molar.
- The angular measurements were performed on maxillary (Fig. I) and mandibular dental casts (Fig. II) forming a pentagon by using computer analysis. A vertex of the pentagon was placed between the two central incisors; two other vertices lie on the cusp of the canines, and the other two are placed at the center of first molars. Internal angles of the pentagon were measured as shown in Fig I and II.

The angular measurements (Ang1, Ang2R, Ang2L) representing the anterior arch form and angular

measurements (Ang3R, Ang3L), representing the posterior arch form were evaluated. The ratio between the intercanine distance and the intermolar distance was calculated.

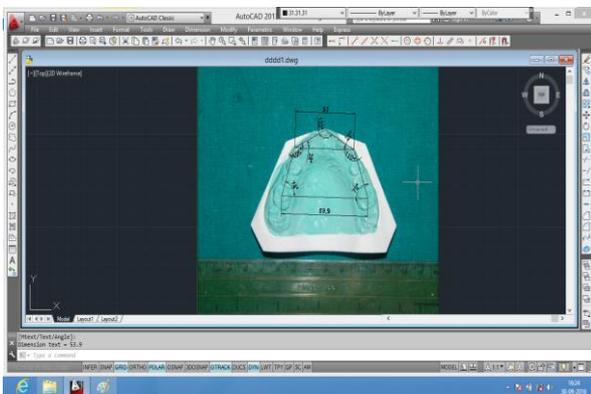
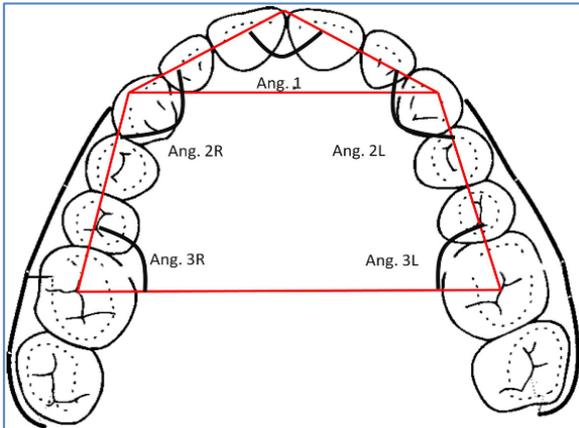


Fig-II: Shows the angular and linear measurements using computer analysis (AutoCad software) on the maxillary arch

STATISTICAL ANALYSIS

The analysis was performed on both dental arches, the upper and lower, in an independent manner. All the linear and angular measurements on the digital photographs of the plaster models and lateral cephalogram were made twice by same examiner to minimize the error of measurements. Assessment of interexaminer reliability analysis was performed using Kappa statistic. The interexaminer reliability was found to be $\text{Kappa} = .80-1.00 (p < 0.001)$ which shows perfect agreement according to Landis and Koch. Pearson correlation was used to analyze the dental arch form and facial vertical dimensions in class I malocclusion using SPSS (Statistical package for social sciences) software.

RESULT

The study includes total 60 subjects. The subjects were further divided into three subgroups according to the values of angle SN-MP: (1) low angle ($\text{MP-SN} < 27^\circ$), (2) average angle ($\text{MP-SN} > 27^\circ$ and $< 36^\circ$), and (3) high angle ($\text{MP-SN} > 36^\circ$).

Table I and Table II shows the mean, the standard deviation, the standard error, the minimum and maximum value of different parameters of class II malocclusion in three different groups divided based on SN-MP angle (Low, medium and high angle).

The mean value of angle Ang I in class II malocclusion in different vertical facial patterns was 124.43 in low angle, 120.71 in average angle and 120.66 in high angle in maxillary arch and 134.29 in low angle, 131.29 in average angle and 134.71 in high angle in mandibular arch.

The mean value of angle Ang 2R in class II malocclusion in different vertical facial patterns was 123.14 in low angle, 130.57 in average angle and 132.57 in high angle in maxillary arch and 138.57 in low angle, 123.43 in average angle and 132.43 in high angle in mandibular arch.

The mean value of angle Ang 2L in class II malocclusion in different vertical facial patterns was 112.14 in low angle, 128.86 in average angle and 133.43 in high angle in maxillary arch and 138.86 in low angle, 131.14 in average angle and 127.29 in high angle in mandibular arch.

The mean value of angle Ang 3R in class II malocclusion in different vertical facial patterns was 76 in low angle, 79.29 in average angle and 74.29 in high angle in maxillary arch and 68.29 in low angle, 72.43 in average angle and 69.29 in high angle in mandibular arch.

The mean value of angle Ang 3L in class II malocclusion in different vertical facial patterns was 80.14 in low angle, 79.14 in average angle and 77.86 in high angle in maxillary arch and 69.29 in low angle, 73 in average angle and 74.86 in high angle in mandibular arch.

The mean value of intercanine distance in class II malocclusion in different vertical facial patterns was 38.07 in low angle, 35.28 in average angle and 34.77 in high angle in maxillary arch and 26.02 in low angle, 27.25 in average angle and 28.41 in high angle in mandibular arch.

The mean value of intermolar distance in class II malocclusion in different vertical facial patterns was 47.72 in low angle, 44.87 in average angle and 46.67 in high angle in maxillary arch and 41.38 in low angle, 40.67 in average angle and 43.74 in high angle in mandibular arch.

Table III AND IV shows the comparison of mean of different parameters of class II malocclusion in three different groups divided based on SN-MP angle (Low, medium and high angle) by one way ANOVA analysis.

Table V, in class II malocclusion the angle that express the anterior arch form in maxillary arch Ang 1 was correlated with the vertical facial pattern. The value of Ang 1 was significant with negative relationship showing $r = -.816$ and p -value .003. The value of Ang 2R was also highly significant with positive relationship showing $r = .837$ and p value .003. The value of Ang 2L was also significant with positive relationship showing $r = .860$ and p value .001. The value of Ang 3R and 3L were insignificant with positive relationship showing $r = .643$ and p value .056 and $r = .570$ and p value .132 respectively. The value of intercanine and intermolar distance ratio was significant with negative relationship showing $r = -.864$ and p .012.

DISCUSSION

Vertical facial form is an important element of orthodontic assessment. It is an essential criterion for each orthodontist to understand the relationship between vertical facial height and dental arch width for proper diagnosis and treatment planning. Large variations are found in the vertical dimension and these affect the clinician's approach to successful diagnosis, treatment planning, and mechanics. Errors in the evaluation of patient's facial type can lead to undesirable and sometimes irreversible consequences during orthodontic treatment.

Stability of arch form is one of the most desirable goals of orthodontics, yet unfortunately it is the least understood goal. Arch form tends to return to its original form so the patient's existing arch form appears to be the best guide to the future arch form and stability. The size and shape of arches have a considerable clinical implication in orthodontics especially during diagnosis and treatment planning, as it affects the space available, dental esthetics and stability of dentition. Arch form characterization is desirable since a fundamental goal in orthodontics is the maintenance or successful and stable treatment modification of that arch form.

The most commonly used terms of square, ovoid, tapered or wide or narrow forms of the dental arch have not yet been mathematically defined and therefore, three ratios were chosen across the whole of dental arch so as to better define the dimensions as well as form. Arch forms are affected by arch dimensions and, therefore, comparison of dimensions and form simultaneously bears a lot of advantage in knowing the exact associations between the craniofacial skeleton and the dental arches. Factors such as age, sex and ethnic group are important in making a proper orthodontic treatment plan; another important factor is the facial growth pattern and its several clinical characteristics. It is generally accepted among orthodontists that a relationship exists between vertical facial pattern and the dental arch width.

Nowadays, the use of nickel titanium preformed archwire, in association with straight wire techniques, is widespread. The risk is that the results are not stable because the technique and materials do not fit the patient anatomy. Arch forms are affected by arch dimensions and therefore, comparison of dimensions and forms simultaneously bears a lot of advantage in knowing exact association between craniofacial skeleton and the dental arches. So the objective of present study was to evaluate the correlation between vertical facial pattern and dental arch form in different types of skeletal malocclusion.

In present study value of Ang I in skeletal class II malocclusion was decreased from low angle to high angle cases (TABLE I, TABLE II). This is because of downward and backward rotation of the mandible in hyperdivergent facial patterns. This is also in accordance with the study conducted by Kou Xi H[27] who found that the upper and lower incisors of class II, Division 1 malocclusion were labially inclined in vertical growth pattern. When angle Ang 2R, Ang 2L, Ang 3R and Ang 3L were evaluated in skeletal class I malocclusion, it was found that the angular values were increased from low to high angle cases. This may be because as the value of angle Ang 1 decreases, the value of Ang 2R, Ang 2L, Ang 3R and Ang 3L increases as shown in fig1.

In the present study, the shape of dental arch was measured on the digital photographs of the patient plaster model by drawing a pentagon inscribed inside the arches as shown in figure 1. The various internal angles inside the maxillary (fig II) and the mandibular arches of pentagon (Ang 1, Ang 2R, Ang 2L, Ang 3R and Ang 3L) and the ratio between the intercanine and intermolar distance was calculated to evaluate the form of dental arch in different types of skeletal malocclusion.

When dental arch forms were correlated with different vertical facial patterns the result analysis showed a change in upper arch shape with an intercanine diameter proportionately smaller in patients with high angles and greater in patients with low angles ($P < 0.05$) irrespective of malocclusion. The bigger the SN-MP angles were, the narrow is the form of the upper arches. Although the data from the present study showed an inverse trend between SN-MP angle and dental arch widths and it seems that the SN-MP angle might be only one of the contributing factors. There was no statistically significant difference in mandibular arch forms between the three groups with the exception of the angle value Ang. 1. The decrease of this value from low- to high-angle groups should be interpreted as the prevalence of 'V' shapes arch form in subjects with high angle and of ovoid arch forms in low angle patients.

Dental arch form is certainly a multifactorial phenomenon. The data from this study showed an inverse relationship between MP-SN angle and it seems the MP-SN angle might be only one of the contributing factors. Hence, the prediction of dental arch width is generalized and can be influenced by other factors. The relationships between the vertical facial morphology and dental arch widths in untreated Himachali adults have an inverse relationship as in Caucasian population. Hence, irrespective of ethnicity and race of the population group, SN-MP and inter-arch widths can be used as a valuable tool in assessing the vertical and transverse craniofacial and dentoalveolar morphology. This highlights the importance of using individualized archwires according to pretreatment arch form and

width for each patient during orthodontic treatment. Since the wide variations in patient arches cannot be met by the few preformed archwire shapes and sizes available, the concept of individualization of archwires is strongly suggested.

CONCLUSIONS

- Inverse correlation was found between dental arch form and vertical facial pattern indicating narrower arch form in high angle cases and wider arch form in low angle cases.
- As the form of dental arches is associated with the vertical growth patterns, it would be desirable to use individualized arches for each patient.

Table-I: Distribution of mean & standard deviation of different parameters of a class II malocclusion on maxillary arch in three types of vertical facial patterns (Low, Average & High)

Parameters	Vertical Facial Patterns	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Ang1	Low Angle	10	124.43	9.589	3.624	127	146
	Average Angle	10	120.71	19.172	7.246	102	144
	High Angle	10	120.66	17.141	6.479	96	133
	Total	30	125.67	16.614	3.626	96	146
Ang2R	Low Angle	10	123.14	11.187	4.228	110	134
	Average Angle	10	130.57	12.660	4.785	115	146
	High Angle	10	132.57	10.706	4.046	124	148
	Total	30	128.76	11.717	2.557	110	148
Ang2L	Low Angle	10	112.14	1.676	.634	110	114
	Average Angle	10	128.86	13.031	4.925	112	141
	High Angle	10	133.43	11.058	4.180	116	147
	Total	30	124.81	13.280	2.898	110	147
Ang3R	Low Angle	10	76.00	5.831	2.204	69	84
	Average Angle	10	79.29	2.563	.969	77	82
	High Angle	10	74.29	3.147	1.190	72	81
	Total	30	76.52	4.434	.968	69	84
Ang3L	Low Angle	10	80.14	5.699	2.154	68	84
	Average Angle	10	79.14	2.116	.800	77	82
	High Angle	10	77.86	5.398	2.040	75	90
	Total	30	79.05	4.555	.994	68	90
Inter canine distance	Low Angle	10	38.071	.4786	.1809	37.6	38.7
	Average Angle	10	35.286	1.5646	.5914	32.9	37.1
	High Angle	10	34.771	3.1090	1.1751	33.3	41.8
	Total	30	36.043	2.4310	.5305	32.9	41.8
Inter molar distance	Low Angle	10	47.729	.9945	.3759	44.5	46.8
	Average Angle	10	44.871	2.2904	.8657	42.4	47.9
	High Angle	10	46.671	.8538	.3227	45.4	47.6
	Total	30	45.757	1.6299	.3557	42.4	47.9
Intercanine Intermolar distance ratio	Low Angle	10	.843	.0535	.0202	.8	.9
	Average Angle	10	.786	.0900	.0340	.7	.9
	High Angle	10	.729	.0756	.0286	.7	.9
	Total	30	.786	.0854	.0186	.7	.9

Table-II: Distribution of mean & standard deviation of different parameters of a class II malocclusion on mandibular arch in three types of vertical facial patterns. (Low, Average & High)

Parameters	Vertical Facial Patterns	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Ang1	Low Angle	10	134.29	1.604	.606	117	122
	Average Angle	10	131.29	14.244	5.384	113	147
	High Angle	10	134.71	9.087	3.435	120	145
	Total	30	128.43	11.505	2.511	113	147
Ang2R	Low Angle	10	138.57	2.070	.782	136	141
	Average Angle	10	123.43	3.207	1.212	119	126
	High Angle	10	132.43	5.855	2.213	126	144
	Total	30	131.48	7.434	1.622	119	144
Ang2L	Low Angle	10	138.86	.900	.340	138	140
	Average Angle	10	131.14	12.130	4.585	120	145
	High Angle	10	127.29	4.536	1.714	122	136
	Total	30	132.43	8.652	1.888	120	145
Ang3R	Low Angle	10	68.29	.756	.286	67	69
	Average Angle	10	72.43	5.028	1.901	65	80
	High Angle	10	69.29	1.496	.565	66	70
	Total	30	70.00	3.421	.746	65	80
Ang3L	Low Angle	10	69.29	.756	.286	68	70
	Average Angle	10	73.00	5.568	2.104	66	79
	High Angle	10	74.86	4.220	1.595	72	81
	Total	30	72.38	4.522	.987	66	81
Inter canine distance	Low Angle	10	26.029	.4821	.1822	25.3	26.8
	Average Angle	10	27.257	3.0843	1.1658	23.1	30.6
	High Angle	10	28.414	1.5214	.5750	25.9	30.3
	Total	30	27.233	2.1481	.4688	23.1	30.6
Inter molar distance	Low Angle	10	41.386	.8611	.3255	40.1	42.2
	Average Angle	10	40.671	2.2269	.8417	37.8	43.7
	High Angle	10	43.743	.7678	.2902	42.5	44.5
	Total	30	41.933	1.9223	.4195	37.8	44.5
Inter canine Inter molar distance ratio	Low Angle	10	.600	.0000	.0000	.6	.6
	Average Angle	10	.686	.0690	.0261	.6	.8
	High Angle	10	.629	.0488	.0184	.6	.7
	Total	30	.638	.0590	.0129	.6	.8

Table-III: Comparison of mean of different parameters of a class II malocclusion on maxillary arch in three types of vertical facial patterns (Low, Average & High) by one way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Ang1	Between Groups	1000.667	2	500.333	1.992	.015*
	Within Groups	4520.000	18	251.111		
	Total	5520.667	20			
Ang2R	Between Groups	345.524	2	172.762	1.296	.298
	Within Groups	2400.286	18	133.349		
	Total	2745.810	20			
Ang2L	Between Groups	1757.810	2	878.905	8.941	.142
	Within Groups	1769.429	18	98.302		
	Total	3527.238	20			
Ang3R	Between Groups	90.381	2	45.190	2.686	.095
	Within Groups	302.857	18	16.825		
	Total	393.238	20			
Ang3L	Between Groups	18.381	2	9.190	.417	.665
	Within Groups	396.571	18	22.032		
	Total	414.952	20			
Inter canine distance	Between Groups	44.134	2	22.067	5.364	.015*
	Within Groups	74.057	18	4.114		
	Total	118.191	20			
Inter molar distance	Between Groups	11.349	2	5.674	2.444	.115
	Within Groups	41.783	18	2.321		
	Total	53.131	20			
Inter canine Intermolar distance ratio	Between Groups	.046	2	.023	4.114	.034
	Within Groups	.100	18	.006		
	Total	.146	20			

p<0.05 and p<0.01 (significant); p<0.01 (highly significant); p>0.05 (not significant)

Table-IV: Comparison of mean of different parameters of a class II malocclusion on mandibular arch in three types of vertical facial patterns (Low, Average & High) by one way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Ang1	Between Groups	1000.667	2	500.333	1.992	.045*
	Within Groups	4520.000	18	251.111		
	Total	5520.667	20			
Ang2R	Between Groups	345.524	2	172.762	1.296	.298
	Within Groups	2400.286	18	133.349		
	Total	2745.810	20			
Ang2L	Between Groups	1757.810	2	878.905	8.941	.142
	Within Groups	1769.429	18	98.302		
	Total	3527.238	20			
Ang3R	Between Groups	90.381	2	45.190	2.686	.095
	Within Groups	302.857	18	16.825		
	Total	393.238	20			
Ang3L	Between Groups	18.381	2	9.190	.417	.665
	Within Groups	396.571	18	22.032		
	Total	414.952	20			
Inter canine distance	Between Groups	44.134	2	22.067	5.364	.015*
	Within Groups	74.057	18	4.114		
	Total	118.191	20			
Inter molar distance	Between Groups	11.349	2	5.674	2.444	.115
	Within Groups	41.783	18	2.321		
	Total	53.131	20			
Inter canine Intermolar distance ratio	Between Groups	.046	2	.023	4.114	.034
	Within Groups	.100	18	.006		
	Total	.146	20			

p<0.05 and p<0.01 (significant); p<0.01 (highly significant); p>0.05 (not significant)

Table-V: Showed the correlation between dental arch form and vertical facial pattern

		MAXILLA	MANDIBLE
SN/MP	Pearson Correlation		
	P value	Class II	Class II
	N		
Ang1	Pearson Correlation	-.816	-.710
	P value	.010*	.045*
	N	10	10
Ang2R	Pearson Correlation	.837	-.281
	P value	.003*	.541
	N	10	10
Ang2L	Pearson Correlation	.860	.531
	P value	.003*	.062
	N	10	10
Ang3R	Pearson Correlation	.643	-.661
	P value	.056	.106
	N	10	10
Ang3L	Pearson Correlation	.570	.737
	P value	.132	.059
	N	10	10
Inter canine Intermolar distance ratio	Pearson Correlation	-.810	-.565
	P value	.019*	.186
	N	10	10

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