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# Relationship between Vertical Facial Pattern and Dental Arch Forms in skeletal Class I Malocclusion

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**Abstract** **Original Research Article**

***Introduction:*** The purpose of this study was to investigate the relationship between vertical facial pattern and dental arch forms in class I 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 interexaminar 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.

**Keywords**: Reliability, AutoCad, Photographs.



## INTRODUCTION

The determination of dental arch forms is an important aspect of orthodontic treatment. Arch form and arch dimensions are two important factors in case assessment, diagnosis and treatment planning. The size and shape of the dental arches have an effect on space availability, stability of dentition and dental esthetics. 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 which influence the arch form [1].

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]. The form of mandibular dental arch is considered one of the key stone during treatment and its maintenance is an important factor for the stability of orthodontic treatment. One of the purposes of orthodontics is to correct malocclusion and position the teeth in ideal equilibrium with their bony bases. Hence preservation of form and dimensions of dental arches must be one of the first objectives of orthodontic problem.

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].

The literature contain many reports on the relationship between masseter muscle and craniofacial morphology [9, 10]. Among the characteristics of facial morphology, facial type such as –short, average and long is an important factor in orthodontic treatment because the facial type influence the anchorage system and goals of orthodontic treatment [11]. The effect of jaw muscles on facial form has fascinated many investigators. 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 I-ANB 0°-4°). 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°), (2) average angle (MP-SN > 27° and < 36°), and (3) high angle (MP-SN > 36°).

## 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-1) and mandibular dental casts (Fig-2) 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 1 & 2.

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.

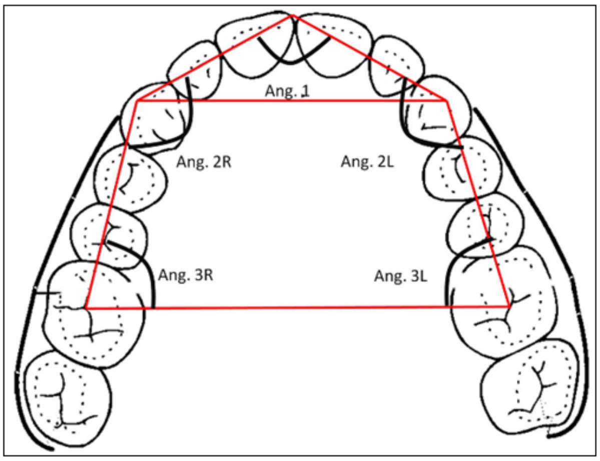


**Fig-1: Shows the angular and linear measurements using computer analysis (AutoCad software) on the maxillary arch**

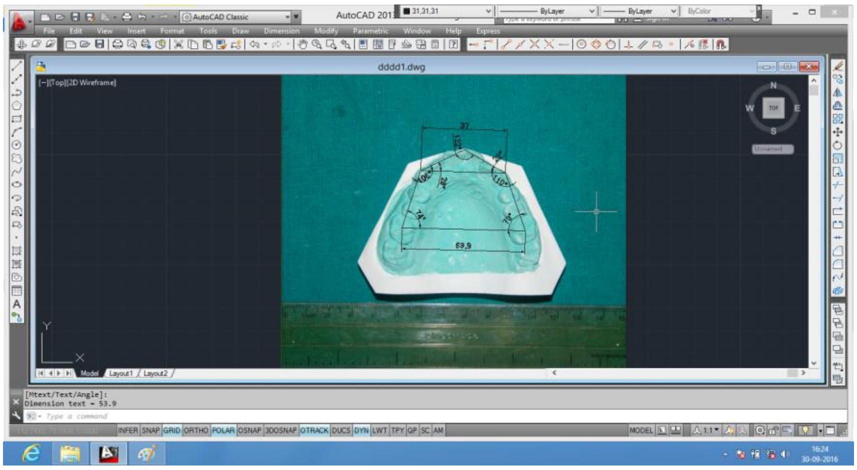

**Fig-2**

## 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 interexaminar reliability analysis was performed using Kappa statistic. The interexaminer reliability was found to be Kappa= .80-1.00 ($p<0.001$) which shows perfect agreement according to Landis and Koch [16]. 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 which were equally divided into three groups consisted of 30 subjects each. The subjects were divided into three groups as skeletal class I, class II and class III based on ANB angle. The subjects were further divided into three subgroups according to the values of angle SN-MP: (1) low angle (MP-SN < 27°), (2) average angle (MP-SN > 27° and < 36°), and (3) high angle (MP-SN > 36°).

Table 1 & 2 shows the mean, the standard deviation, the standard error, the minimum and maximum value of different parameters of class I 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 I maloclussion in different vertical facial patterns was 132 in low angle, 128 .60 in average angle and 126.60 in high angle in maxillary arch and 138 in low angle, 132 in average angle and 128.1 in high angle in mandibular arch.

The mean value of angle Ang 2R in class I maloclussion in different vertical facial patterns was 127.9 in low angle, 130 .90 in average angle and 132.1 in high angle in maxillary arch and 128.2 in low angle, 130 .70 in average angle and 133.5 in high angle in mandibular arch.

The mean value of angle Ang 2L in class I maloclussion in different vertical facial patterns was 126.5 in low angle, 132 .70 in average angle and 134.5 in high angle in maxillary arch and 126.9 in low angle, 133 .50 in average angle and 136.4 in high angle in mandibular arch.

The mean value of angle Ang 3R in class I maloclussion in different vertical facial patterns was 75.5 in low angle, 73 .50 in average angle and 79.1 in high angle in maxillary arch and 69.80 in low angle, 72 .10 in average angle and 71.1 in high angle in mandibular arch.

The mean value of angle Ang 3L in class I maloclussion in different vertical facial patterns was 76.3 in low angle, 72 .80 in average angle and 75.5 in high angle in maxillary arch and 66.90 in low angle, 71 .20 in average angle and 69.7 in high angle in mandibular arch.

The mean value of intercanine distance in class I maloclussion in different vertical facial patterns was 39.96 in low angle, 34.83 in average angle and 37.87 in high angle in maxillary arch and 28.67 in low angle, 27.72 in average angle and 26.85 in high angle in mandibular arch.

The mean value of intermolar distance in class I maloclussion in different vertical facial patterns was 51.77 in low angle, 49.93 in average angle and 49.94 in high angle in maxillary arch and 45.56 in low angle, 44.06 in average angle and 43.81 in high angle in mandibular arch.

Table 3 & 4 shows the comparision of mean of different parameters of class I malocclusion in three different groups divided based on SN-MP angle (Low, medium and high angle) by one way ANOVA analysis.

Table-5, In class I malocclusion the angle that express the anterior arch form in maxillary arch Ang 1was correlated with the vertical facial pattern. The value of Ang 1 was significant with negative relationship showing r = -844 and p-value .002. The value of Ang 2R was also highly significant with positive relationship showing r = .852 and p value .002. The value of Ang 2L was also significant with possitive relationship showing r = .791 and p value .003. The value of Ang 3R and 3L were insignificant with positive relationship showing r = .691 and p value .052 and r = .586 and p value .186. The value of intercanine and intermolar distance ratio was insignificant with negative relationship showing r = -510 and p .129.

**Table-1: Distribution of mean & Standard deviation of different parameters of a class I 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 | 132.00 | 6.880 | 2.176 | 122 | 145 |
| | Average Angle | 10 | 128.60 | 5.777 | 1.827 | 118 | 133 |
| | High Angle | 10 | 126.60 | 14.167 | 4.480 | 115 | 147 |
| | Total | 30 | 129.40 | 10.237 | 1.869 | 115 | 147 |
| Ang2R | Low Angle | 10 | 127.90 | 8.006 | 2.532 | 120 | 148 |
| | Average Angle | 10 | 130.90 | 4.954 | 1.567 | 124s | 137 |
| | High Angle | 10 | 132.10 | 12.360 | 3.909 | 110 | 137 |
| | Total | 30 | 129.97 | 9.419 | 1.720 | 110 | 148 |
| Ang2L | Low Angle | 10 | 126.50 | 6.096 | 1.928 | 116 | 139 |
| | Average Angle | 10 | 132.70 | 3.433 | 1.086 | 132 | 142 |
| | High Angle | 10 | 134.50 | 6.852 | 2.167 | 116 | 137 |
| | Total | 30 | 131.23 | 6.927 | 1.265 | 116 | 142 |
| Ang3R | Low Angle | 10 | 75.50 | 2.799 | .885 | 72 | 80 |
| | Average Angle | 10 | 73.50 | 2.593 | .820 | 71 | 77 |
| | High Angle | 10 | 79.10 | 7.125 | 2.253 | 69 | 88 |
| | Total | 30 | 76.03 | 5.082 | .928 | 69 | 88 |
| Ang3L | Low Angle | 10 | 76.30 | 3.368 | 1.065 | 70 | 80 |
| | Average Angle | 10 | 72.80 | 4.131 | 1.306 | 67 | 77 |
| | High Angle | 10 | 75.50 | 2.718 | .860 | 73 | 82 |
| | Total | 30 | 74.87 | 3.665 | .669 | 67 | 82 |
| Inter canine distance | Low Angle | 10 | 39.960 | 2.9098 | .9202 | 35.8 | 43.2 |
| | Average Angle | 10 | 34.830 | 1.0414 | .3293 | 33.3 | 36.6 |
| | High Angle | 10 | 37.870 | 3.3059 | 1.0454 | 35.3 | 44.2 |
| | Total | 30 | 37.887 | 3.3754 | .6163 | 33.3 | 44.2 |
| Inter molar distance | Low Angle | 10 | 51.770 | 2.4980 | .7899 | 47.5 | 55.5 |
| | Average Angle | 10 | 49.930 | 2.1380 | .6761 | 46.0 | 52.0 |
| | High Angle | 10 | 49.940 | 2.2292 | .7049 | 47.9 | 54.3 |
| | Total | 30 | 50.213 | 2.7772 | .5070 | 46.0 | 55.5 |
| Intercanine Intermolar distance ratio | Low Angle | 10 | .758 | .0475 | .0150 | .7 | .8 |
| | Average Angle | 10 | .713 | .0343 | .0109 | .7 | .8 |
| | High Angle | 10 | .749 | .0665 | .0210 | .7 | .9 |
| | Total | 30 | .740 | .0532 | .0097 | .7 | .9 |

**Table-2: Distribution of mean & Standard deviation of different parameters of a class I 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 | 138.30 | 4.572 | 1.446 | 128 | 145 |
| | Average Angle | 10 | 132.60 | 3.950 | 1.249 | 127 | 138 |
| | High Angle | 10 | 128.10 | 4.909 | 1.552 | 133 | 145 |
| | Total | 30 | 136.33 | 5.101 | .931 | 127 | 145 |
| Ang2R | Low Angle | 10 | 128.20 | 4.849 | 1.533 | 124 | 140 |
| | Average Angle | 10 | 130.70 | 8.616 | 2.725 | 126 | 150 |
| | High Angle | 10 | 133.50 | 4.882 | 1.544 | 126 | 139 |
| | Total | 30 | 134.13 | 8.055 | 1.471 | 124 | 150 |
| Ang2L | Low Angle | 10 | 126.90 | 3.178 | 1.005 | 131 | 140 |
| | Average Angle | 10 | 133.50 | 1.080 | .342 | 132 | 136 |
| | High Angle | 10 | 136.40 | 6.059 | 1.916 | 117 | 134 |
| | Total | 30 | 132.27 | 5.889 | 1.075 | 117 | 140 |
| Ang3R | Low Angle | 10 | 69.80 | .789 | .249 | 68 | 71 |
| | Average Angle | 10 | 72.10 | 5.744 | 1.816 | 58 | 76 |
| | High Angle | 10 | 71.40 | 3.893 | 1.231 | 65 | 75 |
| | Total | 30 | 71.10 | 4.012 | .732 | 58 | 76 |
| Ang3L | Low Angle | 10 | 66.90 | 2.234 | .706 | 65 | 72 |
| | Average Angle | 10 | 71.20 | 4.104 | 1.298 | 68 | 77 |
| | High Angle | 10 | 69.70 | 1.703 | .539 | 68 | 74 |
| | Total | 30 | 69.27 | 3.311 | .604 | 65 | 77 |
| Inter canine distance | Low Angle | 10 | 28.670 | 2.6949 | .8522 | 23.6 | 29.4 |
| | Average Angle | 10 | 27.720 | 1.4490 | .4582 | 25.8 | 29.7 |
| | High Angle | 10 | 26.851 | 2.0002 | .6325 | 25.8 | 31.8 |
| | Total | 30 | 27.747 | 2.2288 | .4069 | 23.6 | 31.8 |
| Inter molar distance | Low Angle | 10 | 45.560 | 2.1246 | .6718 | 43.4 | 47.8 |
| | Average Angle | 10 | 44.060 | 1.9546 | .6181 | 42.6 | 48.9 |
| | High Angle | 10 | 43.810 | 2.2781 | .7204 | 40.7 | 48.7 |
| | Total | 30 | 45.810 | 2.1812 | .3982 | 40.7 | 48.9 |
| Intercanine Intermolar distance ratio | Low Angle | 10 | .784 | .0352 | .0111 | .5 | .6 |
| | Average Angle | 10 | .616 | .0376 | .0119 | .6 | .7 |
| | High Angle | 10 | .606 | .0270 | .0085 | .6 | .7 |
| | Total | 30 | .605 | .0359 | .0065 | .5 | .7 |

**Table-3: Comparison of mean of different parameters of a class I malocclusion on maxillary arch in three types of vertical facial patterns (Low, Average & High) by one way ANOVA**

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| | | Sum of Squares | Df | Mean Square | F | Sig. |
| Ang1 | Between Groups | 506.400 | 2 | 253.200 | 2.699 | .035* |
| | Within Groups | 2532.800 | 27 | 93.807 | | |
| | Total | 3039.200 | 29 | | | |
| Ang2R | Between Groups | 400.267 | 2 | 200.133 | 2.487 | .102 |
| | Within Groups | 2172.700 | 27 | 80.470 | | |
| | Total | 2572.967 | 29 | | | |
| Ang2L | Between Groups | 528.267 | 2 | 264.133 | 8.263 | .042* |
| | Within Groups | 863.100 | 27 | 31.967 | | |
| | Total | 1391.367 | 29 | | | |
| Ang3R | Between Groups | 161.067 | 2 | 80.533 | 3.699 | .038* |
| | Within Groups | 587.900 | 27 | 21.774 | | |
| | Total | 748.967 | 29 | | | |
| Ang3L | Between Groups | 67.267 | 2 | 33.633 | 2.818 | .077 |
| | Within Groups | 322.200 | 27 | 11.933 | | |
| | Total | 389.467 | 29 | | | |
| Inter canine distance | Between Groups | 146.089 | 2 | 73.044 | 10.700 | .000** |
| | Within Groups | 184.326 | 27 | 6.827 | | |
| | Total | 330.415 | 29 | | | |
| Inter molar distance | Between Groups | 81.649 | 2 | 40.824 | 7.761 | .002* |
| | Within Groups | 142.026 | 27 | 5.260 | | |
| | Total | 223.675 | 29 | | | |
| Intercanine Intermolar distance ratio | Between Groups | .011 | 2 | .006 | 2.150 | .136 |
| | Within Groups | .071 | 27 | .003 | | |
| | Total | .082 | 29 | | | |

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

**Table-4: Comparison of mean of different parameters of a class I malocclusion on mandibular arch in three types of vertical facial patterns (Low, Average & High) by one way ANOVA**

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| | | Sum of Squares | Df | Mean Square | F | Sig. |
| Ang1 | Between Groups | 509.267 | 2 | 104.633 | 9.180 | .001* |
| | Within Groups | 545.400 | 27 | 20.200 | | |
| | Total | 1054.667 | 29 | | | |
| Ang2R | Between Groups | 787.267 | 2 | 393.633 | 4.713 | .121 |
| | Within Groups | 1094.200 | 27 | 40.526 | | |
| | Total | 1881.467 | 29 | | | |
| Ang2L | Between Groups | 274.067 | 2 | 287.033 | 7.948 | .012 |
| | Within Groups | 431.800 | 27 | 15.993 | | |
| | Total | 1005.867 | 29 | | | |
| Ang3R | Between Groups | 27.800 | 2 | 13.900 | .855 | .436 |
| | Within Groups | 438.900 | 27 | 16.256 | | |
| | Total | 466.700 | 29 | | | |
| Ang3L | Between Groups | 95.267 | 2 | 47.633 | 5.778 | .118 |
| | Within Groups | 222.600 | 27 | 8.244 | | |
| | Total | 317.867 | 29 | | | |
| Inter canine distance | Between Groups | 23.795 | 2 | 11.897 | 2.671 | .087 |
| | Within Groups | 120.265 | 27 | 4.454 | | |
| | Total | 144.060 | 29 | | | |
| Inter molar distance | Between Groups | 16.250 | 2 | 8.125 | 1.802 | .184 |
| | Within Groups | 121.717 | 27 | 4.508 | | |
| | Total | 137.967 | 29 | | | |
| Intercanine Intermolar distance ratio | Between Groups | .007 | 2 | .003 | 3.011 | .066 |
| | Within Groups | .031 | 27 | .001 | | |
| | Total | .037 | 29 | | | |

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

**Table-5: Showed the correlation between dental arch form and vertical facial pattern**

| | | MAXILLA | MANDIBLE |
|---|---|---|---|
| SN/MP | Pearson Correlation | | |
| | P value | Class I | Class I |
| | N | | |
| Ang1 | Pearson Correlation | -.844 | -.770 |
| | P value | .002* | .019* |
| | N | 10 | 10 |
| Ang2R | Pearson Correlation | .852 | .230 |
| | P value | .002* | .523 |
| | N | 10 | 10 |
| Ang2L | Pearson Correlation | .791 | .356 |
| | P value | .019* | .312 |
| | N | 10 | 10 |
| Ang3R | Pearson Correlation | .691 | .394 |
| | P value | .052 | .261 |
| | N | 10 | 10 |
| Ang3L | Pearson Correlation | .586 | .374 |
| | P value | .186 | .339 |
| | N | 10 | 10 |
| Intercanine Intermolar distance ratio | Pearson Correlation | -.864 | -.513 |
| | P value | .012* | .129 |
| | N | 10 | 10 |

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

## 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 specially 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 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-2) 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.

In present study, value of Ang1in skeletal class I malocclusion was decreased from low angle to high angle cases (Table 1 & 2). This means that the person with dolichofacial pattern has a narrow dental arch and person with brachyfacial pattern has a wide dental arch. This is in accordance with the study conducted by Al-Taee and Al-Joubori [17] who found downward and backward rotation of the mandible in hyperdivergent facial patterns and upward and forward rotation of mandible in hypodivergent facial patterns. 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 Fig-1. This is in accordance with the study conducted by Tsunori M, Mashita M, Kasai K [14] who evaluate the comparison between average, short and long-face persons. It was concluded that short-face subjects had larger intercanine and intermolar widths and this was the reason that the value of Ang 2R, Ang 2L, Ang 3R and Ang 3L increases from low to high angle case. Also Isaacson *et al.*, [15] reported that subjects with long faces showed decreased maxillary intermolar width. This is also with accordance with Nasby *et al*., [18] who noted increased mandibular molar diameters and length of maxillary and mandibular arches in subjects with reduced Sella-nasion/mandibular plane angle (SN-MP).

In present study value of Ang1in skeletal class II malocclusion was decreased from low angle to high angle cases (Table 4 & 5). This is because of downward and backward rotation of the mandible in hyperdivergent facial patterens. This is also in accordance with the study conducted by Kou Xi H [19] 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 Fig-1.

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.

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