RELATIONSHIP BETWEEN ARCH WIDTH AND VERTICAL FACIAL MORPHOLOGY IN UNTREATED ADULTS OF NAGPUR POPULATION

Dr. Anjali Khekade, Dr. Usha Shenoy, Dr. Pankaj Akhare, Dr. Sujoy Banerjee, Dr. Ananya Hazare, Dr. Himija Karia, Dr. Sangita Bhattacharya

ABSTRACT

Background: It is generally accepted that an important relationship exists between the arch width and vertical facial morphology. The size and form of the dental arches can have considerable implications on orthodontic diagnosis and treatment planning.

Aim & Objective: The objectives of this study were to evaluate the relationship between dental arch dimensions and the vertical facial pattern determined by the Jarabak ratio, and to examine the differences in dental arch dimensions between male and female untreated adults.

Material and method: Lateral cephalograms and study models were obtained from 60 untreated subjects (30 males, 30 females) between 18 and 30 years of age with no crossbite, no/minimal crowding and spacing. The Jarabak ratio (posterior facial height/anterior facial height) was measured on cephalograms of each patient. Study models were used to obtain dental measurements, including maxillary and mandibular intercanine, first premolar and first intermolar widths.

Results: The results showed that, for both males and females, there was a trend that as vertical facial height increased, arch width decreased and males have significantly larger arch dimensions than those of females.

Conclusion: It was concluded that the dental arch width is associated with gender and vertical facial morphology. Thus using individualized arch wires according to each patient's pre-treatment arch form and width is suggested during orthodontic treatment.

Correspondence:
Dr. Anjali Khekade
Post Graduate Student,
Department Of Orthodontics and Dentofacial Orthopaedics,
VSPM's Dental College and Research Centre, Digdoh Hill, Hingna Road, Nagpur
Email: anjalikhekade13@gmail.com
INTRODUCTION
The relationship between malocclusion and facial form has been a focus of orthodontists since an early 20th century. The dental arch width and facial form are important factors for determining success and stability of orthodontic treatment. Arch form is defined as the position and relationship of teeth to each other in all three dimensions.\(^1\) According to Hawley\(^2\), ideal arch width was based on an equilateral triangle with a base representing the inter-condylar width in which the lower anterior teeth were arranged on an arc of a circle with radius determined by the combined width of the lower incisors and canines, and the premolars and molars aligned with the second and third molars toward the center.

The dental arch forms is a multifactorial trait. The genetic component could be related to vertical growth patterns and the environmental components related to functional, muscular, and local factors. Orthodontic treatments are conditioned by arch forms, which must be respected to provide successful treatment and avoid serious consequences, such as relapse or iatrogenic damage to teeth being moved beyond their bone edges.

A long-face individual usually has narrower transverse dimensions (dolichofacial) and a short-face individual wider transverse dimensions (brachyfacial), according to Ricketts \textit{et al.}\(^3\) (1982), Enlow and Hans\(^4\) (1996), and Wagner and Chung\(^5\) (2005). Isaacson \textit{et al.} (1972)\(^6\) reported that long face subjects showed decreased maxillary intermolar width. Nasby \textit{et al.}\(^7\) (1972) noted increased mandibular molar diameters and length of maxillary and mandibular arches in subjects with decreased Sella-nasion/mandibular plane angle (SN-MP). Forster \textit{et al.}\(^8\) showed that the transverse diameters were decreased in both males and females with high-angle SN-MP.

Nowadays, preformed archwires are routinely used by orthodontists regardless of the facial type, facial proportions, and gender of the patients. However, using individualized archwires according to each patient's pre treatment arch form and width is necessary during orthodontic treatment. The purpose of the this study was to
investigate if dental arch widths are correlated with vertical facial types (MP – SN angle) and if there are any differences in dental arch widths between untreated male and female Nagpur adults.

**MATERIAL AND METHODS:**

**SAMPLE**

The present study was conducted on 60 subjects comprising of 30 males and 30 females aged from 18-30 years. The lateral cephalograms and study models for the purpose of the study were obtained from the records of patients visiting the OPD of the Department of Orthodontics and Dentofacial Orthopedics, VSPM’s Dental College and Research Centre, Digdoh Hills, Hingna. The subjects were selected on the basis of inclusion and exclusion criteria. Inclusion criteria included Subjects with skeletal Class I pattern and Angle's Class I molar relation, full dentition except for third molars, pre-treatment lateral cephalogram, and maxillary and mandibular dental casts available. Exclusion criteria included history of previous orthodontic treatment, edentulous spaces, history of trauma, significant cuspal wear, extensive restorations or prosthetics, anterior and posterior crossbites, and severe crowding (>9 mm) or spacing (>9 mm) and individuals with marked jaw asymmetries and temporomandibular Joint (TMJ) abnormality.

The sample was randomly selected, and then, for descriptive purposes, the subjects were classified into three different groups according to jarabak’s ratio.

- **GROUP I - HORIZONTAL** >65 %
- **GROUP II - AVERAGE** 62-65 %
- **GROUP III - VERTICAL** <62 %

**MEASUREMENTS**

High-quality orthodontic impressions for study models were taken with alginate impression material. The lateral cephalograms of the selected subjects were taken using the standard technique. The lateral cephalograms were traced on acetate tracing sheets, 0.5micron in thickness using a sharp 4H pencil.

For each subject, Jarabak ratio (Siriwat and Jarabak 1985) was measured. The posterior facial height was drawn from sella to gonion (Go) and anterior facial height was drawn from nasion to menton (Me). (Figure 1)
Dental cast measurements were performed using a digital caliper (Figure 2) accurate to 0.01 mm. The following maxillary and mandibular dimensions were measured (Figure 3):

1. Intercanine width (from buccal cusp tip),
2. First interpmolar widths (from buccal cusp tip),
3. First intermolar widths (from mesiobuccal cusp tip)

**STATISTICAL ANALYSIS**

Mean values of Jarabak ratio, maxillary and mandibular arch dimensions amongst three facial types were determined along with their standard deviations using descriptive statistics. (Table 1, 2, 3)

- **Group 1:** Average
- **Group 2:** Horizontal
- **Group 3:** Vertical

The statistical analysis was done using the Statistical Package for the Social Science (SPSS version 22, Armonk, NY: IBM Corp). The recorded values were statistically evaluated using the one-way analysis of variance test (ANOVA), followed by Tukey post hoc test for multiple comparisons. The one-way analysis of variance (ANOVA) is used to determine whether there are any significant differences between the
means of two or more independent (unrelated) groups.

RESULTS:
Tab. 1 shows the comparison of Jarabak ratio amongst the three facial types. It was seen that horizontal facial type had the highest Jarabak ratio whereas the vertical types had the lowest values. This difference was highly statistically significant (p≤0.001).

Tab.1 Comparison of Jarabak ratio amongst three facial types

<table>
<thead>
<tr>
<th>Facial types</th>
<th>Sample size (n)</th>
<th>Average Jarabak ratio (Mean ± SD)</th>
<th>Vertical Jarabak ratio (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>64.65 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>70.10 ± 4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>60.15 ± 1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.001*</td>
<td></td>
</tr>
</tbody>
</table>

*p≤0.001 highly significant using one way ANOVA

Fig 4. Comparison of Jarabak ratio across three facial types

Tab. 2 depicts the comparison of maxillary arch dimensions which includes: intercanine width, interpmolar width and intermolar width among the three facial types. (fig 5)
Intercanine width was seen to largest for the horizontal group followed by average and vertical groups. This difference was statistically significant (p≤0.05) using one way ANOVA followed by Tukey post hoc test. Interpmolar and intermolar widths were also seen to be greater for the horizontal group and lowest in the vertical group. This difference was statistically significant (p≤0.05).

Tab. 3 depicts the comparison of mandibular arch dimensions amongst the three facial types. (fig 6)
It revealed that intercanine and intermolar widths were greater for the horizontal group and lowest for the vertical group. This difference was highly significant (p≤0.001) using one way ANOVA followed by Tukeys Post hoc test.
Interpmolar width was seen to be larger in the horizontal group followed by vertical and lowest in the average group. This difference was statistically significant (p≤0.05) using one way ANOVA followed by Tukey post hoc test.
Tab 4 shows the correlation between the facial types as measured by Jarabak ratio and arch dimensions.
Tab. 2. Comparison of maxillary arch dimensions amongst three facial types

<table>
<thead>
<tr>
<th>Maxillary parameters</th>
<th>Facial types</th>
<th>ANOVA p-value</th>
<th>Multiple comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average (n=20)</td>
<td>Horizontal (n=20)</td>
<td>Vertical (n=20)</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Intercanine width</td>
<td>34.10 ± 3.1</td>
<td>36.55 ± 2.8</td>
<td>33.60 ± 2.7</td>
</tr>
<tr>
<td>Interpremolar width</td>
<td>38.5 ± 3.1</td>
<td>39.9 ± 3.6</td>
<td>36.5 ± 3.5</td>
</tr>
<tr>
<td>Intermolar width</td>
<td>44.35 ± 3.2</td>
<td>47.15 ± 2.9</td>
<td>42.75 ± 2.2</td>
</tr>
</tbody>
</table>

*p≤0.05 statistically significant, **p≤0.001 highly significant using one way ANOVA; NS - not significant

Tab. 3 Comparison of mandibular arch dimensions amongst three facial types

<table>
<thead>
<tr>
<th>Mandibular parameters</th>
<th>Facial types</th>
<th>p-value</th>
<th>Multiple comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average (n=20)</td>
<td>Horizontal (n=20)</td>
<td>Vertical (n=20)</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Intercanine width</td>
<td>25.50 ± 2.7</td>
<td>28.30 ± 3.1</td>
<td>24.25 ± 1.8</td>
</tr>
<tr>
<td>Interpremolar width</td>
<td>30.7 ± 3.2</td>
<td>33.5 ± 4.3</td>
<td>32.0 ± 4.1</td>
</tr>
<tr>
<td>Intermolar width</td>
<td>39.85 ± 2.4</td>
<td>42.05 ± 1.9</td>
<td>38.5 ± 2.7</td>
</tr>
</tbody>
</table>

*p≤0.001 highly significant using one way ANOVA ; **p≤0.05 statistically significant

All the parameters had a significant correlation (p≤0.05) with the facial type except for interpremolar width in both the arches.

Maxillary and mandibular intercanine and intermolar widths had a moderate correlation with facial type.
Tab. 4. Correlation between the arch dimensions and facial types

<table>
<thead>
<tr>
<th>Jarabak ratio</th>
<th>Maxillary parameters</th>
<th>Mandibular parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercanine width</td>
<td>Interpemolar width</td>
</tr>
<tr>
<td></td>
<td>0.42</td>
<td>0.25</td>
</tr>
<tr>
<td>Pearson correlation p-value</td>
<td>0.05*</td>
<td>0.06 (NS)</td>
</tr>
</tbody>
</table>

Sample size (N) 60

*Correlation is significant at the 0.05 level (2-tailed); ** correlation is significant at the 0.01 level (2-tailed); NS- not significant

Fig 5. Comparison of maxillary arch dimensions amongst three facial types
Fig 6. Comparison of mandibular arch dimensions amongst three facial types

Fig. 7 Gender-wise distribution of mean values of maxillary arch dimensions

Fig. 8 Gender-wise distribution of mean values of mandibular arch dimensions
DISCUSSION:
Research has established the importance of vertical dimension. It has been suggested that a subject with a high MP-SN angle tends to have a long face and narrower arch dimensions and one with a low MP-SN angle often has a shorter face and wider arch dimensions (Ricketts et al 1982, Enlow and Hans 1996).
Although several studies have addressed this topic, their results were inconclusive for example most of these studies used MP-SN angle as a measure of the vertical facial pattern but due to natural cranial variation, there may be variation in the anterior cranial base (SN), which may tip up or down.
For the maxillary arch, there was a statistically significant direct relationship between the Jarabak’s ratio and dental arch width between the maxillary canines, first premolars, first molars. Intercanine width was seen to largest for the horizontal group followed by average and vertical groups. Statistically significant (p≤0.05) difference was seen using one way ANOVA followed by Tukey post hoc test. Interpremolar and intermolar widths were also seen to be greater for the horizontal group and lowest in the vertical group. This difference was statistically significant (p≤0.05). For the mandibular arch, it revealed that intercanine and intermolar widths were greater for the horizontal group and lowest for the vertical group. This difference was highly significant (p≤0.001) using one way ANOVA followed by Tukey post hoc test. Interpremolar width was seen to be larger in the horizontal group followed by vertical and lowest in the average group. This difference was statistically significant (p≤0.05) using one way ANOVA followed by Tukey post hoc test. All the parameters had a significant correlation (p≤0.05) with the facial type except for interpremolar width in both the arches. Maxillary and mandibular intercanine and intermolar widths had a moderate correlation with facial type. Inter‑arch width measurements shows a significant difference in arch widths among males and females in untreated Nagpur adult population [Fig 7 & 8]. For maxillary canine, mean inter‑arch width from cusp tip is 35.3 mm for males and 33.3 mm for females. The statistical analysis shows that (P < 0.05) the arch width is significantly greater for males compared to females in the maxillary arch at the inter‑canine region.
Similar observations were seen in all dental arch width measurements in both the arches. These observations are in accordance with the observations seen in Caucasians\(^8\), where the arch width measurements were larger for males compared to females. Wei\(^{10}\) studied posteroanterior cephalograms of Chinese adults and noted gender differences in maxillary and mandibular inter-canine widths. Gross *et al.*\(^{11}\) observed that boys displayed greater arch width than girls, due to the fact that boys tend to be physically larger than girls.

As per the results of this study mean inter-canine width decrease as the vertical angle increases hence individualized arch forms should be used in patients with the variable vertical pattern. This confers to the basic law of stability according to which arch dimensions should not be changed especially across the canines. Use of arch expansion mechanics in patients with low jarabak's ratio should be avoided or used with maximum caution. Musculature has been considered as the possible link in close relationship between the transverse dimension and vertical facial morphology. A number of studies\(^{12-14}\) have illustrated the influence of masticatory muscles on craniofacial growth. The general consensus is\(^8\) that individuals with strong or thick mandibular elevator muscles tend to exhibit wider transverse head dimensions. Strong masticatory musculature is often associated with a brachyfacial pattern (short face) and muscular hyper-function causes an increased mechanical loading of the jaws. This, in turn, cause an introduction of sutural growth and bone apposition which then results in an increased transverse growth of the jaws and bone bases for the dental arches. Spronsen *et al.*\(^{15}\) found that long-faced subjects have significantly smaller medial pterygoid and masseter muscles than normal subjects. Satirglu *et al.*\(^{14}\) Ultrasonographically measured masseter muscle thickness and found that individuals with thick masseter had a vertically shorter facial pattern and individuals with thin masseter have a long face. Their results showed a significant association between vertical facial pattern and masseter muscle thickness. similar results are found with previous studies done by Weijis *et al.*, Kiliardis and Kalebo, Benington *et al.*, and Raadsheer *et al.*,\(^{16-18}\) Proffit *et al.* have proved that the mean bite force is greater for short face, normal in the
average face, and low in long face subjects. The mechanical stress brought about by occlusal bite forces and volume of certain masticatory muscles might influence the morphology and dimensions of adjacent craniofacial skeletal regions. This might be another reason for the variation in arch widths according to the facial pattern. Helkimo et al. have found that mean bite forces were significantly higher in males than in females. The increased bite force might be a reason for the increased arch width in males than in females. As the direction of mandibular growth is influenced by the tongue base position, as the anterior tongue pressure might influence the rotation of mandibular corpus. High-angle subjects had a larger tongue gap than those with normal and low angles and the tongue position may be parallel to downward and backward rotation of mandible. This indicated the relationship between tongue base position and long face syndrome because increased tongue base position causes an increased lower anterior facial height. Because of the lowered positioning of the tongue, the balance between the tongue and buccinators muscle (buccinators mechanism) might be disturbed and this can be a reason for the arch constriction in the maxilla. Mandible also constricts along with maxilla since maxillary and mandibular arches are mutual counterparts according to Enlows counterpart principle. Functional matrix theory also suggests that the width of the palatal complex is influenced by the location of tongue.

Ideally, this type of study should have been conducted on patients with ideal dentitions without any crowding or spacing. However, due to difficulties in finding ideal untreated subjects and subsequent limitations in sample size, the degree of crowding and spacing was not included in the accepted criteria.

CONCLUSION

The following conclusions were made from this study:
1. The dental arch widths (maxillary and mandibular) in males were significantly greater than those in females.
2. In both males and females, as Jarabak's ratio increased, arch width also tended to increase.
3. Since the dental arch width is associated with gender and facial vertical morphology, using individualized archwires according to each patient's pre-treatment arch form.
and widths is suggested during orthodontic treatment.

REFERENCES

13. Weijs WA, Hillen B. Relationships between masticatory muscle
Authors

Dr. Anjali Khekade
Post Graduate Student,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur

Dr. Usha Shenoy
HOD and Professor,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur

Dr. Pankaj Akhare
Associate Professor,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur

Dr. Sujoy Banerjee
Associate Professor,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur

Dr. Ananya Hazare
Senior Lecturer,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur

Dr. Himija Karia
Senior Lecturer,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur

Dr. Sangita Bhattacharya
Lecturer,
Department Of Orthodontics and
Dentofacial Orthopaedics, VSPM’s
Dental College and Research Centre,
Digdoh Hill, Hingna Road, Nagpur
Submit your next manuscript to CRJMS and take full advantage of:

- Convenient manuscript submission (through website) and by mail (editorcrjms@gmail.com).
- Thorough Peer review
- Author friendly Article Processing Charges
- No space constraints or extra color figure charges
- Immediate publication on acceptance Inclusion in International Database including Google Scholar
- Manuscript writing assistance for New Authors