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Relationship between Dental Arch Width and Vertical Facial Morphology in Untreated Adults- A Retrospective Study

Sameer Narkhede [a*≡], Kretikka Sabharwal [aφ], Vivek Soni [a#], Karthick Shetty [a≡], Sushma Sonawane [a≡], Nitin Gadhiya [a≡], Rakesh Singh [a≡], Aparna Khamatkar [a†] and Veera Sawant [a‡]

[a] Department of Orthodontics, DYPU School of Dentisitry, Nerul, Navi Mumbai-400706, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Early orthodontic research has focused on the link between face shape and malocclusion. Orthodontic treatment's effectiveness and stability are heavily influenced by a patient's dental and facial anatomy. An orthodontist's knowledge of arch shapes is essential since it affects the patient's treatment and future growth.
For this study, the researchers wanted to see if there was a link between vertical face morphology and arch width, and if there was a difference in arch width between males and females. Arch width measurements (in millimetres) were utilised to determine the association.
For both males and females, participants with the lowest mandibular plane angle had the widest arch, followed by those with the average mandibular angle and those with the highest.

Keywords: Facial morphology; dental arch; mandibular angle; untreated adults.

[≡] Professor;
[φ] Former PG Student;
[#] HOD and Professor;
[†] Reader;
[‡] Lecturer;
**Corresponding author: E-mail: Sameer.narkhede@dypatil.edu;*

1. INTRODUCTION

Penrose has characterised the arch form as a linear formula [1]. as 'form = size + shape'. For cosmetic and functional reasons, the upper and lower dental arches are like flexible ribbons that may be flexibly modified to different jaw relationships.

According to Hawley, [2] He utilised an equilateral triangle with the base showing the breadth of the intercondylar joints to calculate the ideal arch widths. An arc of the circle is formed by the alignment of the lower premolars and molar teeth, with their widths and lengths determined by the width of the lower canines and incisors combined.

It is a complex characteristic that determines the shape of dental arches. Vertical development patterns and environmental variables associated with functional, muscular, and local factors may be part of the genetic component [3]. Arc forms dictate the course of orthodontic treatment, and failure to do so might result in recurrence or irreversible damage to teeth that have been shifted beyond their bony margins. Orthodontic arch wires are available in a variety of dental arch configurations so that orthodontists may select the best one for each patient's needs. To identify the perfect arch shape, several writers conducted study [4-6]. Consequently, archwires come in a wide variety of shapes and sizes, making it difficult to select the best one for our patients.

Genes and phenotypes have long been considered to have an important role in shaping a person's facial structure. Many people believe that the functional capacity of teeth-clenching muscles is influenced by their size, as well as the shape of their face. [7]. Facial morphology may be broken down into three fundamental categories: short, medium, and long.

According to Schudy, hypodivergent and hyperdivergent vertical facial dysplasia are two extremes [8]. or Opdebeeck's short and long face syndromes (SFS and LFS) [9]. When the condylar development is quite large and the alveolar process and/or anterior facial sutures are relatively short, hypodivergent individuals have a forward rotating mandible. The backward rotation of the jaw in hyperdivergent people is related to the opposite development trend.

People with long faces (leptoprosopic) have narrower arch dimensions, whereas people with short faces (euryprosopic) have wider arch dimensions, according to Rickets and colleagues' findings [10].

Each individual is a different person in this world, no one is similar with the other in any way, and so is the case with facial morphology. Facial morphology is influenced by various factors like genetic, racial, ethnic geographical etc. But each type of face has a proportion of its own, in turn the facial morphology is closely related to the size and shape of the dental arches.

Hence in orthodontics for proper diagnosis and treatment planning it is necessary to know the facial morphology of each patient which in turn can influence the treatment plan.

The transverse dimensions (dolichofacial) of a long-faced human are less than those of a short-faced one, and there is a proportion between each dimensions of face. [10].

Many orthodontists utilize premade arch wires on a regular basis in their practices. As a result, a correlation between arch width and vertical face morphology is necessary. Dental arch width and vertical facial morphology in male and female participants can be used to determine the best treatment mechanics for long-term success [11].

1.1 Aims and Objective

The purpose of this study was to determine if there is a correlation between dental arch widths and vertical facial pattern, and if there are variations in arch widths between untreated male and female patients.

The objective is to prevent increase in intercanine width and provide a more stable occlusion by using correct arch form and reduce the rate of relapse by customizing arch forms.

2. MATERIALS AND METHODS

The study was carried out at the D.Y. Patil University School of Dentistry in Navi Mumbai, Department of Orthodontics and Dentofacial Orthopedics.

Study models and pretreatment lateral cephalograms from the D. Y. Patil University, School of Dentistry, Navi Mumbai, were used in the study, which focused on the age range of 15 to 34 years.

Full dentition except for the third molars, lateral cephalogram, maxillary and mandibular dental casts were required to be included in the study.

Edentulous gaps, trauma, significant cusp wear, extensive prostheses, and previous orthodontic treatment were all exclusions from the study. And extreme crowding (>9 mm) or space that is more than nine millimetres.

100 lateral cephalograms and study models, were selected meeting the above mentioned inclusion criteria. All radiographs were obtained from D.Y.Patil University, School of Dentistry, OMDR department using XTROPAN 2000 (Fig.1) /KODAK 9000 3D,voxel size 76.5x76.5x76.5 and focal spot 0.5mm (IEC 60336), and magnification of 1:1. Everyone was positioned in the cephalostat with their sagittal plane at right angle to the X-ray path, their Frankfort plane perpendicular to the horizontal, and their teeth locked in centric occlusion.

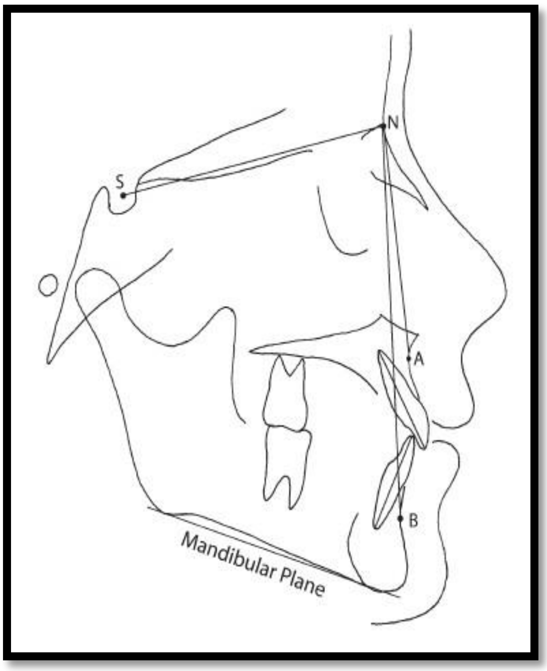

Fig. 1. Mandibular plane

This study categorised participants based on their MP-SN angles into three groups: low< 27 degrees, average 27-37, and high >37.The lateral cephalogram was also used to determine the ANB angle and Jarabaks ratio. (Fig. 1).

The study models were measured using a digital Vernier calliper accurate to 0.01mm. Ten measurements were carried out with the help of a digital Vernier calliper for this study (Fig 2).

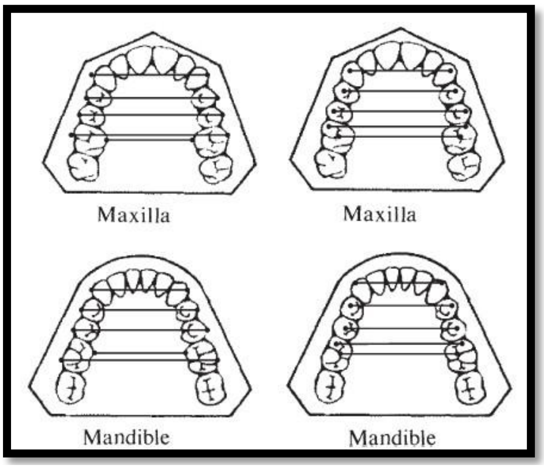

Fig. 2. Measurements of maxilla and mandible

1. Inter canine width- buccal cusp tip of canine on one side to the buccal cusp tip of canine on the opposite side,
2. Inter canine width- widest labial aspect canine on one side to the widest labial aspect of canine on the opposite side,
3. First inter premolar width- buccal cusp tip of premolar on one side to buccal cusp tip of premolar on opposite side,
4. First inter premolar width- widest labial aspect of premolar on one side to widest labial aspect of premolar on opposite side,
5. Second inter premolar width- buccal cusp tip of premolar on one side to buccal cusp tip of premolar on opposite side,
6. Second inter premolar width- widest labial aspect of premolar on one side to widest labial aspect of premolar on opposite side,
7. First inter molar width- mesio buccal cusp of 1st molar on one side to mesio buccal cusp of 1st molar on the opposite side,
8. First inter molar width- central fossa of 1st molar on one side to central fossa of 1st molar on the opposite side,
9. First intermolar width- widest buccal of 1st molar on one side to widest aspect of 1st molar on the opposite side,
10. First intermolar width- narrowest lingual aspect of 1st molar on one side to narrowest lingual aspect of 1st molar on the opposite side.

Additionally, a tooth-arch length difference was found utilising the research models.

The difference between the available arch length and the tooth size was used to compute the tooth arch length discrepancy. The arch length was then deducted from this figure. The needed arch length was equal to the sum of the mesiodistal widths of each individual tooth from the second premolar to the second premolar, as measured from the contact sites.

Two tests were utilized to evaluate the mean arch widths of the maxillary and mandibular arches in males and females and to investigate the link between the vertical facial morphology and arch width.

Student's unpaired t-test was performed to evaluate whether the differences in measures between the male and female groups were significant.

A linear regression analysis was also performed to examine the extent to which dental arch width predicted the change in MP–SN.

3. RESULTS

Men and women's average arch width measures for the maxillary and mandibular arches are shown in the tables below. To put it simply, the mean values for all metrics in the maxillary and mandibular arch were higher in men than girls.

Males and females' mandibular arch measures were tested using a Student's T-test to see whether or not the differences were statistically significant. The statistical significance of a P value less than 0.05 was shown. The tests showed that male arch widths was greater in dimensions as compared to female arch widths in both maxilla and mandible for all parameters and this difference was statistically significant.

This research employed a total of 100 samples. The mandibular plane angles were used to further separate these samples. For the study, 34 males and 18 females were included with low plane angle, as well as 33 males and 17 females with an averge plane angle and 33 guys and 17 women with an high plane angle.

For males with low, moderate, and high mandibular plane angles, the mean maxillary and mandibular arch width measurements are shown in Tables 3 and 4. Maxillary arch width measurements were largest in low angle instances, followed by medium angle cases, and finally high-angle case. The width dimensions of the mandibular arch are maximum in low angle instances, followed by average angle cases and high angle cases. The mean of all the results indicates that the arches were wider in low angle situations than in medium or high angle ones. For both maxilla and mandible, arch width measurements decline with increasing mandibular plane angle, according to the table above.

Table 1. The mean values and standard deviation of the arch width in the maxillary arch for males and females

“Males (n=48)			Females (n=52)		P Value
	Mean	**SD**	**Mean**	**SD**	**(Student t test)**
Intercanine width (cusp tip)	35.78	2.53	33.74	2.55	<0.001*
Intercanine width (most buccal)	38.66	2.30	36.17	2.31	<0.001*
First premolar width (buccal cusp tip)	41.37	2.78	39.39	2.93	0.001*
First premolar width (most buccal)	45.26	2.39	42.60	3.04	<0.001*
Second premolar width (buccal cusp tip)	46.99	2.73	44.14	2.82	<0.001*
Second premolar width (most buccal)	49.80	2.83	47.08	2.82	<0.001*
Intermolar width (mesiobuccal cusp tip)	53.13	3.42	50.06	2.49	<0.001*
Intermolar width (central fossa)	46.49	2.91	44.12	2.36	<0.001*
Intermolar width (most buccal)	56.08	3.29	53.12	2.41	<0.001*
Intermolar width (most lingual)	39.86	3.14	38.37	2.61	0.011*

**p ≤ 0.05 is statistically significant*

Table 2. Mean and standard deviation of arch width in the mandibular arch for men and females, respectively

Males (n=48)			Females (n=52)		P Value
	Mean	SD	Mean	SD	(Student t test)
Intercanine width (cusp tip)	27.09	2.35	25.59	2.32	0.002*
Intercanine width (most buccal)	30.09	2.29	28.46	2.16	<0.001*
First premolar width (buccal cusp tip)	34.68	2.55	32.85	2.81	0.001*
First premolar width (most buccal)	38.63	2.50	36.53	2.59	<0.001*
Second premolar width (buccal cusp tip)	38.84	3.42	37.39	3.02	0.027*
Second premolar width (most buccal)	43.14	3.20	41.32	3.27	0.008*
Intermolar width (mesiobuccal cusp tip)	45.37	3.08	43.72	2.13	0.002*
Intermolar width (central fossa)	40.22	3.13	38.42	1.83	0.001*
Intermolar width (most buccal)	50.14	3.04	48.98	2.14	0.029*
Intermolar width (most lingual	33.47	2.72	32.50	1.68	0.032*

**p ≤ 0.05 is statistically significant”*

Table 3. Maxillary Arch width measurements in millimetres for low, average, and high MP – SN angle males

	“Low (n=16)	Average (n=16)	High (n=16)
		Mean ± SD	
Intercanine width (cusp tip)	37.30 ± 1.55	36.48 ± 1.19	33.54 ± 1.94
Intercanine width (most buccal)	40.33 ± 2.03	39.15 ± 0.88	36.52 ± 1.89
First premolar width (buccal cusp tip)	42.15 ± 2.99	41.99 ± 2.22	39.96 ± 2.69
First premolar width (most buccal)	46.30 ± 2.26	45.44 ± 2.07	44.03 ± 2.40
Second premolar width (buccal cusp tip)	47.99 ± 2.50	47.14 ± 2.22	45.83 ± 3.10
Second premolar width (most buccal)	51.14 ± 2.18	50.08 ± 1.99	48.18 ± 3.40
Intermolar width (mesiobuccal cusp tip)	54.81 ± 2.36	52.98 ± 3.21	51.61 ± 3.92
Intermolar width (central fossa)	48.16 ± 2.10	45.79 ± 2.75	45.51 ± 3.18
Intermolar width (most buccal)	58.14 ± 2.32	55.87 ± 2.84	54.21 ± 3.50
Intermolar width (most lingual)	41.87 ± 2.45	38.83 ± 2.74	38.89 ± 3.30

Table 4. In millimetres, the breadth of the mandibular arch for low, medium, and high angle males

	Low (n=16)	Average (n=16)	High (n=16)
		Mean ± SD	
Intercanine width (cusp tip)	27.98 ± 2.07	25.99 ± 1.20	27.31 ± 3.06
Intercanine width (most buccal)	30.20 ± 2.13	29.88 ± 1.35	29.19 ± 3.17
First premolar width (buccal cusp tip)	35.39 ± 3.08	34.60 ± 2.28	34.05 ± 2.32
First premolar width (most buccal)	38.67 ± 3.02	38.81 ± 2.23	38.41 ± 2.32
Second premolar width (buccal cusp tip)	39.54 ± 3.31	37.89 ±1.78	37.07 ± 4.59
Second premolar width (most buccal)	43.89 ± 2.94	42.57 ± 1.98	41.14 ± 4.63
Intermolar width (mesiobuccal cusp tip)	46.58 ± 2.77	45.13 ± 2.46	44.39 ± 3.57
Intermolar width (central fossa)	41.43 ± 2.52	39.97 ± 3.19	39.46 ± 3.39
Intermolar width (most buccal)	51.60 ± 2.77	49.87 ± 2.38	49.44 ± 3.48
Intermolar width (most lingual)	34.76 ± 2.28	32.53 ± 2.11	32.14 ± 3.26”

Table 5. Maxillary arch width measurements in millimetres for low, average, and high MP – SN angle females

	“Low (n=18)	Average (n=17)	High (n=17)
		Mean ± SD	
Intercanine width (cusp tip)	35.24 ± 1.29	35.07 ± 2.00	30.84 ± 1.26
Intercanine width (most buccal)	37.58 ± 1.89	37.25 ± 1.81	33.58 ±1.27
First premolar width (buccal cusp tip)	41.18 ± 2.36	40.41 ± 2.13	36.48 ± 1.78
First premolar width (most buccal)	44.55 ± 2.35	43.47 ± 2.36	39.67 ± 1.93
Second premolar width (buccal cusp tip)	45.42 ± 2.39	45.08 ± 2.29	41.85 ± 2.37
Second premolar width (most buccal)	48.46 ± 2.42	48.00 ± 2.21	44.69 ± 2.26
Intermolar width (mesiobuccal cusp tip)	51.05 ± 2.59	50.84 ± 2.03	48.24 ± 1.81
Intermolar width (central fossa)	45.09 ± 2.24	44.61 ± 1.84	42.59 ± 2.31
Intermolar width (most buccal)	54.01 ± 2.51	53.91 ± 1.92	51.39 ± 1.83
Intermolar width (most lingual)	38.92 ± 2.16	38.45 ± 2.00	37.71 ± 3.45

Table 6. Low, moderate, and high angle girls' maxillary arch width measures in millimeters are shown

	Low (n=18)	Average (n=17)	High (n=17)
		Mean ± SD	
Intercanine width (cusp tip)	26.16 ± 2.69	26.31 ± 2.12	24.27 ± 1.50
Intercanine width (most buccal)	28.69 ± 2.52	28.31 ± 2.08	27.35 ± 1.29
First premolar width (buccal cusp tip)	33.44 ±2.35	33.44 ± 2.52	30.91 ± 2.47
First premolar width (most buccal)	38.96 ± 2.36	36.19 ± 1.81	34.43 ± 2.09
Second premolar width (buccal cusp tip)	37.61 ± 2.42	37.31 ± 3.25	36.64 ± 3.36
Second premolar width (most buccal)	41.69 ± 2.68	41.32 ± 3.55	40.26 ± 3.49
Intermolar width (mesiobuccal cusp tip)	44.38 ± 2.03	43.99 ± 2.22	42.76 ± 1.88
Intermolar width (central fossa)	39.22 ± 1.39	38.46 ± 1.68	37.54 ± 2.06
Intermolar width (most buccal)	49.43 ±1.69	49.39 ± 2.09	48.09 ± 2.45
Intermolar width (most lingual)	33.02 ± 1.50	32.40 ± 1.92	32.04 ± 1.55”

Tables 5 and 6 illustrate the mean maxillary and mandibular arch width measurements for low, moderate, and high mandibular plane angles in females. Maxillary arch width measurements were largest in low angle instances, followed by medium angle cases, and finally high-angle cases. In the mandibular arch, the width measurements in low angle instances are followed by the average angle cases and the high angle cases in terms of width. The mean of all the results indicates that the arches were wider in the low angle instances than in the average or high angle situations. The arch width measurements of the maxilla and mandible for females decrease as the mandibular plane angle rises.

Table 7 demonstrates the relationship between maxillary arch width and mandibular plane angle. The significance of a p value less than or equal to 0.05 is determined by the following: It indicates a statistically significant link between the angle of the mandibular plane and the arch width for both males and girls. According to this study, maxillary arch width measurements decrease statistically when the mandibular plane angle rises Males and females had p values of 0.940 and 0.218, respectively, for the association between the degree of crowding or spacing and the mandibular plane angle. R^2 value for intercanine width (cusp tip and buccal cusp tip) in men and first premolar width (cusp tip and most buccal) for females revealed modest connection with the mandibular plane angles in the maxiila. For both boys and females, R values for various arch width measures in the maxilla were shown to have little association with the angle of the mandibular plane.

Table 7 demonstrates the relationship between the arch width in the mandible and the mandibular plane angle. Statistical significance is attained when the p-value is less than or equal to 0.05. When it comes to arch width, the mandibular plane angle and arch width are statistically significant negative correlations in intercanine width, first premolar width (cusp tip and the most buccal), intermolar width (mesio buccal cusp tip, the central follicle and the most buccal) for women. For males there was significant inverse relationship for intercanine region(cusp tip), inter second premolar (most

Table 7. Proposed maxillary and mandibular predictors were used in regression analysis

Maxillary Predictors		**“Males (n=48)**		**Females (n=52)**
	R square	**P value**	**R square**	**P value**
		(Pearson’s correlation)		**(Pearson’s correlation)**
Intercanine width (cusp tip)	0.401	<0.001*	0.505	<0.001*
Intercanine width (most buccal)	0.403	<0.001*	0.506	<0.001*
First premolar width (buccal cusp tip)	0.089	0.040*	0.474	<0.001*
First premolar width (most buccal)	0.152	0.006*	0.469	<0.001*
Second premolar width (buccal cusp tip)	0.113	0.020*	0.291	<0.001*
Second premolar width (most buccal)	0.207	0.001*	0.321	<0.001*
Intermolar width (mesiobuccal cusp tip)	0.173	0.002*	0.208	0.001*
Intermolar width (central fossa)	0.162	0.005*	0.231	<0.001*
Intermolar width (most buccal)	0.251	<0.001*	0.215	0.001*
Intermolar width (most lingual)	0.14	0.009*	0.079	0.044*
Crowding	0	0.94	0.03	0.218
Mandibular Predictors				
Intercanine width (cusp tip)	0.089	0.050*	0.142	0.006*
Intercanine width (most buccal)	0.005	0.625	0.092	0.029*
First premolar width (buccal cusp tip)	0.005	0.622	0.115	0.014*
First premolar width (most buccal)	0.008	0.536	0.161	0.003*
Second premolar width (buccal cusp tip)	0.003	0.707	0.009	0.492
Second premolar width (most buccal)	0.002	0.049*	0.024	0.282
Intermolar width (mesiobuccal cusp tip)	0.028	0.252	0.099	0.023*
Intermolar width (central fossa)	0.048	0.134	0.109	0.017*
Intermolar width (most buccal)	0.075	0.050*	0.08	0.042*
Intermolar width (most lingual)	0.07	0.07	0.06	0.08
Crowding	0.132	0.011*	0.003	0.691”

buccal), inter molar region (most buccal). The R^2 value for all parameters showed poor correlation with the mandibular plane angle. P value was statistically significant for crowding in males which showed a correlation between the plane and amount of crowding.

4. DISCUSSION

The purpose of this research was to investigate whether there is a correlation between vertical facial morphology and arch width, as well as to determine if there is a difference in arch width between men and girls.

To test for statistical significance, the students used a t-test, which found that the arch width differences between men and females were statistically significant (p value of less than 0.05) in both the mandibular and maxillary arches.

Participants with low mandibular plane angles had the greatest amount of arch width, followed by those with normal or high mandibular angles. Those who had low mandibular plane angles had the widest arch widths, while those who had normal or high plane angles had narrower arch widths as a result. There was a statistically significant difference between the intermolar regions and the most buccal, according to the student's t-test results (mesiobuccal cusp tip, most buccal, central fossa and palatal cusps).

Mandibular plane angle variation was predicted by arch width and crowding to some degree, as shown by regression analysis. The factors in the maxillary arch exhibited statistically significant values (p value less than 0.05). Neither in men nor in women did researchers find a link between the degree of crowding and the degree of mandibular plane angle change. Intercanine width (cusp tip and buccal cusp tip) and first premolar width (cusp tip and most buccal) in men and females were moderately correlated using R^2. When it comes to maxillary arch characteristics, there was statistical significance in the difference in averages between the different kinds of mandibular plane angle Mandibular arch angle variation and intercanine width (cusp tip, buccal cusp tip, first premolar width, intermolar width, central fossa and most buccal) for females were shown to be statistically significant in the regression analysis findings for the mandible. Statistical analysis revealed a weak relationship between the R^2 scores and the data. It is statistically significant for men to have a high degree of crowding and a low degree of mandibular plane angle.

Wei SH [12] conducted a similar study wherein he used the PA cephalograms to determine the differences in arch width based on gender in the Chinese population. He found a significant difference between the inter canine widths in males and females.

In a study carried out by Mandava Prasad [13] where he studied the differences in male and female arch widths among the South Indian population, as well as the variations in arch width among distinct development patterns. Results from this study were consistent with the findings of the previous study, which found a statistically significant relationship between arch width and mandibular plane angle in the maxillary arch, and an inverse relationship between arch width and mandibular plane angle in the mandibular arch for males. The link between arch width and mandibular plane was not found to be statistically significant in our research. Women were exempt from this rule. The mandibular plane angle had a low to moderate connection with the maxillary and mandibular predictors, as shown by R^2 values in our research. The maxillary and mandibular predictors had moderate to strong association in this investigation.

The findings of this investigation are consistent with the findings of the previous study. Amit Kumar Khera [14] where he showed that the arch width of men was greater than that of females.

In a study by Christina G [15] No correlation was found between the angle of the mandibular plane and the arch width in the population studied. The mandibular plane angles were not divided into low, medium, or high in this research.

Study carried out by Forester [16], Males had considerably wider dental arch widths than females (P 0.05), according to the research. For the majority of measures, the low-angle group had wider arches than the high-angle group.

Muscles are mostly responsible for the relationship between the transverse dimension and vertical face morphology. Many studies have shown that masticatory muscles impact the development of the craniofacial region. As a rule of thumb, those with larger transverse head measurements have larger mandibular elevator muscles, according to the common agreement (Ringqvist, 1973; Weijs and Hillen, 1984; Hannam and Wood, 1989;Kiliaridis, 1991; Bakke et al., 1992; Kiliaridis, 1995). A brachyfacial pattern is generally coupled with a strong masticatory muscle. It is because of this greater mechanical stress of the jaws that the muscles become hyperactive. This, in turn, may lead to an increase in the transverse growth of the jaws and bone bases for the dental arches as a consequence of enhanced sutural development and bone apposition.

5. CONCLUSION

Following the findings of this research, we can say the following:

1. Males' dental arch widths were substantially larger than those of their female counterparts.
2. It was shown that when the MP–SN angle rose in men and females, the arch width shrank.
3. Using arch wires based on each patient's pre-treatment arch shape and widths is recommended during orthodontic treatment, since dental arch width is linked to gender and face vertical morphology.

Using Individualized arch wires for each patient on the basis of the pre- treatment arch form during Orthodontic treatment will help in maintaining the inter canine width and thus reducing the chances of relapse and help in maintaining a stable occlusion.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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