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Original Article

Dentistry Section

Correlation of Arch Width and Vertical Facial Morphology in Untreated Adults at a Tertiary Care Centre: A Cross-sectional Study

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ABSTRACT

Introduction: The vertical dimension of a face is crucial in determining facial aesthetics and harmony. It is important for the orthodontist to understand the relationship between dental arch width and facial morphology for correct diagnosis and proper treatment plan.

Aim: To determine the relationship between the vertical face pattern, dental arch width and also, to compare arch widths among both untreated female and male adults.

Materials and Methods: This quantitative cross-sectional study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, at Sharad Pawar Dental College, Sawangi, Wardha, Maharashtra, India. The duration of the study was one month, from June 2019 to July 2019. Dental casts and lateral cephalograms were collected from 50 untreated adults (25 males and 25 females), aged between 18-30 years, who had minimal spacing, crowding and no crossbite. On every patient's cephalogram, the angle between the plane of the mandible to the cranial base anterior Sella Nasion (SN) angle was calculated. Intercanine, intermolar, and interpremolar widths were measured on dental casts. Females and males arch width were compared. The significance of the differences was assessed using Student's t-test, one-way Analysis of Variance (ANOVA) test and regression analysis.

Results: The mean age of male study participants in the study was 24.44±5.04 years, whereas, mean age of females was 24.88±3.08 years. There were 25 males and 25 females of 18-30 years with mean age of 24 and 25 years, respectively. Arch widths of males were found to be significantly greater than, those of females ($p<0.05$) and it was observed that, interarch width decreased significantly as the Sella Nasion-Mandibular Plane (SN-MP) angle increased. Regression analyses of male subjects revealed a significant positive relationship between the SN-MP angle. Whereas, the SN-MP angle and width of maxillary first premolar's buccal cusp tip and the width of the second premolar (most buccal and buccal cusp tip), was found to have a strong correlation in female subjects.

Conclusion: It was found that, the width of the dental arch is related to vertical face morphology and gender. During orthodontic therapy, it is recommended to use individualised archwires based on each individual's pretreatment arch shape and width.

Keywords: Dental arch, Growth pattern, Intercanine width, Intermolar width, Lateral cephalogram

INTRODUCTION

Since the early 20th century, orthodontists have been interested in the relationship between the vertical face structure and the mandibular plane. Sagittal facial growth has been well known to be made up of horizontal and vertical growth [1]. The desire to improve one's facial aesthetic is among the most popular motives for getting orthodontic treatment. This can only be accomplished with a comprehensive diagnosis that includes an intraoral and extraoral examination of the arches and face and their association with both genders [2]. The location and relation of teeth in Three Dimension (3D) is referred to as arch shape [3]. For a long time, it was believed that, a person's phenotypic and genotypic expression would determine their facial shape [4]. It is widely believed that, the dimensions of the masticatory muscles, craniofacial morphology, and occlusal force interacts and determine the facial shape [4]. There are three types of facial morphologies: short, medium, and large. Excess vertical growth of the face is related to the open bite, a greater SN-MP angle, a greater gonial angle, as well as, a greater MP angle. Individuals, who have different mandibular plane inclinations have different morphological characteristics [5,6]. Small face forms have less vertical growth, which is associated with a deep bite, shorter face heights, and a smaller SN-MP angle [6]. The average face is located between two different types [6-8]. Nasby JA et al., found that, individuals with a reduced SN-MP angle had larger mean mandibular and maxillary arch diameters and a larger mandibular arch width between the molars [9].

Hannam AG and Wood WW evaluated dental and skeletal changes in individuals with various vertical facial forms and observed that, vertical face heights and dentoalveolar heights differed significantly [10]. According to Janson G et al., all of these are linked with a vertical pattern of growth [11]. Such results suggest that, such a vertical facial type is related to morphology and dentoalveolar sequence.

To compare arch width in both genders, Wei SH, conducted a study in which they used the posteroanterior cephalograms to determine the differences in the arch width based on gender in the Chinese population and found gender differences in intercanine width in both arches [12]. According to Eroz UB et al., males had notably greater intermolar width as compared to females [5]. Orthodontists use customised archwires in their clinical practices [5]. Therefore, correlation between arch width and vertical facial morphology is necessary in both genders. In orthodontics, it is important to understand the facial morphology of each and every patient for diagnostic and therapeutic factors of several vertical malocclusion issues. Facial morphology and arch width varies according to different region and treatment plan should be done accordingly [5]. There are various similar studies in different population by Nasby JA et al., Isaacson JR et al., in which, the observed arch width of both genders were combined [9,13]. In present study, both males and females arch width was studied separately. Male and female has different arch form according to facial pattern. Therefore, it is important to understand the arch form of both the genders according to facial pattern for proper diagnosis and treatment plan [5]. Arch form can be customised according to the facial pattern and gender for better treatment mechanics and to avoid the chance of relapse [2,14,15].

Hence, present study was conducted to determine whether, there is a relation between the vertical face pattern and the arch width evaluated by the slope of a plane of mandible and to look at the arch width discrepancies among both genders in tertiary care centre of Wardha district.

MATERIALS AND METHODS

This quantitative cross-sectional study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics at Sharad Pawar Dental College, Sawangi, Wardha, Maharashtra, India. The duration of the study was one month, from June 2019 to July 2019. Study was commenced after Institutional Ethics Committee (IEC) clearance {ref. no. DMIMS(DU)/IEC/2020-21/259}. Informed verbal consent was taken from all the study subjects for the present study.

Inclusion criteria: Lateral cephalograms of untreated adults, aged between 18-30 years, with presence of full dentition except for the third molar, and Angle's class I malocclusion were included in the study.

Exclusion criteria: Subjects with past orthodontic treatment, edentulous spacing, trauma history, considerable cusp wear, extensive prosthesis or restorations, any crossbites, and crowding more than 9 mm or spacing more than 9 mm were excluded from the study.

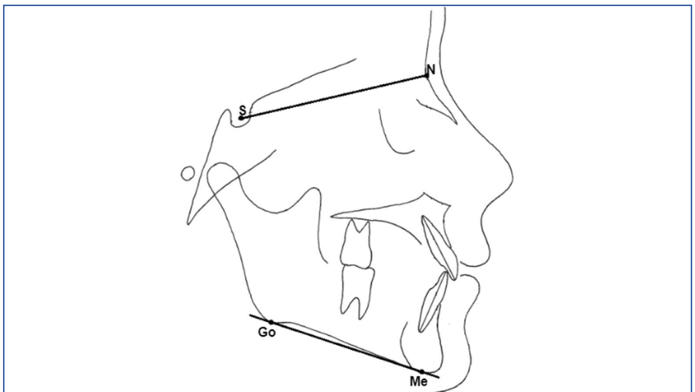
Sample size calculation: The sample size formula for the difference between the two means is given by:

n=(2+2β)2{(Δ12+Δ22)k}÷Δ2 Where, 2α is the level of significance at 5%, i.e., 95% confidence interval=196; 2β is the power of the test=80%=0.84; Δ1 is the standard deviation of the intercanine width for males=2.62; Δ2 is the standard deviation of the intercanine width for females=2.2; Δ is the difference between two means=38.49–37.08=1.41; K=1 [2].

n=(1.96+0.84) *2{(2.522+2.212)1}÷1.412=46.85; and n=50 patients needed in the study.

Study Procedure

Lateral cephalograms of 50 untreated adults were selected and divided into two groups: group 1 includes lateral cephalograms of 25 male patients, and group 2 includes lateral cephalograms of 25 female patients. The dental casts of mandible and maxilla and cephalogram (lateral) of the same sample were obtained from the Orthodontics Department. The SN-MP angle was measured manually with the help of ruler and protractor at each cephalogram. The plane of mandible was constructed from the lower boundary of the angle to menton manually [Table/Fig-1].

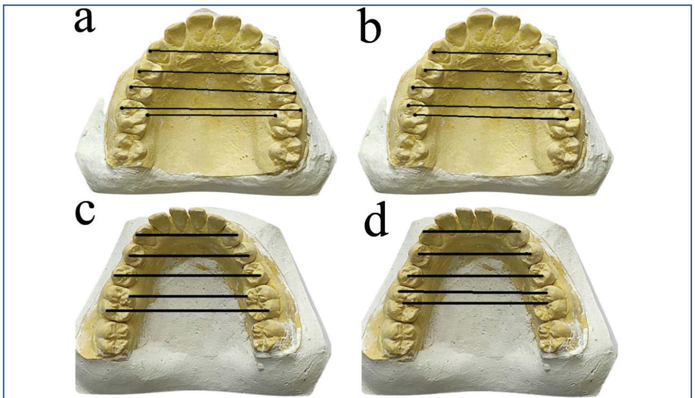


[Table/Fig-1]: The landmarks used in lateral cephalometry.

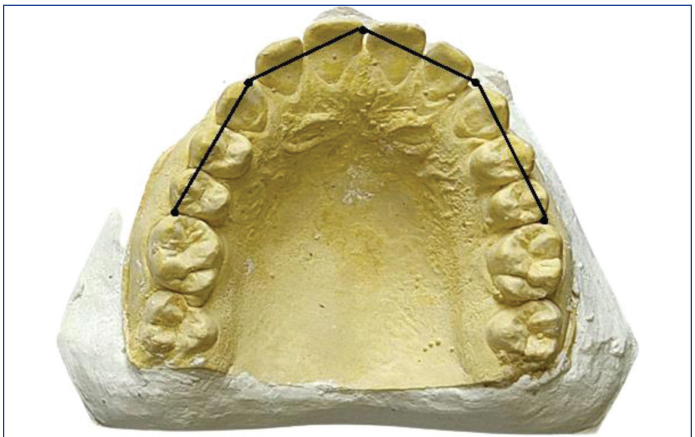
According to the SN-MP angle, the subjects were divided into three groups: high, >37°; average, 27°-37°; and low, <27° [3]. An electronic calliper was used to manually measure the arch width of the dental cast. The following maxillary and mandibular measurements were assessed: the intercanine distance, the first and the second interpremolars widths, the first intermolar width [Table/Fig-2], and a disparity between the size of the teeth and the length of the arch. The disparity between the tooth size and the length of arch was evaluated by first measuring the length of the available arch. The required length of arch was calculated by combined mesiodistal dimensions of each tooth, measured from points of contact, between right and left second premolar. The required length of arch was then deducted by available arch value [Table/Fig-3] [16-18].

Measurements of [Table/Fig-2] are:

- Intercanine width-labial cusp tip of canine of one side to the labial cusp tip of opposite side of canine.
- Intercanine width- most labial aspect of canine of one side to the most labial aspect of opposite side of canine.
- First interpremolar width- buccal cusp tip of one side to buccal cusp tip on opposite side of premolar.
- First interpremolar width- widest labial aspect of one side to widest labial aspect on opposite side of premolar.
- Second interpremolar width- buccal cusp tip on one side to buccal cusp tip on opposite side of premolar,
- Second interpremolar width- widest labial aspect on one side to widest labial aspect of on opposite side of premolar.
- First intermolar width- mesio buccal cusp on one side to mesio buccal cusp on the opposite side of molar.
- First intermolar width- central fossa on one side to central fossa on the opposite side of molar.
- First intermolar width- widest buccal on one side to widest aspect on the opposite side of molar.
- First intermolar width- narrowest lingual aspect of on one side to narrowest lingual aspect on the opposite side.



[Table/Fig-2]: On the study model, the fossa, cusp, most lingual, and most labial arch width measurements were taken.



[Table/Fig-3]: Length of arch is calculated by adding the space between the distal contact point of the left second premolar, the distal contact point of incisor (left lateral), the contact point between central incisor, distal contact point of incisor (right lateral) and distal contact point of second premolar (right) [16-18].

The SN-MP angle was measured and all of these measurements were then tabulated together, through descriptions of ages of both the genders.

STATISTICAL ANALYSIS

After obtaining the following measurements, the Student's unpaired t-test was done to evaluate the difference between the groups of females and males. One-way ANOVA test was done to evaluate the significance between mean values of three groups (low angle, high angle and average angle groups). Regression analysis was also done to evaluate the extent to which SN-MP disparity was estimated by dental arch within males and females separately. Software used in the analysis was Statistical Package for Social Sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY, USA) and p<0.05 was considered as a level of significance.

RESULTS

Mean age of males was 24.44±5.04 years whereas, mean age of females was 24.88±3.08 years. The total mean age of 50 subjects was 24.66±4.14 years [Table/Fig-4].

Gender	Frequency (n)	Mean age (in years)	Range (in years)
Males	25	24.44±5.04	18-30
Females	25	24.88±3.08	18-30
Total	50	24.66±4.14	18-30

[Table/Fig-4]: Differences in the mean age of males and females.

[Table/Fig-5] showed the measurement of arch width of males and females with low, average and high SN-MP angle groups. It was shown that, in majority of measurements i.e., intercanine width, interpremolar width and intermolar width, males had larger arch width than females in both the arches.

Maxillary arch width measurements	Males (n=25)	Females (n=25)	Mean difference	p-value
	Mean±SD	Mean±SD		
Maxillary				
Width between canine {Cusp Tip (CT)}	33.22±1.67	32.9±1.51	0.32	0.48
Width between canine {Most Buccal (MB)}	37.96±1.88	37.84±1.56	0.12	0.80
Width of first premolar {Buccal Cusp Tip (BCT)}	38.62±2	38.88±1.88	-0.26	0.63
Width between first premolar (MB)	44.5±2.01	43.38±1.58	1.12	0.033
Width between second premolars (BCT)	45.42±2.42	44.38±1.86	1.04	0.09
Width of second premolar (MB)	49.42±2.1	49.22±2.27	0.2	0.74
Width between molars {Mesiobuccal Cusp Tip (MBCT)}	50.64±2.5	48.76±1.69	1.88	0.003
Width between molars {Central Fossa (CF)}	45.04±1.95	44.1±1.85	0.94	0.08
Width between molars (MB)	54.66±2.75	52.34±1.33	2.32	0.0001
Width between molars {Most Lingual (ML)}	33.12±2.27	29.9±1.77	3.22	0.0001
Mandibular				
Width between canine (CT)	24.02±1.91	23.75±1.65	0.27	0.59
Width between canine (MB)	29.82±1.44	28.85±1.36	0.97	0.020
Width of first premolar (BCT)	32.46±2.1	32.38±1.5	0.08	0.87
Width of first premolar (MB)	37.28±3.06	37.35±1.41	-0.07	0.91
Width of second premolar (BCT)	37.02±2.24	37.27±1.76	-0.25	0.66
Width of second premolar (MB)	44.12±1.91	43.15±1.4	0.97	0.048
Width between molars (MBCT)	43.34±2.33	42.21±2.4	1.13	0.10
Width between molars (CF)	41.64±2.37	39.5±1.77	2.14	0.001
Width between molars (MB)	53.3±2.53	51.08±1.59	2.22	0.001
Width between molars (ML)	31.24±1.9	30.71±1.73	0.53	0.31

[Table/Fig-5]: Arch width measurements of upper and lower arch (in millimetres).
Student's unpaired t-test, p-value is probability value shows a significant difference at p≤0.05

[Table/Fig-6,7] shows the arch width assessments of subjects (males and females) in average, low and high SN-MP angle groups. It showed that, in most measurements, the low angle group exhibited a wider arch width and the high angle group exhibited smaller arch width indicating a co-relationship between the total arch width and SN-MP angle.

Maxillary arch width measurements	SN-MP angle Low SN-MP angle (<27°)	Average SN-MP angle (27°-37°)	High SN-MP angle (>37°)	One-way ANOVA test
	Mean±SD	Mean±SD	Mean±SD	p-value
Maxillary				
Width between canine (CT)	33.85±1.84	33.3±1.86	31±1.58	0.0324
Width between canine (MB)	38.85±1.43	38.3±1.89	36.8±1.92	0.1565
Width of first premolar (BCT)	39.42±2.63	38.57±1.85	38.6±2.7	0.7066
Width of first premolar (MB)	45±2.16	41.8±2.72	43.8±3.11	0.0484
Width of second premolar (BCT)	46.28±2.56	44.84±1.76	44.6±3.2	0.3535
Second premolar width (MB)	50±2.16	49.07±1.84	47.8±3.83	0.3156
Width between molars (MBCT)	51±2.16	48.46±2.79	49.4±3.04	0.1552
Width between molars (CF)	46.57±2.63	45±1.91	44.4±3.36	0.2704
Width between molars (MB)	56.57±2.63	55.5±2.24	55.2±3.96	0.6313
Width between molars (ML)	33±2.16	33.11±2.13	31.4±3.43	0.3996
Mandibular				
Width between canine (CT)	25.14±1.95	32.46±1.53	31.8±1.92	2.4562
Width between canine (MB)	31.07±1.64	29.84±1.43	30±1.58	0.2363
Width of first premolar (BCT)	33±2.16	31.96±2.05	31.4±2.4	0.4214
Width of first premolar (MB)	38.57±2.82	39±1.44	37.2±4.14	0.4165
Width of second premolar (BCT)	37.71±2.87	38.34±1.94	37±1.58	0.4963
Width of second premolar (MB)	45±2.16	43.92±1.86	43.6±2.3	0.4314
Intermolar width (MBCT)	44.28±3.81	43.26±1.8	43.6±3.04	0.7325
Width between molars (CF)	41.14±2.41	40.57±2.21	40.2±3.49	0.8086
Width between molars (MB)	54.28±3.25	53.23±2.06	54.6±3.2	0.5371
Width between molars (ML)	31.85±3.13	31.07±2.13	31.4±2.7	0.8091

[Table/Fig-6]: Comparison of the SN-MP angle in male subjects (in millimetres).
SD: Standard deviation; SN-MP: Sella nasion-mandibular plane

The multiple regression of the SN-MP angle versus the upper and lower arch width in subjects is shown in [Table/Fig-8] to determine the association between the SN-MP angle and the dental arch width. Regression analyses of male subjects revealed a significant positive relationship between the SN-MP angle and the mentioned arch width dimensions: maxillary canine buccal most aspect Most Buccal (MB), Cusp Tip of canine (CT), Buccal Cusp Tip of first premolar (BCT), Cusp Tip of second premolar (CT), Central Fossa of first molar (CF), Buccal Most aspect of first molar (MB), Cusp Tip of mandibular canine (CT), buccal most aspect of first premolar (MB). The SN-MP angle, as well as, arch width assessments of the width of maxillary first premolar's buccal cusp tip and the width of the second premolar (MB and BCT), was found to have a strong correlation in female subjects.

	SN-MP angle			
Maxillary arch width measurements	Low SN-MP angle (<27°)	Average SN-MP angle (27°-37°)	High SN-MP angle (>37°)	One-way ANOVA test
	Mean±SD	Mean±SD	Mean±SD	p-value
Maxillary				
Width between canine (CT)	31.92±2.12	32.25±1.67	31.25±1.73	0.5178
Width between canine (MB)	37.14±2.11	36.6±2.05	36±1.53	0.5249
Width of first premolar (BCT)	39.21±2.23	37.5±2	37.62±1.62	0.1858
Width of first premolar (MB)	43±2.16	42±1.63	42.56±1.84	0.549
Width of second premolar (BCT)	44±2.16	43.35±2.22	42±2.92	0.2859
Second premolar width (MB)	47.35±1.745	47.85±2.35	45.93±2	0.1697
Width between molars (MBCT)	49±2.16	49.1±2.34	48.81±1.75	0.9596
Width between molars (CF)	43.21±1.86	43.6±2.15	42.93±2	0.788
Width between molars (MB)	54±2.21	53.15±2	53.75±2.12	0.691
Width between molars (ML)	32.21±1.955	30.7±2.25	31.25±1.73	0.3308
Mandibular				
Width between canine (CT)	23.64±1.97	24.15±2.04	22.31±1.62	0.1406
Width between canine (MB)	29.07±1.39	29.15±1.27	28.87±1.38	0.9088
Width of first premolar (BCT)	31.42±2.24	32.1±2.01	31.68±1.81	0.7884
Width of first premolar (MB)	36.35±1.74	37.95±1.9	37.43±1.74	0.2232
Width of second premolar (BCT)	37.35±1.74	37.95±2.3	36.87±2.48	0.6
Width of second premolar (MB)	43.57±2.92	42.9±1.98	42.5±1.66	0.643
Intermolar width (MBCT)	41.21±2.48	41.45±2.19	42.43±1.78	0.5015
Width between molars (CF)	38.42±2.63	39.3±2.75	37.93±2.09	0.52
Width between molars (MB)	51±2.16	52.25±2.05	52.25±1.73	0.386
Width between molars (ML)	30.21±1.86	29.3±1.68	30.62±1.78	0.2847

[Table/Fig-7]: Comparison of the SN-MP angle in female subjects (in millimetres).

Arch width measurements	Males (n=25)	p-value	Females (n=25)	p-value
	R^2		R^2	
Maxillary				
Width between canine (CT)	0.105	0.0012	0.023	0.612
Width between canine (MB)	0.093	0.0056	0.031	0.212
Width of first premolar (BCT)	0.123	0.031	0.056	0.041
Width of first premolar (MB)	0.069	0.012	0.058	0.062
Width of second premolar (BCT)	0.45	0.056	0.061	0.031
Width of second premolar (MB)	0.021	0.078	0.016	0.20
Intermolar width (MBCT)	0.031	0.081	0.019	0.319
Width between molars (CF)	0.056	0.012	0.015	0.412
Width between molars (MB)	0.041	0.031	0.012	0.642
Width between molars (ML)	0.016	0.21	0.032	0.19
Mandibular				
Width between canine (CT)	0.031	0.025	0.002	0.451
Width between canine (MB)	0.04	0.085	0.0213	0.213
Width of first premolar (BCT)	0.076	0.0123	0.0316	0.316
Width of first premolar (MB)	0.152	0.0196	0.005	0.413
Width of second premolar (BCT)	0.126	0.316	0.001	0.879
Width of second premolar (MB)	0.121	0.121	0.002	0.926
Width between molars (MBCT)	0.072	0.169	0.0123	0.835
Width between molars (CF)	0.0156	0.125	0.016	0.271
Width between molars (MB)	0.0212	0.136	0.009	0.421
Width between molars (ML)	0.018	0.142	0.004	0.532

[Table/Fig-8]: Regression analysis of hypothetical predictors versus SN-MP angle.
SN-MP: Sella nasion-mandibular plane

DISCUSSION

The goal of the present study was to determine whether, the correlation between arch width and vertical facial morphology, as well as, to evaluate the difference between arch width of males and females. Regression analyses were used to analyse the arch width and the SN-MP angle relationship. This investigation was possible as samples were randomly taken from untreated individuals. In the maxillary arch, between the width of the arch and the plane of the mandible, there had been a significant inverse relation between canines of upper arch, first premolars, second premolars, and first molars in males and between the widths of second premolar in females (measurements of MB and CT). However, the analysis revealed that, the value of R^2 was low, implying that the correlation was weak. Males demonstrated a statistically significant association between the MP angle, the intercanine width of the mandibular, and the width between first premolar in the arch of mandible. The value of R^2 was low, suggesting that, the correlation was weak. In the lower arch, males had a remarkable correlation between the first interpremolar width and the second premolar width and the mandibular plane angle. The values of R^2 are also low, identical to the maxillary arch, indicating a weak correlation. For females, no significant association was found.

In the present study, vertical face morphology was measured using the SN-MP angle. The anterior cranial base (SN), on the other hand, may vary due to natural cranial variation and may tilt down or up. According to Björk A, another measure for vertical face morphology that is not reliant on a mandibular plane is the proportion of posterior facial height to anterior facial height [17]. To see if there is a relation between the posterior facial height/anterior facial height proportion and the width of the dental arch, more research is needed. Many studies were done to show the importance of vertical facial dimension. In the present study, arches of untreated adult males and females were examined [5,9,13]. The measurement was SN-MP angle for vertical facial morphology. In other previous studies by Nasby JA et al., and Isaacson JR et al., the observed arch width of both the genders were combined [9,13]. Secondly, according to Eroz UB et al., the arch width of males was significantly more than females [5].

Vertical facial morphology and arch width varies with ethnicity and race as well. The present study observed the inverse relation between dental arch and SN-MP angle with a strong correlation. Moreover, according to Eroz UB et al., Wei SH and Christie TE the arch width of males were significantly more than females, which is similar to the present study [5,12,19]. A similar study conducted by Grippaudo C et al., concluded that, there was no correlation between the arch width and mandibular plane angle in the studied population [20]. The mandibular plane angles were not divided into average, low, or high. In the present study, there was inverse relation between arch width and SN-MP angle. A study by Wei SH, in which they used the posteroanterior cephalograms to determine the differences in the arch width based on gender in the Chinese population [12]. Several other studies, also found a significant difference between the intercanine arch width in both the genders. Males and females have different skeletal facial dimensions, along with different maxillary and mandibular dental arch widths [12,13]. Untreated adult females and males were studied separately in the present study. According to Nasby JA et al., high angle children had a lesser width between the mandibular molars; however, the current data had not shown such a correlation between the MP angle and the width between the mandibular molars [9]. According to Ringqvist M, a strong correlation between transverse dimension musculature and vertical face morphology has just been proposed as the possible link [21]. Masticatory muscles have been shown to influence craniofacial growth in a variety of studies. Individuals with thick or strong elevator muscles have greater transverse head measures [21,22].

Wagner DM and Chung CH discovered that, while maxillary growth stops around the age of 14 years, the bony mandibular width keeps growing, atleast through average and low angle people [1]. Khera AK et al., conducted a study, to evaluate the correlation between vertical facial morphology and dental arch width in class I subjects [23]. They concluded that, for both males and females, a trend was observed with the increase in the vertical facial height, there was a decrease in the arch width, the arch perimeter, and the overbite but an increase in the curve of spee and palatal height. Females have significantly smaller arch dimensions than males [23]. Similarly, in the present study, it was shown that, as the vertical facial height increases, arch width decreases and arch width of males was greater than female. The present study measured only static entity like cephalometry and dental cast. The study can be modified by including dynamic entity like muscle activity by using Ultrasonography (USG) in both, vertical and horizontal grower patients.

Limitation(s)

The present study measured only static entity, like cephalometry and dental cast. Muscular activity and its orientation is not measured in the present study.

CONCLUSION(S)

It was found that, the arch width is correlated with facial vertical morphology and gender. The arch widths of males were substantially larger than those of females and tend to decrease when the SN-MP angle is increased in both genders. As the arch width is associated with vertical facial morphology and gender, it is recommended that, during orthodontic therapy, customised archwires should be used based on every individual's pretreatment shape and arch width. This is recommended that, dynamic entity such as, Electromyography (EMG) or USG can be included in vertical and horizontal growers to check the muscle activity.

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