Evaluation of arch width variations among different skeletal patterns in South Indian population

Mandava Prasad, Senny Thomas Kannampallil, Ashok Kumar Talapaneni, Suja Ani George[1], Sharath Kumar Shetty[2]

Department of Orthodontics and Dentofacial Orthopedics, Narayana Dental College and Hospital, Chinthareddypalem, Nellore, Andhra Pradesh, Departments of Orthodontics, [1]Government Dental College, Thiruvananthapuram, [2]KVG Dental College, Sullia, Karnataka, India

Address for correspondence:
Dr. Mandava Prasad, Department of Orthodontics and Dentofacial Orthopedics, Narayana Dental College and Hospital, Chinthareddypalem, Nellore - 524003, Andhra Pradesh, India.
E-mail: mandavabruno9@hotmail.co.in

Abstract

Background: Anterior cranial base can be taken as a reference line (SN) to determine the steepness of mandibular plane. Subjects with high mandibular plane angle tend to have a long face and one with low MP-SN angle has a shorter face. **Objective**: This study was done to investigate if dental arch widths correlated with vertical facial types and if there are any differences in arch widths between untreated male and female adults in South Indian population. **Materials and Methods**: Lateral cephalogram and dental casts were obtained from 180 untreated South Indian adults (90 males and 90 females) above 18 year old with no cross bite, minimal crowding and spacing. The angle between the anterior cranial base and the mandibular plane was measured on lateral cephalogram of each patient. Dental casts were used to obtain comprehensive dental measurements including maxillary and mandibular inter canine, inter premolar and inter molar widths, as well as amount of crowding or spacing. **Results**: The results showed that male arch widths were significantly larger than those of females ($P < 0.05$) and there was a significant decrease in inter arch width as the MP-SN angle increased in untreated adult South Indian population. The results obtained in our study when compared with studies done in other population groups showed that there is difference in inter arch widths according to ethnicity and race. **Conclusion**: It was concluded that the dental arch width is associated with gender, race 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.

Key words: Arch width, facial height, mandibular plane–sella nasion angle

INTRODUCTION

The relationship between malocclusion and facial form has been a focus of orthodontists since early 20th century. Dental arch width and facial form are important factors for determining success and stability of orthodontic treatment. Arch form is 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. The lower anterior teeth were arranged on an arc of a circle with a radius determined by the combined width of the lower incisors and canines, with the premolars and molars aligned with the second and third molars toward the center.

Access this article online	
Quick Response Code:	Website: www.jnsbm.org
	DOI: 10.4103/0976-9668.107267

Facial morphology has long been accepted to be the result of each person's genotype and its phenotypic expression. It is also commonly believed that there is interaction between the functional capacity and the size of masticatory muscles and craniofacial form.[3] Three basic types of facial morphology exist: Short, average, and long. Those with long face have excessive vertical facial growth which is usually associated with an anterior open bite, increased sella-nasion–mandibular plane (SN-MP) angle, increased gonial angle, and increased maxillary/mandibular plane angle. The short face types have reduced vertical growth that is accompanied by a deep overbite, reduced facial heights, and reduced SN-MP angle. Between the two types lies the average face.[4]

Nasby *et al.*[5] noted that the mean maxillary and mandibular arch circumferences and mandibular inter-molar width were greater in subjects with low MP-SN angle. In their study, the subjects were adolescents without discussion of gender and ethnicity. Using posteroanterior cephalograms, Christie[6] found that adult brachyfacial males, when compared with standard males had greater maxillary and mandibular widths. No difference, however, was found in arch widths of brachyfacial versus standard females. In terms of difference in arch width between males and females, Wei[7] evaluated posteroanterior cephalograms of Chinese adults.

Correct identification of a patients' arch form is an important aspect of achieving a stable, functional and aesthetic orthodontic treatment result; failure to preserve the arch form might increase the probability of relapse.[8]. Improper arch wire changes can result in periodontal breakdown, recurrence of crowding of buccal segments, or increased crowding of labial segments particularly when inter-canine width and inter-molar width have been expanded.

The original arch form for straight wire appliance was determined based on the mean dental arch form of orthodontically untreated normal occlusal samples of US population. Most of the orthodontic arch wires are designed in the USA and have been distributed all over the world without much research. Therefore, even with latest orthodontic appliances, education in the biological diversity of our patients and reasonable technical training for arch wire fabrication and adjustment are still essential in advanced orthodontic programs.[9]

One genetic factor contributing to the dental arch form and facial type is the patient's ethnic background.[9] The purpose of this study is to investigate whether dental arch widths are correlated with vertical facial types (MP-SN angle) and whether there are any differences in arch widths between untreated adult males and females in South Indian population.

MATERIALS AND METHODS

A total of 180 untreated patients above 18 years old were employed in the study. The samples included natives of Andhra Pradesh, Tamilnadu, Karnataka, and Kerala. The samples employed in the study consisted of two groups, males and females, of 90 patients each. Each group was further divided into low angle [Figures 3a, 4a], average angle, [Figures 3b, 4b] and high angle [Figures 3c, 4c].Subjects with a full dentition were included in the study (except third molars). The exclusion criteria were previous orthodontic treatment, edentulous spaces, history of trauma, significant cuspal wear, extensive restorations or prosthetics, anterior and posterior cross bites, and severe crowding (>9 mm) or spacing (>9 mm). Lateral cephalogram and upper and lower impressions were collected from each patient. The lateral cephalograms were traced individually and Sella Nasion PointA SNA, Sella Nasion PointB SNB, PointA Nasion PointB ANB, and SN-MP were measured. The dental arch width was measured on the dental cast using a digital calliper accurate to 0.001 mm.

The following maxillary and mandibular dimensions were measured [Figure 1].

- Inter-canine width (buccal cusp tip and widest labial aspect),
- first and second inter-premolar width (buccal cusp tip and widest labial aspect),
- first inter-molar widths (mesiobuccal cusp, central fossa, widest buccal, and narrowest lingual aspect).

Tooth size-arch length discrepancy

Tooth size-arch length discrepancy was calculated by first determining the arch length available and then subtracting the sum of mesiodistal widths of teeth anterior to first molar from it [Figure 2].

Statistical analysis

Descriptive statistics, including mean and standard deviation (SD) were calculated for all measurements.

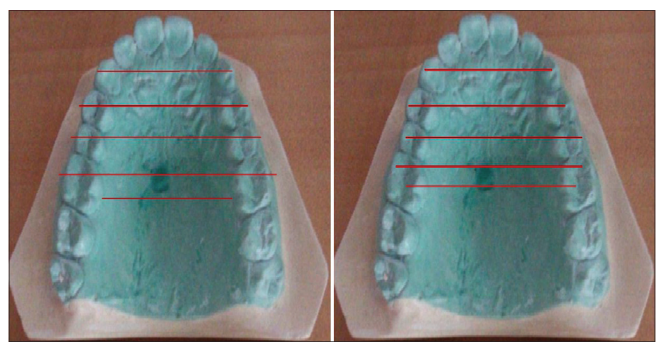

Figure 1: Maxillary study model (arch width measurements)

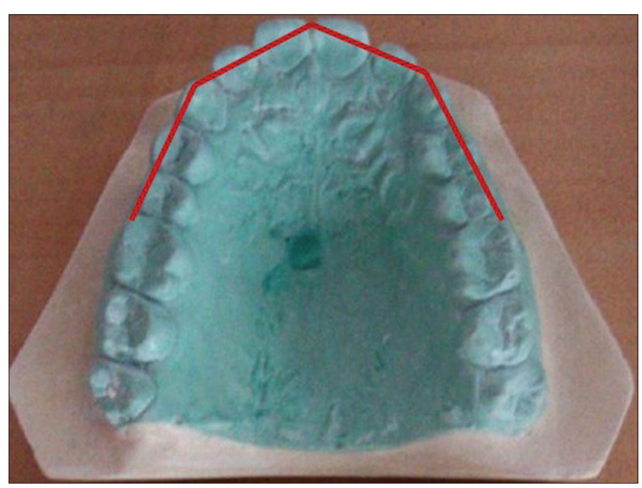

Figure 2: Tooth size-arch length discrepancy on study model

Figure 3a: Low-angle male: Casts, lateral cephalogram, photographs

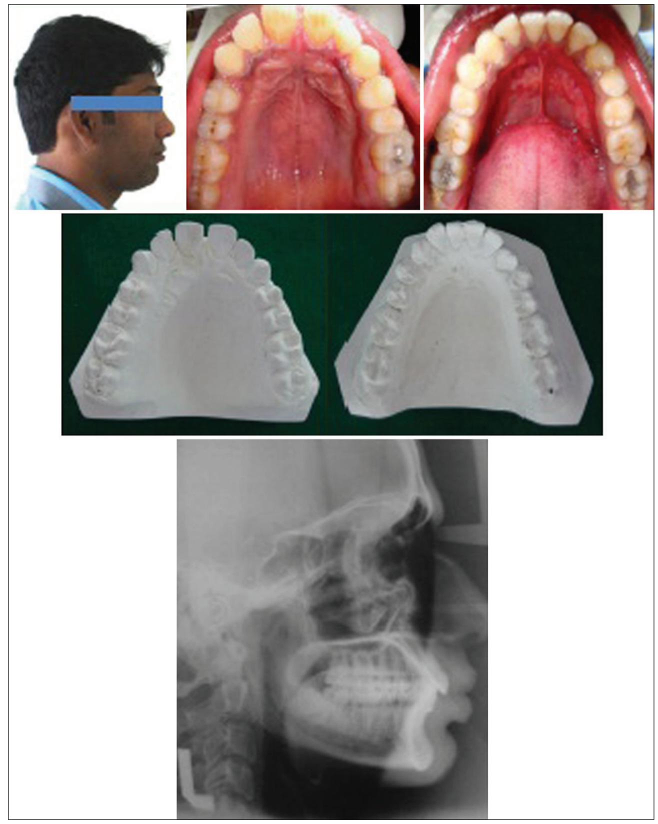

Figure 3b: Average-angle male: Casts, lateral cephalogram, photographs

A Student's two-tailed *t*-test was used to determine whether the differences in measurements between male and female groups were significant. Analysis of variance ANOVA test was carried out to show that inter-arch width varies significantly with different levels of MP-SN. Regression analyses were carried out to predict arch widths with known values of MP-SN. β-coefficients were taken to check whether the relation between inter-arch widths and MP-SN is inverse or direct. In order to evaluate intraexaminer error, lateral cephalograms and models of 15 males and 15 females were re-measured after 4 weeks, and their mean differences were assessed with paired *t*-test and compared with Pearson's correlation coefficients.

RESULTS

ANOVA statistics is done to compare the arch widths of the samples at different levels of MP-SN. The result showed that the arch width significantly varies at different levels of MP-SN ($P < 0.05$). The mean arch widths at maxillary canine (cusp tip) for males are 31.72, 32.66, and 33.35, respectively, for high, average, and low MP-SN values. ANOVA statistics ($P < 0.05$) shows that the arch width at inter-canine cusp tip varies significantly at different levels of MP-SN. Similar statistical results were obtained in all dental arch width measurements on maxillary and mandibular arches in both males and females. Regression analysis was used to predict arch widths, with known values of MP-SN (independent variable). β-coefficients for arch widths were calculated and results show that as MP-SN increases, the dental arch widths decreases. The β-coefficient for arch width for males at maxillary inter-canine at cusp tip is − 0.848. It indicates that as MP-SN increases, the dental arch width at canine cusp tip decreases significantly and for every 10 increase in MPSN, the inter-canine width decreased by 0.848 mm. The R^2 value of 0.720 for males at maxillary canine cusp tip shows that 72% variation of inter-canine width can be explained by MP-SN. Similar statistical results were obtained in all dental arch width measurements on maxillary and mandibular arches in both males and females. A student's '*t*'-test was applied to find the difference in arch widths of male and female samples. Average arch width of maxillary inter-canine (from cusp tip) for males is 32.67 mm, whereas for females, 31.77 mm. Student's '*t*'-statistics ($P < 0.05$) shows that the arch width measurements of female samples in the maxillary canine cusp tip were significantly less when compared to male samples. The results were similar for all the inter-arch measurements in maxillary and mandibular arches. Paired '*t*'-test was done to check the intra examiner error in both maxillary and mandibular inter-arch measurements and MP-SN values on lateral cephalogram. Since all the P values were greater than 0.05, there is no significant difference in the first and second measurements.

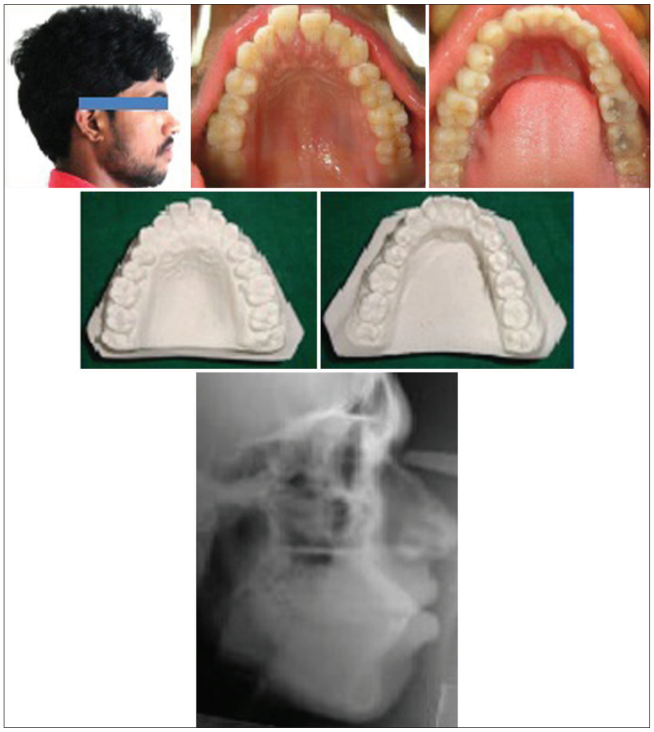

Figure 3c: High-angle male: Casts, lateral cephalogram, photographs

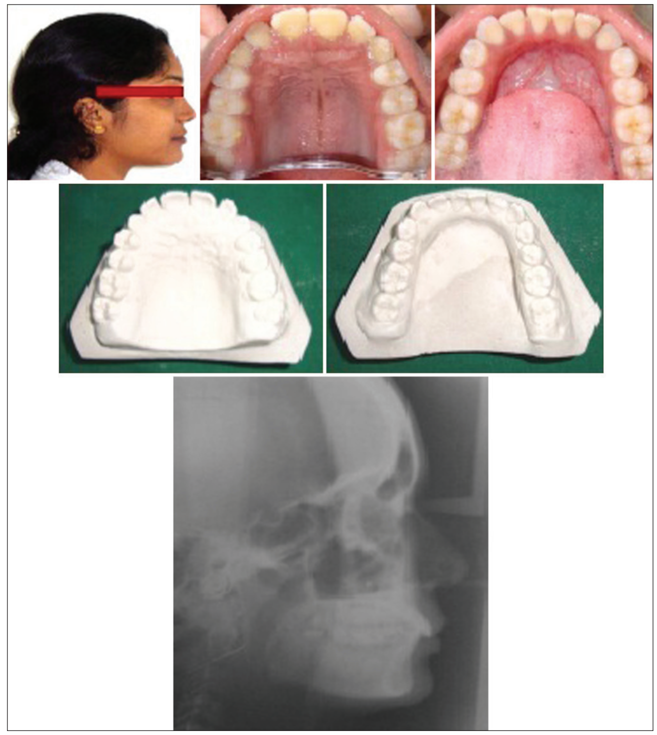

Figure 4a: Low-angle female: Casts, lateral cephalogram, photographs

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.[10] Errors in the evaluation of patient's facial type can lead to undesirable and sometimes irreversible consequences during orthodontic treatment.

This study aims to evaluate the inter-relationship between vertical facial height and inter-arch widths in untreated South Indian adult males and females. It also compares the dental arch widths between male and female samples and to find out whether there is a difference between them or not.

In this study, subjects without previous orthodontic treatment were only included because prior treatment might have influenced the vertical development of the dentoalveolar process or the dimensions of mid-face structures. Additionally, care was taken that all samples were of south Indian origin to avoid any major ethnic difference in craniofacial morphology. In order to have a greater distribution of the facial patterns, 180 samples were taken and divided into three groups: High angle, average angle, and low angle. Assessment of high, average, and low-angle groups allows estimation of its relation to dental arch widths.

For each patient, standardized lateral cephalogram and study models were taken and confirmed that none of the exclusion criteria were present. The measurements to assess vertical facial height were done from the lateral cephalogram and study models were used to measure the dental arch widths in both upper and lower arches. After the initial tracing of anatomical landmarks, SN-MP angle was traced and it was used as a measurement for vertical facial morphology. Ten dental arch width measurements were taken from both maxillary and mandibular study models (inter-canine cusp tip and most buccal, first premolar buccal cusp tip and most buccal, second premolar buccal cusp tip and most buccal, first molar mesiobuccal cusp tip, central fossa, most buccal, and most lingual/palatal). These measurements have been taken as a standard for dental arch width analysis by many investigators.[11-13] In order to exclude intra examiner error, lateral cephalograms and models of 15 males and 15 females were selected randomly and re-measured after 4 weeks by the same examiner.

The results showed that, in maxillary and mandibular arches, there was a statistically significant inverse relationship between vertical facial height and dental arch widths among the maxillary canines, first premolars, second premolars, and first molars in male and female samples [Tables 1 and 2]. The mean arch widths of maxillary inter-canine at cusp tip for males are 31.72, 32.66, and 33.35 mm in high-, average-, and low-angled samples, respectively. The

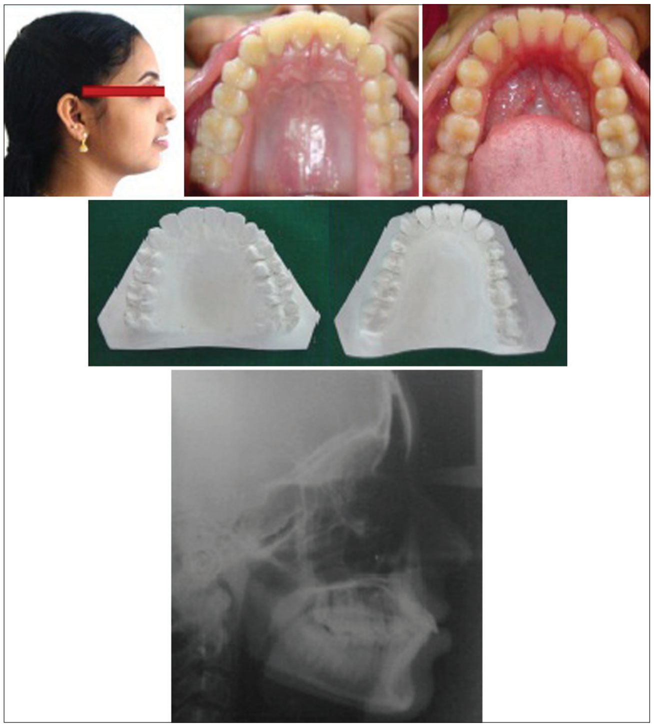

Figure 4b: Average-angle female: Casts, lateral cephalogram, photographs

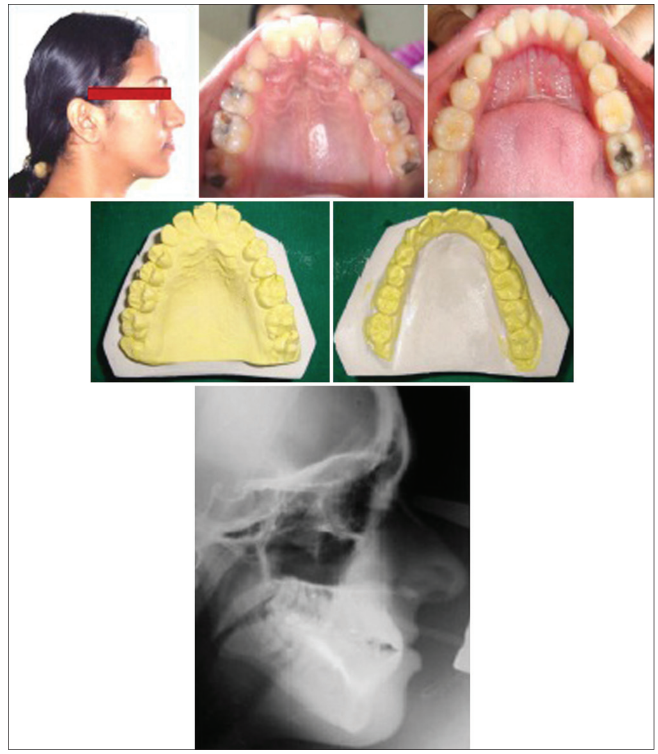

Figure 4c: High-angle female: Casts, lateral cephalogram, photographs

mean inter-canine arch widths from cusp tip for males in mandibular arch were 23.15, 23.82, and 25.10 mm for high-, average-, and low-angled samples, respectively. In females, the inter-arch widths at canine cusp tip in maxilla were 31.11, 31.77, and 32.29 mm, and in mandibular arch 23.07, 23.65, and 24.26 mm for high-, average-, and low-angled samples, respectively. The statistical analysis [Tables 3 and 4] shows that inter-canine arch width at cusp tip decreases significantly ($P < 0.05$) with increase in MP-SN angle. All the 10 measurements in maxillary and mandibular arches showed similar significant difference ($P < 0.05$) in the arch widths among high-angled, average-angled, and low-angled samples. Regression analysis was used to predict arch widths, with known values of MP-SN [Tables 3 and 4]. β-coefficients for arch widths were calculated and results showed that as MP-SN increases, the dental arch widths decreases. The β-coefficient for arch width for males at maxillary inter-canine at cusp tip is − 0.848. It indicates that as MP-SN increases, the dental arch width at canine cusp tip decreases significantly and for every 10 increase in MP-SN, the inter-canine width will be decreased by 0.848 mm. The R^2 value of 0.720 for males at maxillary canine cusp tip shows that 72% variation of inter-canine width can be explained by MP-SN. Similarly, the β-coefficient values of all the 10 measurements in maxillary and mandibular arches showed that the dental arch widths decreased significantly with the increase in vertical facial height and using regression analysis, we can predict the arch widths at all the 10 sites in both the arches with known values of MP-SN. Similar statistical results were obtained in all dental arch width measurements on maxillary and mandibular arches in both males and females. The prediction of inter-arch width helps us in situations such as cross bites, ectopically positioned teeth, transpositions, scissors bite, impacted teeth, missing teeth, etc., where we cannot determine exact inter-arch widths and fabricate customized arch wires for the patient.

Inter-arch width measurements showed that there is significant difference in arch widths among males and females in untreated South Indian adult population [Table 5]. Mean inter-arch width for maxillary canine from cusp tip is 32.67 mm for males and 31.77 mm for females and from most buccal it is 38.02 and 36.63 mm for males and females, respectively. The statistical analysis shows that ($P < 0.05$) the arch width at inter-canine region is significantly greater for males compared to females in maxillary arch. Similar observations were found in all 10 dental arch width measurements in maxillary and mandibular arches. This observation is in accordance with the observations in Caucasians,[11] where the arch width measurements were larger for males compared to females. Wei[7] evaluated posteroanterior cephalograms of Chinese adults and noted gender differences in maxillary and mandibular inter-canine widths. Gross *et al.*[14] observed that boys displayed larger arch width than girls and given that this is due to the fact that boys tend to be physically larger than girls. Increase in arch width during growth was

Table 1: Comparison of arch width based on different levels of mp-sn for males

Dental arch widths	High (*n*=20)		Average (*n*=40)		Low (*n*=30)		F	*P*
	Mean	SD	Mean	SD	Mean	SD		
Maxilla								
Inter canine width (cusp tip)	31.72	0.4	32.66	1.1	33.35	0.8	19.81**	<0.05
Inter canine width (most buccal)	36.96	0.4	37.08	1.1	38.92	1.5	18.28**	<0.05
First premolar width (buccal cusp tip)	37.84	0.4	39.05	1.2	40.17	1.8	18.68**	<0.05
First premolar width (most buccal)	42.73	0.9	43.33	1.1	44.59	1.5	16.16**	<0.05
Second premolar width (buccal cusp)	43.55	0.3	44.69	1.1	45.82	1.3	27.59**	<0.05
Second premolar width (most buccal)	46.99	0.2	48.46	1.1	49.85	1.6	34.07**	<0.05
Inter molar width (mesiobuccal cusp tip)	48.57	0.6	49.46	1.1	50.51	2.7	7.46**	<0.05
Inter molar width (central fossa)	44.15	0.6	45.0	1.0	46.18	1.6	18.31**	<0.05
Inter molar width (most buccal)	54.58	0.8	55.3	1.1	56.40	1.6	13.6**	<0.05
Inter molar width (most palatal)	31.90	1.0	32.23	1.0	33.32	1.7	8.91**	<0.05
Mandible								
Inter canine width (cusp tip)	23.15	0.5	23.82	1.0	25.10	0.9	32.71**	<0.05
Inter canine width (most buccal)	29.31	0.8	29.5	1.0	30.54	0.8	16.46**	<0.05
First premolar width (buccal cusp tip)	31.19	1.1	31.80	1.1	32.96	0.8	20.72**	<0.05
First premolar width (most buccal)	37.27	1.3	38.13	1.2	38.74	0.9	9.66**	<0.05
Second premolar width (buccal cusp)	36.27	1.1	36.90	1.1	38.19	1.0	22.12**	<0.05
Second premolar width (most buccal)	43.15	1.6	43.50	1.2	44.51	1.1	8.03**	<0.05
Inter molar width (mesiobuccal cusp tip)	42.31	1.8	42.75	1.2	44.02	0.9	13.22**	<0.05
Inter molar width (central fossa)	39.30	1.0	40.50	1.6	41.68	1.0	21.52**	<0.05
Inter molar width (most buccal)	51.74	1.8	52.77	1.4	54.17	0.8	20**	<0.05
Inter molar width (most lingual)	30.32	1.0	30.78	0.9	31.82	0.6	21.68**	<0.05

*Significant, **Highly significant

Table 2: Comparison of arch widths based on different levels of mp-sn for females

Dental arch widths	High (*n*=20)		Average (*n*=40)		Low (*n*=30)		F	*P*
	Mean	SD	Mean	SD	Mean	SD		
Maxilla								
Inter canine width (cusp tip)	31.11	1.3	31.77	1.2	32.29	1.0	6.55**	<0.05
Inter canine width (most buccal)	36.21	1.1	36.58	1.2	37.06	1.0	4.06*	<0.05
First premolar width (buccal cusp tip)	37.36	1.2	38.02	1.2	38.69	1.0	8.67**	<0.05
First premolar width (most buccal)	41.36	1.2	42.01	1.1	42.78	1.0	10.52**	<0.05
Second premolar width (buccal cusp)	42.20	1.3	42.50	1.2	44.03	1.0	22.14**	<0.05
Second premolar width (most buccal)	45.64	1.2	46.82	1.2	47.29	0.9	13.41**	<0.05
Inter molar (mesiobuccal cusp tip)	47.37	1.2	48.16	1.2	49.16	0.9	17.18**	<0.05
Inter molar width (central fossa)	43.03	1.2	43.48	1.1	44.08	1.0	6.07**	<0.05
Inter molar width (most buccal)	53.11	1.2	53.55	1.2	54.08	0.9	5.22**	<0.05
Inter molar width (most palatal)	30.34	1.3	30.73	1.1	31.75	0.9	12.22**	<0.05
Mandible								
Inter canine width (cusp tip)	23.07	1.1	23.65	1.2	24.26	1.0	7.85**	<0.05
Inter canine width (most buccal)	28.37	1.3	29.02	1.2	29.54	1.0	6.55**	<0.05
First premolar width (buccal cusp)	30.60	1.2	30.96	1.1	31.69	1.1	6.38**	<0.05
First premolar width (most buccal)	36.56	1.2	37.36	1.2	37.71	1.0	8.97**	<0.05
Second premolar width (buccal cusp)	35.41	1.2	36.62	1.1	37.96	1.0	12.26**	<0.05
Second premolar width (most buccal)	41.92	1.2	43.15	1.2	42.93	1.0	14.21**	<0.05
Inter molar width (mesiobuccal cusp tip)	40.71	1.2	42.07	1.2	42.48	1.0	19.46**	<0.05
Inter molar width (central fossa)	38.13	1.2	38.69	1.2	39.15	1.0	4.68*	<0.05
Inter molar width (most buccal)	50.84	1.2	51.87	1.2	52.29	1.0	9.74**	<0.05
Inter molar width (most lingual)	29.24	1.2	29.81	1.2	29.28	0.9	6.11**	<0.05

*Significant, **highly significant

found more in males than females and this can be a reason for males having broader arch than females.[15,16] The results in this study were similar to Nasby *et al.*'s[5] evaluation. He demonstrated narrower inter-molar widths in high-angled children.

Musculature has been considered as the possible link in this close relationship between the transverse dimension and vertical facial morphology. A number of studies[17-19] have illustrated the influence of masticatory muscles on craniofacial growth. The general consensus[11] is that

Table 3: Linear regression analysis for males

Dental arch widths	Constant	B	R^2	Significance
Maxilla				
Inter canine width (cusp tip)	36.32	-0.848	0.720	*P*<0.001
Inter canine width (most buccal)	41.82	-0.665	0.442	*P*<0.001
First premolar (buccal cusp tip)	43.49	-0.636	0.404	*P*<0.001
First premolar width (most buccal)	46.61	-0.515	0.265	*P*<0.001
Second premolar width (buccal cusp tip)	48.96	-0.715	0.511	*P*<0.001
Second premolar width (most buccal)	53.66	-0.722	0.521	*P*<0.001
Inter molar width (mesiobuccal cusp tip)	52.96	-0.397	0.158	*P*<0.001
Inter molar width (central fossa)	48.88	-0.614	0.377	*P*<0.001
Inter molar width (most buccal)	58.99	-0.590	0.348	*P*<0.001
Inter molar width (most palatal)	35.38	-0.489	0.240	*P*<0.001
Mandible				
Inter canine width (cusp tip)	33.82	-0.795	0.590	*P*<0.001
Inter canine width (most buccal)	38.21	-0.711	0.443	*P*<0.001
First premolar width (buccal cusp tip)	40.36	-0.800	0.572	*P*<0.001
First premolar width (most buccal)	44.50	-0.867	0.389	*P*<0.001
Second premolar width (buccal cusp)	46.21	-0.901	0.549	*P*<0.001
Second premolar (most buccal)	49.17	-0.817	0.351	*P*<0.001
Inter molar width (mesiobuccal cusp tip)	51.21	-0.924	0.444	P<0.001
Inter molar width (central fossa)	45.45	-0.803	0.373	P<0.001
Inter molar width (most buccal)	55.53	-0.771	0.497	P<0.001
Inter molar width (most lingual)	33.47	-0.860	0.641	P<0.001

Table 4: Linear regression analysis for females

Dental arch widths	Constant	B	R^2	Significance
Maxilla				
Inter canine width (cusp tip)	27.80	-0.768	0.628	*P*<0.001
Inter canine width (most buccal)	32.40	-0.666	0.505	*P*<0.001
First premolar (buccal cusp tip)	35.52	-0.756	0.640	*P*<0.001
First premolar width (most buccal)	41.09	-0.624	0.751	*P*<0.001
Second premolar (buccal cusp tip)	41.00	-0.741	0.813	*P*<0.001
Second premolar (most buccal)	46.70	-0.592	0.667	*P*<0.001
Inter molar width (mesiobuccal cusp tip)	46.48	-0.667	0.855	*P*<0.001
Inter molar width (central fossa)	44.67	-0.611	0.644	*P*<0.001
Inter molar width (most buccal)	57.42	-0.705	0.595	*P*<0.001
Inter molar width (most palatal)	34.21	-0.801	0.740	*P*<0.001
Mandible				
Inter canine width (cusp tip)	25.81	-0.839	0.703	*P*<0.001
Inter canine width (most buccal)	31.03	-0.797	0.634	*P*<0.001
First premolar width (buccal cusp tip)	33.14	-0.749	0.562	*P*<0.001
First premolar width (most buccal)	39.64	-0.815	0.665	*P*<0.001
Second premolar width (buccal cusp)	38.75	-0.762	0.580	*P*<0.001
Second premolar (most buccal)	45.54	-0.812	0.659	*P*<0.001
Inter molar (mesiobuccal cusp tip)	44.54	-0.843	0.710	*P*<0.001
Inter molar width (central fossa)	40.41	-0.719	0.518	*P*<0.001
Inter molar width (most buccal)	53.98	-0.759	0.576	*P*<0.001
Inter molar width (most lingual)	31.75	-0.726	0.527	*P*<0.001

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). This muscular hyper-function causes an increased mechanical loading of the jaws. This in turn may cause an introduction of sutural growth and bone apposition which then results in increased transverse growth of the jaws and bone bases for the dental arches. Spronsen *et al.*[20] found that long-faced subjects have significantly smaller masseter and medial pterygoid muscles than normal subjects. Satirglu *et al.*[19] ultrasonographically measured masseter muscle thickness. They 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. These results are in agreement with previous studies done by Weijis *et al.*, Kiliardis and Kalebo, Benington *et al.*, and Raadsheer *et al.*[21-23]

Table 5: Difference in arch widths among males and females in untreated South Indian adult population

In mm	Male (n=90)		Female (n=90)		T	P
	Mean	SD	Mean	SD		
Maxilla						
Inter canine width (cusp tip)	32.67	1.1	31.77	1.2	5.21**	<0.05
Inter canine width (most buccal)	38.02	1.3	36.63	1.1	7.55**	<0.05
First premolar (buccal cusp tip)	39.11	1.6	38.07	1.2	4.93**	<0.05
First premolar width (most buccal)	43.71	1.4	42.10	1.2	7.75**	<0.05
Second premolar width (buccal cusp tip)	44.81	1.4	42.92	1.4	9.32**	<0.05
Second premolar width (most buccal)	48.60	1.6	46.68	1.2	8.96**	<0.05
Inter molar (mesiobuccal cusp tip)	49.69	1.9	48.29	1.3	5.88**	<0.05
Inter molar width (central fossa)	45.21	1.4	43.55	1.2	8.68**	<0.05
Inter molar width (most buccal)	55.51	1.4	53.63	1.1	9.94**	<0.05
Inter molar width (most palatal)	32.54	1.4	30.96	1.2	7.9**	<0.05
Mandible						
Inter canine width (cusp tip)	24.10	1.2	23.71	1.2	2.23*	<0.05
Inter canine width (most buccal)	29.79	1.0	29.02	1.2	4.62**	<0.05
First premolar width (buccal cusp tip)	32.05	1.2	31.11	1.2	5.25**	<0.05
First premolar width (most buccal)	38.14	1.3	37.35	1.2	4.27**	<0.05
Second premolar width (buccal cusp)	37.19	1.3	36.44	1.2	3.98**	<0.05
Second premolar width (most buccal)	43.78	1.4	43.00	1.3	4**	<0.05
Inter molar (mesiobuccal cusp tip)	43.07	1.4	41.96	1.3	5.43**	<0.05
Inter molar width (central fossa)	40.63	1.5	38.67	1.2	9.63**	<0.05
Inter molar width (most buccal)	53.01	1.6	51.75	1.2	5.81**	<0.05
Inter molar width (most palatal)	30.98	1.0	29.84	1.2	7.22**	<0.05

*Significant, **highly significant

Proffit *et al.* have proved that the mean bite force is greater for short face, normal in average face, and low in high-angle subjects.[24] The mechanical stress brought about by occlusal bite forces and volume of certain masticatory muscles might influence the size of adjacent craniofacial skeletal regions.[20] This might be another reason for variation in arch widths according to facial pattern. Helkimo *et al.*[24] have found that mean bite force values were significantly higher in males than in females. The increased bite force might be a reason for the increased arch width in males when compared to females.

The direction of mandibular growth is influenced by the tongue base position, as the anterior tongue pressure might influence on the rotation of mandibular corpus. High-angle subjects had a larger tongue gap[25] 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 correlated with an increased lower anterior facial height.[19] Because of the lowered positioning of 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 maxilla. Mandible also constricts along with maxilla since maxillary and mandibular arches are mutual counterparts according to Enlows[26] counterpart principle. Functional matrix theory also suggests that width of palatal complex is influenced by location of tongue.[27]

Dental arch width is certainly a multifactorial phenomenon.[28] The data from this study showed an inverse relationship between MP-SN angle and dental arch widths with a strong correlation. 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. Moreover, in agreement with Eroz *et al.*[29] and Forster,[11] the results demonstrated that the male arch widths were significantly greater than female arch widths. When comparing the arch width of South Indian populations with the observations of Forster *et al.* in Caucasian population,[11] the inter-arch widths of South Indian population are narrower than the Caucasian population. Christie[6] already proved that the Caucasians with normal occlusion tend to be more brachyfacial than dolichofacial. Compared to Caucasian's, Japanese have a narrower width. Sokamoto *et al.*[30] proved that Japanese population has been found to be more retrognathic with a greater vertical direction of facial growth than Caucasians. African-Americans[14] had larger maxillary arch width than Caucasian youths. Southern Chinese population has a greater arch width when compared to Caucasians.[31]

The relationships between the vertical facial morphology and dental arch widths in untreated South Indian adults have an inverse relationship as in Caucasian population.[1] 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. The variation of arch widths between Caucasians and South Indians and between males and females highlights the variations of arch widths according to race, ethnicity, and gender and also the importance of using customized arch wires according to pre-treatment arch form and width for every patient during orthodontic treatment.

CONCLUSION

Within the parameters of the study, following conclusions are made:

- Relationship between dental arch width and vertical facial pattern is determined by the steepness of mandibular plane in untreated South Indian adult population.
- The relationship was found to be an inverse relation in both males and females of untreated South Indian adults, as MP-SN angle increased, the dental arch widths tended to decrease.
- A generalized prediction was done for the dental arch widths with a given SN-MP.
- The dental arch widths of males were found to be wider than females among untreated South Indian adults.
- Since dental arch width is associated with gender, vertical facial morphology, and population groups, during orthodontic treatment, it is suggested to use individualized arch wires according to each patient's pre-treatment arch form and widths.

REFERENCES

1. Lee RT. Arch width and form: A review. Am J Orthod Dentofacial Orthop 1999;115:305-13.
2. Hawley CA. The principles and art of retention. Inter J Orthod 1925; 11:315-26.
3. Hong JC, Michael W, Damien S. Mandibular muscle morphology in children with different vertical facial patterns: A 3-dimensional computed tomography study. Am J Orthod 2008;133:10.e1-10.e13.
4. Abu Alhaija ES, Al Zo'ubi IA, Al Rousan ME, Hammad MM. Maximum occlusal bite forces in Jordanian individuals with different dentofacial vertical skeletal patterns. Eur J Orthod 2010;32:71-7.
5. Nasby JA, Isaacson RJ, Worms FW, Speidel TM. Orthodontic extractions and the facial skeletal pattern. Angle Orthod 1972;42:116-22.
6. Christie TE. Cephalometric patterns of adults with normal occlusion. Angle Orthod 1977;47:128-35.
7. Wei SH. Craniofacial width dimensions. Angle Orthod 1970;40:141-7.
8. Bayome M, Sameshima GT, Kim Y, Nojima K, Baek SH, Kook YA. Comparison of arch forms between Egyptian and North American white populations. Am J Orthod Dentofacial Orthop 2011;139:e245-52.
9. Oda S, Arai K, Nakahara R. Commercially available archwire forms compared with normal dental arch forms in a Japanese population. Am J Orthod Dentofacial Orthop 2010;137:520-7.
10. Anwar N, Fida M. Compensation for vertical dysplasia and its clinical application. Eur J Orthod 2009;31:516-22.
11. Forster CM, Sunga E, Chung CH. Relationship between dental arch width and vertical facial morphology in untreated adults. Eur J Orthod 2008;30:288-94.
12. McNamara C, Sandy JR, Ireland AJ. Effect of arch form on the fabrication of working archwires. Am J Orthod Dentofacial Orthop 2010;138:257-62.
13. Al-Khateeb SN, Abu Alhaija ES. Tooth size discrepancies and arch parameters among different malocclusions in a Jordanian sample. Angle Orthod 2006;76:459-65.
14. Gross AM, Kellum GD, Franz D, Michas K, Walker M, Foster M, *et al.* A longitudinal evaluation of open mouth posture and maxillary arch width in children. Angle Orthod 1994;64:419-24.
15. Sangwan S, Chawla HS, Goyal A, Gauba K, Mohanty U. Progressive changes in arch width from primary to early mixed dentition period: A longitudinal study. J Indian Soc Pedod Prev Dent 2011;29:14-9.
16. Harris EF. A longitudinal study of arch size and form in untreated adults. Am J Orthod Dentofacial Orthop 1997;111:419-27.
17. Tsunori M, Mashita M, Kasai K. Relationship between facial types and tooth and bone characteristics of the mandible obtained by CT scanning. Angle Orthod 1998;68:557-62.
18. Weijs WA, Hillen B. Relationships between masticatory muscle cross-section and skull shape. J Dent Res 1984;63:1154-7.
19. Satiroğlu F, Arun T, Işik F. Comparative data on facial morphology and muscle thickness using ultrasonography. Eur J Orthod 2005;27:562-7.
20. van Spronsen PH, Weijs WA, Valk J, Prahl-Andersen B, van Ginkel FC. A comparison of jaw muscle cross-sections of long-face and normal adults. J Dent Res 1992;71:1279-85.
21. Kiliaridis S, Kälebo P. Masseter muscle thickness measured by ultrasonography and its relation to facial morphology. J Dent Res 1991;70:1262-5.
22. Weijs WA, Hillen B. Correlations between the cross-sectional area of the jaw muscles and craniofacial size and shape. Am J Phys Anthropol 1986;70:423-31.
23. Benington PC, Gardener JE, Hunt NP. Masseter muscle volume measured using ultrasonography and its relationship with facial morphology. Eur J Orthod 1999;21:659-70.
24. Ingervall B, Helkimo E. Masticatory muscle force and facial morphology in man. Arch Oral Biol 1978;23:203-6.
25. Ucar FI, Uysal T. Orofacial airway dimensions in subjects with Class I malocclusion and different growth patterns. Angle Orthod 2011;81:460-8.
26. Donald HE, Mark GH. Essentials of Facial Growth. 3rd ed. Philadelphia, USA, 1996. p. 143-52.
27. Moss ML, Young RW. A functional approach to craniology. Am J Phys Anthropol 1960;18:281-92.
28. Schulhof RJ, Lestrel PE, Walters R, Schuler R. The mandibular dental arch: Part III. Buccal expansion. Angle Orthod 1978;48:303-10.
29. Eröz UB, Ceylan I, Aydemir S. An investigation of mandibular morphology in subjects with different vertical facial growth patterns. Aust Orthod J 2000;16:16-22.
30. Sakamoto T. A study on the development changes of dentofacial complex of Japanese with special reference to sella turcica. J Jap Orthod Soc 1959;18:1-17.
31. Ling JY, Wong RW. Dental arch widths of Southern Chinese. Angle Orthod 2009;79:54-63.

How to cite this article: Prasad M, Kannampallil ST, Talapaneni AK, George SA, Shetty SK. Evaluation of arch width variations among different skeletal patterns in South Indian population. J Nat Sc Biol Med 2013;4:94-102.

Source of Support: Nil. **Conflict of Interest:** None declared.