ORIGINAL ARTICLE

Clinical Application of Variations in Maxillary Transverse Arch Dimensions among Various Vertical Facial Patterns.

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ABSTRACT

Objective: To investigate the relationship between maxillary arch widths and various vertical facial patterns.

Methodology*:* Subjects of age ranging 17-30 years were reviewed having full complement of teeth with no tooth deformity or record of restoration or stripping. Exclusion criteria included dental anomalies, spacing or crowding (> 8 mm), previous dentoalveolar surgery, trauma or orthodontic treatment. Three hundred sixty subjects (180 Females, 180 Males), with skeletal Class I relation, including 120 each for Normodivergent, Hypodivergent and Hyperdivergent facial patterns were selected. Maxillary intercanine, interpremolar, and intermolar widths were measured. Student's two-tailed t-test was used to determine differences in measurements between male and female groups. Analysis of variance was used to determine whether inter-arch width varies with different vertical facial patterns. Statistical differences were determined at the 95% confidence level (*p*, .05).

Results: The dental arch widths in males were significantly greater ***(p = 0.00 to 0.03)*** than those in females. An inverse relationship ***(Males p = 0.001 to 0.91) (Females p = 0.005 to 0.81)*** was found between vertical facial morphology and dental arch widths.

Conclusion: Since dental arch width is associated with gender and facial vertical morphology, using individualized arch wires according to patient's pre-treatment arch form is suggested.

Key Words: Transverse Arch Dimensions, Vertical Facial Patterns.

INTRODUCTION

Stability of arch form is undoubtedly one of the most desirable goals of orthodontics yet unfortunately it is the least understood goal.[1] Stability of a treated orthodontic case is conditioned by arch forms which in turn is determined by the respective arch widths at canine, pre molars and molars, which must be respected to avoid serious consequences, such as relapse or iatrogenic damage to teeth being moved beyond their bony edges.[2] However traditionally, change in the arch form has been analyzed in terms of the behavior of various linear dimensions, such as arch width, length and perimeter.[3]

Orthodontic arch wires are manufactured in several different forms of dental arch in order to give the orthodontist the chance to choose the most suitable ones for each patient.[4] Yet, a research that analyzed the arch form of the Italian population found that none of the commercial archwire fits exactly the patient archform.[5] Improper arch wire changes can result in periodontal breakdown, recurrence of crowding of buccal segments, or increased crowding of labial segments

mandibular plane (MP) according to Schudy, patients can be

Table I **Maxillary arch width measurements (in mm) comparison for Males & Females.**

	Male		Female		
	Mean	SD	Mean	SD	(*p*)
Average SN – MP Angle					
Intercanine width (cusp tip)	35.26	3.67	34.98	3.26	0.79
First premolar width (buccal cusp tip)	41.62	4.18	41.34	3.77	0.82
cond premolar width (buccal cusp tip)	46.67	4.04	47.1	3.82	0.73
Intermolar width (mesiobuccal cusp tip)	52.58	3.59	51.96	2.85	0.55
High SN – MP Angle					
Intercanine width (cusp tip)	34.81	3.11	33.58	2.48	0.17
First premolar width (buccal cusp tip)	40.18	3.29	40.15	2.96	0.98
Second premolar width (buccal cusp tip)	44.96	2.83	45.03	2.77	0.94
Intermolar width (mesiobuccal cusp tip)	49.39	3.3	49.73	2.97	0.73
Low SN – MP Angle					
Intercanine width (cusp tip)	34.98	3.34	33.57	3.06	0.17
First premolar width (buccal cusp tip)	43.08	4.61	40.24	2.82	0.02
Second premolar width (buccal cusp tip)	48.12	2.73	44.62	3.31	0.00
Intermolar width (mesiobuccal cusp tip)	53.42	3.28	49.52	3.74	0.00

particularly when inter-canine width and inter-molar width have been expanded.[6] 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.[7] Most of the orthodontic arch wires are designed in the USA and have been distributed all over the world without much research.[8] 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]

The determination of dental arch forms is a multifactorial trait. The genetic component could be partly related to vertical growth pattern of facial morphology and the environmental components related to functional, muscular, and local factors.[10] The facial type can be determined by subjective evaluation or by using cephalometric analyses, i.e., a set of measurements of the facial complex that shows the predominant direction of growth. Several authors described different facial type analyses.[11]

It has been known that there is a relationship between vertical facial morphology and steepness of mandibular plane.[12] The steepness of mandibular plane angle is an important variable of face height to be considered in determining orthodontic diagnosis and treatment.[13] Taking the anterior cranial base (SN) as a reference point to determine the inclination of the

differentiated as individuals with high-angle SN-MP and long face and as individuals with low-angle SN-MP and short face.[14]

Ricketts reported that a correlation can exist between facial type and dental arch.[15] Previous knowledge suggests a correlation between craniofacial structures and arch forms. However, the strength of associations is not clearly reported in the literature. Also individual variations still are not uncommon and therefore, understanding the pattern in the patient pool being received at our doorstep becomes essential.[16] The data present still seem insufficient to correlate face types with arch widths and therefore, this study was undertaken to quantify the nature of the arch form in various vertical facial patterns.

MATERIALS AND METHOD

Pre treatment study models and lateral cephalograms of 360 subjects (180 Females, 180 Males), with 17-30 years of age, were derived from patients attending for routine dental treatment, with no history of orthodontic treatment. Only skeletal Class I (as determined by ANB angle) subjects were examined because more dental compensation is expected in skeletal Class II or III subjects, which might obscure the relationship between vertical facial morphology and transverse dental arch widths.

The inclusion criteria required all permanent teeth to be erupted and present from right to left second molar in upper and lower arches, good quality study casts and lateral cephalograms, absence of tooth deformity, no record of restoration or stripping of teeth and non-orthodonticaly treated subjects. The exclusion criteria included patients with previous orthodontic treatment, edentulous spaces, history of trauma, significant cuspal wear, extensive restorations or prosthesis, anterior and/or posterior crossbites and severe crowding or spacing (> 8 mm).

Lateral cephalogram and maxillary impressions were obtained for each patient. The lateral cephalograms were traced individually and for each subject, MP – SN angle was measured. The mandibular plane was drawn from menton (Me) to the inferior border of the angular area of the mandible (Schudy, 1965).[17] The subjects were categorized into three groups, each consisting of 120 subjects each (60 Females and 60 Males), classified by the MP-SN angle as: Hypodivergent (< 27˚), Normodivergent (27˚ to 37˚) and Hyperdivergent (> 37˚). The dental arch width was measured on the study model using a digital caliper (Classic, Yamayo, Japan) accurate to 0.01 mm.

The following maxillary arch width dimensions were measured (Figure I):

- Inter-canine width at cusp tip
- First and second inter-premolar widths at buccal cusp tips,
- First inter-molar width at mesiobuccal cusp tip.

Fig. I Maxillary arch width dimensions (Arch width at cusptip - intercanine, 1st interpremolar, 2nd interpremolar, 1st intermolar at mesiobuccal) measured in each subject

The readings were recorded at the 0.01-mm level on an Excel spreadsheet (Microsoft, Redmond, Wash). All measurements were performed by the same investigator (Figure II).

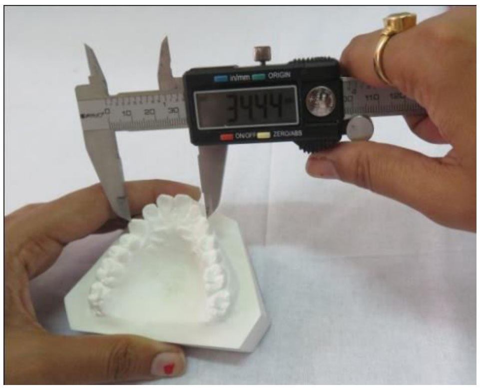

Fig. II Photograph depicting maxillary inter – canine width being measured from a Pre treatment study model of a subject with Digital Caliper

After collection of data, the obtained data was checked, verified and edited. Descriptive statistics, including mean and standard deviation (SD) were calculated for all measurements. 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. Statistical differences were determined at the 95% confidence level (*p*, .05).

RESULTS

Table I shows the maxillary dental arch width measurements of male and female subjects. No significant differences were observed in all the arch width measurements of males and females for Average and High angle subjects. However, the males had statistically significantly higher arch widths in the first and second premolar as well as intermolar areas than the females in Low angle subjects.

The arch width measurements of Average, High and Low MP-SN angle groups of males are shown in Table II. The high angle group had lower arch widths than the Average and Low angle groups in all the measurements. Analysis of Variance showed statistically significant correlations between MP-SN angle and the second premolar width as well as intermolar width.

The arch width measurements of Average, High and Low MP-SN angle groups of females are shown in Table III. The Average angle group shows the highest values for all the measurements as compared to the High and Low angle groups. The high angle group had lower arch width than the Low angle group only at the first premolar area. Rest all the measurements showed higher values for High angle group than the Low angle group. Analysis of Variance showed statistically significant correlations between MP-SN angle and the second premolar as well as the intermolar widths.

DISCUSSION

We undertook this study to quantify the nature of the arch width in various vertical facial patterns in untreated adult males and females of Rajasthan. It is a well versed fact that dental arch width and vertical facial morphology certainly varies with race and ethnicity as well. Christie[1] already proved that the Caucasians with normal occlusion tend to be more brachyfacial than dolichofacial. Compared to Caucasian's, Japanese have a narrower width. Sakamoto et al[2] proved that Japanese population has been found to be more retrognathic with a greater vertical direction of facial growth than Caucasians. African-Americans had larger maxillary arch width than Caucasian youths.[5] These studies suggest the need to study the arch form for local population and not to blindly follow the arch form prescriptions that are made up after studies on different populations.

Hyperdivergent, Normodivergent, and Hypodivergent groups allows estimation of its relation to dental arch widths. For each patient, standardized lateral cephalogram and study models were

Table II **Arch width measurements (in mm) comparison for Average, High & Low MP-SN angle Males**

	Average		**High**		**Low**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**(*p*)**
Intercanine width (cusp tip)	35.26	3.67	34.81	3.11	34.98	3.34	0.91
First premolar width (buccal cusp tip)	41.62	4.18	40.18	3.29	43.08	4.61	0.08
Second premolar width (buccal cusp tip)	46.67	4.04	44.96	2.83	48.12	2.73	0.01
Intermolar width (mesiobuccal cusp tip)	52.58	3.59	49.39	3.3	53.42	3.28	0.001

If the arch wires that are fabricated after studies on other populations are used on our population patients, the difference in their respective arch widths would result in unstable arch expansion or contraction and the results thus obtained would tend to relapse towards pre-treatment form. Hence, in this study, care was taken that all samples were of local origin to avoid any major ethnic difference in craniofacial morphology and the results obtained for our population were compared with other populations.

When comparing the arch width of our study population with the observations of Forster et al.[3] and in South Indian population[13], the inter-arch widths of our local population are wider than the Caucasian[3] ***(Max Intercanine – 2.36, Max Interpremolar – 2.41, Max Intermolar – 2.04)*** and the South Indian[13] ***(Maxillary Intercanine – 2.31, Max Interpremolar – 2.51, Max Intermolar – 2.11)*** populations. Southern Chinese population[14] has a greater arch width when compared to Caucasians[3] ***(Max Intercanine – 3.83, Max Interpremolar – 4.94, Max Intermolar – 4.52)*** as well as our study population ***(Max Intercanine – 1.47, Max Interpremolar – 2.53, Max Intermolar – 2)*** too.

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. In order to have a greater distribution of the facial patterns, 360 samples were taken and divided into three groups: Hyperdivergent, Normodivergent, and Hypodivergent. Assessment of

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. Four dental arch width measurements were taken from maxillary study models (inter-canine cusp tip, first premolar buccal cusp tip, second premolar buccal cusp tip and first molar mesiobuccal cusp tip). These measurements have been taken as a standard for dental arch width analysis by many investigators.[3],[18],[19],[20] In addition; the present sample was limited to non-growing, adult individuals, unlike many of the previous investigations that included only growing children (Isaacson et al., 1971[18]; Nasby et al., 1972[19]; Eroz et al., 2000[20]). Ideally, this type of study should be conducted using patients with ideal dentitions without any crowding or spacing. However, due to difficulties in finding ideal untreated subjects and subsequent limitations in sample size, those with crowding and spacing upto 8 mm were included.

In previous studies the genders of the observed arch widths were combined Howes;[21] Isaacson et al;[19] Schulhof et al.[5] Moreover, in agreement with Christie et al[1] ***(Max width – Males 64.2, Females 62)*** and C. Matthew Forster[3] ***(p <0.001)*** the results demonstrated that the male arch widths were significantly greater than female arch widths. Wei[6] evaluated posteroanterior cephalograms of Chinese adults and noted gender differences ***(p = 0.001 to 0.01)*** in maxillary inter-canine width. Gross et al.[22] observed that boys displayed larger arch

Table III **Arch width measurements (in mm) comparison for Average, High & Low MP-SN angle Females**

	Average		**High**		**Low**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**(*p*)**
Intercanine width (cusp tip)	34.98	3.26	33.58	2.48	33.57	3.06	0.22
First premolar width (buccal cusp tip)	41.34	3.77	40.15	2.96	40.24	2.82	0.43
Second premolar width (buccal cusp tip)	47.1	3.82	45.03	2.77	44.62	3.31	0.04
Intermolar width (mesiobuccal cusp tip)	51.96	2.85	49.73	2.97	49.52	3.74	0.03

width than girls ***(p < 0.006)*** 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 found more in males than females and this can be a reason for males having broader arch than females.[5],[6],[21],[22] Christie et al[1] and Wei[6] conducted a study evaluating the skeletal arch widths through PA view whereas our study has utilized study models to evaluate dental arch widths. Inspite of the methods being different, their results well support the findings of our study. Jarabak and Siriwat (1985),[23] Bishara and Jakobsen (1985)[24] **(*p* < 0.05)** had also found a sexual dimorphism to exist among various facial types. Hence, our study has compared the dental arch widths between male and female samples and have found out a significant difference ***(p = 0.00 to 0.03)*** between them.

In our study, all the arch width measurements in average angle group, except the maxillary second pre molar widths ***(Difference – 0.43)***, showed statistically insignificantly higher values for males than females ***(Difference – 0.07 to 1.35)***. For the low angle group, all the arch width measurements except the maxillary intercanine widths showed significantly ***(p = 0.00 to 0.03)*** higher values for males than females. These results are in consent with those demonstrated by Eroz et al[20] ***(Max Intermolar width p < 0.01)*** and C. Matthew Forster[3] ***(p <0.001)***.

The variation of arch widths between Caucasians,[3] South Chinese,[14] Japanese,[2] South Indians[13] and our local populations as well as 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.

The data from this study showed an inverse relationship between MP-SN angle and dental arch widths with a strong significance ***(p = 0.001 to 0.05)***. As the MP-SN angle increased from Low angle to Average to High angle, the relative dental arch widths decreased. This has been suggested decades earlier that a subject with a high MP-SN angle tends to have a longer 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),[25] Enlow and Hans (1996)[26]). Our study shows a significant inverse relationship between MP-SN angle and maxillary arch width at second premolar ***(p = 0.01)*** and molar ***(p = 0.001)*** areas in males as well as only between first molar widths ***(p = 0.005)*** for females. There is a high degree of similarity between our finding and those by Forster et al[3] wherein he observed that for the maxillary arch, there was a statistically significant inverse relationship between vertical facial morphology and dental arch width at maxillary canine ***(p = 0.002)***, first premolar ***(p = 0.017)*** and first molar ***(p = 0.019*** region in males and only between first pre molar width ***(p = 0.039)*** and second pre molar width ***(p = 0.042)*** in females. These findings were supported by Nasby et al (1972)[19] ***(Difference – 2.3)***. Isaacson et al (1971)[18] reported that steep mandibular plane individuals generally had narrower maxillary first intermolar width (***Difference – 4.97 mm)*** than flat mandibular plane individuals. Nasby et al (1972)[19] also reported that backward rotating mandible (hyperdivergent pattern) were associated with narrower intermolar widths **(*Difference – 2.3)***.

SCOPE FOR FURTHER STUDIES

Musculature has been considered as a possible link in this close relationship between the transverse dimension and vertical facial morphology. A number of studies[15],[16],[27-30] has illustrated the influence of masticatory muscles on craniofacial growth.

Proffit et al.[31] have proved that the mean bite force is greater for short face, normal in average face, and low in high-angle subjects. The mechanical stress brought about by occlusal bite forces and volume of certain masticatory muscles might influence the size of adjacent craniofacial skeletal regions.

Tongue position can also be a contributing factor in determining the arch widths.

The limitations of present study must be acknowledged because of the large individual variation encountered and dental arch dimensions are certainly a multifactorial phenomenon (Schulhof et al, 1978).[5] Although the data from the present study showed an inverse trend between MP – SN angle and dental arch widths, the correlation was not very strong. 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. This study can be made more exhaustive by observing the effects of various other contributing factors like muscle activity, bite force and tongue position on arch dimensions in different dentofacial patterns.

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