Evaluating The Correlation Between Dental Arch Dimensions And Facial Morphology In Class Ii Division 1 Malocclusion - A Retrospective Study

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ABSTRACT

Orthodontics bridges dental health and facial aesthetics by correcting malocclusion and aligning teeth. It combines scientific precision with artistic sensitivity, tailoring treatments to individual dental arch morphology and facial growth patterns. Therefore, this study was conducted to evaluate the relationship between dental arch dimensions and vertical facial morphology in Class II Division 1 subjects and examine the differences in dental arch dimensions between untreated male and female adults. ***MATERIAL & METHODOLOGY:*** The study examined pre-treatment lateral cephalograms and orthodontic models from 90 subjects, divided into two groups by gender: Group I (males) and Group II (females). Within each group, participants were further classified based on the Jarabak ratio, Y-axis, and Gonial angle as Hypodivergent, Normodivergent, and Hyperdivergent growth patterns. Using digital callipers, measurements were taken from orthodontic study models. Parameters included intercanine, first interpremolar and interfirst molar distances, arch perimeter, mesiodistal crown width, palatal height, overjet, overbite, and Curve of Spee. Statistical analyses (ANOVA, Post Hoc Games Howell, Post-Hoc Tukey, Independent 't' Test) identified significant differences ($P < 0.05$) among groups. ***RESULTS:*** After analysing observations the following results were obtained: (1) Normodivergent males displayed the largest arch perimeter, while Normodivergent subgroups generally exhibited greater interdental distances. (2) Measurements such as Inter-canine, Inter-first premolar and Inter-first molar distances were notably greater in the Normodivergent subgroup. (3)Overjet values varied significantly by gender and growth pattern; Normodivergent males and Hyperdivergent females had the highest values. (4) Palatal height was notably increased in Normodivergent females and Hyperdivergent males, and Hyperdivergent females showed a pronounced Curve of Spee. ***CONCLUSION:*** These findings underscore the impact of vertical facial morphology and gender on dental arch characteristics, informing personalized orthodontic approaches using customized archwires. Thus, customization of archwires and using individualized arch wires according to each patient"s pre-treatment arch form and arch width is beneficial during orthodontic treatment

Keywords: Vertical facial pattern, Dental arch dimensions, Study models, Lateral cephalogram.

INTRODUCTION

Orthodontists have long studied the relationship between malocclusion and facial form. Understanding these connections is crucial in orthodontics, where treatment plans consider individual facial morphology and arch dimensions.[1] Maintaining the patient's natural arch form during treatment minimizes risks of relapse and periodontal issues.[15] **.** Orthodontic archwires, pivotal in expanding arches, should align with the patient's original form to optimize stability.[10] This study aimed to investigate correlations between dental arch widths and facial types, exploring differences among untreated subjects. Understanding these associations could refine orthodontic treatment strategies, optimizing outcomes based on individual facial morphology and arch dimensions.

MATERIAL AND METHODOLOGY

INCLUSION CRITERIA

1. Patients having complete permanent dentition, between the age group of 18-26 years, (3rd Molar may or may not be present).

2. Class II skeletal bases and Angle's Class II Division 1 malocclusion.
3. No history of previous orthodontic treatment

EXCLUSION CRITERIA

1. Craniofacial anomalies like cleft lip, palate and syndromes.
2. History of trauma to dentofacial region.
3. Individuals with marked jaw asymmetries and Temporo-Mandibular Joint (TMJ) abnormalitywere excluded from the study.
4. Subjects with deleterious oral habits like mouth-breathing, tongue thrusting and thumb sucking, were excluded.

METHODOLOGY

A total of 90 pre-treatment lateral cephalograms and study models of patients with Class II Division 1 malocclusion were included in this study from the Department of Orthodontics & Dentofacial Orthopedics, Dasmesh Institute of Research & Dental Sciences, Faridkot. The subjects were divided into two groups according to gender as follows:

- Group I Male (
- Group II Female (

ANALYSIS OF LATERAL CEPHALOGRAMS

On the basis of Jarabak ratio, Y-axis, Gonial angle Group I male subjects were further subdivided into three sub groups of 15 each i.e. Subgroup I(a) (Hypodivergent male), Subgroup I(b) (Normodivergent male) and Subgroup I(c) (Hyperdivergent male) (Figure 1).

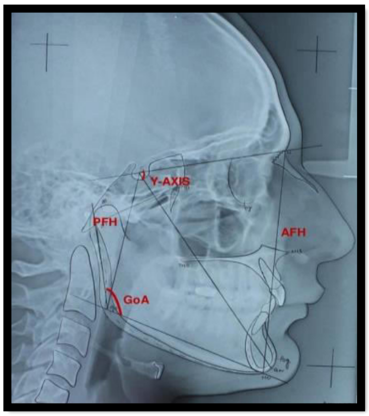


FIGURE 1: Illustration of Cephalometric measurements

Similarly, Group II female subjects were subdivided into three subgroups of 15 each, i.e. Subgroup II(a) (Hypodivergent female), Subgroup II(b) (Normodivergent female) and Subgroup II(c) (Hyperdivergent female).

Measuring Procedure: The measurements taken from Pre-treatment lateral cephalograms were traced using tracing sheet made of lead acetate 0.05mm thickness.To obtain the Jarabak's ratio anterior facial height was measured from nasion to menton andthe posterior facial height from sella to gonion. The ratio was obtained by the formula Posterior Facial Height (PFH) / Anterior Facial Height (AFH) x 100. The Gonial Angle (GoA) was measured by taking the tangent to the posterior border of the ramus and tangent to the lower border of the mandible on the lateral cephalogram (Ar-Go-Me). The Y-axis, also called the growth-axis was measured as the posteriorinferior angle on S-N plane and Sella to Gnathion.

ANALYSIS OF STUDY MODELS

The measurements were taken from Pre-treatment study models using digital caliper. The reference points for the measurements were marked by using the sharp-pointed pencil to create the exact landmark points. Following reference lines & measurements were taken (Table 1)(Figure 2,3).

Reference Lines	Definition
Inter-Canine Width (ICW)	**The distance between the cusp tips of the maxillary right permanent canines and left permanent canines.**
Interpremolar Width (IPW)	**The distance between the buccal cusp tips of first premolars of the contra-lateral sides.**
Intermolar Width (IMW)	**The distance between the mesiobuccal cusp tips of the right and left maxillary and mandibular first molars.**
Over jet	**The extent of horizontal overlap of the maxillary central incisor over the mandibular**

	central incisor.
Over bite	**The extent of vertical overlap of the maxillary central incisors over the mandibular central incisors.**
Arch Perimeter (AP)	**Transverse line connecting between three points as from the mesio-bucal cusp tip to the mesio-bucal cusp tip of the opposite side and the line then protracted from both side anteriorly to the centre point between the central incisors.**
Palatal height	**The distance of the perpendicular line from the connecting line between midpoints of the fissures of upper first molars to the surface of the palate**
Curve of Spee	**Measured as the perpendicular distance between the deepest cusp tip and a flat plane that was laid on the top of the mandibular dental cast, touching the incisal edges of the central incisors and the distal cusp tips of the most posterior teeth in the lower arch**
Cumulative Crown Width (CCW)	**The cumulative mesiodistal crown width is calculated as the sum of mesiodistal crown width upto first permanent molars**

TABLE 1:Landmarks, Reference points and Reference lines for study model

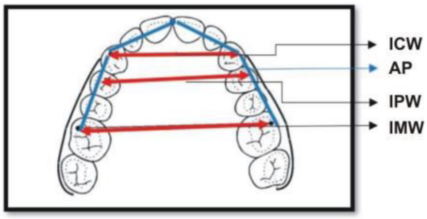


FIGURE 2: Linear Parameters for study model evaluation

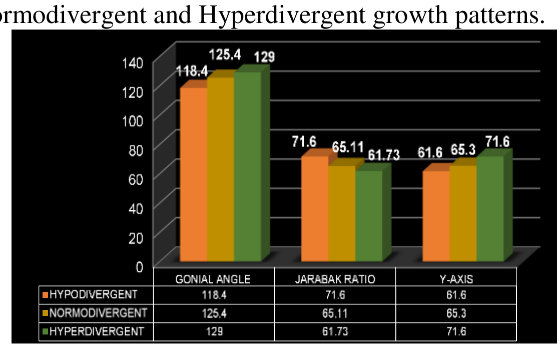
FIGURE 3: Measurementof (A) in tercanine width and (B) in termolar width

Statistical Test

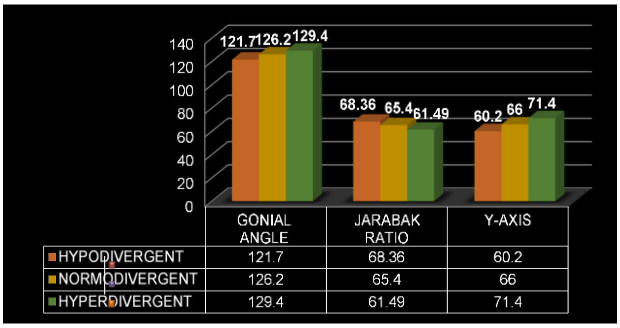
Descriptive statistics were calculated, including the mean and standard deviation of various parameters. ANOVA, Post-Hoc Tukey, Independent 't' test was used for multiple comparisons to find difference in all groups for statistical analysis, 'P' value of <0.05 was considered significant.

Results

The comparison of the mean of all cephalometric findings amongst males and females is illustrated in Table 2; Graphs 1 & 2 respectively. On the basis of these cephalometric findings the subjects where divided into Hypodivergent, Normodivergent and Hyperdivergent growth patterns.



GRAPH 1: Comparison of the mean of all cephalometric findings amongst all males



GRAPH 2: Comparison of the mean of all cephalometric findings amongst all females

GROUPS	MEAN		'P' VALUE	INFERENCE
	MALES	FEMALES		
Gonial Angle	124.29	125.82	**0.00**	**HIGHLY SIGNIFICANT**
Jarabak's Ratio	66.18	65.00	**0.00**	
Y-Axis	66.17	65.93	**0.00**	

TABLE 2: Comparison of Cephalometric Parameters of groups using ANOVA

The study model measurements compared in various subgroups of males are depicted in table 3 and graphs 3,4 & 5 while those amongst females are illustrated in table 4 and graphs 6,7 & 8. .

The results revealed that:

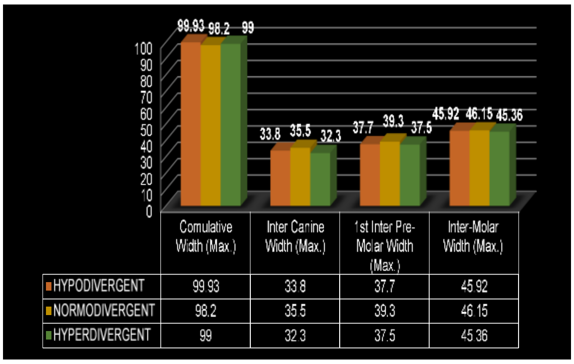
Inter-canine, Inter-first premolar and Inter-first molar measurements were highest in the Normodivergentgroup for both males and females.

Overjet was identified as the highest amongst the Normodivergent group in males, while among females, it was highest in the Hyperdivergent group.

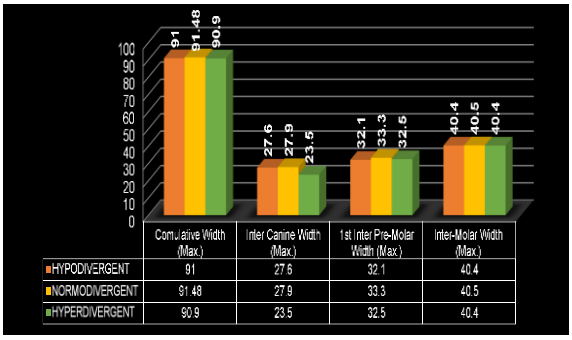
Palatal height was found to be higher in Normodivergent females and Hyperdivergent males, whereas the Curve of Spee was most pronounced in Hyperdivergent females.

GROUPS	MEAN	'P' VALUE	INFERENCE
CCW max.	99.26	0.84	NON-SIGNIFICANT
CCW mand.	91.11	0.93	NON-SIGNIFICANT
IMW max.	45.56	0.48	NON-SIGNIFICANT
IMW mand.	40.47	0.99	NON-SIGNIFICANT
IPW max.	**36.22**	**0.00**	**HIGHLY SIGNIFICANT**
IPW mand.	**34.64**	**0.00**	**HIGHLY SIGNIFICANT**
COS	3.60	0.10	NON-SIGNIFICANT
OVERJET	7.55	0.95	NON-SIGNIFICANT
OVERBITE	7.32	0.70	NON-SIGNIFICANT
ICW max.	**33.90**	**0.004**	**HIGHLY SIGNIFICANT**
ICW mand.	**25.80**	**0.00**	**HIGHLY SIGNIFICANT**
PALATAL HT.	20.37	0.64	NON-SIGNIFICANT

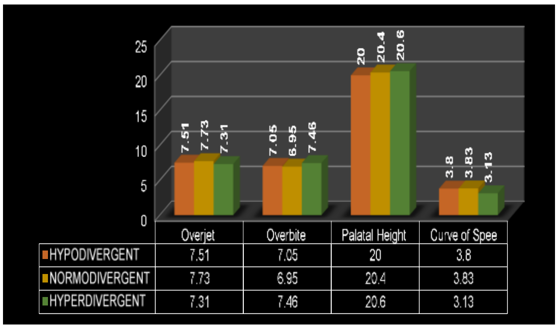
TABLE 3: Comparison of mean of study model measurementsamongst males using ANOVA



GRAPH 3: Comparison of the mean of all study model findingsin maxilla amongst males



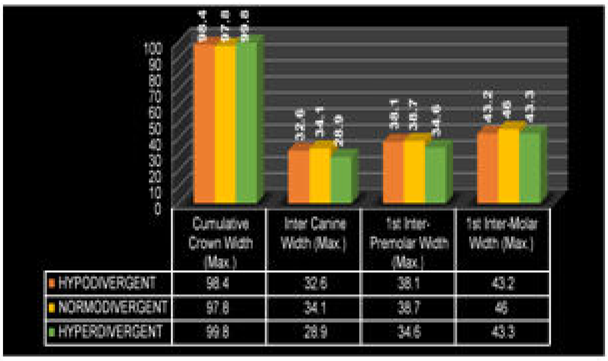
GRAPH 4: Comparison of the mean of study model findings in mandible amongst males



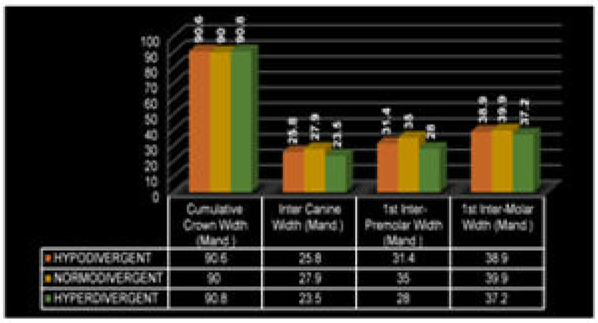
GRAPH 5: Comparison of the mean of study model findings amongst males

GROUPS	MEAN	'P' VALUE	INFERENCE
CCW max.	98.71	0.57	NON-SIGNIFICANT
CCW mand.	90.40	0.77	NON-SIGNIFICANT
IMW max.	44.86	).059	NON-SIGNIFICANT
IMW mand.	38.70	0.053	NON-SIGNIFICANT
IPW max.	**36.66**	**0.00**	**HIGHLY SIGNIFICANT**
IPW mand.	**31.56**	**0.00**	**HIGHLY SIGNIFICANT**
COS	3.22	0.67	NON-SIGNIFICANT
OVERJET	7.06	0.94	NON-SIGNIFICANT
OVERBITE	6.34	0.94	NON-SIGNIFICANT
ICW max.	**33.01**	**0.00**	**HIGHLY SIGNIFICANT**
ICW mand.	**25.65**	**0.00**	**HIGHLY SIGNIFICANT**
PALATAL HT.	18.73	0.38	NON-SIGNIFICANT

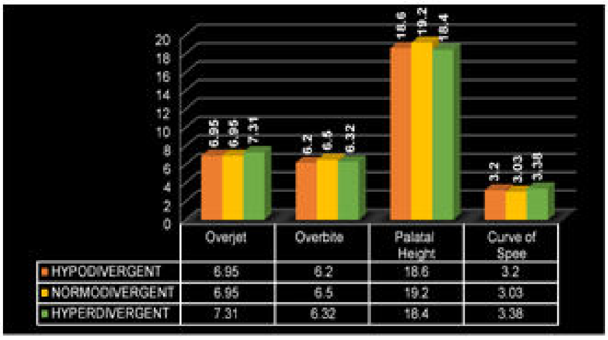
TABLE 4: Comparison of mean of study model measurements amongst females using ANOVA



GRAPH 6: Comparison of the mean of all study model findings in maxilla amongst females



GRAPH 7: Comparison of the mean of all study model findings in mandible amongst female

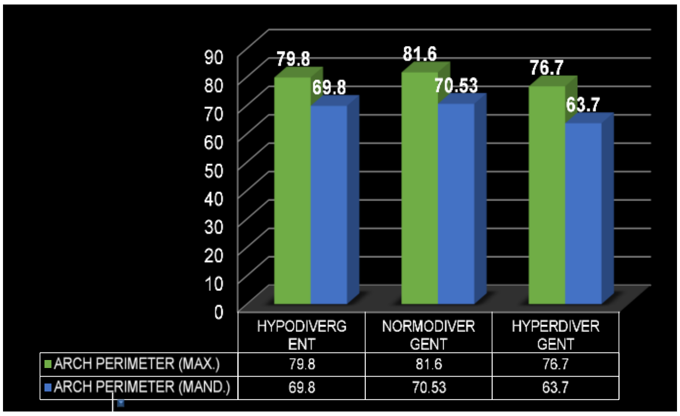


GRAPH 8: Comparison of the mean of all study model findings amongst females

Arch Perimeter was observed to be the greatest in Normodivergent groups for both males and females (Table 5,6 and Graphs 9,10). Slightly higher values were noted in males during inter-gender comparison (Table 7;Graph 11).

	GROUPS	**NUMBER**	**MEAN**	**STD. DEV**
MAXILLA	HYPODIVERGENT	15	79.8	5.60
	NORMODIVERGENT	**15**	**81.6**	**5.82**
	HYPERDIVERGENT	**15**	**76.7**	**7.08**
MANDIBLE	HYPODIVERGENT	15	69.8	5.28
	NORMODIVERGENT	**15**	**70.5**	**5.02**
	HYPERDIVERGENT	**15**	**63.7**	**4.89**

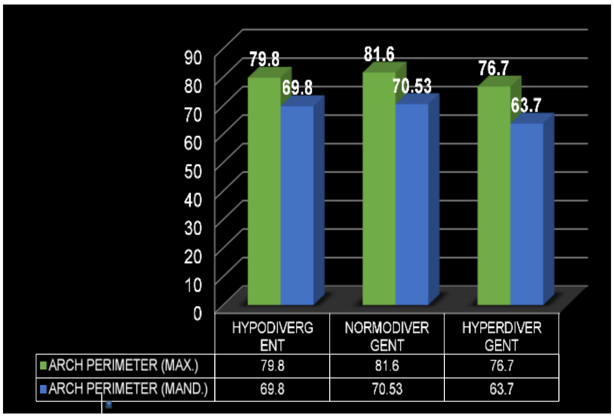
TABLE 5: Mean arch perimeter values amongst males



GRAPH 9:Comparison of mean arch perimeter values amongst males

	GROUPS	NUMBER	MEAN	STD. DEV
MAXILLA	**HYPODIVERGENT**	**15**	**81.26**	**6.57**
	NORMODIVERGENT	15	79.80	5.60
	HYPERDIVERGENT	**15**	**75.38**	**6.23**
MANDIBLE	HYPODIVERGENT	15	66.60	5.27
	NORMODIVERGENT	**15**	**69.80**	**5.28**
	HYPERDIVERGENT	**15**	**63.70**	**4.89**

TABLE 6:Mean arch perimeter values amongst female

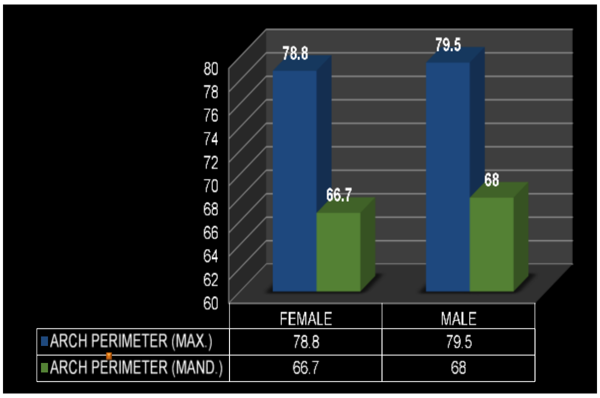


GRAPH 10: Comparison of mean arch perimeter values amongst females

ARCH PERIMETER COMPARISONS AMONGST MALES AND FEMALES

	'P' Value	Mean Diff.	Std. Error diff.	95% Confidence Interval ofthe Difference	
				Lower	Upper
AP (max.)	0.98	-.55	1.36	3.26	2.15
		-.55			
AP (mand.)	0.86	-1.31	1.20	3.71	1.09
		-1.31			

TABLE 7:Comparison of mean arch perimeter between males and females using student 't' test



GRAPH 11:Comparison between means of arch perimeter of males and females

DISCUSSION

Improving facial aesthetics is a fundamental objective in orthodontic treatment, necessitating precise diagnosis through intra and extraoral measurements of the face and dental arches. Dental arches undergo changes during treatment and growth, making accurate identification of the arch form crucial for achieving stable, functional, and aesthetically pleasing outcomes. Failure to maintain arch form can increase the risk of relapse, highlighting its critical role in orthodontic care.[1]

Dental arch size and shape are pivotal in orthodontic diagnosis and treatment planning, influencing space availability, dental aesthetics, and the stability of the dentition. Dimensions such as arch length, width, and depth are adjusted throughout treatment to align with treatment goals. Different types of arch wires used during treatment can alter arch dimensions, affecting final stability and aesthetics.[2]

The dental arch form reflects underlying bony structure, with dental compensation for any irregularities. In dentofacial orthopedics, the mandibular dental arch is crucial for diagnosing and treating malocclusions. Despite being a primary goal, maintaining arch form stability is complex as arches tend to revert to original shapes over time. Therefore, accurately assessing current arch form is crucial for predicting future stability. Various geometric forms and mathematical models exist for dental arches, but none accurately describe arch form singularly. Quantitative assessment of size and shape across individuals is optimal.[2]

Facial morphology varies globally, influencing orthodontic assessments. Initial evaluations focus on proportional relationships between facial height and width, which vary among individuals. Understanding how dental arch dimensions correlate with vertical dentofacial patterns is essential for comprehending arch size and shape diversity.[13]

Vertical facial assessment emphasizes parameters like the MP-SN (Mandibular Plane to Sella-Nasion) angle. Those with high MP-SN angles often exhibit longer facial dimensions and narrower arches, while those with low angles show shorter facial dimensions and wider arches**.**[17,6] Sexual dimorphism complicates arch dimensions in the vertical plane, with males generally having larger arch widths**.**[20,5,7] This necessitates sex-based stratification for homogeneous samples**.**[19,4]

Studies focusing on Class I populations suggest preformed archwires often fail for most patients, leading to issues like excessive intercanine width. Hence our study was aimed to find out comparable results in skeletal Class II patients who represent the most prevalent malocclusion.

In our study, male and female subjects were divided into hypodivergent, normodivergent, and hyperdivergent subgroups based on the Gonial Angle, Jarabak ratio, and Y-axis. The Jarabak ratio was selected due to its reliability, as it is constructed from anatomical landmarks[4] and minimizes the likelihood of human error by utilizing a ratio rather than a linear parameter. Additionally, the Gonial Angle and Y-axis were employed as confirmatory indicators to further validate the determination of growth patterns.

Comparisons revealed normodivergent groups generally had highest arch perimeters, except for maxillary arches in females, where hypodivergent groups showed higher values. Males generally had higher arch perimeters, though statistically insignificant, aligning with gender-based differences.[3]

Female hyperdivergent groups had highest cumulative mesiodistal width, with males showing higher values in specific hypodivergent and normodivergent subgroups, indicating independent variations relative to vertical growth patterns.

Masticatory muscles significantly influence craniofacial growth and arch dimensions. Robust mandibular elevator muscles often correlate with wider transverse head dimensions and broader dental arches, contrasting with narrower forms in individuals with weaker muscles.[12]

Isaacson et al. described that as the face height increases, the muscles lengthen and the increase in this muscle elongation leads to an increase in passive stretch tension, which had a constricting effect on the jaws.[11] In studies investigating the impact of vertical morphology on dentition, Foster et al., Khera et al., Ribeiro et al., Grippaudo et al. reported a statistically significant negative relationship in the maxillary canine, first premolar and first molar regions.[8,9,13,16]

The results of our study suggested that as the vertical angle increases, the mean Intercanine width decreases. Therefore, it is advisable to utilize individualized arch forms for patients with different vertical patterns. This recommendation aligns with the fundamental law of stability, which highlights the importance of maintaining arch dimensions, particularly across the canines, without alteration.

In the analysis of interpremolar width, the Normodivergent groups of both males and females demonstrated the highest value, which was statistically highly significant. Conversely, while the intermolar width in Normodivergent groups of both males and females displayed the highest value, it was statistically non-significant. These findings suggested an inverse correlation of transverse dimensions to the vertical facial morphology.

Overjet and overbite showed no significant correlations across vertical facial patterns. Normodivergent groups had higher overjet in males and hyperdivergent groups in females.Palatal height differences were not significant, consistent with vertical facial morphology associations**.**[18,14]

Hyperdivergent females and normodivergent males had pronounced Curve of Spee, suggesting gender-specific influences on dental arch morphology due to vertical facial patterns.[18]

Our study provides normative arch dimension data across hypodivergent, normodivergent, and hyperdivergent groups, crucial for orthodontic treatment planning. Acknowledging individual arch size and shape variations among different vertical facial patterns stresses personalized approaches. Tailoring treatment based on pre-treatment arch form and width minimizes limitations of standardized archwires, promoting stability and aesthetics.

However, it's important to acknowledge the study's limitations due to the substantial individual variation encountered, as dental arch dimensions are undoubtedly influenced by multiple factors. Several other short comings and limitations include procedural difficulties and problems with the actual identification of landmarks. Several layers of error were compounded in tracing, digitalising and measurement steps of the process. Measurement accuracy is sensitive to human error and is governed by sensitivity of measuring instruments. There were unlikely unavoidable differences among different cephalometric films.The prevailing theory suggested that individuals with robust mandibular elevator muscles tend to possess wider transverse head dimensions. To enhance the comprehensiveness of this study, further exploration could involve examining the impact of muscle activity on arch dimensions across different dentofacial patterns, potentially employing techniques like ultrasonography.

CONCLUSION

From this study it was concluded that the relationship exists between the dental arch dimensions and vertical facial morphology and gender. The study's conclusion highlighted the significance of understanding the interplay between dental arch dimensions, vertical facial morphology and gender in orthodontic treatment.

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