Evaluation and comparison of palatal depth, transverse arch width and buccolingual inclination of maxillary molars among different facial types using cone beam computed tomography

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ABSTRACT

Introduction - The purpose of this study was to evaluate and compare palatal depth, transverse arch width and buccolingual inclination of maxillary first molars among different facial types using cone beam computed tomography (CBCT).

Methods - This retrospective study was conducted using pre-treatment CBCT records of 30 patients (skeletal class 1) and were divided into 2 groups by their mandibular plane angle, Group A (brachyfacial type SN.GoGn <30°), and Group B (dolichofacial type SN.GoGn >34°) . Coronal views of the images were analyzed. Vertical facial pattern differences and related factors were assessed with independent t test and Pearson correlation analysis.

Results - In subjects with brachyfacial type (horizontal growth pattern) inclination of right first molar was 90.13±1.6º, and inclination for left first molar was 90.73±1.49º. In subjects with dolichofacial type (vertical growth pattern) the inclination of right first molar was 93.47±1.41 º and inclination for left first molar was 92.93±1.53º. In subjects with horizontal growth pattern mean palatal depth was 14.46±1.37mm and in subjects with vertical growth pattern mean palatal depth was 16.25±1.42mm. Statistically significant differences were found between Group A and B (in both buccolingual inclination and palatal depth). In subjects with horizontal growth pattern mean transverse arch width was 34.73±2.11mm and in subjects with vertical growth pattern mean transverse arch width was 34.02±1.87mm. No significant difference in values of transverse arch width.

Conclusions- subjects with a vertical growth pattern had greater buccal inclination and palatal depth than subjects with a horizontal growth pattern. There were no statistically significant differences in transverse arch widths among horizontal growth pattern and vertical growth pattern. An increase in mandibular plane angle is associated with tendencies of deep palate and increased buccal inclination of maxillary first molars.

Index Terms – Palatal Depth, Transverse Arch Width, Buccolingual Inclination of Maxillary First Molars, Different Facial Types, Cone Beam Computed Tomography (CBCT).

INTRODUCTION

Factors such as age, sex, and ethnic group are important in making a proper orthodontic treatment plan; another important factor is the facial growth pattern and its several clinical characteristics.[1]

The facial type of an individual comprises variations of the craniofacial skeleton structures and it is related to genetic and environmental factors. The classification of facial types has a direct relationship with craniofacial growth and is divided in three types: brachyfacial, mesofacial and dolichofacial. In the brachyfacial type, there is a tendency to horizontal facial growth; mesofacial type is characterized by balanced growth of all facial thirds and dolichofacial type has a tendency to vertical facial growth.[2]

The subject must have adequate transverse alveolar width and optimum molar inclinations. The torque expression of the posterior segment plays an influential role in optimum function and occlusal stability.[3]

Unfortunately, transverse problems, such as dental and skeletal crossbite are quite prevalent.[4]The importance of transverse dimension becomes apparent when the potential and limits of certain treatment options, such as palatal expansion, have to be explored or when deciding between extraction and non-extraction in borderline cases. [5]

Arch width is one of the parameters in deciding the arch form, which plays a key role in creating the optimum esthetics, functional occlusion, stability, and well-finished results. Broad arches are implicated in having stable, well-balanced, functional occlusion. Hence, there is a need for a delineation of broad or normal arches from narrow or deficient arches based on arch width.[6]

Andrews described the six keys to normal occlusion. The third key relates to crown inclination, showed lingual crown inclination for the maxillary and mandibular molars.[7] It is important not only for occlusal intercuspation but also for the aesthetics of the frontal smile.[8]

The American Board of Orthodontics (ABO) Objective Grading System also assessed the buccolingual inclination as a part of its final phase III clinical examination. [11] A list of clinical problems could occur without the concern of transverse discrepancies, such as relapse, occlusal interference, poor buccal interdigitation and periodontal risks (dehiscence and fenestration). Therefore, transverse compensation of the first molars needs to be explored to achieve acceptable treatment results and avoid relating clinical risks.[9]

Assessing the depth of the palate mostly occurs in a qualitative manner with general classifications being as high, moderate and shallow. In 1939, Korkhaus attempted to classify palatal depth in a more organised, quantitative manner and devised the Korkhaus Palatal Index to determine palate depth and arch width in a reproducible manner.[10]

In the Korkhaus Palatal Index, the palates were classified into three types: high palate, if the palate depth was > 22 mm; moderate palate, if the palate depth was in the range of 19–22 mm; and shallow palate, if the palate depth was < 19 mm. He used the palatometer to determine the palate depth and central fossa of the molars as a reference point for determining transverse arch width. One potential drawback of this method was that the inclination of the molars was not taken into consideration. Hence, it would not give a correct assessment on the arch width and values indicating either expansion or constriction would be based more on clinician experience and feasibility rather than evidence.[3]

A new 3D imaging method CBCT that allows an unobstructed view of crown and root structure is critical in assessing inclination of tooth.[11]

If the transverse width of the dental arch and the molar inclination has correlations to vertical facial types, patients would benefit from treatment plans that include differentiated approaches for facial patterns to improve the transverse discrepancy to achieve an ideal functional and esthetic occlusion. [12]

Some authors have suggested that in subjects with increased vertical dimensions, the maxillary dental arch is narrower, the palates have higher arches, and the posterior teeth are buccally inclined, whereas those with decreased vertical dimensions have the opposite characteristics such as lingually inclined molars. [13] However, Ross et al found no differences in molar inclinations and facial types. [14]

Janson et al. also explored the relationship between buccolingual inclinations of posterior teeth with horizontal and vertical growth patterns. They found that maxillary posterior teeth of subjects with a vertical growth pattern had a greater buccal inclination compared with those of subjects with a horizontal growth pattern.[1]Ross et al. looked at variations in buccolingual tooth inclination and their correlation with skeletal growth patterns in the vertical dimension. They found that the maxillary posterior teeth were buccally inclined, and

the mandibular posterior teeth were lingually inclined. However, they did not find a correlation between the molar buccolingual inclination and the mandibular plane angle. [14]
Relationship between palatal depth, transverse arch width, buccolingual inclination of molars and vertical facial type has been studied, but the results are disorganised, heterogeneous, thereby resulting in more confusion than clarity.
In most previous studies, evaluation of buccolingual inclination has been limited to the crowns of teeth utilizing model casts. However, there are limitations to using models due to the variations in crown morphology.[14] With the advent of three-dimensional (3D) imaging, such as cone beam computed tomography (CBCT), practitioners can visualize and measure the true 3D anatomy of patients, which allows measurements to be made in three planes of space.[11]
Therefore, the purpose of this study is to evaluate the palatal depth, transverse arch width and buccolingual inclination of maxillary molars with CBCT specifically in skeletal Class I patients with different vertical facial type.
This would give us a correct idea about the type of expansion required—whether bodily or tipping—and can aid in the diagnosis and treatment planning of cases with transverse discrepancies. It can also help in distinguishing between skeletal and dental crossbites.

AIM AND OBJECTIVES

Aim: Evaluation and comparison of palatal depth, transverse arch width and buccolingual inclination of maxillary first molars among different facial types usingCBCT.

Objectives: 1. To evaluate palatal depth, transverse arch width and buccolingual inclination of maxillary first molars among brachyfacial type (horizontal growth pattern) and dolichofacial type (vertical growth pattern) byCBCT. 2. To compare the palatal depth, transverse arch width and buccolingual inclination of molars in subjects with horizontal growth pattern and vertical growth pattern.

MATERIALS AND METHODS

This retrospective CBCT study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Jaipur Dental College, in co-ordination with Oral Radiology Department for CBCT examination. This study was approved by the ethical committee of the university. The study was pursued with the written informed consent obtained from the patients before entering the study.
Pre-treatment lateral cephalogram records of selected 30 patients in the age range of 18-35 years, 15 each of brachyfacial (SN.GoGn angle <30°) (Group A) and dolichofacial (SN.GoGn angle >34°)(Group B) categories were selected. The cephalograms were traced on acetate and the cephalometric measurements carried out were ANB angle and SN.GoGn angle (Figure 1).
Inclusion criteria were Full complement of teeth in the permanent dentition except third molars, fully erupted first molars, Class I subjects with an ANB angle of 0° to 4° [15,16] , subjects with SN.GoGn angle less than 30° and more than 34°.
Exclusion criteria were missing, extracted or supernumerary teeth, unerupted first molar, severe rotation, Crossbite, decay, large filling or restoration of first molars, craniofacial deformities or evident facial asymmetry, presence of periapical or periodontal pathologies, periodontal bone loss, history of trauma, malignancy, malformed teeth/ anodontia/ oligodontia, systemic disease affecting bone metabolism, impacted teeth in the measurement site, prior history of orthodontic or orthognathic surgery treatment, transverse discrepancies.
The mean SN.GoGn angle and demographics for the 2 groups shown in Table 1.

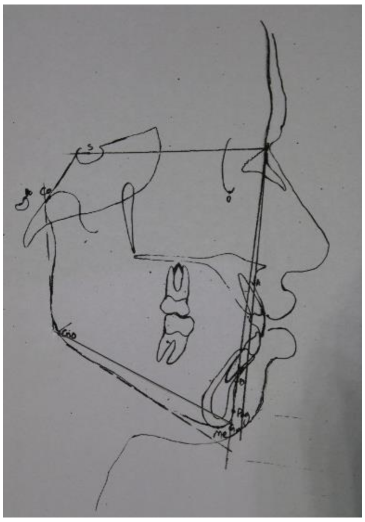


Figure 1 Cephalometric landmarks used in the study.

Table1. Descriptive data of all samples

Variables	Horizontal growth pattern (n=15)			Vertical growth pattern (n=15)		
	Mean ± SD	**Min**	**Max**	**Mean± SD**	**Min**	**Max**
Age (Years)	25±4.11	18	31	24.07±4.03	18	31
ANB (Degree)	1.8±1.32	0	4	2.47±1.41	0	4
SN.GoGn (Degree)	25.27±3.59	19	29	37.33±2.19	35	42

All the CBCT scans were taken with the patient in the natural head position and the lower borders of the orbit were aligned with the Frankfurt Horizontal Plane. All the subjects were scanned using CS 8200 3D CBCT (Carestream Dental LLC, Atlanta, GA), with the same exposure settings - tube current: 4mA (pulsed mode), tube voltage: 90 kV, voxel dimensions: 150µmx150µmx150µm, and scanning time: 20 seconds.

The data were recorded in DICOM (Digital Imaging and Communication in Medicine) format and processed using CS 3D Imaging (Carestream) software.

REFERENCE PLANES

The sagittal guideline of the tooth axis was defined (per Masumoto's guideline) as a line passing through the midpoint of the mesiodistal crown width and the midpoint roots at one-third the distance from the apex. [17]

Once the sagittal orientation was determined, the coronal cross-section was obtained in a 0.5-mm slice, using a section that best fitted the right and left molar mesiodistal midpoints. The coronal section was used to measure the tooth axis. The long axis of the tooth was defined as a line connecting the midpoint of the buccal and lingual cusp tips and the midpoint of the buccolingual width at the cervical base of the anatomic crown.

MEASUREMENTS

Maxillary first molar buccolingual inclinations were measured as the inner angles formed by the long axis of the teeth, relative to the palatal plane (PP) (Figure 2).

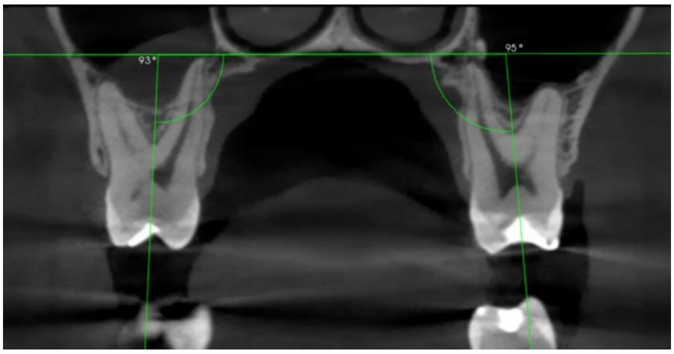


Figure 2 Coronal view of CBCT scan showing angular measurements of buccolingual inclination of maxillary first molars.

The distance from mid-palatal suture to the alveolar crest was used to determine the palatal depth. (Figure3).

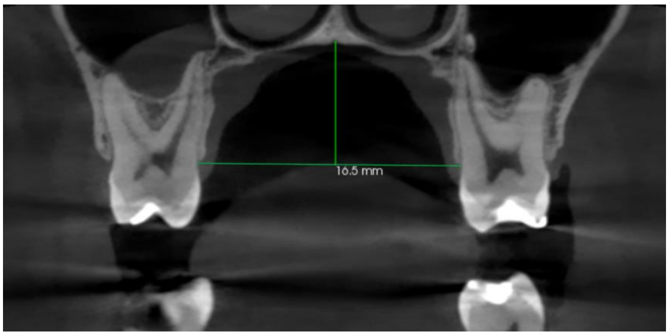


Figure 3 Evaluation of palatal depth

For measurement of transverse arch width, distance was measured from lingual alveolar crest point of one side to opposite side of maxillary first molar. (Figure4).

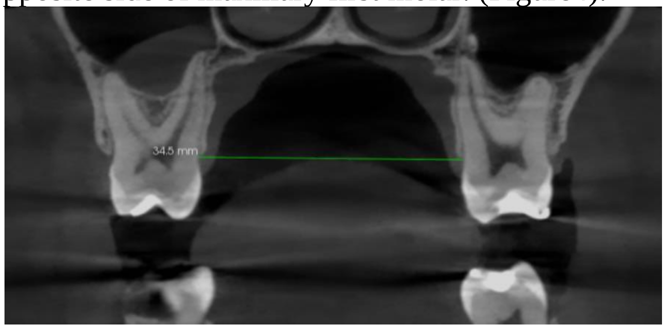


Figure 4 Evaluation of transverse arch width.

STATISTICAL ANALYSIS

The data collected was tabulated in Microsoft Excel (Microsoft office 2013, Microsoft, USA) and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS, IBM version 20.0). The level of significance was fixed at 5% and $p \leq 0.05$ was considered statistically significant.

Descriptive statistics, including the mean, standard deviation, and range were calculated for all measurements. Normality test was performed using the Shapiro-Wilk test. All variables were normally distributed.

Unpaired t-test was used for intergroup comparisons. Factors that were affected by an increase in the mandibular plane angle were further checked by Pearson correlation analysis.

Ten CBCT scans randomly selected were measured 10 days after first measurements by the same examiner for assessing intraexaminer variability. Systemic error was calculated using intraexaminer reliability tests, which were determined via Pearson's correlation coefficients and paired t –test.

RESULTS

The intra-examiner variability test showed no significant differences between the two measurements. A high correlation with Pearson's correlation coefficient values of 0.98-0.99 for all angular and linear measurements, indicating high reproducibility.

Table 2 shows inter-group comparison of means of buccolingual inclination of right and left upper first molar. In subjects with brachyfacial type (horizontal growth pattern) the average inclination of maxillary right first molar was $90.13 \pm 1.6^{\circ}$, average inclination for maxillary left first molar was $90.73 \pm 1.49^{\circ}$ and the average inclination of maxillary first molars was $90.43 \pm 1.1^{\circ}$. In subjects with dolichofacial type (vertical growth pattern) the average inclination of maxillary right first molar was $93.47 \pm 1.41^{\circ}$, average inclination for maxillary left first molar was $92.93 \pm 1.53^{\circ}$ and the average inclination of maxillary first molars was $93.2 \pm 1.18^{\circ}$. There was no significant difference between the right and left mean values. There was significant difference between the horizontal growth pattern and vertical mean values ($P < 0.05$).

The maxillary first molars of subjects with a vertical growth pattern had a significantly greater buccal inclination compared with those of subjects with a horizontal growth pattern (Table 2, Graph 1).

Table 2 Inter-group comparison of means of buccolingual inclination of right and left upper first molar.

Buccolingual Inclination (Degree)	Horizontal Growth Pattern (n=15)			Vertical Growth Pattern(n=15)			P value
	Mean ± SD	Min	Max	Mean± SD	Min	Max	
Right	90.13±1.6	87	92	93.47±1.41	91	96	<0.001 HS
Left	90.73±1.49	87	92	92.93±1.53	91	97	<0.001 HS
Average	90.43±1.1	87	92	93.2±1.18	91	96.5	<0.001 HS

p>0.05 not significant; p<0.05 significant; p<0.001 highly significant

Graph 1 Inter-group distribution of means of buccolingual inclination of right and left upper first molar.

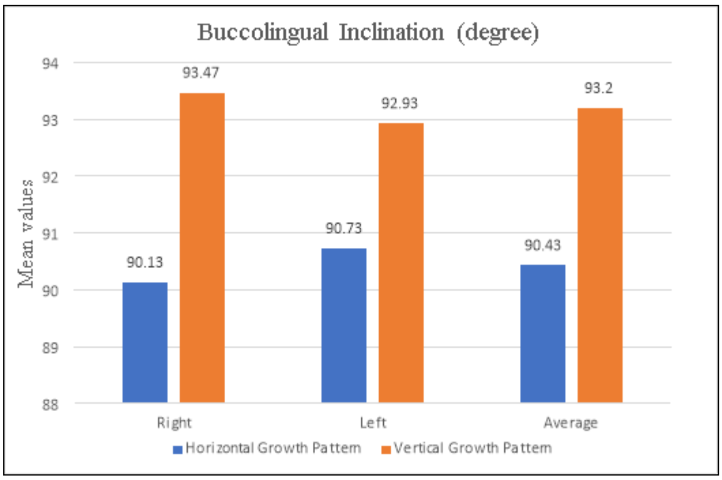


Table 3 showsinter-group comparison of means of palatal depth. In subjects with horizontal growth pattern mean palatal depth was 14.46 ± 1.37 mm and in subjects with vertical growth pattern mean palatal depth was 16.25 ± 1.42 mm.
The subjects with a vertical growth pattern had a significantly greater palatal depth compared with those of subjects with a horizontal growth pattern (P < 0.05). (Table 3, Graph 2)

Table 3 Inter-group comparison of means of palatal depth.

Variable	Horizontal Growth Pattern (n=15)			Vertical Growth Pattern(n=15)			P value
	Mean ± SD	Min	Max	Mean± SD	Min	Max	
Palatal Depth (mm)	14.46±1.37	12.1	15.9	16.25±1.42	12.4	18.1	0.0015 HS

p>0.05not significant; p<0.05 significant; p<0.001 highly significant

Graph 2 Inter-group distribution of means of palatal depth

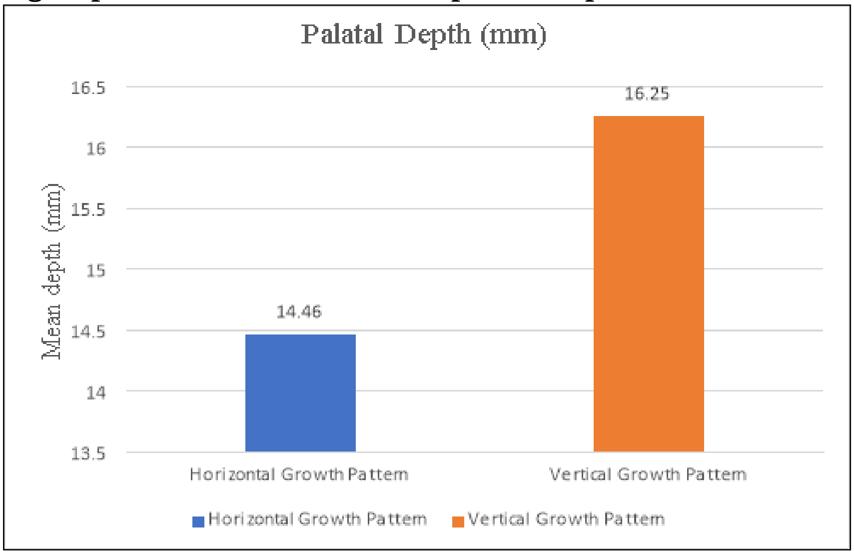


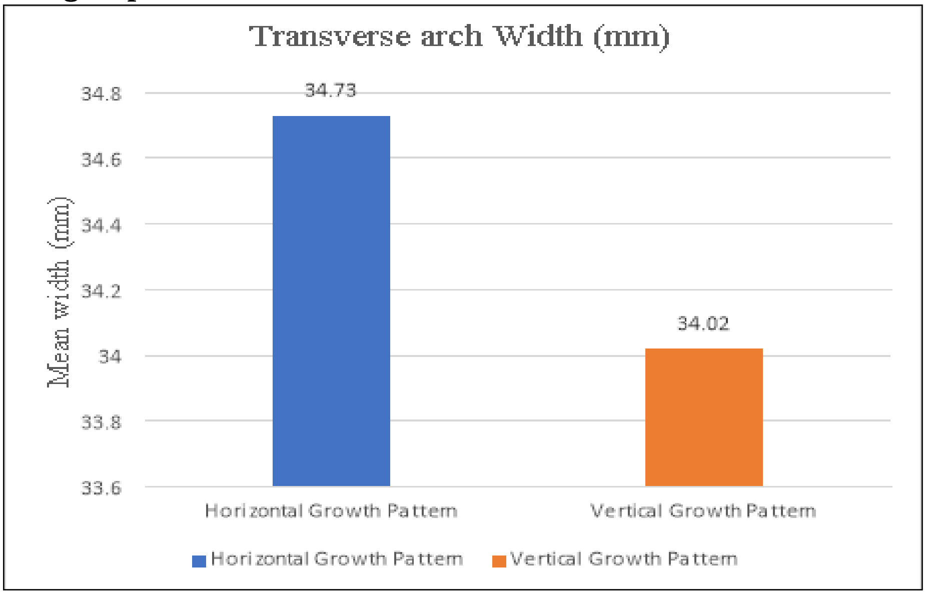
Table 4 shows inter-group comparison of means of transverse arch width. In subjects with horizontal growth pattern mean transverse arch width was 34.73 ± 2.11 mm and in subjects with vertical growth pattern mean transverse arch width was 34.02 ± 1.87 mm. (Table 4, Graph 3)
There was no significant difference in values of transverse arch width between brachyfacial (Horizontal Growth Pattern) and dolichofacial type (Vertical Growth Pattern) (P > 0.05).

Table 4 Inter-group comparison of means of transverse arch width.

Variable	Horizontal Growth Pattern (n=15)			Vertical Growth Pattern(n=15)			P value
	Mean ± SD	Min	Max	Mean± SD	Min	Max	
Transverse arch width (mm)	34.73±2.11	31.3	39	34.02±1.87	32.2	39.2	0.33 NS

p>0.05 not significant; p<0.05 significant; p<0.001 highly significant

Graph 3 Inter-group distribution of means of transverse arch width.



There was a moderate positive correlation between buccolingual inclination of maxillary first molars and growth pattern (SN.GoGn angle). The positive correlation showed a relationship between SN.GoGn angle and buccolingual inclination of maxillary first molars move in the same direction, which is the greater SN.GoGn angle , the larger the buccolingual inclination. (Table5).

There was a weak positive correlation between palatal depth and growth pattern (SN.GoGn angle). The positive correlation showed a relationship between SN.GoGn angle and buccolingual inclination of maxillary first molars move in the same direction, which is the greater SN.GoGn angle , the larger the buccolingual inclination (Table 5) .

Table 9 Pearson correlation between buccolingual inclination and growth pattern (SN.GoGn angle).

Correlated Variable	Horizontal Growth Pattern (n=15)		Vertical Growth Pattern(n=15)	
	Pearson 's r correlation	P-value	Pearson 's r correlation	P-value
Buccolingual Inclination(right) (Degree)	0.49	0.06	0.36	0.18
Buccolingual Inclination(left) (Degree)	0.52	0.04	0.47	0.07
Palatal Depth (mm)	0.14	0.59	0.16	0.55

p>0.05 not significant; p<0.05 significant; p<0.001 highly significant

DISCUSSION

The diagnosis in orthodontics is mainly based on the morphological and quantitative description of craniofacial structures in the three planes of space, but greater attention has been given to the assessment of malocclusions in the sagittal and vertical dimensions, ignoring that the transverse plane is equally important to the final position of maxillary teeth and their coordinated function.[18]

If the estimated arch width values were mildly decreased (as determined from the palatal index), then on determining the inclinations we can say whether the transverse discrepancy can be corrected by tipping alone or would require a more bodily expansion as appropriately facilitated by Hyrax or MARPE.[3]

The Korkhaus Index is a reference parameter for determining arch width and palate depth.[10] One of the limitations of Korkhaus Index is that the exact position of the molars in the alveolar housing cannot be determined by plaster models alone and their inclinations, critical to addressing the transverse discrepancy, is left unexplored. Identifying them can aid in resolving existing transverse problems through different arch expansion protocols.[3]

The individual with different facial patterns (sagittal and vertical) have different facial and dental features.[19] On evaluating the orthodontic literature, we come across studies where vertical and sagittal differences between the compared groups are poorly organised, creating confusion and heterogeneity.

Ross et al compared the inclination of the occlusal surface of first molars in subjects with different growth patterns and did not find statistically significant differences.[14] Shu et al. and [1]Mueez et al. found that Class II division 1 subjects showed more lingually inclined maxillary molars, compared with individuals with Class I occlusion.[20,21] Janson et al. reported that subjects with vertical growth patterns have greater buccal inclinations of the maxillary molars and those with horizontal growth patterns have more lingually inclined.[1] Roy et al. found that maxillary posterior alveolar and basal height was greater in the hyperdivergent facial type than the other facial types.[22] Conversely, Barbosa et alfound that there were no significant differences between the palatal measurements evaluated in the three different facial patterns.[2]

Gu et al. found no significant difference in the intermolar width of the first molars, and in vertical skeletal discrepancy.[9] Conversely, Forster et al. and Lubis et al. found that as MP – SN angle increased, arch width decreased.[23,24]

Mitra S, and Ravi MS found that greater lingual inclination of molars in short face individuals.[25] Conversely, Lydie et al. and Eraydin et al. found that there was no significant difference in dental inclination of the first molars according to the vertical facial profile.[8,26]

Hwang et al. found an increase in the mandibular plane angle is associated with higher palatal arches in both sexes. Intermolar widths and molar inclinations were not significantly affected by vertical facial patterns.[12]

A potential link between palatal depth, transverse arch width, buccolingual inclination of molars and vertical facial type has been studied, but the results are disorganised, thereby resulting in more confusion than clarity. [1,14,17,25]

This study aimed at evaluating the palatal depth, transverse arch width and buccolingual inclination of maxillary molars and correlating it with different facial types usingCBCT.

Patients between 18 and 35 years were included in this study because the inclination of teeth can change during the period of growth and development. Thus, we evaluated patients with completed growth.[27] The SN- MP(GoGn) angle was used as the measurement of different facial patterns in the present study.

ANB angle is a widely accepted diagnosis for sagittal jaw discrepancy. [15,16] 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 of vertical facial morphology to palatal depth, transverse dental arch widths, and buccolingual inclination.[23]

One of the advantages of using CBCT is the ability to visualize the whole tooth, thus removing some of the uncertainty in long-axis inclination that can result from using casts with uneven cusp wear or tooth morphology.[25,28] In this study, the whole anatomic crown was used to determine the long axis of the first molars. This would eliminate any uncertainly due to variation in root morphology or divergence. Mitra measured maxillary molar inclinations using CT; however, only the buccal roots were measured.[25] Barrera et al. used a line connecting the central groove to the furcation for the molar axis, which is similar to the method used in this study.[28] Kasai and Kawamura defined the long axis as passing through the midpoint at one-half the crown width and the midpoint at one-third the distance from the apex.[17]In present CBCT study, Masumoto et al guidelines were used in defining the sagittal position of the tooth axis [17]and the tooth axis was measured in the coronal section. The long axis of the tooth was defined as a line connecting the midpoint of the buccal and lingual cusp tips and the midpoint of the buccolingual width at the cervical base close to the furcation of the anatomic crown. [29] Angular measurements were obtained from the long axis of each maxillary to palatal plane.

In the present study, we noted that palatal depth of subjects with vertical growth pattern had a higher palatal depth than those in subjects with a horizontal growth pattern. This finding was in agreement with Esteves and Bommarito, who stated that dolichofacial individuals have deep palate while brachyfacial patients have shallow palate, demonstrating differences in the palatal morphology in each facial type.[30]Similar finding also reported by Hwang et al. and Roy et al who found that an increase in the mandibular plane angle is associated with higher palatal arches in both sexes.[12,22]

In current sample, there was no significant difference in transverse arch width in horizontal and vertical growth pattern. Similar finding also reported by Hwang et al and Gu et al who found that there were no significant differences in intermolar widths among the hypodivergent, normodivergent, and hyperdivergent groups in both sexes.[9,12]

In this study, we noted that buccolingual inclination of subjects with vertical growth pattern had a greater buccal inclination than those in subjects with a horizontal growth pattern. This finding concurs with Banari A et al. and Isaacson et al who found hyperdivergent subjects have relatively more buccal inclination in maxillary molars.[19,25]

In this study Pearson correlation analysis showed that the palatal depth, and buccal inclination increased as the SNGoGN angle increased.

Clinical implications:

The depth of the palate, the corresponding arch width and molar inclinations give us an idea about the type of correction required. Identifying them can aid in resolving existing transverse problems through different arch expansion protocols.[3]

Related complications including periodontal risk could happen without transverse consideration.[31]Using CBCT to determine the buccolingual inclinations of molars, we can verify the periodontal biotype of the patient. This can be helpful in framing the limits of expansion and prevent undesirable side effects such as fenestration, dehiscence due to increased buccal crown torque.[32]

When there is a severe discrepancy between dental and a bone size, extraction of permanent teeth is usually indicated. However, slight-to-moderate discrepancies between dental and bone sizes can be corrected through reducing dental structures by interproximal stripping, expanding the dental arch, or a combination of both. [1,33] Therefore, when slight or moderate crowding is associated with a narrow dental arch and not with an increased dental size, procedures to increase arch dimensions might be considered, to avoid the need for extractions. The suggestion of Howe et al, to treat borderline patients with palatal expansion and buccal inclination of the posterior teeth, is especially applicable for those with horizontal facial patterns, as compared with those with vertical growth patterns.[33,34] A common collateral effect of maxillary expansion is buccal tipping of the maxillary posterior teeth. Therefore, because of the greater palatal inclination of the maxillary posterior teeth in this facial pattern, a greater maxillary expansion could be carried out without causing an accentuated and unfavorable buccal tipping of the posterior teeth, which could lead to a greater relapse of the expansion.[34-38]

Extractions usually have more favorable results in vertical facial type, and nonsurgical palatal expansion can accentuate the buccal inclination of the maxillary posterior teeth, thus jeopardizing maxillary expansion stability (surgically assisted palatal expansion would have fewer collateral effects in these aspects).[39-45]

Especially when camouflaged treatment is planned for mild or moderate skeletal malocclusions, the potential of molar compensation needs to be clearly defined. Otherwise, surgery assisted expansion should be considered to avoid dehiscence or fenestration.[9]

Southard et al. explain the differentiating factor between dental and skeletal crossbites. Decompensating the molar inclinations would give us a positive outcome (resolved crossbite) in case of a dental crossbite and a negative outcome (worsened crossbite) in case of a skeletal crossbite.[32]

Further studies are recommended considering both sagittal and vertical characteristics involving different malocclusions, may provide a discussion regarding what can be done for normo-, hyper-, and hypodivergent Class I, Class II, and Class III subjects. This biologic variation suggests the need for proper assessment of the positioning of the teeth within the alveolar bone for optimum function and treatment stability.Determining the appropriate buccolingual inclination for different populations can help us in formulating treatment plans that are more soundly supported by evidence rather than a qualitative assessment alone.

CONCLUSION

According to the methodology of this study, the following conclusions can be made:

- The maxillary first molars of subjects with a vertical growth pattern had a significantly greater buccal inclination compared with those of subjects with a horizontal growth pattern.
- The subjects with a vertical growth pattern had a significantly greater palatal depth compared with those of subjects with a horizontal growth pattern.
- There were no statistically significant differences in transverse arch widths among horizontal growth pattern and vertical growth pattern.

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