ORIGINAL ARTICLE

CORRELATION BETWEEN FACIOLINGUAL INCLINATION OF MAXILLARY CENTRAL INCISORS AND MOLARS WITH MAXILLARY AND MANDIBULAR MORPHOLOGY

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Background: The torque of maxillary incisors and molars forms an important component of smile esthetics. The inclination of these teeth may be affected by maxillary and mandibular dimensions. The study aimed to evaluate the correlation between the faciolingual inclinations of maxillary incisors and first molars with palatal width (PW), palatal depth (PD), maxillomandibular angle (MMA) and mandibular width (MW) using cone beam computed tomography scans. **Methods:** A retrospective analysis of cone-beam computed tomography (CBCT) images of 66 adult subjects (males-37; females-29) was performed. The Planmeca Romexis viewer 6.2.1 software was utilized to determine the faciolingual inclination of the maxillary central incisor (UIPP) and first molars (right-MMR; left-MML). The correlation of UIPP, MMR and MML with age, PW, PD, MW and MMA was determined using Pearson's correlation. **Results:** The mean age of the sample was 32.8±11.4 years. The UIPP showed a mild negative correlation with age (r=-0.430; p<0.001). Only the PW showed a mild significant correlation with MMR (r=-0.287; p=0.019) and MML (r=-0.343; p=0.005). All the other maxillomandibular parameters had insignificant (p>0.05) correlations with the inclinations of maxillary incisors and molars. **Conclusion:** The current study concludes that the PW had a significant inverse correlation with bilateral maxillary molar inclinations. Other parameters such as MMA, MW and PD had no statistically significant correlation with incisors and molars inclinations.

Keywords: Cone-beam computed tomography; Correlations; Aesthetics

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INTRODUCTION

The facial proportions and smile form an important component of facial esthetics.[1] Both micro and mini-aesthetics should be taken into consideration during treatment planning as they are essential for an ideal smile. The faciolingual inclinations of the maxillary anterior and posterior teeth may affect the smile esthetics.[2] For example, maxillary incisors with increased palatal root torque may result in excessive jetting out teeth, affecting the lip form.[3] Whereas, up righted maxillary molars with an exaggerated buccal root torque may result in a smile with very wide buccal corridors leading to an aged appearance due to unsupported muscles of the cheeks and lips.[4] Moreover, appropriate maxillary molar inclination is also essential for adequate bite function and dental arch stability.[5]

The transverse, vertical and sagittal patterns may affect the maxillary teeth inclinations. One study reports that the vertical facial pattern has a significant impact on maxillary and mandibular incisors inclination with incisors being significantly proclined in hyperdivergent patients as compared to hypodivergent patients.[6] However, these studies rely on the overall vertical facial dimensions with a little emphasis on maxillary and mandibular morphology. Some studies[7-9] have reported that individuals with increased vertical growth pattern tend to have reduced transverse dimension of maxilla that ultimately results in increased buccal inclination of maxillary posterior teeth. On the contrary, brachyfacial individuals tend to have broad maxillary arches that are associated with more upright maxillary posterior teeth.[7-9] Furthermore, reduced transverse dimensions of the maxilla may result in crowded and tipped anterior teeth.[10]

Previous studies[11-13] relied on lateral cephalogram and orthopantomogram (OPG) to assess the skeletal morphology of craniofacial structures. However, features like palatal depth and width cannot be accurately determined by using these modalities.[14] Transverse discrepancy can also be determined by using plaster models (Korkhaus palatal index), but they also have their limitations.[15] The advent of cone-beam computed tomography (CBCT) and with increase in understanding of its proper use has allowed clinicians to utilize it to overcome the limitations of two dimensional (2D) radiographs.[16,17]

Altered maxillary morphology due to genetic and environmental causes may potentially affect the faciolingual inclinations of maxillary teeth.[18] Secondly, the effect of mandibular transverse dimensions on the faciolingual inclinations of maxillary teeth has not been explored previously. A survey of the pertinent literature shows inconclusive data on the relationship between palatal vault depth and mandibular width relationship with maxillary teeth inclination. To our knowledge, the relationship of labiopalatal inclination of central incisors with divergence of face is yet to be determined using CBCT.

Therefore, this study aimed to determine the correlation between faciolingual inclinations of upper first molars and central incisors with maxillary and mandibular morphology (palatal width and depth, mandibular width and maxillomandibular plane angle) using CBCT. The better understanding of this relationship may result in incorporation of strategies and biomechanics for adequately positioning maxillary incisors and molars in relation to the maxillary and mandibular morphology to achieve an ideal smile and optimum function.

MATERIAL AND METHODS

A cross-sectional study was conducted using the CBCT scans of orthodontic patients presenting at the department of orthodontics, in our institute. The duration of the study was 6 months, starting from September 2022 to February 2023. The sample size was calculated by using the findings of Vasquez *et al*[19] who reported the Pearson correlation between maxillary molar inclination and palatal width to be 0.335. The α and power were set at 0.5 and 80%, respectively to calculate the sample size. This showed that we required at least 66 subjects. Ethical approval was taken from the institutional research board (ERC No.xx) prior to conduct of the study.

The CBCT images of 66 subjects (male-37; females-29) were selected using simple random sampling technique (using a computer-generated table of random numbers) from a database of 1000 patients following our inclusion criteria i.e. patient aged 16 to 60 years with all permanent dentition except third molars. Patients with palatal cleft or craniofacial deformity, growth disturbances affecting growth of maxilla and mandible, traumatic injuries to craniofacial structures or with history of orthodontic treatment were excluded from the study.

All CBCT scans were obtained from the Carestream CS 9600 machine with 120 kVp, 3.5 mA current, field of view (FOV) 16x12 cm and 75 µm voxel size. The exposure and scan time were set at 3.6s, and 18 seconds, respectively with minimal layer thickness of 0.3 mm. The patients were instructed to stand upright keeping the Frankfort plane paralleled to the floor and occlude teeth in intercuspal position during scanning. A line passing from the buccal cusps of the maxillary first molars was used for orientation in the axial and coronal planes.[19] The obtained graphics were uploaded in the Planmeca Romexis viewer 6.2.1 software. All the uploaded images were analyzed by a trained researcher under the supervision of a dental radiologist.

Each image was standardized and oriented such that the functional occlusal plane was parallel to the floor. The obtained images from CBCT scans were evaluated systematically and the required parameters were assessed. The labiolingual inclinations of both upper central incisors to palatal plane (UIPP) were recorded as the angle between line joining anterior nasal spine (ANS) and posterior nasal spine (PNS) with line along long axis of maxillary central incisors (Figure-1). The mean UIPP angle of left and right side was used for statistical analyses. The bucco-palatal inclination of upper molars was assessed separately (right – MMR; left- MML) as the line joining jugale points and maxillary first molar palatal root axis (Figure-2). The palatal depth (PD) was taken as the distance from the line connecting mesiopalatal cusps of right and left first maxillary molars and midpalatal raphe (Figure-3). The palatal width (PW) was measured at the line joining the right and left jugale points (JR and JL) i.e., interjugale distance JR-JL (Figure-4) The mandibular width (MW) was taken as distance from ante-gonial notch from right to left (Figure-5). The vertical growth pattern in terms of maxillomandibular plane angle (MMA) was taken on virtual lateral cephalogram image as angle between maxillary and mandibular planes (Figure-6).

The data was analyzed in SPSS. The means were calculated for quantitative variables i.e., age, UIPP, MMR, MML, PW, PD, MW and MMA. The normality of the quantitative measurements was assessed using Shapiro-Wilk test that showed a normal distribution of our data. Since, gender is an effect modifier, the means of these variables were compared between males and females using independent sample t-test. Correlations among these quantitative variables were determined using Pearson's correlation. A *p* value$\leq$0.05 was taken as statistically significant.

RESULTS

The mean age of the sample was 32.8±11.4 years. Among the 66 subjects included in the study, 37(56%) were males and 29(44%) were females. The comparison of variables between genders is shown in Table-I. Only the PW showed mild significant difference (*p*<0.001) between males and females, hence the results were not segregated for gender.

The correlation of UIPP, MMR and MML with PW, PD, MW, MMA and patients' age are shown in Table-II. The results showed a mild negative correlation between UIPP and patient's age (r=-0.430; *p*<0.05). The PW had a mild negative correlation with MMR (r=-0.287; *p*=0.019) and MML (r=-0.343; *p*=0.005). The MMR and MML also showed a mild inverse correlation with PW (r = -0.287, -0.343; *p*<0.05)

Table-1: The comparison of means between males and females

Variable	Males n= 37 Mean ± SD	Females n = 29 Mean ± SD	*p*-value
1. Age (years)	33.45±12.45	32.13±10.17	0.645
2. UIPP (°)	111.84±8.63	113.36±9.33	0.494
3. MMR (°)	103.97±4.70	104.04±5.66	0.957
4. MML (°)	103.49±4.52	103.43±5.02	0.958
5. PW (mm)	64.30±4.50	62.77±4.64	0.182
6. PD (mm)	23.19±2.36	21.82±2.30	**0.021***
7. MW (mm)	75.90±2.72	75.27±2.59	0.344
8. MMA (°)	24.72±6.91	23.61 ± 6.33	0.506

UIPP-Upper incisor palatal plane angle; MMR-Right Maxillary molar angle; MML-Left Maxillary molar angle; PW-Palatal Width; PD-Palatal depth; MW-Mandibular width; MMA-Maxillomandibular angle; SD – Standard Deviation; N = 66; Independent sample *t*-test; * *p*-value <0.05

Table-II: The correlation of UIPP, MMR and MML with maxillary and mandibular parameters

	Age		Palatal Width (PW)		Palatal Depth (PW)		Mandibular Width (MW)		Maxillo-mandibular angle (MMA)	
	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
UIPP	**-0.430**	**0.00****	- 0.195	0.117	- 0.190	0.126	-0.050	0.691	- 0.113	0.365
MMR	0.141	0.260	**-0.287**	**0.019***	- 0.035	0.782	0.061	0.625	- 0.060	0.630
MML	0.118	0.345	**- 0.343**	**0.005****	- 0.006	0.960	0.012	0.414	- 0.017	0.893

UIPP-Upper incisor palatal plane angle; MMR-Right Maxillary molar angle; MML-Left Maxillary molar angle; N = 66; r = correlation; Pearson's correlation; *p*-value = significance * *p*-value<0.05 ** *p*-value<0.01

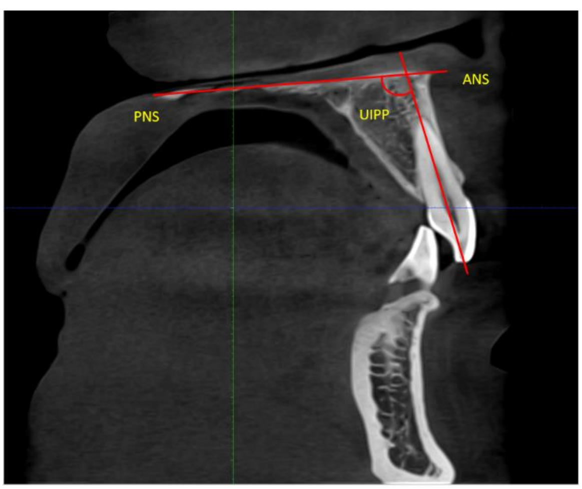

Figure-1: Upper Incisor Palatal Plane angle (UIPP)
UIPP= Upper Incisor Palatal Plane Angle (Angle between line joining ANS and PNS with line along the long axis maxillary central incisor). **ANS**= Anterior Nasal Spine. **PNS**= Posterior Nasal Spine

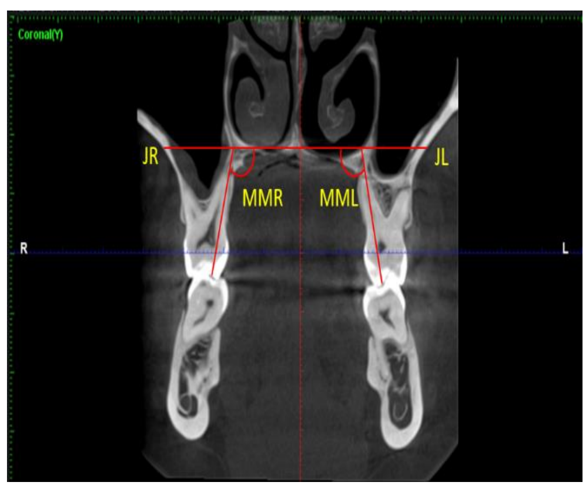

Figure-2: Bucco-palatal inclination of upper molars (MMR, MML)
MMR= Right First Maxillary Molar. **MML**= Left First Maxillary Molar. **JR**= Jugale Right. **JL**= Jugale Left
Jugale= The point at which lines following the margin of the frontal and temporal processes of the zygomatic bone are joined

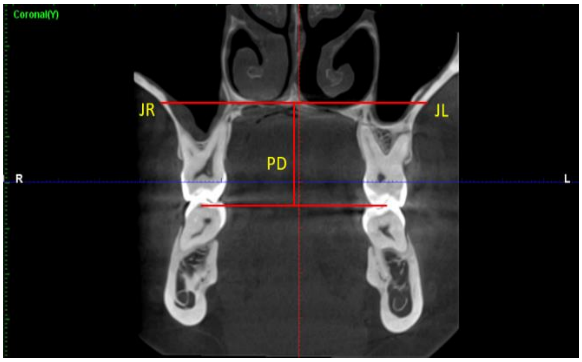

Figure-3: Palatal depth (PD)
PD= Palatal depth (Line connecting mesio-buccal cusps of right and left first maxillary molars and mid-palatal raphe)
JR= Jugale Right. **JL**= Jugale Left. **Jugale**= The point at which lines following the margin of the frontal and temporal processes of the zygomatic bone are joined

Figure-4: Palatal Width (PW)
PW= Palatal Width (Line joining jugale points (J) i.e., inter-jugale distance JR-JL). **JR**= Jugale Right. **JL**= Jugale Left. **Jugale**= The point at which lines following the margin of the frontal and temporal processes of the zygomatic bone are joined

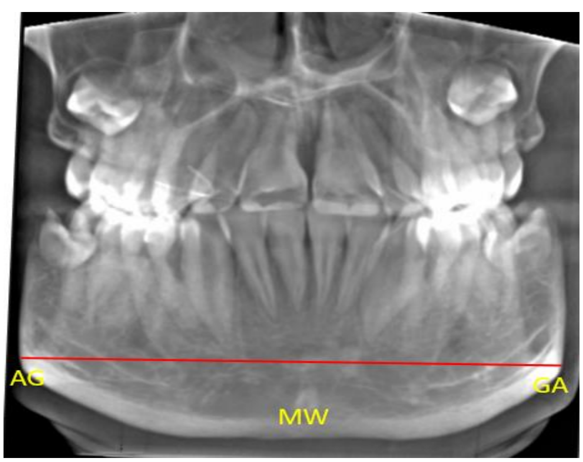

Figure-5: Mandibular Width (MW)
MW= Mandibular Width. **AG**= Right Antegonial Notch. **GA**= Left Antegonial Notch. **Antegonial notch**= Depression present on the lower margin of the mandibular body, at the junction between the ramus and the body of the mandible, immediately anterior to its angle

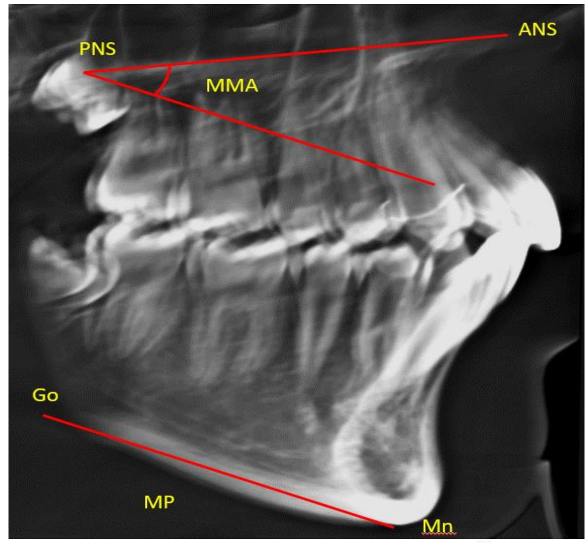

Figure-6: Maxillomandibular plane angle (MMA)
MMA= Maxillomandibular plane angle (angle formed between maxillary plane and the mandibular plane). **ANS**= Anterior Nasal Spine. **PNS**= Posterior Nasal Spine. **MP**= Mandibular Plane. **Mn**= Menton (Most inferior point of outline of mandible). **Go**= Gonion (The most posterior inferior point on the angle of the mandible)

DISCUSSION

The inclination of maxillary anterior and posterior teeth forms an important component of smile aesthetics. These inclinations may also be affected by the palatal morphology and mandibular widths.[20] Moreover, PD and MW may also affect the maxillary molar inclination to achieve a functional occlusion.[21] Masumoto *et al*[22] has reported increased lingual inclination of mandibular molars in short face subjects regardless of the variations in MW. To validate the results of previous studies[7-9] conducted on 2D imaging technologies and to explore the relationship between maxillary anterior teeth inclination and PD, PW and MW the current study was planned using CBCT. The CBCT gives us the opportunity to create views that are generally employed in clinical settings (e.g. panoramic, cephalometric, or bilateral multiplanar projections) having greater implications in diagnosis and treatment-planning.[23] In addition, CBCT offers a 3D view of a tooth which was not possible previously using dental casts or panoramic radiographs.[19,23]

In the current study, we a found a mild significant correlation between maxillary incisor inclination and the age of the patient. This in concordance with the normal physiologic age changes as reported by Bjork *et al*[24] that maxillary incisors tend to become more retroclined with age.

The other variables i.e., PW, PD and MW and MMA though non-significant also showed an inverse trend with the incisor's inclination. A logical explanation may be that a wider maxilla may result in reduced arch length leading to more retroclined incisors to maintain a normal overjet with the mandibular incisors. Increased PD is usually associated with a long face and open bite. Hence, deeper palates may be related to retroclined incisors to achieve an adequate overbite. Sharma et al[25] have reported increased labial inclination of incisors in long-face subjects. The variation in results may be due to the inclusion of a specific sect of population and the utilization of a two-dimensional imaging technique.

The maxillary molar inclination showed a mild significant inverse correlation with the PW. Hence a narrower palate may be associated with more buccally inclined molars and vice versa to compensate and form a functioning occlusion with the mandibular molars. This finding is coherent with previous studies. [26,27] The PD, MW and MMA did not show any significant correlation with the maxillary molar inclination.

The findings of this study show the maxillary incisors tend to be more retroclined in individuals with older age, wider and deeper palates, increased mandibular width and long faces. The maxillary molars were found to be more lingually inclined with increased palatal width and depth, wider mandible and short-face subjects. Hence clinicians need to be vigilant when planning biomechanics for subjects undergoing palatal expansion. This may result in achieving adequate results with appropriate torque of anterior and posterior achieving adequate smile esthetics and occlusal stability. In this study, the use of a reliable measurement tool i.e. CBCT, has ensured that the data collected is reproducible and has no magnification error. The Planmeca Romexis viewer 6.2.1 software allowed us to precisely measure the linear and angular measurements up to a 100th of a millimetre and degree, respectively. A small sample size of all patients in the permanent dentition stage is a limitation of this study.

CONCLUSION

The maxillary incisor inclinations showed a mild inverse correlation with the age of the patient. The maxillary molars showed a significant negative correlation with PW. Thus, practitioners could be advised to use palatal width as a determinant for the type of expansion required whether bodily or tipping and can aid in the diagnosis and treatment planning of cases with transverse discrepancies. Future studies should incorporate a large sample size and explore the correlation between PW, PD and MMA with the inclinations of maxillary premolars and mandibular dentition.

AUTHOR'S CONTRIBUTION

AMC: Literature search, Data collection, Write-up. WJ: Conceptualization of study design, Data interpretation, Proofreading. MA: Data analysis, Data interpretation, Proofreading. MA: Data interpretation, Proofreading.

Conflict of Interest: All authors declare that they have no conflict of interest.

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