

Determining norms of antero-posterior relationship of maxillary central incisors to the forehead among Malay, Chinese and Indian females in Malaysia

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Abstract

Introduction: The aim of the study was to establish norms of antero-posterior relationship of maxillary central incisors to forehead for different ethnic groups in a sample of female students in Malaysia. **Materials and methods:** Seventy-eight smile profile photographs of female students grouped under three ethnicities (Malay, Chinese and Indian), age range of 18- 26 years, were analyzed. The antero-posterior (AP) relationship of the maxillary central incisors to the forehead was measured and norms were established for the different groups. The mean values of the measurements were compared with the control group and among the different groups. **Results:** The AP position of the maxillary central incisor in relation to glabella vertical (GVL) was smaller than the range value of study groups in all ethnicities. There was no difference in the forehead inclination between the ethnicities. Only Chinese ethnicity showed significant difference of forehead inclination and AP relationship in its control group. However, only study groups in both Malay and Indian ethnicities show significant difference in forehead inclination and AP relationship. In the Chinese ethnicity, the AP position of maxillary central incisors was significantly associated with forehead inclination. **Conclusion:** This study may be useful in providing racially specific norms for diagnosis and treatment planning in orthodontics in Malaysian adult females.

Keywords: Forehead, Orthodontics, Maxilla, Tooth, Incisor, Aesthetics, Facial appearance

Introduction

Orthodontic treatment has become a popular trend worldwide. This might be due to one's emphasis on improvement of aesthetics which is influenced through mass media¹. As beautiful teeth and smile always make a perfect first

impression, one tends to perceive the individual as more attractive, charismatic, and educated²⁻³. Thus, it plays a significant role in motivating the public to have a more attractive smile to boost their confidence level.

Due to increase in facial aesthetics demands, extensive research in this field has led to

advancement in orthodontic planning and diagnosis⁴. Fundamental part of a complete orthodontic diagnosis is evaluating face profile⁵. In older days, orthodontists usually focused only on static profile assessment, but nowadays, dynamic smile evaluations are of utmost importance⁶.

Hard and soft tissue cephalometric analyses and Andrew's six elements of facial harmony have been widely used to assess facial harmony. However, uses of internal osseous landmarks can be unreliable because of both errors in identification and variability in their positions between individuals⁵. Due to its limitations, external soft tissue landmarks such as the nose, lips and chin are used to replace the traditional methods⁵. Furthermore, the soft tissue profile is influenced by the antero-posterior (AP) position of maxillary incisors which can be utilized by orthodontists to give the best treatment for their patients since they influence overall facial harmony, not only in frontal view but as well as profile view. This method can function as an adjunct to conventional cephalometry as well as an effective tool in diagnosis and treatment planning, thereby aiding in creating harmonious balanced profiles.

Despite the global interest in orthodontic treatment and the recognized importance of evaluating soft tissue profiles, to date, no study in Malaysia has specifically examined the relationship between maxillary incisor position and facial harmony using soft tissue analysis. This highlights a clear gap in localized evidence and underscores the need for research in the Malaysian population to inform region-specific orthodontic diagnosis and treatment planning.

The primary objective of the study was to determine the normative antero-posterior position of maxillary central incisors relative to the glabella vertical line among Malay, Chinese, and Indian female students in Malaysia. Additionally, we also aimed to evaluate the forehead inclination among the three ethnic groups, assess the correlation between forehead

inclination and AP position of maxillary central incisors and compare differences between control (balanced profile) and study (non-balanced profile) groups within each ethnicity

Methodology

In this cross-sectional study, smile profile photographs were obtained from university students. Consent was obtained and the confidentiality of the participants was maintained throughout the study. The study was approved by the institutional ethics committee. Participants were included if they met all the following criteria: Female students aged between 18 and 26 years, presence of full permanent dentition excluding third molars, no previous history of orthodontic treatment, no systemic diseases affecting craniofacial growth, no major dentofacial deformities, no dental prosthesis. A total of 72 subjects were selected, 24 Malay, 24 Chinese, 24 Indian.

Smile profile photographs were evaluated by an orthodontic panel. Subjects demonstrating optimum facial balance, pleasing profile, competent lips, and harmonious soft tissue features were categorized as control group and those not fulfilling the above aesthetic criteria as study groups. Each ethnicity was further subdivided into control and study groups based on this evaluation.

Smile profile photographs were taken with forehead and maxillary incisors in full view and have been categorized into two groups, i.e., control group (Criteria: Optimum facial balance showing a pleasing profile with competent lips and normal soft tissue features of face⁷) and study group (Criteria not met to be in the control group) by an orthodontic panel.

Three vertical reference lines were constructed; line 1: through the Forehead Facial Axis (FFA) point, line 2: through glabella (GVL) – Glabellar Vertical Line, line 3: through the maxillary central incisors Facial Axis (FA) point and line 4: for assessing forehead inclination was constructed by connecting glabella to the

uppermost point of the clinical forehead (superion point or trichion).

Images were imported into PowerPoint (Microsoft PowerPoint version 2016), resized to approximate life size and estimated to upright head position. The AP relationship of the maxillary central incisors to the forehead was measured as the distance between line 2 and line 3 using a metric ruler to the closest 0.5 mm.

All recorded data were tabulated and statistically analyzed. Descriptive Statistics was performed using Epi Info (mean, standard deviation, range for maxillary central incisor position relative to forehead and for forehead inclination in both samples). Inferential Statistics was done using unpaired t-test and correlation coefficient. Linear regression was plotted to create regression equations. The level of statistical significance was set at $\alpha = 0.05$. A p-value less than 0.05 ($p < 0.05$) was considered statistically significant.

Results

Descriptive statistics show majority of our sample size consists of students in the range of 21-23 years old with the percentage of 43.59% followed by 41.03% between 24-26 years old and the remaining samples lie between 18-20 years old. For ethnicity, Indian has larger sample size than Malay and Chinese which is 30 (Table 1).

Table 1. Socio Demographic profile of participants

Characteristics	n (%)
Age	12 (15.38)
18-20	34 (43.59)
21-23	32 (41.03)
24-26	
Ethnicity	
Malay	24 (30.77)
Chinese	24 (30.77)
Indian	30 (38.46)

Table 2 shows the AP position of the maxillary central incisor in relation to glabella vertical (GVL) for the control and study group of each ethnicity. The mean value in control group for Malay ethnicity is -2.13 ± 4.57 while -0.13 ± 7.91 in study group. For Chinese ethnicity, the mean

value for control group is -3.0 ± 3.51 respectively, whereas the mean for study group is -0.67 ± 7.34 . It has been found that Indian ethnicity has mean value of -2.45 ± 3.22 in control group with 1.23 ± 5.69 for study group. For the control sample, the AP position of the maxillary central incisor in relation to glabella vertical (GVL) ranged from -2.13 to -3.0 mm which is smaller than the range value of study group in all ethnicities.

Table 2. Anteroposterior (AP) relationship of maxillary central incisors to glabella vertical (GVL) among Malay, Chinese and Indian female students

Ethnicity	Group	n	Mean (SD)
Malay	Control	8	-2.13 (4.57)
	Study	16	-0.13 (7.91)
Chinese	Control	12	-3.0 (3.51)
	Study	12	-0.67 (7.34)
Indian	Control	13	-2.45 (3.22)
	Study	17	1.23 (5.69)

Table 3. Forehead inclination of Malay, Chinese and Indian female students

Ethnicity	Group	n	Mean (SD)
Malay	Control	8	13.31 (6.00)
	Study	16	17.09 (6.00)
Chinese	Control	12	13.79 (6.15)
	Study	12	13.67 (6.20)
Indian	Control	13	14.65 (5.21)
	Study	17	17.38 (5.70)

Table 3 describes the forehead inclination of Malay, Chinese, and Indian female of for the control and study group of each ethnicity. The mean value in control group for Malay ethnicity is 13.31 ± 6.00 while 17.09 ± 6.00 in study group. For Chinese ethnicity, the mean value for control group is 13.79 ± 6.15 respectively, whereas the mean for study group is 13.67 ± 6.2 . In addition, Indian ethnicity shows the mean value of 14.65 ± 5.21 in control group with 17.38 ± 5.70 for study group. For the study group, the forehead inclination of all ethnicities ranged from 13.67 to 17.38 which shows enormous difference compared to that in control group.

Table 4 shows that the maxillary central incisor position relative to GVL in Malay and Chinese ethnicities was not significantly different between control and study groups ($p = 0.518$ and $p = 0.332$, respectively; $p > 0.05$). However, a statistically significant difference was observed in the Indian ethnicity ($p = 0.046$; $p < 0.05$). Forehead inclination was not significantly different between control and study groups in all ethnicities ($p > 0.05$)

Figures 1,2 and 3 depict the distribution of the anteroposterior maxillary central incisor position relative to the forehead for control and study group in the three ethnic groups, respectively.

Figure 1. Distribution of the anteroposterior maxillary central incisor position relative to the forehead for control and study group in Malay ethnicity.

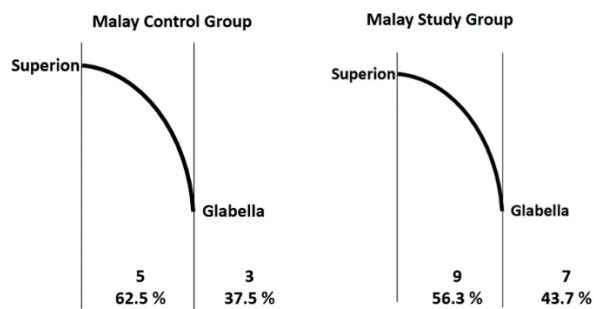


Figure 2. Distribution of the anteroposterior maxillary central incisor position relative to the forehead for control and study group in Chinese ethnicity.

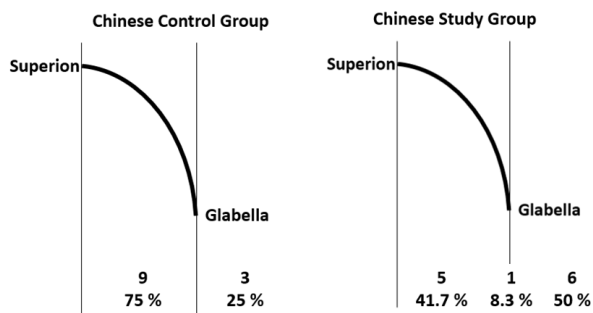


Figure 3. Distribution of the anteroposterior maxillary central incisor position relative to the forehead for control and study group in Indian ethnicity

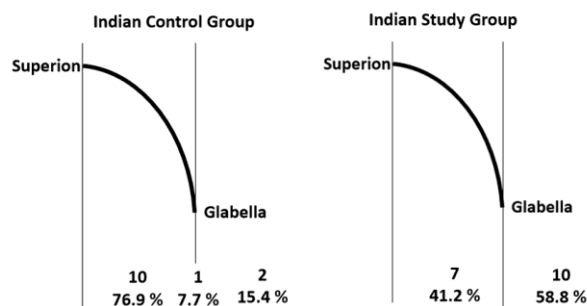


Table 5 displays correlation between AP relationship of maxillary central incisors to the forehead among Malay, Chinese, and Indian female students. Only Chinese ethnicity shows significant difference of forehead inclination and AP relationship in its control group with ($P=0.029$). However, only study groups in both Malay and Indian ethnicities show significant difference in forehead inclination and AP relationship with ($P=0.005$) and ($P=0.027$) respectively.

Table 5. Correlation between AP relationship of maxillary central incisors to the forehead among Malay, Chinese and Indian female students

Ethnicity	R value	P- value
Malay	0.37	0.359
Control	0.67	0.005
Study		
Chinese	0.62	0.029
Control	0.57	0.056
Study		
Indian	0.17	0.558
Control	0.54	0.027
Study		

Correlation coefficient. $P < 0.05$ is significant

In the control group of Chinese ethnicities, the AP position of maxillary central incisors was significantly associated with forehead inclination ($P=0.029$). In relation to GVL, the AP position of upper central incisors could be determined by multiplying the forehead inclination by 0.357 and adding -7.921 mm. Thus, it indicates in every one-degree increase of forehead inclination, there

will be increase of 0.357 mm in AP position of maxillary central incisors. However, the association between AP position of maxillary

central incisors and the inclination of the forehead were not significant in both control groups of Malay and Indian ethnicities (Table 6)

Table 4. Differences in maxillary central incisor position (mm) and forehead inclination (°) between control group and study group among Malay, Chinese and Indian female students

Ethnicity	Variable	Control group (SD)	Study group (SD)	Difference	P-value
Malay	Forehead inclination	13.31 (6.00)	17.09 (6.00)	-3.78 (-9.17, 1.61)	0.160
	AP position	-2.13 (4.57)	-0.13 (7.91)	-2.00 (-8.31, 4.31)	0.518
Chinese	Forehead inclination	13.79 (6.15)	13.67 (6.20)	0.13 (-5.10, 5.35)	0.961
	AP position	-3.0 (3.51)	-0.67 (7.34)	-2.33 (-7.21, 2.54)	0.332
Indian	Forehead inclination	14.65 (5.21)	17.38 (5.70)	-2.73 (-6.88, 1.42)	0.189
	AP position	-2.45 (3.22)	1.23 (5.69)	-3.68 (-7.30, -0.07)	0.046

Unpaired t-test. $P < 0.05$ is significant

Table 6. Regression equation for calculating the AP position of maxillary central incisor using forehead inclination

Ethnicity	Slope (b)	P value	Y = a + bx
Malay			
Control	0.286	0.359	AP= 5.932 + (-0.286) FI
Study	0.879	0.005	AP= 15.146 + (-0.879) FI
Chinese			
Control	0.357	0.029	AP= -7.921 + (0.357) FI
Study	0.669	0.056	AP= -9.807 + (0.669) FI
Indian			
Control	0.111	0.558	AP= -4.068 + (0.111) FI
Study	0.534	0.027	AP= -8.044 + (0.534) FI

AP = anteroposterior position; FI = forehead inclination; b = regression coefficient (slope) of FI in the linear regression model; p-values represent the significance of the regression coefficient within each group

Discussion

Facial aesthetics has become the main concern in orthodontic treatment besides a harmonious occlusion which helps to align the teeth to prevent loss of bone structure⁴. This leads to our study's aim which was to find an esthetically acceptable AP relationship of maxillary central incisors with the forehead among Malaysian population, thereby providing guidelines for orthodontic treatment planning. Instead of using conventional cephalometric analysis, this study utilized method proposed by Andrews for assessing the optimal AP position of the upper central incisors in relation to the forehead⁶. According to N. Ghaleb et al., cephalometric standards should only be a general guide and a complement to visual aesthetic appreciation and

not the main goal of orthodontists, which is also agreed with the results of Schabel et al².

Anteroposterior relationship of maxillary central incisor to glabella vertical (GVL)

This study showed the mean value for control group in Malay ethnicity is -2.13mm with 62.5% indicates the central incisor is positioned 2.13 mm behind the glabella vertical. Similarly, the same negative values were seen in both control groups of Chinese and Indian ethnicities with 75% and 76.9%, respectively. The results shown in Andrews' study coincide with this study where 97% of the AP position of maxillary central incisors of Caucasian females in control sample were behind the glabella. In addition, Amit Jaikumar and V. Abrol reported the same result as

95% and 88% of control sample in Indian population had their AP position of maxillary central incisors posterior to the glabella. This may be attributed to the fact that the most aesthetic position of upper central incisors is located between FFA and glabella which is behind the glabella vertical^{10,11}.

In contrast, a study done by Matthew P. Gidaly (2018) showed that all the optimally positioned maxillary incisors in African American females were anterior to glabella vertical while study investigated by Cho S.W. et al. also showed that 60% of control group in Korean ethnicity displayed the AP position of maxillary central incisors were anterior to glabella vertical as well^{6,8}. These variations may be due to different ethnic group that has various set of cephalometric measurements^{8,9}.

Both study groups in Chinese and Indian ethnicities showed the AP position of maxillary central incisors anterior to glabella with 50% and 58.8% respectively in this study. These results were validated by another study showing that, both the ethnicities have higher tendency to have a more forwardly positioned maxilla and mandible investigated by Kathiravan et al. in Malaysia¹². These characteristics were usually seen with protrusive lips and exaggerated position of nose and chin that make it more dominant. the same position for study group which is 72% among Korean ethnicities. However, contradictory results have been found in studies done by Andrews, V. Abrol et al. and Jaikumar et al. displaying 85%, 72% and 88% of AP position of maxillary central incisors posterior to glabella respectively. Although study groups in both ethnicities showed same position of central incisor, only Indian ethnicity displayed significant difference in association of the forehead inclination and the AP position of maxillary central incisor.

On the other hand, the AP position of maxillary central incisors to the forehead in study group of Malay ethnicity were placed posterior to the glabella with 56.3%. This favored the results of

Andrews, V. Abrol et al. and Jaikumar et al. while contradict with Cho S.W. et al. like Indian ethnicity, the result portrayed statistically significant in association of the two variables. These variations may be due to different ethnic groups that have various sets of cephalometric measurements^{8,9}.

Forehead inclination

Forehead inclination of control group in Malay, Chinese and Indian ethnicities showed a value of 13.31°, 13.79° and 14.65°, respectively. This study is supported by Andrews et al. and Ajmera et al. showing forehead inclination of 13.7° and 12.69°, respectively. The similar mean reported by Zou et al. with 13.63°. This is because forehead is a stable landmark and not associated with changes throughout life⁶. However, study done in African American population displayed a mean of 26.7° forehead inclination which showed higher angle than this study. Forehead shape which varies from individual to individual especially in different sex and ethnic background might be the ultimate reason for the result⁶.

Association between AP of maxillary central incisors to the forehead

This study showed moderate correlation between AP relationship of maxillary central incisors to the forehead in all groups except Malay and Indian control groups. This study partially supported by Andrews et al showing high correlation for control group, but it was poorly correlated for the study group. On the other hand, poor correlation in both control and study group were seen in study done by Abrol et al in Indian population. This correlation might be attributed to the reason that forehead is said to be a stable landmark as its relationship with the incisors is predictable and repeatable.

As the sample size of this study is considerably small to derive a norm, it has become the greatest limitation. Thus, it affected this study statistically as some of the data are not significant and considerations should be made in the generalization of results⁹. Therefore, a larger

sample size of future studies should be done to get a more accurate result and to be able to derive norms in Malaysian populations which consists of different ethnicities.

The results of this study provide ethnicity-specific normative values for Malaysian females; Support the use of forehead-based soft tissue analysis as an adjunct to cephalometry; Help clinicians determine ideal incisor positioning during orthodontic camouflage or extraction planning; Offers guidance for treatment planning in borderline extraction cases; Improves aesthetic predictability in profile-focused orthodontic treatment.

Conclusion

All control groups showed AP position posterior to glabella with a mean of -2.45 mm. All control groups demonstrated forehead inclination with a mean of 13.92° . Moderate correlation was observed between AP incisor position and forehead inclination in most groups. These findings provide preliminary ethnicity-specific soft tissue norms for Malaysian female populations. Larger multi-centre studies are recommended to establish definitive national standards.

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