

Original Research Article

A comparative evaluation of the anteroposterior position of maxillary central incisors in adult females of Gujarati Origin: A photographic study

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Abstract

Introduction: This study investigates the anteroposterior (AP) positioning of maxillary central incisors in Gujarati females, emphasizing the role of soft tissue in orthodontic treatment outcomes. While the goal of orthodontic treatment is to achieve structural balance and functional efficiency, patient satisfaction often hinges on esthetic harmony.

Materials and Methods: A cross-sectional study was conducted with 100 adult females exhibiting aesthetically pleasing profiles. Posed smile photographs were taken to capture key facial landmarks, including Trichion, Glabella, Superion, and the Facial Axis (FA) point. Measurements were recorded for the distances from the FA point to the Goal Anterior Limit Line (GALL), Forehead Anterior Limit Line (FALL), and Glabellar Vertical Line (GVL). Statistical analysis was performed to assess the significance of these distances.

Results: The mean distances measured were 7.6 ± 13.3 mm for GALL, 6.7 ± 3.5 mm for FALL, and 8.2 ± 3 mm for GVL, with an average forehead inclination of 9 ± 3 degrees. GALL and FALL were found to be clinically significant (p -value = 0.000), while GVL was less significant (p -value = 0.243).

Conclusion: GALL and FALL are more clinically relevant landmarks for assessing the AP position of maxillary central incisors in Gujarati females, underscoring the forehead's importance in evaluating facial aesthetics.

Keywords: Anteroposterior position, Maxillary central incisors, Forehead landmarks.

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1. Introduction

A successful orthodontic treatment outcome is perceived differently by the patient and the orthodontist. The goal of orthodontic treatment is primarily to achieve structural balance, functional efficiency, and esthetic harmony but, to the patient, esthetic outcome is the most appreciated. The shift to soft tissue paradigm has changed the perspective of the orthodontist. The treatment approach has evolved from being dentition-oriented to profile-oriented. With increasing awareness and preceding current trends, more adults especially females are inclined towards orthodontic treatment for achieving a pleasing smile. Geron et al. have also demonstrated that females are more concerned about their smile aesthetics as compared to males.^{1,2}

Evaluating the facial profile is a crucial element of a comprehensive orthodontic diagnosis. Research on facial aesthetics within orthodontic literature has primarily focused on the profile view of the face, particularly on the profile outline derived from photographs or cephalometric radiographs. With advancements in orthodontic and surgical techniques, there has been a shift towards prioritizing the ideal positioning of the upper incisors as the foundation for treatment planning.³ This allows for the development of treatment strategies that aim to position the incisors optimally, subsequently aligning the other teeth around this ideal position.⁴

Andrews' six keys⁵ of occlusion served as the foundation for orthodontic treatment planning from 1972 until 1991, when he changed his strategy to the six elements of orofacial harmony, which included lateral cephalograms and soft

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tissues.⁶ In order to improve facial harmony, Andrews used the forehead as a stable marker in element II to assess the maxillary incisors' anteroposterior location.^{7,8} This notion states that the goal anterior-limit line (GALL) and the FA point (which is the clinical midpoint facial axis of the clinical crown of the upper incisor and splits it into an occlusal half and gingival half), correspond to represent the optimal position of the maxilla. The glabellar vertical line (GVL)⁹ and the forehead's anterior-limit line (FALL) are the points where the GALL, (a line parallel to the frontal plane of the head), crosses.

The frontal plane of the head is parallel to both the GVL and the FALL. The facial axis (FFA) point on the forehead is where the FALL passes through, and the GVL crosses the glabella. The FFA point is clinically determined according to the type of forehead: if the forehead is angular and round, it is located between the Superior (a point near the Trichion at the prominent upper region of the forehead) and the Glabella. If the forehead is straight, it is located between the Trichion and the Glabella.

As proposed by Sarver and Ackerman, to effectively address a patient's smile, orthodontists need to assess and quantify it in both static and dynamic conditions. They noted that while rigid rules for facial aesthetics are difficult to establish, general guidelines can be developed. They emphasized that the optimal positioning of the upper incisors, both antero-posteriorly and vertically in relation to adjacent soft tissues, is crucial.^{10,11} Their approach introduced the concept of using the positioning of the upper incisors as the initial step in the diagnostic process.¹⁰

Andrews shift from hard-tissue internal cephalometric landmarks to soft-tissue profile landmarks, suggested the placement of the upper incisors crucial for facial aesthetics from both frontal and lateral views. His study, conducted on the Caucasian population, highlighted that there are ethnic variations in the position of central incisors, which means the positioning of the GALL may differ across ethnic groups. Several studies have assessed the anteroposterior (AP) position of maxillary incisors in various populations. To enhance diagnostic value, this study aims to determine the standard for the AP position of maxillary incisors in Gujarati females.

2. Materials and Methods

A cross-sectional study was carried out in the Department of orthodontics and dentofacial orthopedics. Randomized sampling was done to select the subjects for this study. Informed consent was obtained from all participants. Adult females (N=100) with pleasing profiles and optimum smile esthetics were selected for the study and smile profile photographs were recorded. Subjects, who had undergone any orthodontic and/or prosthetic rehabilitation or any candidates with facial asymmetry and jaw deformities, were excluded.

Posed-smile photographs with adequately visible forehead structures and fully bared maxillary incisors were obtained from all the participants in natural head position (NHP) by the same clinician. A distance of 56.0 cm between the tripod stand of the camera and the patient was established by the use of a measuring tape and maintained while taking all the photographs. (**Figure 1**) After that, pictures were added to Microsoft Office 2010 and enlarged to around life size. The average vertical measurement from the trichion to the incisal border of the maxillary central incisors was used to determine life size image. This measurement was obtained from lateral cephalograms of ten randomly chosen adult female patients.) Thereafter, all the photographs were imported to Autocade 2018 designing software for the identification of landmarks and determination of distances among them.

The following landmarks were used in this study: (**Figure 2**)

1. Trichion: The central point of the forehead where the hairline meets the forehead.
2. Glabella (Mesophryon): The region between the eyebrows and above the nasion on the frontal bone.
3. Superior: On angular and rounded foreheads, this point indicates the superior boundary of the clinical forehead, or the area of the forehead that is more closely associated with the face than the scalp.
4. The forehead's FFA point, which is located halfway between the glabella and superior on the midsagittal plane,
5. Forehead inclination: This is the angle formed by the FFA line, which goes via the FFA point, and the clinical forehead.

After identifying all of the above landmarks on photograph, lines were constructed on the forehead & measured its inclination as mentioned in **Figure 3**.

1. FA point (facial axis point) – the clinical midpoint of the facial axis of clinical crown of upper incisors
2. GVL line (Glabellar vertical line) - line parallel to FA point and that passes through the glabella.
3. FALL line (forehead's anterior limit line) – a line that parallels the head's frontal plane and passes through the FFA point.
4. GALL line (Goal Anterior Limit Line) – A line representing optimal anterior border according to Andrew's element I concept. When the cant of forehead is 7 degrees or less it passes through the FFA point. For every increase in the degree, it passes through a point on the forehead that is 0.6mm anterior to the FFA point.⁶

Once these landmark points were identified, three vertical lines were drawn as seen in **Figure 3**.

1. Line 1: Through glabella
2. Line 2: Through FFA point
3. Line 3: Through maxillary central incisor FA point

Following this the horizontal linear measurements were recorded from FA point of upper incisor to FALL, GALL and GVL line.(Figure 3)

3. Result

The graph in Figure 4 shows that the descriptive analysis of the AP position of the maxillary incisor from GALL was found out 7.6±13.3mm, for FALL was 6.7±3.5 mm and GVL is 8.2±3 mm. The average forehead inclination for all the subjects was 9±3degree.

The results are highly significant. GALL and FALL are clinically more significant (p-value – 0.000) than GVL (0.243). (Table 1)

GALL & FALL are statistically significant (p-value – 0.000) when compared to GVL (p-value – 0.243) (Table 2)

Linear regression analysis derives a formula

$$Y = 8.773 + 1.530 * \text{Gall line} - 1.574 * \text{Fall line} - 0.140 * \text{GVL line}$$

Here, Y was considered as forehead inclination.



Figure 1: A distance of 56.0 cm between the camera's tripod stand and the patient was maintained using a measuring tape while capturing all photographs

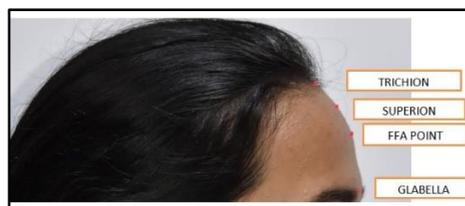


Figure 2: Landmark identification on photographs



Figure 3: Measurement of GALL, FALL, GVL and Forehead inclination

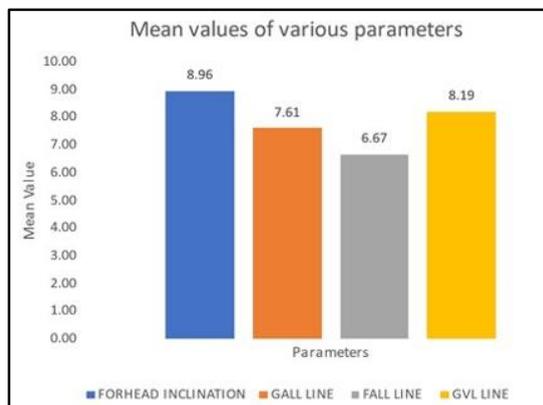


Figure 4: Descriptive analysis of the AP position of the maxillary incisor from GALL, FALL and GVL.

Table 1: Depicts that GALL and FALL are clinically more significant than GVL

Model Summary				
Model	R	R Square	Adjusted R Square	Std. The error in the estimate
1	.947 ^a	.897	.894	1.066

a. Predictors: (Constant), GVL LINE, FALL LINE, GALL LINE

Table 2: Depicts that GALL & FALL are statistically significant when compared to GVL.

Coefficients							
Model	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value (Sig.)	95% Confidence Interval for B	
	B	Std. Error				Beta	Lower Bound
(Constant)	8.773	0.306	—	28.626	0.000	8.165	9.381
GALL LINE	1.530	0.092	1.539	16.657	0.000	1.348	1.713
FALL LINE	-1.547	0.071	-1.678	-21.767	0.000	-1.688	-1.406
GVL LINE	-0.140	0.119	-0.139	-1.174	0.243	-0.376	0.097

a. Dependent variable: Forehead inclination

4. Discussion

The Angle's paradigm,⁵ considered that optimal oral occlusion and hard tissue interactions, served as the foundation for orthodontic diagnosis and treatment planning until now. The goal of orthodontic treatment was to achieve best possible occlusal and facial results for each patient, with aesthetic considerations often being prioritized from the patient's perspective.¹² The orthodontist must plan the treatment based on soft tissue adaptability of the patients since the soft tissues significantly dictate the boundaries of orthodontic treatment. The soft tissue paradigm emphasizes the function and aesthetics of soft tissue in both diagnosis and treatment planning.

The role of soft tissue is crucial, as changes in the anteroposterior position of the maxillary incisors, such as when anterior retraction is performed, typically result in the soft tissue conforming to the new position of the teeth. This results in the alteration of the facial profile and aesthetics of the patient. Moreover, the soft tissue profile plays a vital role in defining the smile, as the lips and surrounding soft tissues are framed by the teeth, thereby affecting the overall balance and appeal of the smile.¹³

The smile arc, as defined by Frush and Fisher,¹⁴ is the harmony between the curvature of the upper border of the lower lip and the curvature of the incisal edges of the maxillary front teeth. A harmonic curve of the maxillary anterior incisal margins has been important for producing a youthful and attractive aesthetic look for more than 50 years, according to prosthodontists.¹⁵ Even though orthodontists have always used the phrase "curved smile line," Sarver favours the word "smile arc."¹⁰

In addition to the importance of the smile arc, forehead inclination has a major role in determining the extraction and non-extraction treatment approach.¹⁶ The theory that, in people with facial harmony, there is a correlation between the prominence and inclination of the forehead and the AP locations of the teeth and jaws serves as justification for using the forehead to define the target for the maxillary incisors. In this case, Dr. LF Andrews¹⁷ also recommends utilizing the forehead as a suitable reference point. The forehead's inclination is generally the same among ethnic groups, despite differences in the hard and soft tissue architecture.^{18,19}

In a smiling profile view, the labiolingual angle and the AP position of the maxillary incisors have a significant impact on facial appearance. The significance of the incisors' optimal AP location when viewed sagittally was verified by Cao et al.²⁰ The Andrews study, which has a strong correlation with this particular study, demonstrated that the forehead inclination was a crucial landmark in determining the maxillary incisors' AP position.

The maxillary central incisors should be positioned halfway between the glabella, which ranges from -8.5 mm to

9.0 mm, and the forehead's FA point, according to a study by Andrews²¹ on adult white females.

Numerous investigations were conducted thereafter to evaluate the same in other ethnic groups. The nearly varied findings from each study indicate to various maxillary central incisor locations. According to Cho et al.,²² the maxillary central incisors of most Korean female patients undergoing orthodontic treatment were positioned anteriorly to the glabella. In adult African American females, Gidaly et al.²³ investigated the ideal AP relationship between the maxillary central incisors and the forehead and glabellar vertical (GV). According to his findings, Andrews recommended optimal AP position for maxillary central incisors, which was meant for Caucasian females and not for African American females. Alternatively, African ladies have the best maxillary incisor position in front of the GV. Gidaly also suggested using the patient's forehead inclination to create an equation for the ideal AP upper incisor location in relation to GV. According to a study by Tomblyn et al.,²⁴ in the majority of Caucasian patients, the GV and GALL matched. In 95% of the population, the GALL is 1 mm behind the GV, and in 99.7% of the population, it is 1.5 mm behind the GV. These variances emphasize how crucial it is to take racial and cultural diversity into account when developing a treatment strategy.

This study provides important insights into the facial profiles of Gujarati females with aesthetically pleasing features. It was observed that the GALL and FALL are positioned at nearly identical distances from the FA line, suggesting that these two measurements are closely aligned in individuals with harmonious facial profiles. The research emphasizes that GALL and FALL hold greater clinical significance in evaluating facial balance and symmetry compared to the GVL making them crucial parameters in the assessment of facial aesthetics.

Building on these observations, the study derived a mathematical formula to estimate forehead inclination:

$$\text{Forehead inclination} = 8.773 + 1.530 * \text{Gall line} - 1.574 * \text{Fall line} - 0.140 * \text{GVL line}$$

This formula is particularly valuable in clinical practice, as it allows practitioners to calculate the GALL distance from the FA line when the FALL and GVL measurements are already known. By integrating these variables, the formula offers a practical method for assessing the spatial relationships between key facial landmarks, contributing to more precise evaluations of facial profiles and supporting the development of individualized aesthetic treatments.

The above study confirmed the optimal efficacy of the forehead in deciding the optimal AP position of incisors and GALL and FALL has more reliability in the Gujarati population rather than GVL. Therefore, it suggests that there

is a difference in the distance of the FA line from GALL, FALL, and GVL indifferent racial groups.

5. Conclusion

In comparison to the Glabellar vertical line, the Goal anterior limit line and the Forehead anterior limit line are clinically more significant landmarks for assessing the antero-posterior location of maxillary central incisors in Gujarati females.

When evaluating the facial profile of adult Gujarati females in relation to the AP maxillary central incisor location, the forehead can be an important marker.

6. Source of Funding

None.

7. Conflict of Interest

None.

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