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“OPTIMAL ANTEROPOSTERIOR POSITION OF MAXILLARY INCISORS IN CAUCASIAN FEMALES”

by:

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A thesis submitted to the faculty of the Medical University of South Carolina in partial fulfillment of the requirement for the degree of Masters of Science in Dentistry in the College of Dental Medicine.

Department of Orthodontics

Approval Date

Approved by:

(Name of mentor)
Chairman Advisory Committee

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(Name of committee member)

Optimal Anteroposterior Position of Maxillary Incisors in Caucasian Females

Abstract

Introduction: This study investigated an ideal anteroposterior position of maxillary incisors viewed from a facial profile perspective in Caucasian females. **Methods:** Smiling profile photographs were collected from pre-treatment records of 40 Caucasian female patients within the Department of Orthodontics at the Medical University of South Carolina. The 40 patient photographs were randomly compiled in a REDCAP survey. The survey was distributed to 82 orthodontists and 31 laypersons who were asked to determine whether the maxillary incisor in the photographs were too far forward, too far back or just about right within the face. An optimal group (Group O) was established from the photographs of patients whose incisors were rated as “just about right” by 75% of the raters. The same method was applied to find a “too far back” group (Group B) and “too far forward” group (Group F). A mean incisor to glabella vertical distance and the standard deviation was determined for both groups. **Results:** Within the optimal group, the average incisor to GV measurement rated by all judges as “just about right” was -1.17 mm. Within Group F, the average incisor to GV measurement rated by all judges was 2.67 mm. Within Group B, the average incisor to GV measurement rated by all judges was -2.75 mm. There was a statistically significant difference between the overall way orthodontists and laypeople rated the upper incisor position (p -value <0.0001). There was no correlation between forehead inclination and incisor position relative to GV within the optimal group (p -value = 0.2658, Spearman correlation = 0.34). **Conclusions:** The optimal AP position of maxillary incisors in Caucasian females is -1 mm to 0 mm relative to Glabella Vertical. Glabella Vertical may be a useful landmark to determine the optimal position of maxillary incisors in Caucasian females.

Introduction

The possibility of improving one’s facial esthetics has become a key factor in the motivation for modern day patients seeking orthodontic treatment.^{1,4} Traditionally, orthodontic diagnoses and treatment plans have relied heavily on the use of cephalometric analyses and the average norms constructed by the forefathers of orthodontics. An ideal orthodontic outcome was measured by an optimal occlusion scored via dental casts. However, cephalometric analyses and dental casts did not consider the overall facial appearance of the patient being treated and instead relied heavily on unreliable cephalometric norms. Currently, orthodontists may agree on treatment objectives such as proper occlusion, balanced facial form, straight teeth, good jaw relationship, stability, and healthy periodontium, but not on treatment goals relating to the position of incisors with regard to the overall facial profile. There has been a paradigm shift in the awareness of orthodontists, as well as patients, regarding their expectations for good facial esthetics as a treatment goal.

Orthodontists evaluate hard tissue and soft tissue esthetics during comprehensive treatment planning. Orthodontic records conventionally include a frontal smiling and a frontal repose photograph as well as a repose profile photograph. Recent studies have highlighted the importance of including a smiling profile photograph.^{13,14,20} Soft tissue drapes can disguise underlying hard tissue disharmony, so evaluation of the profile in both repose and smiling is beneficial. A major benefit of the evaluation of the smiling profile is the added ability to assess the position of the upper incisor.^{13,14,20} Positioning the maxillary incisors in an optimal antero-posterior (AP) position within the bony housing relative to an extracranial landmark correlates to

harmonious facial esthetics.⁴ The AP position of the maxillary incisors can affect the soft tissue profile and is often manipulated during orthodontic treatment.¹ Cao et al confirmed the validity of an ideal AP position of the incisor in a sagittal view, concluding that its position affected both smiling profile esthetics and facial harmony.³ In recent years, studies have been conducted to determine the optimal AP position of maxillary incisors in African American males and females as well as Asian females using a lateral smiling photograph.^{1,3} Despite the extent of literature on the subject matter, the American Board of Orthodontics does not require a lateral smiling photograph for case records and diagnosis.

Cephalometric analyses exist to compare linear and angular measurements with population norms to aid in diagnosis. Studies have shown that cephalometric diagnosis does not always correlate to clinical impressions of malocclusions. In fact, research has shown that good facial harmony can exist within a wide range of cephalometric measurements.¹ Multiple authors reported that orthodontic treatment planning that adheres strictly to cephalometric norms does not necessarily yield optimal facial esthetics.³ Tourne et al suggested that dental professionals often rely more on their clinical impressions of malocclusions than diagnoses from cephalometric analyses.²⁸

Contrary to traditional cephalometrics, Andrews first introduced the concept of treating incisors to an optimal position relative to a soft tissue landmark in a profile view in his Six Elements of Orofacial Harmony™. Andrews described a range of optimality of the AP position of the central incisor using the boundaries of Goal Anterior Limit Line (GALL) and Forehead Anterior Limit Line (FALL). Andrews stated that the AP position of the maxilla is optimal when the Facial Axis (FA) points of maxillary incisors that are centered in alveolar bone are on the GALL¹⁷. Resnick et al found that maxillary incisor position 2 mm to 4 mm anterior to GALL was found as the most esthetic range in women and 0 mm to 4 mm posterior to GALL was the most esthetic range in men.²² Schlosser et al showed a statistically significant difference in esthetic judgment with each AP millimetric change in the maxillary incisor position in a smiling profile.⁹

Glabella Vertical (GV), a derivative of Andrews range utilizing GALL and FALL, has been proposed as a reliable landmark for assessment of the AP position of the central incisor when the patient is in Natural Head Position (NHP). Cephalometric analyses that utilize extracranial referents, related to a patient in NHP, have been confirmed to be more reliable than analyses that utilize intracranial referents. Studies have found that NHP has good intraindividual reproducibility and represents the true-life appearance of the patient.^{1,10,30} NHP has been defined as the most balanced, natural position of the head when a person views an object at their eye level. Madsen et al confirmed that a true vertical or horizontal plane from NHP is the most valid craniofacial reference.³¹ GV is an extracranial referent that relates soft tissue glabella, a landmark between one's eyebrows, to the most anteriorly positioned maxillary central incisor of a patient oriented in NHP. Recently, a study by Tomblyn et al showed that the GV corresponded with GALL in most Caucasian patients: In 95% of the population the GALL is within 1 mm of GV and within 1.5 mm of GV in 99.7% of the population.²⁹

Gidaly et al studied the optimal AP relationship of the maxillary central incisors relative to the forehead and GV in adult African American females.¹ His results found that Andrews' proposed optimal AP position of the maxillary central incisors for Caucasian females is not applicable to the African American female population. Instead, all optimally positioned maxillary incisors in AA females were anterior to GV. Gidaly also proposed an equation for optimal AP upper incisor position relative to GV by using the patient's forehead inclination.¹ Will Andrews conducted a similar study in the adult Caucasian female population using a range between a landmark on the patient's forehead and soft tissue glabella. According to Andrews, treatment goals for white

female adults should include a maxillary central incisor position somewhere at or between the Forehead Facial Axis (FFA) point and GV.⁴

No previous studies have investigated the definite relationship between the AP position of the upper incisor and GV. Additionally, there is no defined range of optimality for the AP position of the maxillary incisor in Caucasian females. This study investigated the relationship between the upper incisor and GV to elucidate an optimal AP position for the upper incisor in Caucasian females.

The aims of this study are to improve diagnostic and treatment planning methodology in the orthodontic community. By providing the possibility of an orthodontic standard for the AP placement of maxillary incisors in Caucasian females, orthodontic professionals will have the ability to craft treatment plans with the most esthetic, optimally positioned incisors. The null hypotheses were: 1) there is no difference in rating of AP incisor position between orthodontists and laypersons, 2) there is no difference in the position of upper incisors relative to GV between groups of patients with incisors judged as “too far forward,” “too far back,” and “just about right,” 3) there is no difference in rated optimal AP incisor position among Caucasian females with various forehead inclinations.

Materials and Methods

Retrospective data from pre-treatment records of forty consecutive Caucasian females who presented for initial records were collected from the Medical University of South Carolina Department of Orthodontics. Initial diagnostic records included a lateral smiling photograph taken with the subject placed in natural head position by a trained orthodontic resident and/or faculty member. All photographs were taken in front of a light box. A true vertical line was established on the light box along with a millimeter ruler at the patient’s midsagittal plane for the purpose of calibration. All subjects had their maxillary incisors and forehead in plain view. Inclusion criteria for the patient population included Caucasian females between the ages of fifteen to sixty. All patients were willing and able to consent for themselves during their initial records appointment. Patients with craniofacial anomalies or visible facial trauma, determined by the screening doctor and/or in the patient medical history were excluded. Also excluded were patients whose incisors were determined to be too severely rotated to be accurately measured. The present study was approved by the Institutional Review Board of the Medical University of South Carolina in Charleston, SC.

All photographic records from the MUSC orthodontic clinic were taken with the patient placed in adjusted natural head position by an orthodontic resident and/or faculty member as described by previous studies. These photographs were uploaded into a Microsoft PowerPoint™ presentation, calibrated for size with a digital ruler, deidentified with eye and eyebrow coverage, and converted to black and white to minimize confounding variables of various facial features (Figures 1,2,3).

Once uploaded into Microsoft PowerPoint™, a digital measurement from Glabella Vertical to most anterior facial surface of the maxillary incisor was determined and recorded using the calibrated digital ruler. The digital GV measurements were determined by one orthodontist. One month later, the operator repeated all measurements of the forty subjects to evaluate intra-rater reliability.

Figure 1. Example of original picture with measurements and constructed vertical line

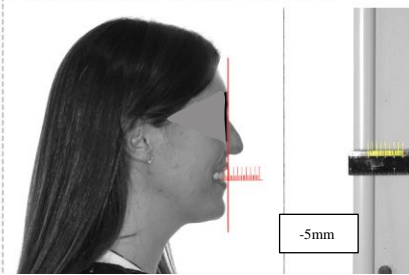


Figure 2. Example of a ruler calibration

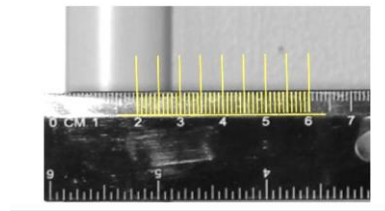
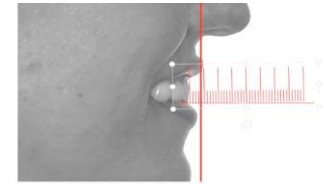


Figure 3. Example of incisor measurement



A power analysis was performed using results from prior similar studies and determined that the number of subjects needed to yield significant results of 80% power was thirty. Another power analysis was performed to determine the number of orthodontic raters and layperson raters needed to yield significant results of 80% power and was determined to be fifty total raters (25 from each group).

Once calibrated and measured, each photograph was de-identified and randomized into a REDCAP survey. The survey was distributed to a group of male and female orthodontists and laypersons who had no prior knowledge of the study hypothesis. The survey asked for the rater's background and dental experience. Orthodontic professionals were required to designate the specific number of years of experience within the field. The forty randomized lateral photographs of the subjects were then shown with a multiple-choice question asking the rater to designate the position of the subject's maxillary incisors as "Too Far Forward," "Too Far Back," or "Just About Right."

A control group (Group O) was constructed from the data using a threshold of 75% or greater agreement of the maxillary incisors being diagnosed as "just about right" between the raters. The same threshold of 75% or greater agreement was used to create two study groups that comprised "too far forward" (Group F) or "Too Far Back" (Group B).

Once the survey was completed, the statistics were run by the Division of Population Oral Health at the James B. Edwards College of Dental Medicine. Descriptive statistics were run to determine if a difference existed between the variables. Differences were considered significant if $p < 0.05$.

Results

The optimal group (Group O) was defined as the subjects who were rated as "just about right" by over 75% of judges. Within the optimal group, the average incisor to GV measurement rated by all judges as "just about right" was -1.17 mm. Orthodontists averaged an incisor to GV measurement of -0.90 mm for the optimal group. When the threshold was increased to 80%, the distance was reduced to -0.83 mm from GV. Laypersons yielded an average incisor to GV measurement of -2.20 mm in the optimal group. When the threshold was increased to 80%, the distance reduced to -1.50 mm to GV (Table 1).

Subjects who were rated as either "too far forward" (Group F) or "too far back" (Group B) were similarly organized into study groups when their photographs were rather as such by a minimum of 75% of the raters.

Within Group F (Table 1), the average incisor to GV measurement rated by all judges was 2.67 mm. Orthodontists averaged an incisor to GV measurement of 4.50 mm. Laypersons, yielded an average incisor to GV measurement of 1.75 mm.

Within Group B (Table 1), the average incisor to GV measurement rated by all judges was -2.75 mm. Orthodontists alone averaged an incisor to GV measurement of -2.81 mm. Laypersons, however, yielded an average incisor to GV measurement of -2.50 mm.

A chi square test was used to compare the total responses of orthodontists versus the total responses of laypersons. There was a statistically significant difference between the overall way orthodontists and laypeople rated the upper incisor position (p-value<0.0001) (Table 2). Furthermore, within each category of “too far forward,” “too far back,” and “just about right” there was a statistically significant difference between the orthodontists and laypersons ratings. Orthodontists were more likely to rate people as “just about right” or “too far back” in comparison to layperson’s ratings. Laypersons more frequently rated the incisors as “too far forward” than the orthodontists did.

A generalized linear regression model was used to compare the GV measurements that comprised the three groups. There was a statistically significant difference found between the groups that orthodontists rated as “too far forward” and “too far back” (p-value=0.0348) (Table 3).

There was no correlation between forehead inclination and incisor position relative to GV within the optimal group (p-value = 0.2658, Spearman correlation = 0.34).

Table 1. The average, range, and standard deviation of Glabella Vertical measurements in the “optimal,” “too far back,” and “too far forward” groupings.

OPTIMAL GROUP			TOO FAR BACK GROUP			TOO FAR FORWARD		
Orthodontists			Orthodontists			Orthodontists		
n=10	75%	80%	n=7	75%	80%	n=2	75%	80%
Average	-0.9	-0.83	Average	-2.81	-2.81	Average	4.5	4
Range (mm)	-6 to +5	-6 to +5	Range (mm)	-6 to +1	-6 to +1	Range (mm)	+4 to +5	+4 to +5
SD	3	3.87	SD	2.51	2.51	SD	0.71	n/a
Laypersons			Laypersons			Laypersons		
n=5	75%	80%	n=2	75%	80%	n=4	75%	80%
Average	-2.2	-1.5	Average	-2.5	-2.5	Average	1.75	3
Range (mm)	-5 to 0	-2 to -1	Range (mm)	-6 to +1	-6 to +1	Range (mm)	-2 to +5	0 to +5
SD	1.92	0.71	SD	4.95	4.95	SD	3.3	2.65
Combination			Combination			Combination		
n=12	75%	80%	n=7	75%	80%	n=4	75%	80%
Average	-1.17	-0.83	Average	-2.75	-2.75	Average	2.67	3.5
Range (mm)	-6 to +5	-6 to +5	Range (mm)	-6 to +1	-6 to +1	Range (mm)	-2 to +5	0 to +5
SD	2.98	3.87	SD	3.65	3.65	SD	2.94	2.38

Table 2. Differences in ratings of all responses by all orthodontists vs. all laypersons.

Rating (p-value<0.0001, there is a significant difference)	Layperson	Orthodontist
	Just about right	554 41.31%
Too far back	412 30.68%	1305 39.94%
Too far forward	377 28.07%	371 11.36%

Table 3. Comparison of GV measurements of all patients that comprise the individual groups.

	Laypersons Optimal	Laypersons Too far forward	Laypersons Too far back	Orthodontists Optimal	Orthodontists Too far forward	Orthodontists Too far back
Laypersons Optimal		0.3359	1.0000	0.8811	0.0887	0.9989
Laypersons Too far forward	0.3359		0.5308	0.7635	0.8709	0.1307
Laypersons Too far back	1.0000	0.5308		0.9413	0.1757	1.0000
Orthodontists Optimal	0.8811	0.7635	0.9413		0.2452	0.5377
Orthodontists Too far forward	0.0887	0.8709	0.1757	0.2452		0.0348
Orthodontists Too far back	0.9989	0.1307	1.0000	0.5377	0.0348	

Discussion

Two of the three null hypotheses proposed were rejected. The results showed that there was a difference in rating of AP incisor position between orthodontists and laypersons. There was a difference in the position of upper incisors relative to GV between groups of patients with incisors judged as “too far forward,” “too far back,” and “just about right.” There was no difference in rated optimal AP incisor position among Caucasian females with various forehead inclinations.

The results of this study showed a statistically significant difference in the way laypersons rated the AP incisor position in Caucasian females when compared to orthodontic professionals. Both groups judged more subjects as “just about right,” than “too far back,” and least “too far forward.” However, laypersons judged statistically more patients as “too far forward” compared to orthodontists. A major factor for this could be the orthodontic profession preferring and accepting a fuller facial profile than laypersons. Another factor for this discrepancy could be the education of the raters. Orthodontists are familiar with the difference between teeth that are too proclined and teeth that are too protrusive. This is depicted well by Figure 4. The patient was diagnosed with an incisor to GV distance of +3 mm. A layperson may misinterpret excessive inclination with the AP position of the teeth being too far forward. Orthodontists, given their training, may be more discerning in their interpretation of the incisor position and inclination.

Figure 4. Subject with excessively proclined maxillary incisors.



Within the optimal group defined by orthodontists, the average distance for incisor to GV was -0.90 mm. When the threshold was increased to 80%, the distance was reduced slightly to -0.83 mm from GV. Within the defined optimal group defined by laypersons, the average distance for incisor to GV was -2.20 mm from GV. When the threshold increased to 80%, the distance reduced to -1.50 mm to GV. With evaluation by all raters, the average distance for incisor to GV was -1.17 mm from GV. At a threshold of 80%, the average distance reduced to -0.83 mm from

GV. Because the average distance from GV to an incisor deemed in an optimal position was less than 1 mm from GV, GV may be an accurate referent to determine the optimal AP position of maxillary incisors.

This was proven true in all three groups. Within Group B, the incisor to GV distance rated by both orthodontists and laypersons averaged -2.75 mm from GV. Within Group F, the incisor to GV distance rated by both orthodontists and laypersons averaged +2.67 mm from GV. This again confirms that optimal esthetics are associated with an upper incisor that is in close proximity to GV. The further an incisor is positioned from GV, either forward or behind, statistically the less optimal one's esthetics are rated.

The upper incisor to GV measurements for the subjects in the optimal group established by orthodontists ranged from -6 mm to +5 mm. By eliminating the outliers, the range of measurements for the orthodontic optimal group was -3 mm to +2 mm. The upper incisor to GV measurements for the subjects in the optimal group established by laypersons ranged from -5 mm to 0 mm. By eliminating the outliers, the range of measurements for the layperson optimal group was -3 mm to 0 mm. The defined range within this optimal group further validates that the closer proximity one's incisors are to GV, the more optimal Caucasian female's esthetics are rated.

Andrews proposed that there was a relationship between forehead inclination and AP incisor position. According to his study, the more inclined the forehead, the more forward the incisors should be in an optimal face with the anterior limit of GV in Caucasians. Gidaly¹ performed a similar study with African American females and found that the optimal AP position of incisors was in front of GV. He concluded that as forehead inclination increased, incisor AP position within optimal faces would progressively be more forward. However, within this study there was no correlation between forehead inclination and incisor position relative to GV within the optimal group. A reason the forehead did not have a relationship to incisor position in Caucasians may be because their anterior limit is GV. In fact, Tomblyn²⁹ showed this in her study by concluding the GALL was located -1 mm to 0 mm from GV in Caucasian females 95% of the time but never in front of GV. This study confirms the validity of GV as a reliable and reproducible frontal reference plane that can be used to determine the optimal AP position of maxillary incisors in Caucasian females.

Cephalometric analyses attempt to define what a patient's optimal jaw structure should be but may not account for the AP position of a subject's incisors when smiling. Using GV as a landmark allows the orthodontist to diagnose and treatment plan to a more esthetic smiling face leading to a more esthetic result both in repose as well as smiling.

A limitation of this study was the number of subjects that were studied. An investigation with a higher sample size would be beneficial to confirm these results on a larger scale. In addition, there was a lack of subjects with incisors either on or in front of GV to provide an adequate stratified randomly selected study group. This is due to there being a higher prevalence of Caucasians with incisors posterior to GV. Another limitation was the inclusion of all responses, even from those raters that did not complete the entire survey. Further follow up studies will need to investigate this topic within different ethnic backgrounds and different gender norms. A hypothesis for future research is that there is a greater range of optimality in the soft tissue repose profile than the range of optimality of the upper incisor displayed in a smiling profile.

Assumptions

This study was conducted on the assumptions that the orthodontic raters had no formal training or background on treatment planning using a smiling profile and glabella vertical. In addition, this study assumed that all patient photos were taken in NHP, that black and white photographs minimized confounding facial features and that the linear/angular measurements were accurately made with a digital rule and protractor.

Conclusions

- The optimal AP position of maxillary incisors in Caucasian females is -1 mm to 0 mm relative to Glabella Vertical.
- Non-optimal AP positioned incisors are further from GV than optimally AP positioned incisors.
- There is no correlation between forehead inclination and AP incisor position relative to GV in Caucasian females.
- There is a statistically significant difference in the way laypersons rate the AP position of upper incisors in Caucasian females when compared to orthodontic professionals.
- Glabella Vertical may be a useful landmark to determine the optimal position of maxillary incisors in Caucasian females.

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