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by

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Approval Date

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Abstract

Introduction: This study investigated an optimal anteroposterior (AP) position of maxillary incisors displayed in a smiling profile in Caucasian males relative to Glabella Vertical (GV). The study also assessed any difference in preferred AP incisor position between orthodontists and laypersons, among orthodontists in various years of practice, among laypersons in various age groups, and between genders of orthodontists and laypersons. **Methods:** Existing smiling profile photographs of 40 Caucasian males, ages 15 to 60, were retrospectively collected from the Medical University of South Carolina (MUSC) Department of Orthodontics database. Photographs were numerically randomized and uploaded into a Research Electronic Data Capture (REDCAP) survey. Seventy-one orthodontists and forty-six laypersons age 18 and older responded to the survey having assessed the AP incisor position in each profile photograph as: 1) too far forward, 2) too far back, or 3) just about right, which were considered Group F, Group B, Group O, respectively. Orthodontists were divided into five groups based on years in practice. Laypersons were divided into three groups based on age. **Results:** An optimal group (Group O) was constructed based on incisor AP position rated "just about right" from 70% of all judges. Group O yielded a mean maxillary incisor to GV of -1.5mm. Mean maxillary incisor to GV measurement for orthodontists was -1.1mm, while the measurement for laypersons was -2.4mm. The "too far back" group (Group B) was similarly developed with the same 70% threshold. Mean maxillary incisor to GV was -5.8mm for orthodontists and -6.1mm for laypersons. There was insufficient agreement (below 70%) for the "too far forward" group (Group F) to conduct a similar analysis. Results indicate the mean GV for "just about right," "too far forward," and "too far back" groups are statistically different for both orthodontists ($p<0.05$) and laypersons ($p<0.05$). There were no differences in ratings by orthodontists based on years in practice, by laypersons based on age groups, or between genders of orthodontists and laypersons. **Conclusions:** Among orthodontists and laypersons combined, the optimal AP maxillary incisor position in Caucasian males was found to be 1.5mm behind GV. Orthodontists rated the optimal AP maxillary incisor position as 1.1mm behind GV, while laypersons rated the optimal AP maxillary incisor position as 2.4mm behind GV. While statistically significant, the difference was only 1.3mm. There were no differences in AP ratings among orthodontists based on years in practice, among laypersons based on age group, or between genders of orthodontists and laypersons. GV may be a useful landmark for assessing the AP position of the maxillary incisor in Caucasian males.

Introduction:

While orthodontists are tasked with providing patients straight teeth and an optimal occlusion, it is essential to consider overall facial appearance when constructing an orthodontic treatment plan.[1] Orthodontists evaluate jaws and teeth in three planes of space: anteroposterior, transverse, and vertical. In the anteroposterior (AP) dimension, a multitude of factors contribute to successful orthodontic outcomes including the skeletal position of the maxilla and mandible, intra- and interarch tooth relationships, and incisor position.[2] With the ability to alter the lower third of the face with hard tissue AP movements, clinicians must be cognizant of soft tissue changes, smile esthetics, and incisor positioning which can impact overall profile facial esthetics. Thus, orthodontic diagnosis and treatment planning must account for both hard and soft tissue changes to maximize patient outcomes.

Angle's classification of the dental occlusion and cephalometric analyses have historically been used to diagnose malocclusions. Although attaining appropriate occlusal relationships is important, emphasis on achieving an Angle's Class I dental occlusion does not account for treatment effects on overlying soft tissue structures or overall smile esthetics. Cephalometric analyses use hard tissue points, lines, and angles to identify skeletal and dental discrepancies from various norms.[3] However, studies indicate that cephalometric analyses are somewhat unreliable due to difficulties in identification of landmarks and inconsistent anatomical

positioning among patients.[4,5] Therefore, results of traditional cephalometric analyses should be interpreted with caution and used as an adjunct to diagnosis and treatment planning, while increased emphasis should be placed on treatment goals that enhance overall soft tissue and smile esthetics.[6] Reference points including the nose, lips, and chin have been used to evaluate the soft tissue and changes produced by tooth movements.[6, 7, 8] However, the variability of these points and inaccuracy in predicting underlying hard tissue structures introduced the need for a reliable soft tissue landmark that could be correlated to the teeth.[9, 10] Use of the forehead has been suggested as such a landmark as it has been found to be predictable, repeatable, and unchanged by orthodontic treatment.[3, 11, 12]

Recognizing the need for standardization in diagnosis and treatment planning to optimize facial esthetics with defined hard and soft tissue references and landmarks, Andrews proposed an analysis known as the Six Elements of Orofacial Harmony.[13, 14, 15] Element I outlines the optimal arch form and specifies that teeth be at their optimal inclination and angulation, centered in bone.[15, 16] Element II sequentially builds upon Element I and describes the optimal AP jaw position based on the soft tissue forehead and the hard tissue maxillary incisor position.[15] Utilizing the forehead inclination and a frontal plane in the lateral perspective, the Goal Anterior Limit Line (GALL) is constructed and represents the anterior limit for the maxillary incisor.[15] Andrews advocated that the Facial Axis (FA) point of an Element I maxillary incisor fall on the GALL for the optimal anteroposterior maxillary position.[13, 14] Schlosser et al studied the effects of incremental millimetric advances of the maxillary incisor on facial profile attractiveness and found Element II to be useful in planning maxillary incisor position to enhance profile esthetics.[17] Resnick et al found GALL to be useful in establishing an acceptable range for the ideal AP maxillary incisor position.[18] As hard tissue changes have an effect on the overlying soft tissue and smile esthetics, moving maxillary incisors forward or backward may positively or negatively affect a patient's profile.[19] Multiple studies have demonstrated that the AP maxillary incisor position is an important component of facial harmony as it influences overjet, contributes to upper lip support, and is strongly correlated with an attractive smiling profile. [11, 12, 20, 21, 23, 24]

It may be beneficial to observe the AP position of the maxillary incisor by utilizing a smiling profile photograph of the patient in natural head position (NHP), as advocated by previous studies.[3, 21] NHP is defined as the orientation the patient assumes when relaxed and looking straight ahead at a point on the horizon.[22] While NHP is generally reproducible and reliable, it is dictated by the patient and may be inconsistent.[24, 25] Experienced clinicians and staff may adjust the patient when the assumed head posture seems unnatural into what is referred to as natural head orientation (NHO); thereby increasing the accuracy of the head position.[24]

While the GALL shows good evidence in the esthetic AP positioning of the maxillary incisor, Glabella Vertical (GV) has been recommended as a reliable and simple alternative.[26] A vertical line lying tangent to soft tissue glabella, the most anterior point of the forehead in the midsagittal plane, to the most anterior position of the maxillary incisor is used to construct GV when the patient is smiling and in NHO. A study by Tomblyn concluded that using GV to identify the optimal AP maxillary incisor position in Caucasian patients is similar or superior to use of the GALL.[26] Boyles-Horan et al found that subjects with maxillary incisors positioned on GV in the AP dimension were rated more attractive than those with maxillary incisors anterior or posterior to GV by orthodontists.[27] Though multiple studies conclude that GV is a valuable landmark, differences may exist among races, genders, and ethnicities regarding optimal AP maxillary incisor position. In addition, differences may exist in preferences of laypersons versus orthodontists when evaluating profiles. Only moderate information exists in the literature addressing optimal AP incisor display in smiling profiles.

The purposes of this study are to investigate the optimal AP incisor position displayed in a smiling profile for Caucasian males as well as find any differences in preferred AP incisor position between orthodontists and laypersons. Findings may demonstrate any differences among orthodontists based on years in practices reflecting different timepoints in training and may show differences among laypersons in various age groups. Additionally, findings may demonstrate any differences between genders of orthodontists and laypersons.

The null hypotheses were: 1) there is no difference in judgement of optimal AP maxillary incisor position between orthodontists and laypersons, 2) there is no difference in judgement of preferred AP incisor position among orthodontists in various years of practice; between laypersons of various age groups; and across genders of orthodontists and laypersons.

Material and Methods:

The investigation (ID# 5483) was approved by the Institutional Review Board of the Medical University of South Carolina. Searching existing pretreatment records from August 2019 to October 2020, sixty-five photographs of Caucasian males over the age of fifteen were retrospectively collected from MUSC Department of Orthodontics database. As part of MUSC record's protocol, each record included 4 facial photographs: repose frontal, smiling frontal, repose profile, and smiling profile. For the purposes of this study, only smiling profile photographs were collected. Photographs were taken in front of a light box by trained senior orthodontic residents with a mounted ruler at the subject's midsagittal plane for future digital calibration. The subject was oriented into natural head position prior to image capture. Inclusion criteria comprised smiling profile photographs of Caucasian males aged fifteen to sixty with maxillary incisors and foreheads clearly visible. Exclusion criteria included subjects with craniofacial anomalies, severely rotated and/or displaced maxillary incisors, and photographs of insufficient clarity for measurement purposes. Based on protocol of a predicate study investigating similar objectives, a total of forty smiling profile photographs were evaluated and met the inclusion and exclusion criteria.

The forty eligible photographs were uploaded into Microsoft PowerPoint™ (2019, Redmond, WA) and NHO of each subject was verified by an experienced faculty member (TT). A digital ruler was calibrated to the midsagittal plane ruler in the photographs (Figure 1). All photographs were deidentified by covering the lower eye to eyebrow and adjusting the tint of the image to black and white. A vertical line representing the coronal plane was constructed and placed tangent to soft tissue glabella (i.e., Glabella Vertical). Utilizing the digital ruler, measurements were made of the distance from the facial surface of the maxillary incisor to GV (Figure 2). All measurements were based on maxillary incisors being behind GV (-), on GV, or in front of GV (+) and recorded in Microsoft Excel™ (2019, Redmond, WA). All measurement points were then deleted from the deidentified photograph.

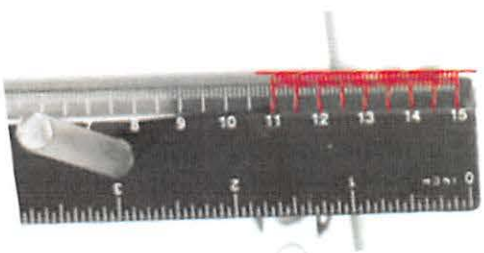

Figure 1: Example of digital ruler calibration

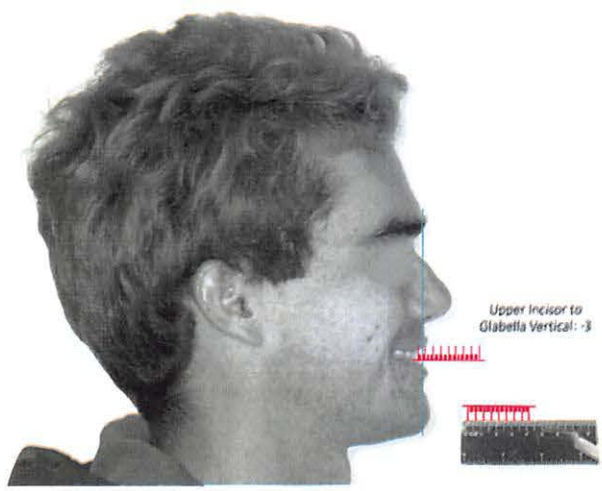

Figure 2: Smiling profile photograph with subject in natural head position and ruler at midsagittal plane.

Next, photographs were numerically randomized and uploaded into a REDCAP survey. Surveys were distributed to 300 orthodontists and 100 laypersons via email requesting voluntary completion and consent to use data for research purposes. Orthodontists emails were obtained utilizing the American Association of Orthodontist's member site as well as MUSC orthodontic faculty. Laypersons email addresses were obtained from faculty, staff, and residents at MUSC. Seventy-one orthodontists and forty-six laypersons ages eighteen and older completed the entire survey. All incomplete surveys were deleted. Demographics including age, gender, ethnicity, designation as an orthodontist or layperson, and years of orthodontic experience were collected. Laypersons were defined as those who had no formal dental training. Orthodontists were divided into five groups based on years in practice: 1-5 years, 6-15 years, 16-25 years, 26-35 years, and over 36 years. Laypersons were divided into three age groups: 18-35 years old, 36-55 years old, and 55 years and older. Each rater assessed the AP maxillary incisor position in each of the forty smiling profile photographs as 1) too far forward, 2) too far back, or 3) just about right.

Statistical analysis

Data analysis was generated using SAS software (Version OnDemand for Academics 2021, Cary, NC). Descriptive statistics (mean, standard deviation, range) were used to identify a group representing the optimal AP incisor position (Group O). Analysis for significant differences between Group O and "too far back" and "too far forward" groups were performed ($p<0.05$). A one-way ANOVA was used to determine if there was a difference in the mean incisor to GV for each of the three groups (including all subjects) for both orthodontists and laypersons. Tukey's post-hoc test was used to determine which groups differed. In addition, analysis for significant differences among orthodontist based on years in practice, between orthodontists and laypersons, and among genders of orthodontists and laypersons regarding preferred AP incisor position were determined.

Results:

Subjects rated "just about right" (Group O), defined by a threshold of 70% or more agreement by judges, were categorized as the optimal group. Within Group O, the mean maxillary incisor to GV measurement was -1.5mm as rated by all judges. The mean maxillary incisor to GV measurement for orthodontists was -1.1mm, while the measurement for laypersons was -2.4mm (Table 1).

Subjects rated "too far back" (Group B), defined by a threshold of 70% or more agreement by judges, were similarly categorized (Table 1). Within Group B, the mean maxillary incisor to GV measurement for orthodontists was -5.8mm, while the measurement for laypersons was -6.1mm.

Orthodontists			
	Mean to GV	SD	Range
Group O	-1.1mm	1.9	5
Group B	-5.8mm	3.4	13

Laypersons			
	Mean to GV	SD	Range
Group O	-2.4mm	2.4	7
Group B	-6.1mm	3.5	13

Table 1: Mean, standard deviation, and range of GV in "optimal" and "too far back" groups

There was insufficient agreement (below 70%) for the group "too far forward" (Group F) to complete a similar analysis.

For Group O, there was a statistically significant difference between ratings of orthodontists and laypersons ($t=7.49$, $p<0.0001$) (Table 2); however, for Group B there was no statistical difference between the ratings of orthodontists and laypersons ($t=1.22$, $p=0.2233$) (Table 3).

Group O			
	Mean to GV	SD	Range
Orthodontists	-1.1mm	1.9	5
Laypersons	-2.4mm	2.4	7
	t=7.49		
	p<0.0001		

Table 2: Difference in Group O for orthodontists and laypersons

Group B			
	Mean to GV	SD	Range
Orthodontists	-6.1mm	3.4	13
Laypersons	-5.8mm	3.5	13
	t=1.22		
	p=0.2233		

Table 3: Difference in Group B for orthodontists and laypersons

To compare the total responses from orthodontists to the total responses of laypersons, a chi square test was utilized. As illustrated in Table 4, there was a statistically significant difference between the overall way orthodontists and laypersons rated the maxillary incisor position (p-value <0.0001).

Ratings (p-value <0.0001)	Laypersons	Orthodontists
Just about Right	800 43.48%	1240 43.68%
Too far back	697 37.88%	1490 52.48%
Too far forward	343 18.64%	109 3.84%

Table 4: Chi-squared test for relationship between total responses of orthodontists and total responses of laypersons

A one-way ANOVA determined there was a difference in the mean incisor to GV distance for each of the three groups (including all subjects) for both orthodontists ($F=253.9$, $p<0.0001$) and laypersons ($F=83.9$, $p<0.0001$). Tukey's post-hoc test was additionally used to determine which groups differed and found that the mean incisor to GV distance for "just about right," "too far back," and "too far forward," statistically differ for both orthodontists ($p<0.05$) and laypersons ($p<0.05$).

Results indicated there were no differences in ratings by orthodontists based on years in practice or by laypersons based on age groups. In addition, there were no differences in ratings based on gender for both orthodontists and laypersons.

Discussion:

The purposes of this study were to investigate the optimal AP incisor position in smiling profiles of Caucasian males and to assess any difference in preferred AP incisor position between orthodontists and laypersons, among orthodontists in various years of practice, among laypersons in various age groups, and between genders of orthodontists and laypersons.

There was a statistically significant difference in the way orthodontists and laypersons rated the overall position of the AP maxillary incisor. Orthodontists' overall ratings indicated that they judged more profiles to have

incisors that were "too far back" as compared to laypersons (Table 4). Orthodontists also rated fewer incisor positions as "too far forward" as compared to laypersons (Table 4). These differences between orthodontic and layperson ratings may be attributed to orthodontists' advanced training and education in facial esthetics, more critical assessment of profile appearance, and a preference for a fuller smiling profile.[23, 28, 29, 30]
The results also indicated that an optimal AP maxillary incisor position for Caucasian males as rated by orthodontists is 1.1mm behind GV. The optimal position as rated by laypersons is 2.4mm behind GV. A statistically significant difference was present for the ratings of optimality between orthodontists and laypersons, which can similarly be explained by the reasons stated beforehand. However, the average difference of 1.3mm in ratings between orthodontists and laypersons is minimal, and likely clinically insignificant, but does suggest the optimal maxillary incisor position is slightly behind GV. Societal preferences are important considerations in treatment planning. Findings from this study suggest a marginally greater tolerance among laypersons for incisors to be slightly more posterior than the preference among orthodontists.

A previous study with a similar protocol evaluated the optimal position of the AP maxillary incisor in Caucasian females.[27] Results indicated that orthodontists judge maxillary incisors in Caucasian females to be more attractive when the maxillary incisors are on GV in the AP dimension. Another study concluded that orthodontists rate the optimal AP maxillary incisor position in Caucasian females as 0.90mm behind GV.[31] Results of these studies conducted on Caucasian females are similar to results of this study conducted for Caucasian males when assessing the optimal AP maxillary incisor position relative to GV from the orthodontist's perspective. Orthodontists rate the maxillary AP incisor position as optimal within a range of 1.1mm from GV for both Caucasian males and females, suggesting GV may be a useful landmark in identifying an optimal AP incisor position in Caucasian patients. This is consistent with results of other studies which identify GV as a reliable landmark.[26, 27]

Finally, there were no differences in preferred AP maxillary incisor position among orthodontists in various years of practice or genders. There were also no differences in ratings among laypersons of various ages or genders. These findings may indicate a more ubiquitous preference for maxillary AP incisor positioning among orthodontists in various years of practice, among laypersons in various age groups, and across genders of orthodontists and laypersons, respectively.

Limitations of this study include the sample size which was ascertained by a previous study with nearly identical protocols.[31] Fewer subjects presented with maxillary incisors that were in front or on GV. The majority of subjects presented with maxillary incisors behind GV. A higher sample size may have increased numbers in all categories, thus strengthening the results. Although the reliability and reproducibility of the method to find NHO was not statistically evaluated and could introduce imprecision in measurements, previous studies have shown good reproducibility with NHO.[24] Additional studies with similar protocols are needed to find the optimal AP maxillary incisor position in various genders and ethnicities.

Conclusions:

- Among orthodontists and laypersons combined, the optimal AP maxillary incisor position in Caucasian males was found to be 1.5mm behind GV.

- Orthodontists rated the optimal AP maxillary incisor position as 1.1mm behind GV, while laypersons rated the optimal AP maxillary incisor position as 2.4mm behind GV. While statistically significant, the difference was only 1.3mm.

- There were no differences in AP ratings among orthodontists based on years in practice, among laypersons based on age group, or between genders of orthodontists and laypersons.

- GV may be a useful landmark for assessing the AP position of the maxillary incisor in Caucasian males.

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