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ANTEROPOSTERIOR (AP) RELATIONSHIP OF THE MAXILLARY CENTRAL INCISORS TO THE FOREHEAD IN ADULT AFRICAN AMERICAN FEMALES

by

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A THESIS

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2015

ANTEROPOSTERIOR (AP) RELATIONSHIP OF THE MAXILLARY CENTRAL INCISORS TO THE FOREHEAD IN ADULT AFRICAN AMERICAN FEMALES

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ABSTRACT

Objective: Determine the optimal anteroposterior (AP) relationship of the maxillary central incisors to the forehead in adult African American females (AAF). **Materials and Methods:** Smile profile photographs of 48 AAF with optimal AP incisor positions (control); 49 seeking/wanting orthodontic treatment (Group 1), and 53 not seeking/wanting treatment (Group 2) were acquired. All images were scaled to life-size and printed. The AP position of the maxillary central incisors and forehead inclination were measured relative to reference lines. **Results:** The mean AP position of the maxillary central incisors relative to Glabella Vertical (GV) for the controls was 8.58 ± 3.96 mm ahead of GV. The mean AP position for Group 1 was 11.3 ± 4.32mm ahead of GV. The mean AP position for Group 2 was 11.1 ± 4.65 mm ahead of GV. For controls, a strong correlation between the AP position of the maxillary central incisors and forehead inclination was found. **Conclusion:** The forehead is a reliable landmark for AP maxillary incisor positioning in the AAF population seeking improved facial harmony. A prediction equation for the optimal positioning of the upper incisor for AAF is proposed. The AP relationship of the upper central incisor to the forehead varies with ethnic background.

Keywords: Incisors, Forehead, African American Females, Six Elements, landmark, anteroposterior jaw position

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LIST OF ABBREVIATIONS

AAF ..... African-American Female

AP ..... Anteroposterior

CF ..... Caucasian Female

DALL ..... Dental Anterior Limit Line

FA ..... Facial Axis

FALL ..... Forehead Anterior Limit Line

FFA ..... Forehead's Facial Axis

FI ..... Forehead Inclination

G ..... Glabella

GALL ..... Goal Anterior Limit Line

GV ..... Glabella Vertical

ICC ..... Intra-Class Correlation Coefficient

STCA ..... Soft Tissue Cephalometric Analysis

TVL ..... True Vertical Line

TX ..... Treatment

CHAPTER 1

INTRODUCTION

Many studies involving hard/soft tissue cephalometric and profile standards for Caucasians have been published, but to date there are no studies that emphasize the ideal individualized position of the upper incisor for African Americans. The development of such a norm will aid the orthodontist in creating the best diagnosis and treatment plan for the significant and increasing female African American population seeking orthodontic care. These results will be especially useful to orthodontists and oral surgeons when planning combined orthodontic and orthognathic surgery cases, through the use of prediction analyses such as the STO (surgical treatment objective) or the VTO (visual treatment objective).

Importance of This Study

Currently, 13.2% of the total United States population, 26.6% of the total Alabama population, and near 50% of population in metropolitan areas are African American. This is leading to an increasing number of African Americans seeking orthodontic treatment.[1] Nearly all studies provide normative data for Caucasians and the most recent analyses (Soft Tissue Cephalometric Analyses[2] and Andrews Element II[3]) which incorporate the soft tissue and are esthetically driven fail to provide African American normative values. In order to be diagnosed and treatment planned consistently,

a reliable landmark which is stable must be utilized so that the clinician can place the upper incisor in the correct position for the African American female population seeking orthodontic care. Even though normative values for upper incisor location have been created, most have not addressed the African American population. The ones that have established African American norms all utilize arbitrary landmarks that have no scientifically proven correlation to facial balance and harmony. This is an important concept to understand since treating strictly to normalize patient's values to cephalometric norms has been challenged and could actually have a detrimental effect on the patients profile and esthetic outcome.[4-11]

Orthodontic Treatment Goals

Achieving oral and facial harmony for a patient involves setting attainable and defendable goals in all three planes of space. Treatment goals for the position of the upper incisor need to be defined by referents and landmarks. A landmark is a point or line representing stable anatomical structures (i.e. Goal Anterior Limit (GALL) or Glabella Vertical (GV); discussed later). A referent is a point or line representing anatomy of a tooth or jaw whose position is being measured relative to this landmark (i.e. Upper Incisor; discussed later). Clearly defined referents, landmarks, and goals are necessary in order to measure, diagnose, treatment plan, communicate, execute, and verify our treatment goals as orthodontists. Dr. Timothy Tremont states, "If our profession could agree upon defendable referents, landmarks, and goals we could then approach science. We could then expect the work of our specialty to be exact, repeatable, and easier to learn."[12]

Cephalometric-Based Treatment Planning

Overview

Following World War II, cephalometric analyses gained widespread use in diagnosing and treatment planning.[13] Past work has yielded a plethora of cephalometric and profilometic measurements to improve the prediction of the most proper position of the maxillary incisors, but each have their diagnostic and esthetic drawbacks. Most utilize internal referents and landmarks which are highly variable and unpredictable in regard to their ability to create an esthetic outcome since peri-oral soft tissue structures do not consistently convey hard tissue structure location. The frustration also lies in the fact that different diagnoses and treatment plans are often generated when different cephalometric analyses are used to examine the same patient. This implies not only a lack of consistency with diagnosis, but also fosters a subjective treatment planning approach.[14]

Drawbacks and Considerations

Cox et al stated that cephalometric analyses provide normative values for various hard tissue references, yet it has been shown that good facial harmony can exist within a wide range of cephalometric values.[15] Even though normative values for upper incisor location have been created, most have not addressed the African American population. As mentioned earlier, previous African American norms have all utilized arbitrary landmarks that have no scientifically proven correlation to facial balance and harmony. Traditional cephalometric goals are based on averages, so creating tooth and jaw positions that are uniquely correct for each person is difficult to achieve consistently.[16] This is especially true when the orthodontist tries to predict soft tissue outcome using

only hard tissue values since it has been proven that soft tissue structures do not reliably convey hard tissue structures.[17] Holdaway determined that patients for whom orthodontic treatment adhered only to cephalometric standard did not meet the esthetic principles stated in his article.[18] Peck and Peck found that attractive faces were more protrusive and fuller than cephalometric standards would like to permit.[19] Within the fields of orthodontics and oral surgery, the multitude of diagnostic methods and the various referents and landmarks utilized have blurred our vision in regard to creating predictable treatment plans for our patients, particularly if they are from diverse ethnic backgrounds.

Paradigm Shift

In recent years a new paradigm in the orthodontic progression has shifted our treatment planning approach from a cephalometric-based diagnosis to an esthetic-based one. Both the inconsistencies in cephalometric-based diagnosis and the lack of predictable esthetic outcomes has led to the creation of analyses that utilize external landmarks to guide our diagnosis and treatment planning. In order to do so properly, one must know the normal range of soft tissue traits while concomitantly accounting for familial and ethnic variations. Currently, only Caucasian norms exist for these most recent analyses.

Lower Incisor Focus

Charles H. Tweed prescribed to the idea that the mandibular dental arch plays a key role in both the stability and esthetics of a case. He stated that "facial esthetics are better with a dentition in balance, regardless of the degree of the irregularity of arrangement of the teeth, than when the irregularities are corrected at the expense of loss of dental balance."[20] Essentially he advocated for an upright lower incisor that was stationed within the alveolar process and over medullary bone with an angle ranging from 85° to 93° in relation to the mandibular plane. This range of lower incisor angle is also corroborated by Allan Brodie and Holly Broadbent and historically has been considered a major factor in the orthodontic treatment objective.[21,22] Holdaway proposed that the lower incisor and pogonion distance in millimeters to the NB line should be a one to one relationship in order to obtain ideal facial contour and lower incisor stability.[18] The stability of a 'Tweed' incisor has been refuted multiple times in the literature. A recent article by Janson et al concluded that proclining the lower incisors does not make the treatment result less stable.[23] Even though the authors did not indicate how much proclination was acceptable, a recent thesis out of the Saint Louis University showed that there was not a statistically significant difference in incisor irregularities of cases with a change in the lower incisor angle $\geq 4°$ with those with a change $<4°$.[24] This implies that the stability is the same whether the lower incisor angle is proclined more than 4° or not. These results were supported by another study which showed no difference in irregularity index between a group whose lower incisors were proclined 10° lower incisors with a group who has minimal change in incisor inclination.[25] Not only has the stability of the

'Tweed' incisor been debunked, but Peck and Peck showed that the profile produced in Tweed's cases fit a very narrow esthetic model which is not the norm in our current society.[19] Today, the general public admires a full, more protrusive pattern.

Soft Tissue Profile

Traditional orthodontic treatment planning uses profile outlines to assess facial attractiveness with particular emphasis on the horizontal lip position in relation to reference lines. Currently, several analytic reference lines are utilized to assess the AP position of the lips which in turn dictates the orthodontist treatment plan for the position of the upper incisor. The five most common reference lines used by most orthodontists are the Ricketts E-line,[26] Steiner's S Line (S1),[27] Holdaway's H-Line,[28] Burstone's B-Line,[29] and Sushner's S-Line (S2).[30] In relation to the African American population, only norms for the H-Line, E-Line, and S1 line have been published in a study conducted by Sushner.[30] The study showed that all the African American populations were more protrusive in relation to all three reference lines. Sushner also concluded that the standards of Ricketts, Steiner and Holdaway are not applicable to African American individuals. The main drawback of using the aforementioned reference lines is the extreme variability of the nose and chin and the lack of hard tissue structure correlation. None of these analytical tools allows the orthodontist to predictably place the upper incisor and all were shown to have fairly low sensitivity and consistency values.[31] Predicting lip changes based on dentoalveolar movement is complex and dependent on ethnicity, skin thickness and adaptation. Also worth noting is a study by Kasai which stated that the smile is dynamic and lip position can change due to excessive/lack of mobility, skin tonicity and muscle pull

variations.[32] All of these points make using the soft tissue profile reference lines inconsistent when diagnosing and planning treatment for an orthodontic case.

Problems with Soft Tissue Profile Repose Analyses

The AP position of the maxillary incisor effects the appearance of the soft tissue profile in both repose and animation and can fortunately be manipulated by orthodontic and/or surgical techniques. Recently, great attention has been paid to obtaining optimal facial profile esthetics while concomitantly establishing ideal occlusal relationships, function, and stability.[33] In order to do so, the soft tissue-hard tissue relationship in a profile view should be included in every orthodontist diagnostic work-up in efforts to obtain the best maxillary incisor AP position for that individual patient. It can be misleading to treat orthodontic patients utilizing repose photographs due to the inconsistency of the diagnostic information yielded. Also, an orthodontist's opinion of a harmonious outcome in profile repose does not always match their opinion in a dynamic profile smile. This can lead to very different diagnosis of the patients underlying skeletal/dental problems, which in turn leads to an unpredictable and possibly poor esthetic outcome (Figure 1, A-C). It is important to note that until recently, facial balance and AP positions of the jaws was assessed utilizing the repose profile only.

Figure 1 (A-C). Drawbacks of Assessing Facial Harmony in Repose.

Note: From [or adapted from] "Orofacial Harmony" by Lawrence F. Andrews, 2001, Andrews Journal or Orthodontics and Orofacial Harmony, vol. 1, no. 2, pg. 13; Spring 2001. Copyright 2001 by the Lawrence F. Andrews. Reprinted [or Adapted] with permission.

The optimal harmonious range of the soft tissue in a repose profile is much greater than the optimal range for the maxillary incisors in a smiling profile. Essentially, it is much more critical to precisely set an upper incisor AP goal in a smiling profile photograph because the range of perceived harmony is much less forgiving. Previous studies have shown that there is a statistically significant difference in esthetic perception between each AP millimetric increment of the maxillary incisor position during the smiling profile. Both lay persons and orthodontists could rate the facial balance/harmony in one millimeter increments, whereas there is a larger range of optimality for one millimeter morphs of patients judged in repose profile.[34] Later, Cao et al confirmed the validity of an ideal AP position of the incisor in a sagittal view, concluding that its position is significant for both smiling profile esthetics and facial harmony to be optimal.[35]

Cephalometric-Based Upper Incisor Position: Hard-Tissue Focus

Various cephalometric analyses exist not only to describe the craniofacial complex but also to help aid the clinician with the placement of the upper incisor in all three planes of space. Most of these analyses rely on reference points or planes in the cranial base that serve as reference points by which to measure the incisor position and have emphasis on the hard tissue relationships. The most common reference planes utilized in analyses that help aid in placement of the upper incisor include Sella-Nasion, Frankfort Horizontal, Nasion-A point, AP plane, palatal plane, occlusal plane, mandibular plane, and the true vertical line (TVL). Out of these, only three have well established African American norms, but none of them have a soft tissue or esthetic focus. They merely prove that the upper incisor is positioned more anteriorly in African American individuals, but their inclination is similar to that of Caucasians.[4,6,8] The TVL is the only reference plane which is part of an analysis that is soft tissue driven but African American norms are not established and issues still arise in regard to the variability of the TVL placement, especially in individuals with lip thickness variability. Also, since all the reference planes with the exception of TVL have referents within the cranial base, inherent landmark identification variations are inevitable, producing diagnostic inconsistency. The same malocclusion when evaluated with each of the aforementioned reference planes can provide a different diagnosis, treatment plan, and therefore a different outcome.

Hard-Tissue/Soft-tissue Combined

In today's society, emphasis is being placed on treatment planning based on facial harmony/balance of both hard and soft tissues in both frontal and profile views. Currently, two treatment systems utilize external landmarks to aid in diagnosis rather than the internal skeletal landmarks found in traditional cephalometrics. Both focus their diagnosis and treatment planning on the anterior soft tissue balance to the posterior occlusion and function. This is opposite to traditional cephalometric analyses which rely on a diagnosis from internal structures and then build treatment plans following an inside-out path, namely from the occlusion to the facial soft tissue. Also, traditional cephalometric analyses have no universally accepted standards for facial harmony/balance which makes placement of the teeth and jaws more of an art than a science. The Arnett soft tissue cephalometric analysis (STCA) positions the teeth and jaws based on soft tissue anterior-posterior landmarks to a defined vertical line running through or near Subnasale called the TVL. The Andrews's Six Elements of Orofacial Harmony™ utilizes a frontal facial plane identified as GALL which creates a landmark for diagnosing and treatment planning AP jaw positions and most importantly, the position of the maxillary incisor.

Andrews Six Elements Overview

Dr. Andrews's Six Elements philosophy began in the early 1960's when he collected study models from dentists and orthodontists and discovered casts of 120 patients who were considered to have excellent occlusion. Among these casts, six characteristics were common to all and he termed these traits the Six Keys of Optimal Occlusion.[36] These six keys now make up Andrews Element I and were the basic foundation for the development of the Straight-Wire Appliance System in 1970. It was not until the 1980's that Andrews's began examining photos of models from magazines and found shared characteristics in the group of photos which essentially led to the development of the Six Elements ™ Philosophy. The philosophy highlights six areas that orthodontists can utilize when diagnosing and treatment planning a case and include: 1) Arch Shape and Length, 2) Anterior-posterior jaw positions, 3) Buccolingual jaw widths, 4) Vertical jaw measurements, 5) Pogonion prominence, and 6) Occlusion. This diagnostic method uses landmarks and referents to properly position the aforementioned elements and fabricate a treatment plan for each individual that is unique to their face and based on harmony and balance, not norms.[16] Since this thesis only entails optimizing Element II for the African American female, only this element will be discussed in detail. Information on Element I, III, IV, V, and VI can be found in previous papers written by Andrews.[3]

Element II Introduction

The maxilla is in Element II position when the maxillary incisor is Element I with the Facial Axis (FA) point touching the GALL. The mandible is in Element II if it is in Key I occlusion with an Element II maxilla. In order to properly determine the Element II position of the jaws, both clinical and radiographic data must be examined. Element II position utilized the forehead as a clinical landmark for positioning of the upper incisor FA point in the AP dimension. The main reasons for utilizing the clinical forehead as a landmark are: 1) there is a correlation between the prominence and inclination of the forehead and the anterior positions of the teeth and jaws, and 2) the AP relationship of the maxillary incisor to the forehead remains unchanged throughout the patient's life.[3] Further reasons will be explained in a later section. Even though current research has shown that the shape of the clinical forehead is not important and the upper incisor should be placed in line with Glabella Vertical; this only pertains to the Caucasian population. Therefore, forehead shape must be included in the discussion when assessing the AP position of the upper incisor for the African American female population, as we do not currently know if there is a clinically meaningful correlation between its shape and the upper incisor position. The forehead is classification can be round, straight, or angular (Figure 2), and is used to aid in determining the forehead facial axis (FFA, Figure 3). The FFA point is the midpoint of the clinical forehead and is a landmark used for forehead angulation measurement. For straight foreheads, the clinical and anatomical foreheads are the same. Therefore, the FFA is the midpoint between trichion and glabella. For angular and round foreheads, the clinical (superior to glabella) is different from the anatomical forehead (trichion to glabella).

Figure 2. Forehead Shapes

Figure 3. FFA Point Determination

Note: From [or adapted from] "Diagnostic Records" by Will A. Andrews, 2013, *Syllabus of the Andrews Six Elements Orthodontic Philosophy*, pg.1-2. Copyright 2001-2013 by Lawrence F. Andrews. Reprinted [or Adapted] with permission.

GALL Construction

In order to find the GALL, the FFA must be located. The FFA point is the midpoint of the clinical forehead on the forehead's sagittal plane and is adjusted accordingly based on the patient's forehead shape (straight, angular, or rounded). Clinically, the upper incisor is measured in regard to how anterior or posterior it is located in relation to the FFA point, and this position is known as the dental anterior limit line (DALL). A dot is placed opposite of this distance in the AP direction on the patient's cephalometric tracing. This serves as the second point to drop a vertical line from the FFA and creates the Forehead's Anterior

Limit Line (FALL). The forehead inclination is then measured. This is done by measuring the angle between the line connecting Trichion (Superion) and Glabella and the FALL. If the inclination is 7° or less, the GALL is the same as the FALL. If the inclination exceeds 7° the GALL is calculated by multiplying 0.6 millimeters times the amount the foreheads inclination exceeds 7°. This distance is then added to the AP position of the FALL. It should be noted that the GALL should not exceed Glabella unless it is demanded by the patient (Figure 4). By drawing the GALL line on the lateral head film, a reliable and individualized landmark is established to facilitate the ideal placement of the upper incisor via conventional orthodontics or surgically. This in turn provides the orthodontist with an upper jaw and upper incisor position that are optimal. The occlusion and position of the lower jaw can then be treatment planned to create oral and facial harmony and is further discussed in Elements III-VI.[3]

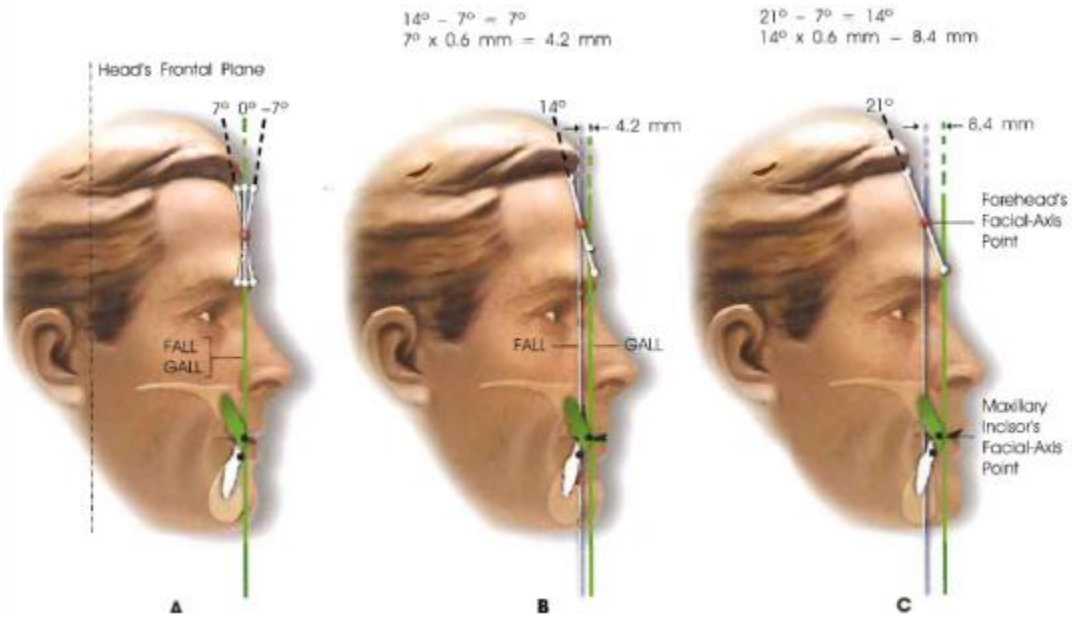


Figure 4. Schematic showing GALL construction

Note: From [or adapted from] "The Six Elements of Orofacial Harmony ™" by Lawrence F. Andrews, 2000. *Andrews Journal of Orthodontics and Orofacial Harmony*, vol.1, no.1, Winter, 2000. pg. iii. Copyright 2001-2013 by Lawrence F. Andrews. Reprinted [or Adapted] with permission.

GALL Modification

A recent thesis at West Virginia University showed that 'Glabella Vertical' is where the GALL ends up plus or minus one millimeter in most Caucasian patients. In 95% of the population the GALL is located within one millimeter, and in 99.7% of the population it is located within one and a half millimeters. This means that a Glabella Vertical (GV) measurement can be used instead of FALL and forehead inclination to determine maxillary incisor position. In essence, this establishes the new frontal plane as Glabella Vertical, but its application can only be reliably utilized in Caucasian patients. Intra-rater and Inter-rater reliability for judging the frontal plane was clinically insignificant meaning that Glabella Vertical is a reliable way to establish the frontal plane of the face and can be implemented with confidence.[37]

Related Research Findings

Similar studies have been conducted with Caucasian males and females and yielded promising results which warrants further investigation in groups of various ethnic backgrounds. . In the female version of the study, ninety-four photographs of adult white females with good facial harmony (control sample) were compared with ninety-four photographs of adult white females seeking orthodontic treatment (study

sample). All images were of the face in profile with the maxillary central incisors and the forehead in full view. Reference lines were constructed to assess the anteroposterior position of the maxillary central incisors as well as forehead inclinations. The male version of this study was nearly identical in regard to materials and methods and similar results were found. In both the male and female groups, the control samples maxillary central incisors were positioned between the FFA point and glabella. In the study groups for both genders, a majority of the maxillary central incisors were positioned posterior the FFA point. Forehead inclination and maxillary incisor positions were also significantly correlated in both control groups whereas the sample groups showed a poor correlation. In essence, both studies showed that the forehead is an important landmark for anteroposterior maxillary incisor positioning for adult Caucasian patients seeking improved facial harmony.[38,39]

Schlosser et al found that Andrews' method of profile assessment was "a useful method to evaluate attractiveness relative to the maxillary incisor position." They utilized smiling photographs taken of a female subject who best fit the chosen soft tissue normative values and whose maxillary incisors were in an Element II position. The photograph was manipulated to simulate maxillary protrusion and retrusion at 1-mm increments to a maximum of +/- 4mm. Panels of orthodontists and non-orthodontists scored the attractiveness of the photographic variations utilizing a visual analogue scale. Resulted showed that the 4mm retrusive photograph was significantly less desirable than all others, indicating that a fuller and more protrusive maxillary dentition is perceived as more desirable. Also, there is a statistically significant difference in esthetic perception between each anteroposterior millimetric increment of the maxillary incisor position during the smiling profile.[34] Later, Cao et al confirmed the validity of an ideal AP

position of the incisor in a sagittal view, concluding that its position is significant for both smiling profile esthetics and facial harmony to be optimal.[35]

Advantages of an External Referent

Many advantages for using the forehead as the primary referent in determining the AP goals of the upper incisor have been proposed by Andrews. The five main reasons include: (1) the forehead is a part of the face, internal referents are not, (2) for individuals with facial harmony there is a correlation between the prominence and inclination of the forehead and the prominence of the dentition, (3) the forehead can be seen clinically, internal referents cannot, (4) the shape and AP position of the forehead is more likely to be normal than are the shapes and AP of structures that comprise the middle of lower thirds of the face, and (5) barring environmental intervention, the AP relations of the upper incisor to the forehead remains the same throughout life, whereas the AP relationship of the upper incisor to internal referents do not stay the same throughout life.[16]

Specific Aims of the Study

Primary: This study aims to investigate the AP relationship of maxillary central incisors to the forehead in adult African American females seeking/wanting orthodontic treatment versus those who have good facial harmony. This dental position will be evaluated in relation to Glabella Vertical, as well as forehead inclination.

Secondary: Determine if there is a difference between the maxillary incisor-forehead inclination relationships of Adult White females versus Adult African American females.

Null Hypotheses

Null Hypothesis (H_0-1): There is no significant difference in the position of the maxillary central incisors with reference to the forehead facial axis (FFA) point between Adult African American females with good facial harmony versus those who were seeking/wanting orthodontic treatment.

Null Hypothesis (H_0-2): There is no significant difference in the correlation of the maxillary central incisors with the inclination of the forehead between adult African American female patients with good facial harmony versus those who were seeking/wanting orthodontic treatment.

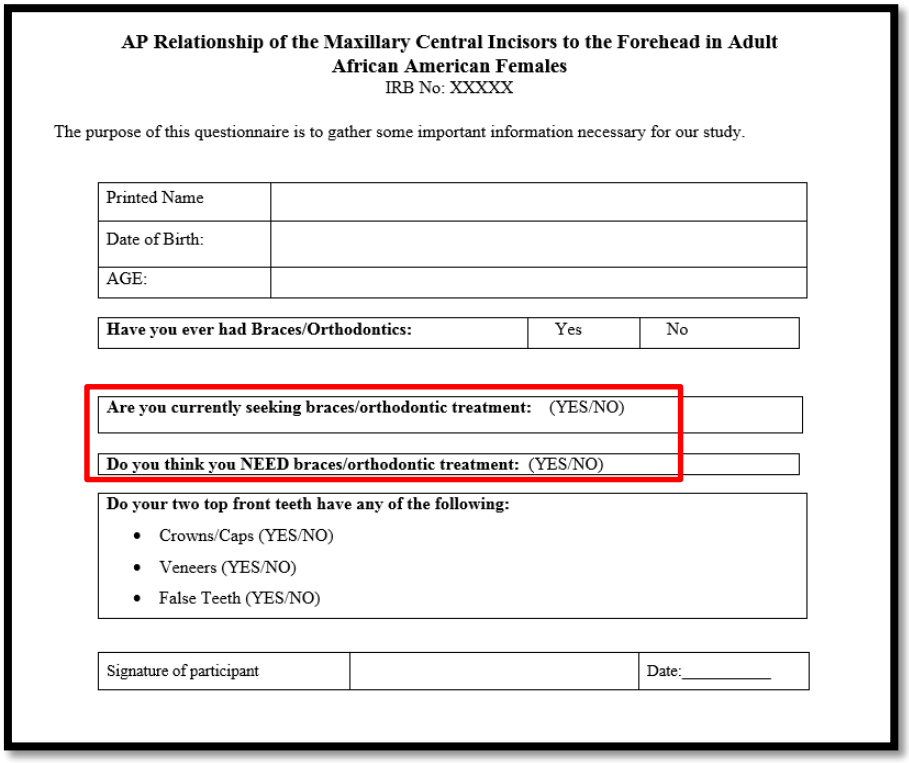
Null Hypothesis (H_0-3): There is no difference between the AP relationship of the maxillary central incisors to the forehead between adult African American females and adult Caucasian females.

CHAPTER 2

MATERIALS AND METHODS

Forty-eight photographic images of adult African American females with optimal AP incisor positions (control sample) will be compared with forty-nine photographs of adult African American female's actively or passively seeking/wanting orthodontic treatment (study sample one), and fifty-three photographs of subjects who are not seeking/wanting treatment (study sample two). All images will be of the face in smile profile with the maxillary central incisors and the forehead in full view. The subjects were consecutively recruited from the UAB Orthodontic Clinic and/or UAB hospital. A self-assessment was completed by all subjects utilizing a questionnaire in order to divide the sample group into two subgroups (seeking/wanting treatment versus not seeking wanting treatment, Figure 5). Photos were taken at a fixed distance to the subject's mid-sagittal plane and a one-hundred millimeter ruler located at the patient's mid-sagittal plane was utilized to 'scale' the image to life-size. All photographs were then printed on 8.5 x 11 paper. Landmark points for the forehead were identified and marked (Trichion, Superion, Glabella, and the FFA point). Three reference lines were then constructed to assess the AP position of the maxillary central incisor, as well as forehead inclinations on the facial photograph. The two vertical reference lines are Glabella Vertical and FFA point, and the third was utilized to measure forehead inclination. The AP position of the upper incisor was then measured via the distance between Glabella Vertical and the upper maxillary

incisor FA point using a millimetric ruler to the closest 0.5mm (Line 3 to Upper Incisor FA Point). Forehead inclination was measured as the angle between line one and two using a protractor to the closest whole degree. Distance measurements were then scaled to life-size by utilizing the one-hundred millimeter ruler with a simple magnification calculation (Figure 6).



AP Relationship of the Maxillary Central Incisors to the Forehead in Adult African American Females

IRB No: XXXXX

The purpose of this questionnaire is to gather some important information necessary for our study.

Printed Name	
Date of Birth:	
AGE:	

Have you ever had Braces/Orthodontics:	Yes	No

Are you currently seeking braces/orthodontic treatment: (YES/NO)

Do you think you NEED braces/orthodontic treatment: (YES/NO)

Do your two top front teeth have any of the following:

- Crowns/Caps (YES/NO)
- Veneers (YES/NO)
- False Teeth (YES/NO)

Signature of participant		Date:_____

Figure 5. Questionnaire Provided to Subjects for Study Group Allocation

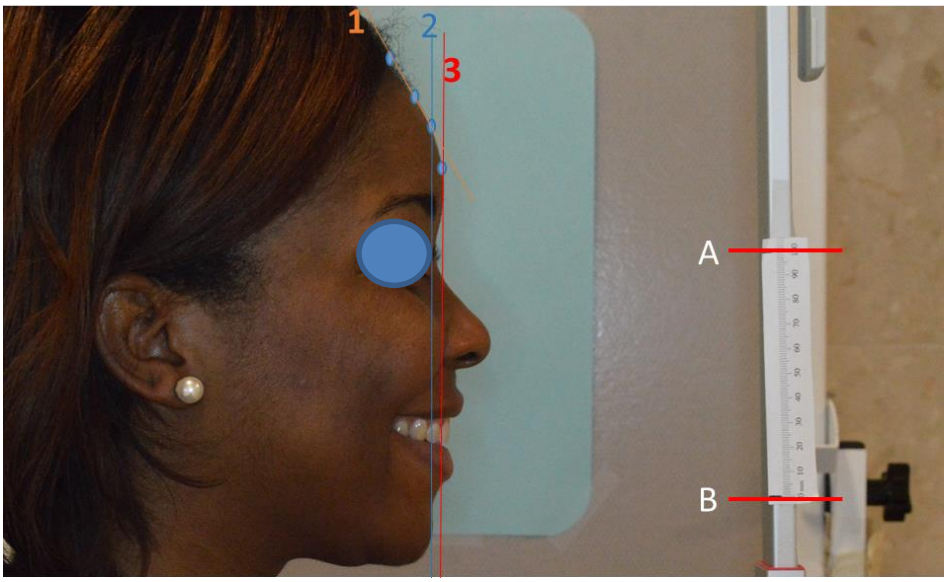


Figure 6. Reference Line Construction. Two vertical reference lines (FFA Point Vertical and Glabella Vertical, Lines 2 and 3 respectively). Angle between 1 and 2 is forehead inclination. Lines ‘A’ and ‘B’ demarcate 100mm ruler utilized for scaling.

Subject Selection Criteria

- Subjects need to be female and of African American descent
- Subjects between the ages of 18-60 years
- Subjects having no major dento-facial deformities
- Subjects who currently are not undergoing orthodontic treatment with conventional braces

Control Group Allocation

Forty-eight 'control' profile smiling photographs were selected based on the individual having an optimal upper incisor AP position via a questionnaire-type assessment given to nine faculty orthodontists and six residents at the University of Alabama at Birmingham orthodontic residency (Figure 7). The panel of fifteen raters were given a questionnaire-type survey to determine, on each picture, if they would like to move the maxillary incisor backwards, forward or keep it in the same position. Profile smiling photographs were shown to these three groups with the lower third of the face not in view (Figure 8). In order to be allocated into the control group, fourteen out of fifteen raters needed to agree that they wanted to keep the upper central incisors in the same anteroposterior position.

Please indicate whether you would prefer the upper incisors/front two teeth to:

Move Backward (B)

Stay the Same (S)

Move Forward (F)

Subject	Backward (B)	Stay the Same (S)	Forward (F)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Figure 7. Questionnaire Provided to the Fifteen Raters for Upper Incisor Assessment

Figure 8. Example of Photo Utilized in Questionnaire for Raters

Study Group Allocation

If a subject was not selected by fourteen of fifteen raters as wanting to keep the upper incisor in the same anteroposterior position, that subject was then automatically allocated to the study group. These remaining 102 subjects were then further broken down into two groups based on participants own answers to a questionnaire (Figure 5), one actively/passively seeking orthodontic treatment (n=49), and one not seeking orthodontic treatment (n=53).

Statistical Analysis

Both descriptive and comparative statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA) software for analysis and R 3.2.0 for graphical displays. The means, standard deviations, and ranges were calculated for maxillary central incisor positions in relation to the forehead, as well as forehead inclination in all subjects. The means for both samples were compared using a paired two-tailed t-test. All samples from this study were compared to published values for Caucasian Females to note any differences. P-Values of 0.05 or less indicated significant differences. A post-hoc analysis revealed a minimum of 80% Power was reached in all comparisons between groups noted with significant differences. A second-order regression analysis was performed between maxillary central incisor position and forehead inclination for all sample groups.

Intra/Inter-Rater Reliability

Measurements were made by two independent raters for both parameters (anteroposterior position of the upper incisor and forehead inclination) at two different time points. Time points were set at two weeks apart to assess intra/inter-rater reliability and consistency of quantitative measurements made by the different raters. Table 1 shows the Intra-Class Correlation Coefficients (ICC) that were computed for both anteroposterior position and forehead inclination for both raters in regard to intra-rater reliability (Rater A ICC = 0.985, 0.958 respectively; Rater B ICC = 0.976, 0.979 respectively). Table 2 shows the Inter-rater reliability ICC that was computed for both time points and raters for anteroposterior position (Time Point 1 &2 ICC: 0.972, 0.928 respectively) and forehead inclination (Time Point 1 &2 FI ICC =0.869, 0.841 respectively).[40-42]

Table 1.

Intra-Rater Reliability for AP Position of the Upper Incisor and Forehead Inclination Measurements for Both Time Points

Intra-Class Coefficient (ICC), Variable	Rater A	Rater B
Anteroposterior Position of Upper Incisor	0.985	0.976
Forehead Inclination	0.958	0.979

Table 2.

Inter-Rater Reliability for AP Position of the Upper Incisor and Forehead Inclination Measurements for Both Time Points

Intra-Class Coefficient (ICC) , Variable	Time Point 1	Time Point 2
Anteroposterior Upper Incisor Position	0.972	0.928
Forehead Inclination	0.869	0.841

CHAPTER 3

RESULTS

Sample Size and Power

The sample size included a total of 150 subjects (48 Control, 49 Sample Seeking Treatment, 53 Sample Not Seeking Treatment). The sample consisted of African-American subjects ages 18-60. Adequate sample size was dictated by the study having a minimum of 80% power. A post-hoc analysis was conducted to calculate the power of the study for the sample size utilized. Based on the sample size of each group of subjects, the differences noted between all groups reached a minimum of 80% power. 89% power was achieved when determining differences between the control and sample group seeking treatment. 83% power was achieved when determining differences between the control and sample group not seeking treatment. 95% power was achieved when determining differences between the control and combined sample groups.

Measurements

Upper Incisor AP Distance to Glabella Vertical

Using the protocol discussed earlier, linear measurements to the closest 0.5mm were taken from the FA point of the upper incisor to Glabella Vertical (Figure 5, Line 3 to the FA point of the upper incisor) in all 150 subjects. This dictates the

anteroposterior position of the upper incisor in relation to the frontal plane (Glabella Vertical). Table 1 shows the results of the AP position of the maxillary central incisor in relation to Glabella Vertical for the control and study samples. For the control sample, the AP position of the maxillary central incisors relative to Glabella Vertical ranged from +1.7mm to +17.6mm, with a mean of +8.58 mm, and a standard deviation of 3.96. For the study sample seeking orthodontic treatment, the AP position of the maxillary central incisors relative to Glabella Vertical ranged from +1.7mm to +21.2mm, with a mean of 11.3 mm, and a standard deviation of 4.32. For the study sample not seeking orthodontic treatment, the AP position of the maxillary central incisors relative to Glabella Vertical ranged from 1.5mm to +20.0mm, with a mean of +11.1 mm, and standard deviation of 4.65 (Table 2). The maxillary central incisor position relative to Glabella Vertical was significantly different between the control sample and the study samples seeking treatment, not seeking treatment, and combined (P = 0.002, 0.005, 0.001 respectively; Table 3).

In the control sample, 21 subjects (44%) had maxillary central incisors positioned less than or equal to 7.5mm ahead of Glabella Vertical, 14 subjects (29%) had maxillary central incisors positioned between 7.5mm and 10.5mm ahead of Glabella Vertical, 7 subjects (15%) had maxillary central incisors positioned between 10.5mm and 13.5mm, and 6 subjects (12%) had maxillary central incisors positioned greater than or equal to 13.5mm. The average of the 21 subjects less than or equal to 7.5mm ahead of Glabella Vertical was 5.1mm, and the average of the 35 subjects less than or equal to 10.5mm ahead of Glabella Vertical was 6.7mm (Figure 9). In the study sample seeking/wanting orthodontic treatment, 9 subjects (18%) had maxillary central incisors positioned less than or equal to 7.5mm ahead of Glabella Vertical, 14 subjects (29%) had

maxillary central incisors positioned between 7.5mm and 10.5mm ahead of Glabella Vertical, 9 subjects (18%) between 10.5mm and 13.5mm, and 17 subjects (35%) greater than or equal to 13.5mm ahead of Glabella Vertical (Figure 10). In the study sample not seeking/wanting orthodontic treatment, 14 subjects (26%) had maxillary central incisors positioned less than or equal to 7.5mm ahead of Glabella Vertical, 11 subjects (21%) positioned between 7.5mm and 10.5mm, 9 subjects (17%) between 10.5mm and 13.5mm, and 19 subjects (36%) with maxillary central incisors positioned greater than or equal to 13.5mm ahead of Glabella Vertical (Figure 11).

Table 3

Anteroposterior Position (mm) of the Maxillary Central Incisors Relative to Glabella Vertical (Distance between Line 3 and the FA Point of the Upper Central Incisor)

Sample	n	Mean	SD	Min	Max
Control	48	8.58	3.96	1.7	17.6
Seeking Treatment	49	11.3	4.32	1.7	21.2
Not Seeking Treatment	53	11.1	4.65	1.5	20
Combined	102	11.2	4.48	1.5	21.2

Table 4.

Differences in Maxillary Central Incisor Position and Forehead Inclination Between Control and Study Samples.

Variable	Control	Seeking Treatment	Difference	p
AP Position, mean	8.58	11.3	-2.75	0.002
Forehead Inclination, mean	26.7	29.1	-2.43	0.05
	Control	Not Seeking Treatment	Difference	p
AP Position, mean	8.58	11.1	-2.48	0.005
Forehead Inclination, mean	26.7	27.4	-0.73	0.59
	Control	Combined	Difference	p
AP Position, mean	8.58	11.2	-2.61	0.001
Forehead Inclination, mean	26.7	28.2	-1.55	0.16

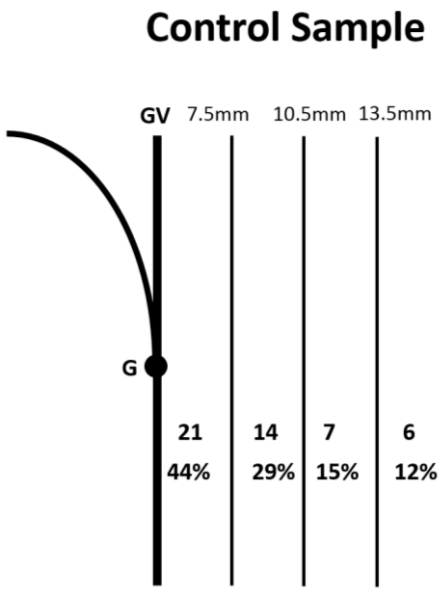


Figure 9. Distribution of the anteroposterior maxillary central incisor positions relative to Glabella Vertical (GV) for the Control Sample.

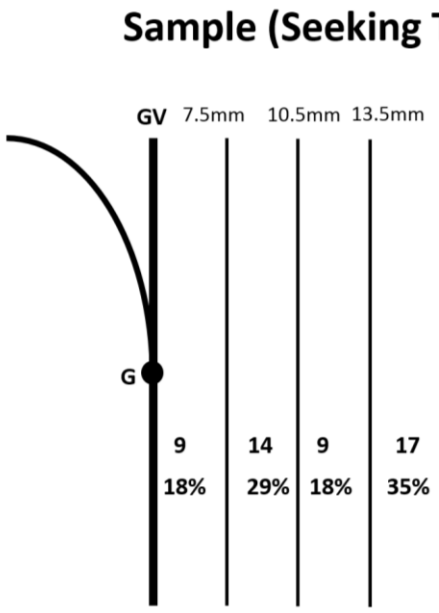


Figure 10. Distribution of the anteroposterior maxillary central incisor positions relative to Glabella Vertical (GV) for the Study Sample Seeking/Wanting Orthodontic Treatment.

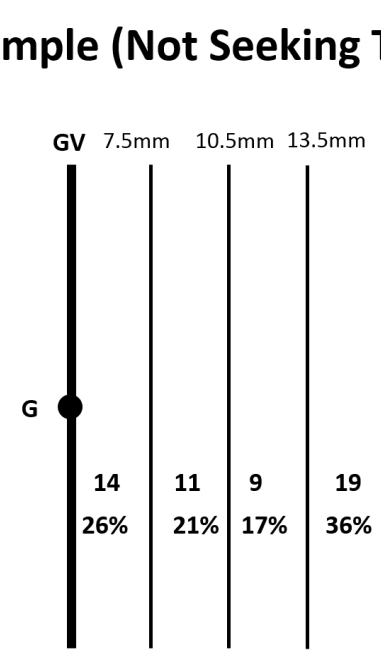


Figure 11. Distribution of the anteroposterior maxillary central incisor positions relative to Glabella Vertical (GV) for the Study Sample Not Seeking Orthodontic Treatment.

Forehead Inclination

Forehead inclinations to the closest degrees were measured based on the reference lines (Figure 6) which are dependent on patient's forehead shape (Figure 2), and was discussed earlier in this text. Table 3 shows the forehead inclination for the control and study samples. For the control sample, the forehead's inclination ranged from 3° to 39°, with a mean of 26.7° and standard deviation of 6.95. For the study sample seeking/wanting orthodontic treatment, the forehead's inclination ranged from 17° to 38° with a mean of 29.1° and a standard deviation of 5.13. For the study sample not seeking/wanting orthodontic treatment, the forehead's inclination ranged from 12° to 46° with a mean of 27.4° and a standard deviation of 6.65 (Table 4). Forehead inclination between the control sample and study sample seeking/wanting orthodontic treatment was

significantly different (P=0.05; Table 3). Forehead inclination between the control sample and the study sample not seeking treatment was not significantly different (P=0.59; Table 3). Forehead inclination between the control sample to the combined study sample was not significantly different (P=0.16; Table 3).

Table 5

Forehead Inclination of the Control and Study Samples (Angle Between Line 1 and 2).

Sample	n	Mean	SD	Min	Max
Control	48	26.7	6.95	3	39
Seeking Treatment	49	29.1	5.13	17	38
Not Seeking Treatment	53	27.4	6.65	12	46
Combined	102	28.2	6	12	46

Correlations

Forehead Inclination to Upper Incisor Position

Table 5 shows the results of the regression analysis between the AP maxillary central incisor position and forehead inclination for both samples. In the control sample, the AP positions of the maxillary central incisors were strongly correlated with forehead inclination (p for $\beta =< 0.0001$). In relation to Glabella Vertical, the AP position of the upper central incisor could be found by multiplying the forehead inclination by 0.3 and adding 0.42 mm (Figure 12). Utilizing the formula provided from the regression analysis, for every 5° the forehead is inclined greater than 0°, the upper incisor can be correspondingly placed 1.5mm more anterior to Glabella vertical. In the study samples (seeking/wanting orthodontic treatment, not seeking treatment, and combined) the AP positions of the maxillary central incisors were not as strongly correlated with the inclinations of the forehead (p for β =0.13, 0.07, and 0.017 respectively; Figure 13, Figure 14, Figure 15, respectively).

Table 6 shows the average forehead inclinations for the control group based on where the upper incisors fell in relation to Glabella Vertical. For those subjects in the control sample whose maxillary central incisors were less than or equal to 7.5mm ahead of Glabella Vertical, the average inclination of their forehead's were 23°, with a range of 3° to 32°. Control subjects whose maxillary central incisors fell between 7.5mm and 10.5mm had average forehead inclinations of 27°, with a range of 21° to 35°. Control subjects whose maxillary central incisors fell between 10.5mm and 13.5mm had average forehead inclinations of 30°, with a range of 25°-37°. Control subjects whose maxillary central

incisors were located greater than or equal to 13.5mm had average forehead inclinations of 33°, with a range of 26°-37°.

Table 7 shows the average forehead inclinations for study sample seeking/wanting orthodontic treatment based on where the upper incisors fell in relation to Glabella Vertical. Study subjects whose maxillary central incisors were located less than or equal to 7.5mm had average forehead inclinations of 28°, with a range of 25°-37°. Study subjects whose upper incisor was located between 7.5mm and 10.5mm had average forehead inclinations of 26°, with a range of 17°-34°. Study subjects whose upper incisor was located between 10.5mm and 13.5mm had average forehead inclinations of 30°, with a range of 19°-38°. Study subjects whose upper incisors fell greater than or equal to 13.5mm had average forehead inclinations of 30°, with a range of 19°-38°.

Table 8 shows the average inclinations for the study sample not seeking/wanting orthodontic treatment based on where the upper incisors fell in relation to Glabella Vertical. The average forehead inclination for those incisors that were located less than or equal to 7.5mm was 26°, with a range of 12°-38°. The average forehead inclination for those incisors located between 7.5mm and 10.5mm was 24°, with a range of 16°-34°. The average forehead inclination for those incisors located between 10.5mm and 13.5mm was 28°, with a range of 20°-35°. Lastly, the average forehead inclination for those incisors located greater than or equal to 13.5mm was 30°, with a range of 17°-46°.

Table 6.

Linear Regression of AP Position of the Upper Central Incisor and FI for all groups.

Sample	n	β	Intercept	p for β
Control	48	0.306	0.42	<.0001
Seeking Treatment	49	0.183	6	0.13
Not Seeking Treatment	53	0.174	6.29	0.07
Combined	102	0.177	6.2	0.017

Table 7.

Average forehead inclinations for the Control Group based on the relation of the upper incisor position to Glabella Vertical.

Upper Incisor Position In Relation to Glabella Vertical (mm)	Avg. Forehead Inclination (degrees)	Range (degrees)
≤ 7.5	23	3-32
7.5 – 10.5	27	21-35
10.5-13.5	30	25-37
≥ 13.5	33	26-37

Table 8.

Average forehead inclinations for the Study Group Seeking/Wanting Orthodontic Treatment based on the relation of the upper incisor position to Glabella Vertical.

Upper Incisor Position In Relation to Glabella Vertical (mm)	Avg. Forehead Inclination (degrees)	Range (degrees)
≤ 7.5	28	25-37
7.5 – 10.5	26	17-34
10.5-13.5	30	19-38
≥ 13.5	30	19-38

Table 9.

Average forehead inclination for the Study Group Not Seeking/Wanting Orthodontic Treatment based on the relation of the upper incisor position to Glabella Vertical.

Upper Incisor Position In Relation to Glabella Vertical (mm)	Avg. Forehead Inclination (degrees)	Range (degrees)
≤ 7.5	26	12-38
7.5 – 10.5	24	16-34
10.5-13.5	28	20-35
≥ 13.5	30	17-46

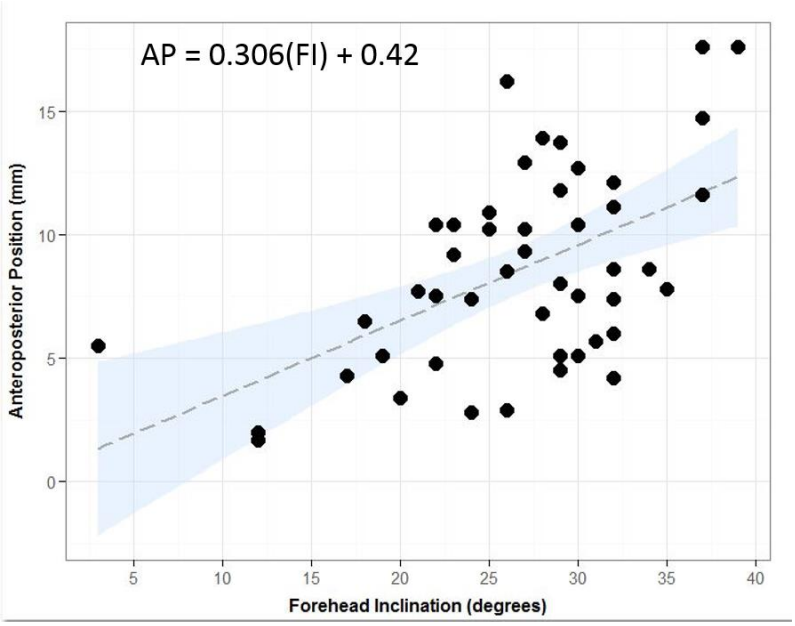


Figure 12. Change in anteroposterior maxillary central incisor position vs change in forehead inclination for the control sample, p for β =< 0.0001.

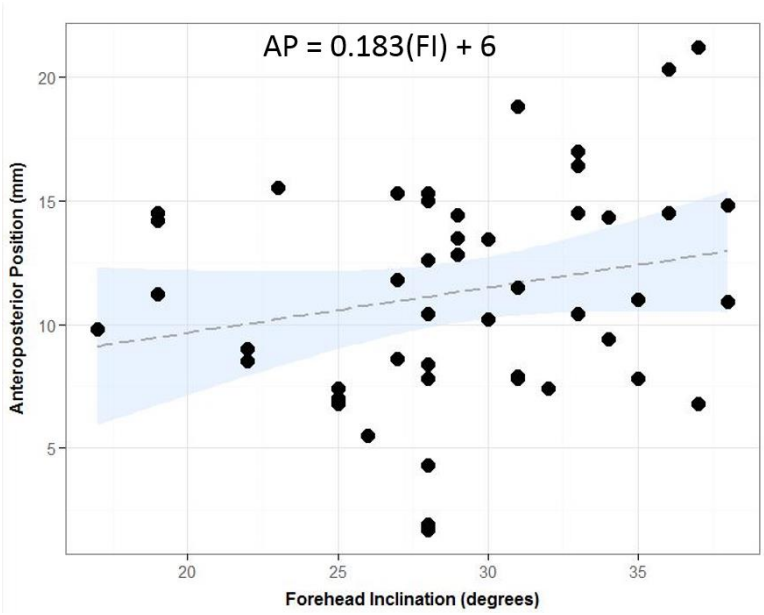


Figure 13. Change in anteroposterior maxillary central incisor position vs change in forehead inclination for the study sample seeking treatment, p for β = < 0.13.

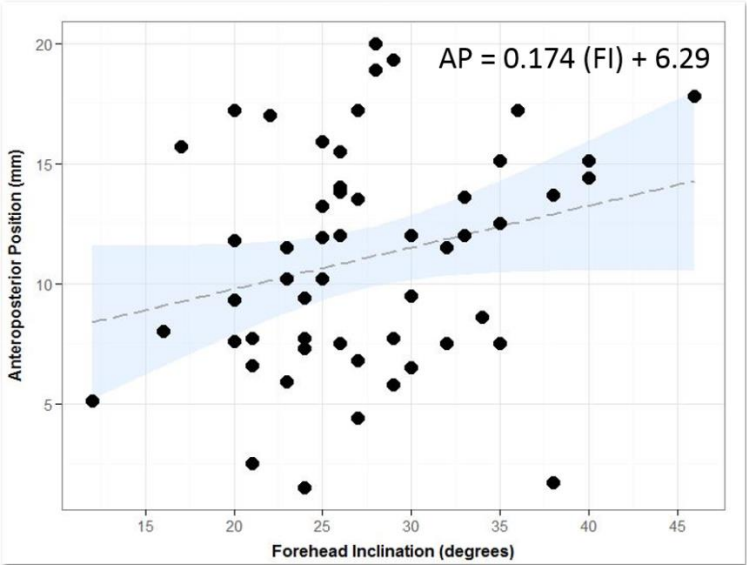


Figure 14. Change in anteroposterior maxillary central incisor position vs change in forehead inclination for the study sample not seeking treatment, p for $\beta = 0.07$.

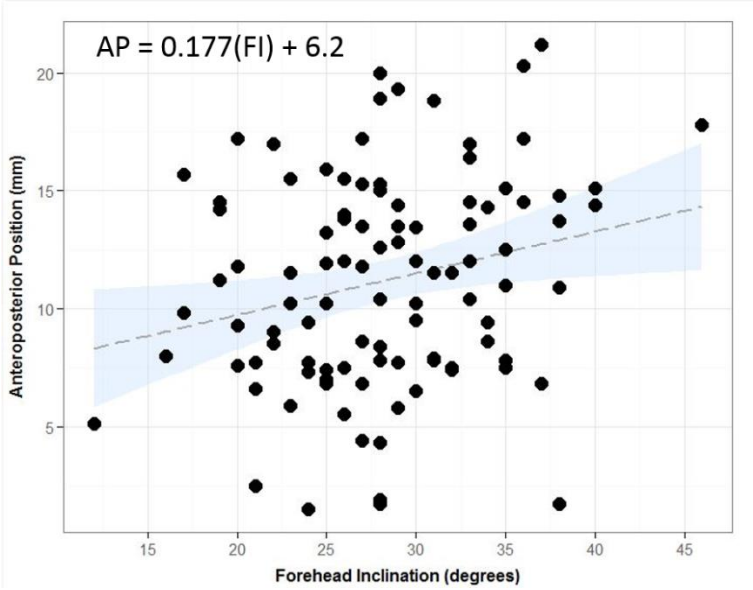


Figure 15. Change in anteroposterior maxillary central incisor vs change in forehead inclination for the combined study sample, p for $\beta = 0.017$.

CHAPTER 4

DISCUSSION

The main question addressed by this study is whether the same method proposed by Andrews and Adams et al for positioning the upper central incisors in relation to the forehead for Caucasian Males/Females can be utilized for the African-American female population.[38,39] The initial statement by Andrews, "The Six Elements of Orofacial Harmony are universal and work equally well for more than ninety percent of the patient population, regardless of race, age, or gender," was challenged in order to gain a better understanding of the best possible position of the upper incisor in African American females.[3] Support for this research was provided in a later publication by Andrews in which he states, "Additional studies are needed to extend these findings to other racial, age, and gender group."[38] The results of this study indicate that there is in fact a clinically relevant difference in the perceived ideal upper incisor position of African American females when compared to the aforementioned published studies of Caucasian females. Also, the findings of this study show that the forehead can be utilized as a reliable landmark when positioning the upper incisor in this population through the use of forehead inclination and soft tissue point Glabella. As discussed earlier, not only does relying on cephalometric analysis or repose soft tissue analysis have major drawbacks and possible detrimental impacts on the esthetic outcome of the case, but these analyses are solely norm values, and lack individualization. The African American

female population has minimal published literature specifically focusing on the ideal placement of the jaws and dentition, and most importantly current literature lacks reliable landmarks to correlate treatment goals too. The results also support multiple publications which indicate that the addition of a smiling profile photograph with the forehead and maxillary incisors in full view to the routine diagnostic records are most certainly advantageous and allow for individualized and tailored treatment goals.[34,35,38,39]

Even though the results of this study show that Andrews' method for AP positioning of the upper incisor may not hold true in the African American female population, it does support using the forehead as a landmark for assessing the anteroposterior position of the maxillary central incisors. The results can be used as a guideline for establishing treatment goals for patients that will undergo significant anteroposterior changes in maxillary incisor position as advocated by Andrews and Adams et al.[38,39]

The findings of this study indicate that the ideal position for the upper incisor in the African American female population should never be located posterior to Glabella Vertical nor anterior of 10.5mm ahead of Glabella Vertical unless insisted upon by the patient or allowed for due to an increased slope of the clinical forehead. The average upper incisor location for the 21 subjects whose maxillary incisors fell between Glabella Vertical and 7.5mm ahead of Glabella Vertical was 5.1mm, and the average of the 35 subjects whose upper incisor was located between Glabella Vertical and 10.5mm ahead of Glabella Vertical was 6.7mm. These averages indicate that the clinical orthodontist can feel comfortable setting treatment goals for the upper incisor in the African American female population between Glabella Vertical and 6.7mm ahead of this frontal plane reference in order to be safely perceived as balanced/harmonious in most

patients. One must also keep in mind that forehead inclination steepness can alter this position to an extent. Steeper foreheads can clinically afford to have more anteriorly placed upper incisors and should be accounted for accordingly. Optimal ranges of the maxillary central incisor position based on forehead inclination was also supported by Andrews' study which showed that treatment goals for white females included placing the maxillary central incisor somewhere between FFA point and glabella and was influenced by forehead inclination. [38] In the AAF population, the AP position of the upper incisor in relation to Glabella Vertical should be treatment planned utilizing the formula, AP = 0.3 (Forehead Inclination) + 0.4. This formula gives an upper limit in regard to incisor position in the AP dimension in relation to GV. The upper incisor should also not be placed posterior to Glabella Vertical unless insisted by the patient, and not more anterior than the aforementioned formula. This formula affords the orthodontic clinician with an objective diagnostic aid when locating the ideal AP maxillary upper incisor position in the African American female population while treatment planning.

Room to Improve

The following are improvements that could be made to this study:

- Have multiple groups of raters (orthodontists, orthodontic residents, oral and maxillofacial surgeons/residents, and lay people)
- Have African American raters evaluate the same subjects this study recruited
- Have the sample group be consecutive screening patients in the UAB Orthodontic Clinic seeking treatment
- Look at additional factors in cases which protrusion was considered acceptable or harmonious aside from forehead slope

- Increase sample size of both the control and sample groups

Clinical Application

- Based on the ideal formula provided, an individualized norm can be created for our AAF patients in regard to AP position of the upper central incisor based on forehead inclination. The posterior limit is always Glabella Vertical.
- For patients with straight foreheads with an inclination of zero degrees, upper maxillary central incisor should be located between Glabella Vertical and 0.42mm anterior to Glabella Vertical
- Utilizing the formula provided from the regression analysis, for every 5° the forehead is inclined greater than 0°, the upper incisor can be correspondingly placed 1.5mm more anterior to Glabella vertical.
- Example: Patients' forehead is 20°
    - Posterior limit for the maxillary upper incisor is Glabella Vertical
    - Anterior limit for the maxillary upper incisor is 6.4mm, based on:
        - AP Position of Upper Incisor = 0.3(20) +0.4

CHAPTER 5

CONCLUSIONS

- Most (73%) of the African American Females judged by the raters to have an adequate AP position of the maxillary central incisors were located between Glabella Vertical and 10.5mm ahead of Glabella Vertical. Furthermore the position of the maxillary central incisors were strongly correlated with forehead inclinations, especially in the control group.

- In the Study Sample seeking orthodontic treatment, only 18%, as compared to 44% of the Control Sample had upper incisors located between Glabella Vertical and 7.5mm ahead of Glabella Vertical. Also, the positions of the maxillary central incisors were weakly correlated with forehead inclinations.

- In the Study Sample seeking orthodontic treatment, 53% had upper incisors located 10.5mm or greater in relation to Glabella Vertical, whereas in the Control Sample, only 26% had upper incisors that were located 10.5mm or greater in relation to Glabella Vertical.

- It is important to note that the average AP position of those subjects whose incisors fell less than or equal to 10.5mm ahead of Glabella Vertical was 6.7mm, and the average of those incisors that fell less than or equal to 7.5mm was 5.1mm.

- The forehead can be considered a useful landmark for assessing the facial profile for adult African American females as it relates to the AP maxillary central

incisor position. Treatment goals should include obtaining a harmonious relationship in the AP dimension between the forehead and maxillary central incisors for adult African American females.

- The upper incisor should not be placed posterior to Glabella Vertical unless insisted by the patient, and not more anterior than the below formula allows:
    - AP Position of the Upper Central Incisor (mm) = 0.3 x (Forehead Inclination) + 0.4
- Based on the results of this study, the orthodontic clinician should not treat Caucasian Females the same as African American Females in regard to upper incisor placement in the AP dimension while treatment planning.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Institutional Review Board for Human Use

Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on January 24, 2017. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator:	SOUCCAR, NADA M
Co-Investigator(s):	GIDALY, MATTHEW P
Protocol Number:	**X141001008**
Protocol Title:	*Antero-Posterior Relationship of the Maxillary Central Incisors to the Forehead in Adult African American Females*

The IRB reviewed and approved the above named project on 10/30/14. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.

IRB Approval Date: 10/30/14

Date IRB Approval Issued: 10-30-14

IRB Approval No Longer Valid On: 10-30-15

Member - Institutional Review Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.

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