Original Article

Optimal antero-posterior position of the maxillary central incisors and its relationship to the forehead in adult African American females

Matthew P. Gidaly[a]; Timothy Tremont[b]; Chee Paul Lin[c]; Chung How Kau[d]; Nada M. Souccar[e]

ABSTRACT

Objectives: To determine an optimal anteroposterior (AP) position of the maxillary central incisors and their relationship to the forehead in adult African American (AA) females.

Materials and Methods: Smile profile photographs of 150 AA females were acquired and divided into an optimal control group (N = 48) and a study group (N = 102) based on the position of the maxillary central incisors, as judged by a panel of orthodontists and orthodontic residents. The AP position of the maxillary central incisors and the forehead inclination (FI) were measured relative to Glabella vertical (GV). A two-sample *t*-test was used to compare the incisor AP position and the FI between the two groups. Linear regression was used to quantify the relationship between the incisor AP position and the FI.

Results: In all groups, the maxillary incisors were anterior to GV. However, a significant difference was found in the incisor AP position between the groups (8.58 ± 3.96 mm for the control group and 11.2 ± 4.48 mm for the study group; $P = .001$). Furthermore, the control group demonstrated a positive association between the optimal AP position of the maxillary central incisors and FI ($P < .0001$).

Conclusions: GV is a reliable landmark with which to access the AP maxillary incisor position in AA females. The optimal AP position of the maxillary central incisors is significantly associated with FI; the greater the FI, the more anterior the optimal maxillary incisor position. A prediction equation to determine the optimal position of the maxillary incisors relative to GV for AA females is proposed. (*Angle Orthod.* 2019;89:123–128.)

KEY WORDS: Incisors; Forehead; Forehead inclination; African American female; Landmark; Glabella vertical

INTRODUCTION

Improving facial esthetics is a major motive for patients seeking orthodontic care. Recently, orthodontists have focused their attention not only on static profile assessments but also on dynamic smile evaluations.[1–9] This interest illustrates the importance of harmonious positioning of the maxillary incisor and stresses the significance of the profile smiling view. Clinicians are encouraged to evaluate the profile during smile to achieve optimal static and dynamic facial esthetics while concomitantly establishing ideal occlusal relationships, function, and stability.[2,10]

Various studies have investigated the characteristics of the African American (AA) profile at rest in an effort to individualize treatment plans and achieve optimal esthetics. Most studies[11–15] used panels of judges to determine the acceptable amount of lip protrusion. Scott and Johnston[15] investigated the impact of premolar extractions on the profile of patients of African descent. Their results indicated that the panel preferred the reduced profile convexity in the extraction group; however, the preferred reduction relative to the E-line was different based on the initial malocclusion,

[a] Private Practice, Charlotte, NC.
[b] Professor and Chair, Department of Orthodontics, College of Dental Medicine, Medical University of South Carolina, SC.
[c] Statistician, Center for Clinical & Translational Science, University of Alabama at Birmingham, Birmingham, Ala.
[d] Professor and Chair, Department of Orthodontics, School of Dentistry, University of Alabama at Birmingham, Ala.
[e] Assistant Professor, Department of Orthodontics, School of Dentistry, University of Alabama at Birmingham, Ala.
Corresponding author: Dr Nada Souccar, Assistant Professor, Department of Orthodontics, Room 302-A, School of Dentistry, University of Alabama at Birmingham, 1919 7th Avenue South, Birmingham, AL 35294
(e-mail: nsouccar@uab.edu)

Accepted: July 2018. Submitted: December 2017.
Published Online: September 1, 2018

both the patient's and the rater's ethnic backgrounds, and the rater's professional background. Peck and Peck[12] found attractive faces were more protrusive than cephalometric standards would like to permit, suggesting that the ideal profile for AA females was straighter than the average AA profile but more convex than the Caucasian profile norm. Additionally, the work of Dandajena and Chung[16] highlighted the differences between Caucasian and African faces. Their findings showed profile norms developed for Caucasians, particularly the nose and upper lip measurements, could not be used for a native African population. Therefore, it was recommended to tailor treatment plans to specific population groups to achieve optimal outcomes.[16]

Cephalometric analyses are often relied upon by orthodontists to diagnose and plan treatment. Sushner[17] updated the norms for the H-Line, E-Line, and S1 line for AA populations since they differed from Caucasian norms. Various AA cephalometric analyses were introduced.[18,19] A mesh diagram was also developed, aimed at individualizing orthodontic treatment for AA patients.[20] One of the interesting findings was that, in African Americans, the upper incisor had a more anterior position than in Caucasians, but its inclination was similar. Cox and van der Linden[21] 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 these cephalometric values.

The anteroposterior (AP) position of the maxillary incisor affects the soft tissue profile and can be manipulated by orthodontic and/or surgical treatment. It has a direct impact on oral and facial harmony in both frontal and profile views, with the profile being emphasized as an important diagnostic view when patients are smiling.[3,4]

Schlosser et al.[5] showed that there were statistically significant differences in esthetic judgment with each AP millimetric change in the maxillary incisor position in a smiling profile. Both laypersons and orthodontists rated the facial balance/harmony in 1-mm increments. Cao et al.[6] 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.

In the Six Elements of Orofacial Harmony™, Andrews[2] introduced a three-dimensional approach to diagnosis and treatment planning. In particular, Element II of his analysis addressed the optimal AP position of the upper incisor and utilized the forehead as a landmark. The forehead was proposed as a useful landmark because it does not change considerably over time. According to Andrews, the maxillary incisor position is optimally positioned when the Forehead Facial Axis point (FFA), defined as the midpoint of the clinical crown, coincides with the Goal Anterior Limit Line (GALL). The AP location of GALL was shown to be directly associated with the forehead inclination utilizing the formula published by Andrews. He further proposed this concept as being universal regardless of race, age, and gender. Previous studies[3,7] demonstrated this correlation to hold true in Caucasian males/females. Recently, a study[8] showed that the Glabella Vertical (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. Therefore, GV has been proposed as a new reliable frontal plane and boundary for the anterior maxillary incisor AP position, but its application was only investigated in Caucasian patients.[8]

The purpose of this study was to investigate the optimal AP relationship of the maxillary central incisors to the forehead and GV in adult AA females, which would be useful for orthodontic and surgical diagnosis and treatment planning.

MATERIALS AND METHODS

One hundred fifty participants were consecutively recruited from the University of Alabama at Birmingham (UAB) Orthodontic Clinic and Hospital. Inclusion criteria were the following: AA female aged 18 to 60 years with no major dentofacial deformities who had not undergone orthodontic treatment with conventional braces. A smile profile photograph of each participant was taken with the forehead and maxillary incisors in full view and uploaded into a PowerPoint™ slideshow. All photographs were taken at a fixed distance to the subject's midsagittal plane with the subject positioned in a natural head orientation, as described by previous studies.[22–24]

The deidentified images were then shown to a panel of 15 raters (nine Caucasian faculty members and six Caucasian residents in the Department of Orthodontics). The panel was asked to evaluate the AP position of the maxillary central incisors and decide if they preferred the incisors to be more anterior, more posterior, or to remain in the presenting AP position. Based on the collective answers, the sample was divided into two groups. Forty-eight photographic images of adult AA females judged to have optimal incisor AP position formed the control group. For inclusion in this group, 14 of the 15 raters had to agree that the subject had an optimal incisor AP position. The remaining 102 photographs constituted the study group. The study was approved by the institutional review board at UAB.

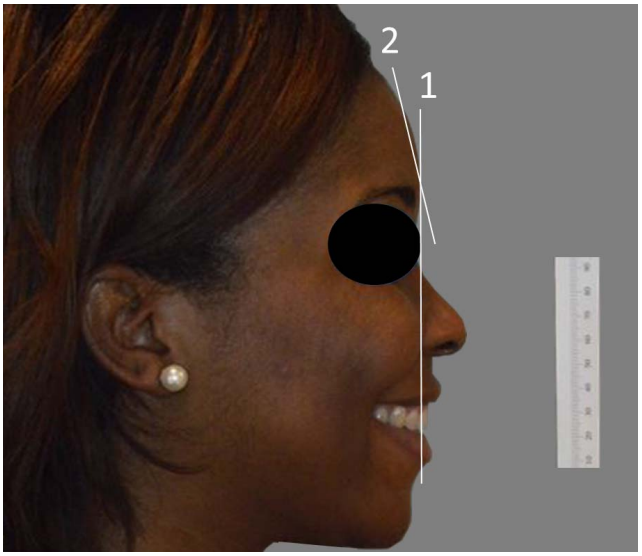

Figure 1. Two reference lines constructed on the facial photograph to assess the AP position of the maxillary central incisor as well as forehead inclination. Line 1 touches the Glabella Point and parallels true vertical. Line 2 represents the forehead inclination, depending on forehead shape, as defined by Andrews.

A plummed 100-mm ruler located at the patient's midsagittal plane was utilized to scale the image to life size. All pictures were then printed on 8.5 × 11-inch paper. Landmark points for the forehead were identified and marked (Trichion, Superion, and Glabella). Two reference lines were constructed on the facial photograph to assess the AP position of the maxillary central incisor as well as forehead inclination. GV (Figure 1, Line 1) was drawn so it paralleled the ruler, and therefore represented "true vertical." The second line (Figure 1, Line 2) represented the forehead inclination and connected the Glabella with the uppermost point of the clinical forehead (Superion or Trichion), depending on forehead shape, as defined by Andrews and Andrews (Figure 2).[9]

Linear measurements to the closest 0.5 mm were taken from the facial axis (FA) point of the upper incisor to GV (Figure 1, Line 1 to the FA point of the upper incisor) on all 150 subjects. This dictated the AP position of the upper incisor relative to the frontal plane, GV. Forehead inclination was measured as the angle between Lines 1 and 2 using a protractor to the closest whole degree. Distance measurements were then scaled to life size utilizing the 100-mm ruler with a simple magnification calculation (Figure 1).

Table 1. 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, Figure 1)[a]

Sample	n	Mean	SD	Minimum	Maximum
Control	48	8.58	3.96	1.7	17.6
Study group	102	11.18	4.48	1.5	21.2

[a] SD indicates standard deviation.

Table 2. Differences in Maxillary Central Incisor Position (mm) and Forehead Inclination (°) Between Control Group and Study Group[a]

Variable	Control	Study Group	Difference	*P*
AP position, mean ± SD	8.58 ± 3.96	11.2 ± 4.48	−2.61	.001
Forehead inclination mean ± SD	26.7 ± 6.95	28.2 ± 6	−1.55	.16

[a] AP indicates anteroposterior.

To ensure the accuracy and validity of the data, all measurements were taken by two independent raters for AP position of the upper incisor and forehead inclination at two different time points, 14 days apart. The average interrater agreements for both parameters between the two raters at time points 1 and 2 were 0.92 and 0.88, respectively. Similarly, the average intrarater agreement was 0.97 for rater 1 and 0.98 for rater 2.

Statistical Analysis

The intraclass correlation coefficient (ICC) was used to assess the inter- and intra-rater reliability in a random sample of 150 patients. The ICCs were computed for the two raters at time points 1 and 2 (inter-rater) and then for each rater over the two time points (intra-rater). An ICC score of 0.75 or higher was considered an acceptable reliability.[25] Descriptive statistics were used to summarize maxillary central incisor AP positions in relation to the forehead and forehead inclination (n, mean, standard deviation, and minimum and maximum). The differences in maxillary central incisor AP position and forehead inclination between the study and control groups were examined using a two-sample *t*-test. Linear regression was used to quantify the relationship between maxillary central incisor position and forehead inclination for all groups. The normality assumption for the data was verified using a Shapiro-Wilk test. A *P*-value of $<.05$ was considered statistically significant in two-tailed statistical tests. All analyses were conducted using SAS 9.4 software (SAS Institute, Cary, NC). The scatter plots were created using R 3.3.0.

RESULTS

Table 1 shows the AP position of the maxillary central incisor in relation to GV for the control and study groups. Table 2 shows that the maxillary central incisor position relative to GV was significantly different between the control group and the study group ($P = .001$), but the forehead inclination was not significantly different ($P = .16$). Forehead inclination distribution between the sample and control group is reported in

Figure 2. The three forehead shapes, as defined by Andrews. Straight, rounded, and angular are defined by connecting the Glabella with the uppermost point of the clinical forehead (Superion or Trichion).

Table 3. Table 4 displays the results of the regression analysis between the AP maxillary central incisor position and forehead inclination.

In the control group, the AP position of the maxillary central incisors was significantly associated with forehead inclination ($P < .0001$; Figure 3). In relation to GV, the AP position of the upper central incisor could be determined by multiplying the forehead inclination by 0.3 and adding 0.42 mm. Utilizing this formula provided from the regression analysis, foreheads with slopes between 0° and 5° had upper incisors located 0.5 to 2 mm anterior to GV. For every 5° that the forehead was inclined greater than 5°, the upper incisor was correspondingly 1.5 mm more anterior to GV (Figure 4). In the study sample, the association between the AP position of the maxillary central incisor and the inclination of the forehead was, however, not as significant ($P = .017$).

DISCUSSION

The study's aim was to identify an optimal AP position for the maxillary central incisors in a select group of adult AA females. In particular, it addressed whether the method proposed by Andrews for assessing the optimal AP position of the upper central incisors in relation to the forehead could be utilized for the AA female population. The published literature on the AA profile, specifically the female profile, did not focus on the ideal placement of the jaws and dentition. According to Peck and Peck,[12] attractive protrusive faces did not fit traditional cephalometric standards. Moreover, Scott and Johnston[15] demonstrated that AA patients seemed to classify a profile as excessively protrusive when the lower lip was forward to Rickett's E-line by 4 mm or more, the normal variation for Caucasians being −2 to +2 mm. Since the maxillary incisors provide support to the upper lip, they can significantly contribute to profile convexity. Having an extraoral assessment of the optimal incisor position is a useful and convenient tool to use while planning treatment of AA females. The sample included in this study had a large age variation. The aging process has been shown to alter facial features, as the nose and the chin elongate while the lips flatten.[26] However, these variables did not affect the results of this study since the measurements were made in relation to the forehead.

Natural head position (NHP) has been defined[27] as a most balanced, natural position of the head when a person views an object at her eye level. NHP was shown[23] to have good intraindividual reproducibility and to represent the true-life appearance of a patient. All pictures in this study were taken in NHP to allow for a realistic evaluation of the dental and facial landmarks.

Andrews[3] and Adams et al.[7] investigated the position of the maxillary central incisor from a profile view in Caucasian females and males, respectively. The

Table 3. Forehead Inclination (°) for Control and Study Groups (Angle Between Line 1 and Line 2, Figure 1)[a]

Sample	n	Mean	SD	Minimum	Maximum
Control	48	26.69	6.95	3	39
Study group	102	28.24	6	12	46

[a] SD indicates standard deviation.

Table 4. Linear Regression of Anteroposterior (AP) Position of the Upper Central Incisor on FI for All Groups[a]

Sample	n	β Coefficient	SE	*P*
Control	48	0.31	1.95	<.0001
Study group	102	0.18	0.07	.017

[a] SE indicates standard error.

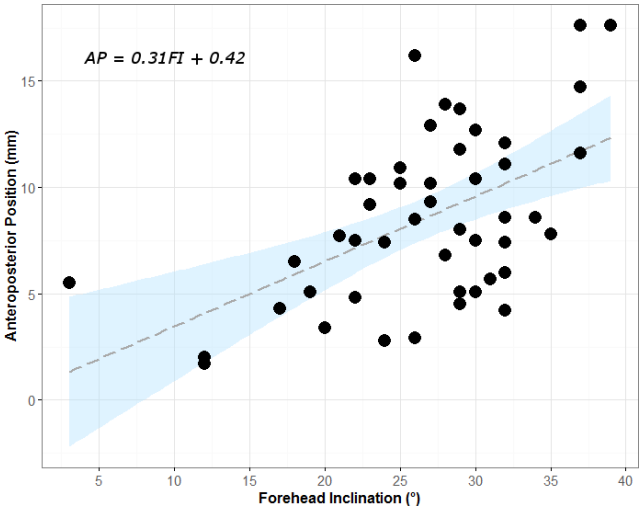

Figure 3. Linear regression analysis of the association between AP position of the maxillary central incisor (mm) and forehead inclination (°) in the control group. The bands on the fitted line depict the 95% confidence interval for the linear regression.

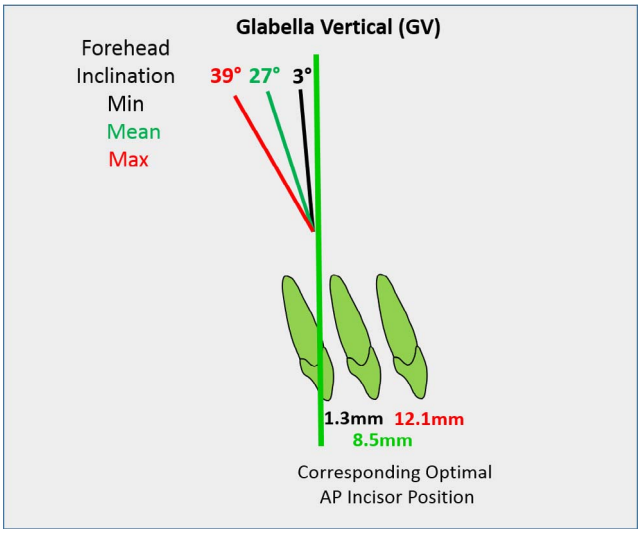

Figure 4. Optimal positioning of the maxillary incisor relative to the minimum, mean, and maximum variation in forehead inclination using the proposed regression formula: Optimal AP upper incisor position (millimeters to GV) = forehead inclination × 0.3 + 0.4 mm.

current study agreed with their findings in that the forehead was shown to be a useful landmark for the assessment of the maxillary incisor position. By evaluating the AP position of the maxillary incisor relative to GV and forehead inclination, clinicians can plan an optimal AP placement of the incisors, with the goal of maximizing facial harmony. While the forehead shape might vary from individual to individual, the definition and outline presented by Andrews and Andrews[9] allow for a consistent evaluation and tracing of this anatomical area.

Andrews' proposed treatment goals for Caucasian females included placing the maxillary central incisor between FFA point and GALL, based on forehead inclination.[3] In the AA female population, this study proposes to plan the optimal AP position of the upper incisor in relation to GfV utilizing the equation Optimal AP upper incisor position (in millimeters to GV) = forehead inclination × 0.3 + 0.4 mm.

This equation indicates that AA female patients with steeper foreheads can afford to have upper incisors positioned more anteriorly. This formula gives the orthodontic clinician an objective aid when diagnosing and treatment planning. The results of this study also support multiple publications[3,5–7] that indicated that the addition of a smiling profile photograph with the forehead and maxillary incisors in full view to diagnostic records was advantageous and allowed for tailored treatment goals.

Similar to all panel-based studies, the composition of the judging panel might be a delimitation of this investigation. Previous publications[14,15] showed that the rater's judgement was affected by his ethnic and educational backgrounds. In the current study, all the raters were Caucasians and were either orthodontic residents or practicing orthodontists. However, even though not ideal, the panel composition was reflective of the orthodontic community in the United States.[28] More research is needed to include raters from a more diverse ethnic background and also to study male African Americans.

CONCLUSIONS

- There is a significant difference in the position of the maxillary central incisors with reference to GV between AA females with optimal upper incisor AP position and those not judged to have an optimal upper incisor AP position.
- Based on the results of this study, Andrews' proposed optimal AP position of the maxillary central incisor for Caucasian females is not applicable to the AA female population. All optimally positioned maxillary incisors in AA females were anterior to GV.
- There is a strong association between the upper incisor AP position and the forehead inclination in subjects who had optimally placed maxillary central incisors.
- The forehead can be considered a useful landmark for assessing the facial profile for adult AA females as it relates to the AP maxillary central incisor position. Treatment objectives should include obtaining a harmonious relationship between the forehead and maxillary central incisor AP position.
- The optimal AP position of the upper incisors relative to GV in AA females can be determined by the

formula Optimal AP upper incisor position (millimeters to GV) = forehead inclination × 0.3 + 0.4 mm.
- The inclusion of a smiling profile photograph as part of the orthodontic diagnostic and final records is recommended.

ACKNOWLEDGMENTS

The authors would like to thank William Dyer for his help in conducting the project. Research reported in this article was supported by the National Center for Advancing Translational Sciences of the National Institutes of Health under award UL1TR001417.

REFERENCES

1. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. *Am J Orthod Dentofacial Orthop*. 2001;120(2):98–111.
2. Andrews LF, Andrews WA. The six elements of orofacial harmony. *Andrews J Orthod Orofac Harmony*. 2000;1:13–22.
3. Andrews WA. AP relationship of the maxillary central incisors to the forehead in adult white females. *Angle Orthod*. 2008;78(4):662–669.
4. Tremont T. *Diagnosis and Treatment Planning for Orthognathic Surgery*. Charleston: Ortho Gnathics, LLC; 2016. p. 1–30.
5. Schlosser JB, Preston CB, Lampasso J. The effects of computer-aided anteroposterior maxillary incisor movement on ratings of facial attractiveness. *Am J Orthod Dentofacial Orthop*. 2005;127(1):17–24.
6. Cao L, Zhang K, Bai D, et al. Effect of maxillary incisor labiolingual inclination and anteroposterior position on smiling profile esthetics. *Angle Orthod*. 2011;81(1):121–129.
7. Adams M, Andrews W, Tremont T, et al. Anteroposterior relationship of the maxillary central incisors to the forehead in adult white males. *Art Pract Dentofacial Enhancement*. 2013;14:2–9.
8. Tomblyn J. *Facial Planes as Landmarks for Diagnosis and Treatment Planning*. Morgantown: West Virginia University; 2015.
9. Andrews L, Andrews W. *Syllabus of the Andrews Orthodontic Philosophy,* 8th ed. San Diego, Calif; L.A. Wells Inc., 1999.
10. Işiksal E, Hazar S, Akyalçin S. Smile esthetics: perception and comparison of treated and untreated smiles. *Am J Orthod Dentofacial Orthop*. 2006;129(1):8–16.
11. Hall D, Taylor RW, Jacobson A, Sadowsky PL, Bartolucci A. The perception of optimal profile in African Americans versus white Americans as assessed by orthodontists and the lay public. *Am J Orthod Dentofacial Orthop*. 2000;118(5):514–525.
12. Peck H, Peck S. A concept of facial esthetics. *Angle Orthod*. 1970;40(4):284–318.
13. Farrow AL, Zarrinnia K, Azizi K. Bimaxillary protrusion in black Americans—an esthetic evaluation and the treatment considerations. *Am J Orthod Dentofacial Orthop*. 1993;104(3):240–250.
14. Polk MS, Farman AG, Yancey JA, et al. Soft tissue profile: a survey of African-American preference. *Am J Orthod Dentofacial Orthop*. 1995;108(1):90–101.
15. Scott SH, Johnston LE. The perceived impact of extraction and nonextraction treatments on matched samples of African American patients. *Am J Orthod Dentofacial Orthop*. 1999;116(3):352–360.
16. Dandajena T, Chung KW. The role of the nose and cranial base in profile assessment: a morphological comparison between native African and Caucasian samples. *SADJ*. 2012;67(7):394–399.
17. Sushner NI. A photographic study of the soft-tissue profile of the Negro population. *Am J Orthod*. 1977;72(4):373–385.
18. Alexander TL, Hitchcock HP. Cephalometric standards for American Negro children. *Am J Orthod*. 1978;74(3):298–304.
19. Drummond RA. A determination of cephalometric norms for the Negro race. *Am J Orthod*. 1968;54(9):670–682.
20. Bailey KL, Taylor RW. Mesh diagram cephalometric norms for Americans of African descent. *Am J Orthod Dentofacial Orthop*. 1998;114(2):218–223.
21. Cox NH, van der Linden FP. Facial harmony. *Am J Orthod*. 1971;60(2):175–183.
22. Lundström F, Lundström A. Natural head position as a basis for cephalometric analysis. *Am J Orthod Dentofacial Orthop*. 1992;101(3):244–247.
23. Lundström A, Lundström F, Lebret LM, Moorrees CF. Natural head position and natural head orientation: basic considerations in cephalometric analysis and research. *Eur J Orthod*. 1995;17(2):111–120.
24. Lundström A, Lundström F. The Frankfort horizontal as a basis for cephalometric analysis. *Am J Orthod Dentofacial Orthop*. 1995;107(5):537–540.
25. Cicchetti DV, Sparrow SA. Developing criteria for establishing inter-rater reliability of specific items: applications to assessment of adaptive behavior. *Am J Ment Defic*. 1981;86:127–137.
26. Proffit W, Fields H, Sarver D. *Contemporary Orthodontics,* 5th ed. St Louis, Mo; Mosby Elsevier; 2013.
27. Moorrees CF. Natural head position—a revival. *Am J Orthod Dentofacial Orthop*. 1994;105(5):512–513.
28. ADEA Snapshot of Dental Education 2017-2018. Washington, DC; American Dental Education Association Publications. Available from: adea.org/snapshot