Original Article

Overbite depth indicator and anteroposterior dysplasia indicator cephalometric norms for African Americans

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ABSTRACT

Objectives: To examine normal Overbite Depth Indicator (ODI) and Anteroposterior Dysplasia Indicator (APDI) values in African Americans and to compare them with mean values from white patients. Secondary aims were to compare mean ODI and APDI values among different age, gender, and combined age-gender groups in African American patients.

Materials and Methods: Lateral cephalometric radiographs of 160 African American patients (97 boys and 63 girls; age, 7 to 14 years) with normal occlusion and no history of orthodontic treatment were collected from the Bolton-Brush Growth Center. Cephalometric images were hand traced, and ODI and APDI values were assessed. Two-sample *t* tests were used to compare mean ODI and APDI values between African American and white patients; and between male and female African American patients. One-way analysis of variance, followed by the Tukey test, was used to compare mean ODI and APDI values among different African American age and combined age-gender groups.

Results: Mean ODI and APDI values were significantly lower ($P < .0001$) in African American than white patients with normal occlusion and no history of orthodontic treatment. Mean ODI and APDI values increased with age in African American patients, and there were no significant gender differences.

Conclusions: The mean ODI and APDI values in 7- to 14-year-old African Americans with normal occlusion and no history of orthodontic treatment were 70.9° and 78.1°, respectively, and were significantly lower than the mean values for white patients in the same age range. (*Angle Orthod.* 2019;89:897–902.)

KEY WORDS: Anteroposterior dysplasia indicator; Cephalometric norms; Overbite depth indicator; Races

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INTRODUCTION

The advent of cone beam computed tomography has facilitated the three-dimensional evaluation of the craniofacial region. Nonetheless, conventional, two-dimensional radiographic techniques, such as panoramic and lateral cephalometric radiographs, are still widely used in orthodontic practice.[1] Cephalometric radiography has played, and still plays, an important role in orthodontic diagnosis and planning since it was introduced by Broadbent[2] in 1931. Different cephalometric analyses have been developed, including Downs, Tweed, Steiner, and Ricketts analyses; and cephalometric norms have been established for different racial and ethnic groups.[3–6]

The Overbite Depth Indicator (ODI), as described by Kim[7] in 1974 has been used to assess the vertical component of malocclusion. Kim evaluated the lateral cephalometric radiographs of 119 patients (56 boys

and 63 girls) with normal occlusion from the Forsyth Dental Center to determine predictors of incisal overbite depth. The patients were all white children between the ages of 7 and 14 years (mean age 10 years and 8 months). Additionally, lateral cephalometric radiographs of 500 white patients with untreated malocclusions from the private dental office of Kim in Weston, Massachusetts, were assessed in a similar fashion. Findings from this study showed that the incisal overbite depth was most strongly correlated with the angle formed by the AB plane to the mandibular plane combined with the angle formed by the palatal plane and the Frankfort horizontal plane; and this combined measurement was termed "ODI."[7] The mean ODI value for the clinically normal occlusion sample was 74.5° (standard deviation = 6.07°); mean ODI values were significantly different in patients with, than those without, malocclusion. Furthermore, it was reported that as ODI increased, there was a tendency for the overbite to increase, and as the ODI decreased, there was a tendency toward an anterior open bite.

The Anteroposterior Dysplasia Indicator (APDI) as described by Kim et al.[8] has been used to assess the skeletal relationship in the anteroposterior plane. The APDI is obtained from three measurements: the facial angle, the A-B plane, and the palatal plane in relation to the Frankfort horizontal plane. Geometrically, the APDI is equal to the angle formed by the A-B plane and the palatal plane.[9] The mean APDI value for patients with normal (Class I) occlusion was found to be 81.4° (standard deviation = 3.79°). Smaller APDI values relative to the mean indicate a Class II malocclusion, while larger APDI values suggest a Class III malocclusion.

Several cephalometric analyses have been developed to diagnose dental malocclusion and the corresponding skeletal discrepancy with varying predictability.[10] Previous researchers have shown that he ODI and APDI variables demonstrate a high diagnostic value in making a link between dental malocclusion and the corresponding skeletal discrepancy using the receiver operating characteristic analysis.[11,12] The ODI and APDI cephalometric variables have assisted orthodontists in proper diagnosis and treatment planning; however, mean ODI and APDI values have been assessed only in whites[7,8] and Asians.[13,14] To date, there are no published data regarding the mean ODI and APDI values in African Americans.

Because differences exist in dentoskeletal and cephalometric characteristics among different racial groups,[15,16] we hypothesized that mean ODI and APDI values would be significantly different between African American and white patients. With this background, the aim of this retrospective study was to evaluate mean ODI and APDI values in African American patients and to compare them with previously published mean values from whites.[7,8] Secondary aims were to compare mean ODI and APDI values among different age, gender, and combined age-gender groups in African American patients.

MATERIALS AND METHODS

This retrospective, cross-sectional study was exempt from review by an Institutional Review Board (no. RSRB00071427) at Eastman Institute for Oral Health, University of Rochester, Rochester, New York, under category 45 CFR 46.101.

The study sample consisted of 160 African American patients (97 boys and 63 girls) ranging in age from 7 to 14 years. The sample was collected from records derived from the Bolton-Brush Growth Center at Case Western Reserve University (publicly available at www. AAOFlegacycollection.org). The inclusion criteria) were (a) radiographs of adequate diagnostic quality; (b) Angle[17] Class I molar relationship; (c) normal occlusion (no crossbite, no openbite, no spacing, no crowding, overbite and overjet within normal limits); (d) 7 to 14 years old; (e) African American; and (f) no history of orthodontic treatment. Participants with malocclusion (such as crossbite, openbite, spacing, crowding, Angle Class II or Class III malocclusion), history of orthodontic treatment, age younger than 7 years or older than 14 years, radiographs of poor diagnostic quality, and races other than African American were excluded.

Participants were categorized into different age (7, 8–9, 10–11, 12, 13, 14 years), gender (male and female) and combined-age gender groups. Female patients (n = 63) were divided in 4 chronological age groups; ages 7 (n = 16), 8-9 (n = 16), 10-11 (n = 15), and 12-14 (n = 16) years. Male patients (n = 97) were divided into 6 chronological age groups: ages 7 (n = 17), 8–9 (n = 16), 10–11 (n = 16), 12 (n = 16), 13 (n = 16), and 14 (n = 16) years.

Lateral cephalometric radiographs were obtained for each patient, and cephalometric images were hand traced and measured by one standardized and calibrated investigator (S.O.). The mandibular plane (from menton to gonion), A-B plane (A point to B point plane), palatal plane (Posterior Nasal Spine [PNS] to Anterior Nasal Spine [ANS]), and Frankfort horizontal (FH) plane were traced to determine the ODI and APDI variables. The ODI variable was defined as the angle formed by the A-B plane to the mandibular plane combined with the angle formed by the palatal plane and the FH plane. When the palatal plane (PNS-ANS) slopes upward anteriorly (ANS) in relation to the FH plane, the value of the angle between the palatal plane and FH plane (PP-FH angle) is subtracted from the
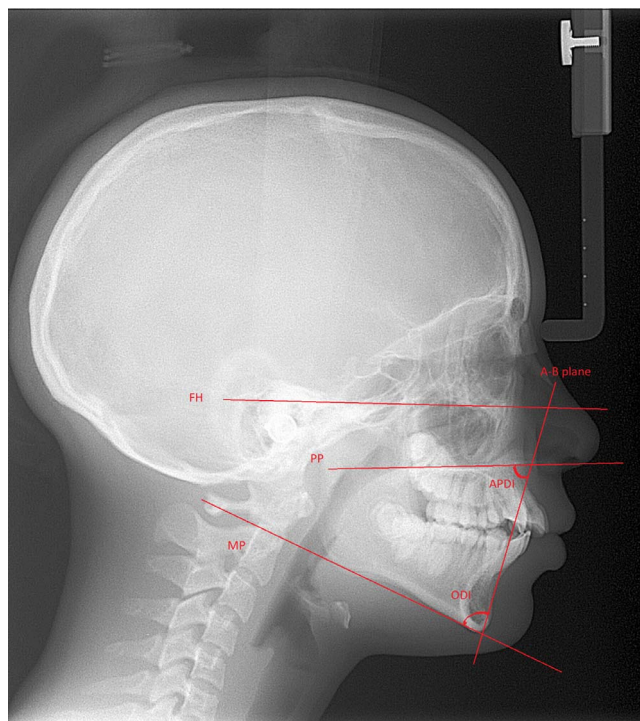
Figure 1. Digital lateral cephalometric radiograph illustrating the planes used to determine the ODI and APDI variables. Abbreviations: A-B plane indicates A-point to B-point plane; APDI, Anteroposterior Dysplasia Indicator; FH, Frankfort horizontal plane; MP, mandibular plane; ODI, Overbite Depth Indicator; PP, palatal plane.

ODI value, whereas if the palatal plane slopes downward anteriorly (ANS), the value of the PP-FH angle is added to the ODI value.[7] The APDI variable was defined as the angle formed by the A-B plane and the palatal plane (Figure 1).[7,8]

The same investigator (S.O.) retraced 16 randomly selected radiographs 1 week later to evaluate the intrainvestigator reliability. A second investigator (E.S.) retraced 16 randomly selected radiographs to assess the interinvestigator reliability.

Statistical Analysis

The sample-size estimation was based on power analysis. A sample size of 144 patients achieved 80% power, with significance level set at .05, assuming that the length of the 95% confidence interval was 2. The concordance correlation coefficient was used to measure the intra- and interobserver reliabilities.[18] Descriptive statistics, including mean, median, standard deviation, and range values were calculated for the ODI and APDI measurements. A two-sample t-test was used to compare the mean ODI and APDI values between African American and white[7,8] patients. A two-sample t-test was performed to compare the mean ODI and APDI values between male and female African American patients. One-way analysis of variance ,

Table 1. Descriptive Statistics of ODI and APDI Values for the Total Study Sample and Age Groups[a]

Age, y	Variable	N	Mean	SD	Median
7	ODI	33	68.1	4.4	68.0
	APDI	33	76.4	4.4	76.0
8–9	ODI	32	72.0	5.5	70.5
	APDI	32	77.1	3.9	77.0
10–11	ODI	31	71.1	5.8	71.0
	APDI	31	79.2	3.6	79.0
12	ODI	17	70.9	5.9	73.0
	APDI	17	77.6	3.8	76.0
13	ODI	17	69.4	6.2	69.5
	APDI	17	79.9	4.9	80.5
14	ODI	30	73.2	6.4	71.5
	APDI	30	79.2	4.1	79.0
Total	ODI	160	70.9	5.8	70.0
	APDI	160	78.1	4.2	77.5

[a] APDI indicates Anteroposterior Dysplasia Indicator; F, female; M, male; N, number of patients; ODI, Overbite Depth Indicator; SD, standard deviation.

followed by the Tukey test, was used to compare the mean ODI and APDI values among different African American age, and combined age-gender groups. Differences were considered significant when $P <$ .05. All data were implemented with SAS 9.2 software (SAS Institute Inc, Cary, NC).

RESULTS

The intra- and interobserver reliabilities were high (concordance correlation coefficient >0.95).

ODI

Tables 1 through 3 present the ODI values of the total study sample and age groups, gender groups, and combined age-gender groups, respectively. The total study sample had a mean age of 10.28 (standard deviation = 2.67 years). The ODI values of the total study sample (n = 160) ranged between 56° and 90°. The overall mean and median ODI values for the total study sample were 70.9° and 70°, respectively (Table 1). The mean ODI values were significantly different between African American (70.9) and white (74.5)[7] patients ($P <$ .0001). There were significant differences (P = .0048) in the mean ODI values among the

Table 2. Descriptive Statistics of ODI and APDI Values for Gender Groups[a]

Gender	N	Variable	N	Mean	SD	Median	Min	Max
F	63	ODI	63	70.3	5.2	70	59	83
		APDI	63	78.6	4.7	79	68	90
M	97	ODI	97	71.2	6.2	70	56	90
		APDI	97	77.8	3.9	77	70	90

[a] APDI indicates Anteroposterior Dysplasia Indicator; F, female; M, male; Min, minimum; Max, maximum; N, number of patients; ODI, Overbite Depth Indicator; SD, standard deviation.

Table 3. Descriptive Statistics of ODI and APDI Values for Combined Age-Gender Groups[a]

Group	N	Variable	Mean	SD	Median
F7	16	ODI	67.4	4.5	68.5
		APDI	76.1	5.2	75.5
F8–9	16	ODI	71.3	5.6	69.5
		APDI	77.4	3.8	77
F10–11	15	ODI	71	5.7	71
		APDI	80.5	3.9	80
F12–14	16	ODI	71.7	4.3	71
		APDI	80.7	4.4	80
M7	17	ODI	68.6	4.2	67
		APDI	76.6	3.6	76
M8–9	16	ODI	72.7	5.5	72
		APDI	76.8	4.2	76.5
M10–11	16	ODI	71.3	6	71
		APDI	78.1	3.1	78
M12	16	ODI	70.9	5.9	73
		APDI	77.6	3.8	76
M13	16	ODI	69.4	6.2	69.5
		APDI	79.9	4.9	80.5
M14	16	ODI	74.8	7.9	71.5
		APDI	77.6	3.1	77

[a] APDI indicates Anteroposterior Dysplasia Indicator; F, female; M, male; N, number of patients; ODI, Overbite Depth Indicator; SD, standard deviation.

African American age groups. Specifically, the Tukey test showed that mean ODI values were significantly different ($P = .0043$) between patients aged 7 years and 14 years, and there were no significant differences among the other age groups. There were no significant differences in the mean ODI values among male (n = 97) and female (n = 63) African American patients. No significant differences in the mean ODI values were reported among combined age-gender groups.

APDI

The APDI values of the total study sample (n = 160) ranged between 68° and 90°. The overall APDI mean and median values of the total study sample were 78.1° and 77.5°, respectively (Table 1). The mean APDI values were significantly different ($P < .0001$) between the African American (78.1) and white (81.4)[8] samples. Significant differences ($P = .004$) were identified in the mean APDI values among African American age groups; in addition, the mean APDI values were significantly increased ($P = .05$) in 13-year-old patients compared with 7-year-old patients. There were no significant differences in the mean APDI values among male (n = 97) and female (n = 63) African American patients. There were no significant differences in the mean APDI values among combined age-gender groups.

DISCUSSION

The normal ODI and APDI values used in cephalometric analysis were derived from white patients between 7 and 14 years old with normal occlusion and no history of orthodontic treatment.[7,8] To date, mean ODI and APDI values have not been assessed in an African American sample. In the present retrospective study, it was hypothesized that mean ODI and APDI values were significantly different between African American and white patients. To test this hypothesis, and to examine normal ODI and APDI values in African Americans, lateral cephalometric radiographs from African American patients with normal occlusion and no history of orthodontic treatment, between 7 and 14 years old, were assessed. Results from the present study supported the research hypothesis and showed significant racial differences in the mean ODI and APDI values between white and African American patients.

It has been reported that differences exist in the craniofacial form and dentoskeletal characteristics among various races.[15,16] In the present study, it was shown that the mean ODI value was significantly lower in African American patients than white patients with normal occlusion and no history of orthodontic treatment. This finding indicates that African American patients had a more vertical growth pattern compared with white patients and a tendency toward decreased overbite.[7] Similarly, Dibbets and Nolte[19] found that, while both European American and African American patients exhibited identical upper face height, the African Americans had a longer total face height resulting from a significantly longer lower face height than European Americans. Other studies[3,19] have also reported that the mandibular plane angle was steeper[20] and the palatal plane was tipped up anteriorly[3] in African American patients compared with white patients. Results from the present study indicated that the mean APDI values were significantly lower in African American patients compared with white patients. Since lower APDI values have been associated with a more convex skeletal profile,[8] the results also indicated that skeletal convexity was increased in African American patients compared with white patients with normal occlusion and no history of orthodontic treatment. This is in accordance with previous studies[3,21] that found greater mean SNA, SNB, and ANB angles[3] and more convex, bimaxillary protrusive profiles in African Americans compared with whites.[22] Future research is warranted to assess and compare mean ODI and APDI values among other racial groups, such as Asians, Hispanics, Native Americans, and Native Hawaiians.

It is important to note that, based on the inclusion criteria, more male patients (n = 97) than female patients (n = 63) were included in the present African American sample. Since no significant differences were found in the mean ODI and APDI values between

male and female African American patients, male and female African American patients were pooled together to test the primary hypothesis. Faustini and coworkers[22] reported an increased vertical skeletal divergence in African American males than females. While an increased hyperdivergence would suggest lower ODI values in males, this was not observed in the present study. Nonetheless, the findings of the present study were congruent with the results of Huang et al.,[3] who found no significant differences in various angular and linear cephalometric measurements between male and female white and African American patients. Additionally, a trend was shown in the present study for both the ODI and APDI values to increase with age in African American patients between 7 and 14 years. This may be explained by normal growth of the mandible during the prepubertal growth period,[23] which increases both the vertical and anteroposterior dimensions of the mandible, resulting in larger ODI and APDI values. Although the present study found no significant differences in the mean ODI and APDI values among the combined age-gender groups in African American patients, this could be attributed to sample-size limitations, leading to limited power when performing combined age-gender group comparisons. Furthermore, due to a limited number of patients representing specific ages (such as 9 and 11 years), patients were grouped based on age ranges to perform meaningful statistical comparisons. In this respect, further research is needed to assess the impact of age and gender on the mean ODI and APDI values in African American patients.

A limitation of the present study was that a white sample was not selected from the Bolton Brush sample as were the African American patients; instead, normal ODI and APDI values in white patients were derived from previous publications.[7,8] It has been reported that results from historical controls should be interpreted with caution due to an increased risk of selection bias.[24,25] Studies have shown that the severity of selection bias when using historical data as controls has not yet been fully appreciated in the field of human evolutionary demography. [26,27] The decision to use the white norms by Kim[7] and Kim et al.[8] was based on their wide use and acceptability when utilizing ODI and APDI variables in orthodontic diagnosis and treatment planning. In this respect, African American patients with normal occlusion between the ages of 7 and 14 years (mean age = 10.28 ± 2.67 years) were included in this study in an effort to match the Kim[7] and Kim et al.[8] sample (age 7 to 14 years; mean age 10.67 years) and minimize selection bias. Another limitation of the present study was that the tracing measurements for the African American and white patients were conducted by different examiners, which may potentially

introduce bias in the measurements. Nonetheless, radiographs of adequate diagnostic quality were included in the present study, a standardized and calibrated examiner conducted all measurements, and the intra- and interobserver reliabilities were high, thus minimizing the risk of measurement errors.

It is pertinent to mention that in the present study and the study by Kim,[7] mean ODI and APDI values were assessed in patients between 7 and 14 years old with mean ages of 10.28 ± 2.67 and 10.67 years, respectively. It has been reported that craniofacial growth changes occur between the ages of 13 and 17 years that affect the mandible and, to a lesser degree, the maxilla.[28] Studies have also shown that subtle anteroposterior and vertical changes in craniofacial morphology may continue throughout adulthood.[29,30] It is therefore hypothesized that mean ODI and APDI values are significantly different between patients younger than 7 years, between 7 and 14 years old, and older than 14 years (late adolescents and adults). Further research is needed to test this hypothesis.

It has been reported that significant differences exist in the mean ODI and APDI values between white patients with and without malocclusion.[7,8] It is worth noting that, in the present study, mean ODI and APDI values were assessed in African American patients with normal occlusion and no history of orthodontic treatment. It is suggested that mean ODI and APDI values are significantly different among African American patients with and without malocclusion. Further research is needed in this regard.

CONCLUSIONS

- The mean ODI and APDI values in 7- to 14-year-oldAfrican American patients with normal occlusion and no history of orthodontic treatment were 70.9° and 78.1°, respectively.
- The null hypothesis of the present study was rejected; the mean ODI (70.9°) and APDI (78.1°) values are significantly lower in African American patients compared with white patients between 7 and 14 years old.
- Mean ODI and APDI values increased with age in African American patients between 7 and 14 years old.
- No significant differences exist in the mean ODI and APDI values between African American male and female patients between 7 and 14 years old.

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