*Original Article*

# Assessing anteroposterior basal bone discrepancy with the Dental Aesthetic Index

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## ABSTRACT

**Objective:** To investigate dental appearance and cephalometric features, using a sample of orthognathic and/or orthodontic patients. A special interest was to identify the relationship of the Dental Aesthetic Index (DAI) with anteroposterior basal bone discrepancy (APBBD) and cephalometric indicators.

**Materials and Methods:** A full sample of 159 patients in two Japanese hospitals was used. Each patient was assessed with a preorthodontic dental cast and cephalometric radiography.

**Results:** Malocclusion with APBBD was more prevalent among high DAI subjects ($P = .034$, OR = 1.04, 95% CI: 1.00–1.08), Class III malocclusion patients ($P = .048$, OR = 2.32, 95% CI: 1.01–5.34) and male patients ($P = .008$, OR = 2.96, 95% CI: 1.33–6.61). Participants scoring 88 points (the highest score in this sample) of the DAI had 16.84 times the risk of APBBD of those who scored 17 points (the lowest score in this sample). Patients with APBBD presented with a greater adjusted ANB angle ($t = -8.10$, $P < .001$) and a larger adjusted A-B/NF appraisal ($t = -9.65$, $P < .001$). The SNA angle ($P < .001$), the SNB angle ($P = .002$), the adjusted ANB angle ($P = .001$), and the adjusted A-B/NF appraisal ($P = .035$) were associated with DAI scores in cubic regression models.

**Conclusion:** This study has demonstrated a relationship between the DAI and APBBD. Feasibility of using the adjusted ANB angle and the adjusted A-B/NF appraisal to assess severity of APBBD has been confirmed. The DAI may provide a supportive method to evaluate orthognathic needs. Future investigations are indicated. (*Angle Orthod.* 2013;83:527–532.)

**KEY WORDS:** Dental Aesthetic Index; Jaw disharmony; ANB angle

## INTRODUCTION

Various diagnostic methods for orthodontic and/or orthognathic needs, mainly involving cephalometric analysis[1–3] and three-dimensional analysis,[4,5] have been introduced from the last century. Among those, the ANB angle[1–3,6,7] and the A-B/NF appraisal (also known as the anteroposterior distance of the jaws)[7–9] are two of the popular criteria to distinguish between dental displacement with and without anteroposterior basal bone discrepancy (APBBD). The ANB angle is formed with the vertex at point N (nasion, the most anterior aspect of the frontonasal suture, located by visual inspection on the

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tracing) and two sides respectively extending to A-point (the deepest point on the contour of the premaxilla) as well as B-point (the deepest point on the contour of the mandible).[6] Taking point S (sella, canter of the pituitary fossa located by visual inspection on the tracing) into account, the SNA and the SNB angles were also commonly used to assess positions of the upper and the lower jaws, respectively.[1–3,6,7] The difference between the SNA and the SNB angles is equivalent to the ANB angle.[1] Of further note, the A-B/NF appraisal represents the distance between the orthogonal projections from A-point and B-point onto the nasal floor plane.[7,8] This indicator is similar to the Wits appraisal.[1,7] Nevertheless, identifying the anatomic landmarks largely relies on the aid of cephalometric radiography which entails radiation exposure and usage of special equipment.[10] A similar concern has also been raised for application of three-dimensional analysis.[4] These compromised establishing the prevalence of APBBD from a large sample.

On the other hand, the Dental Aesthetic Index (DAI) has been suggested to assess dental appearance using objective measures of occlusal conditions since decades ago.[11] A higher DAI score indicated a severer impairment in the dental profile.[11] Without the need of using special equipment and the risk of radiation exposure, "the DAI can serve the dental epidemiologist as an index of severity and need for orthodontic treatment."[12] An adequate validity of this approach has been reported by population-based studies of malocclusion.[13,14] In addition, literature has demonstrated a better interexaminer consistency provided by the DAI than other approaches.[15] The DAI has also displayed a correlation with the Index of Orthodontic Treatment Need,[14,16] although some papers suggested a higher differentiability[17] and sensitivity[18] of the former over the latter. To the best of our knowledge, however, application of the DAI on assessing jaw deformity has involved cleft lip and palate only.[19,20] A relationship between the DAI and orthognathic needs has never been reported.

Therefore, this study aimed to carry out an investigation in dental appearance and cephalometric features, using a sample of orthognathic and/or orthodontic patients in Japan. A special interest was to identify the association of the DAI with cephalometric indicators such as the SNA angle, the SNB angle, the ANB angle as well as the A-B/NF appraisal, and occurrence of APBBD.

## MATERIALS AND METHODS

This study was conjunctly conducted at two university hospitals in western Japan. Appropriate research ethics approval has been obtained from the Human Research Ethics Committees of Kyoto University and Okayama University, respectively. The size of the sample was calculated for satisfactory precision of a logistic regression model and a curve estimation model. Firstly, we estimated 100 subjects was the minimal number of subjects, using the reported proportion of APBBD at 40.3% in malocclusion,[21] for reporting four independent variables including DAI, age, sex, and occlusion type in a logistic regression model.[22] Secondly, to separately estimate the relationship between DAI and cephalometric indicators in a linear, a quadratic, and a cubic regression model, 120 subjects as the minimal number of subjects were estimated to report 95% confidence limits for the regression coefficients with an anticipated squared multiple correlation coefficient ($R^2$) at 0.25.[23] When calculating the sample size required, a cubic regression model was estimated as a linear regression model with three predictor variables. Since 100 and 120 subjects were respectively needed in a logistic and a cubic regression model, the minimal sample size required was decided to be 120 to meet criteria for both models. Formulae for estimations of the models have been reported earlier.[22,23] A possible negative response rate of 20% further raised the estimation to 150 subjects. All patient records dated from October 2009 to September 2011 (24 months) at the two hospitals were thereby screened and selected to contribute to a sufficient number of orthodontic and/or orthognathic cases. To avoid unnecessary radiation exposure, nonpatient individuals were not included in this study. An opt-out consent option has been provided to all patients approached and their legal guardians in cases younger than 18 years of age.[24] A pilot study has been carried out and the results confirmed that the protocol was feasible.

To be eligible for inclusion, a subject needed to have a preorthodontic dental cast and lateral cephalometric radiograph available in either of the two hospitals. Casts and radiographs were assessed by two examiners. Interexaminer reliability was measured with Cohen kappa coefficient and Pearson product moment correlation coefficient in categorical and continuous variables, respectively.[25] From the dental cast, data collected included missing teeth, crowding, spacing, diastema, largest anterior irregularity, overjet, open bite, and molar relation. Calculating with predetermined weights, the DAI score was generated from the data above.[11] In addition, occlusal type based on Angle's classification of malocclusion was recorded.[26] On the other hand, point N, point S, A-point, B-point, and the nasal floor plane were identified from the tracing of the lateral cephalometric radiograph. Thus, the ANB, the SNA as well as the SNB angles and the A-B/NF appraisal were generated and calculated. Using these indicators was due to their clinical relevance for assessing needs and outcomes of orthognathic surgery.[27–29] Based on predetermined clinical and radiographic criteria,[7] malocclusion and/or APBBD were diagnosed by two senior clinicians and then subjects were classified as the cases (with APBBD) or the controls (without APBBD). Of further note, participants' age and sex were gathered from the patient records.

Data entry and statistical analysis were carried out with IBM SPSS Statistics (version 20, IBM Corporation, Somers, NY). Data analysis included descriptive statistics. The absolute value of the ANB angle has been applied to denote severity of APBBD.[30] When generating absolute values, the two indicators containing negative values (the ANB angle and the A-B/NF appraisal) were adjusted according to the following methods in order to preserve deviation distances from the mean of the general population. The means of the ANB angle and the A-B/NF appraisal in the general population are 3.7° and 6.1 mm, respectively.[9] Thus, 3.7 and 6.1 were separately subtracted from the original values of the ANB angle and the A-B/NF appraisal before calculation of the absolute values. Means of the adjusted ANB angle and the adjusted A-B/NF appraisal were compared between APBBD and non-APBBD subjects with an independent samples *t*-test.[25] A multivariate binary logistic regression method was used to examine the relationship between APBBD and age, sex, occlusal type as well as the DAI.[25] The reference indicators of categorical variables used in the logistic regression model were female and Class I occlusion for sex and occlusal type, separately. Furthermore, a curve estimation method including a linear, a quadratic and a cubic regression model was applied to assess the contribution of the DAI to cephalometric indicators such as the SNA angle, the SNB angle, the adjusted ANB angle, and the adjusted A-B/NF appraisal.[25] The level of two-sided significance was set at 5%.

## RESULTS

One hundred ninety-eight orthodontic and/or orthognathic patients were identified from the records of the two hospitals. Among these, 15 patients opted not to participate, providing a response rate of 92.4%. Excluding 12 cases without a valid cephalometric radiograph, eight cases in lack of a preorthodontic dental cast and four cases with incomplete data of cephalometric measurements, a total of 159 subjects were included in this sample. The participants' age ranged from 10 to 54 years (21.6 ± 7.6). One hundred seventeen subjects (73.6%) were female. The patients' SNA, SNB, and ANB angles ranged from 68.1° to 98.8° (80.2 ± 4.1), from 64.9° to 92.9° (78.3 ± 4.8), and from −10.6° to 11.4° (1.9 ± 3.8), respectively. The distance of A-B/NF appraisal ranged between −13.0 and 27.5 mm (4.7 ± 6.7). Forty-nine cases were diagnosed with APBBD (30.8%). The number of subjects with Class I, Class II, and Class III malocclusion were 58 (36.5%), 40 (25.2%), and 61 (38.3%), respectively. In addition, DAI scores calculated according to outcomes of dental casts ranged from 17 to 88 (38.2 ± 10.5). Results of Cohen kappa coefficients and Pearson product moment correlation coefficients indicated a good interexaminer agreement. Kappa values ranged from 0.86 to 1.00 and Pearson coefficients ranged from 0.83 to 0.98. Patients with APBBD presented with a greater adjusted ANB angle ($t = -8.10$, $P < .001$) and a larger adjusted A-B/NF appraisal ($t = -9.65$, $P < .001$). Table 1 shows the frequency distribution of participants' age, sex, occlusal type, DAI scores, and occurrence with APBBD.

Those subjects who reported a higher DAI score ($P = .034$, OR = 1.04, 95% CI: 1.00–1.08), who were male ($P = .008$, OR = 2.96, 95% CI: 1.33–6.61), or who had Class III malocclusion ($P = .048$, OR = 2.32, 95% CI: 1.01–5.34), were more likely to sustain APBBD over nonskeletal related malocclusion (Table 1). Age was not associated with the occurrence of APBBD ($P = .172$). The result of the logistic regression model displayed a model chi-square at 30.57 ($df = 5$, $P < .001$), a correct percentage at 76.7% and a Hosmer-Lemeshow Goodness of fit at 7.01 ($df = 8$, $P = .535$). When assessing with a cubic regression model, the SNA angle ($R^2 = 0.110$, $P < .001$), the SNB angle ($R^2 = 0.090$, $P = .002$), the adjusted ANB angle ($R^2 = 0.098$, $P = .001$), and the adjusted A-B/NF appraisal ($R^2 = 0.054$, $P = .035$) were all associated with DAI scores. Table 2 showed regression relationships between the above indicators and DAI scores.

## DISCUSSION

This study has suggested for the first time a relationship between high DAI scores and occurrence of APBBD. An odds ratio of the effect of DAI scores at 1.04 indicated that an increase of one DAI score raised 1.04 times the risk of APBBD. Thus, patients scoring 88 points (the highest score in this sample) of the DAI had 16.84 times the risk of APBBD of those who scored 17 points (the lowest score in this sample). The binary logistic regression model displayed a good model chi-square, an appropriate correct percentage, and an excellent Hosmer-Lemeshow goodness of fit. All of these indicated a properly explanatory power of the logistic regression model.[31] Hence, the DAI could assist to identify patients of APBBD when cephalometric radiography and three-dimensional analysis are not available. Even though, this study does not recommend using the DAI in full substitution for cephalometric radiography and three-dimensional analysis. Future investigation is indicated.

The results of the independent samples *t*-test confirmed the relationship between APBBD and the adjusted cephalometric indicators such as the adjusted ANB angle and the adjusted A-B/NF appraisal. As original values of the ANB angle and the A-B/NF appraisal have been used

**Table 1.** Frequency Distribution of Anteroposterior Basal Bone Discrepancy (APBBD) by DAI Score, Age, Sex, and Occlusal Type in the Sample of the Study (n = 159)

| | With APBBD | Without APBBD | All | OR (95% CI) | *P* Value |
|---|---|---|---|---|---|
| Mean of DAI scores | 41.0 ± 15.5 | 36.9 ± 6.9 | 38.2 ± 10.5 | 1.04 (1.00–1.08) | .034* |
| Mean of age | 22.3 ± 7.3 | 21.2 ± 7.8 | 21.6 ± 7.6 | 1.04 (0.99–1.09) | .172 |
| Sex | | | | | |
| Female | 27 (23.1%) | 90 (76.9%) | 117 (73.6%) | 1 | |
| Male | 22 (52.4%) | 20 (47.6%) | 42 (26.4%) | 2.96 (1.33–6.61) | .008* |
| Occlusal type | | | | | |
| Class I | 14 (24.1%) | 44 (75.9%) | 58 (36.5%) | 1 | |
| Class II | 5 (12.5%) | 35 (87.5%) | 40 (25.2%) | 0.39 (0.12–1.29) | .122 |
| Class III | 30 (49.2%) | 31 (50.8%) | 61 (38.3%) | 2.32 (1.01–5.34) | .048* |

* $P < .05$.

for diagnosis of APBBD, this demonstrated that the adjusted indicators are still able to differentiate malocclusion with and without APBBD. The outcomes agreed with a previous study which used the absolute value to assess the sagittal base relationship.[30] The ANB angle could be calculated by subtracting the SNB angle from the SNA angle[32] or by subtracting the SNA angle from the SNB angle.[28] Similarly, the A-B/NF appraisal could be measured from the projection of A-point to that of B-point, and vice versa.[7] Therefore, it would be appropriate to use the formulae with adjusted absolute values of the ANB angle and the A-B/NF appraisal to represent the magnitude of APBBD for a statistical purpose.

The low $R^2$ value found in the cubic regression models assessing the relationship between the DAI score and the cephalometric indicators suggested a poor prediction.[25] This could result from a small sample size in this study as the $R^2$ value used for estimating the minimal number of subjects has been decided as 0.25.[23] Nevertheless, the cubic regression relationships between the DAI score and the indicators including SNA angle, the SNB angle, the adjusted ANB angle, and the adjusted A-B/NF appraisal could confirm the association between DAI scores and APBBD as demonstrated by the logistic regression model earlier in this article.

Class III malocclusion was a predisposing factor of APBBD in this study. This could be due to a severer jaw disharmony of Class III malocclusion generally found in the Japanese population over other ethnic backgrounds.[33,34] Since patients' occlusal status regarding Angle's classification of malocclusion can be identified with a dental cast,[26] the enhancing effect of Class III malocclusion observed in this sample would not compromise future application of the model. On the other hand, the higher risk of APBBD among the male subjects found in this study agreed with a previous study.[35] Nevertheless, literature suggested distinct appearance motives between male and female orthognathic patients,[36] which influenced their decisions to seek orthodontic/orthognathic management.[37] Since subjects of this study were recruited from hospital patient pools, sampling bias resulting from

**Table 2.** Regression Relationships Between Cephalometric Indicators (y) and DAI Scores (x), $y = a_0 + a_1x + a_2x^2 + a_3x^3$

| Equation | $R^2$ Value | *F* Value | *P* Value | $a_0$ Value | $a_1$ Value | $a_2$ Value | $a_3$ Value |
|---|---|---|---|---|---|---|---|
| y = SNA angle | | | | | | | |
| Linear | 0.020 | 3.173 | .077 | 82.306 | −0.056 | | |
| Quadratic | 0.023 | 1.855 | .160 | 80.217 | 0.044 | −0.001 | |
| Cubic | 0.110 | 6.383 | <.001* | 109.187 | −2.006 | 0.043 | −0.0003 |
| y = SNB angle | | | | | | | |
| Linear | <0.001 | 0.014 | .905 | 78.492 | −0.004 | | |
| Quadratic | 0.002 | 0.127 | .881 | 80.115 | −0.082 | 0.001 | |
| Cubic | 0.090 | 5.115 | .002* | 114.065 | −2.483 | 0.053 | −0.0003 |
| y = Adjusted ANB angle | | | | | | | |
| Linear | 0.057 | 9.495 | .002* | 0.488 | 0.067 | | |
| Quadratic | 0.070 | 5.892 | .003* | 3.368 | −0.070 | 0.001 | |
| Cubic | 0.098 | 5.631 | .001* | 14.941 | −0.889 | 0.019 | −0.0001 |
| y = Adjusted A-B/NF appraisal | | | | | | | |
| Linear | 0.006 | 0.991 | .321 | 3.717 | 0.035 | | |
| Quadratic | 0.007 | 0.544 | .582 | 2.709 | 0.083 | −0.001 | |
| Cubic | 0.054 | 2.944 | .035* | 26.370 | −1.591 | 0.036 | −0.0002 |

* $P < .05$.

sex-differentiated appearance motives might also contribute to the larger likelihood of APBBD seen in men. This was a research limitation of the study.

Without a need of radiation exposure and special equipment, the DAI may provide a supportive method to evaluate orthognathic needs of APBBD. This would be especially workable when conducting large-scale epidemiological studies and/or screening patients at rural/remote areas. Further investigations are indicated.

## CONCLUSION

- This study has demonstrated a relationship between the DAI and APBBD. Feasibility of using the adjusted ANB angle and the adjusted A-B/NF appraisal to assess severity of APBBD has been confirmed. In addition, a higher risk of APBBD was reported in Class III malocclusion and/or male patients.

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