# Comparison of Japanese and European overbite depth indicator and antero-posterior dysplasia indicator values

Josef Freudenthaler*, Aleš Čelar*, Mitsuyoshi Kubota**, Susumu Akimoto**, Sadao Sato** and Barbara Schneider***

*Bernhard Gottlieb Dental Clinic, Division of Orthodontics, ***CESIIS, Institute for Medical Statistics, Medical University of Vienna, Austria and **Department of Craniofacial Growth and Developmental Dentistry, Division of Orthodontics, Kanagawa Dental College, Yokosuka, Japan

*Correspondence to:* Prof. Josef Freudenthaler, Bernhard-Gottlieb-Universitätszahnklinik, Währingerstrasse 25a, 1090 Wien, Austria. E-mail: ales.celar@meduniwien.ac.at

SUMMARY This study evaluated cephalometric differences between 113 Japanese (43 males and 70 females, aged $14.1 \pm 5$ years) and 106 European subjects (36 males and 70 females, aged $13.5 \pm 7.3$ years) using two compound angular measurements and their single components: the overbite depth indicator (ODI) for the assessment of vertical skeletal relationships and the antero-posterior dysplasia indicator (APDI) for an evaluation of sagittal dysgnathia. Both populations were assigned to groups representing Angle Classes I, II, and III, and an anterior open bite (AOB) group. Two sample *t*- and Wilcoxon signed-ranks tests were performed ($P < 0.05$).

The ODI values showed no statistically significant differences between the Japanese and European samples. The Japanese sample showed a significantly smaller APDI but only in the Class II group. In the Japanese Class II and III subjects, the malocclusion patterns were more pronounced than those in the Caucasian sample (overbite, overjet, and APDI).

## Introduction

Most malocclusions are combinations of bone- and tooth-based disharmonies (Harris and Johnson, 1991). A cephalometric analysis identifies skeletally derived and dentoalveolar malocclusions (Graber *et al.*, 1997) and evaluates the sagittal and vertical relationships of skeletal and dental functional units for diagnosis and treatment planning (Proffit and Fields, 2000).

In the lateral head film, the diagnostic value of single cephalometric measurements has been enhanced by introducing composite angular measurements, such as the overbite depth indicator (ODI) and antero-posterior dysplasia indicator (APDI; Kim, 1974, 1979; Kim and Vietas, 1978; Han and Kim, 1998; Čelar *et al.*, 1999; Freudenthaler *et al.*, 2000; Klocke *et al.*, 2002; Beane *et al.*, 2003; Bock and Fuhrmann, 2007).

The ODI describes the skeletal trend towards bite opening or deep bite, while the APDI scores sagittal skeletal relationships. ODI and APDI differentiate skeletal malocclusions reliably (Kim and Vietas, 1978; Kim, 1979; Oktay, 1991; Wardlaw *et al.*, 1992; Han and Kim, 1998; Freudenthaler *et al.*, 2000; Ishikawa *et al.*, 2000; Chen *et al.*, 2004; Bock and Fuhrmann, 2007) and have been recommended as adjuncts to cephalometric differential diagnosis (Kim and Vietas, 1978; Kim 1979; Freudenthaler *et al.*, 2000).

The most commonly used cephalometric analyses were based on samples of Caucasian individuals. Norms define an ideal status dependent on age, gender, and ethnicity (Engel and Spolter, 1981). Previously, the cephalometric analyses of Tweed, Steiner, Downs, and Ricketts were applied to Japanese samples and compared with Caucasians, except ODI and APDI (Aoki, 1972; Reitz *et al.*, 1973; Engel and Spolter, 1981; Miyajima *et al.*, 1996; Alcalde *et al.*, 1998; Ishii *et al.*, 2002a,b; Ioi *et al.*, 2007).

As ODI and APDI were found to be better diagnostic criteria for the presence of malocclusions than any other commonly used single cephalometric measurement or ratio, the aim of the present study was to compare Japanese and Caucasian subjects using the ODI and APDI. The null hypothesis tested is that there are no statistically significant differences between the ethnic samples either for groups with Angle Class I, II, or III malocculusions or with an anterior open bite (AOB).

## Subjects and methods

### Japanese sample

One hundred and thirteen untreated patients from the Kanagawa Dental College in Yokosuka, Japan, comprised the Japanese sample. Thirty-one subjects showed an Angle Class I molar relationship (10 males and 21 females; average age $13.3 \pm 3.7$ years), 43 an Angle Class II (17 males and 26 females; average age $12.9 \pm 3.6$ years), and 16 an Angle Class III (11 males and 5 females; average age $11.4 \pm 3.5$ years) malocclusion. Another 23

subjects had an AOB (zero or negative overbite). These individuals were included in a single group regardless of their molar intercuspation (5 males and 18 females; average age 19.5 ± 6.1 years). Molar relationship and overbite were determined on plaster casts obtained in maximum intercuspation.

*European sample*

The pre-treatment records of 116 individuals were selected from two private orthodontic offices and five dental centres in Vienna, Austria. The Angle Class I molar relationship group consisted of 32 subjects (12 males and 20 females; average age 11.6 ± 4.3 years), the Class II group 40 subjects (14 males and 26 females, average age 13.3 ± 6.3 years), and the Class III group 16 subjects (6 males and 10 females, average age 11.4 ± 4 years). Eighteen subjects with an AOB represented the fourth Caucasian group (4 males and 14 females; average age 19.4 ± 11.8 years). Molar relationship and overbite were determined on casts in maximum intercuspation.
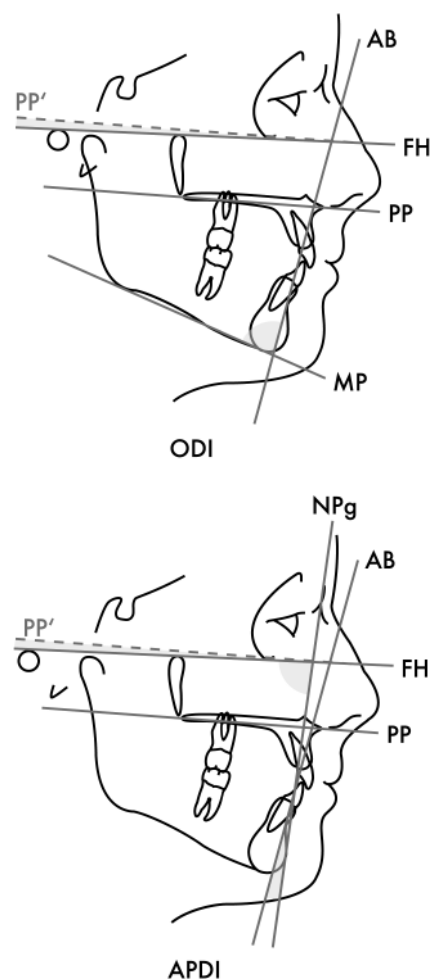
*ODI and APDI*

The ODI is the sum of two angular measurements (Figure1): A–B line to mandibular plane and palatal plane to Frankfort horizontal (FH). When the palatal plane slopes upward and forward in relation to FH, the measurement is read as a negative angle. When the palatal plane slopes downward and forward to FH, the measurement is read as positive.

The APDI is obtained from three angular measurements (Figure1): the angle between FH and a line connecting nasion (N) with pogonion (Pg) plus or minus the angle between the A–B line to the N–Pg line (facial plane) and again plus or minus the angle between FH and the palatal plane. The angle between the A–B line (denture plane) and facial plane will be read as negative if perpendicular to FH and point B is found more posterior than point A. Conversely, a positive value will result if point B is anterior to point A.

The operator variability in measuring ODI and APDI was assessed by manual tracings of 10 cephalometric radiographs and computations according to the formula of Dahlberg (1940) $s = \sqrt{\dfrac{\sum d^2}{2n}}$. Four investigators conducted the tracings, which had been selected from the sample at random.

The statistics of this investigation were calculated using the SAS Statistical Package® (SAS Institute Inc., Cary, North Carolina, USA). The data were checked for normality by applying the Wilk–Shapiro test ($\alpha > 0.1$). For normal distribution, an unpaired two sample *t*-test ($P < 0.05$) was calculated; otherwise, the Wilcoxon signed-ranks test was performed ($P < 0.05$).



**Figure 1**  Cephalometric tracings showing the angles FH-NP$_g$, FH-PP, AB-MP, and AB-NP$_g$, which yield the overbite depth indicator (ODI) and antero-posterior dysplasia indicator (APDI).

**Results**

*Error method*

Statististical calculations of the intra- and inter-operator variablity yielded differences between the investigators within 2 degrees.

*Descriptive statistics and analysis of variance*

The means and standard deviations of eight cephalometric measurements are shown in Table 1 for both populations divided into Class I, II, III, and AOB groups. Table 2 lists the differences between the Japanese and Caucasians in these four groups.

In subjects with an AOB, there were no significant differences between the Japanese and Europeans for any of the parameters tested. Age and ODI were also not significantly different between the populations or groups. One component of the ODI, i.e. the angle between the A–B line and mandibular plane, was significantly smaller in the Japanese Class I group.

**Table 1**  Means and standard deviations of overbite and overjet (millimetres), angular components of overbite depth indicator (ODI), and antero-posterior dysplasia indicator (APDI; degrees), and both indicators for the Japanese and European samples.

| | Class I | | Class II | | Class III | | Anterior open bite | |
|---|---|---|---|---|---|---|---|---|
| | Japanese | European | Japanese | European | Japanese | European | Japanese | European |
| Overbite | 2 ± 1.3 | 2.8 ± 1.6 | 3.5 ± 2.5 | 3.4 ± 1.6 | 2.7 ± 2.6 | 1.1 ± 1.1 | −2.6 ± 2.2 | −2.6 ± 1.9 |
| Overjet | 3.6 ± 2.5 | 2.7 ± 1.3 | 9.8 ± 3.1 | 5.2 ± 2.9 | −2.2 ± 2.9 | 0.6 ± 1.6 | 4.3 ± 3.8 | 3.5 ± 3 |
| FH–PP | −0.3 ± 3.3 | −1.5 ± 2.4 | −0.7 ± 3.6 | −2.3 ± 4 | −1.6 ± 2.7 | −2.3 ± 3.4 | 0.4 ± 3 | −1.8 ± 5.3 |
| AB–MP | 68.7 ± 6.5 | 71.8 ± 4.9 | 79.1 ± 5.9 | 78 ± 5.6 | 60.6 ± 7.1 | 63.4 ± 5.2 | 68.7 ± 8 | 67.9 ± 6.3 |
| AB–NPg | -4.2 ± 3.2 | −3.8 ± 3.9 | −12.1 ± 7.4 | −7.5 ± 3.8 | 2.6 ± 4.6 | −0.4 ± 3.8 | −6.2 ± 4.5 | −5.5 ± 6 |
| FH–NPg | 85.6 ± 3.2 | 88.4 ± 2.5 | 82.6 ± 4 | 87.1 ± 3.3 | 89.6 ± 3.7 | 89.6 ± 5.1 | 84.7 ± 4.4 | 87 ± 4.8 |
| ODI | 68.4 ± 7.6 | 70.2 ± 5.8 | 78.4 ± 6.9 | 75.7 ± 5.9 | 59 ± 6.3 | 61.1 ± 5.2 | 69.1 ± 8.4 | 66.2 ± 9.5 |
| APDI | 81.4 ± 5.6 | 83.2 ± 4.7 | 70.5 ± 5.1 | 77.4 ± 5.4 | 90.5 ± 7.9 | 87 ± 5.2 | 79.3 ± 7 | 79.8 ± 8.5 |

**Table 2**  Analysis of variance of significant differences between the Japanese and European samples; overbite and overjet in millimetres and angular measurements in degrees.

| | Class I | Class II | Class III | Anterior open bite |
|---|---|---|---|---|
| Age | ns | ns | ns | ns |
| Overbite | 0.042 | ns | ns | ns |
| Overjet | ns | 0.0001 | 0.002 | ns |
| FH–PP | ns | 0.048 | ns | ns |
| AB–MP | 0.04 | ns | ns | ns |
| AB–NPg | ns | 0.0001 | ns | ns |
| FH–NPg | 0.0005 | 0.0001 | ns | ns |
| ODI | ns | ns | ns | ns |
| APDI | ns | 0.0001 | ns | ns |

ns, not significant.

The APDI and every angular APDI component differed significantly between the European and Japanese but only in the Class II groups. While the APDI did not differ significantly in the Class I, Class III, and AOB groups, the facial plane angle (component of the APDI) showed a significant difference between the Japanese and Caucasian Class I groups (Table 2). In the Class I Japanese, Pg was positioned significantly more distal ($P < 0.01$). The null hypothesis was rejected for the APDI.

Japanese subjects with an Angle Class I occlusion had a significantly reduced overbite, and the angles between the A–B line and mandibular plane as well as FH and N–Pg were significantly smaller. The overjet was significantly larger in the Japanese Class II group and significantly more negative in the Japanese Class III group than in the Caucasians.

**Discussion**

The objective of any analytical approach is to reduce the practically infinite set of possible cephalometric measurements to a manageable small group of specific measurements that can be compared with specific norms providing useful diagnostic information (Proffit and Fields, 1993). A comparison of samples requires valid parameters of interest and parameters that describe the degree of dysgnathia. ODI and APDI fulfil these criteria of diagnostic usefulness (Kim and Vietas, 1978; Wardlaw et al., 1992; Han and Kim, 1998; Freudenthaler et al., 2000).

The present study was a cephalometric comparison of different ethnic samples in which different prevalences of malocclusion exist (Sassouni, 1969; Susami et al., 1971, Droschl, 1984; Ishii et al., 1987; Kajiyama et al., 2000). Separate norms have existed for specific populations in terms of single cephalometric measurements (angular and linear analyses, such as Steiner, Ricketts, and Tweed) but compound measurements should allow better interpretations of the inherent dysgnathia. The comparability of both ethnic samples was represented by an insignificant difference in their ages.

Different from the results of other investigators (Engel and Spolter, 1981; Ioi et al., 2007), the ODI values did not indicate significant vertical skeletal differences between either ethnic sample in any of the groups. However, in the Japanese sample, the Class II group tended to be more hypodivergent while the Class I and III groups tended more towards hyperdivergence (AB–MP, ODI). The hyperdivergence of the Japanese Class I and III groups was expressed by a steep mandibular plane (AB–MP) and not by maxillary inclination (FH–PP).

In the antero-posterior direction, the Japanese Class II group showed a more retrognathic pattern. This statistically significant difference encompassed a greater incisor overjet, a more negative angle between AB and N–Pg, a smaller angle between FH and N–Pg, less forward and upward inclination of the palatal plane, and a smaller APDI value. Other studies found a more pronounced skeletal Class II pattern in Japanese than in Caucasians and a bimaxillary protrusive dental pattern (Miura et al., 1965; Reitz et al., 1973; Engel and Spolter, 1981). Smaller SNA and SNB angles indicate a more posterior relationship of the denture

bases relative to the cranial base and a shorter mandible with procumbent mandibular incisors (Uesato *et al.*, 1978). In agreement with those findings, Pg was positioned more posteriorly in the Japanese (FH–NPg and AB–NPg) in the present study. The correction of the sagittal jaw relationship discrepancy is considered a greater challenge in the Japanese.

In the present study, the Japanese Class I group showed a more distal position of Pg. Other investigators who compared Japanese and Caucasian Class I subjects concluded that the sagittal mandibular position was significantly more retruded in the Japanese, again with more protruded mandibular incisors but without a difference in maxillary position (Miyajima *et al.*, 1996; Ioi *et al.*, 2007). The same investigators described a more hyperdivergent skeletal frame in their Japanese samples. Japanese Class I subjects were also described as being more retrognathic (Engel and Spolter 1981; Ioi *et al.* 2007). In the present study, the hyperdivergence of the Japanese Class I group was expressed by a significantly smaller AB–MP angle and a reduced overbite. However, the ODI values did not substantiate significant vertical skeletal differences between the Japanese and Caucasian patient subgroups.

Comparing the Class III groups, the Japanese presented a more pronounced negative overjet and more pronounced sagittal dysgnathia. The Caucasian Class I sample was closer to the Caucasian Class III group than the Japanese Class I to the Japanese Class III when the facial plane angle was compared.

Richardson (1980) compared traits of several races and concluded that the differences in means within ethnic groups were often greater than the differences in means among ethnic groups. What then is the benefit of comparing different ethnic samples? Orthodontic surveys of populations have shown that the incidence of malocclusions is different between ethnic groups (Beane *et al.*, 2003). The knowledge of malocclusion patterns of subjects of various ethnic groups is important for clinical and research purposes. In a similar study, Miyajima *et al.* (1996) found differences indicating fundamental variation in the craniofacial structure of Japanese and Americans of European descent. The aetiology of malocclusion is found in genetic, epigenetic, and environmental factors. In the present study, the phenotype of Class II and III was more pronounced in the Japanese sample. The evaluation of APDI and ODI values allows for a comparison of the severity of malocclusion and treatment outcome between Japanese and Caucasian patterns. Further investigations should focus on the latter issue and study gender-specific traits.

## Conclusions

In contrast to former studies, the present comparison of Japanese and Europeans using ODI and APDI showed a significant difference in subjects with a skeletal Class II

pattern. The Japanese sample showed a significantly smaller APDI but only in the Class II group. With regard to the vertical skeletal configuration, the ODI did not show significant differences between the Japanese and European samples.

## References

Alcalde R E, Jinno T, Pogrel M A, Matsumura T 1998 Cephalometric norms in Japanese adults. Journal of Oral and Maxillofacial Surgery 56: 129–134

Aoki H 1972 A comparative cephalometric study of the profiles of young Japanese and American (Caucasian) males and females. Shikwa Gakuho 72: 94–135

Beane R A, Reimann G, Phillips C, Tulloch C 2003 A cephalometric comparison of black open-bite subjects and black normals. Angle Orthodontist 73: 294–300

Bock J J, Fuhrmann R A 2007 Evaluation of vertical parameters in cephalometry. Journal of Orofacial Orthopedics 68: 210–222

Čelar A G, Freudenthaler J W, Schneider B 1999 Cephalometric discrimination of vertical and horizontal malocclusions in 122 Europeans using the Denture Frame Analysis and standard measurements. Journal of Orofacial Orthopedics 60: 195–204

Chen Z Q, Qian Y F, Shen G, Wang G M 2004 APDI and ODI estimated from substitute palate plane. Shanghai Kou Qiang Yi Xue 13: 13–16

Dahlberg G 1940 Statistical method for medical and biological students. Interscience, New York

Droschl H 1984 Die Fernröntgenwerte unbehandelter Kinder zwischen dem 6. und 15. Lebensjahr. Quintessenz Verlags-GmbH, Berlin

Engel G, Spolter B M 1981 Cephalometric and visual norms for a Japanese population. American Journal of Orthodontics 80: 48–60

Freudenthaler J W, Čelar A G, Schneider B 2000 Overbite depth and anteroposterior dysplasia indicators: relationship between occlusal and skeletal patterns studied using the receiver operating characteristic (ROC) analysis. European Journal of Orthodontics 22: 75–83

Graber T M, Rakosi T, Petrovic A (eds.) 1997. Dentofacial orhopedics with functional appliances. Mosby, St Louis

Han U K, Kim Y H 1998 Determination of Class II and Class III skeletal patterns: receiver operating characteristic (ROC) analysis on various cephalometric measurements. American Journal of Orthodontics and Dentofacial Orthopedics 113: 538–545

Harris E F, Johnson M G 1991 Heritability of craniometric and occlusal variables: a longitudinal sib analysis. American Journal of Orthodontics and Dentofacial Orthopedics 99: 258–268

Ioi H, Nakata S, Nakasima A, Counts A L 2007 Comparison of cephalometric norms between Japanese and Caucasian adults in antero-posterior and vertical dimension. European Journal of Orthodontics 29: 493–499

Ishii N, Deguchi T, Hunt N P 2002a Morphological differences in the craniofacial structure between Japanese and Caucasian girls with Class II division 1 malocclusions. European Journal of Orthodontics 24: 61–67

Ishii N, Deguchi T, Hunt N P 2002b Craniofacial differences between Japanese and British Caucasian females with a skeletal Class III malocclusion. European Journal of Orthodontics 24: 493–499

Ishii H, Morita S, Takeuchi Y, Nakamura S 1987 Treatment effect of combined maxillary protraction and chincap appliance in severe skeletal Class III cases. American Journal of Orthodontics and Dentofacial Orthopedics 92: 304–312

Ishikawa H, Nakamura S, Iwasaki H, Kitazawa S 2000 Seven parameters describing anteroposterior jaw relationships: postpubertal prediction accuracy and interchangeability. American Journal of Orthodontics and Dentofacial Orthopedics 117: 714–720

Kajiyama K, Murakami T, Suzuki A 2000 Evaluation of the modified maxillary protractor applied to Class III malocclusion with retruded maxilla in early mixed dentition. American Journal of Orthodontics and Dentofacial Orthopedics 118: 549–559

Kim Y H 1974 Overbite depth indicator with particular reference to anterior open-bite. American Journal of Orthodontics 65: 586–611

Kim Y H 1979 A comparative cephalometric study of Class II, division 1 nonextraction and extraction cases. Angle Orthodontist 49: 77–84

Kim Y H, Vietas J J 1978 Anteroposterior dysplasia indicator: an adjunct to cephalometric differential diagnosis. American Journal of Orthodontics 73: 619–633

Klocke A, Nanda R S, Kahl-Nieke B 2002 Anterior open bite in the deciduous dentition: longitudinal follow-up and craniofacial growth considerations. American Journal of Orthodontics and Dentofacial Orthopedics 122: 353–358

Miura F, Inoue N, Suzuki K 1965 Cephalometric standards for Japanese according to the Steiner analysis. American Journal of Orthodontics 51: 288–295

Miyajima K, McNamara J A Jr, Kimura T, Murata S, Iizuka T 1996 Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces. American Journal of Orthodontics and Dentofacial Orthopedics 110: 431–438

Oktay H 1991 A comparison of ANB, WITS, AF-BF, and APDI measurements. American Journal of Orthodontics and Dentofacial Orthopedics 99: 122–128

Proffit W R, Fields H W (eds). 1993 Contemporary orthodontics, 2nd edn. Mosby, St Louis

Proffit W R, Fields H W (eds). 2000 Contemporary orthodontics, 3rd edn. Mosby, St Louis

Reitz P V, Aoki H, Yoshioka M, Uehara J, Kubota Y 1973 A cephalometric study of tooth position as related to facial structure in profiles of human beings: a comparison of Japanese (Oriental) and American (Caucasian) adults. Journal of Prosthetic Dentistry 29: 157–166

Richardson E 1980 Racial differences in dimensional traits of the human face. Angle Orthodontist 50: 301–311

Sassouni V 1969 A classification of skeletal facial types. American Journal of Orthodontics 55: 109–123

Susami R, Asai Y, Hirose K, Hosoi T, Hayashi I 1971 The prevalence of malocclusion in Japanese school children. 1. Total frequency. Nippon Kyosei Shika Gakkai Zasshi 30: 221–229

Uesato G, Kinoshita Z, Kawamoto T, Koyama I, Nakanishi Y 1978 Steiner cephalometric norms for Japanese and Japanese-Americans. American Journal of Orthodontics 73: 321–327

Wardlaw D W, Smith R J, Hertweck D W, Hildebolt C F 1992 Cephalometrics of anterior open bite: a receiver operating characteristic (ROC) analysis. American Journal of Orthodontics and Dentofacial Orthopedics 101: 234–243