Dentoalveolar compensation related to variations in sagittal jaw relationships

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Abstract: The purpose of this study was to investigate dentoalveolar compensation for variations in sagittal jaw relationships in 44 adult females with normal incisor relationships and either skeletal Class I or skeletal Class III jaw relationships. Cephalometric analysis was performed to evaluate sagittal jaw relationship, maxillary and mandibular incisor inclination, and the cant of the occlusal plane. Molar relationships were evaluated from study models. Correlation analysis was performed between skeletal and dental measurements. The most appropriate cephalometric parameters describing dental compensation quantitatively were SN-AB as a skeletal measurement and SN-U1, SN-L1, and SN-OP as dental measurements. Among the compensatory dentoalveolar changes, lower incisor inclination was strongly related to the sagittal jaw relationship and played an important role in obtaining a normal incisor relationship. Compensatory changes in the occlusal plane angulation were slight when compared with changes in the incisor regions. A Class I molar relationship was rare when SN-AB exceeded 84°, even when incisor relationships were normal.

Key Words: Dental compensation, Skeletal Class III, Incisor angulation, Occlusal plane

When planning treatment for an adult with Class III malocclusion, the decision of whether to include jaw surgery is key to a successful result. With severe discrepancies in the jaw relationship, orthognathic surgery is generally required. In patients with mild jaw discrepancies and no cosmetic problems, orthodontic treatment without surgery is often preferable. As a practical matter, decision making is often difficult.[1] This appears to be due to a lack of sufficient information on appropriate tooth positions, information that would guide the clinician toward the objective of achieving a stable treatment result.

During facial growth and development, normal occlusion can be attained and maintained despite some variation in facial pattern, primarily as a result of dental compensation.[1-17] For existing sagittal jaw discrepancies, compensatory inclination of the maxillary and mandibular incisors results in normal incisal relationships.[1-8,11-16] The cant of the occlusal plane also acts to adjust sagittal relationships between the maxillary and mandibular dental arches.[9,10,15,17] Quantitative evaluation of the dentoalveolar adaptation to jaw relationships would provide additional information for planning treatment for adults with Class III malocclusion.

In this study, we examined 44 adult females with normal incisal relationships and either skeletal Class I or skeletal Class III apical base relationships. The purpose was threefold: (1) to evaluate cephalometrically the relationship between incisor inclination and the cant of the occlusal plane to the sagittal jaw relationship, (2) to determine cephalometric parameters that quantitatively describe dental compensations, and (3) to evaluate the effects of dental compensation on molar relationships.

Materials and methods

The present analysis was carried out on pretreatment lateral cephalograms of 44 untreated Japanese females with mild anterior crowding. The cephalograms were obtained from orthodontic records

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Table 1
Correlation coefficients between six jaw relationship and eight dental measurements

	SN-U1	FH-U1	PP-U1	SN-L1	FH-L1	MP-L1	SN-OP	FH-OP
ANB	-0.569***	-0.538***	-0.579***	-0.486***	-0.496***	0.452**	0.186	0.124
A-B plane	0.617***	0.558***	0.617***	0.455**	0.439**	-0.454**	-0.205	-0.097
Convexity	-0.499***	-0.492***	-0.515***	-0.496***	-0.526***	0.418**	0.156	0.137
SN-AB	0.647***	0.353*	0.471**	0.806***	0.551***	-0.600***	-0.507***	0.086
Wits	-0.560***	-0.298*	-0.458**	-0.573***	-0.344*	0.468**	0.045	-0.317*
APDI	0.509***	0.386**	0.665***	0.704***	0.615***	-0.583***	-0.355*	-0.074

*p<.05; **p<.01; ***p<.001

at the Hokkaido University Dental Hospital. The criteria for the selection were: (1) 16 years old or older at the first examination, (2) ANB angle[18] <3.39° (the mean for Japanese adult females[19]), (3) overbite and overjet from 1 to 5 mm without severe rotation of the maxillary or mandibular central incisors, (4) no missing permanent teeth, (5) no obvious mesial shift of the posterior teeth due to early loss of deciduous molars and no posterior crossbite, (6) no excessive curve of Spee, and (7) no clinical symptoms of temporomandibular joint dysfunction or periodontal disease. Ages ranged from 16 years 0 months to 30 years 2 months, and ANB ranged from -5.29° to 3.34°.

The cephalometric analysis was based on six skeletal and eight dentoalveolar parameters. For the jaw relationship parameters, A-B plane angle,[20] angle of convexity,[20] SN-AB angle (the angle formed by S-N and A-B planes),[2] Wits appraisal,[21] and anteroposterior dysplasia indicator (APDI, the facial plane angle plus or minus the A-B plane angle and again plus or minus the Frankfort-palatal plane angle)[22] were measured along with the ANB angle. The dentoalveolar parameters were measured as shown in Figure 1, to assess incisor inclination and the cant of the occlusal plane. In measuring the occlusal plane angulation and the Wits appraisal, the occlusal plane was located as the bisected occlusal plane. The midpoint of the overlap of the mesiobuccal cusps of the upper and lower first molars was joined with a point bisecting the overbite of the incisors because of the higher reliability in identifying landmarks than with the functional occlusal plane.[23,24]

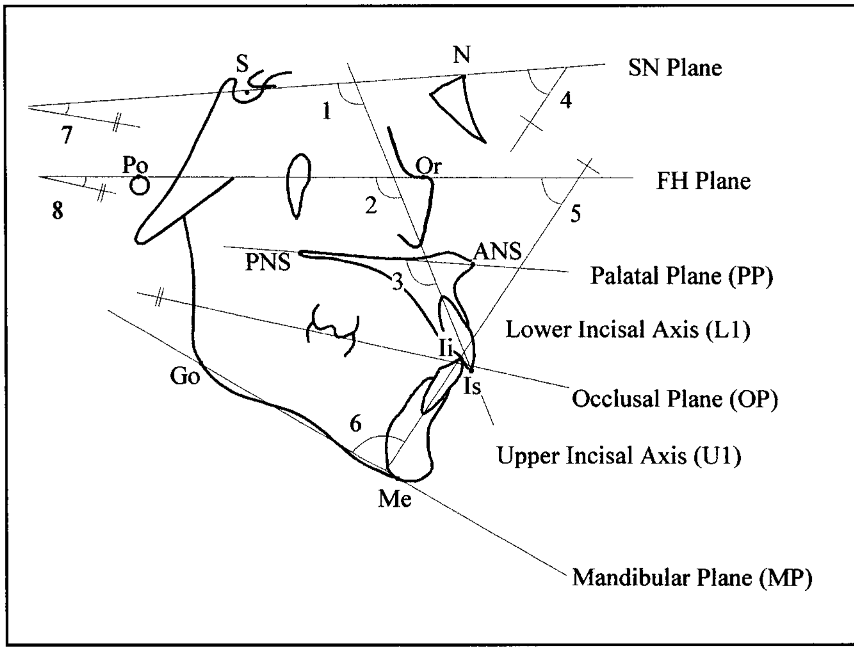

Figure 1
Cephalometric measurements of dental variables. 1. SN-U1; 2. FH-U1; 3. PP-U1; 4. SN-L1; 5. FH-L1; 6. MP-L1; 7. SN-OP; 8. FH-OP

Molar relationships were examined from pretreatment study models. Excellent molar relationship and less than half a cusp deviation were defined as Class I;[25] molar relationships out of this range were defined as Class II or Class III.

To evaluate dental compensation for skeletal jaw discrepancies quantitatively, correlation analysis was performed between skeletal and dental measurements, and the most appropriate parameters describing dental compensation were determined. For these parameters, regression equations were obtained. In addition, classification of the molar relationship was compared with jaw discrepancies.

Results

Table 1 shows correlation coefficients between six jaw relationship measures and eight dental ones. For the relationship of incisor inclination to jaw discrepancy, all incisor measurements were statistically significant in correlating to all six jaw relationship measurements, but correlation coefficients varied considerably. The highest, 0.806 ($p<0.001$), was found between the angles SN-L1 and SN-AB. With regard to upper incisor inclination, all correlation coefficients were less than 0.7. The closest relationship, 0.665 ($p<0.001$), was found between PP-U1 and APDI, and the second closest, 0.647 ($p<0.001$), was between SN-U1 and SN-AB. As the compensatory relationship of the occlusal plane angulation to the jaw relationship, SN-OP related statistically significantly to SN-AB and APDI, with correlation coefficients of -0.507 ($p<0.001$) and -0.355 ($p<0.05$), respectively. The correlation between the Wits appraisal and FH-OP was statistically significant but opposite to the compensatory relationship. From the relationships to SN-U1, SN-L1, and SN-OP, SN-AB was statistically significantly related to both incisal inclination and the occlusal plane angulation, with higher correlation coefficients than the other parameters. However, the degree of the relationship was different among the three dental measures.

Figure 2 shows scatter diagrams and regression lines of SN-AB versus SN-U1, SN-L1, and SN-OP. The regression lines show that, as SN-AB increases by 1.0°, the upper incisor inclines labially by 0.82°, the lower incisor inclines lingually by 1.07°, and the occlusal plane flattens by 0.26° with reference to the S-N plane.

Figure 3 shows a histogram representing the frequency distribution of SN-AB with the classification by molar relationships. A Class I molar relationship was found in 32 of 44 subjects, and the others showed a Class III relationship. There were no Class II cases. All subjects with an SN-AB angle below 80° had a Class I malocclusion, a relationship rarely found in subjects with an SN-AB angle exceeding 84°. The range from 80° to 84° included both Class I and Class III cases.

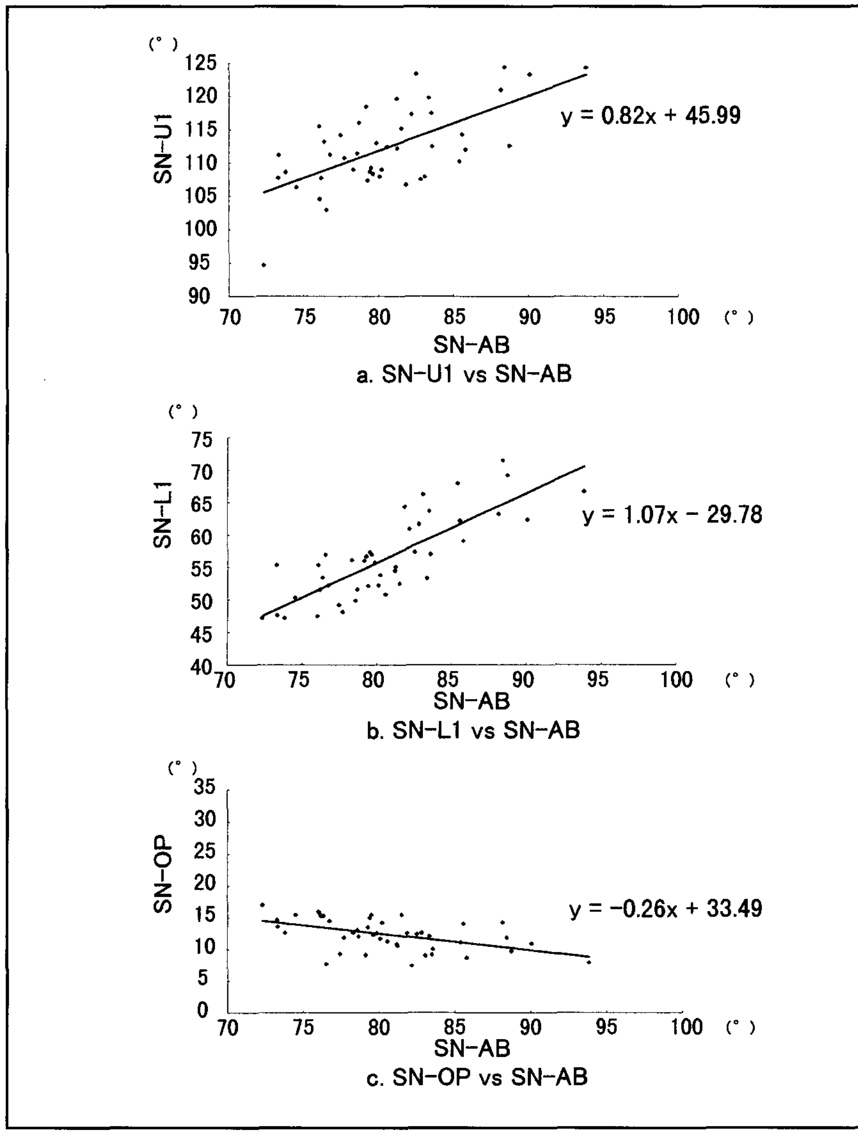

Figure 2
Scatter diagrams of SN-AB versus SN-U1, SN-L1, and SN-OP with regression lines.

Discussion

The role of dental compensation in the development of normal occlusion has been described in a number of studies.[1-17] Incisal adaptation to growth changes in the sagittal jaw relationship has been demonstrated in some longitudinal studies.[3,4,6,11,16] Solow[5] confirmed statistical associations between incisal inclination and jaw relationships using correlation and factor analysis. Hasund and Böe[14] modified Steiner's analysis[26] and developed a multiple regression equation for positioning the lower incisors using the ANB angle and two skeletal measures as guiding variables.

In this study, we investigated dental compensation in subjects with ANB angles from -5.29° to 3.34°. With the normal range of Japanese adult females 3.39° to 1.77° (as reported by Izuka and Ishikawa[19]), the range of the deviation was calculated from -4.90 to -0.03 standard deviation. Variation in the sagittal jaw relationships obviously extended from skeletal Class I to skeletal Class III categories.

The degree of association between skeletal and dental measures was evaluated by correlation analysis. For all reference planes, the parameters describing maxillary or mandibular incisor inclination were statistically significant and correlated with all six jaw relationship parameters. The correlations showed that, as the sagittal jaw relationship worsens toward mandibular prognathism, the upper incisors incline more labially and the lower incisors more lingually. In other cephalometric studies of Japanese adults with normal occlusion, Sebata et al.[7] found statistically significant correlations between FH-L1 and ANB, and Ohyama[12] found them between SN-L1 and SN-AB, although the correlation coefficients were lower than those found here. In addition, neither of these studies[7,12] showed statistically significant relationships between upper incisor inclination and jaw relationships. This appears to be due to differences in the sagittal jaw relationships of the subjects. Subjects in the present study had more severe jaw discrepancies than in the above studies, which reported mean ANB angles of approximately 4° ± 2°. As a result, the compensatory inclination of the incisors is more clearly reflected in the present results because of the larger variation in the skeletal relationships and discrepancies.

Enlow et al.[9] pointed out in a counterpart analysis that the cant of the occlusal plane compensates for skeletal discrepancies between jaws to attain a Class I occlusal relationship. The compensatory effect of the occlusal plane angulation has also been substantiated both statistically[15] and geometrically.[17] In this study, compensatory angulation of the occlusal plane was statistically substantiated with only two variables: one between SN-AB and SN-OP angles, and the other between APDI and SN-OP. The former showed a higher correlation coefficient than the latter. The statistically significant correlation found in the Wits appraisal appears to result from geometric distortion effects of the occlusal plane angulation.[27] Considering the consistency of the reference plane with values of the correlation coefficients, the most appropriate method of describing dental compensation quantitatively would be to use the SN-AB angle as a jaw relationship parameter and SN-U1, SN-L1, and SN-OP as dental parameters. These results support those of Donovan,[2] who stressed the clinical importance of the relationship between SN-AB and SN-U1. By using the relationship between SN-AB and the three dental measures, dentoalveolar compensation for skeletal Class III jaw discrepancies can be expressed as counterclockwise rotational changes in the entire dentoalveolar structure.

Of the three dental parameters, SN-L1 showed the strongest correlation to SN-AB. Horowitz and Hixon[28] suggested that correlation coefficients greater than 0.8 indicate biologically significant relationships for clinical prediction. Furthermore, SN-L1 showed the largest change for each degree of change in SN-AB. Therefore, lower incisor inclination may be strongly regulated by the sagittal jaw relationship, and it plays a very important role in obtaining normal incisor relationships, although morphological compensatory dentoalveolar changes are produced by the soft tissue or the force of occlusion.[5,6,11] At the same time, the accommodation of the occlusal plane to sagittal jaw discrepancies appears relatively weak and seems to display a somewhat greater degree of variation.

Examination of the study models showed that 32 of 44 subjects had a Class I molar relationship, and the remaining 12 had a Class III relationship. The Class I molar relationship was rare when the SN-AB angle exceeded 84°. This appears to indicate that there are limitations to achieving a Class I molar relationship via spontaneous dentoalveolar compensation, even when the incisor relationship is normal. Further investigation with a larger sample

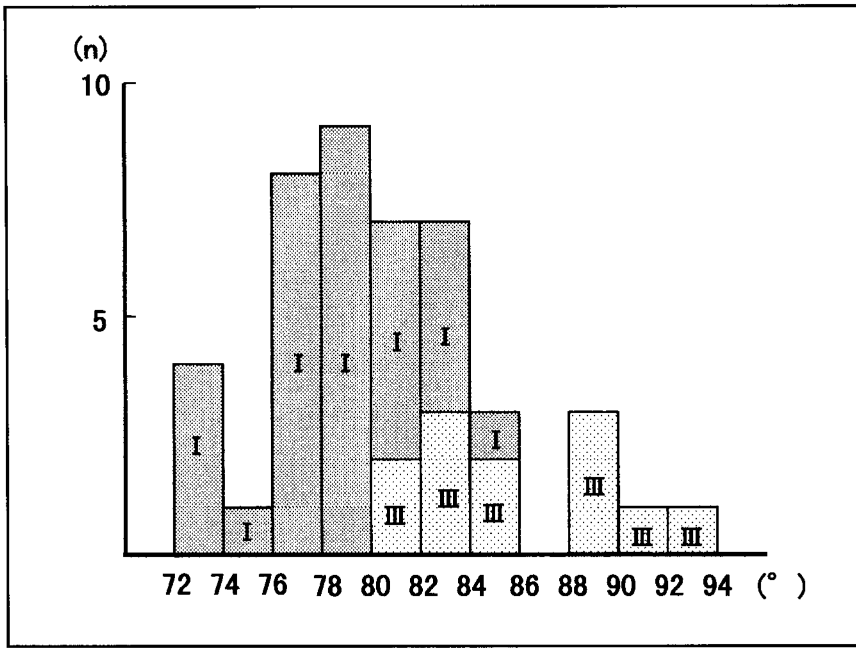

Figure 3
Histogram of frequency distribution in SN-AB angles with classification by molar relationships

is necessary to establish the limits in sagittal jaw relationships where normal molar and incisal relationships are obtained in the natural growth process.

Conclusions

Dentoalveolar compensations for variations in sagittal jaw discrepancies were investigated in 44 adult females with normal incisor relationships and skeletal Class I or Class III jaw relationships. The most appropriate cephalometric parameters for describing dental compensation quantitatively were SN-AB as a skeletal measure, and SN-U1, SN-L1, and SN-OP as dental measures. Lower incisor inclination was strongly influenced by the sagittal jaw relationship, which plays an important role in achieving normal incisor relationships. Compensatory changes in the cant of the occlusal plane were relatively slight.

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