European Journal of Orthodontics 25 (2003) 325–330

The effects of overjet on dentoalveolar compensation

İsmail Ceylan, İbrahim Yavuz and Fatma Arslan
Department of Orthodontics, Faculty of Dentistry, Atatürk University, Erzurum, Turkey

SUMMARY The purpose of this study was to investigate the relationship between overjet and dentoalveolar compensation in different overjet patterns. The lateral cephalometric head films of 80 untreated subjects (40 males and 40 females) aged 13–15 years were divided into four groups based on a normal, edge-to-edge, negative, or positive overjet. Seven linear and eight angular cephalometric measurements were used to assess dentoalveolar compensation in the different overjet patterns, and the differences between the groups and between genders were assessed by means of analysis of variance and the least significant difference (LSD) test. In addition, correlation coefficients between overjet and other variables were calculated.

The results showed that there were statistically significant differences in measurements of MxAABH (mm), MxPABH (mm), and angles $\underline{1}$–NA, $\underline{1}$–$\overline{1}$, $\underline{1}$–SN, $\overline{1}$–SN, $\overline{1}$–MP, and SN–AB among the overjet groups. In addition, significant correlation coefficients were found between overjet and MxAABH (mm), $\underline{1}$–NA (mm), and angles $\underline{1}$–$\overline{1}$, $\underline{1}$–SN, $\overline{1}$–SN, $\overline{1}$–MP, and SN–AB.

The evaluation of dentoalveolar compensation in different overjet patterns may be useful in treatment planning and treatment success.

Introduction

During facial growth and development, normal occlusion can be attained and maintained despite some variations in facial pattern, primarily as a result of dental compensation (Donovan, 1954; Björk, 1963, 1966; Solow, 1966, 1980; Enlow *et al*., 1971a,b; Björk and Skieller, 1972; Bibby, 1980; Hasund and Böe, 1980; Casko and Shepherd, 1984; Sinclair and Little, 1985; Braun and Legan, 1997; Ishikawa *et al*., 1999, 2000). For existing sagittal jaw discrepancies, compensatory inclination of the maxillary and mandibular incisors results in normal incisor relationships (Donovan, 1954; Björk, 1963, 1966; Solow, 1966; Björk and Skieller, 1972; Bibby, 1980; Casko and Shepherd, 1984; Sinclair and Little, 1985; Ishikawa *et al*., 1999, 2000).

Solow (1980) stated that co-ordination of the development of the upper and lower arches is not always perfect. Some mechanism is therefore needed to co-ordinate the eruption and position of the teeth relative to their jaw bases in order for a normal relationship between the upper and lower dental arches to be achieved and maintained. This mechanism is termed 'dentoalveolar compensation' and can be defined as a system, which attempts to maintain normal interarch relationships under varying jaw relationships (Solow, 1980).

The differences in the interarch relationships of subjects with Class I, II, and III malocclusions are probably not directly due to differences in skeletal morphology, but rather to the fact that in the Class I group, in contrast to Class II and III subjects, the variation in jaw relationship has been compensated for by the dentoalveolar compensatory mechanism (Solow, 1980). Therefore, a better understanding of the differences in dentoalveolar compensation in different overjet subjects may be useful in the analysis and treatment planning of these cases.

The purpose of the present study was to investigate and compare dentoalveolar compensation in subjects with different overjet patterns.

Materials and methods

The sample consisted of lateral cephalometric records of 80 untreated subjects (40 males and 40 females), obtained from approximately 3500 patient records at the Orthodontic Department, Faculty of Dentistry, Atatürk University. The chronological ages of the subjects ranged from 13 to 15 years. The 80 subjects were selected on the basis of overjet and were divided into four groups according to overjet size. Finally, each overjet group consisted of 20 subjects (10 males and 10 females).

The four overjet groups were classified as follows:

1. normal: overjet more than +1 mm but less than or equal to +2 mm
2. edge-to-edge: overjet more than –1 mm but less than +1 mm
3. negative (decreased): overjet less than –1 mm
4. positive (increased): overjet more than +2 mm.

The subjects included in this study had no missing permanent teeth and no severe craniofacial disorders, such as a cleft palate. None had undergone orthodontic therapy.

Overjet was measured as the distance between the incisal tip of the maxillary central incisor and the buccal surface of the mandibular central incisor parallel to the occlusal plane.

Seven linear and eight angular cephalometric measurements were used to assess dentoalveolar compensation. The linear and angular cephalometric measurements used are described in Figures 1 and 2, respectively.

To determine the method errors, lateral cephalometric head films from 20 randomly selected subjects were retraced and remeasured by the same operator with a 2-week interval.

Dahlberg's formula (Dahlberg, 1940) was used to calculate the method error:

Method error = $\sqrt{\sum d^2/2n}$ where d is the difference between two measurements of a pair and n is the number of subjects. The method error did not exceed 0.41 mm (range 0.30–0.41 mm) or 0.48 degrees (range 0.25–0.48 degrees).

Differences between the overjet groups and between genders were assessed by means of analysis of variance. The least significant difference (LSD) test (Keppel, 1973) was applied to the measurements in which F values were found to be statistically significant. Correlation coefficients between overjet and other variables used in the study were calculated. In addition, mean and standard deviation values were computed for all measurements separately for each overjet group.

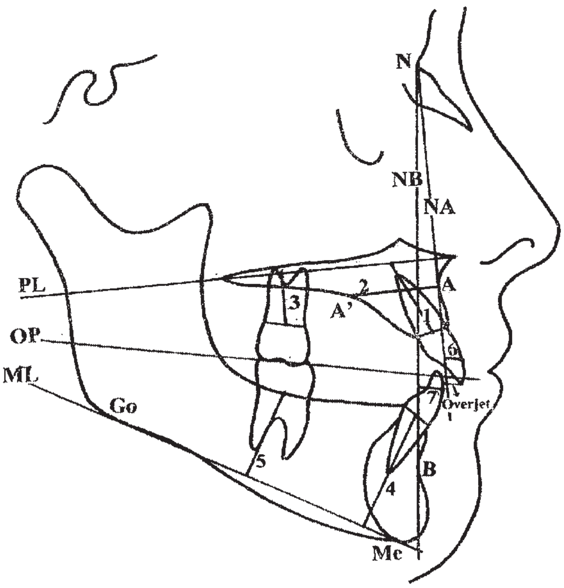

Figure 1 Linear cephalometric measurements used in the study: (1) MxAABH (mm), (2) MxAD (mm), (3) MxPABH (mm), (4) MdAABH (mm), (5) MdPABH (mm), (6) $\underline{1}$–NA (mm), (7) $\overline{1}$–NB (mm).

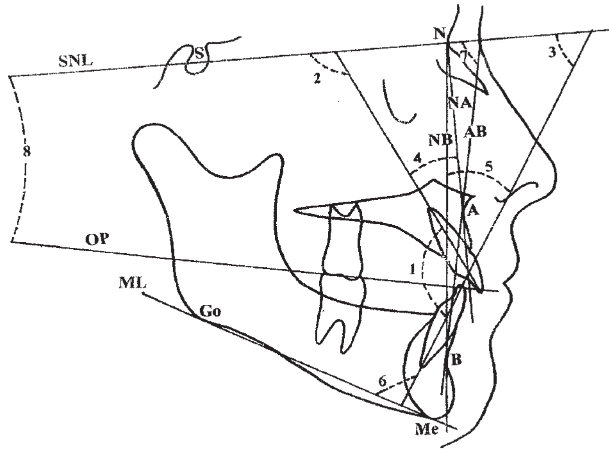

Figure 2 Angular cephalometric measurements used in the study: (1) $\underline{1}$–$\overline{1}$ (angle), (2) $\underline{1}$–SN (angle), (3) $\overline{1}$–SN (angle), (4) $\underline{1}$–NA (angle), (5) $\overline{1}$–NB (angle), (6) $\overline{1}$–MP (angle), (7) SN–AB (angle), (8) SN–OP (angle).

Dentoalveolar cephalometric measurements used in the study

Linear measurements (Figure 1)

1. MxAABH (maxillary anterior alveolar and basal height): the distance between the midpoint of the alveolar meatus of the maxillary central incisor and the intersection point between the palatal line and the long axis of the maxillary central incisor
2. MxAD (maxillary anterior depth): the distance between points A and A′ (A′: from point A, a line was drawn parallel to the palatal line intersecting the dorsal contour of the maxillary alveolar bone)
3. MxPABH (maxillary posterior alveolar and basal height): the perpendicular distance between the midpoint of the alveolar meatus of the maxillary first molar and the palatal line
4. MdAABH (mandibular anterior alveolar and basal height): the perpendicular distance between the midpoint of the alveolar meatus of the mandibular central incisor and the mandibular line
5. MdPABH (mandibular posterior alveolar and basal height): the perpendicular distance between the midpoint of the alveolar meatus of the mandibular first molar and the mandibular line
6. $\underline{1}$–NA: the horizontal distance between the buccal surface of the maxillary central incisor and N–A line
7. $\overline{1}$–NB: the horizontal distance between the buccal surface of the mandibular central incisor and N–B line.

Angular measurements (Figure 2)

1. $\underline{1}$–$\overline{1}$: the angle between the long axes of the maxillary and mandibular central incisors
2. $\underline{1}$–SN: the angle between the long axis of the maxillary central incisor and the S–N line

Table 1 Means and standard deviations of chronological ages and overjet measurements for each group and *F* values found by analysis of variance.

	Normal overjet $n = 20$	Edge-to-edge overjet $n = 20$	Negative overjet $n = 20$	Positive overjet $n = 20$	*F* values
Age (years)	13.0 ± 0.7	13.9 ± 1.2	13.3 ± 1.1	13.3 ± 1.0	2.6
Overjet (mm)	1.7 ± 0.3	0.1 ± 0.3	–1.8 ± 0.9	6.6 ± 2.4	145.0***

***$P < 0.001$.

3. $\overline{1}$–SN: the angle between the long axis of the mandibular central incisor and the S–N line
4. $\underline{1}$–NA: the angle between the long axis of the maxillary central incisor and the N–A line
5. $\overline{1}$–NB: the angle between the long axis of the mandibular central incisor and the N–B line
6. $\overline{1}$–MP: the angle between the long axis of the mandibular central incisor and the mandibular line (Go–Me)
7. SN–AB: the angle between the S–N and A–B lines
8. SN–OP: the angle between the S–N and occlusal lines.

Results

The mean and standard deviation values of the chronological ages and overjet measurements for each overjet group and the *F* values are presented in Table 1. No statistically significant chronological age difference among the overjet groups was found. However, there were statistically significant differences in overjet measurements among the groups ($P < 0.001$).

The results of variance analysis are shown in Table 2. As can be seen, maxillary anterior and posterior alveolar and basal heights (MxAABH, MxPABH), $\underline{1}$–NA (mm), $\underline{1}$–$\overline{1}$ (angle), $\underline{1}$–SN (angle), $\overline{1}$–SN (angle), $\overline{1}$–MP (angle), and SN–AB (angle) measurements showed statistically significant differences among the overjet groups. In addition, maxillary anterior and posterior alveolar and basal heights (MxAABH, MxPABH), maxillary anterior depth (MxAD), and mandibular anterior and posterior alveolar and basal heights (MdAABH, MdPABH) demonstrated significant gender differences. No interaction effects between gender and overjet groups were found. The LSD test was applied to determine differences among the overjet group, and the results are given in Table 3. The results of the LSD test showed that the most significant differences among the overjet groups were concentrated between the edge-to-edge and negative (decreased) overjet groups and between negative (decreased) and positive (increased) overjet groups.

Correlation coefficients between the overjet and other variables used in the study are illustrated in

Table 2 The results of the analysis of variance.

Parameters	Overjet groups	Gender	Overjet × gender
Linear (mm)			
MxAABH	3.5*	8.1*	0.7
MxAD	1.0	15.6***	0.0
MxPABH	3.1*	4.9*	0.1
MdAABH	0.9	10.7**	0.3
MdPABH	0.6	5.1*	0.2
$\underline{1}$–NA	4.7**	0.2	0.7
$\overline{1}$–NB	1.6	0.0	1.0
Angular (°)			
$\underline{1}$–$\overline{1}$	7.8***	0.3	1.0
$\underline{1}$–SN	3.2*	0.2	0.2
$\overline{1}$–SN	9.1***	0.7	0.2
$\underline{1}$–NA	0.4	0.6	1.0
$\overline{1}$–NB	2.4	0.5	0.8
$\overline{1}$–MP	3.6*	0.2	0.5
SN–AB	35.6***	0.4	0.3
SN–OP	0.9	0.5	0.4

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

Table 4. The largest correlations were found between overjet and SN–AB (angle –0.71) and $\underline{1}$–$\overline{1}$ (angle –0.51) measurements. In addition, significant correlation coefficients were found between overjet and $\underline{1}$–NA (mm 0.43), $\overline{1}$–SN (angle –0.39), $\underline{1}$–SN (angle 0.29), MxAABH (mm 0.29), and $\overline{1}$–MP (angle 0.25) measurements.

Descriptive statistics, including the mean and standard deviations determined separately for each overjet group are shown in Table 5.

Discussion

The concept of the dentoalveolar compensatory mechanism and its relationship to the development of malocclusion is of considerable importance to the way in which cephalometric radiographs are analysed in orthodontic cases (Solow, 1980).

Some investigators have suggested that malocclusions result from insufficient dentoalveolar compensation to variations in facial patterns (Solow, 1966, 1980; Björk and Skieller, 1972; Ishikawa *et al*., 2000).

Table 3 The results of the least significant difference (LSD) test.

Parameters	Overjet groups				Mean differences					
	Group 1 normal *n* = 20	Group 2 edge-to edge *n* = 20	Group 3 negative *n* = 20	Group 4 positive *n* = 20	1–2	1–3	1–4	2–3	2–4	3–4
Linear (mm)										
MxAABH	18.6	19.9	19.5	21.2	NS	NS	–2.6*	NS	NS	–1.7*
MxPABH	15.4	18.2	17.0	17.1	–2.9*	NS	NS	NS	NS	NS
$\underline{1}$–NA	5.3	6.2	4.9	7.0	NS	NS	–1.7*	1.3*	NS	–2.1*
Angular (°)										
$\underline{1}$–$\overline{1}$	129.6	132.1	138.8	127.6	NS	–9.3*	NS	–6.7*	NS	11.2*
$\underline{1}$–SN	101.4	103.5	95.7	103.5	NS	NS	NS	7.8*	NS	7.8*
$\overline{1}$–SN	50.8	55.4	63.5	51.2	NS	–12.7*	NS	–8.1*	NS	12.3*
$\overline{1}$–MP	91.6	90.0	85.1	91.9	NS	6.5*	NS	4.8*	NS	6.8*
SN–AB	71.8	78.3	82.3	68.3	6.5*	10.5*	3.6*	4.0*	10.0*	14.1*

NS, not significant; *$P < 0.05$.

Table 4 Correlation coefficients between overjet and the other variables used in the study.

Parameters	Overjet *R*
Linear (mm)	
MxAABH	0.29*
MxAD	0.11
MxPABH	–0.06
MdAABH	0.06
MdPABH	0.01
$\underline{1}$–NA	0.43**
$\overline{1}$–NB	0.15
Angular (°)	
$\underline{1}$–$\overline{1}$	–0.51**
$\underline{1}$–SN	0.29**
$\overline{1}$–SN	–0.39**
$\underline{1}$–NA	0.20
$\overline{1}$–NB	0.20
$\overline{1}$–MP	0.25*
SN–AB	–0.71**
SN–OP	0.01

*$P < 0.05$, **$P < 0.01$.

On the other hand, there is no available data concerning vertical dentoalveolar adaptation related to variations in sagittal jaw relationships. Therefore, evaluation of both the vertical and sagittal dentoalveolar adaptation in relation to different overjet patterns would provide additional information for treatment success and post-treatment stability.

The results of this study indicate that there are statistically significant differences in the vertical and sagittal dentoalveolar measurements among the overjet groups. Maxillary anterior and posterior dentoalveolar heights showed significant differences, but not mandibular dentoalveolar height. Maxillary anterior alveolar and basal heights in subjects with positive (increased) overjets were greater than in the other groups. However, maxillary posterior alveolar and basal heights in the edge-to-edge overjet group were larger than in the other groups. To provide an adaptation to a variable amount of overjet in different overjet patterns, maxillary anterior and posterior dentoalveolar heights showed significant variations, but not mandibular dentoalveolar height. According to these results, maxillary dentoalveolar heights were more effective in providing dentoalveolar compensation in different overjet patterns than mandibular dentoalveolar heights.

The statistically significant correlation between overjet and maxillary anterior alveolar and basal height confirmed this result. Thus, from the clinical viewpoint, the assessment of maxillary anterior and posterior dentoalveolar heights may be useful in treatment planning of overjet problems.

Janson *et al*. (1994) reported that maxillary and mandibular dentoalveolar heights were similar between Class I and Class II dental and skeletal malocclusions. However, the results of the present investigation show that whilst there were significant differences in maxillary dentoalveolar heights between the overjet groups, mandibular dentoalveolar heights were similar.

This investigation demonstrates that there are dentoalveolar compensatory changes in the position and axial inclination of the maxillary and mandibular incisors related to the variations in the overjet pattern. Bibby (1980), who investigated incisor relationship in different skeletofacial patterns, reported that the proclination of the lower incisors is similar in skeletal

Table 5 Means and standard deviations for all variables separately for each group.

Parameters	Normal overjet $n = 20$	Edge-to-edge overjet $n = 20$	Negative overjet $n = 20$	Positive overjet $n = 20$
Linear (mm)				
MxAABH	18.6 ± 2.5	19.9 ± 2.5	19.5 ± 3.2	21.2 ± 2.2
MxAD	15.7 ± 2.5	16.3 ± 2.7	16.5 ± 2.8	16.9 ± 2.5
MxPABH	15.4 ± 2.9	18.2 ± 3.0	17.0 ± 3.2	17.1 ± 2.7
MdAABH	29.9 ± 2.4	31.3 ± 3.1	30.4 ± 3.6	31.0 ± 2.6
MdPABH	23.1 ± 2.4	23.8 ± 3.5	22.7 ± 2.7	22.9 ± 2.3
$\underline{1}$–NA	5.3 ± 1.5	6.2 ± 1.8	4.9 ± 1.7	7.0 ± 2.6
$\overline{1}$–NB	5.7 ± 1.5	5.7 ± 2.2	4.6 ± 1.9	5.6 ± 2.1
Angular (°)				
$\underline{1}$–$\overline{1}$	129.6 ± 5.3	132.1 ± 7.2	138.8 ± 7.2	127.6 ± 10.5
$\underline{1}$–SN	101.4 ± 4.1	103.5 ± 5.9	95.7 ± 14.5	103.5 ± 7.8
$\overline{1}$–SN	50.8 ± 5.4	55.4 ± 7.9	63.5 ± 13.2	51.2 ± 5.4
$\underline{1}$–NA	23.6 ± 4.2	24.8 ± 4.2	23.5 ± 4.0	24.6 ± 7.0
$\overline{1}$–NB	24.5 ± 4.2	22.8 ± 6.5	19.8 ± 5.4	23.5 ± 6.5
$\overline{1}$–MP	91.6 ± 4.9	90.0 ± 9.8	85.1 ± 6.1	91.9 ± 7.4
SN–AB	71.8 ± 3.8	78.3 ± 5.7	82.3 ± 4.1	68.3 ± 4.8
SN–OP	18.0 ± 4.8	16.1 ± 3.6	16.2 ± 3.5	16.3 ± 5.2

Class I and II subjects, whereas in Class III they are very upright or retroclined relative to the other Classes. These findings are in agreement with those of the present study, where it was found that the axial inclination of the mandibular incisors in subjects with normal and positive (increased) overjet were similar, whereas lower incisor inclinations in the negative (decreased) overjet subjects were significantly different from those of the normal and positive overjet cases. The lower incisors in the negative overjet cases were more upright than in the other overjet groups. Bibby (1980) also found that the upper incisor inclination was significantly different between all three skeletal Classes, Class II having relatively retroclined upper incisors and Class III relatively proclined upper incisors. The data from the present investigation show that maxillary incisor inclination was significantly different between the negative and positive overjet groups, whereas there was no statistically significant difference between the normal and positive overjet groups or between the normal and negative overjet groups.

On the other hand, Ishikawa *et al*. (1999, 2000) reported that the upper incisors incline more labially and the lower incisors more lingually in negative overjet cases. In the present investigation, it was found that the upper incisors in positive overjet cases have a proclined tendency relative to the normal overjet cases, and that in negative overjet subjects they have a retroclined tendency, but these changes were not statistically significant. Retroclination of the upper incisors in negative overjet cases is an unexpected finding, which can be explained by insufficient maxillary dentoalveolar compensation.

Correlation analysis showed statistically significant relationships between overjet and the measurements of the position and axial inclination of the upper and lower incisors. However, these correlation coefficients were relatively low, except for the measurements of angles SN–AB and $\underline{1}$–$\overline{1}$. These low correlation coefficients may indicate insufficient dentoalveolar compensation for variations in the overjet patterns.

Conclusions

This study demonstrated that there are vertical and sagittal dentoalveolar compensatory changes related to variations in overjet pattern. Maxillary dentoalveolar height was more effective than mandibular dentoalveolar height at providing dentoalveolar compensation in different overjet patterns. In addition, dentoalveolar compensatory changes in the position and axial inclination of the upper and lower incisors were found between the different overjet groups. The most pronounced compensatory changes were determined between the negative (decreased) and positive (increased) overjet groups. The upper and lower incisors inclined more labially in the positive than in the negative overjet cases. Statistically significant correlations were found between overjet and other dentoalveolar compensatory measurements, but these correlation coefficients were relatively low, except for angles SN–AB and $\underline{1}$–$\overline{1}$.

Evaluation of dentoalveolar compensation in different overjet patterns may be useful in treating increased overjets and for post-treatment stability.

Address for correspondence

Dr İsmail Ceylan
Atatürk Üniversitesi
Diş Hekimliği Fakültesi
Ortodonti Anabilim Dalı
25240-Erzurum, Turkey

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