Orthodontic treatment of openbite and deepbite high-angle malocclusions

Klaus Hering, DDS, Dr. med. dent.; Sabine Ruf, DDS, Dr. med. dent.; Hans Pancherz, DDS, Odont. Dr.

Abstract: The aim of the investigation was to assess the effect of orthodontic treatment on dentoskeletal morphology in children with openbite and deepbite high-angle malocclusion. Subjects (n=54) in the mixed dentition with a hyperdivergent mandibular plane angle (high-angle, NSL/ML ≥ 40°) were surveyed. Pre- and posttreatment lateral roentgenographic cephalograms were analyzed. Subjects were divided into three subgroups according to the amount of pretreatment overbite: < 0 mm = insufficient/no compensation (openbite); 0 - 4 mm = acceptable compensation (normal overbite); > 4 mm = overcompensation (deepbite). Pretreatment, 20% of the high-angle cases exhibited insufficient dentoskeletal compensation (overbite < 0 mm), and 35% displayed overcompensation (overbite > 4 mm). Influences of habits such as lip sucking and tongue-thrust swallowing were more common in the openbite group. No major difference in treatment approach could be found between subgroups. In 82% of the openbite group and 90% of the deepbite group, overbite was corrected by orthodontic treatment. The mandibular plane angle was unaffected in both groups. The mechanisms of overbite correction differed between groups. The openbite group exhibited a significant decrease in interjaw-base angle. Increases in anterior and posterior dentoalveolar heights were comparable. The deepbite group showed no significant changes in skeletal morphology. The increase in dentoalveolar height was approximately twice as large posteriorly as anteriorly. The majority of children (80%) with high-angle morphology had a positive pretreatment overbite, thus exhibiting compensation of jaw-base hyperdivergency. Orthodontic treatment of high-angle malocclusions did not influence the mandibular plane angle in openbite or deepbite cases. Overbite correction was accomplished by tipping the maxilla downward anteriorly in openbite subjects, and by controlling incisor eruption in deepbite subjects.

Key Words: Orthodontic treatment, Compensation, High angle, Skeletal, Dentoalveolar, Mixed dentition

High-angle dysmorphology has been discussed under numerous headings, such as clockwise growth rotation, adenoid face, total maxillary alveolar hyperplasia, vertical maxillary excess, and long face syndrome.[1,2,3,4] High-angle malocclusions are characterized by an increased inclination of the mandible in relation to the anterior cranial base, excessive lower facial height, small posterior facial height, and large gonial and mandibular plane angles.[1,2,4,5] According to Riedel,[6] a high-angle malocclusion is present when the mandibular plane angle exceeds 38 degrees.

As a result of increased anterior facial height, many high-angle patients present with an anterior openbite (Figure 1).[7-10] However, an openbite is not necessarily associated with a long face, and not all long-faced patients have an openbite,[1,7,10] as compensatory tooth movements and adaptation of the alveolar processes may mask the divergency of the jaw-base relationship partially or totally,[8,11-13] even resulting in a frontal deepbite (Figure 2).

Orthodontic treatment of high-angle malocclusions aims at influencing the vertical development of the dentoalveolar processes, position of the teeth, and the dimensions of the midface structures to create a functional and stable occlusion.[5,11,14,15] However, most clinicians agree that malocclusions with marked vertical facial imbalances are difficult to treat and maintain.[16]

In the literature, only a small

Author Address
Dr. Sabine Ruf
Dept. of Orthodontics
Justus-Liebig-Universität of Giessen
Schlangenzahl 14
D-35392 Giessen, Germany

Klaus Hering, assistant professor, Department of Orthodontics, University of Giessen, Germany.

Sabine Ruf, assistant professor, Department of Orthodontics, University of Giessen, Germany.

Hans Pancherz, professor and chairman, Department of Orthodontics, University of Giessen, Germany.

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number of investigations deal with the effect of orthodontic treatment on the dentoskeletal structure in high-angle individuals. Furthermore, the results of these studies are often contradictory, perhaps due to the lack of differentiation between openbite and deepbite high-angle cases.[5,8,14,15,17-19]

Therefore, the aim of this study was to investigate the influence of orthodontic treatment on vertical dentoskeletal morphology in noncompensated (openbite) and compensated (normal or deepbite) high-angle malocclusions, with special reference to the change in mandibular plane angle and to the mechanism of overbite correction.

Figure 1
Lateral headfilm of a high-angle subject (NSL/ML = 43°) with openbite

Figure 2
Lateral headfilm of a high-angle subject (NSL/ML = 47°) with deepbite

Materials and methods

Subjects

One hundred ninety-one patients in the Department of Orthodontics at the University of Giessen exhibited a large pretreatment mandibular plane angle (NSL/ML≥40 degrees) and had at least all permanent incisors and first molars completely erupted.

From this subject material, 54 individuals were in the mixed dentition, had completed orthodontic treatment (active treatment time and retention period), and had pre- and posttreatment lateral headfilms available. The mean pretreatment age was 10.1 years (Table 1).

By analyzing the lateral headfilms, subjects were further divided into three subgroups with respect to the amount of pretreatment overbite as a measure of skeletal and/or dentoalveolar compensation of the jaw-base hyperdivergency:

- Overbite < 0 mm: insufficient/no compensation (openbite)
- Overbite = 0 - 4 mm: acceptable compensation (normal overbite)
- Overbite > 4 mm: overcompensation (deepbite)

Roentgenocephalometric analysis

The pre- and posttreatment lateral headfilms of each patient were traced on matte acetate paper and evaluated cephalometrically by one investigator (KH). Dual images of bilateral structures were bisected. Measurements were performed to the nearest 0.5 mm and 0.5 degrees, respectively. No correction was performed for linear enlargement (approximately 8% in the median sagittal plane).

The reference points, reference planes, and variables used in the evaluation of the vertical facial morphology are shown in Figure 3.

Skeletal variables

NSL/ML (degrees): inclination of the mandibular jaw-base (ML) to the anterior cranial base (NSL) (= mandibular plane angle)

NSL/NL (degrees): inclination of the maxillary jaw-base (NL) to the anterior cranial base (NSL) (=maxillary plane angle)

NL/ML (degrees): inclination of the maxillary jaw-base (NL) to the mandibular jaw-base (ML) (= interjaw-base angle)

s-go (mm): distance from sella (s) to gonion (go) (=posterior total facial height)

n-gn (mm): distance from nasion (n) to gnathion (gn) (=anterior total facial height)

n-spa (mm): distance from nasion (n) to anterior nasal spine (spa) (=anterior upper facial height)

spa-gn (mm): distance from anterior nasal spine (spa) to gnathion (gn) (=anterior lower facial height)

Dentoalveolar variables

is-NL (mm): distance of the tip of the most extruded maxillary incisor (is) to the maxillary jaw-base (NL) (= upper incisor height)

ii-ML (mm): distance of the tip of the most extruded mandibular incisor (ii) to the mandibular jaw-base (ML) (= lower incisor height)

ms-NL (mm): distance of the mesial cusp tip of the maxillary first molar (ms) to the maxillary jaw-base (NL) (= upper molar height)

mi-ML (mm): Distance of the mesial cusp tip of the mandibular first molar (mi) to the mandibular jaw-base (ML) (= lower molar height)

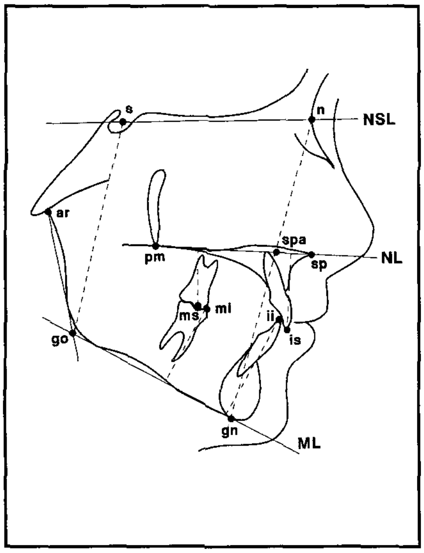

Figure 3
Cephalometric reference points, reference lines, and skeletal and dentoalveolar variables

Table 1
Age distribution pretreatment and treatment time of mixed dentition high-angle subjects

Overbite (mm)	Age before treatment (years)	Active treatment time (years)	Time of retention (years)	Total treatment time (years)
Openbite (< 0 mm)	9.6	4.1	1.7	5.8
Normal overbite (0-4 mm)	10.2	3.5	1.6	5.2
Deepbite (> 4 mm)	10.2	3.9	1.8	5.7

Table 2
Incidence (percentage and number) of habits in 54 high-angle subjects

	Mixed dentition		
	Open bite (n = 11)	Normal overbite (n = 24)	Deep bite (n = 19)
Fingersucking	55% (6)	42% (10)	21% (4)
Lipsucking	27% (3)	21% (5)	37% (7)
Tongue-thrust swallowing	64% (7)	17% (4)	5% (1)

Etiologic factors

Habits, including finger sucking, lip sucking, and tongue-thrust swallowing, were registered in all subjects as possible etiologic factors for the overbite condition.

Appliances and treatment approaches

Registrations of the different kinds of appliances (removable and/or fixed) were made, as well as the treatment approaches (extraction or nonextraction).

Statistical methods

For each cephalometric variable the arithmetic mean (mean) and standard deviation (SD) were determined. To analyze statistical differences between various subject groups, the Student's-*t*-test for unpaired samples was applied. The level of significance was set at $p < 0.05$.

Error of the method

To determine the method error (ME) in the registration of the different variables, the lateral cephalograms of 15 randomly selected cases were traced and evaluated twice by the same examiner (KH) on two separate occasions at least 1 month apart. The method error was assessed using the formula of Dahlberg [20]

$$ME = \sqrt{\frac{\sum d^2}{2n}}$$

where d is the difference between two measurements of a pair and n is the number of subjects. The method error did not exceed 0.7 mm for the linear measurements or 0.8 degrees for the angular ones.

Results

Pretreatment, only 20% of the high-angle cases exhibited an anterior openbite (overbite < 0 mm), implying an insufficient/no compensation of the diverging jaw-base relationship. Acceptable jaw-base compensation with normal overbite (overbite = 0 - 4 mm) was found in 45% of the cases, overcompensation with a deepbite (overbite > 4 mm) could be recognized in 35%.

On average, treatment started about half a year earlier in the openbite group (9.6 years) than in the other groups (10.2 years). The length of active treatment and retention was comparable in the three groups (Table 1).

The occurrence of possible etiologic factors for the existing overbite conditions are given in Table 2. Lip sucking and tongue-thrust swallowing were more common in the openbite group than in the normal and deepbite groups.

A variety of fixed and removable appliances was used in the treatment of all three overbite subgroups (Table 3). Removable appliances were used about equally in all three subgroups. The use of headgear revealed no real differences between the groups. Due to insufficient patient records, no differentiation between different directions of traction was possible. The use of transpalatal bars was more common in openbite patients. More than 80% of the patients in each group were treated with multibracket appliances. In both the openbite and deepbite groups, 50% of the patients were treated by extractions, while nonextraction therapy predominated in the normal overbite group (Table 3).

In the closer analysis of the treatment effects on the dentoskeletal structures and the mechanism of overbite correction, the openbite and deepbite groups were compared. Skeletal and dentoalveolar variables were evaluated separately (Table 4).

Skeletal changes

Skeletal changes were assessed using the angular parameters NSL/ML, NL/ML, and NSL/NL, and the linear parameters s-go, n-gn, n-spa, and spa-gn (Table 4).

In the openbite group, no significant changes in mandibular plane angle (NSL/ML) or maxillary plane angle (NSL/NL) could be proven. However, the interjaw-base angle (NL/ML) decreased significantly ($p < 0.05$) by an average of 2.14 degrees (Figure 4). Posterior total facial height (s-go) increased less (mean: 7.95 mm, $p < 0.001$) than anterior total facial height (n-gn, mean: 11.19 mm, $p < 0.001$).The increase in upper anterior facial height (mean: 5.50 mm, $p < 0.001$) was similar to the increase in lower anterior facial height (mean: 5.69 mm, $p < 0.001$).

In the deepbite group, no significant changes in mandibular plane angle (NSL/ML), maxillary plane angle (NSL/NL), or interjaw-base angle (NL/ML) were noted (Figure 5). Posterior total facial height (s-go) increased less (mean: 9.84 mm, $p < 0.001$) than anterior total facial height (n-gn, mean: 13.55 mm, $p < 0.001$). The increase in anterior upper facial height (n-spa, mean: 5.42 mm, $p < 0.001$) was less than in anterior lower facial height (spa-gn, mean: 8.13 mm, $p < 0.001$).

Dentoalveolar changes

Dentoalveolar changes were assessed using the linear parameters overbite, is-NL, ms-NL, ii-ML, and mi-ML (Table 4).

In the openbite group, overbite increased significantly (mean: 2.68 mm, $p < 0.001$). The openbite was corrected in 82% of the cases. There was a comparable increase in maxillary (mean: 3.31 mm, $p < 0.001$) and mandibular (mean: 3.77 mm, $p < 0.001$) incisor heights as well as in maxillary (mean: 3.45 mm, $p < 0.001$) and mandibular (mean: 3.99 mm, $p < 0.001$) molar heights (Figure 6).

Table 3
Distribution of removable and fixed appliances as well as extraction and nonextraction treatment approaches in the three overbite groups

Appliances/ approach	openbite (n = 11)	Overbite groups normal overbite (n = 24)	deepbite (n = 19)
Dental plate without bite-bloc	73% (8)	58% (14)	58% (11)
Dental plate with frontal bite-bloc			26% (5)
Dental plate with lateral bite-bloc		21% (5)	
VanBeek-/Headgear-activator		13% (3)	
Activator (Andresen Häupl)	18% (2)	4% (1)	32% (6)
Activator with bite-bloc	9% (1)		
Herbst-appliance			11% (2)
Headgear	45% (5)	58% (14)	42% (8)
Transpalatal bar	45% (5)	29% (7)	16% (3)
Multibracket-appliance	82% (9)	88% (21)	89% (17)
Chin-cap	27% (3)		5% (1)
Extraction	54% (6)	33% (8)	47% (9)
Nonextraction	46% (5)	67% (16)	53% (10)
Others	27% (3)	38% (9)	26% (5)

In the deepbite group, a significant decrease (mean: 3.40 mm, $p < 0.001$) in overbite was found. The deepbite was corrected in 90% of subjects. The increase in maxillary (mean: 4.48 mm, $p < 0.001$) and mandibular (mean: 4.81 mm, $p < 0.001$) molar height was about twice as large as the increase in maxillary (mean: 2.13 mm, $p < 0.001$) and mandibular (mean: 2.68 mm, $p < 0.001$) incisor height (Figure 7).

The comparison of skeletal and dentoalveolar changes in the openbite and deepbite groups is given in Table 5. Significant group differences could be found only for overbite ($p < 0.001$) and interjaw-base angle (NL/ML, $p < 0.05$).

Discussion

Only subjects without previous orthodontic treatment were included in this study, because such treatment might have influenced the vertical development of the dentoalveolar processes or the dimensions of the midface structures. Additionally, care was taken that all subjects were of central European origin to avoid major ethnic differences in craniofacial morphology. Furthermore, to exclude interobserver variation and to minimize the error of the method, which was comparable with those of other studies,[12,21-23] all lateral headfilms were traced and analyzed cephalometrically by the same investigator.

No sex differences were assessed, as subgroups would have been too small for statistical analysis. Besides, with respect to vertical or sagittal variables,[7,24] previous investigators couldn't find differences between male and female high-angle subjects.

Although associated with enlarged lower anterior facial heights[1,25] and smaller upper anterior facial heights,[16] not all long-faced patients exhibit an openbite.[13] This was also the case in the present subject material, in which most high-angle cases (80%) showed a normal overbite (0 - 4 mm) or a deep overbite (> 4 mm) prior to orthodontic treatment.

The reasons some high-angle patients exhibit an openbite while others show a deepbite are controversial. According to Creekmore,[14] the adaptability of the dentoalveolar processes can mask the hyperdivergency of the jaw-base relationship, while lack of compensation leads to openbite.[12,13] Sassouni and Nanda[26] and Fields et al.[10] found that posterior dentoalveolar heights were increased in openbite subjects, and Betzenberger et al.[13] described a relative anterior inclination of the maxilla (small NSL/NL) and a relative decrease in maxillary and mandibular anterior dentoalveolar heights in openbite mixed dentition high-angle subjects.

Habits could influence the adaptability of the dentoalveolar processes. In the present subjects, finger sucking and tongue-thrust swallowing were more common in the openbite group. These findings are in agreement with those of other authors, who found an association between a frontal openbite and oral habits.[3,7,9,16,27-29] The interrelationship between masticatory muscle activity and a long-face pattern is not clear.[10] However, reduced masticatory muscle activity[30] or a smaller size[2] of the elevator muscles may contribute to development of an openbite. This would be in agreement with Ingervall and Bitsanis,[31] who showed that an anterior rotation of the mandible can occur in long-faced children who underwent training and strengthening of the masticatory muscles.

The effects of orthodontic treatment on the skeletal and dentoalveolar variables differed when

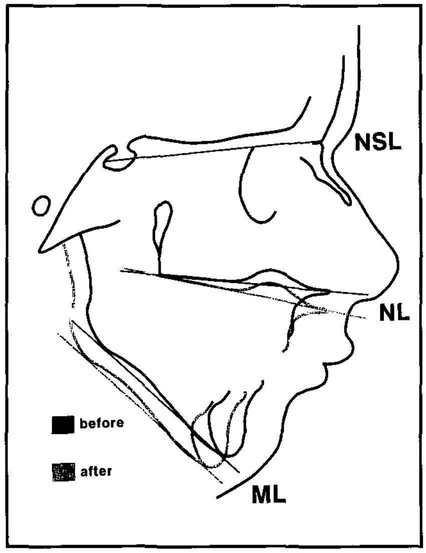

Figure 4
Skeletal changes during orthodontic treatment in the openbite group

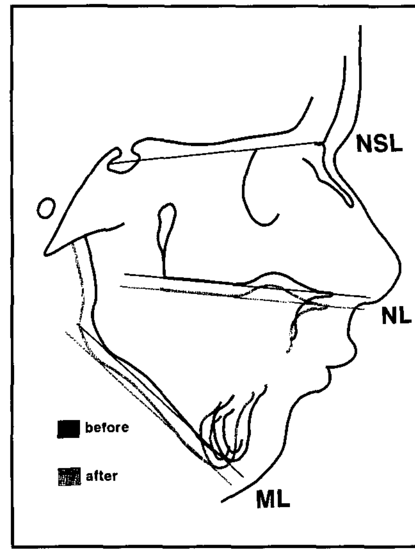

Figure 5
Skeletal changes during orthodontic treatment in deepbite group

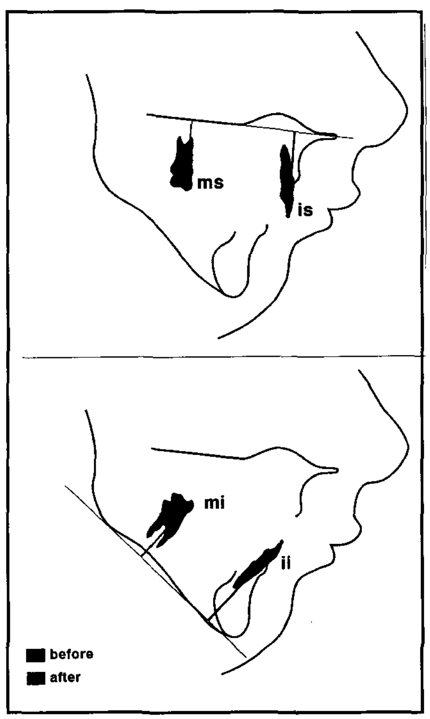

Figure 6
Dentoalveolar changes during orthodontic treatment in openbite group

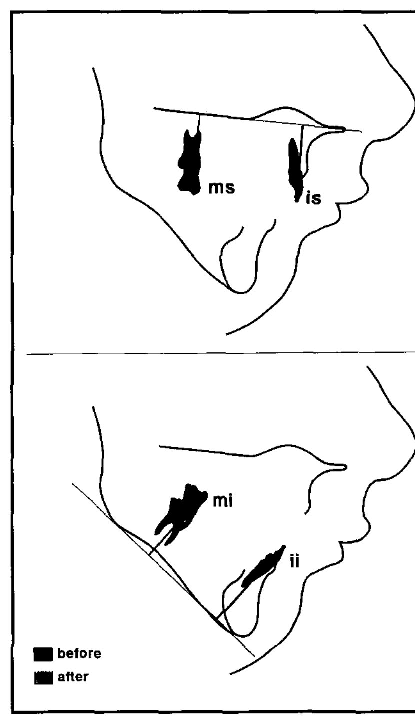

Figure 7
Dentoalveolar changes during orthodontic treatment in deepbite group

Table 4
Changes in skeletal and dentoalveolar variables in openbite (n=11) and deepbite (n=19) groups

	Openbite group (n = 11)						Deepbite group (n = 19)					
	Before		After		After - before		Before		After		After - before	
	Mean	SD	Mean	SD	Mean	Signif.	Mean	SD	Mean	SD	Mean	Signif.
Subject selection												
NSL/ML (degrees)	43.41	1.82	42.09	3.03	-1.32	n.s.	42.97	3.10	42.37	3.67	-0.60	n.s.
Overbite (mm)	-1.73	1.47	0.95	1.18	2.68	***	5.11	0.50	1.71	0.71	-3.40	***
Skeletal												
NSL/NL (degrees)	7.27	3.04	8.09	3.60	0.82	n.s.	8.50	2.74	7.95	3.64	-0.55	n.s.
NL/ML (degrees)	36.14	2.40	34.00	3.16	-2.14	*	34.47	3.83	34.42	4.45	-0.05	n.s.
s - go (mm)	67.05	3.18	75.00	6.43	7.95	***	69.37	4.01	79.21	6.96	9.84	***
n - gn (mm)	118.36	3.83	129.55	7.68	11.19	***	119.58	6.28	133.13	8.94	13.55	***
n - spa (mm)	50.36	2.50	54.86	3.70	5.50	***	52.11	3.30	56.53	3.92	5.42	***
spa - gn (mm)	68.00	3.04	74.68	5.64	5.69	***	67.47	3.40	76.61	5.89	8.13	***
Dentoalveolar												
is - NL (mm)	28.75	1.97	32.06	2.31	3.31	***	32.39	1.78	34.52	2.99	2.13	***
ms - NL (mm)	21.64	1.95	25.09	1.83	3.45	***	21.63	2.00	26.11	2.77	4.48	***
ii - ML (mm)	40.55	2.19	44.32	3.39	3.77	***	42.84	2.46	45.52	4.33	2.68	***
mi -ML (mm)	30.42	1.52	34.41	3.04	3.99	***	30.55	1.75	35.36	3.17	4.81	***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; n.s. = not significant

openbite and deepbite cases were compared. In the openbite group, the interjaw-base angle[13] could be reduced significantly during treatment by tipping the maxillary plane downward anteriorly (Figure 4). As the pretreatment incidence of habits was high in the openbite group, it might be hypothesized that the spinal point was displaced upward by finger sucking and moved downward into its normal position by orthodontic forces. In the deepbite group, on the other hand, no significant treatment change in the interjaw-base angle occurred (Figure 5). The mandibular plane angle was not affected by orthodontic treatment in either group.

Regarding the dentoalveolar variables, similar amounts of incisor and molar eruption were noted in the openbite group (Figure 6), while in the deepbite group, incisor eruption was only about half that seen for the molars (Figure 7). This difference in dentoalveolar changes between the groups probably reflects the difference in treatment goals and thus the difference in orthodontic forces used.

Table 5
Comparison of skeletal and dentoalveolar changes in openbite (n=11) and deepbite (n=19) groups

	Openbite group After - before Mean	Deepbite group After - before Mean	Group differences Significance
Subject selection			
NSL/ML (degrees)	-1.32	-0.60	n.s.
Overbite (mm)	2.68	-3.40	***
Skeletal			
NSL/NL (degrees)	0.82	-0.55	n.s.
NL/ML (degrees)	-2.14	-0.05	*
s - go (mm)	7.95	9.84	n.s.
n - gn (mm)	11.19	13.55	n.s.
n - spa (mm)	5.50	5.42	n.s.
spa - gn (mm)	5.69	8.13	n.s.
Dentoalveolar			
is - NL (mm)	3.31	2.13	n.s.
ms - NL (mm)	3.45	4.48	n.s.
ii - ML (mm)	3.77	2.68	n.s.
mi -ML (mm)	3.99	4.81	n.s.

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; n.s. = not significant

The pretreatment overbite condition (openbite or deepbite) did not seem to influence the length of treatment. Furthermore, differences in appliances or treatment approaches had no significant impact on treatment outcome, the overbite being successfully corrected in 82% of the openbite subjects and 90% of those with deepbite.

The importance of controlling the posterior dentoalveolar heights in long-faced patients has been well documented.[2,5,14] Maxillary and mandibular molar and incisor changes found in the present subjects were within the physiologic range of eruption reported by Bathia and Leighton[32] for subjects 10 to 16 years old.

An increase in the mandibular plane angle's worsening the facial pattern by downward and backward rotation of the mandible[26] could not be seen in any of the overbite groups. The recommendation to postpone extensive orthodontic treatment in vertically growing patients until the end of the pubertal growth spurt in order to reduce the potential for posterior rotation of the mandible[8,33] was not verified by these findings. More than 80% of the present subjects were treated with a full-banded multibracket appliance.

Since it is often stated that high-angle cases tend to become worse throughout the course of orthodontic treatment, the use of transpalatal arches and occipital-pull headgears are recommended for vertical control.[14] On the other hand, Burke and Jacobson[15] observed no major difference in mandibular plane angle changes when comparing patients treated with cervical- or occipital-pull headgear. Although different extraoral tractions (cervical-, straight-, and occipital-pull headgear) were used in the present subjects, the mandibular plane angle, on average, was unaffected. This was true for both the openbite and deepbite groups.

Tooth extractions did not seem to have a significant effect on treatment outcome in the present subjects, although Garlington[18] and Kuhn[34] showed that second premolar extractions could be useful in treating anterior openbite by reducing the posterior vertical dimension.

The findings of this study seem to confirm the conclusion of Zaher et al.[35] in the respect that facial type does not seem to influence orthodontic treatment results. However, it should be pointed out that the present findings are based on group comparisons of relatively small sample size. The results do not allow any conclusions for the individual patient.

Conclusions

Pretreatment, 20% of the present high-angle subjects in the mixed dentition showed an anterior openbite, while 80% had a normal or deep overbite.

Orthodontic treatment did not increase the mandibular plane angle (NSL/ML). This was true for both the openbite and deepbite high-angle individuals.

Overbite was efficiently corrected in both overbite groups, by tipping the maxillary plane anteriorly downward in the openbite group, and by controlling incisor eruption in the deepbite group.

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