European Journal of Orthodontics 28 (2006) 553–560
doi:10.1093/ejo/cjl022

The influence of functional orthodontics and mandibular sagittal split advancement osteotomy on dental and skeletal variables—a comparative cephalometric study

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SUMMARY Lateral head films of 200 Class II patients (106 females, 94 males) with a mean pre-treatment age range of 9.9–10.25 years successfully treated with functional orthodontics were analysed before (T1) and after (T2) treatment. The resulting data and findings were compared with lateral head films (T1, T2) of 20 patients (15 females, five males) with a mean pre-treatment age of 25.75 years whose Class II malocclusion and antero-posterior jaw discrepancy had been corrected by a mandibular sagittal split advancement osteotomy. The median and interquartile distances were calculated for every variable, at T1 and T2. The difference between the medians (T2–T1) was analysed using a signed rank test. The changes in scattering (T2–T1) were assessed by means of a *F*-test.

Significant differences regarding the therapeutic influence on skeletal [ANB, Wits, Index, mandibular line–nasal line (ML–NL)], functional (β′, μ), and dental (1-NA°, 1-NB°) variables were found. In the group initially treated with functional appliances in order to enhance mandibular prognathism, the antero-posterior (A-P) jaw discrepancy was reduced (ANB, Wits). The vertical skeletal pattern (Index) changed towards a more skeletal open relationship, whereas the ML–NL angle was reduced, which indicates a deepening of the bite. The comparison between biomechanical incisor position analysis (β′, μ) and dental variables (1-NA°, 1-NB°) revealed different changes in incisor inclination depending on the type of analysis used. The findings for the dental variables (1-NA°, 1-NB°) showed a protrusion of both upper and lower incisors after therapy. The results for the functional variables (β′, μ) showed a retrusion of the upper and a protrusion of the lower incisors. This change in incisor inclination is a dental compensation of the remaining sagittal jaw discrepancy. This effect is most clearly reflected by the functional analysis and the changes of the biomechanical variables β′ and μ.

For the orthognathic surgery group, a clear improvement in the dental and skeletal relationship was observed: the skeletal discrepancies in the A-P plane were completely corrected (ANB, Wits) and the inclination of the incisors according to biomechanical and functional aspects was optimized (β′, μ). The alteration in both the Index and ML–NL angle in this group indicated an increase of the open bite components.

Introduction

The treatment of a Class II malocclusion and an antero-posterior (A-P) jaw discrepancy with backward positioning of the mandible is a standard form of orthodontic treatment. The use of functional orthodontic appliances for the correction of this malocclusion in the mixed dentition has proved to be an appropriate method (Dal Pont, 1959; Calvert, 1982; Cohen, 1983; Remmer *et al.*, 1985; Versyck and Rakosi, 1989; Stüber, 1990; Hashim, 1991; Ruf *et al.*, 2001). A variety of functional appliances have been recommended, e.g. activators, activator-headgear appliances or bite jumping plates (Andresen and Häupl, 1945; Sander and Wichelhaus, 1995; Miethke and Drescher, 1996).

Combined orthodontic-surgical treatment is indicated in subjects with skeletal dysgnathia, in the event of highly developed jaw discrepancies, or growth has ceased and influence on growth by orthodontic treatment alone is no longer possible. This applies particularly in patients with existing mandibular skeletal retrognathism. Surgical intervention may further be indicated by skeletal deviations, both vertical and transverse. The aim of such a combined method of treatment is to harmonize the dental and skeletal structures and to optimize function and aesthetics. The goal in habitual intercuspation has to be an ideal biomechanical/functional alignment in the region of the incisors as well as in the temporomandibular joint. For this purpose, the Göttingen concept of joint-related orthodontic-surgical therapy was developed (Luhr, 1989; Luhr *et al.*, 1991; Schwestka-Polly *et al.*, 1992; Schwestka-Polly, 1998).

Correction of a Class II malocclusion should not only be concerned with dental deformity, but skeletal deviations should also be considered. It is beyond any doubt that orthodontic treatment has dental effects. The influence of orthognathic surgery on skeletal structures can be guaranteed, while the orthopaedic effect of functional orthodontic appliances and a stimulation of condylar growth is still controversial (Jacobsson, 1967; Calvert, 1982; Cohen, 1983; Hashim, 1991; Collett, 2000).

The aim of this investigation was to evaluate and compare the different dental and skeletal changes caused by the described therapeutic procedures.

Materials and methods

Subjects

The lateral head films taken before (T1) and after (T2) treatment of two groups were traced. All patients showed a Class II malocclusion of at least half a cusp distal molar relationship as well as a severe A-P jaw discrepancy (ANB > 4.0 degrees) prior to treatment. At the time of the examination, orthodontic or combined orthodontic-surgical treatment had been successful in correcting to a Class I molar relationship and horizontal overlap of the incisors.

Groups 1A and 1B—patients undergoing functional orthodontic treatment

Lateral head films of 200 patients selected retrospectively and treated by two different orthodontists were evaluated. The composition of the groups is shown in Table 1.

The subjects in groups 1A and 1B were treated with functional orthodontic appliances which they were instructed to wear 14 hours/day. Different types of appliances were used in the two groups: in Group 1A activators and bite jumping plates (Sander and Wichelhaus, 1995), and in Group 1B the activator (elastisch offener Aktivator) according to Klammt (1984). During the second phaseof treatment, as and when necessary, upper and lower multibracket appliances were used for precise adjustment of the occlusion.

Group 2—patients undergoing combined orthodontic-surgical treatment

The therapeutic changes in groups 1A and 1B were compared with the results in 20 adult patients who had undergone combined orthodontic-surgical treatment. Prior to treatment this group exhibited a severe A-P jaw discrepancy (ANB > 4.0 degrees). The distinct skeletal backward displacement of the mandible was corrected by means of a mandibular sagittal split advancement osteotomy (Obwegeser and Trauner, 1955; Dal Pont, 1959). The treatment was undertaken according to the Göttingen concept (Luhr *et al.*, 1991; Schwestka-Polly *et al.*, 1992; Schwestka-Polly, 1998). This therapy is performed in three stages: the pre-surgical orthodontic phase serves to decompensate the dental arches of the maxilla and mandible with multibracket appliances. The aim of this treatment was to achieve a precise axis adjustment of the teeth on the alveolar bone. During the second phase of treatment, a mandibular sagittal split advancement osteotomy is undertaken. A speciality of the Göttingen concept is that during surgery, it is possible to maintain the condylar position (Luhr, 1989; Luhr and Kubein-Meesenburg, 1989; Luhr *et al.*, 1991; Schwestka-Polly, 1998). Subsequent to the osteotomy and a consolidation phase, orthodontic adjustment of the occlusion is undertaken.

The composition of the surgical group is shown in Table 2.

Variables and measuring procedure

Skeletal [ANB, Wits, Index, and mandibular line–nasal line (ML–NL)], dental (1-NA°, 1-NB°), and functional variables (β′, μ) were determined for the examined groups. These variables are shown in Figures 1–3.

The head films were traced manually on acetate paper. The angles were measured with an accuracy of 0.5 degrees, the distances at 0.5 mm.

Method error

In order to establish reliability, 40 lateral head films were traced by two different authors (BL and DI). The measurements were repeated after an interval of 4 weeks. Spearman rank correlation coefficient (r_s) was calculated. In addition, analysis of variance was carried out to establish which parts of the scattering had been caused by the two evaluators, and the F value was then calculated. The differences between the average values of two measurements were then analysed by a t-test. A significance of $\alpha = 0.05$ was set for all tests.

A systematic assessment variation could not be proven for any of the variables. The correlation coefficient of the measurements

Table 1 Characteristics of patients treated with functional orthodontic appliances.

	Class II/1	Class II/2	Female	Male	Pre-treatment age (years)	Treatment time functional appliance (years)	Total treatment time (years)
Group 1A ($n = 100$)	77	23	50	50	9.9	1.3	5.2
Group 1B ($n = 100$)	79	21	56	44	10.25	1.5	4.0

varied between $r_s = 0.81$ and $r_s = 0.96$. With only one exception, the μ variable, was in the region $r_s = 0.67$. A weak significant difference between the average values of the two measurements was shown for the Wits variable ($P = 0.02$).

Statistical analysis

Statistical evaluation was carried out with the computer program SAS/STAT® (SAS Institute Inc., Cary, North Carolina, USA). The median and interquartile distances were calculated for each variable, prior and subsequent to therapy. The differences between the medians (T2−T1) within the treatment groups were analysed by means of a signed rank test. In order to estimate the changes in scattering during treatment, the differences (T2−T1) were checked with an *F*-test to establish homogeneity. A significance of α = 0.05 was used.

Table 2 Characteristics of patients treated by orthognathic surgery.

	Class II/1	Class II/2	Female	Male	Pre-treatment age (years)
Group 2 (*n* = 20)	19	1	15	5	25.75

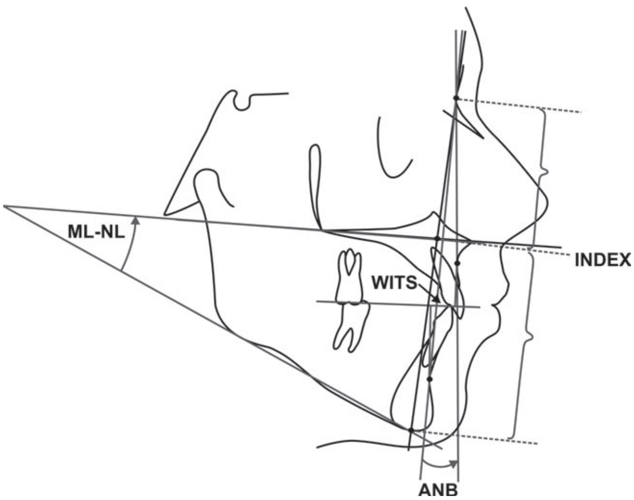

Figure 1 Definitions of the skeletal variables: variables ANB and Wits were employed for the appraisal of the skeletal sagittal relation. ANB angle (Riedel, 1957) the sagittal position of the maxilla in relation to the mandible measured between the lines NA (nasion-point-A) and NB (nasion-point-B). Point-A the lowest point of the anterior outline in the alveolar process of the maxilla, point-B the corresponding positions in the mandible. Depending on the facial type, a neutral skeletal relationship will lead to ANB readings between −2.0 and +6.0 degrees. Within a group of subjects with skeletal distal occlusion, the ANB will increase correspondingly. WITS analysis: the horizontal distance of a vertical dropped from points A and B, respectively, on to the occlusal plane (Jacobsson, 1975). The clinical median is 0.0 mm for females and 1.0 mm for males. In subjects with skeletal distal occlusion, this variable will also result in higher values. Variables Index and mandibular line–nasal line (ML–NL) were used for the analysis of the skeletal vertical situation. The Index, as a percentage (Segner and Hasund, 1998) describes the relationship between maxillary height (distance N-Sp′) and lower face height (distance Sp′-Gn). This type of variable is important for assessment of an open or deep skeletal configuration. For a neutral skeletal configuration, the Index adopts values between 71.0 and 89.0 per cent. Anterior open skeletal relationships with an enlarged anterior face height will lead to values below 71 per cent, while in deep skeletal configurations the values will exceed 89 per cent. ML–NL angle (Steiner, 1953): the vertical interbasal relationship based on the inclination of ML towards NL in the sagittal vertical plane. The average angular degree is 20.0.

Results

Groups 1A and 1B

The results of the statistical analysis are shown in Table 3.

Sagittal skeletal variables. On average, the median of the ANB angle in both groups was reduced by 2.0 degrees ($P < 0.001$). The scattering of the values remained unchanged during treatment. The median of the Wits was reduced in both groups. The variance in Group 1A was not reduced by treatment ($P = 0.2056$). However, in group 1B the variance was reduced ($P = 0.0128$).

Vertical skeletal variables. The median of the Index was reduced in both groups (3.0 per cent 1A, and 2.0 per cent 1B; $P < 0.001$). Variance was not influenced. The median of the ML–NL angle was in the region of 1.0 degree in group A, but reduced by 2.5 degrees ($P < 0.001$) in group B. In both groups, no significant reduction in scattering of the variable values could be established.

Functional variables. In group 1A, the median of the β′ angle was reduced by 1.25 degrees ($P = 0.02$) and in group 1B by 3.25 degrees ($P < 0.001$). The scattering was reduced in both groups (group 1A: $P = 0.0004$; group 1B: $P < 0.001$). In group 1A, the median of the μ angle was increased by 1.0 degree ($P = 0.2$); whereas the scattering was not reduced ($P = 0.1138$). In group 1B, changes in the median could not be determined ($P = 0.1$); on the other hand, scattering of the values was significantly reduced ($P = 0.0024$).

Dental variables. In both groups, the median of angle 1-NA was increased by 1.0 degree (group 1A: $P = 0.02$; group 1B: $P = 0.20$). In group 1A, the scattering was only slightly reduced ($P = 0.0276$); in group 1B the scattering of the values was close to being halved ($P < 0.001$). In group 1A, the median of angle 1-NB was increased by 1.0 degree ($P = 0.02$); the variance was not influenced (group 1A: $P = 0.5213$). In group 1B, protrusion was seen at an average of 3.0 degrees ($P < 0.001$); the scattering was reduced by more than 50 per cent ($P = 0.0007$).

Group 2

The results of the statistical analysis are shown in Table 4.

Sagittal skeletal variables. The median of the ANB angle was reduced by 4.5 degrees ($P < 0.001$). The scattering of the values was significantly reduced ($P = 0.009$). The median of the Wits was reduced by 6.0

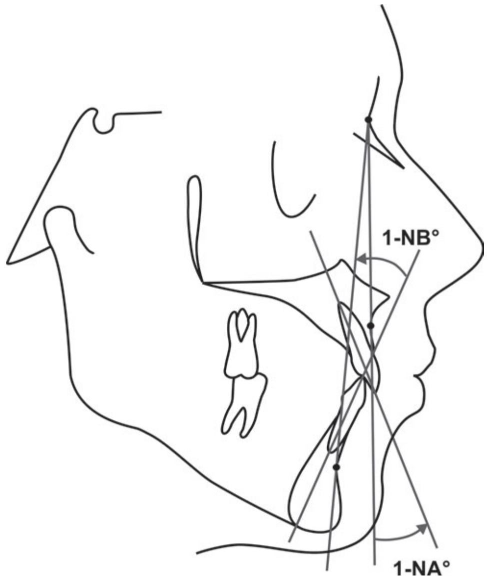

Figure 2 Definitions of the dental variables: the position of the incisors was assessed by means of 1-NA and 1-NB (Steiner, 1953). These variables describe the antero-posterior positions of the incisors, by measurement of the incisor axes in relation to the NA and NB lines. According to Steiner, there is an angle of, on average, 22.0 degrees between the axis of the upper incisor and the NA line for neutral incisor alignment. The lower incisor axis is, on average, at an angle of 25.0 degrees in front of the NB line.

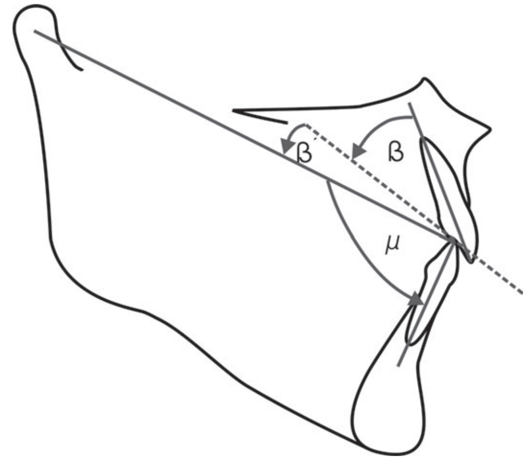

Figure 3 Definitions of the functional variables: the variables β′ and μ were measured in accordance with biomechanical incisor position analysis (Kubein-Meesenburg *et al.*, 1983, 1988; Kubein-Meesenburg and Nägerl, 1990, 1993). Each incisor has its own sagittal morphological angle β, which describes the angle between the axis of the incisor and a tangent placed on the inflection point between palatal concavity and convexity (point zero). Deviation of this inflection point tangent from the connecting line between inflection point and the centre of the curvature of the force transmitting condylar surface is defined as angle β′. Hence, the angle β′ records a retruded or protruded position of the incisor under individual functional aspects. Under ideal functional circumstances, the inflection point tangent, in its extension, runs through the centre of the condylar curvature. In this particular case, angle β′ is 0.0 degrees. In order to assess the position of the lower incisor, its axis towards the connecting line between the incisal edge of the lower incisor and the centre of the curvature of the force transmitting condylar surface is measured. This relationship is reflected by angle μ. The lower incisors receive their ideal occlusal load at μ = 90.0 degrees.

mm ($P < 0.001$). The reduction in scattering was highly significant ($P < 0.001$).

Vertical skeletal variables. The median of the Index was reduced by 3.0 per cent ($P < 0.001$). The median of the ML–NL angle was increased by 2.5 degrees ($P < 0.001$). Variance was not influenced for either variable (Index: $P = 0.055$; ML–NL: $P = 0.54$).

Functional variables. The median of the β′ angle was reduced by 4.5 degrees ($P < 0.1$). The reduction in scattering was highly significant ($P < 0.001$). Subsequent to treatment, a median of β′ = 0.0 degrees could be determined. The median of the μ angle was increased by 0.5 degrees ($P < 0.001$) to 90.0 degrees, post-surgically. Additionally, a highly significant reduction in variance was evident ($P < 0.001$). The classification of the incisors at the end of treatment corresponded with a functional 'ideal' classification.

Dental variables. The median of 1-NA angle was increased by 1.0 degree ($P < 0.001$); the reduction in scattering of the values was highly significant ($P < 0.001$). The median of 1-NB angle remained, on average, unchanged ($P < 0.001$); the reduction in scattering was highly significant ($P < 0.001$).

Discussion

Treatment of a Class II malocclusion with an A-P jaw discrepancy and a skeletal backward displacement of the mandible is usually carried out by reducing the mandibular retrognathism with a simultaneous inhibition of growth of the maxillary complex. The orthopaedic effect of functional orthodontic treatment continues to be controversial. While some authors are of the opinion that the primary effect should concern an inhibition of maxillary growth with a dentoalveolar compensation (Jacobsson, 1967; Harvold and Vargervik, 1971; Calvert, 1982; Cohen, 1983; Hashim, 1991; Collett, 2000), others favour a stimulation of condylar growth by means of anterior repositioning of the lower jaw (Pancherz, 1984; Ehmer, 1985; Bishara and Ziaja, 1989; Derringer, 1990; Jacobsson and Paulin, 1990; Sander and Lassak, 1990; Erverdi and Özkan, 1995; McNamara *et al.*, 1996; Baltromejus *et al.*, 2002). The therapeutic effect on the sagittal plane should result in a reduction of the skeletal variables, ANB and Wits. The results of the present investigation reveal that in both groups treated with functional appliances, a reduction of mandibular retrognathism resulted in an improvement of the A-P jaw discrepancy. Both variables showed a reduction by 2.0 degrees (ANB) and by 2.0 mm (Wits group 1A) and 2.5 mm (Wits group 1B). These findings confirm the results of previous clinical studies (Sander and Wichelhaus, 1995;

Table 3 Median (MED) and interquartile distances (IQA) at the beginning (T1) and end (T2) of treatment, their difference (T2−T1) and significance (*P* value) for Groups 1A and 1B.

	T1		T2		T2−T1		*P* value	*P* value
	MED	IQA	MED	IQA	MED	IQA	Signed rank (T2−T1)	*F*-test (T2−T1)
ANB (1A)	5.5	2.5	3.0	3.0	−2.0	2.0	<0.001***	0.0904, NS
ANB (1B)	5.0	1.8	3.0	2.0	−2.0	1.5	<0.001***	0.5373, NS
Wits (1A)	4.0	2.0	2.0	3.0	−2.0	3.5	<0.001***	0.2056, NS
Wits (1B)	5.0	2.75	2.3	2.0	−2.5	2.5	<0.001***	0.0128*
Index (1A)	84.0	11.0	83.0	10.0	−3.0	5.0	<0.001***	0.6857, NS
Index (1B)	82.0	8.0	80.5	8.5	−2.0	6.0	<0.001***	0.9274, NS
ML–NL (1A)	26.0	8.0	25.5	8.5	−1.0	3.0	<0.001***	0.6270, NS
ML–NL (1B)	26.0	6.25	23.8	6.0	−2.5	3.5	<0.001***	0.9120, NS
β′ (1A)	−8.25	14.0	−7.0	10.5	−1.25	10.75	0.02**	0.0004***
β′ (1B)	−6.5	11.25	−3.75	6.75	−3.25	10.75	<0.001***	<0.001***
μ (1A)	88.0	9.0	88.0	8.0	1.0	9.0	0.2 NS	0.1138, NS
μ (1B)	87.0	9.0	89.0	4.5	0.0	7.75	0.1 NS	0.0024**
1-NA° (1A)	20.0	10.0	23.0	7.5	1.0	9.0	0.02*	0.0276*
1-NA° (1B)	20.0	11.25	21.0	6.5	1.0	10.25	0.20 NS	<0.001***
1-NB° (1A)	23.0	9.5	25.0	8.0	1.0	9.5	0.02*	0.5213, NS
1-NB° (1B)	22.0	10.25	24.5	5.0	3.0	6.0	<0.001***	0.0007***

$^{*}P < 0.05$, ** $0.001 < P < 0.005$, $^{***}P < 0.001$; NS, not significant.

Table 4 Median (MED) and interquartile distances (IQA) at the beginning (T1) and end (T2) of treatment, their difference (T2−T1) and significance (*P* value) for Group 2.

	T1		T2		T2−T1		*P* value	*P* value
	MED	IQA	MED	IQA	MED	IQA	Signed rank (T2−T1)	*F*-test (T2−T1)
ANB	7.0	2.5	3.0	2.0	−4.5	3.0	<0.001***	0.009**
Wits	8.0	4.5	2.0	1.5	−6.0	4.0	<0.001***	<0.001***
Index	75.5	9.5	74.0	7.0	−3.0	6.5	<0.001***	0.055, NS
ML–NL	26.0	9.5	27.5	8.5	2.5	2.5	<0.001***	0.54, NS
β′	−5.5	12.5	0.0	1.5	4.5	11.0	0.1 NS	<0.001***
μ	89.5	10.0	90.0	2.0	0.5	8.5	<0.001***	<0.001***
1-NA°	20.0	10.0	22.0	2.0	1.0	7.5	<0.001***	<0.001***
1-NB°	23.5	7.5	25.5	1.0	0.0	7.0	<0.001***	<0.001***

$^{*}P < 0.05$, $^{**}0.001 < P < 0.005$, $^{***}P < 0.001$; NS, not significant.

Baltromejus *et al.*, 2002; Berger *et al.*, 2005) regarding the influence of functional appliances onthe skeletal sagittal relationship. However, for ANB, there was no significant reduction in scattering, and for Wits, a reduction of low statistical significance was observed. This diminishes, to a certain extent the 'therapeutic success', which would be clearly shown, if these highly significant changes were indicated statistically by the median values as well as by the variance.

Surgical correction of the backward positioning of the lower jaw strongly influenced ANB and Wits. On completion of surgery, a harmonized A-P jaw relationship was achieved (ANB 3.0 degrees, Wits 2.0 mm). In addition, scattering was significantly reduced. However, this therapeutic effect was to be expected, since with surgery an anterior displacement of the complete mandible is possible. The changes determined in this study correspond with the results of previous investigations (Dermaut and De Smit, 1989; Watted *et al.*, 2000; Watted and Reuther, 2001).

The different therapeutic effects of both modes of treatment, i.e. functional orthodontics and sagittal split advancement osteotomy, are also shown by the influence on the vertical skeletal pattern. For both groups, changes in Index indicated a change towards a more skeletal open bite relationship. However, in the functional appliance group, the ML–NL angle was reduced, which is a sign of a deepening of the bite. Comparison with the literature shows that the vertical effects of functional orthodontic devices may well lead to a variety of results. A post-activator therapy study by Baltromejus *et al.* (2002) showed an anterior rotation of the mandible as a result of a vertical condylar growth without enlargement of anterior face height. These different therapeutic changes possibly originate from other factors which may have some influence on treatment success. One decisive factor is the mode of mandibular growth, which can either improve or deteriorate skeletal relationships (Van der Linden, 2005). The type of functional appliance and patient compliance may also have played a role (Tulloch *et al.*, 1998). It was, however, not the purpose of this study to analyse different mechanisms of a variety of functional devices.

In the surgical group, the ML–NL angle also indicated an enlargement and, therefore, the open bite components were increased. In this respect, the therapeutic effects of both forms of treatment differ in their skeletal vertical effects. Scattering was not reduced by treatment method, but statistical evaluation indicated a shift of the median. The increase in anterior face height, subsequent to surgical Class II correction, is a phenomenon which has frequently been described. This is caused by anterior displacement and a simultaneous posterior rotation of the lower jaw (Vargervik and Harvold, 1985; Watted and Reuther, 2001; Pancherz *et al.*, 2004; Berger *et al.*, 2005).

The dental effect of functional orthodontic treatment is described as being a retrusion of the upper and a protrusion of the lower incisors (McNamara *et al.*, 1985; Remmer *et al.*, 1985; Jones, 1991; Eckardt *et al.*, 1995; Sander and Wichelhaus, 1995). This alteration in inclination contributes to a reduction of the horizontal overlap of the incisors and, at the same time, is considered to be a dental compensation for the skeletal deformity. The findings of the present study illustrate a dissimilar change in the position of the axis of the incisors, depending on whether dental or functional parameters were used for assessment.

Biomechanical functional analysis demonstrated a retrusion of the maxillary incisors, with different values for groups 1A and 1B. However, for both groups, the reduction in scattering was highly significant. Functional assignment of the lower incisors was also influenced: in group 1A the median of the μ variable was increased by 1.0 degree, whereas the variance was not influenced. In group 1B, there were no differences in the medians; scattering was significantly reduced. As a result, neither for the β′ nor μ variable could a highly significant simultaneous difference in median or variance be registered in either of the two groups. In summary, with functional treatment functional incisor alignment is not optimal but, nevertheless, the move towards an ideal alignment has been improved.

After completion of functional orthodontic treatment, protrusion of the upper incisors (1-NA) was observed in both groups, while the reduction in scattering differed. The changes in 1-NB variables also indicated a protrusion of the lower incisors. This variable differed in the two groups; in group 1A the variance remained unchanged while in group 1B the reduction in variance was highly significant. Remarkably, only in group 1B did 1-NB show a highly significant influence on both the median and variance. This did not apply to the other variables.

Depending on the cephalometric method of analysis used, the change of incisor inclination varied. The compensatory inclination of the incisors in patients with mandibular retrognathism, which has been frequently described in literature (McNamara *et al.*, 1985; Remmer *et al.*, 1985; Eckardt *et al.*, 1995; Sander and Wichelhaus, 1995), and which contributes to the reduction of the horizontal overjet, was in the present study best reflected by the functional incisor analysis and changes in the parameters β′ and μ.

The different dental changes in the groups treated by two different orthodontists were probably influenced by other factors, such as the type of functional appliance. Additionally, the inclination of the incisors was probably slightly influenced during the post-functional correction of the occlusion with fixed appliances. These changes will require verification by future clinical studies.

The dental effects resulting from combined orthodontic-surgical treatment differ considerably from functional treatment. Functional alignment of the incisors was optimized: post-surgery the upper and lower incisors were in biomechanical ideal alignment ($\beta' = 0.0$ degrees, $\mu = 90.0$ degrees).

In accordance with the evaluation of the dental variable (1-NA), the upper incisors protruded slightly. This protrusion is beneficial during pre-surgical forming of the dental arches and can be classified as decompensating the inclination of the incisors (Drescher, 1990). On the other hand, the fact that the lower incisors (1-NB) were also slightly protruded is unusual, since no decompensation was found. All parameters show a reduction of high statistical significance in both median and variance. This effect increases the influence of combined orthodontic-surgical treatment on the dental alignment of the incisors.

Conclusions

The findings of the present study show that treatment of a Class II malocclusion in growing patients with functional appliances is an appropriate method to reduce mandibular retrognathism and to ameliorate the sagittal skeletal relationship. The change in incisor inclination varies depending on the method of analysis employed. With functional orthodontic devices incisor alignment was improved. In comparison an increased positive change of dental and skeletal variables was observed, subsequent to combined orthodontic surgery.

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