Original Article

The Mechanism of Class II Correction in Surgical Orthodontic Treatment of Adult Class II, Division 1 Malocclusions

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Abstract: The purpose of this investigation was to assess the dentoskeletal effects and facial profile changes as well as the mechanism of Class II correction in adult Class II subjects treated by surgical mandibular advancement in combination with orthodontics. The subject material comprised 46 adults with a Class II, division 1 malocclusion treated by nonextraction with a mandibular sagittal split osteotomy as well as with pre- and postsurgical multibracket appliances. Lateral head films from before treatment and after treatment were analyzed. The results revealed the following statistically significant ($P < .001$) treatment changes: (1) the mandibular prognathism enhanced; (2) the sagittal interjaw base relationship improved; (3) the mandibular plane angle increased; (4) the lower anterior facial height increased; (5) the lower posterior facial height decreased; (6) the facial profile straightened; (7) the overjet and Class II molar relationship were corrected. Overjet reduction was accomplished by 63% skeletal and 37% dental changes. The Class II molar correction was accomplished by 81% skeletal 19% dental changes. In conclusion, it can be said that mandibular sagittal split osteotomy in combination with pre- and postsurgical orthodontics is an effective and consistent method for the correction of Class II, division 1 malocclusions and for the straightening of the facial profile. A negative effect of treatment counteracting Class II correction is an increase in the mandibular plane angle. (*Angle Orthod* 2004;74:798–807.)

Key Words: Sagittal mandibular split osteotomy; Orthodontics; Treatment effects; Facial profile

INTRODUCTION

In the literature, a large number of surgical mandibular advancement procedures have been described for the therapy of skeletal Class II malocclusions with mandibular deficiency.[1] However, the current standard method is the retromolar mandibular sagittal split osteotomy introduced originally by Schloessmann in 1922.[2] The most frequently used modifications of this method are those of Obwegeser[3] and Dal Pont[4] and of Hunsuck[5] and Epker.[6]

Many studies have been performed evaluating the skeletofacial changes occurring during surgical–orthodontic treatment of Class II malocclusions.[7–12] However, no study has ever addressed the relative contribution of the skeletal and dental components involved in the changes of the sagittal occlusion.

Therefore, the purpose of this investigation was to analyze the effects of a sagittal split osteotomy in combination with pre- and postsurgical orthodontics on the facial hard and soft tissue structures in adult Class II, division 1 malocclusions.

METHODS AND MATERIALS

The subject material in this study comprised 46 (38 females and eight males) adult Class II, division 1 malocclusions treated surgically; exclusively by a mandibular retromolar sagittal split osteotomy. For the tooth alignment pre- and postsurgery fixed (multibracket) appliances were used for different periods of time. The mean pretreatment age of the subjects was 26 years (SD 8.1 years). The youngest subject (a female) was 16 years old (skeletal maturity stage R-J according to Hägg and Taranger,[13] indicating that growth was completed). Total treatment time (surgery plus pre- and postsurgical orthodontics) for the 46 subjects amounted to an average of 1.7 years (SD 0.7 years).

Twenty-three of the 46 subjects were treated at the Orthognathic Surgery Department in Malmö, Sweden, using

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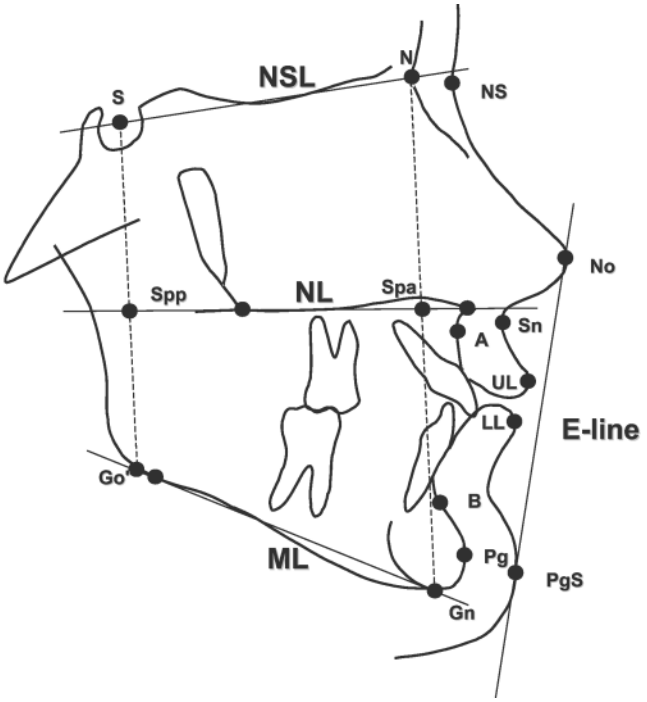

FIGURE 1. Reference points and lines used in the standard cephalometric analysis.

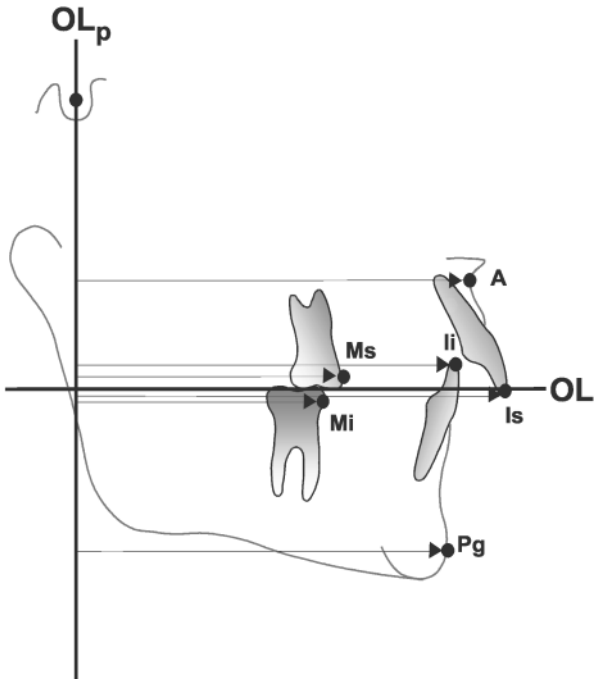

FIGURE 2. SO-Analysis. The OL/OLp reference grid and the measuring landmarks are shown.

the Hunsuck[5] and Epker[6] sagittal split osteotomy. The other 23 subjects were treated at the Orthognathic Surgery Clinic in Minden, Germany, with the Obwegeser[3] and Dal Pont[4] procedure.

Lateral head films in habitual (centric) occlusion from before treatment and after all treatments (which means from after postsurgical orthodontics) were analyzed. All registrations were performed twice, and the mean value of the duplicate registrations was used in the final evaluation. No correction was made for linear enlargement (approximately 8% in the median plane for both the Swedish and German head films).

Standard cephalometrics

Changes of sagittal and vertical jaw base relationship, overbite, facial height, facial profile convexity, and lip position were assessed using standard variables. The cephalometric landmarks used are shown in Figure 1.

SO-Analysis

The SO-Analysis of Pancherz[14] was used for the assessment of sagittal occlusal changes (Figure 2).

Individual changes

For the assessment of the clinical significance of individual changes only those exceeding ±0.5 mm, ±0.5° or ±0.5 Index values were considered.

Statistical methods

For the different variables, the arithmetic mean (Mean) and standard deviation were calculated. Student's *t*-test for paired samples was used to assess the significance of treatment changes. The statistical significance was determined on the confidence levels of 0.1%, 1%, and 5%. A confidence level larger than 5% was considered not significant (NS).

RESULTS

No differences in pre- and posttreatment cephalometric records existed when comparing the 23 subjects treated in Sweden and the 23 subjects treated in Germany. Therefore, the two subject samples were pooled in the presentation of the results. Furthermore, no sex differentiation was made because only eight of the 46 subjects (17%) were males.

Standard cephalometrics

The standard cephalometrics in 46 adult subjects are shown in Table 1.

Sagittal jaw relation. The surgical mandibular advancement resulted in a significant ($P < .001$) increase in the angles SNB (mean 2.12°) and SNPg (mean 1.60°). There was a significant ($P < .001$) reduction in the angles ANB (mean 2.41°), ANPg (mean 1.89°), and in the Wits (mean 4.11 mm). Considering clinical significant individual changes, there was an increase of the SNPg angle in 78% (36 of 46) and a reduction of the ANPg angle in 89% (41 of 46) of the subjects (Figures 3 and 4, respectively).

TABLE 1. Standard Cephalometrics in 46 Adult Subjects Treated by Orthognathic Surgery (Mandibular Sagittal Split) in Combination with Pre- and Postsurgical Orthodontics

	Surgery				Treatment changes After − before		
	Before		After				
Variable	Mean	SD	Mean	SD	Mean	SD	*t*
Sagittal jaw relation							
SNA (°)	81.41	4.01	81.12	3.89	−0.29	1.13	−1.72 NS[a]
SNB (°)	75.37	3.39	77.49	3.41	2.12	1.31	10.98***
SNPg (°)	77.08	3.75	78.68	3.80	1.60	1.31	8.25***
ANB (°)	6.04	2.75	3.62	2.73	−2.41	1.29	−12.71***
ANPg (°)	4.33	3.46	2.44	3.19	−1.89	1.33	−9.59***
Wits (mm)	4.72	3.01	0.61	3.36	−4.11	1.90	−14.64***
Vertical jaw relation							
ML/NSL (°)	30.08	7.82	33.41	7.86	3.33	2.48	9.12***
NL/NSL (°)	8.77	2.91	8.39	3.57	−0.38	1.73	−1.47 NS
ML/NL (°)	21.31	7.34	25.02	7.78	3.71	2.63	9.54***
Incisor relation							
Overbite (mm)	4.23	2.84	2.16	0.94	−2.06	2.56	−5.43***
Facial height							
Spa-Gn × 100/N-Gn (index)	54.84	2.34	56.11	2.58	1.27	0.92	9.36***
Spp-Go′ × 100/S-Go′ (index)	46.89	4.89	44.88	5.64	−2.01	2.51	−5.43***
Profile convexity							
NAPg (°)	170.87	7.33	175.32	6.79	4.45	2.80	10.78***
NS/Sn/PgS (°)	158.12	6.71	163.57	6.71	5.45	3.37	10.97***
NS/No/PgS (°)	121.35	4.22	124.55	4.50	3.20	2.67	8.12***
Lip position							
UL–E-line (mm)[b]	−2.55	2.84	−5.05	2.87	−2.49	1.74	−9.73***
LL–E-line (mm)[b]	−1.67	3.27	−2.79	3.38	−1.12	2.33	−3.26*

[a] NS indicates $P > .05$ (not signifigant).
[b] UL indicates upper lip; LL indicates lower lip.
* $P < .05$
*** $P < .001$

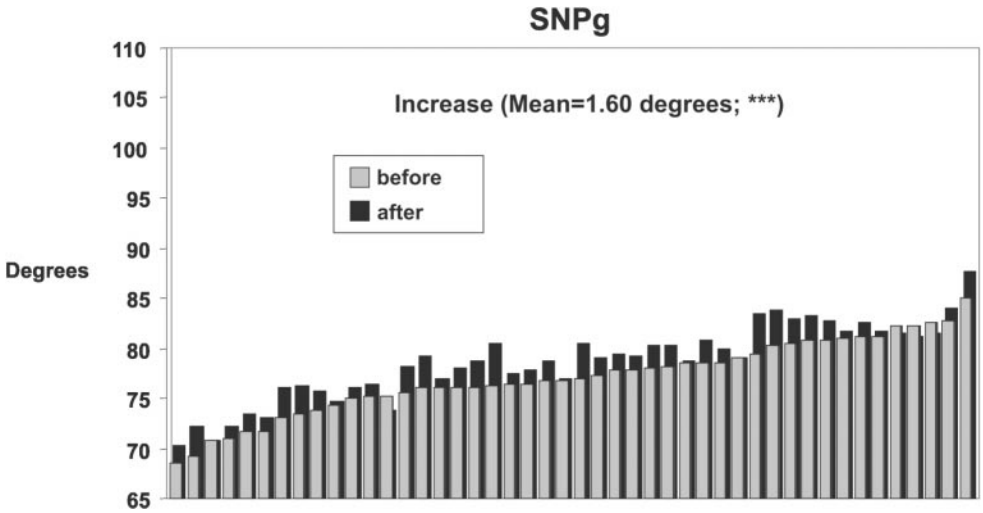

FIGURE 3. SNPg angle (sagittal mandibular position). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

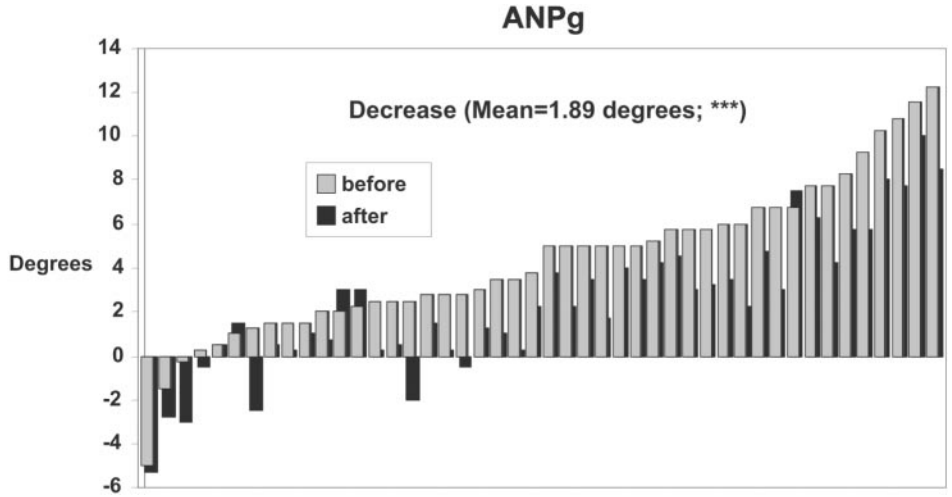

FIGURE 4. ANPg angle (sagittal interjaw base relationship). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

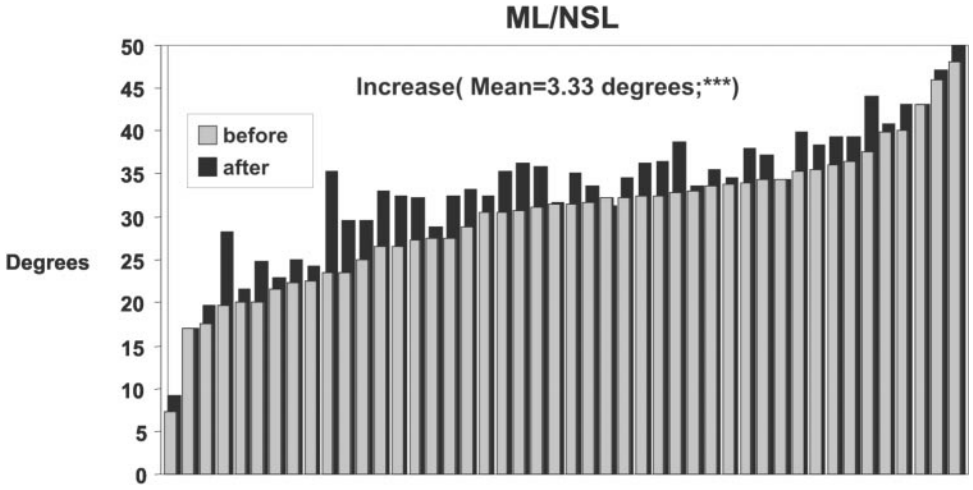

FIGURE 5. ML/NSL angle (mandibular plane angle). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

Vertical jaw relation. The mandibular plane angle (ML/NSL) and interjaw base angle (ML/NL) were increased significantly ($P < .001$) by an average of 3.33° and 3.71°, respectively. With respect to clinical significant individual changes, the ML/NSL was increased in 89% (41 of 46) of the subjects (Figure 5).

Facial height. The lower anterior facial height was, on average, increased by an Index value of 1.27 ($P < .001$), whereas the lower posterior facial height was reduced by an Index value of 2.01 ($P < .001$). Considering clinical significant individual changes, lower anterior facial height was increased in 80% (37 of 46) and lower posterior facial height was reduced in 72% (37 of 46) of the subjects (Figures 6 and 7, respectively).

Profile convexity. The convexity of the hard and soft tissue facial profiles were significantly ($P < .001$) reduced. The average reduction in the hard tissue profile convexity (NAPg) was 4.45°, in the soft tissue profile excluding the nose (NS/SN/PgS) 5.45°, and in the soft tissue profile including the nose (Ns/No/PgS) 3.20°. With respect to clinical significant individual changes, the straightening of the hard tissue profile occurred in 91% (42 of 46), the soft tissue profile excluding the nose in 98% (45 of 46), and of the soft tissue profile including the nose in 76% (35 of 46) of the subjects (Figures 8–10, respectively).

Lip position. The upper (UL) and lower (LL) lips became significantly more retrusive in relation to the Esthetic (E) line of Ricketts.[15] Average changes were: for UL, 2.49 mm ($P < .001$) and for LL, 1.12 mm ($P < .05$).

SO-Analysis

The results of SO-Analysis are shown in Figures 11 and 12 and Table 2.

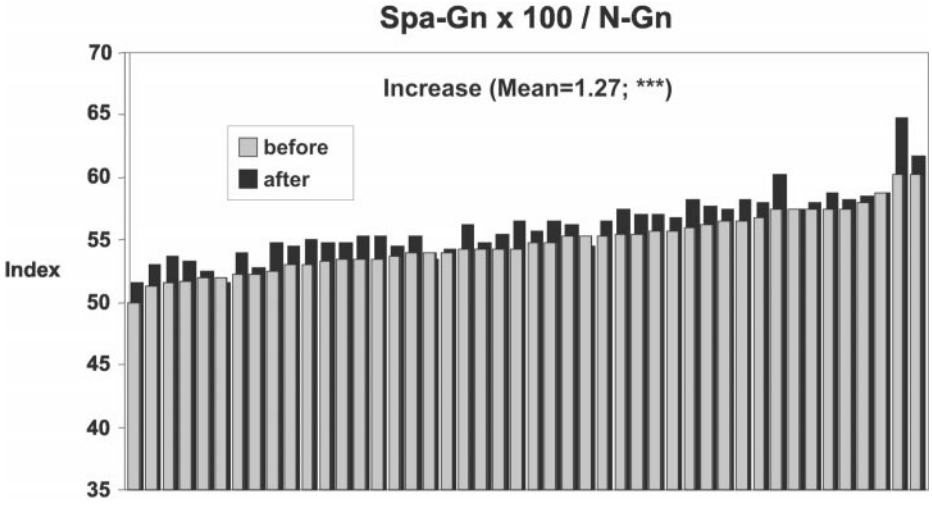

FIGURE 6. Spa-Gn × 100/N-Gn (lower anterior facial height index). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

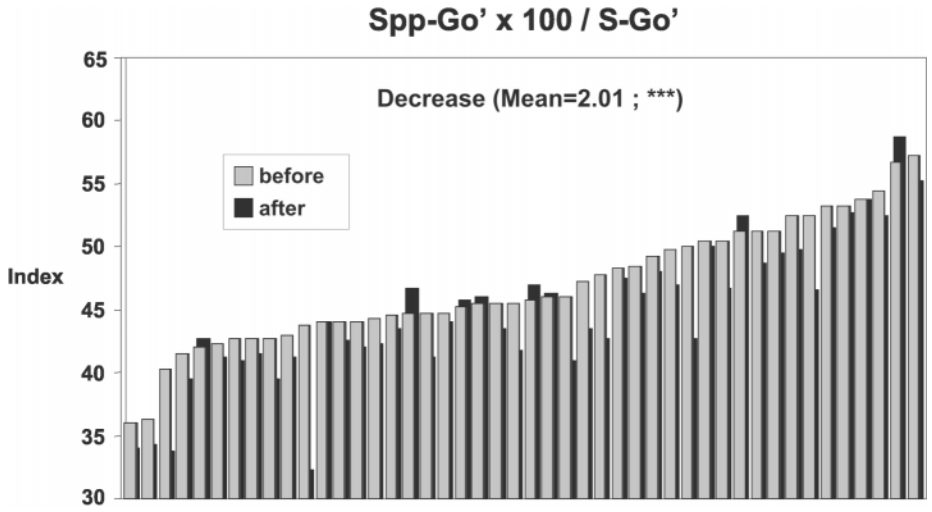

FIGURE 7. Spp-Go′ × 100/S-Go′ (lower posterior facial height index). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

Mechanism of overjet correction. The overjet was, on average, reduced by 6.31 mm. This was accomplished by 63% skeletal and 37% dental changes. When considering clinical significant individual changes, overjet reduction was achieved in 98% (45 of 46) of the subjects (Figure 13).

Mechanism of class II molar correction. The sagittal molar relation was, on average, improved by 5 mm. This was accomplished by 81% skeletal and 19% dental changes. With respect to clinical significant individual changes, the molar relation was improved in 96% (44 of 46) of the subjects (Figure 14).

A clinically significant individual mandibular base (Pg/OLp) advancement was seen in 89% (41 of 46) of the subjects (Figure 15).

DISCUSSION

In the literature, there is general agreement that one of the main reasons for adult Class II subjects seeking treatment are dental and facial esthetics.[16–18] The more dissatisfied the patients are with their facial appearance, the more likely they will choose a surgical instead of an orthodontic approach.[19,20]

No difference in the outcome of treatment was found when comparing the Swedish sample in which the Hunsuck[5] and Epker[6] method was used with the German sample treated by the surgical procedure according to Obwegeser[3] and Dal Pont.[4] This was somewhat surprising because the two surgical approaches differed in terms of the preservation (Hunsuck and Epker procedure) and the nonpreserva-

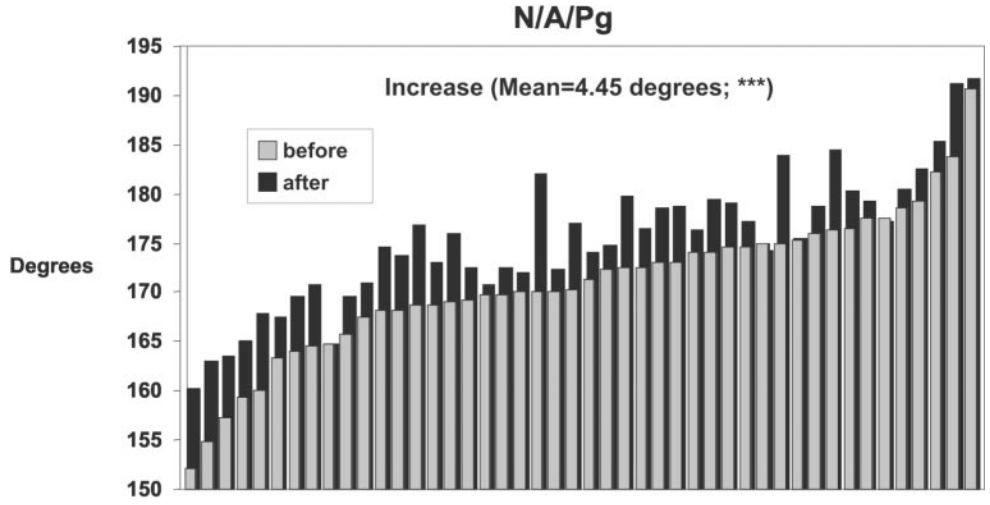

FIGURE 8. NAPg angle (hard tissue profile convexity). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

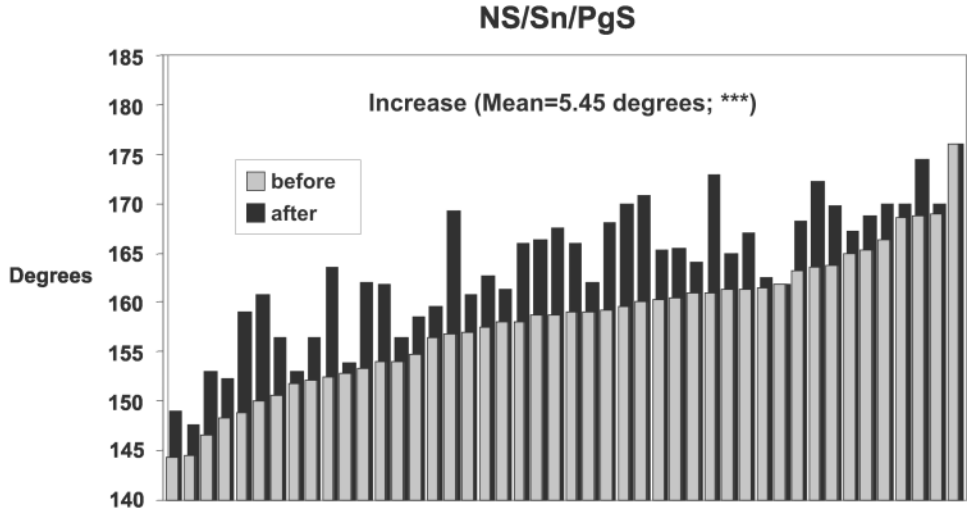

FIGURE 9. NS/Sn/PgS angle (soft tissue profile convexity excluding the nose). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

tion (Obwegeser or Dal Pont) of the chewing muscle attachments at the proximal mandibular bone fragments. It would, namely, have been expected that the more the elevator muscles are detached during surgery, the more the remodeling of the gonial area and the shortening of ramus height will occur.

In accordance with earlier studies in adult orthodontic and orthognathic subjects,[7,9,10,21,22] there was an overrepresentation of females. This might be associated with the observation that women are more interested in their facial appearance than men.[23]

An interesting finding in the present subjects was the increase in anterior facial height and the decrease in posterior facial height. These changes were also reflected in the increase of the mandibular plane angle (ML/NSL), an observation which has been described earlier.[7] As the mandibular plane angle and the anterior as well as the posterior facial heights were, on average, normal pretreatment,[24] the observed changes counteract the mandible coming forward, which is one of the goals in surgical Class II treatment. Furthermore, an increase in the mandibular plane angle would be disadvantageous in especially those Class II subjects with an increased anterior facial height pretreatment.

The increase in the anterior facial height was most likely due to the bite rising effect in conjunction with the surgical mandibular advancement procedure. The reduction of the posterior facial height could be explained by the bone remodeling processes at Gonion taking place after mandibular surgery. Possible causes discussed are an inadequate overlap between the two bony fragments,[25,26] the postsurgical adaptive processes of the soft tissues, tendons, and muscles that have been directly or indirectly affected by the surgical

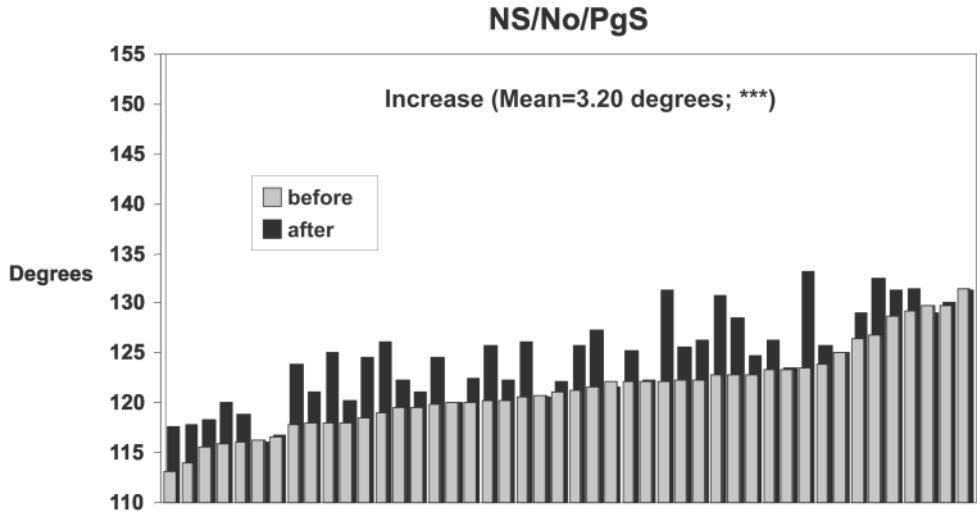

FIGURE 10. NS/No/PgS angle (soft tissue profile convexity including the nose). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

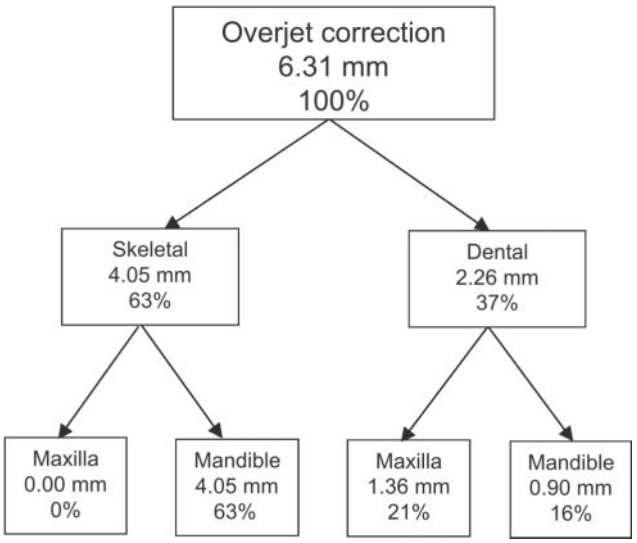

FIGURE 11. Mechanism of overjet correction in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

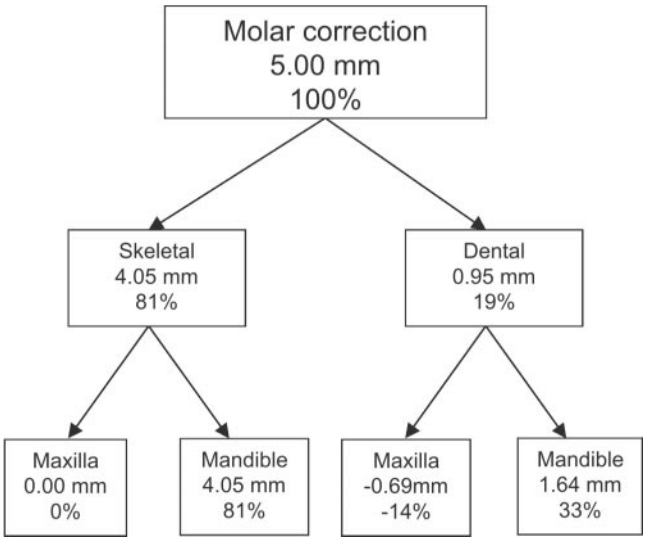

FIGURE 12. Mechanism of Class II molar correction in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

procedure and the jaw displacement.[8,11,27,28] Finally, the possibility of a condylar resorption can not be excluded as a cause for the lower posterior facial height reduction. Such a resorption has been reported to occur rather frequently in orthognathic surgery subjects[8,22] and especially in those with a pretreatment derangement of the TMJ.[29]

In the present Class II subjects, the surgical advancement of the mandible and thereby also of the chin resulted in a straightening of the hard and soft tissue profiles, which is one of the main treatment objectives in Class II subjects with a convex facial profile. However, by a mandibular advancement, the distances of the UL and LL to the E-line will increase.[30] Such a retrusion of the lips in relation to the E-line may result in a disadvantageous older appearence of the face.

In the therapy of the present Class II subjects, surgical–orthodontic treatment was most successful. When considering individual cases, overjet was reduced in 98% and sagittal molar relationship was improved in 96% of the subjects. Furthermore, both standard cephalometrics and the SO-Analysis demonstrated that the Class II correction was accomplished mainly by skeletal changes. Mandibular advancement contributed 63% to overjet correction and 81% to Class II molar correction. All dental changes seen were certainly a result of both the multibracket appliance treatment and the postsurgical dental compensation of the skeletal relapse.[31]

TABLE 2. The Mechanism of Class II Correction (SO-analysis) in 46 Adult Class II, Division 1 Subjects Treated by Orthognathic Surgery (Mandibular Sagittal Split) in Combination with Pre- and Postsurgical Orthodontics

	Surgery				Treatment changes After − before		
	Before		After				
Variable (mm)	Mean	SD	Mean	SD	Mean	SD	*t*
Overjet Is/OLp–Ii/OLp	9.69	2.68	3.38	1.13	−6.31	2.46	−17.40***
Molar relation[a] Ms/OLp–Mi/OLp	+1.77[a]	1.97	−3.23[a]	3.00	−5.00	3.13	−10.84***
Maxillary base A/OLp	78.89	4.80	78.89	4.80	0	0	0 NS[b]
Mandibular base Pg/OLp	77.67	5.54	81.72	5.97	4.05	2.49	11.03***
Maxillary incisor Is/OLp	88.36	5.11	86.99	5.59			
Mandibular incisor Ii/OLp	78.66	5.41	83.61	5.81			
Maxillary molar Ms/OLp	56.37	5.51	57.06	5.71			
Mandibular molar Mi/OLp	54.60	5.95	60.29	6.65			
Maxillary incisor Is/OLp(D)–A/OLp(D)					−1.36	2.21	4.17***
Mandibular incisor Ii/OLp(D)–Pg/OLp(D)					0.90	2.36	2.56**
Maxillary molar Ms/OLp(D)–A/OLp(D)					0.69	1.99	2.35*
Mandibular molar Mi/OLp(D)–Pg/OLp(D)					1.64	2.02	5.51***

[a] Plus (+) implies Class II molar relation; minus (−) implies Class I molar relation.
[b] NS, $P > .05$.
* $P < .05$.
** $P < .01$.
*** $P < .001$.

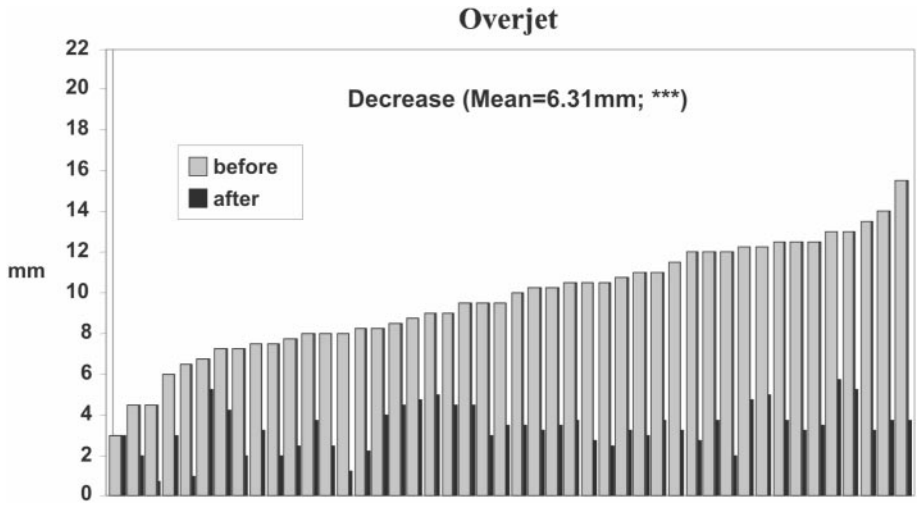

FIGURE 13. Overjet. Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

In adult skeletal Class II treatment, two alternatives to surgery are possible, either camouflage orthodontics with the extractions of maxillary teeth[9,32] or dentofacial orthopedics using the Herbst appliance.[33–38] However, in camouflage orthodontics, only the main symptom of the Class II malocclusion (the large overjet) is dealt with whereas the basic mandibular and facial esthetic problems remain. On the other hand, in adult Herbst treatment, the mandibular and esthetic problems are attacked and also solved, although to a lesser extent as compared with mandibular surgery (S. Ruf and H. Pancherz; in preparation). When choosing between the different treatment options of surgery, Herbst, or camouflage, one should not forget the costs and risks[11,12,39–41] involved, which are clearly larger with the surgical approach.

CONCLUSIONS

Mandibular sagittal split osteotomy in combination with pre- and postsurgical orthodontics is an efficient approach in the therapy of adult Class II, division 1 malocclusions. Sagittal occlusal malrelationships are corrected and the hard- and soft tissue profiles straightened in a consistent way. A negative effect of treatment counteracting Class II correction is an increase in the mandibular plane angle. Such an angular increase would also be a disadvantage,

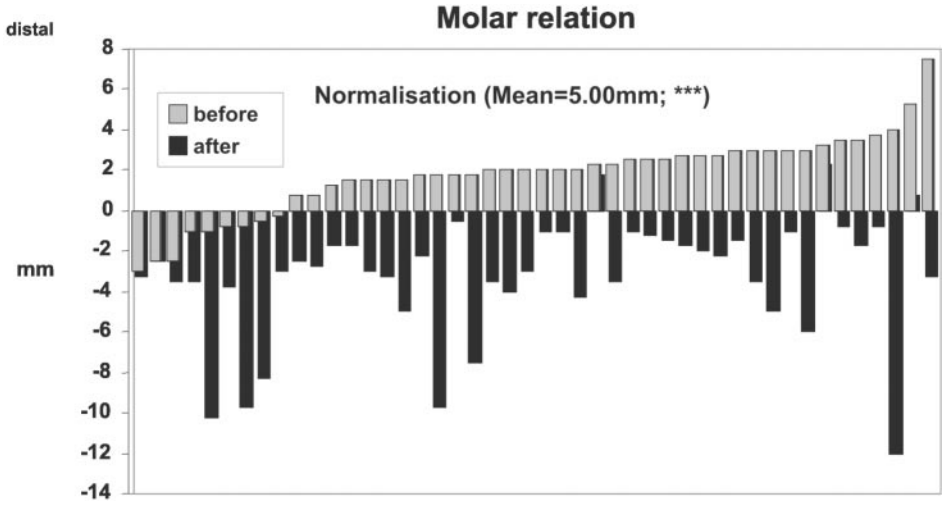

FIGURE 14. Molar relation. Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

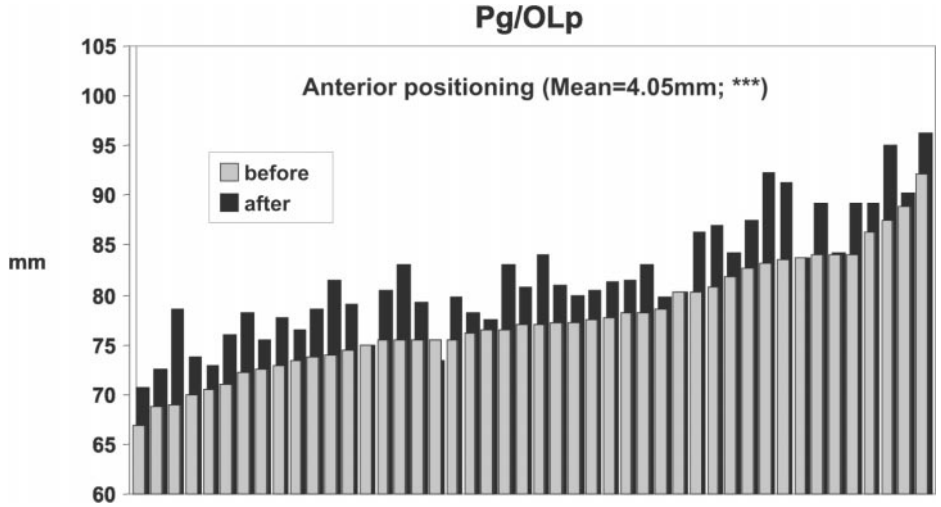

FIGURE 15. Pg/OLp (sagittal mandibular position). Individual treatment changes in 46 adult subjects treated by orthognathic surgery (mandibular sagittal split) in combination with pre- and postsurgical orthodontics.

especially in those Class II subjects with a pretreatment increased anterior facial height.

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