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Occlusal changes during and after Herbst treatment: a cephalometric investigation

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SUMMARY The aim of this study was to evaluate quantitatively sagittal, skeletal and dental changes occurring during and after Herbst treatment and relate these changes to alteration in the occlusion. Lateral roentgenograms in centric occlusion were analysed. The sample consisted of 40 Class II, division 1 cases treated with the Herbst appliance for an average period of 7 months. The subjects were re-examined 6 and 12 months post treatment. The results revealed the following: during the treatment period all subjects were treated to Class I or overcorrected Class I or Class III dental arch relationships. Overjet and sagittal molar relationship improved by an average of 6.9 mm and 6.3 mm respectively. This was a result of a 2.2 mm greater mandibular than maxillary growth, a 2.3 mm lingual movement of the maxillary incisors, a 2.4 mm labial movement of the mandibular incisors, a 2.0 mm distal movement of the maxillary molars and a 2.1 mm mesial movement of the mandibular molars. During the post treatment period of 12 months the occlusion settled into Class I in all subjects. Overjet and sagittal molar relationship relapsed by an average of 2.2 mm and 1.7 mm respectively. About 90 per cent of the occlusal relapse occurred during the first 6 months post treatment. In 58 per cent of the subjects the occlusal relapse was exclusively a result of tooth movements while unfavourable maxillary and mandibular jaw growth contributed to the relapse in 42 per cent of the subjects. As Herbst treatment is performed during a relatively short period, the dentition will be in a state of instability after the appliance is removed. Post treatment retention as well as interocclusal adjustments with an activator are therefore recommended.

Introduction

The effectiveness of the Herbst appliance in consecutively treated Class II malocclusion cases has been documented in several investigations (Pancherz 1979, 1982, 1985; Pancherz and Hägg 1985). Overcorrected sagittal dental arch relationships in combination with an incomplete cuspal interdigitation at the end of treatment are a general finding. Adaptive occlusal changes thus tend to occur after the appliance is removed (Pancherz 1981).

The purpose of this investigation was to evaluate quantitatively on lateral roentgenograms, skeletal and dental changes occurring during and after Herbst treatment and to relate these changes to alterations in the occlusion.

Material and method

In 1984 the original sample of consecutive patients treated successfully with the Herbst appliance at the Orthodontic Department, Faculty of Odontology, in Malmö comprised of 70 cases of Class II malocclusions. Following Herbst treatment tooth irregularities and arch discrepancy problems were dealt with in 30 subjects using conventional multibracket appliances (with or without extractions of teeth). These 30 subjects were not included in this study. The remaining 40 Herbst subjects were re-examined 6 and 12 months post treatment (Table 1). A selection of cephalometric records describing dentofacial morphology in the subjects before treatment, after treatment, 6 months and 12 months post treatment are shown in Table 2. The measuring points and reference lines used have been defined by Björk (1947) and Jacobson (1975).

The design of the Herbst appliance used in treating the patients is shown in Figure 1. Partial anchorage was utilized in 16 subjects and total anchorage in 24 subjects (Table 1). The construction of the appliance has been described elsewhere (Pancherz 1985).

Table 1 Herbst appliance treatment of 40 Class II, division 1 malocclusions. Distribution of the patient material: Sex (M = male, F = female); age at start of Herbst treatment; length of treatment period (T), post treatment period 1 (P_1), post treatment period 2 (P_2), and total observation period (O); anchorage system of the appliance (S = simple, T = total); retention after Herbst treatment (None, A = activator, P = upper plate, L = lower lingual arch wire).

Case	Sex	Age at start (years)	T (years)	P_1 (years)	P_2 (years)	O (years)	Anchorage	Retention
1	M	12.8	0.5	0.5	.5	1.5	S	None
2	M	13.3	0.5	0.5	0.5	1.5	S	None
3	M	11.3	0.6	0.5	0.5	1.6	S	None
4	M	11.9	0.5	0.5	0.5	1.5	S	A
5	M	11.4	0.5	0.5	0.5	1.5	S	None
6	M	11.6	0.6	0.5	0.5	1.5	S	None
7	M	11.7	0.6	0.5	0.5	1.6	S	None
8	M	10.6	0.5	0.5	0.5	1.5	S	None
9	M	13.1	0.5	0.5	0.5	1.5	S	None
10	M	13.4	0.5	0.5	0.5	1.5	S	A
11	F	12.6	0.7	0.5	0.5	1.7	S	A
12	M	12.7	0.6	0.5	0.5	1.6	S	None
13	M	11.9	0.6	0.5	0.5	1.6	S	A
14	F	11.6	0.6	0.5	0.7	1.8	S	A
15	F	10.8	0.6	0.5	0.6	1.7	S	A
16	M	12.3	0.6	0.5	0.5	1.6	T	A
17	M	11.4	0.6	0.5	0.5	1.6	S	None
18	M	11.6	0.5	0.5	0.5	1.5	T	A
19	M	12.3	0.6	0.5	0.5	1.6	T	A
20	M	13.1	0.6	0.5	0.6	1.7	T	A
21	F	11.1	0.4	0.5	0.5	1.4	T	A
22	M	12.3	0.5	0.5	0.5	1.5	T	None
23	M	13.1	0.5	0.5	0.5	1.5	T	P/L
24	F	11.8	0.8	0.4	0.5	1.7	T	A
25	M	13.0	0.8	0.4	0.5	1.7	T	P/L
26	M	13.2	0.6	0.5	0.5	1.6	T	A
27	F	12.7	0.6	0.5	0.5	1.6	T	P/L
28	M	16.2	0.8	0.5	0.5	1.8	T	A
29	M	12.8	0.6	0.5	0.5	1.6	T	A
30	M	12.2	0.6	0.5	0.5	1.6	T	A
31	M	12.4	0.6	0.5	0.5	1.6	T	A
32	F	12.1	0.5	0.5	0.5	1.5	T	P
33	F	12.1	0.6	0.5	0.5	1.6	T	P/L
34	M	13.6	0.5	0.5	0.4	1.4	T	None
35	M	12.5	1.0	0.6	0.5	2.1	T	P
36	M	12.7	1.0	0.7	0.3	2.0	T	None
37	M	15.8	0.5	0.6	0.5	1.6	T	None
38	M	14.3	0.8	0.5	0.5	1.8	T	None
39	F	12.4	0.8	0.7	0.4	1.9	T	A
40	M	12.1	0.5	0.5	0.5	1.5	T	A
Mean		12.5	0.6	0.5	0.5	1.6		
s.d.		1.1	0.1	0.1	0.1	0.2		

Sagittal, skeletal and dental changes occurring during and after Herbst treatment were evaluated cephalometrically on lateral roentgenograms in centric occlusion. Roentgenograms from before treatment, after treatment, 6 months and 12 months post treatment were analysed.

The registrations from the roentgenograms were performed on matte acetate tracing film. Measurements and calculations were done with the aid of a Hi-pad digitizer connected to a Zenith 100 microcomputer. No correction was made for linear enlargement (approximately

Table 2 Cephalometric records describing dentofacial morphology in 40 Class II, division 1 malocclusion treated with the Herbst appliance.

Variable	Before treatment		After treatment		Six months post treatment		Twelve months post treatment	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Maxillary position—SNA (degrees)	81.9	3.7	81.4	3.9	81.6	3.9	81.8	3.9
Mandibular position—SNB (degrees)	75.8	3.3	76.8	3.6	77.0	3.4	77.1	3.4
Sagittal jaw relation—ANB (degrees)	6.1	1.8	4.6	1.8	4.6	1.8	4.7	1.7
Sagittal jaw relation—A/B 'Wits' (mm)	2.9	2.1	0.5	2.0	0.6	2.1	0.6	2.1
Mandibular plane angle—ML/NSL (degrees)	31.1	5.7	31.5	5.9	30.9	5.7	30.6	5.6
Occlusal plane angle—OL/NSL (degrees)	20.0	4.4	21.2	4.2	20.0	4.1	19.2	4.1
Overjet (mm)	8.8	2.1	1.9	1.6	3.9	1.2	4.1	1.3
Molar relation* (mm)	+2.5	1.0	−3.9	1.6	−2.3	1.3	−2.1	1.3

* + indicates a distal molar relation; − indicates a normal molar relation (see Methods)

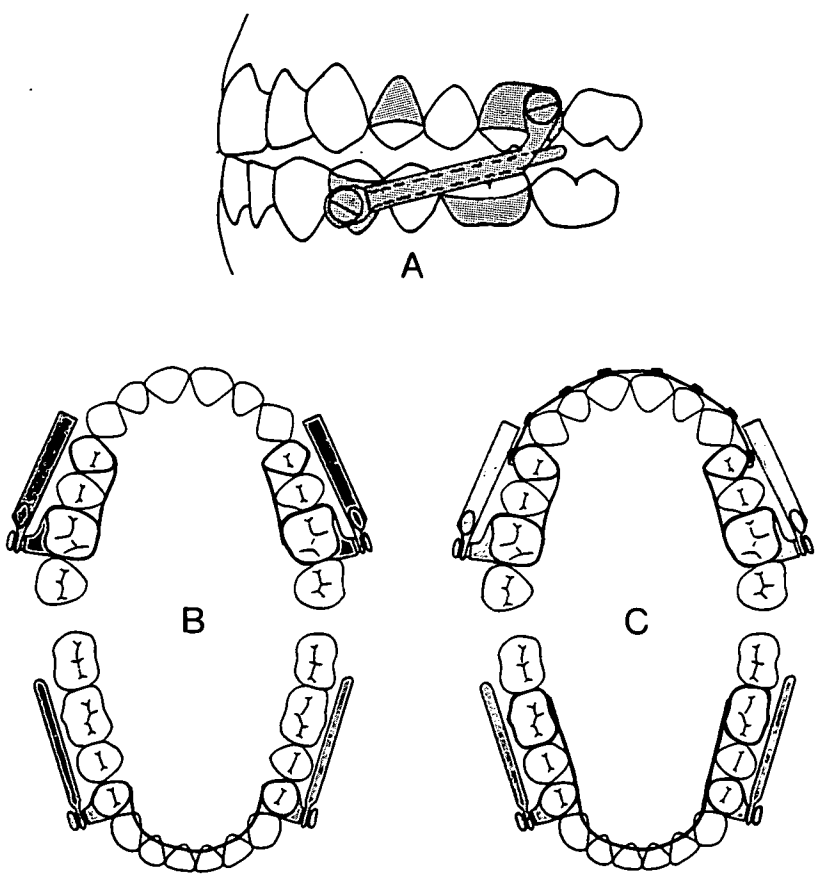

Figure 1 The Herbst appliance. A Working position of the appliance with the teeth in occlusion. B Partial maxillary and mandibular anchorage. C Total maxillary and mandibular anchorage.

7 per cent in the median plane). The reference points, reference lines and measuring points used are shown in Figure 2 and have been defined in an earlier article (Pancherz 1982).

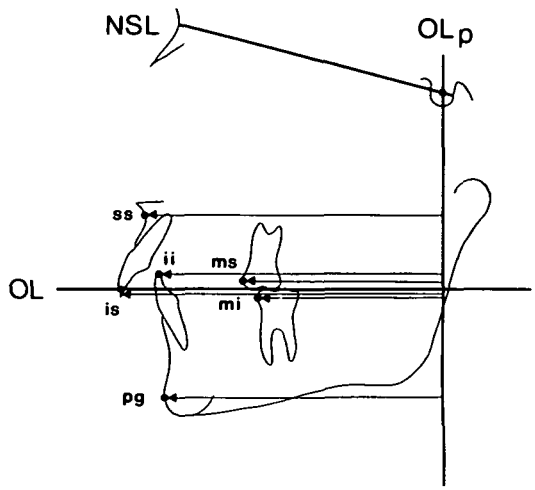

Figure 2 Measuring points used in the cephalometric analysis. The registration line (NSL) and reference grid (OL and OL_p) are shown.

Measuring procedure

For all linear measurements on, before, after and post treatment tracings, the occlusal line (OL) and occlusal line perpendicular (OL_p) *from the first head film* were used as a reference grid for sagittal registrations (Fig. 2). The grid was transferred from the first tracing to the following tracings in a series by superimposition of the tracings on the nasion-sella line (NSL) with sella (s) as registration point. The profile roentgenographic analysis comprised of the following variables:

(1) is/OL_p minus is/OL_p—Overjet
(2) ms/OL_p minus mi/OL_p—Molar relation (a positive value indicates a distal relation; a negative value indicates a normal relation)
(3) ss/OL_p—Position of the maxillary jaw base
(4) pg/OL_p—Position of the mandibular jaw base
(5) is/OL_p—Position of the maxillary central incisor
(6) ii/OL_p—Position of the mandibular central incisor
(7) ms/OL_p—Position of the maxillary permanent first molar
(8) mi/OL_p—Position of the mandibular permanent first molar.

Changes in the different measuring points in relation to OL_p occurring during the various examination periods were registered by calculating the difference (d) in landmark position. Changes in variables 3 and 4 represent skeletal changes, while changes in variables 5 to 8 represent a composite picture of skeletal and dental change. Variables for dental changes within the maxilla and mandible were obtained by the following calculations (variables 9 to 12):

(9) $is/OL_p(d)$ minus $ss/OL_p(d)$—Change in position of the maxillary central incisor within the maxilla
(10) $ii/OL_p(d)$ minus $pg/OL_p(d)$—Change in position of the mandibular central incisor within the mandible
(11) $ms/OL_p(d)$ minus $ss/OL_p(d)$—Change in position of the maxillary permanent first molar within the maxilla
(12) $mi/OL_p(d)$ minus $pg/OL_p(d)$—Change in position of the mandibular permanent first molar within the mandible.

Statistical methods

The arithmetic mean (Mean) and standard deviation (s.d.) were calculated for each cephalometric variable, and *t*-tests were performed to assess the statistical significance of changes occurring during the various examination periods. The interdependence between the treatment and post treatment changes of the different variables was analysed with the Pearson coefficient of correlation (r). Significance was determined at the 0.05 (x), 0.01 (xx) and 0.001 (xxx) levels of significance.

The size of the combined method error (ME) in locating, superimposing, and measuring the changes in the different landmarks was calculated by the formula $ME = \sqrt{(\Sigma d^2/2n)}$, where d is the difference between two registrations of a pair, n is the number of double registrations. Before, after and post treatment cephalograms from 10 randomly chosen subjects were traced and superimposed with measurements recorded on two different occasions. Irrespective of the examination period, the combined method error did not exceed 0.7 mm for any of the variables investigated.

Results

The cephalometric changes occurring in the 40 subjects during and after Herbst treatment as well as during the whole observation period, are presented in Figure 3.

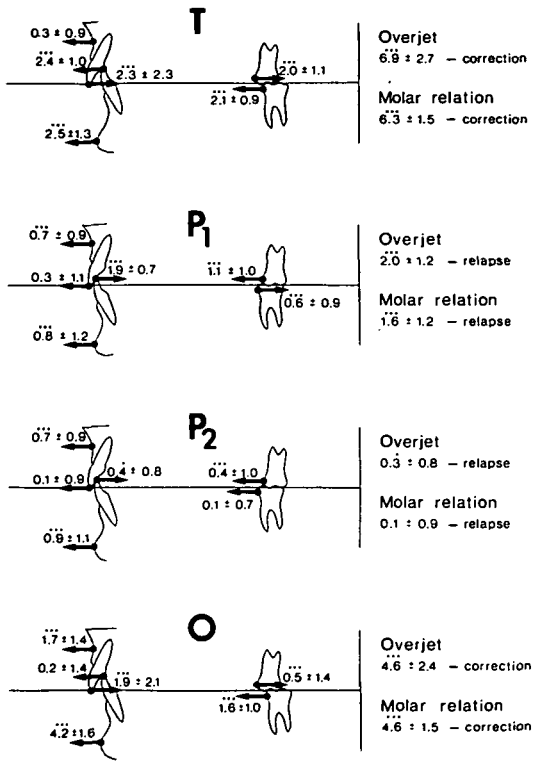

Figure 3 Skeletal and dental changes (mm) contributing to alterations in overjet and sagittal molar relationships in 40 Class II, division 1 malocclusions treated with the Herbst appliance. Registrations (Mean and s.d.) during the treatment period (T), post treatment period 1 (P_1), post treatment period 2 (P_2) and total observation period (O). * indicates significance at 5% level. *** indicates significance at 0.1% level.

Treatment changes

At the end of Herbst treatment when the appliance was removed, a Class I dental arch relationship existed in 7 subjects, and overcorrected Class I or Class III dental arch relationships in 33 subjects.

The improvement in sagittal incisor and molar relationship resulted from both skeletal and dental changes. Overjet was reduced by an average of 6.9 mm ($p < 0.001$). This was accomplished by a 2.2 mm ($p < 0.001$) larger mandibular than maxillary growth, a 2.3 mm ($p < 0.001$) lingual movement of the maxillary incisors and a 2.4 mm ($p < 0.001$) labial movement of the mandibular incisors. Sagittal molar relationship was improved by an average of 6.3 mm ($p < 0.001$). In addition to the difference in mandibular-maxillary growth, this was a result of a 2.0 mm ($p < 0.001$) distal movement of the maxillary molars and 2.1 mm ($p < 0.001$) mesial movement of the mandibular molars.

Post treatment changes

During the follow-up period of 1 year the occlusion settled into Class I in all subjects.

During the first post treatment period (P_1) of 6 months, the overjet relapsed by an average of 2.0 mm ($p < 0.001$) and sagittal molar relationship relapsed by an average of 1.6 mm ($p < 0.001$). During the following post treatment period (P_2) of 6 months only minor occlusal changes occurred. Overjet relapsed by an average of 0.3 mm ($p < 0.05$) while sagittal molar relationship remained on average unchanged. During both post treatment periods (P_1 and P_2) the occlusal relapse was exclusively a result of dental changes in 23 subjects, while unfavourable maxillary and mandibular growth contributed as well to the relapse in 17 subjects.

Influence of anchorage

The anchorage system of the Herbst appliance was partial in 16 subjects and total in 24 subjects (Fig. 2, Table 1). A difference between these two anchorage systems was found for the maxillary incisors and the mandibular molars.

During the treatment period (T) the maxillary incisors were moved lingually on average 3.4 mm ($p < 0.001$) in the total anchorage group, while the teeth remained unchanged in the partial anchorage group. The mandibular molars were moved mesially 0.7 mm more ($p < 0.01$) in the total anchorage group than in the partial anchorage group. During the post treatment periods (P_1 and P_2), an insignificant relapse in maxillary incisor position occurred in the total anchorage group: 0.4 mm during P_1 and 0.2 mm during P_2. The mandibular molars in the total anchorage group relapsed completely during P_1. In the partial anchorage group mandibular molar position was unchanged post treatment (P_1 and P_2).

Influence of retention

After Herbst treatment, retention was performed in 25 subjects while no retention was performed in 15 subjects (Table 1). A difference between the retention and non-retention group was found for maxillary molar position only.

On average during the treatment period (T), the maxillary molars were moved distally equally in the retention and non-retention group (viz. 2.0 mm). During post treatment periods (P_1 and P_2), however, the relapse in maxillary molar position was less in the retention group than in the non-retention group: 0.5 mm ($p < 0.05$) during P_1 and 0.6 mm ($p < 0.05$) during P_2. As a consequence, 12 months post treatment, the sagittal occlusal relationship between the molars was, on average, 1.1 mm better ($p < 0.01$) in the retention group, than in the non-retention group.

Table 3 Relationship between skeletal and dental changes occurring during the treatment period (T) and post treatment periods 1 and 1+2 (P_1 and P_{1+2}); correlation coefficients (r) in 40 Class II, division 1 malocclusions treated with the Herbst appliance.

Variable	r	
	T-P_1	T-P_{1+2}
1. Overjet	−0.51***	−0.45*
2. Molar relation	−0.52***	−0.51***
3. Maxillary base	−0.11	−0.06
4. Mandibular base	−0.42**	−0.40**
9. Maxillary incisor	−0.50***	−0.47**
10. Mandibular incisor	−0.21	−0.15
11. Maxillary molar	−0.24	−0.17
12. Mandibular molar	−0.43**	−0.36*

* Significance at 5% level; ** at 1%; *** at 0.1%

Correlation analysis

The inter-relationship between the amounts of skeletal and dental change occurring during the treatment period (T) and the two post treatment periods (P_1 and P_2) is presented in Table 3). A weak association existed between the treatment and post treatment changes. The correlation coefficients for the different variables should be interpreted in the following way: For sagittal incisor and molar relationship (variables 1 and 2) as well as for the dental variables (variables 9-12) a large change during treatment tended to be followed by a correspondingly large relapse post treatment; for maxillary growth (variable 3) a small amount of growth during treatment tended to be followed by a correspondingly large amount of growth post treatment; for mandibular growth (variable 4) the reverse was true viz., a large amount of growth during treatment tended to be followed by a correspondingly small amount of growth post treatment.

Case reports

The cases of two boys (Cases 13 and 23) and one girl (Case 39) whose Class II, Division 1 malocclusion were treated with the Herbst appliance are presented.

Case 13

The patient (Fig. 4) was 11 years 11 months of age and had been treated with the Herbst appliance for 7 months. Overcorrected Class I dental arch relationships existed at the end of treatment. The Herbst appliance was constructed with partial upper and lower anchorage. An activator for interocclusal adjustments was used after Herbst treatment.

Treatment changes. Overjet was reduced by 5.6 mm. This was accomplished by a 1.9 mm greater mandibular than maxillary growth, a 1.7 mm lingual movement of the maxillary incisors and a 2.0 mm labial movement of the mandibular incisors. Sagittal molar relationship was improved by 7.3 mm. In addition to the difference in mandibular-maxillary growth, this was a result of a 3.2 mm distal movement of the maxillary molars, and a 2.2 mm mesial movement of the mandibular molars.

Post treatment changes. During the follow-up period of 12 months, overjet relapsed by 0.7 mm and sagittal molar relationships by 0.8 mm. These relapses were a result of an unfavourable maxillary and mandibular growth. Tooth movements (with the exception of the mandibular incisor), did not contribute to the occlusal relapse.

Case 23

The patient (Fig. 5) was 13 years and 1 month of age and had been treated with the Herbst appliance for 6 months. Class III dental arch

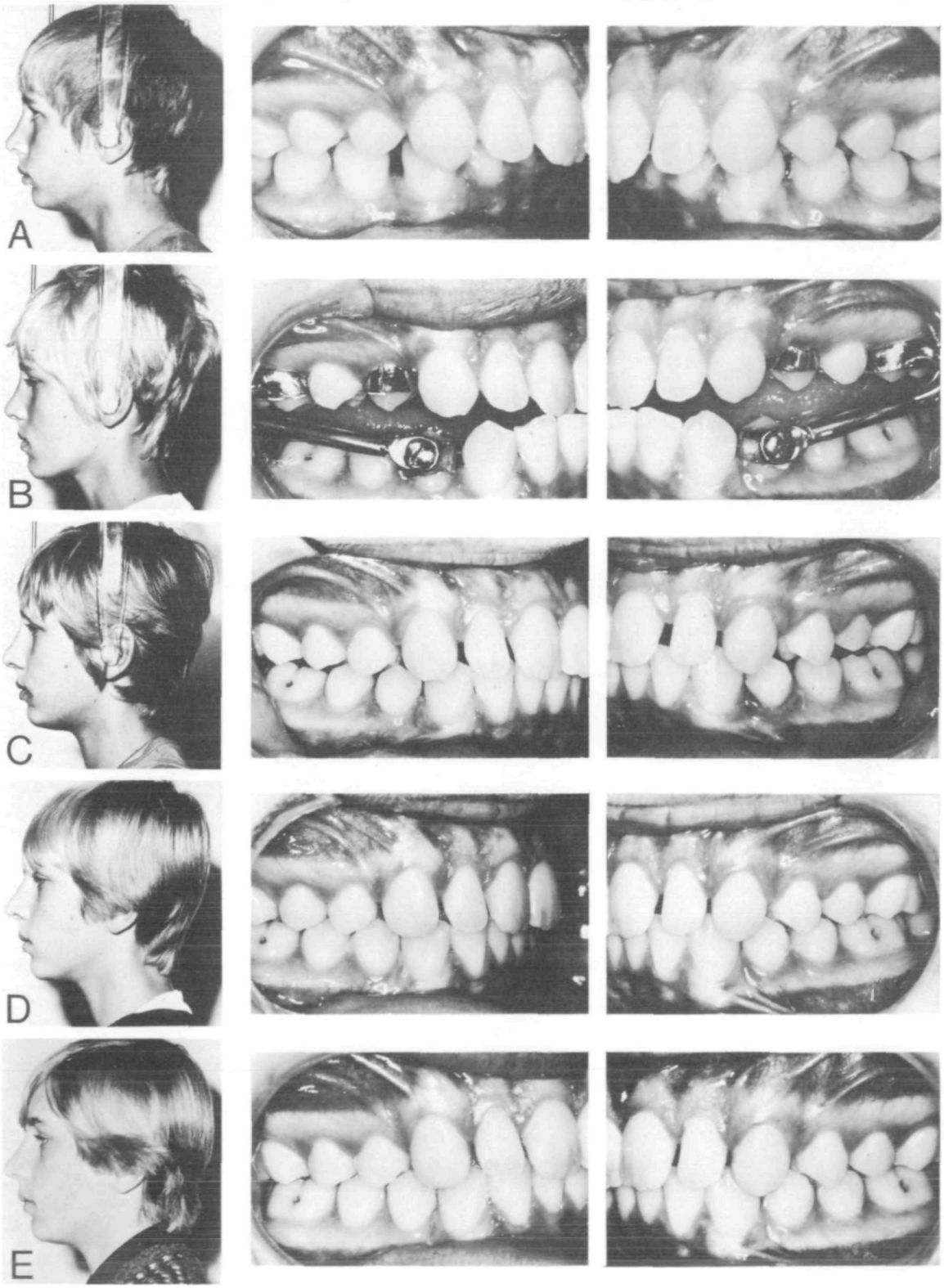

Figure 4A *Case 13.* Extraoral and intraoral photographs. A Before treatment. B At the start of treatment with the Herbst appliance. C After 7 months of treatment when the appliance was removed. D 6 months post treatment. E 12 months post treatment.

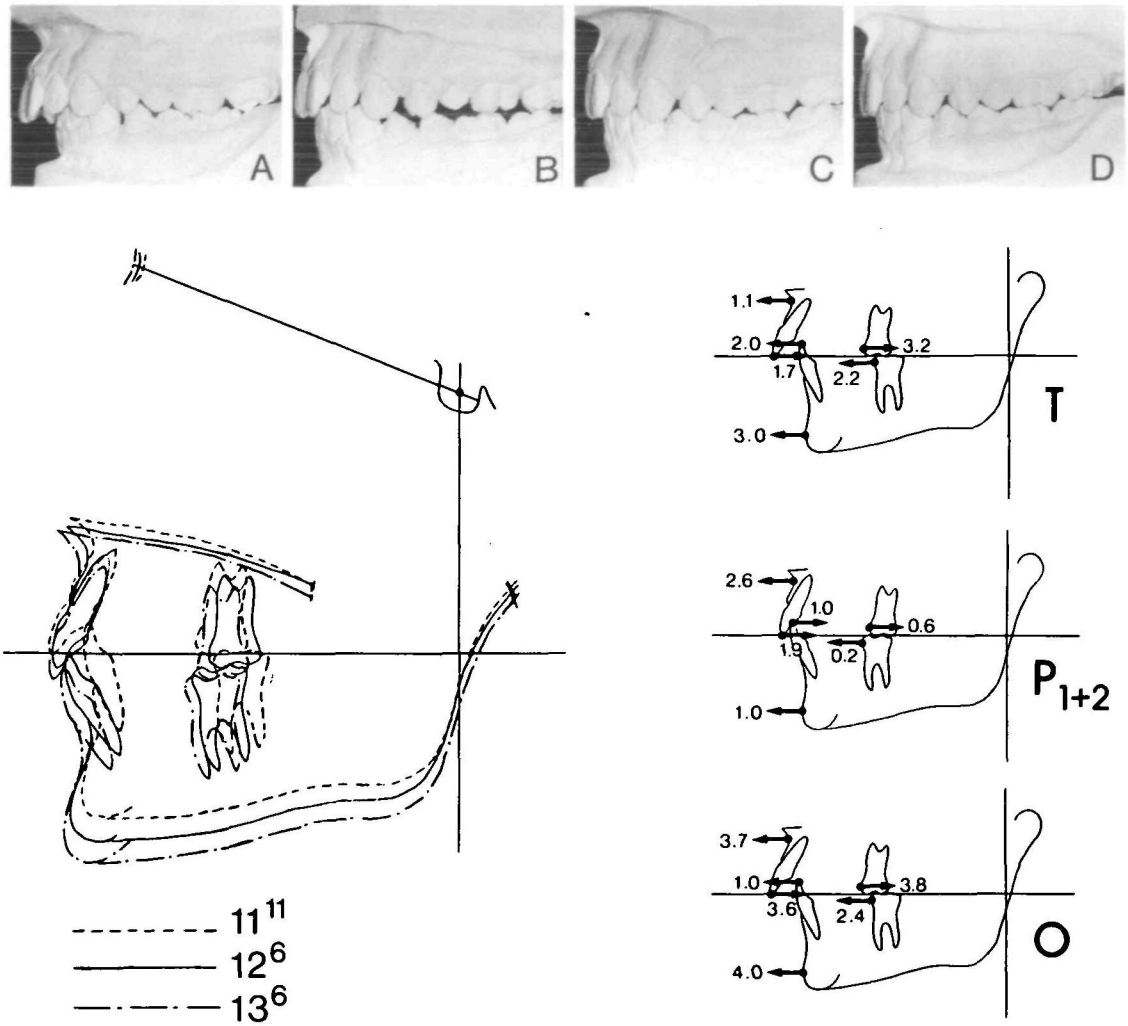

Figure 4B *Case 13.* Plaster casts. A Before treatment. B After 7 months of treatment with the Herbst appliance. C 6 months post treatment. D 12 months post treatment. Cephalometric tracings superimposed on the nasion-sella line with sella as registration point. Diagrammatic representation of sagittal, skeletal and dental changes (mm) occurring during the treatment period of 7 months (T), post treatment period of 12 months ($P_1 + P_2$) and total observation period of 19 months (O).

relationships existed at the end of treatment. The Herbst appliance was constructed with total upper and lower anchorage. An upper plate and a lower lingual arch wire were used for retention after Herbst treatment. The occlusion settled into Class I during the post treatment period.

Treatment changes. Overjet was reduced by 9.7 mm. This was accomplished by a 7.4 mm greater mandibular than maxillary growth, a 0.1 mm lingual movement of the maxillary incisors and a 2.2 mm labial movement of the mandibular incisors. Sagittal molar relationship was improved by 10.9 mm. Besides the difference in mandibular-maxillary growth this was a result of a 2.4 mm distal movement of the maxillary molars and a 1.1 mesial movement of the mandibular molars.

Post treatment changes. During the follow-up period of 12 months, overjet relapsed by 1.6 mm and sagittal molar relationship by 3.6 mm. These relapses were partly a result of an unfavourable

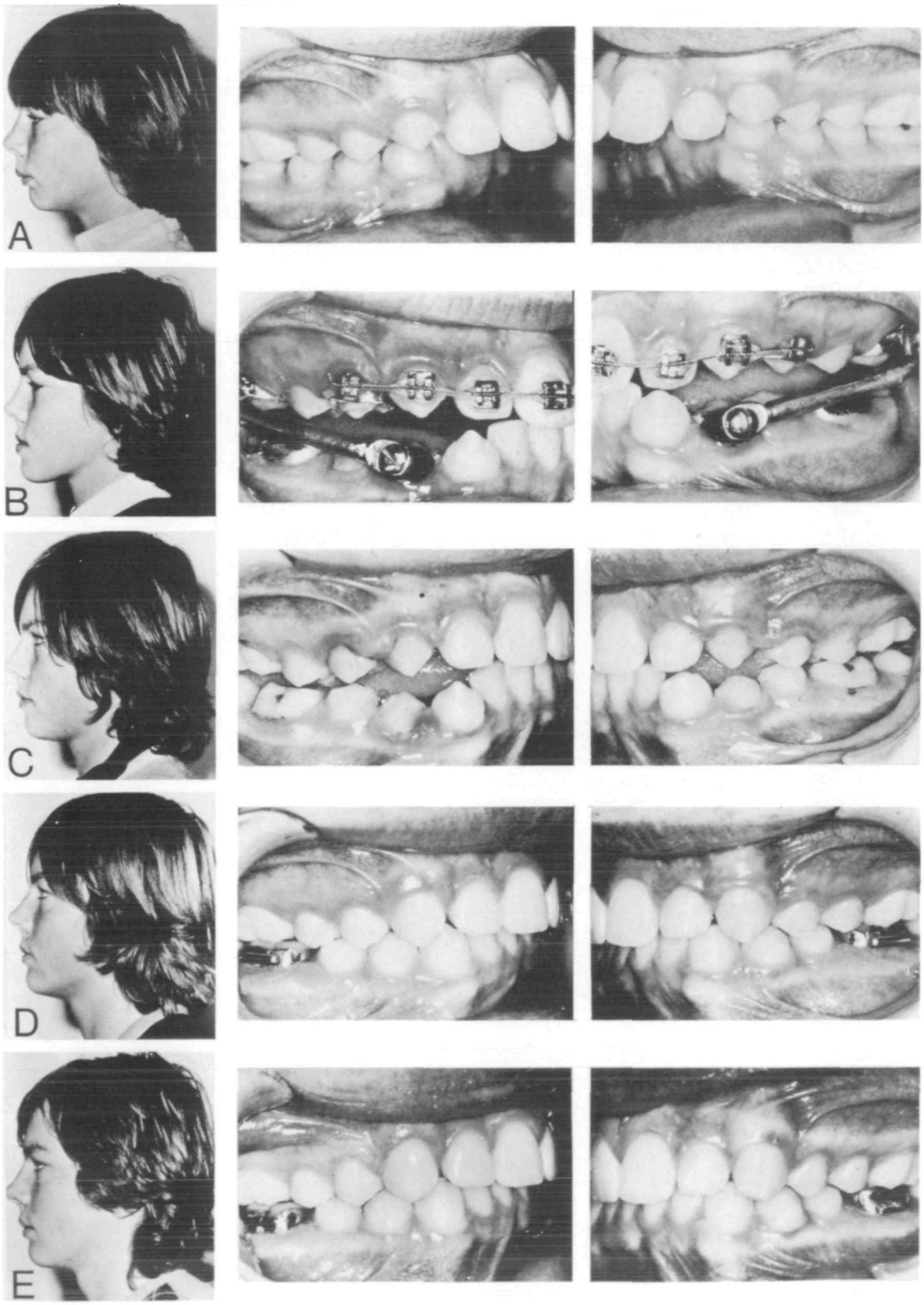

Figure 5A *Case 23.* Extraoral and intraoral photographs. A Before treatment. B At the start of treatment with the Herbst appliance. C After 6 months of treatment when the appliance was removed. D 6 months post treatment. E 12 months post treatment.

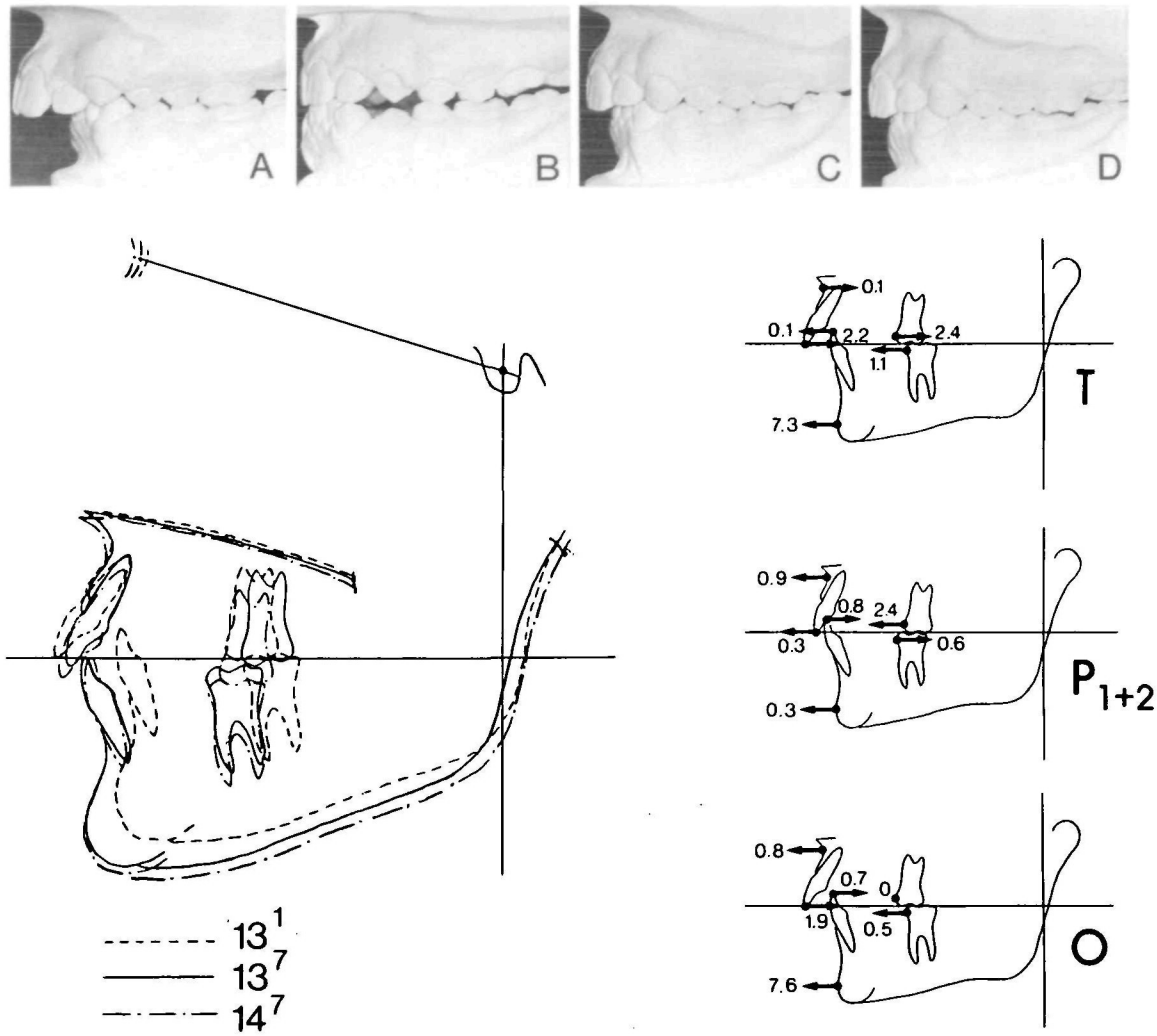

Figure 5B *Case 23.* Plaster casts. A Before treatment. B After 6 months of treatment with the Herbst appliance. C 6 months post treatment. Cephalometric tracings superimposed on the nasion-sella line with sella as registration point. Diagrammatic representation of sagittal, skeletal and dental changes (mm) occurring during the treatment period of 6 months (T), post treatment period of 12 months (P_{1+2}) and total observation period of 18 months (O).

maxillary and mandibular growth and partly due to tooth movements.

Case 39

The patient (Fig. 6) was 12 years 5 months of age and had been treated with the Herbst appliance for 9 months. Class III dental arch relationships existed at the end of treatment. The Herbst appliance was constructed with total upper and lower anchorage. An activator for interocclusal adjustments was used after Herbst treatment. The occlusion settled into Class I during the post treatment period.

Treatment changes. Overjet was reduced by 10.6 mm. This was accomplished by a 3.5 mm greater mandibular than maxillary growth, a 5.0 mm lingual movement of the maxillary incisors and a 2.1 mm labial movement of the mandibular incisors. Sagittal molar relationship was improved by 8.7 mm. As well as the

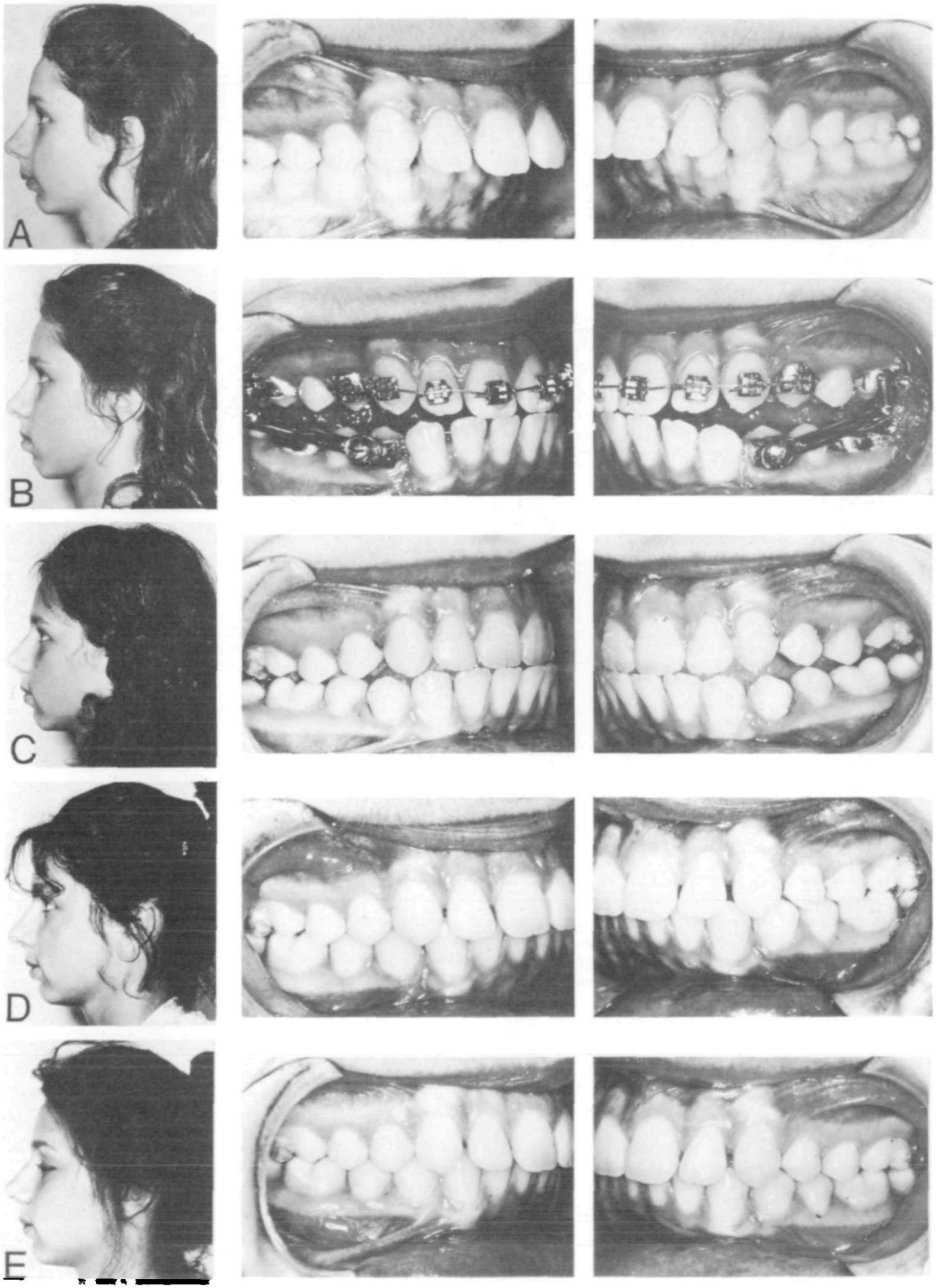

Figure 6A *Case 39.* Extraoral and intraoral photographs. A Before treatment. B At the start of treatment with the Herbst appliance. C After 9 months of treatment when the appliance was removed. D 6 months post treatment. E 12 months post treatment.

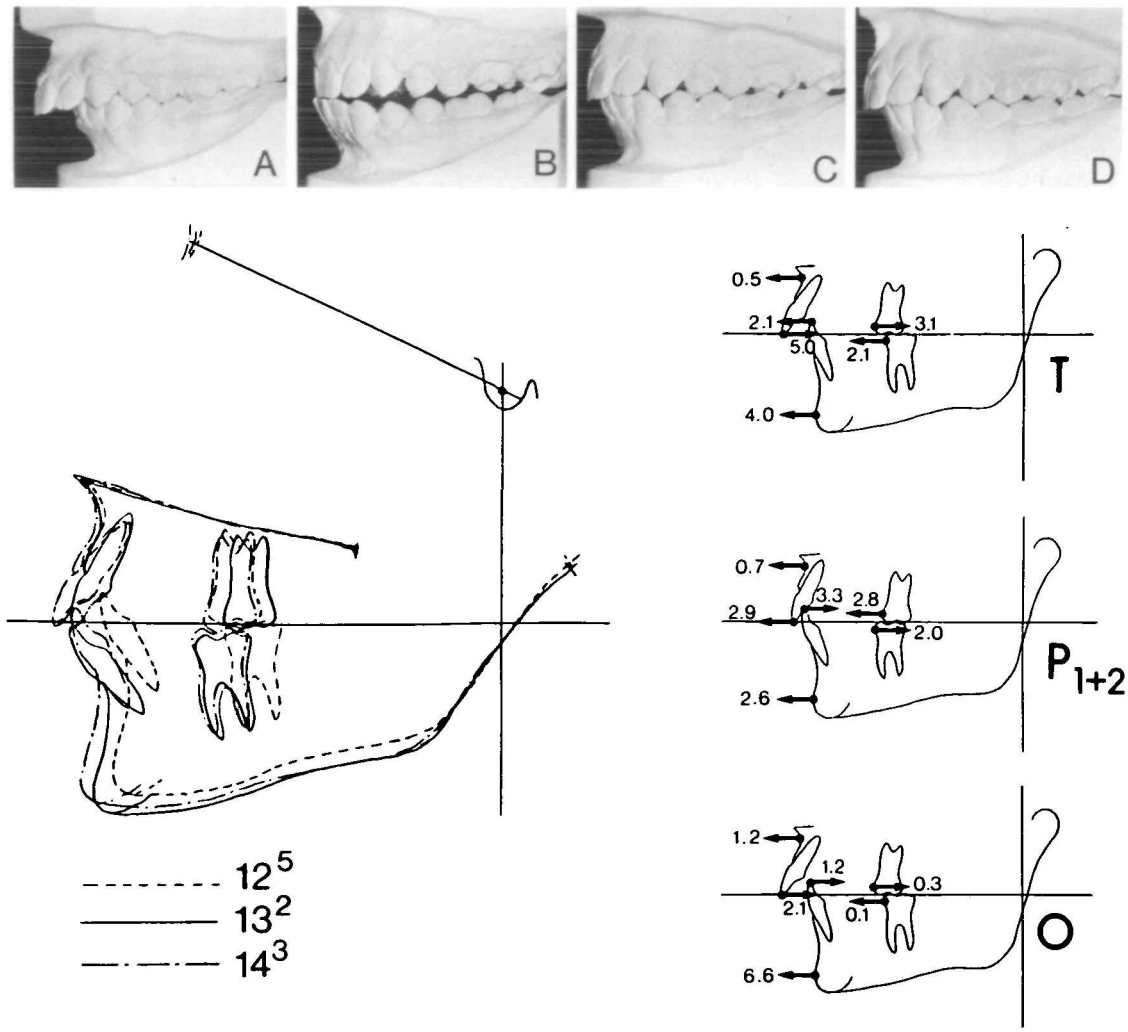

Figure 6B *Case 39.* Plaster casts. A Before treatment. B After 9 months of treatment with the Herbst appliance. C 6 months post treatment. D 12 months post treatment. Cephalometric tracings superimposed on the nasion-sella line with sella as registration point. Diagrammatic representation of sagittal, skeletal and dental changes (mm) occurring during the treatment period of 9 months (T), post treatment period of 13 months (P_{1+2}) and total observation period of 22 months (O).

difference in mandibular-maxillary growth this was a result of a 3.1 mm distal movement of the maxillary molars and a 2.1 mm mesial movement of the mandibular molars.

Post treatment changes. During the follow-up period of 12 months, overjet relapsed by 4.3 mm and sagittal molar relationship by 2.9 mm. These relapses were exclusively a result of tooth movements. Post treatment maxillary and mandibular growth was favourable and partly masked the dental relapse.

Discussion

The cephalometric analysing method used in this present investigation has previously been utilized in the evaluation of the immediate effects of Herbst treatment (Pancherz 1982) and activator treatment (Pancherz 1984). By using the same reference line (OL_p) for all registrations, the analytical procedure makes it possible to assess the interrelationship between skeletal and dental components that contribute to occlusal changes.

Treatment changes

The telescope mechanism of the Herbst appliance produces a posteriorly directed force on the maxilla and its teeth and an anteriorly directed force on the mandible and its teeth. When comparing the skeletal changes occurring during treatment with those occurring in untreated controls (Pancherz 1979, 1982), maxillary growth was inhibited and mandibular growth was enhanced. Besides a possible stimulating effect on condylar growth (Stöckli and Willert 1971; Elgoyhen *et al.* 1972; McNamara 1973) thereby increasing mandibular length (Pancherz 1982), the forward position of the mandible might also be a result of remodelling processes in the articular fossa (Breitner 1930; Stöckli and Willert 1971; Pancherz 1979, 1982; Wieslander 1984).

The dental changes in the maxilla and mandible were basically a result of anchorage loss. Surprisingly in subjects with partial and total anchorage the maxillary molars were moved distally and the mandibular incisors were moved labially on the average by the same amount. The extension of the appliance incorporating more dental units (total anchorage), seemed thus not to reduce the strains placed on the teeth in the lower labial and in the upper buccal segments. It must be pointed out, however, that the extent of dental changes varied considerably between individuals irrespective of the anchorage system used.

The present subjects in the total anchorage group were, on the average, 7 months older than the subjects in the partial anchorage group. Since it is thought that general muscle strength increases with age (Stolz and Stolz 1951) and neuromuscular adaptation will occur less easily in older than in younger subjects, the forces exerted upon the dentition by the appliance will possibly be enhanced in the older subjects. In a recent investigation (Pancherz and Hägg 1985), it was also shown that mandibular incisor tooth movements were more extensive in postpubertal than in pubertal treated patients. Thus the influence of somatic maturation on the treatment response could be a factor of importance in explaining the similarity in anchorage loss in the partial and total anchorage subjects.

Post treatment changes

After the Herbst appliance was removed at the end of treatment a 30 per cent relapse in the sagittal dental arch relationships occurred and a stable cuspal interdigitation in Class I was established. About 90 per cent of the post treatment occlusal changes were seen during the first 6 months after treatment and were, in 23 of the cases, exclusively a result of tooth movements. An unfavourable maxillary-mandibular growth relationship did, however, contribute to a minor degree as well to the occlusal relapse in 17 cases. When comparing the skeletal changes in the Herbst subjects with those in untreated controls there seemed to be a catch-up in maxillary and a reduction in mandibular growth (Pancherz 1981) (Table 3).

When looking at the subjects at the end of the total observation period (treatment and post treatment), (Fig. 3) the mandibular incisors had, on average, returned to their original position, while the lower molars were moved forward. The consequent reduction in dental arch length did not, however, result in anterior crowding in any of the subjects. This was explained by the fact that forward movement of the molars was confined to those cases, with a pre-treatment excess of space in the dental arch (Case 39, Fig. 6).

Retention with an activator after Herbst treatment, is recommended. The appliance holds the teeth in the desired position and selective grinding of the acrylic makes interocclusal adjustments possible by guiding tooth eruption. In the present subjects the activator was used as a retention device only for the teeth in the maxillary buccal segments. In the mandible on the other hand, the acrylic was deliberately removed from behind the anterior teeth and mesially and distally to the buccal segments to allow settling of tooth movements. Thus, post treatment dental changes in the mandible were the same in retention and non-retention subjects.

This investigation was concerned with the short term, follow-up results of Herbst treatment. The long term implications of this treatment method need further consideration.

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