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Therapeutic changes in extraction versus non-extraction orthodontic treatment

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SUMMARY Pre- and post-treatment lateral cephalograms of two extraction groups (E_4: extraction of the four first premolars; E_5: extraction of the four second premolars) and one non-extraction group (NE) were evaluated in patients treated with Begg appliances. It was the intention to investigate the initial amount of crowding, the changes in the position of incisors and molars, the soft tissue profile changes, and the clinical outcome. Ten linear and eight angular measurements were analysed. In order to assess the initial amount of crowding, the Arch Length Discrepancy (ALD) was measured on dental casts taken before treatment. The clinical outcome was evaluated using the PAR Index.

The mean pretreatment crowding was nearly twice as large in group E_4 when compared with groups E_5 and NE. This difference was the main reason for the higher mean PAR score (21.4) for E_4 when compared with E_5 (15.4) and NE (15.2). In addition, for the cephalometric pretreatment values, some significant differences between the three groups were found: the upper and lower incisors and the lower lip region relative to the pterygomaxillary vertical plane (PMV) were more protrusive in group E_5; the inter-incisal angle in both extraction groups was smaller than in the non-extraction group.

During treatment, the lower incisor position relative to PMV did not change significantly, and the upper incisors moved backward approximately 2 mm in both extraction groups. This was not reflected in a significant change in lip position. In the non-extraction group, tooth alignment was accompanied by a significant proclination of the incisors, and a comparable forward movement in the lip region when measured in relation to PMV. In the three types of cases, no unfavourable changes in the facial profile were seen. A mean enlargement of about 6 degrees normalized the inter-incisal angle in both extraction groups, while in the non-extraction group the inter-incisal angle became smaller than the norm value. In the three types of cases, upper and lower molars were moved mesially. This movement was higher in group E_5 than E_4, and lower in the NE cases.

Mainly due to the case selection (Class I or very mild Class II or Class III malocclusions), the pretreatment PAR Index was not very high. The percentage reduction for the three groups was higher than 90 per cent. With post-treatment mean PAR scores less than 2, groups E_4, E_5, and NE can be regarded as having an almost ideal clinical outcome.

Introduction

While many practitioners are convinced that orthodontic treatment influences the soft tissue profile, controversy remains concerning the precise soft tissue response to changes in tooth position. A positive correlation between incisor movement and soft tissue changes has been reported (Roos, 1977). On the other hand, the studies of Angelle (1973) and Hershey (1972) showed that changes in tooth position are not systematically followed by proportional soft tissue profile changes. Variables such as lip morphology, type of treatment (extraction versus non-extraction therapy, choice of extraction), patient gender, and age have been held responsible for individual differences in soft tissue response (Wisth, 1972, 1974).

Extraction decisions have to be made not only by considering the amount of crowding but also

Table 1 Mean age, treatment interval, and gender in the patient groups.

Patient group	Age at T_1	Age at T_2	Interval ($T_1 - T_2$)	Gender
E4	11 years 10 months	14 years 8 months	2 years 10 months	17 girls, 13 boys
E5	13 years	15 years 6 months	2 years 6 months	11 girls, 19 boys
NE	12 years 3 months	14 years 10 months	2 years 7 months	18 girls, 12 boys

T_1: treatment start; T_2: end of treatment.

the eventual influence of orthodontic tooth displacement on the soft tissue surface of the face. No information concerning the correlation between the initial amount of crowding and the changes in profile during orthodontic treatment was found in the literature. In non-extraction therapy without extra-oral traction, one can assume that tooth alignment protrudes the anterior teeth and the facial profile. In extraction therapy, tooth alignment partly consumes the extraction spaces. Closing the remaining spaces could retrocline the anterior teeth and retract the facial profile.

Williams and Hosila (1976) found that orthodontic treatment with extraction of premolars was accompanied by changes of the soft tissue profile. In some cases these changes improved the facial aesthetics, in others an undesired profile outcome could be seen. For this reason, a carefully studied extraction policy, accounting for all possible changes, would be very valuable. The same study indicated that orthodontic treatment with extraction of four first molars results in less incisor retraction than cases treated with extraction of four first premolars or maxillary first premolars and mandibular second premolars. Clinical observation points in the same direction: therapy with more posteriorly situated extractions seems to result in less incisor retroclination. De Castro (1974) recommended extraction of second premolars in cases where retraction of anterior teeth has to be avoided. By this choice, the closing of extraction spaces after alignment would be mainly realized by mesial movement of posterior teeth instead of distal movement of anterior teeth.

The purpose of this study was to investigate (in extraction and non-extraction therapy), the initial amount of crowding, the changes in the position of the incisors and molars, the changes in the soft tissue profile, and the clinical outcome.

Subjects and methods

Sample

Three groups of 30 patients were investigated. In group E_4 the four first premolars were extracted and in group E_5 the four second premolars. In group NE no extractions were performed. The patients were treated in the University of Gent or in one of two private practices. Upper and lower fixed orthodontic appliances according to the Begg method were used (Begg and Kesling, 1977). Light wire forces were applied without the use of extra-oral forces. Class I malocclusions and very mild Class II or Class III malocclusions were accepted. The patients had no congenitally missing teeth and no surgical intervention was planned.

While closing the remaining spaces in the E_4 and E_5 cases, intra-arch elastics were used in combination with torque auxiliaries for the upper incisors. The use of inter-arch elastics (mostly Class II) in order to produce incisor contact was accompanied by upper arch torque devices in the three types of cases.

The mean age, treatment interval and gender in the different patient groups are presented in Table 1.

Model analysis

The pretreatment models were obtained from alginate impressions. In order to assess the initial amount of crowding, the Arch Length Discrepancy

(ALD) was measured on the casts of the upper and lower dental arches according to Nance (1947a,b) and van der Linden and Boersma (1986). The PAR Index (Richmond *et al.*, 1992a,b) was calculated as an objective measure for the pre- and post-treatment differences in irregularity. The percentage reduction in PAR score represents the degree of clinical improvement.

Radiographic analysis

Standardized lateral cephalograms were taken before orthodontic treatment (T_1) and after the end of active treatment (T_2). The patients were asked to close on the molars and not to stress the lips. Those structures on the lateral head films used in this study were traced on acetate paper with a sharp pointed pencil (Figure 1). The tracings were superimposed according to the 'Best Fit' method (Björk, 1947) on the stable structures of the cranial base: anterior and caudal walls of the sella turcica, processus clinoideus anterior, and planum sphenoidale.

The twenty-six reference points identified on each tracing were digitized using cephalometric software designed by the University of Zürich. The co-ordinate system was determined by three points chosen arbitrarily on each T_1 tracing, defining the *x*- and *y*-axis. This co-ordinate system was transferred to the T_2 tracing by superimposition on the structures of the anterior cranial base.

The hard and soft tissue changes were related to the pterygomaxillary vertical plane (PMV) on a parallel or perpendicular basis. The PMV-plane was defined through the points spheno-ethmoidal (Se) and pterygomaxillary (Ptm). The PMV-plane was used as a reliable reference plane in studies by Enlow *et al.* (1971), Nanda and Rains (1982), and Nanda *et al.* (1989).

The linear and angular measurements analysed in this study are shown in Figures 2–5.

Statistical analysis (Howell, 1987)

The data were processed with the software 'Statistical Package for the Social Sciences' [SPSS (SPSS Inc., Chicago, Ill.)]. The following tests were used in this investigation: the one-way

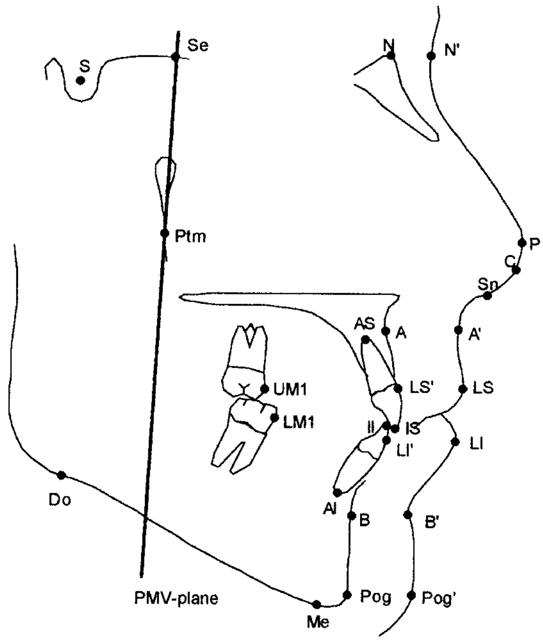

Figure 1 Cephalometric landmarks.

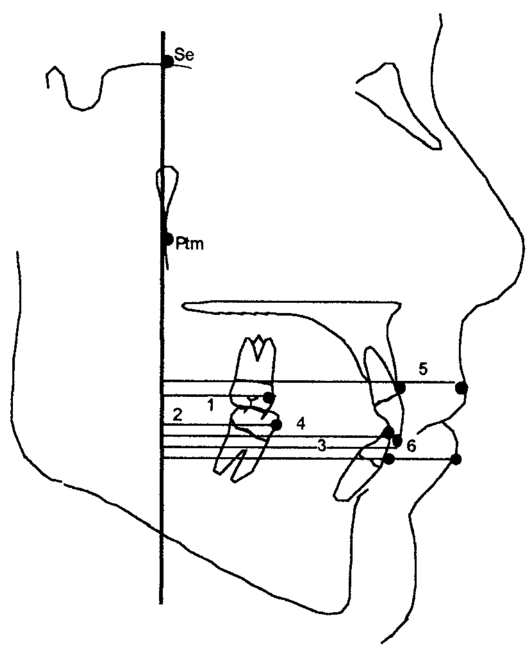

Figure 2 Linear measurements related to PMV (mm). (1) Distance upper M_1 to PMV. (2) Distance lower M_1 to PMV. (3) Distance IS to PMV. (4) Distance II to PMV. (5) Distance LS to PMV. (6) Distance LI to PMV.

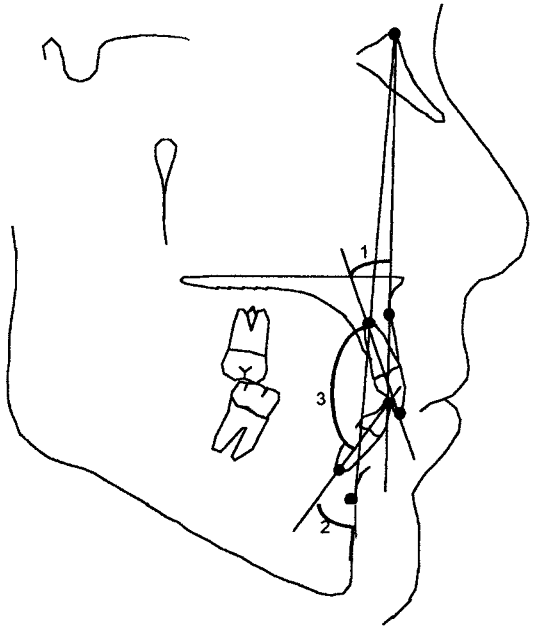

Figure 3 Position of upper and lower incisors. (1) Upper incisor inclination: IS–AS/N–A (degrees). (2) Lower incisor inclination: II–AI/N–B (degrees). (3) Inter-incisal angle (degrees).

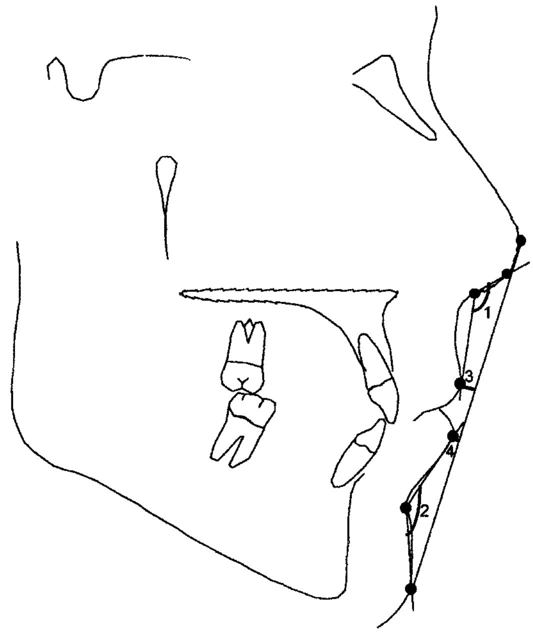

Figure 5 Soft tissue surface. (1) Nasolabial angle: C–Sn–LS (degrees). (2) Labiomental angle: LI–B′–Pog′ (degrees). (3) Position upper lip to P–Pog′ line (mm). (4) Position lower lip to P–Pog′ line (mm).

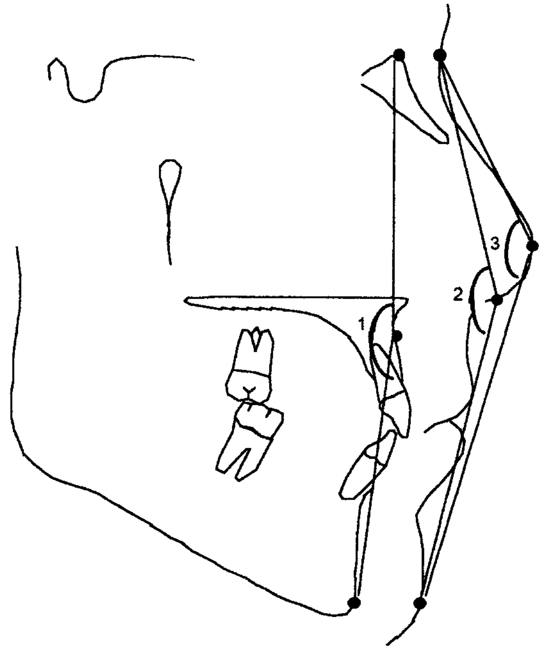

Figure 4 Facial convexity (degrees). (1) N–A–Pog. (2) N′–Sn–Pog′. (3) N′–P–Pog′.

analysis of variance at T_1 in order to evaluate the differences between the three groups before treatment, the paired *t*-test in order to look for the significance of the changes during active treatment within each group and the one-way analysis of variance at T_2 in order to evaluate the differences between the three groups at the end of treatment.

Error of the method

For the evaluation of the intra-examiner error, the complete measurement procedure was repeated by the same person on 10 randomly selected cephalograms and study models, after an interval of at least 1 week. This method was applied for the tracing and digitizing error, and for the measuring error of the crowding. During tracing, digitizing and measuring the crowding on the study models, the standard error (SE) and the percentage error (PE) were calculated using Dahlberg's formula (Dahlberg, 1940).

Table 2 Pretreatment evaluation.

	Pretreatment mean value			*P*-values		
	E_4 (SD)	E_5 (SD)	NE (SD)	$E_4 - E_5$	E_4 – NE	E_5 – NE
Crowding (mm)						
Upper arch	–7.0 (4.6)	–3.0 (3.3)	–3.8 (2.5)	*	*	NS
Lower arch	–6.2 (4.4)	–3.4 (3.3)	–4.1 (1.8)	*	*	NS
Distance to PMV (mm)						
Upper molar	28.6 (4.8)	30.0 (4.9)	27.8 (3.2)	NS	NS	NS
Lower molar	29.4 (4.3)	31.4 (5.5)	28.6 (3.0)	NS	NS	*
Upper incisor	58.6 (4.6)	61.7 (6.0)	58.5 (3.6)	*	NS	*
Lower incisor	54.4 (4.5)	56.9 (5.8)	54.0 (3.3)	*	NS	*
Upper lip	69.7 (4.3)	72.5 (5.8)	70.3 (4.1)	NS	NS	NS
Lower lip	68.1 (5.1)	72.1 (6.4)	68.4 (4.2)	*	NS	*
Incisor inclination						
IS–AS/N–A (°)	20.5 (6.3)	23.1 (5.2)	19.3 (6.5)	NS	NS	*
II–AI/N–B (°)	28.1 (6.9)	25.9 (5.9)	24.2 (4.9)	NS	*	NS
II–Angle (°)	126.4 (9.4)	127.1 (8.3)	132.4 (9.6)	NS	*	*
Lip position (mm)						
Distance to P–Pog′						
Upper	–1.4 (2.8)	–2.4 (3.6)	–3.3 (3.0)	NS	NS	NS
Lower	0.6 (2.9)	0 (3.4)	–1.5 (3.0)	NS	*	NS
Facial convexity (°)						
N–A–Pog	170.2 (5.6)	172.7 (6.4)	173.1 (3.9)	NS	NS	NS
N′–Sn–Pog′	155.4 (4.8)	156.0 (6.0)	156.2 (5.1)	NS	NS	NS
N′–P–Pog′	132.7 (3.9)	132.8 (4.6)	132.6 (4.4)	NS	NS	NS
Soft tissue surface (°)						
C–Sn–LS	121.1 (7.9)	123.7 (8.7)	125.7 (10.6)	NS	NS	NS
LI–B′–Pog′	154.9 (12.0)	151.4 (15.7)	149.8 (17.0)	NS	NS	NS

E_4: four first premolar extraction group; E_5: four second premolar extraction group; NE: non-extraction group.
SD: standard deviation; *significant difference at $P < 0.05$.

Results

Error of the method

The standard errors during tracing, as well as the linear and angular values, were below the maximum values reported by Björk (1947; 1.1 mm and 2.2 degrees). The percentage errors during tracing varied between 0.6 and 14.1 per cent for the linear values, and between 0.5 and 5.4 per cent for the angular values. The high percentages corresponded to measurements of small distances. All standard and percentage errors during digitizing remained limited. The maximum SE found was 0.8 mm and 7.1 per cent for the PE. For the measurement of the crowding, the highest standard error for a whole dental arch quadrant was 0.8 mm.

Pretreatment evaluation (Table 2)

The differences among the three groups before treatment were evaluated by a one-way analysis of variance at T_1. The Student–Newman–Keuls procedure was used to determine which measurements in which pairs of groups ($E_4 - E_5$, E_4 – NE, E_5 – NE) showed significant differences at the 0.05 level.

The mean value for the crowding was nearly twice as large in group E_4 when compared with groups E_5 and NE. The upper and lower incisors and the lower lip relative to the PMV-plane in group E_5 were situated more forwards in the craniofacial complex when compared with groups E_4 and NE. The inter-incisal angle in both extraction groups was smaller than in the NE group. The distance from the mandibular

Table 3 Changes during treatment.

	E4			E5			NE		
	$T_2 - T_1$	SD	*P*	$T_2 - T_1$	SD	*P*	$T_2 - T_1$	SD	*P*
Distance to PMV (mm)									
Upper molar	4.4	3.2	***	5.3	2.2	***	2.6	1.7	***
Lower molar	5.7	3.6	***	6.7	2.8	***	4.4	1.6	***
Upper incisor	–2.1	2.5	***	–1.9	2.4	***	3.3	1.7	***
Lower incisor	–0.6	3.0	NS	0.6	2.7	NS	5.1	1.6	***
Upper lip	–0.06	2.8	NS	1.0	4.2	NS	2.8	2.4	***
Lower lip	0.2	3.2	NS	0.3	3.2	NS	3.8	2.0	***
Incisor inclination									
IS–AS/N–A (°)	–1.4	7.4	NS	–4.3	5.0	***	2.6	6.1	*
II–AI/N–B (°)	–3.5	7.9	*	–1.1	6.2	NS	5.3	4.0	***
II–Angle (°)	6.4	10.6	**	6.2	7.1	***	–7.4	7.3	***
Lip position (mm)									
Distance to P–Pog′									
Upper	–3.2	1.7	***	–2.3	2.5	***	–1.7	1.8	***
Lower	–2.9	2.3	***	–2.7	1.9	***	–0.8	1.5	**
Facial convexity (°)									
N–A–Pog	4.1	3.9	***	2.4	3.0	***	1.5	2.1	***
N′–Sn–Pog′	1.3	3.0	*	–0.9	2.9	NS	–1.3	2.3	**
N′–P–Pog′	–1.5	2.2	**	–2.7	2.6	***	–1.6	2.0	***
Soft tissue surface (°)									
C–SN–LS	3.2	7.4	*	3.2	8.2	*	2.3	7.1	NS
LI–B′–Pog′	–11.1	20.3	NS	6.3	13.5	*	8.4	13.5	NS

E_4: four first premolar extraction group; E_5: four second premolar extraction group; NE: non-extraction group; SD: standard deviation.
P: *P*-value for difference $T_2 - T_1$; NS: not significant; *significant at $P < 0.05$; **significant at $P < 0.01$; ***significant at $P < 0.001$.

first molar to PMV was significantly larger in group E_5.

Changes during treatment (Tables 3 and 4)

Molar, incisor and lip position relative to PMV (Figure 6). For all cases, a significant mesial migration of the posterior teeth took place in both arches. In the extraction groups, the anterior teeth were moved backward in the upper arch, while no significant change was found in the lower arch. In the upper arch, the extraction spaces were closed by a combination of alignment of the anterior teeth, mesial movement of the lateral teeth, and distal movement of the incisal region. In the lower arch, alignment and mesial migration of lateral teeth closed the spaces. For the lip region the changes were not significant.

The upper and lower dentition was proclined in group NE. In this group, a significant protrusion of the lip region was noted.

The incisor inclination. For both extraction groups, the upper and lower incisors showed a retroclination during treatment. In the non-extraction group a forward tipping of the incisors was noted. The changes in incisor inclination proved to be significant, except for the retroclination of the upper incisors in group E_4 and of the lower incisors in group E_5. The mean post-treatment incisor inclination in the two extraction groups was not significantly different. When compared with the normative value according to Steiner (1959), the post-treatment mean in group E_4 and E_5 was too small for the upper incisors and correct for the lower incisors. In the non-extraction group, the mean post-treatment value was close

Table 4 Post-treatment evaluation.

	Post-treatment mean value						P-values		
	E_4	SD	E_5	SD	NE	SD	$E_4 - E_5$	E_4 – NE	E_5 – NE
Distance to PMV (mm)									
Upper molar	33.0	4.0	35.3	5.0	30.4	3.0	*	*	*
Lower molar	35.0	4.1	38.1	5.6	32.9	3.6	*	NS	*
Upper incisor	56.5	4.7	59.9	6.6	61.7	3.9	*	*	NS
Lower incisor	53.8	4.3	57.4	6.4	59.0	3.8	*	*	NS
Upper lip	69.6	4.3	73.5	6.7	73.1	3.9	*	*	NS
Lower lip	68.4	5.0	72.4	7.2	72.2	4.2	*	*	NS
Incisor inclination									
IS–AS/N–A (°)	19.2	7.8	18.8	6.0	21.9	4.6	NS	NS	NS
II–AI/N–B (°)	24.6	6.5	24.7	6.8	29.5	4.3	NS	*	*
II–Angle (°)	132.7	7.7	133.3	6.9	125.0	6.8	NS	*	*
Lip position (mm)									
Distance to P–Pog′									
Upper	–4.6	3.0	–4.6	2.5	–5.0	2.8	NS	NS	NS
Lower	–2.3	3.6	–2.7	2.6	–2.3	2.7	NS	NS	NS
Facial convexity (°)									
N–A–Pog	174.3	6.9	175.1	6.0	174.6	4.0	NS	NS	NS
N′–Sn–Pog′	156.7	5.4	155.2	6.1	154.9	4.6	NS	NS	NS
N′–P–Pog′	131.2	4.6	130.1	5.2	131.0	4.3	NS	NS	NS
Soft tissue surface (°)									
C–Sn–LS	124.3	7.7	126.8	7.3	128.0	9.2	NS	NS	NS
LI–B′–Pog′	143.8	16.4	157.7	15.1	158.2	12.0	NS	NS	NS

E_4: four first premolar extraction group; E_5: four second premolar extraction group; NE: non-extraction group.
SD: standard deviation; *significant difference at $P < 0.05$.

to the normative value for the upper incisors, but the lower incisors were more proclined than that suggested by Steiner (1959).

In the interest of occlusal stability, Downs (1956) preferred an inter-incisal angle of 135.4 degrees. The analysis of Steiner (1959) indicates an inter-incisal angle of 131 degrees. In both extraction groups a significant increase of the inter-incisal angle took place. In the non-extraction group, a comparable decrease was found.

The position of upper and lower lips relative to the line P–Pog′ [E-line according to Ricketts (1968)]. In the three groups, a significant retraction of the lip region was found. The mean backward change of lip position was less pronounced in group NE when compared with both extraction groups. After treatment, no significant differences were found at the 0.05 level between the groups.

The facial convexity: N–A–Pog, N′–Sn–Pog′, N′–P–Pog′. A significant increase of the angle N–A–Pog indicates that the cranial profile adopted a straighter morphology in the three groups. The changes in the angle N′–Sn–Pog′ showed that the soft tissue profile, excluding the nose, led to a less convex form in group E_4, remained stable in group E_5 (no significant change) and became more convex in group NE. The soft tissue profile, including the nose (N′–P–Pog′) became more convex in the three groups. The mean post-treatment values showed no significant differences at the 0.05 level.

Nasolabial and labiomental angles. For the nasolabial angle a significant mean increase was observed in both extraction groups, but in the non-extraction group this was not significant. In the labiomental angle, a mean decrease was seen in group E_4. Due to large standard deviations,

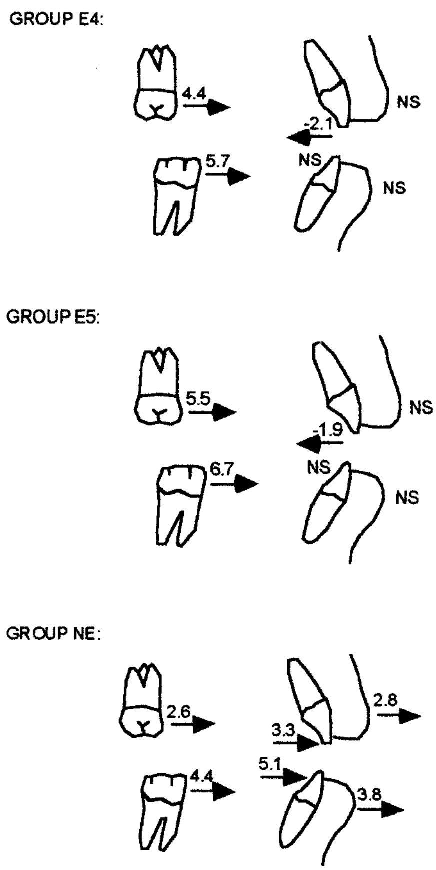

Figure 6 Mean changes in anteroposterior position of molars, incisors and lip position relative to PMV (in mm).

this was not significant. The mean increase proved to be significant in group E_5, but not in group NE. At the end of treatment, no significant differences between the groups were found at the 0.05 level.

The PAR Index (Table 5). The pre- and post-treatment mean scores were higher in the first premolar extraction group. Within the three types of cases, the lowest reduction in PAR score was 73.1 per cent for a case in the E_4 group. The mean percentage changes were higher than 90 per cent for the three types of treatment.

Discussion

Pretreatment evaluation

For a wide range of craniofacial characteristics, the three groups were very similar pretreatment. Some dental values showed significant pretreatment differences. The arch length discrepancy was nearly twice as large in the first premolar extraction group compared with the second premolar extraction group and the non-extraction group. The high mean value for crowding in the first premolar extraction group indicates that in our study, this factor could have played a major role in the extraction decision.

The second premolar extraction group had a more protrusive dentition than the non-extraction group. With crowding of 3–4 mm in this group, the degree of dental protrusion could have been decisive as to whether or not extractions were performed. This was also noted in a study by Paquette *et al.* (1992) who found that the decision for 33 extraction and 30 non-extraction subjects had been partly based on differences in dental protrusion.

Changes during treatment

Molar, incisor, and lip position relative to PMV. The extraction of a first premolar in each

Table 5 Pre- and post-treatment scores for the PAR Index and percentage of improvement.

	Mean			Range		
	E4	E5	NE	E4	E5	NE
Pretreatment	21.4	15.4	15.2	8–35	7–24	9–29
Post-treatment	1.7	0.7	0.5	0–7	0–3	0–2
Percentage change	92.1	95.5	96.7	73.1–100	78.6–100	77.8–100

quadrant produces approximately 14 mm space in each arch. As a mean arch length deficiency of 6–7 mm was found 7–8 mm remaining space had to be closed in each arch after alignment. For this purpose, intra-arch elastics in both arches combined with Class II inter-arch elastics were used. As treatment was performed without extra-oral force or intra-oral anchorage control, mainly a mesial movement of molars and second premolars, and a minor backward movement of the upper anterior teeth took place.

With the extraction of four second premolars and arch length discrepancy values of 3 mm, spaces of 10–11 mm will have to be closed in each arch after alignment. The larger spaces when compared with group E_4 were closed with similar mechanics. This resulted in comparable changes in the anterior teeth and a more extensive mesial movement of the molars. Williams and Hosila (1976) explained this as a difference in natural anchorage: the number of posterior teeth is higher in group E_4 (first molars + second premolars) than in group E_5 (first molars), while the opposite is present in the anterior region.

The position of the lip surfaces remained relatively unchanged in both extraction groups. The retroclination of the upper incisors was not followed by a significant change in the position of the lips. This is in agreement with the findings of Angelle (1973), but it cannot confirm the positive correlations found by Roos (1977).

In the non-extraction group the entire upper and lower dentition moved forwards. No extra-oral force was used and intra-arch elastics were not necessary. This allowed the incisors to tip forwards, while alignment took place. The lateral teeth followed this movement. The larger mesial movement in the lower arch can be attributed to a need for Class II elastics in some of the cases.

In the present study, a mean crowding of about 4 mm in each dental arch treated without extractions, was accompanied by almost the same amount of proclination of anterior teeth and protrusion of lip surfaces. This confirms the findings of Roos (1977) rather than those of Hershey (1972).

Taking into account the flexible and mobile nature of the lip texture, a rather large variability in lip position can be expected on cephalograms even when patients are instructed to keep their lips relaxed and teeth in occlusion (Hillesund *et al.*, 1978). The lip extension can easily adapt to incisor displacements and become wider or narrower, due to extensive mobility.

The incisor inclination. The extraction therapy produced a more retroclined dentition, mainly caused by the use of intra-arch elastics. For the non-extraction group a more proclined dentition was created, especially for the lower incisors. Unravelling without using extra-oral anchorage, and the use of some Class II elastics might have been responsible for this event. In both extraction groups, a backward tipping of the incisors and a distal movement of the incisal edges was accompanied by a mean increase of the inter-incisal angle of about 6 degrees, normalizing the inter-incisal angle. In the non-extraction group, the proclination of the incisors was more evident in the lower incisor region. This tipping was combined with a forward movement of the incisal edges and created a mean decrease of the inter-incisal angle of about 7 degrees compared with a post-treatment value of 125 degrees.

The position of upper and lower lips relative to the E-line (P–Pog′; Ricketts, 1968). Measurements of the lips relative to the line P–Pog′ focus attention on the relationship of nose, lips, and chin. In the three groups, the upper and lower lips were less protrusive after treatment. In both extraction groups the upper and lower lips moved back relative to the E-line. For the non-extraction group the backward change of the lip region was less pronounced. At the end of treatment, the mean values for the upper and lower lips were slightly more retrusive than Ricketts (1968) aesthetic ideal.

The facial convexity. The findings for the cranial convexity indicated that the maxilla became less prominent in relation to the frontal and mandibular area. The tendency to change toward a less convex morphology was more evident in both extraction groups when compared with the NE group. This evolution could be related to the combined result of growth and treatment. As the upper incisors were retroclined in both extraction groups, the alveolar process changed by remodelling in the same direction as the incisor movement, bringing point A more backward.

The changes in the soft tissue profile, excluding the nose were rather small. This was also noticed by Subtelny (1959),who saw little change between the ages of 6 and 18 years.

The results of the soft tissue convexity, including the nose, were in agreement with the study of Subtelny (1959) who found an increased convexity. The nasal forward growth strongly exceeds the forward growth of the other soft tissue structures in the facial profile.

Nasolabial and labiomental angles. The ideal range for the nasolabial angle is defined as being between 90 and 120 degrees. In a study by De Smit and Dermaut (1984), the mean nasolabial angle for a mixed study group was found to be 110 degrees. The mean values of the nasolabial angle in the present study started at a relatively high level, which increased with active treatment. The nasolabial angle was increased in both extraction groups (3.2 degrees); the less pronounced mean increase in the NE group was not significant. These findings were in agreement with the results of Finnöy *et al.* (1987), who found that their extraction group displayed a significantly greater increase of the nasolabial angle (6.5 degrees) than the non-extraction group (2.9 degrees).

The depth of the plica labiomentalis plays an important role in the aesthetic evaluation of the facial profile. In a study concerning the soft tissue profile preference, De Smit and Dermaut (1984) reported that a flattening of the mental fold led to a more drastic loss of aesthetic preference than a deepening. Considering the large standard deviations, the changes during treatment found in the present study are of limited clinical importance.

The PAR Index. The selection of the cases allowed only minor sagittal discrepancies. This was the main cause of the rather low pretreatment PAR scores. The highest individual and mean index at start was found in the first premolar extraction group. The lower mean values in the two other groups could be linked to the lower level of crowding.

Although some higher post-treatment values were found in the E_4 group compared with the other groups, almost all the scores were less than 5. This means that the treatment outcome could be considered as almost ideal (Richmond and Andrews, 1993).

Due to the start scores, the high percentage reduction classifies the presented clinical cases as judged by the PAR normogram as 'improved'.

Conclusion

As most pretreatment craniofacial characteristics of the groups were similar, lip protrusion or other soft tissue factors can not have been important in the extraction decision. On the other hand, the higher crowding in the group treated with extraction of the four first premolars has probably been decisive for this specific extraction choice. The patient group where the decision was made to extract four second premolars showed a smaller degree of crowding, but typically had a more protrusive pretreatment dentition than the other groups. No extractions were performed in patients with moderate crowding and no protrusive dental positions.

In all cases, the orthodontic treatment moved the molars mesially. The lower incisors remained in about the same position in the extraction groups, but they proclined in the non-extraction group. The upper incisors were retroclined approximately 2 mm in the extraction groups. This was not reflected in a significant change in lip position. A change in lip protrusion was found in the non-extraction group, where tooth alignment was accompanied by proclination. By this movement, the incisors were tipped further forwards than standard cephalometric normative values. The retroclination into the extraction groups brought the lower incisors in a nearly ideal position, while the upper incisors retroclined.

When the lip position is evaluated within the frame of the growing nose and chin, the lips drop a little backwards as nose and chin grow forward to a more important extent than the lip regions. This relatively backward evolution of the lips remains within conventional aesthetic prescriptions. The forward lip movement in the non-extraction group proved to be less important than the effect of nose and chin growth, as even in this group, the lip regions moved backwards in respect to the nose-chin line.

The general trends in facial convexity were confirmed: more forward growth in the mandible when compared with the upper jaw leads to a straighter cranial profile; the facial profile becomes more convex as the nose tip grows forward to a much greater extent than the forehead and chin region.

Within the appropriate indications, extraction of first or second premolars, or non-extraction therapy with light-wire appliances and no extra-oral anchorage, leads to good occlusal results without unfavourable changes in the facial profile.

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