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# Comparison of the Changes in Facial Profile After Orthodontic Treatment, With and Without Extractions

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**Abstract.** *A study was made of 31 patients with Angle Class II malocclusion. Fifteen patients did not undergo extraction of teeth (Group A), while 16 underwent extractions of four premolars (Group B). Data was obtained from the corresponding lateral radiographs of the head taken both before and after orthodontic treatment. The main aim of the study was to compare the response of the soft and hard tissues of the facial profile in Class II malocclusion treated with the extraction of four premolars and the response of borderline cases presenting with similar malocclusions, but not subjected to extraction. In this latter group reasonable doubt existed as to whether or not to remove teeth in order to solve the occlusal and aesthetic problems.*

*It is concluded that significant hard tissue differences between the groups at the end of treatment were limited to a more retruded position of the incisors and a reduced overbite amongst those patients subjected to extraction. The main soft tissue differences between the groups at the end of treatment were a more retruded lower lip and a more pronounced lower labial sulcus in those patients subjected to extraction.*

*Index words*: Extraction, Facial Profile, Non-extraction, Orthodontic Treatment

Refereed Paper

## Introduction

The effects of orthodontic treatment on facial profile, with or without the extraction of teeth, has greatly concerned orthodontists (Bloom, 1961; Birch and Huggins, 1963; Rudee, 1964; Hershey, 1972; Anderson *et al.*, 1973; Garner, 19074; Wisth, 1974; Huggings and McBride, 1975; Roos, 1977; Jacobs, 1978; Stromboni, 1979; Lo and Hunter, 1982; Rains and Nanda, 1982; Waldman, 1982; Oliver, 1982; Remmer *et al.*, 1985; Looi and Mills, 1986; Park and Burstone, 1986; Denis and Speidel, 1987; Finnoy *et al.*, 1987; Talass *et al.*, Drobocky and Smith, 1989; Battagel, 1990; Yogosawa, 1990). Recently, Young and Smith (1993), and Luppanapornlarp and Johnston (1993) compared the general effects on the facial profile of orthodontic treatment either with or without extractions, and their results indicated that it is simplistic and incorrect to blame undesirable facial aesthetics after orthodontic treatment, exclusively on the extraction of premolars. Proffit (1994), analysing data from the orthodontic clinic at the University of North Carolina, indicates that changes in extraction frequencies over the past 40 years are almost entirely due to an increase and then a decrease in the extraction of four first premolars. The initial increase in first premolar extractions (from 1953 to 1963), occurred primarily in a search for greater long-term stability; the more recent decline (from 1983 to 1993), seems to be due to a number of factors including greater concern about the impact of extraction on facial aesthetics, data to suggest that extraction does not guarantee stability, concern about temporomandibular dysfunction, and changes in technique. Proffit also states that 'in borderline cases, nonextraction treatment is more efficient, a further incentive to treat in that way if feasible'.

In an earlier paper Bravo (1994) stressed the importance of securing favourable change in the soft tissues of the face after orthodontic treatment and analysed the consequences of extracting four premolars. In the present study the results obtained in that investigation are compared with those from the adoption of the opposite approach (i.e. orthodontic treatment *without* extraction).

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The main aim of this current study is to compare the profile response of the hard and soft tissues of the face in Class II malocclusions treated by means of extraction of four premolars, (where no doubt existed about such a procedure), with the response of more borderline cases which presented with a similar malocclusion but treated without extractions. In the latter group reasonable doubt existed as to whether or not to remove teeth, to solve the occlusal and facial profile aesthetic problems.

## Materials and Methods

### *Patients*

A study was made of 31 patients presenting with Angle Class II malocclusion with an average overjet greater than 5·5 mm (minimum and maximum values for the non-extraction groups were 1·5 and 8·6 mm; minimum and maximum values for the extraction group were 2·5 and 10·9 mm). None of the patients presented with severe craniofacial anomalies and all were to be treated with Edgewise appliances.

No extraction of teeth was undertaken in 15 patients (Group A), whilst 16 underwent extractions of four premolars (Group B). The decision on whether to extract or not was based on an evaluation of the need for space to align the teeth; the cephalometric position of the incisors; the indications and possibilities of securing space in the upper jaw by distalizing the upper molars; and evaluation of the general consequences on the soft tissues of the facial profile of deciding to either extract teeth or leave them in place, according to the orthodontic skills of the authors to manage the position of the incisors in each case.

The age distribution of the patients before and after treatment was similar in both groups (Table 1). More detailed information on the initial morphological characteristics of both groups is provided in Table 2, with measurements taken from the analyses by Ricketts (1981) and Steiner (1953), and in Figs 1 and 2. Table 3D reflects a number of initial characteristics of the facial profile soft tissues in both groups of patients taken from the analyses of Ricketts (1981), Burstone (1967), and Holdaway (1983) also included are the labiomental and nasolabial angles.

As in the earlier study by Bravo (1994), only post-pubertal female patients were selected, to minimize the effects attributable to residual growth and exclude possible differences in response between sexes. However, as also pointed out before, this design poses the inconvenience of limiting the sample size.

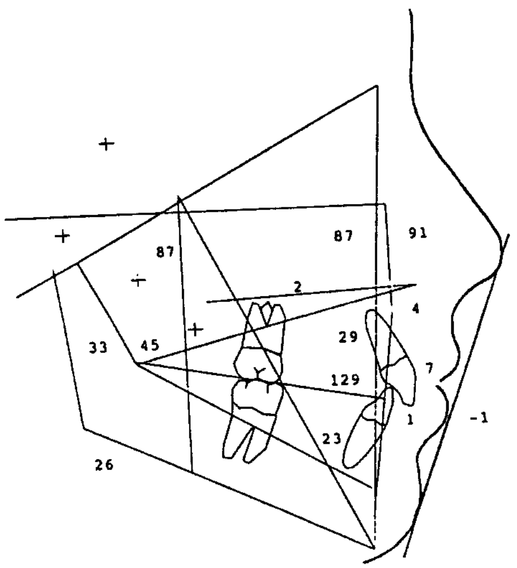


FIG. 1. Initial mean cephalometric tracing (Ricketts' analysis) in the group treated without extractions (*Group A*). The numbers correspond to the variables listed in Table 2, adjusted to 0·5 degree or mm. In all figures the values of incisor overjet, incisor overbite and facial taper in the Ricketts' analysis are not shown. In addition the distance Li–E line (−1 mm) is represented on this figure. The numbers are placed next to where the corresponding measurements are generated in this particular analysis.

## Cephalometric analysis

The data was obtained from lateral cephalometric radiographs taken both before and after orthodontic treatment, with the patient in a standing position, the teeth in occlusion and the lips relaxed. All radiographs were traced by the same person (L.A.B.) and digitized using a Gridmaster® (Numonics Corporation, Montgomeryville, PA, U.S.A.) digitizer linked to an SE/30 Mackintosh® (Apple Computer, Cupertino, CA, U.S.A.) computer using Quick-Ceph II® (Orthodontic Processing, Chula Vista, CA, U.S.A.) software. The magnification factor of the linear measurements was determined individually for each radiograph, and was corrected by the cephalometric software.

The cephalometric points, lines and measurements used in the present study to evaluate the changes in the soft tissues (facial profile) are described in Tables 3A, 3B and 3C, respectively. The rest of the cephalometric measurements pertaining to hard tissues (Table 2) have been extracted from the classical analyses by Ricketts and Steiner, as described above. The values of the variables were obtained by the Quick-Ceph II® program after digitizing the corresponding points. Statistical

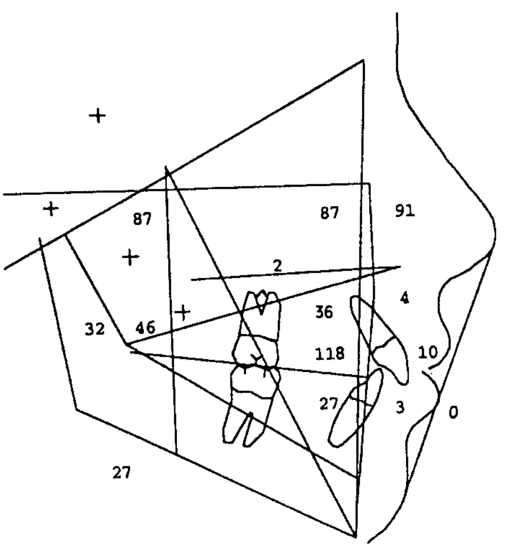


FIG. 2. Initial mean cephalometric tracing (Ricketts' analysis) in the group treated with extractions (*Group B*). The numbers correspond to the variables listed in Table 2, adjusted to 0·5 degree or mm.

analysis was performed using the StatView II® (Abacus Concepts, Berkeley, CA, U.S.A.) program. In the present study non-parametric statistical tests were used: the Wilcoxon *t*-test (analogous to the *t*-test for paired data, to determine the significance of the changes recorded in a given group following the corresponding treatment); and the Mann–Whitney *U*-test (analogous to the *t*-test for non-paired data, to determine differences between the two groups either before or after treatment).

The error of the method is comparable to that referred to by other authors in studies of this type (Looi and Mills, 1986; Battagel, 1990; Bravo, 1994). Prior to the gathering and processing of our measurements, two determinations of method error were made. In order to evaluate error due to the digitization, the same person digitized all the points used on 25 randomly-chosen headfilms, on two separate occasions. Error caused by trace processing was likewise evaluated by tracing 25 headfilms followed by digitization, again performed by the same individual on two separate occasions. For no variable in either study were statistically significant differences encountered between the values obtained on both occasions (paired Student *t*-test, $P > 0.05$). The correlation analyses performed in the two studies of methodological error revealed coefficients consistently above 0·9 for the double measurements made. The magnitude of error in both studies for each cephalometric variable was always under 1·0 mm in the case of the linear measurements and always under 1·0 degrees for the angular measurements.

## Results

### *Pretreatment comparisons*

The patient's age was similar in both groups in that no statistically significant differences were observed between them (Table 1). Nevertheless, the mean age at the start of treatment was slightly less in the patients treated without extractions (Group A) (12·9 ± 0·7 years) than in those treated with extractions (Group B) (13·5 ± 1·8 years). The mean duration of treatment was also very similar in both groups (2·6 ± 0·8 versus 2·7 ± 0·3 years, respectively).

As to the cephalometric characteristics of the hard tissues of the face, Table 2 shows that the main differences between the two groups before treatment were mostly at a dental level. Thus, according to the Ricketts analysis, the incisors of both arches were more protruded in Group B, though only the upper incisors exhibited a significantly greater inclination than in Group A. The lower incisors showed a small (although non-significant) tendency towards greater inclination. In addition, Group B presented with a significantly smaller interincisor angle than Group A. However, no significant differences were observed between the two groups with regard to either the initial overjet and overbite values or the parameters indicative of the craniofacial relationships and facial pattern.

Steiner's analysis confirmed the absence of significant differences in the craniofacial relationships (SNA, SNB, and ANB), and only encountered significant differences in the greater inclination and protrusion of the upper incisors in Group B; on the contrary, only a small tendency towards greater inclination and protrusion of the lower incisors appeared between the groups—with no statistically significant differences.

On the other hand, both groups presented very similar morphological characteristics with regard to the soft tissues of the facial profile, as reflected in Table 3D.

TABLE 1 *Patient age distribution (in years)*

| | Before treatment | | After treatment | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Without extractions (Group A) ($n = 15$) | 12·9 | 0·7 | 15·5 | 0·9 |
| With extractions (Group B) ($n = 16$) | 13·5 | 1·8 | 16·2 | 1·7 |
| Mann–Whitney *U*-test | | N.S. | | N.S. |

N.S.: statistically non-significant differences.

### *Post-treatment comparisons*

Without addressing the normality of the dental, skeletal, or aesthetic values in the two groups, it may be said that the significant intergroup hard tissue differences observed at the end of treatment were limited to a more retruded position of the incisors, only detectable by Ricketts' analysis, and to a reduced overbite in the patients treated with extractions (Table 4). No explanation for the latter observation can be found other than an overcorrection of the overbite in the group subjected to extraction. In addition, the main difference (at the end of treatment) between groups, in terms of the soft tissues of the lower third of the facial profile, is the more retruded lower lip and the more pronounced lower lip sulcus amongst the patients treated with extraction (Table 5). The graphic representation of the above is given in Figures 3 and 4, where the average cephalograms at the end of treatment are schematically presented for Groups A and B, respectively.

### *Changes observed after treatment*

Changes observed in the morphological characteristics of the hard tissues of patients treated with and without extractions following active treatment are shown in Table 6. Changes observed in the soft tissues of the facial profile of patients treated with and without extractions following active treatment are shown in Table 7.

## Discussion

The main purpose of the present study was to compare the effects of dental extraction on the facial profile soft and hard tissues between a sample of patients where extractions were considered necessary, and another similar sample, where reasonable doubt existed as to whether or not to perform extractions. In this latter group a more conservative treatment approach was adopted.

Careful selection of patients for the present study substantially reduced many of the variables, which may have

TABLE 2 *Comparison of morphological characteristics of the patients treated without extractions (Group A) (n = 15) and with extractions (Group B) (n = 16), prior to treatment*

| | Without extractions (Group A) | | With extractions (Group B) | | Mann–Whitney *U*-test |
|---|---|---|---|---|---|
| | mean | s.d. | mean | s.d. | |
| **Ricketts' analysis** | | | | | |
| Occlusal relationship | | | | | |
| Incisor overjet (mm) | 5·7 | 1·9 | 6·6 | 2·5 | N.S. |
| Incisor overbite (mm) | 3·8 | 1·5 | 3·1 | 1·9 | N.S. |
| Interincisor angle (°) | 128·5 | 14·8 | 117·5 | 10·0 | * |
| Max.–mandib. relationship | | | | | |
| Inferior facial height (°) | 44·9 | 2·9 | 46·2 | 3·1 | N.S. |
| Facial convexity (mm) | 3·8 | 1·8 | 3·8 | 2·8 | N.S. |
| Dentoskeletal relationship | | | | | |
| Mandibular incisor position (mm) | 1·1 | 2·8 | 3·0 | 1·4 | * |
| Maxillary incisor position (mm) | 6·5 | 3·4 | 9·6 | 2·5 | * |
| Mandibular incisor inclination (°) | 23·1 | 8·2 | 26·5 | 4·6 | N.S. |
| Maxillary incisor inclination (°) | 28·5 | 8·3 | 36·0 | 7·4 | * |
| Craniofacial relationship | | | | | |
| Facial depth (°) | 87·2 | 2·6 | 87·3 | 2·9 | N.S. |
| Facial axis (°) | 87·1 | 3·1 | 86·7 | 3·8 | N.S. |
| Facial taper (°) | 67·3 | 3·5 | 66·2 | 4·2 | N.S. |
| Mandibular plane (°) | 25·5 | 3·8 | 26·5 | 2·5 | N.S. |
| Palatal plane (°) | 2·4 | 2·8 | 2·1 | 3·6 | N.S. |
| Maxillary depth (°) | 91·0 | 2·7 | 90·8 | 4·3 | N.S. |
| Mandibular structure | | | | | |
| Mandibular arc (°) | 33·0 | 5·6 | 31·7 | 3·7 | N.S. |
| **Steiner's analysis** | | | | | |
| Dentoskeletal relationship | | | | | |
| Lower incisor–NB (mm) | 5·8 | 2·6 | 7·5 | 2·2 | N.S. |
| Upper incisor–NA (mm) | 4·2 | 3·3 | 7·7 | 3·2 | * |
| Lower incisor–NB (°) | 26·4 | 8·2 | 29·6 | 6·0 | N.S. |
| Upper incisor–NA (°) | 20·3 | 8·0 | 28·5 | 8·0 | * |
| Cranofacial relationship | | | | | |
| SNA (°) | 80·9 | 3·8 | 81·0 | 4·2 | N.S. |
| SNB (°) | 76·0 | 3·5 | 76·5 | 2·9 | N.S. |
| ANB (°) | 4·8 | 1·6 | 4·4 | 2·3 | N.S. |

* $P \leqslant 0.05$; N.S.: statistically non-significant differences.

adversely affected the results of earlier studies. Unfortunately, this careful selection also reduced the size of the sample which for female patients was limited to those who already had experienced their first menstruation. This was done in an attempt to reduce the effects of the remaining growth both during and after treatment, and also the possible differences between sexes. Subtelny (1959), and Vig and Cohen (1979) have reported that changes take place in the soft tissue profile with normal growth during early adolescence, nevertheless at the time of the onset of menstruation the growth spurt is considered all but complete (Proffit, 1993). In our study a relaxed lip position at the time cephalograms were taken, reduced variability in lip posture and increased the reproducibility of soft tissue measurements (Burstone, 1967).

One of the major objections that could be posed to the conclusions drawn from such a reduced sample as the one presented here, is the *lack of power* of the statistical tests, when these tests are applied to small size samples. This is so because the results observed are highly influenced by chance, and therefore a difference to be considered statistically significant must be large. Therefore, only large differences can be reliably detected when studying small samples, and small differences, can be overlooked. Those variables of which the values compared between groups do not appear statistically significant, but are considered of clinical interest, will only be used to report tendencies, however, they should be interpreted with caution.

### *Hard tissues*

Only at the dental level were a number of differences observed between the two groups before treatment, including a significantly reduced interincisor angle in Group B. This situation, with differences at the dental level that are not clearly manifest in the soft tissues of the facial profile, agree with the observations of Burstone (1958), who pointed out that lip profile is only partly determined by the characteristics of the underlying hard tissues. Nevertheless, most authors also admit that changes in the position of the incisors—particularly retraction—contribute to changing lip contour (Garner, 1974; Wisth, 1974; Huggins and McBride, 1975; Forsberg and Odenrick, 1981; Oliver, 1982; Holdaway, 1984).

No important changes in the skeletal characteristics of the face were observed as a function of the treatment

TABLE 3 (A) *Definition of the cephalometric points studied in the soft tissue profile of the face*

| | |
|---|---|
| 1–Nt: | *Nose tip:* the most anterior point on the sagittal contour of the nose |
| 2–Sn: | *Subnasale:* point located at the junction of the columella and the upper lip |
| 3–Ss: | *Sulcus superior:* point of greatest concavity located between *labrale superior* and *subnasale* |
| 4–Ls: | *Labrale superior:* the most anterior point on the convexity of the upper lip |
| 5–Li: | *Labrale inferior:* the most anterior point on the convexity of the lower lip |
| 6–Si: | *Sulcus inferior:* point of greatest concavity located between *labrale inferior* and *soft-tissue pogonion* |
| 7–Pg′: | *Soft-tissue pogonion:* the most anterior point on the soft-tissue chin |

TABLE 3 (B) *Description of the reference lines used in the study of the soft tissue profile of the face*

*E-line:* aesthetic line proposed by Ricketts, extending between Nt and Pg
*Subnasale–pogonin plane:* line proposed by Burstone to measure labial protrusion, extending between Sn and Pg′
*Line tangent to labrale superior and perpendicular to Frankfort Horizontal (FH):* line proposed by Holdaway to quantify the depth of sulcus superior
*H-line:* harmony line proposed by Holdaway, tangential to Pg′ and Ls

TABLE 3 (C) *Description of the measurements used to study the soft tissue profile of the face*

*Ss to E-line:* distance (mm) from sulcus superior to the Ricketts' aesthetic line
*Ls to E-line:* distance (mm) from labrale superior to the Ricketts; aesthetic line
*Li to E-line:* distance (mm) from labrale inferior to the Ricketts' aesthetic line
*Si to E-line:* distance (mm) from sulcus inferior to the Ricketts' aesthetic line
*Labiomental angle (°):* formed by the intersection of a line traced between Li and Si, and a line traced between Si and Pg′
*Nasiolabial angle (°):* formed by the intersection of a line originating in Sn, tangent to the lower margin of the nose, and a line traced between Sn and Ls
*Ls to Sn–Pg′:* distance (mm) from labrale superior to the Burstone's aesthetic plane
*Li to Sn–Pg′:* distance (mm) from labrale inferior to the Burstone's aesthetic plane
*Sulcus superior depth:* distance (mm) from Ss to a line tangent to Ls and perpendicular to FH
*Ss to H-line:* distance (mm) from sulcus superior to the Holdaway's harmony line
*Li to H-line:* distance (mm) from labrale inferior to the Holdaway's harmony line
*Si to H-line:* distance (mm) from sulcus inferior to the Holdaway's harmony line

TABLE 3 (D) *Comparison of morphological characteristics of the soft tissues facial profile in patients to be treated without extractions (Group A) (*n = *15) and with extractions (Group B) (*n = *16), prior to treatment*

| | Without extractions (Group A) | | With extractions (Group B) | | Mann–Whitney U-test |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | |
| Ss–E line (mm) | −8·3 | 1·5 | −8·6 | 1·3 | N.S. |
| Ls–E line (mm) | −2·3 | 2·9 | −1·7 | 2·2 | N.S. |
| Li–E line (mm) | −0·7 | 3·5 | −0·3 | 2·9 | N.S. |
| Si–E line (mm) | −5·2 | 1·9 | −5·5 | 1·8 | N.S. |
| Labiomental angle (°) | 141·3 | 13·5 | 137·9 | 9·8 | N.S. |
| Nasolabial angle (°) | 115·7 | 8·5 | 113·3 | 6·2 | N.S. |
| Ls–Sn–Pg′ line (mm) | 3·8 | 2·2 | 4·8 | 1·7 | N.S. |
| Li–Sn–Pg′ line (mm) | 3·7 | 2·9 | 4·3 | 2·5 | N.S. |
| Ss depth (mm) | 2·5 | 1·5 | 2·9 | 1·5 | N.S. |
| Ss–H line (mm) | 5·5 | 2·2 | 6·5 | 2·2 | N.S. |
| Li–H line (mm) | 1·1 | 2·1 | 1·0 | 1·8 | N.S. |
| Si–H line (mm) | 4·1 | 1·5 | 4·8 | 1·5 | N.S. |

N.S.: statistically non-significant differences.

applied. However, in both groups, facial convexity decreased to more adequate levels—an aim of orthodontic treatment in patients presenting with Angle Class II malocclusions and a marked overjet.

Based on the data obtained from Ricketts' analysis, this decrease in convexity in Group A may be regarded as more of a consequence of increased facial depth resulting from the anterior expression of residual growth of the lower jaw in the slightly younger group, than of decreased maxillary depth. However, the patients treated without extractions also showed a tendency towards a diminished maxillary depth, possibly associated with the slight depression of point A implied in the palatal radicular displacement and secondary to the increased upper incisor inclination observed in this group. On the other hand, the decreased convexity seen in Group B was fundamentally attributable to the decrease in maxillary depth, very likely as a result of the retraction of point A due to the marked maxillary incisor retrusion. Moreover, the tendency towards increased facial depth in this group was much less pronounced in absolute terms than the tendency towards diminished maxillary depth in those patients treated without extractions (Group A). Nevertheless, according to Steiner's analysis, the decrease in the ANB angle was due mainly to a diminished SNA angle in both patient series.

TABLE 4 *Comparison of morphological characteristics of the patients treated without extractions (Group A) (*n *= 15) and with extractions (Group B) (*n *= 16), following treatment*

| | Without extractions (Group A) | | With extractions (Group B) | | Mann–Whitney *U*-test |
|---|---|---|---|---|---|
| | mean | s.d. | mean | s.d. | |
| **Ricketts' analysis** | | | | | |
| Occlusal relationship | | | | | |
| Incisor overjet (mm) | 3·8 | 1·0 | 3·3 | 0·9 | N.S. |
| Incisor overbite (mm) | 2·9 | 1·3 | 1·4 | 1·0 | * |
| Interincisor angle (°) | 123·6 | 6·6 | 123·9 | 9·2 | N.S. |
| Max.–mandib. relationship | | | | | |
| Inferior facial height (°) | 45·2 | 2·8 | 44·7 | 4·2 | N.S. |
| Facial convexity (mm) | 2·6 | 1·9 | 1·9 | 2·3 | N.S. |
| Dentoskeletal relationship | | | | | |
| Mandibular incisor position (mm) | 2·4 | 1·7 | 0·8 | 1·4 | * |
| Maxillary incisor position (mm) | 6·1 | 1·7 | 4·0 | 1·5 | ** |
| Mandibular incisor inclination (°) | 26·2 | 5·3 | 27·8 | 5·3 | N.S. |
| Maxillary incisor inclination (°) | 30·3 | 5·2 | 28·3 | 6·6 | N.S. |
| Craniofacial relationship | | | | | |
| Facial depth (°) | 88·1 | 2·3 | 87·5 | 3·1 | N.S. |
| Facial axis (°) | 87·4 | 4·0 | 87·2 | 4·5 | N.S. |
| Facial taper (°) | 66·8 | 3·5 | 66·5 | 4·3 | N.S. |
| Mandibular plane (°) | 25·1 | 3·5 | 25·9 | 3·2 | N.S. |
| Palatal plane (°) | 1·6 | 3·2 | 1·1 | 3·5 | N.S. |
| Maxillary depth (°) | 90·5 | 2·8 | 89·3 | 3·9 | N.S. |
| Mandibular structure | | | | | |
| Mandibular arc (°) | 33·6 | 4·3 | 32·7 | 4·1 | N.S. |
| **Steiner's analysis** | | | | | |
| Dentoskeletal relationship | | | | | |
| Lower incisor–NB (mm) | 6·7 | 1·4 | 5·3 | 1·8 | N.S. |
| Upper incisor–NA (mm) | 5·1 | 2·1 | 4·0 | 1·5 | N.S. |
| Lower incisor–NB (°) | 27·7 | 6·5 | 28·2 | 6·4 | N.S. |
| Upper incisor–NA (°) | 25·1 | 8·0 | 24·5 | 6·9 | N.S. |
| Cranofacial relationship | | | | | |
| SNA (°) | 80·0 | 3·9 | 79·7 | 3·9 | N.S. |
| SNB (°) | 76·4 | 3·7 | 76·3 | 3·5 | N.S. |
| ANB (°) | 3·6 | 1·5 | 3·4 | 1·7 | N.S. |

* $P \leqslant 0.05$; ** $P \leqslant 0.01$; N.S.: statistically non-significant differences.

TABLE 5 *Comparison of morphological characteristics of the soft tissues facial profile in patients treated without extractions (Group A) (*n *= 15) and with extractions (Group B) (*n *= 16), following treatment*

| | Without extractions (Group A) | | With extractions (Group B) | | Mann–Whitney U-test |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | |
| Ss–E line (mm) | −9·5 | 1·6 | −10·3 | 1·4 | N.S. |
| Ls–E line (mm) | −3·5 | 2·4 | −5·1 | 1·7 | N.S. |
| Li–E line (mm) | −1·6 | 2·5 | −4·1 | 2·3 | ** |
| Si–E line (mm) | −6·0 | 1·8 | −7·8 | 1·4 | ** |
| Labiomental angle (°) | 143·0 | 6·8 | 138·0 | 8·7 | N.S. |
| Nasolabial angle (°) | 112·0 | 10·5 | 116·9 | 7·0 | N.S. |
| Ls–Sn–Pg′ line (mm) | 3·5 | 2·1 | 2·4 | 1·7 | N.S. |
| Li–Sn–Pg′ line (mm) | 3·4 | 2·0 | 1·2 | 2·0 | ** |
| Ss depth (mm) | 2·7 | 1·7 | 2·0 | 1·3 | N.S. |
| Ss–H line (mm) | 5·3 | 2·1 | 4·1 | 1·6 | N.S. |
| Li–H line (mm) | 0·9 | 1·2 | −0·5 | 1·4 | ** |
| Si–H line (mm) | 4·5 | 1·3 | 5·6 | 1·1 | * |

* $P \leqslant 0.05$; ** $P \leqslant 0.01$; N.S.: statistically non-significant differences.

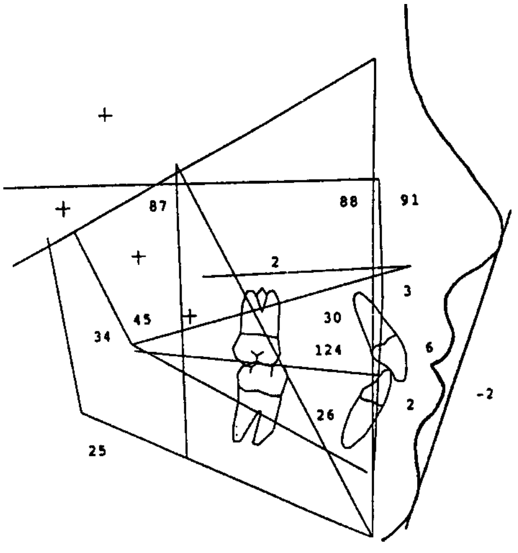


FIG. 3. Final mean cephalometric tracing (Ricketts' analysis) in the group treated without extractions (*Group A*). The numbers correspond to the variables listed in Table 4, adjusted to 0·5 degree or mm.

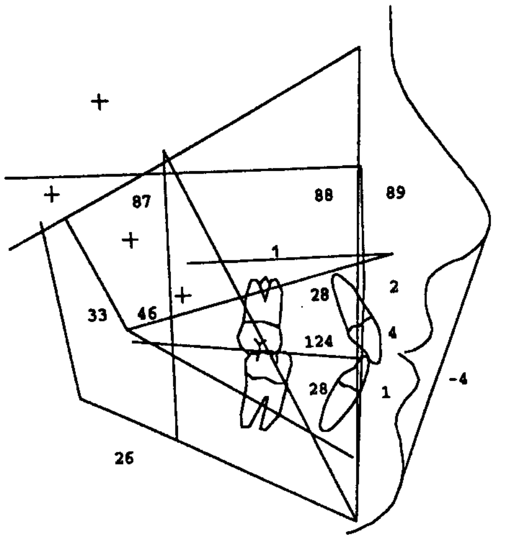


FIG. 4. Final mean cephalometric tracing (Ricketts' analysis) in the group treated with extractions (*Group B*). The numbers correspond to the variables listed in Table 4, adjusted to 0·5 degree or mm.

TABLE 6 *Changes observed in morphological characteristics of the patients treated without extractions (Group A) (*n = 15*) and with extractions (Group B) (*n = 16*), following active treatment*

| | Without extractions (Group A) | | | With extractions (Group B) | | | Mann–Whitney *U*-test |
|---|---|---|---|---|---|---|---|
| | mean | s.d. | Wilcoxon t-test | mean | s.d. | Wilcoxon t-test | |
| **Ricketts' analysis** | | | | | | | |
| Occlusal relationship | | | | | | | |
| Incisor overjet (mm) | −1·8 | 1·3 | * | −3·4 | 2·4 | * | * |
| Incisor overbite (mm) | −0·9 | 1·5 | * | −1·7 | 1·8 | * | N.S. |
| Interincisor angle (°) | −4·9 | 14·9 | N.S. | 6·4 | 6·8 | * | * |
| Max.–mandib. relationship | | | | | | | |
| Inferior facial height (°) | 0·3 | 1·4 | N.S. | −0·5 | 2·0 | N.S. | N.S. |
| Facial convexity (mm) | −1·3 | 1·1 | * | −1·8 | 1·7 | * | N.S. |
| Dentoskeletal relationship | | | | | | | |
| Mandibular incisor position (mm) | 1·3 | 1·9 | * | −2·3 | 1·1 | * | * |
| Maxillary incisor position (mm) | −0·4 | 2·5 | N.S. | −5·6 | 2·2 | * | * |
| Mandibular incisor inclination (°) | 3·1 | 7·5 | N.S. | 1·3 | 5·4 | N.S. | N.S. |
| Maxillary incisor inclination (°) | 1·8 | 8·1 | N.S. | −7·7 | 8·5 | * | * |
| Craniofacial relationship | | | | | | | |
| Facial depth (°) | 0·9 | 1·2 | * | 0·3 | 1·0 | N.S. | N.S. |
| Facial axis (°) | 0·3 | 2·4 | N.S. | 0·6 | 1·5 | N.S. | N.S. |
| Facial taper (°) | −0·5 | 1·1 | N.S. | 0·3 | 1·0 | N.S. | * |
| Mandibular plane (°) | −0·4 | 1·4 | N.S. | −0·6 | 1·7 | N.S. | N.S. |
| Palatal plane (°) | −0·9 | 1·6 | N.S. | −1·0 | 1·9 | N.S. | N.S. |
| Maxillary depth (°) | −0·6 | 1·2 | N.S. | −1·5 | 1·8 | * | * |
| Mandibular structure | | | | | | | |
| Mandibular arc (°) | 0·6 | 2·5 | N.S. | 1·0 | 3·0 | N.S. | N.S. |
| **Steiner's analysis** | | | | | | | |
| Dentoskeletal relationship | | | | | | | |
| Lower incisor–NB (mm) | 0·9 | 1·8 | N.S. | −2·3 | 1·7 | * | * |
| Upper incisor–NA (mm) | 0·9 | 2·8 | N.S. | −4·1 | 2·2 | * | * |
| Lower incisor–NB (°) | 1·3 | 6·9 | N.S. | −1·3 | 6·1 | * | N.S. |
| Upper incisor–NA (°) | 4·9 | 9·3 | N.S. | −4·0 | 8·7 | * | * |
| Cranofacial relationship | | | | | | | |
| SNA (°) | −0·9 | 1·1 | * | −1·2 | 1·6 | * | N.S. |
| SNB (°) | 0·4 | 0·9 | N.S. | −0·2 | 1·1 | N.S. | N.S. |
| ANB (°) | −1·3 | 1·1 | * | −1·0 | 1·4 | * | N.S. |

* $P \leqslant 0.05$; N.S.: statistically non-significant differences.

TABLE 7 *Changes observed in the soft tissue facial profile in patients treated without extractions (Group A) (n = 15) and with extractions (Group B) (n = 16), following active treatment*

| | Without extractions (Group A) | | | With extractions (Group B) | | | Mann–Whitney U-test |
|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Wilcoxon *t*-test | Mean | S.D. | Wilcoxon *t*-test | |
| Ss–E line (mm) | −1·3 | 1·4 | * | −1·6 | 1·0 | * | N.S. |
| Ls–E line (mm) | −1·2 | 1·7 | * | −3·4 | 1·4 | * | * |
| Li–E line (mm) | −1·0 | 1·7 | * | −3·8 | 1·9 | * | * |
| Si–E line (mm) | −0·8 | 0·8 | * | −2·3 | 1·4 | * | * |
| Labiomental angle (°) | 1·6 | 9·9 | N.S. | 0·1 | 6·7 | N.S. | N.S. |
| Nasolabial angle (°) | −3·6 | 7·0 | N.S. | 3·7 | 5·9 | * | * |
| Ls–Sn–Pg′ line (mm) | −0·3 | 1·4 | N.S. | −2·4 | 1·5 | * | * |
| Li–Sn–Pg′ line (mm) | −0·3 | 1·5 | N.S. | −3·1 | 1·9 | * | * |
| Ss depth (mm) | 0·3 | 1·2 | N.S. | −0·9 | 1·0 | * | * |
| Ss–H line (mm) | −0·2 | 1·4 | N.S. | −2·4 | 1·8 | * | * |
| Li–H line (mm) | −0·2 | 1·8 | N.S. | −1·4 | 1·3 | * | N.S. |
| Si–H line (mm) | 0·3 | 1·0 | N.S. | 0·8 | 1·2 | * | N.S. |

* $P \leqslant 0.05$; N.S.: statistically non-significant difference.

Thus, though both analyses are similar in the influence of a relatively more retruded position of point A with respect to the lower jaw, in order to improve the intermaxillary relationship in the group treated with extractions, these same analyses offer conflicting data as to the maxillary or mandibular origin of this correction in the patients treated without extractions (where mandibular growth undoubtedly played a greater role).

Following treatment more important differences regarding the dental changes in both patient groups can be observed. Thus, while according to Steiner's analysis, Group B presented a significantly more retruded position and a significant decrease in the inclination of the incisors in both jaws, in Group A the dentoskeletal relationships remained practically the same and only a tendency towards increased incisor protrusion and inclination was noted. The changes in the dentoskeletal relationship, as observed by Ricketts' analysis, were less consistent. Thus, the only variable of statistical significance found was a more anterior position of the mandibular incisors in Group A, clearly a result of the clinicians intention of solving the crowding problems of the lower arch. According to this analysis, such a change is clearly opposite to the type of displacement of the mandibular incisors seen in Group B. The latter group exhibited a significant retrusion of both incisors and a significant decrease in the inclination of the maxillary incisors, along with a tendency (not of statistical significance) to diminish the inclination of the mandibular incisors.

However, the significant retrusion of the incisors in both jaws as seen in Group B in comparison to Group A (confirmed by both analyses) agrees with the greater protrusion of these incisors in Group B prior to treatment. Likewise, the significant decrease in the inclination of the maxillary incisors in Group B versus Group A (also confirmed by both analyses) agrees with a significantly greater inclination of the maxillary incisors amongst these patients before the start of treatment. In both groups this led to very similar interincisal angles after treatment, though due to opposite mechanisms. Thus, in the patients with extraction there was a significant increase in interincisal angle, whilst in Group A this angle underwent a decrease, that failed to reach statistical significance, probably because of great individual variability amongst the patients treated without extraction.

In both groups, and regardless of the type of treatment involved, incisor overbite and overjet were significantly reduced, this being an important objective in the treatment of these malocclusions. However, the reduction in overjet in Group B was greater than in the other group. Although before treatment no significant intergroup differences were observed for this variable (Table 2), the overjet was initially greater in the patients subjected to extractions and thus required a greater correction.

## *Soft tissues*

On analysing the variables corresponding to the soft tissues of the face, treatment with extraction was found to produce more important changes in facial profile (on average) than amongst the patients belonging to Group A, despite the existence in both groups of marked individual variability (Table 5). These observations agree with those reported by Young and Smith (1993), and Luppanapornlarp and Johnston (1993).

The only significant change observed in the soft tissues of the facial profile in Group A was a retrusion with respect to the Ricketts E-line. However, a degree of retrusion is to be expected with increasing age, and unfortunately there are no well-established norms to characterize its normal behaviour. In the absence of such norms it is very difficult to distinguish between changes caused by growth and those which could be attributed to orthodontic treatment.

According to Ricketts, a distance of −3·0 ± 2·0 mm from the lower lip to the E-line should be considered normal in 15-year-olds. This value decreases 0·25 mm with every year of increasing age. On applying these considerations to our series, the initial mean value of

−0·7 mm at the age of 12·9 years (corresponding to slight protrusion of the lower lip) became −1·6 mm at the age of 15·5 years, thus reflecting a much more balanced lower lip aesthetic effect.

It should also be noted that this protrusion of the soft tissues of the facial profile with respect to the E-line is accompanied by a significantly more anterior position of the mandibular incisors with respect to the A-pogonion line, increasing from an average of 1·1 mm initially, to 2·4 mm at the end of treatment. As pointed out previously, the explanation for the proclination observed is almost certainly related to the need to lessen the lower crowding. Likewise, the reason why a change of this type coexists with a retrusion of the facial profile is due to the fact that the anteroposterior position of the lower incisors in distocclusions, such as those studied, exerts no major influence on the behaviour of the soft profile of the face. Figures 1 and 2 clearly show how the soft tissue profile is supported by the upper incisors. This originally was observed by Angle (1907), who considered the position of the upper incisors to be more important than that of the lower incisors in achieving a correct facial balance. In his own words, 'It is the upper teeth, not the lower, that establish the curve of the lower lip'.

In Group A no significant changes in the position of the upper incisors, with respect to the skeletal reference lines employed (i.e. A-pogonion and nasion-A), were observed; the improved aesthetics obtained in the facial profile of these patients after treatment, must be attributed to the increase in facial depth and to growth of the nose, which secondarily helped to improve the labial protrusion.

At the opposite extreme, and with the exception of the labiomental angle, the remaining variables corresponding to the soft tissues of the facial profile all underwent significant change after treatment with the extraction of four premolars. These changes in Group B reflect the diminished labial protrusion and profile flattening in accordance with the incisor retrusion observed in these patients, and to a lesser degree are secondary to residual growth of the lower jaw and nose. However, only 12% of those who completed treatment with extractions ultimately presented clearly flat soft tissues corresponding to the lower third of the facial profile, with a poorer aesthetic effect than before treatment (Bravo, 1994).

Clearly, the determination of those cases in which extractions should be made as opposed to those situations in which extractions are contraindicated, represents one of the most important requirements in planning the orthodontic treatment of patients (Baumrind, 1986). From the point of view of what is right or wrong in deciding upon therapy, it is easily seen that the appropriate approach is to extract teeth when extraction is correct, and to avoid doing so when extractions are not necessary. On the other hand, it would be wrong to extract when extraction is not necessary to achieve good occlusal, functional and aesthetic results, or to decide against extraction in cases where the latter is indeed indicated.

In order to make the best decision, it would be interesting to establish *a priori* the probability of requiring extractions in patients with concrete facial characteristics (type and degree of skeletal discrepancy; facial growth pattern and growth potential; dental crowding; the position of the incisors with respect to their bony bases; facial soft tissue position and morphology, etc.) Unfortunately, this is an area in which there is little general agreement. However, the suggestion is that a large proportion of patients (the so-called 'border line' situations, approximately 50 per cent) could be treated either way, to a satisfactory and stable, occlusal, functional and aesthetic outcome (Proffit, 1994). The amount of retraction of incisors would be only partially a function of the extraction/nonextraction decision. It would depend on the technique used and the skill of the orthodontist to produce the desired results in terms of incisor position. According to Luppanapornlarp and Johnston (1993), premolar extraction had a greater impact (by 2–3 mm) on the profile of their sample. Nevertheless, it should not be inferred that the extraction profiles were too 'flat' on recall (average interval of 15 years). Instead, it was the non-extraction patients who tended to have concave faces, whereas the extraction patients more often had what non-extraction advocates might call 'nice, full, pleasing profiles'.

Obviously, it is very important to correctly evaluate the consequences of a wrong decision, in other words, the damage caused by either unnecessary extraction or failure to extract where required. However, it seems clear that the consequences of the two types of mistaken decisions are different. Thus, while failure to extract where required may almost always be corrected later on, an early wrong decision to extract leaves little margin for later correction. Besides, Vig *et al.* (1990), using data from practitioners in Michigan, have shown that the average duration of a non-extraction treatment was 3–6 months less than for an extraction treatment. Considerations such as these advocate conservative tactics when planning treatment in cases of reasonable doubt over whether or not to extract teeth. In this way, the risk of making irreversible mistakes can be minimized and the efficacy of treatment enhanced.

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