# Effects of orthodontic treatment on the growth of individuals with Class II division 1 malocclusion

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The growth potential of individuals with Class II malocclusion is of interest to practicing orthodontists because this type of malocclusion constitutes a significant percentage of the cases they treat. Ast, et al.[1] examined 1,413 high school students from up-state New York, aged 15-18 years, and found that 23.8% had Class II malocclusion, while 69.9% had Class I malocclusion. This ratio, approximately 1:3, was similar to that reported by Goldstein and Stanton[2] for white American children and by Massler and Frankel for children aged 14 through 18 years.[3] However, in a group of American blacks evaluated by Altemus[4] the ratio of Class II to Class I malocclusions was about 1 to 6.

The determination of any dysplasia is usually attempted by comparing the dentofacial characteristics of individuals with a certain class of malocclusion to a group with "normal" occlusion. It seems reasonable to assume that individuals with the same type of malocclusion would show similar cephalometric characteristics and would also vary from individuals with normal occlusion and from other types of malocclusions. But are these

**Abstract**

The purpose of this study was to determine the effects of orthodontic treatment on the growth potential and dentofacial characteristics of individuals with Class II, division 1 malocclusion over a 5-year period. The changes were compared to matched, untreated normal individuals. Lateral cephalograms were available on 91 treated Class II, division 1 cases. Of these, 44 individuals (21 males and 23 females) were treated with first premolar extractions and 47 (20 males and 27 females) were treated nonextraction. The Class II groups were compared to 35 normal individuals (20 males and 15 females) matched for age and sex.

Pretreatment, the Class II individuals had larger overjet, deeper overbite, larger ANB angle, more retrusive mandible and a convex soft tissue profile. In addition, the upper and lower lips in males, and the lower lip in females were significantly more protrusive in the subjects that were eventually treated with the extraction of four first premolars.

At the end of the 5-year observation period, there was an overall "normalization" of the skeletal relationships of the treated Class II subjects in both the extraction and the nonextraction groups when compared to normals. Treatment had a differential impact on the dental relationships as well as on lip prominence as a result of the extraction decision. At the end of the observation period, both males and females in the extraction group had more retrusive maxillary and mandibular incisors as well as more retrusive lips than the corresponding normals. In the nonextraction groups, there was a tendency for both the incisors and the lips to be relatively more protrusive.

**Key Words**

Class II, division 1 • Normals • Extraction • Nonextraction • Dentofacial • Cephalometric

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**Table 1**
**Average ages (in years) of the subjects evaluated at the different stages of observation**

| | Normals | | Extraction | | Nonextraction | |
|---|---|---|---|---|---|---|
| | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. |
| Males | N = 20 | | N = 21 | | N = 20 | |
| Initial observation | 12.0 | 0.0 | 11.5 | 1.6 | 12.1 | 1.5 |
| Final observation | 17.0 | 0.0 | 16.8 | 1.6 | 16.5 | 1.3 |
| Treatment time | — | — | 3.1 | 0.9 | 2.3 | 1.2 |
| Females | N = 15 | | N = 23 | | N = 27 | |
| Initial observation | 11.0 | 0.0 | 11.6 | 1.6 | 10.9 | 1.5 |
| Final observation | 16.0 | 0.0 | 16.8 | 1.7 | 15.3 | 1.2 |
| Treatment time | — | — | 2.9 | 0.9 | 2.3 | 1.1 |

$\bar{x}$ = Mean S.D. = Standard Deviation N = Sample size

assumptions correct?

Using Angle's classification as their criteria, several authors have attempted to describe the cephalometric characteristics of the Class II, division 1 malocclusion. Fisk[5] described six possible morphological variations in the dentofacial complex: (1) The maxilla and teeth are anteriorly situated in relationship to the cranium. (2) The maxillary teeth are anteriorly placed in the maxilla. (3) The mandible is of normal size, but is posteriorly positioned. (4) The mandible is underdeveloped. (5) The mandibular teeth are posteriorly placed on an adequate base. (6) Various combinations of the above factors.

In a number of cephalometric studies, the relationship of the maxilla to the cranial base showed no significant differences between the Class II division 1 and the normal groups while the mandible was significantly retrusive.[6-10]

Craig,[6] Blair[11] and Gilmore[12] found minor differences in the mean skeletal patterns of individuals with Class I and Class II, division 1 malocclusions and concluded that a high degree of variability can be seen within each class of malocclusion.

Maj, Luzi and Lucchese[13] found the total mandibular length in 96% of Class II subjects to be similar to that of normal subjects of corresponding age. They concluded that differences in the bony bases were not due to an abnormal development of any specific part, but rather an abnormal relationship of the parts. On the other hand, Rothstein[14] in a comprehensive study comparing Class II, division 1 subjects to normal subjects concluded that the mandible most often was within the range of normal but the maxillary apical base was protrusive.

Ricketts[9,15] observed that prior to treatment the condyle in Class II malocclusion is in a relatively forward position in the fossa. Following treatment the condyle moves back into a normal position.

In summary, a Class II malocclusion may or may not be accompanied by a skeletal discrepancy. Furthermore, describing the skeletal discrepancies that may accompany a Class II malocclusion as a "Skeletal Class II" malrelationship is of limited diagnostic value. Such a description does not specify whether the mandible is normal or retruded in relationship to the maxilla, or whether the maxilla is protruded or normal in relationship to the mandible.

**Comparisons of treated vs. untreated Class II patients**

In growing individuals, the success of treatment depends, in part, on the relative growth changes that occur between the maxilla and mandible.

Moore[16] observed the changes in 46 treated Class II patients, all of whom were initially retrognathic. He found that the relative position of the chin became more prognathic in 50% of the cases, with no change in 25% of the cases, and became more retrognathic in the remaining 25% of the cases.

West[17] evaluated subjects with Class II, division 1 malocclusion treated with maxillary extraoral traction supplemented with light intermaxillary elastics. A satisfactory correction of the occlusion

along with significant improvement in facial esthetics was achieved in 8 to 13 months. Most corrections resulted from a combination of a normal jaw growth patterns accompanied by changes in the maxillary alveolar process and the dentition.[17]

The purpose of this study was to determine the effects of orthodontic treatment on the growth potential and dentofacial characteristics of individuals with a Class II, 1 malocclusion over a 5-year period and compare these changes to those of a matched untreated normal group.

## Materials and methods

The material for this investigation was drawn from the Iowa Facial Growth Study and from the patient records in the Graduate Orthodontic clinic at the University of Iowa.

**Class II sample**: Case selection was based upon the following criteria: (1) All cases were originally diagnosed as having a Class II division 1 malocclusion. Most cases had a full Class II molar and canine relationship with 20% of the cases exhibiting an end-to-end relationship. (2) All cases received comprehensive orthodontic treatment with an edgewise appliance, extra oral forces and Class II mechanics. (3) Patient selection was limited to growing individuals. (4) None of the cases had congenital anomalies, significant facial asymmetries or congenitally missing teeth. (5) Pretreatment and at least 2 years posttreatment orthodontic records were available. The cephalograms were carefully examined to exclude those cases where the lips were not at rest. Using these criteria, only 44 subjects (21 males and 23 females) treated with four first premolar extractions and 47 subjects (20 males and 27 females) treated without extractions, were identified as suitable for inclusion in the present study.

**Normal sample**: Records on 35 normal subjects (20 males and 15 females) were available from the Iowa Longitudinal Facial Growth Study. The cephalograms for the normal individuals were matched for the ages of the initial and final records of the Class II cases. All subjects had clinically acceptable occlusion with no apparent facial disharmonies. They exhibited Class I molar and canine relationships with less than 3 mm of crowding and no gross asymmetries in the dental arches. All subjects were Caucasian; 97% were of northern European ancestry. None of the subjects had undergone orthodontic therapy.

The ages of the subjects in each subgroup are presented in Table 1.

Statistical comparisons of the differences in ages between the extraction, nonextraction, and normal groups for each sex indicated that there were no significant differences between the ages of the different groups.

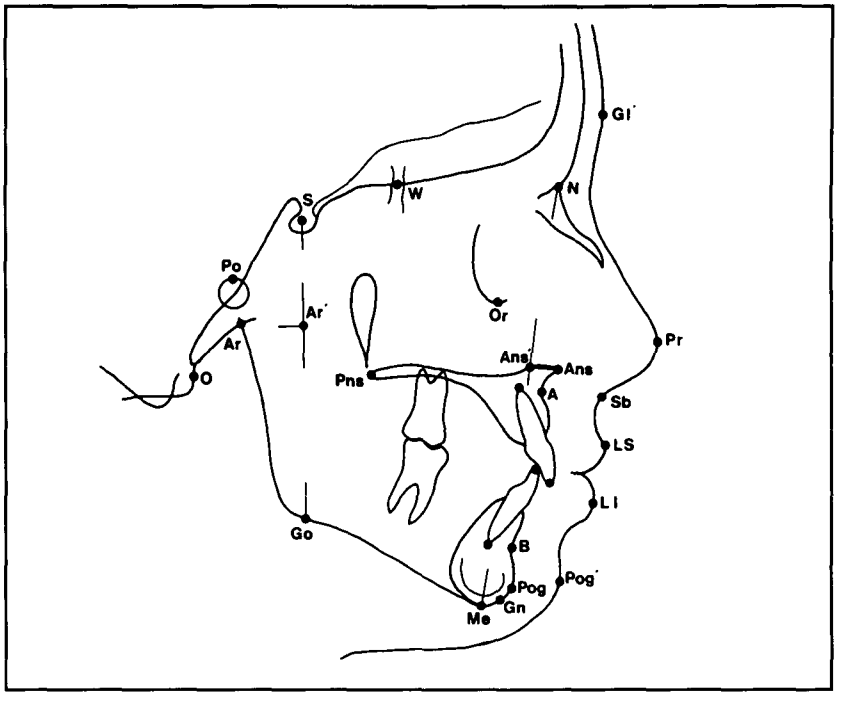


**Figure 1**

**Figure 1**
**Cephalometric landmarks identified on the lateral cephalograms.**

Twenty-one hard tissue and six soft tissue landmarks were identified on each cephalogram and are presented in Figure 1.

The identification of these landmarks was based upon the classic definitions found in the literature.[18-23]

From these landmarks various antero-posterior and vertical, linear and angular measurements were derived and are listed in the various tables.

All landmarks were identified by one investigator and checked for accuracy of location by a second investigator. The landmarks were measured twice at separate intervals by two investigators. Allowable inter- and intra-investigator errors were 0.5 mm and 0.5°.

The initial and final measurements as well as the changes between the two measurement were calculated for the extraction, nonextraction and normal groups and were compared using the analysis of variance. The significance level was predetermined at $p<.05$. Males and females were compared separately.

## Results

### Male-female comparisons:

The results of the analysis of variance indicated that in addition to overbite ($p = 0.003$), the linear measures of face height were significantly larger in males than in females: namely N-Me ($p = 0.001$), S-Go ($p = 0.0008$) and Ar'-Go (0.04). As a result, it

**Table 2**
**Descriptive statistics at the initial and final observations for the three male groups evaluated; normals (N = 20), Class II, 1 non-extraction (N = 20) and Class II, 1 extraction (N = 21)**

| Parameters | Normals | | | | Non-Extraction | | | | Extraction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | | Final | | Initial | | Final | | Initial | | Final | |
| | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. |
| Cranial Base | | | | | | | | | | | | |
| NSO | 130.5 | 5.0 | 130.4 | 5.1 | 128.0 | 4.1 | 127.7 | 4.7 | 127.2 | 4.9 | 126.4 | 5.0 |
| Antero-Posterior | | | | | | | | | | | | |
| SNA | 81.3 | 3.8 | 82.1 | 3.6 | 81.5 | 3.6 | 80.7 | 3.9 | 81.5 | 3.8 | 79.1 | 3.9 |
| SNB | 77.6 | 3.4 | 78.9 | 3.4 | 76.6 | 3.6 | 77.2 | 3.5 | 76.7 | 3.6 | 76.6 | 3.7 |
| ANB | 3.7 | 1.8 | 3.2 | 1.9 | 4.9 | 1.4 | 3.5 | 1.9 | 4.8 | 1.8 | 2.5 | 2.1 |
| NAPog | 6.9 | 4.3 | 5.2 | 5.3 | 8.7 | 2.8 | 4.3 | 4.6 | 8.2 | 5.1 | -0.3 | 6.1 |
| SNPog | 78.0 | 3.7 | 79.6 | 3.9 | 77.5 | 3.9 | 78.7 | 3.9 | 77.7 | 3.6 | 79.2 | 4.0 |
| FH:NPog | 83.0 | 3.7 | 83.7 | 3.9 | 84.0 | 4.3 | 84.3 | 3.8 | 84.0 | 3.7 | 84.3 | 3.8 |
| Vertical | | | | | | | | | | | | |
| MP:SN | 32.4 | 5.2 | 30.0 | 5.6 | 32.5 | 4.9 | 30.9 | 6.4 | 32.8 | 5.2 | 31.1 | 5.9 |
| MP:FH | 27.5 | 4.9 | 26.1 | 5.9 | 26.0 | 6.9 | 25.4 | 7.5 | 26.6 | 4.8 | 26.0 | 5.2 |
| NSGn | 67.8 | 3.2 | 67.3 | 3.5 | 67.1 | 3.1 | 67.7 | 3.4 | 66.4 | 4.1 | 66.9 | 4.1 |
| FH:SGn | 62.8 | 3.3 | 63.3 | 3.9 | 60.6 | 4.1 | 62.1 | 3.9 | 60.2 | 4.4 | 61.8 | 4.2 |
| N-Ans' mm | 48.0 | 2.5 | 52.6 | 2.9 | 47.3 | 2.6 | 51.4 | 3.6 | 45.7 | 2.5 | 51.4 | 2.8 |
| N-Me mm | 108.2 | 4.4 | 118.0 | 5.9 | 108.3 | 3.8 | 119.1 | 5.2 | 103.4 | 6.7 | 115.1 | 7.1 |
| S-Go mm | 74.2 | 4.9 | 84.0 | 5.6 | 74.1 | 4.0 | 84.5 | 6.3 | 70.2 | 4.5 | 81.0 | 5.9 |
| Ar'-Go mm | 48.0 | 3.8 | 55.4 | 5.2 | 45.0 | 4.3 | 52.0 | 6.0 | 41.9 | 3.7 | 49.1 | 4.5 |
| Pog-NB mm | 0.7 | 1.8 | 1.6 | 2.2 | 2.0 | 2.1 | 3.5 | 2.4 | 2.1 | 2.0 | 5.8 | 2.5 |
| Dental | | | | | | | | | | | | |
| Overbite mm | 3.6 | 1.3 | 3.5 | 1.3 | 5.2 | 2.2 | 2.9 | 1.4 | 5.5 | 1.8 | 3.4 | 1.3 |
| Overjet mm | 3.1 | 1.0 | 2.8 | 1.0 | 5.2 | 2.6 | 2.5 | 0.6 | 6.3 | 2.9 | 2.7 | 0.9 |
| U1:L1 | 128.0 | 6.7 | 131.9 | 9.6 | 126.4 | 9.4 | 125.7 | 9.1 | 128.8 | 8.4 | 135.5 | 9.6 |
| U1:SN | 102.2 | 4.9 | 101.6 | 6.6 | 104.1 | 9.1 | 102.1 | 7.5 | 105.9 | 6.4 | 100.8 | 7.2 |
| U1:A-Pog | 5.3 | 1.6 | 4.5 | 1.8 | 6.7 | 2.4 | 5.0 | 2.3 | 6.9 | 2.3 | 2.5 | 1.9 |
| L1:MP | 97.5 | 5.2 | 96.6 | 7.7 | 97.0 | 6.6 | 101.2 | 7.1 | 92.4 | 6.3 | 92.6 | 7.6 |
| L1:FH | 55.4 | 5.7 | 57.5 | 8.0 | 57.0 | 7.0 | 53.5 | 5.4 | 61.0 | 6.9 | 61.4 | 6.8 |
| L1:NB | 4.6 | 1.2 | 4.4 | 1.8 | 4.3 | 1.7 | 5.5 | 2.2 | 3.3 | 1.8 | 2.7 | 1.5 |
| Soft Tissue | | | | | | | | | | | | |
| Gl-Sb-Pog' | 16.8 | 0.4 | 16.8 | 0.5 | 15.1 | 6.1 | 15.3 | 5.6 | 16.1 | 4.7 | 13.5 | 5.9 |
| Ls-Pog':NB | 14.0 | 4.3 | 11.3 | 5.1 | 15.7 | 5.3 | 12.6 | 4.4 | 16.8 | 4.5 | 9.5 | 5.3 |
| Ls:Pr-Pog' mm | 1.0 | 1.9 | 2.6 | 2.7 | -1.3 | 1.9 | 1.1 | 2.2 | 1.0 | 1.7 | -3.6 | 2.3 |
| Li:Pr-Pog' mm | 0.5 | 1.7 | 2.1 | 1.9 | -1.9 | 2.7 | -0.3 | 2.9 | 1.5 | 2.4 | -3.4 | 2.2 |

$\bar{x}$ = Mean S.D. = Standard Deviation
U1 = Long axis of upper incisor L1 = Long axis of lower incisor

was decided to independently present the findings on males and females.

**Pretreatment comparisons between Class II, division 1 and normal subjects (Tables 2-4):**

**Males**: The descriptive statistics for the normal and Class II, division 1 extraction and non-extraction subjects are presented in Table 2. The analysis of variance indicated that there are a number of significant differences between the three groups evaluated (Table 4).

Compared to normal males, both Class II groups had a significantly larger ANB angle, overbite, overjet, protrusive maxillary incisors (U1:A-Pog), Holdaway soft tissue angle (Ls-Pog':NB), and protrusive upper and lower lips (Ls:Pr-Pog' and Li:Pr-Pog').

**Females:** The descriptive statistics on the normal, Class II, 1 extraction and nonextraction subjects are presented in Table 3.

Compared to normal females, both Class II

**Table 3**
**Descriptive statistics at the initial and final observations for the three female groups evaluated; normals (N = 15), Class II division 1 nonextraction (N = 27) and Class II, division 1 extraction (N = 23)**

| Parameters | Normals | | | | Non-Extraction | | | | Extraction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | | Final | | Initial | | Final | | Initial | | Final | |
| | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. |
| Cranial Base | | | | | | | | | | | | |
| NSO | 131.7 | 4.7 | 132.2 | 4.8 | 127.7 | 4.4 | 127.9 | 4.3 | 128.1 | 4.2 | 127.9 | 4.2 |
| Antero-Posterior | | | | | | | | | | | | |
| SNA | 80.3 | 3.8 | 80.4 | 3.7 | 81.5 | 3.4 | 81.1 | 3.2 | 82.4 | 4.6 | 80.8 | 4.5 |
| SNB | 76.5 | 3.1 | 77.4 | 3.3 | 77.3 | 3.4 | 78.2 | 3.4 | 77.4 | 3.8 | 77.1 | 3.8 |
| ANB | 3.7 | 1.9 | 3.1 | 2.1 | 4.2 | 1.9 | 3.0 | 1.9 | 5.0 | 2.5 | 3.6 | 2.2 |
| NAPog | 7.9 | 4.8 | 5.7 | 5.6 | 7.5 | 5.6 | 3.6 | 5.2 | 9.2 | 7.4 | 3.9 | 7.2 |
| SNPog | 76.4 | 3.1 | 77.6 | 3.2 | 78.1 | 3.5 | 79.4 | 3.6 | 76.4 | 8.9 | 79.0 | 3.9 |
| FH:NPog | 83.2 | 2.5 | 83.4 | 2.5 | 85.8 | 3.7 | 86.2 | 3.8 | 85.3 | 4.5 | 84.5 | 3.3 |
| Vertical | | | | | | | | | | | | |
| MP:SN | 34.5 | 3.9 | 33.5 | 4.4 | 32.7 | 6.0 | 31.6 | 6.6 | 33.5 | 7.6 | 32.5 | 8.6 |
| MP:FH | 27.9 | 4.8 | 27.7 | 5.1 | 25.0 | 5.8 | 24.8 | 6.9 | 26.3 | 7.4 | 26.9 | 7.9 |
| NSGn | 68.4 | 2.7 | 68.4 | 3.0 | 66.7 | 4.4 | 67.2 | 4.3 | 67.1 | 3.9 | 67.4 | 4.2 |
| FH:SGn | 61.7 | 2.9 | 62.6 | 3.0 | 59.0 | 4.6 | 60.5 | 4.4 | 59.9 | 4.5 | 61.8 | 4.0 |
| N-Ans'mm | 45.3 | 2.4 | 48.2 | 1.9 | 45.9 | 3.6 | 49.6 | 3.0 | 44.7 | 2.6 | 47.2 | 2.8 |
| N-Me mm | 102.0 | 5.5 | 109.4 | 4.5 | 103.5 | 7.0 | 111.8 | 7.0 | 101.8 | 5.6 | 108.1 | 5.8 |
| S-Go mm | 68.0 | 3.1 | 74.3 | 3.4 | 70.5 | 4.6 | 78.0 | 4.6 | 69.0 | 6.3 | 74.8 | 6.1 |
| Ar'-Go mm | 43.5 | 2.9 | 48.4 | 4.1 | 42.9 | 3.2 | 48.5 | 3.9 | 42.3 | 5.1 | 46.4 | 5.1 |
| Pog-NB mm | 0.1 | 1.4 | 0.7 | 1.6 | 1.5 | 2.0 | 2.6 | 2.0 | 1.4 | 2.4 | 3.7 | 3.2 |
| Dental | | | | | | | | | | | | |
| Overbite mm | 3.2 | 1.5 | 3.0 | 1.6 | 3.9 | 2.1 | 2.9 | 1.2 | 4.2 | 1.7 | 3.4 | 0.8 |
| Overjet mm | 3.5 | 0.7 | 3.2 | 0.8 | 5.4 | 2.1 | 2.7 | 0.8 | 5.4 | 2.1 | 2.6 | 0.9 |
| U1:L1 | 127.6 | 7.3 | 129.5 | 9.2 | 126.6 | 8.3 | 128.9 | 6.9 | 122.3 | 9.3 | 135.3 | 9.4 |
| U1:SN | 101.8 | 4.3 | 102.1 | 5.6 | 105.7 | 4.7 | 102.7 | 6.1 | 107.8 | 7.1 | 98.4 | 5.7 |
| U1:A-Pog | 5.7 | 1.5 | 5.7 | 1.7 | 6.8 | 2.2 | 5.1 | 1.7 | 7.4 | 2.5 | 3.1 | 1.9 |
| L1:MP | 96.2 | 5.1 | 94.9 | 5.8 | 95.0 | 6.3 | 96.8 | 6.6 | 96.4 | 7.4 | 93.9 | 7.2 |
| L1:FH | 56.1 | 5.5 | 57.7 | 6.3 | 60.0 | 7.0 | 58.4 | 6.0 | 57.3 | 7.4 | 59.3 | 8.5 |
| L1:NB | 4.3 | 1.5 | 4.5 | 2.0 | 4.0 | 1.6 | 4.7 | 1.4 | 4.7 | 2.3 | 3.4 | 2.0 |
| Soft Tissue | | | | | | | | | | | | |
| Gl-Sb-Pog' | 16.7 | 0.4 | 17.0 | 0.6 | 13.3 | 6.0 | 11.2 | 6.5 | 15.8 | 4.9 | 12.4 | 6.6 |
| Ls-Pog':NB | 12.9 | 4.8 | 10.1 | 5.9 | 14.1 | 4.4 | 10.0 | 4.5 | 16.6 | 5.0 | 9.4 | 5.6 |
| Ls:Pr-Pog' mm | 2.0 | 1.9 | 4.2 | 2.1 | 0.0 | 2.0 | 2.1 | 2.3 | 0.3 | 2.2 | -3.8 | 2.6 |
| Li:Pr-Pog' mm | 0.3 | 2.2 | 1.8 | 2.3 | -1.1 | 2.2 | 0.3 | 2.5 | 1.1 | 2.9 | -2.8 | 3.1 |

$\bar{x}$ = Mean S.D. = Standard Deviation
U1 = Long axis of upper incisor L1 = Long axis of lower incisor

groups had significantly more protrusive maxillary incisors (U1:SN), larger overjet and Holdaway soft tissue angle (Table 4).

**Comparisons of the changes in the Class II treated and normal subjects (Tables 5 and 6):**

The analysis of variance indicated the presence of significant differences in the dentofacial changes of the different groups compared.

**Male comparisons (Tables 5 and 6):**

Maxillary and mandibular parameters: The changes in the maxillary relationship indicated that in the normal group, the maxilla (SNA) continued to grow forward ( $\bar{x}$ =0.8 ) while in the Class II treated groups there was a reversal in the direction of growth. This trend was greater in the extraction group ( $\bar{x}$ = -2.4 ) than in the nonextraction group ( $\bar{x}$ = -0.8 ).

There was a significant reduction in ANB and

**Table 4**
**Results of analysis of variance indicating significant differences between normals (N), Class II, 1 extraction (E) and non-extraction (NE) cases, at initial observation.**

| Variable | P-Value | Differences |
|---|---|---|
| **Males** | | |
| Skeletal | | |
| ANB | .0465 | N < NE & E |
| Ar-Pog mm | .0001 | N > NE > E |
| N-Ans'mm | .0132 | E < N & NE |
| N-Me mm | .0036 | E < N & NE |
| S-go mm | .0073 | E < N & NE |
| Pog:NB mm | .0470 | N < E & NE |
| Dental | | |
| Overbite mm | .0018 | N < NE & E |
| Overjet mm | .0012 | N < NE & E |
| U1:APog mm | .0402 | N < E & NE |
| L1:MP | .0160 | E > N |
| L1:FH | .0233 | E > N |
| L1:NB | .0244 | E < N & NE |
| Soft Tissue | | |
| Ls-Pog':NB | .0007 | E > N & NE |
| Ls:Pr-Pog' mm | .0007 | NE < N & E |
| Li:Pr-Pog' mm | .0001 | NE < N & E |
| **Females** | | |
| Cranial Base | | |
| NSO | .0170 | NE > N & NE |
| Dental | | |
| Overjet mm | .0003 | N < E & NE |
| U1:SN | .0072 | N < E & NE |
| Soft Tissue | | |
| Ls:Pr-Pog' mm | .0104 | N > E & NE |
| Li:Pr-Pog' mm | .0116 | NE < E |

> = larger than  < = smaller than

NAPog in all three groups but the reduction was significantly greater in the Class II extraction group (ANB=-2.3, NAPog=-8.4) than in the corresponding Class II nonextraction (ANB=-1.4, NAPog=-4.4) and normal groups (ANB=-0.5 and NAPog=-1.8).

There were no significant differences in the magnitude of mandibular rotation (MP:SN and MP:FH) between the three groups during the 5-year observation period.

Dental Parameters: There was a significant decrease in the overjet and overbite in both Class II treated groups over the period of observation. The normal group expressed little or no change in these parameters.

There were significant differences in the changes in the incisor relationships between the three groups. The maxillary incisors (U1:SN) uprighted in the three groups, significantly more in the extraction group ($\bar{x}$ = -5.1) than in either the nonextraction ($\bar{x}$ = -2.0) or normal ($\bar{x}$ = -0.6) groups. The changes in the mandibular incisors (L1:MP, L1:FH, LI:NB) on the other hand, indicated that the incisors became more upright in the normal and Class II extraction groups, but moved significantly more labially in the Class II nonextraction group.

Soft tissue parameters: There were significant decreases in the angles of facial convexity (Gl-Sb-Pog', Ls-Pog':NB) in the Class II extraction group when compared to either the normal or nonextraction groups. Similarly there were greater reductions in upper and lower lip prominence (Ls:Pr-Pog', Li:Pr-Pog') in the extraction group.

**Female comparisons (Tables 5 and 6):**

In general, the changes that occurred in females during the 5-year observation period were similar to those described earlier for the three male groups.

**Dentofacial changes in Class II (Tables 2, 3 and 7)**

As a result of treatment, there was an overall "normalization" of the skeletal relationships in the treated Class II male and female individuals in both the extraction and the nonextraction groups, when compared to normals. On the other hand, the overall treatment plan had a differential impact on the dental relationships as well as on lip prominence as a result of the extraction decision. At the end of the observation period both males and females in the extraction group had more retrusive maxillary and mandibular incisors as well as more retrusive lips than the corresponding normals. In the nonextraction groups, there was a tendency for both the incisors and the lips to be relatively more protrusive.

## Discussion

In general, the success of treatment depends as much on the skill of the orthodontist as on a favorable pattern of facial growth. Lack of sufficient and/or favorable growth during treatment will make it difficult to correct the skeletal malrelationship or significantly improve the profile.

As was evident from the literature review,[5-15] individuals with Class II, division 1 malocclusions vary morphologically in their dentofacial relationships, respond differently to treatment and express their own unique individual growth patterns. These facts materially affect the treatment response, e.g. in one face the correction can be accomplished by tooth movement alone while in another it is more the result of changes in the skeletal relationship. In one patient favorable growth may assist these changes; in another unfavorable growth may even increase the difficulty of the correction.

**Table 5**
**Descriptive statistics on the total changes during the observation period in the three male and female groups.**

| Parameters | Normals | | | | Non-Extraction | | | | Extraction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males | | Females | | Males | | Females | | Males | | Females | |
| | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. |
| Cranial Base | | | | | | | | | | | | |
| NSO | -0.1 | 1.1 | 0.5 | 1.0 | -0.3 | 2.3 | 0.2 | 1.6 | -0.7 | 2.3 | -0.2 | 1.4 |
| Antero-Posterior | | | | | | | | | | | | |
| SNA | 0.8 | 0.9 | 0.1 | 1.0 | -0.8 | 1.5 | -0.4 | 1.8 | -2.4 | 1.7 | -1.6 | 1.4 |
| SNB | 1.3 | 1.0 | 0.8 | 0.8 | 0.6 | 1.8 | 0.9 | 1.9 | -0.1 | 1.6 | -0.2 | 1.2 |
| ANB | -0.5 | 0.7 | -0.7 | 0.9 | -1.4 | 1.5 | -1.3 | 1.7 | -2.3 | 1.6 | -1.4 | 1.4 |
| NAPog | -1.8 | 1.8 | -2.3 | 1.8 | -4.4 | 3.6 | -3.8 | 3.8 | -8.4 | 4.1 | -5.4 | 3.7 |
| SNPog | 1.6 | 1.1 | 1.2 | 0.7 | 1.2 | 1.8 | 1.4 | 1.9 | 1.5 | 1.9 | 2.6 | 1.8 |
| FH:NPog | 0.7 | 1.6 | 0.2 | 1.3 | 0.3 | 3.1 | 0.4 | 3.2 | 0.4 | 1.9 | -0.8 | 3.2 |
| Vertical | | | | | | | | | | | | |
| MP:SN | -2.4 | 1.7 | -1.1 | 1.1 | -1.6 | 3.2 | -1.1 | 2.6 | -1.7 | 2.6 | -1.1 | 1.7 |
| MP:FH | -1.4 | 2.1 | -0.2 | 1.8 | -0.7 | 3.9 | -0.2 | 4.1 | -0.6 | 2.7 | 0.6 | 3.2 |
| NSGn | -0.5 | 1.2 | -0.1 | 0.6 | 0.6 | 1.6 | 0.5 | 1.8 | 0.4 | 1.9 | 0.3 | 1.2 |
| FH:SGn | 0.5 | 1.7 | 0.8 | 1.2 | 1.5 | 3.2 | 1.5 | 3.4 | 1.6 | 2.3 | 2.0 | 3.2 |
| N-Ans'mm | 4.6 | 1.3 | 2.9 | 1.3 | 4.1 | 2.3 | 3.6 | 2.2 | 5.7 | 2.0 | 2.6 | 1.7 |
| N-Me mm | 9.8 | 2.3 | 7.3 | 2.5 | 10.8 | 4.1 | 8.3 | 3.9 | 11.8 | 3.5 | 6.2 | 3.0 |
| S-Go mm | 9.9 | 1.7 | 6.3 | 1.9 | 10.3 | 4.7 | 7.5 | 2.7 | 10.8 | 3.7 | 5.8 | 2.9 |
| Ar'-Go mm | 7.5 | 2.5 | 7.3 | 1.9 | 7.0 | 2.3 | 10.2 | 2.1 | 7.2 | 3.8 | 6.2 | 2.8 |
| Pog-NB mm | 0.9 | 0.8 | 0.6 | 0.7 | 1.5 | 1.2 | 1.2 | 0.8 | 3.7 | 1.5 | 2.4 | 1.5 |
| Dental | | | | | | | | | | | | |
| Overbite mm | -0.0 | 1.1 | -0.2 | 0.9 | -2.3 | 2.1 | -1.0 | 1.7 | -2.1 | 1.7 | -0.9 | 1.4 |
| Overjet mm | -0.3 | 0.6 | -0.2 | 0.5 | -2.7 | 2.4 | -2.7 | 2.1 | -3.6 | 2.5 | -2.9 | 2.5 |
| U1:L1 | 4.0 | 4.5 | 2.0 | 5.8 | -0.7 | 9.0 | 2.3 | 9.2 | 6.7 | 11.1 | 13.0 | 12.1 |
| U1:SN | -0.6 | 2.6 | 0.4 | 2.7 | -2.0 | 7.6 | -3.0 | 8.6 | -5.1 | 8.1 | -9.4 | 8.0 |
| U1:A-Pog | -0.8 | 0.7 | -0.0 | 0.8 | -1.7 | 2.1 | -1.8 | 2.2 | 5.8 | 2.7 | -4.3 | 2.2 |
| L1:MP | -1.0 | 3.4 | -1.3 | 3.8 | 4.2 | 6.5 | 1.8 | -4.5 | 0.1 | 6.0 | -2.5 | 7.2 |
| L1:FH | 2.1 | 3.8 | 1.7 | 3.4 | -3.5 | 7.0 | -1.7 | 5.9 | 0.5 | 5.9 | 1.9 | 8.1 |
| L1:NB | -0.2 | 1.0 | 0.2 | 1.0 | 1.2 | 1.5 | 1.0 | 1.4 | -0.6 | 1.8 | -1.3 | 2.0 |
| Soft Tissue | | | | | | | | | | | | |
| Gl-Sb-Pog' | 0.1 | 0.2 | 0.3 | 0.3 | 2.4 | 1.6 | -2.2 | 3.3 | -4.6 | 2.4 | -3.5 | 3.7 |
| Ls-Pog':NB | -2.7 | 4.9 | -2.9 | 2.9 | -3.1 | 3.0 | -4.1 | 3.0 | -7.3 | 4.0 | -7.2 | 3.3 |
| Ls:Pr-Pog' mm | 1.6 | 1.1 | 1.6 | 1.4 | 1.6 | 1.8 | 1.4 | 1.8 | -4.9 | 2.3 | -3.9 | 1.8 |
| Li:Pr-Pog' mm | 1.6 | 1.2 | 2.1 | 1.3 | 2.4 | 1.6 | 2.1 | 2.1 | -4.6 | 2.4 | -4.1 | 1.7 |

$\bar{x}$ = Mean S.D. = Standard Deviation
U1 = Long axis of upper incisor L1 = Long axis of lower incisor

In the present study an attempt was made to determine the overall differences in the changes between Class II, division 1 individuals treated with and without first premolar extractions and a matched normal sample. From evaluating these dentofacial changes, it was possible to determine whether orthodontic treatment superimposed on the growth potential of each subject will combine to "normalize" the various dentofacial structures over the 5-year observation period. This time span includes both a treatment period as well as a 2- to 3-year posttreatment observation period.

The results of this study indicate that prior to treatment, significant differences in the skeletal, dental and soft tissue relationships were present between normal and Class II, division 1 subjects and to a lesser extent, between the Class II, division 1 subjects who were treated with and without the extraction of first premolars.

During the 5-year observation period, there were

**Table 6**
**Results of analysis of variance indicating significant differences in the total changes between the three groups during the overall observation period.**

| Variable | P-Value | Differences |
|---|---|---|
| **Males** | | |
| Cranial Base | | |
| NSO | .0206 | NE < N & E |
| Skeletal | | |
| SNA | .0001 | N > E & NE |
| SNB | .0189 | N > E |
| ANB | .0002 | N < NE < E |
| NAPog | .0001 | N < NE < E |
| Ar-Pog mm | .0246 | NE < N & E |
| N-Ans' mm | .0276 | E > NE |
| N-Me mm | .0110 | N < E & NE |
| Pog:NB mm | .0001 | E > N & NE |
| Dental | | |
| Overbite mm | .0001 | N < NE & E |
| Overjet mm | .0001 | N < NE & E |
| U1:L1 | .0299 | E > NE |
| U1:APog mm | .0001 | E > N & NE |
| L1:MP | .045 | 2 groups |
| L1:NB | .0007 | NE < N & E |
| L1:FH | .0094 | NE < N & E |
| Soft Tissue | | |
| Gl'-Sb-Pog' | .0143 | E < N & NE |
| Ls-Pog':NB | .0007 | E > N & NE |
| Ls:Pr-Pog' mm | .0001 | E > N & NE |
| Li:Pr-Pog' mm | .0001 | E > N & NE |
| **Females** | | |
| Skeletal | | |
| SNA | .0016 | E > N & NE |
| SNB | .0248 | E < N & NE |
| NAPog | .0272 | N < E |
| S-Go | .0231 | NE > N & NE |
| Pog:NB mm | .0001 | E > N & NE |
| Dental | | |
| Overjet mm | .0003 | N < E & NE |
| U1:L1 | .0003 | E > N & NE |
| U1:SN | .0004 | E > N & NE |
| U1:A-Pog mm | .0001 | E > NE > N |
| L1:MP | .0219 | E > NE |
| L1:NB mm | .0001 | E < N & NE |
| Soft Tissue | | |
| Gl'-Sb-Pog' | .0023 | E > N & NE |
| Ls-Pog':NB mm | .0001 | E > N & NE |
| Ls:Pr-Pog' mm | .0001 | E < N & NE |
| Li:Pr-Pog' mm | .0001 | E < N & NE |

> = larger than  < = smaller than
N = Normals; E = Extraction; NE = Nonextraction

significant differences in the changes between the normal and the Class II groups. These differences were the result of the combined effects of treatment and growth.

Clinicians are particularly interested in determining the overall impact that orthodontic treatment had on the dentofacial structures and growth potential of individuals with Class II, division 1 malocclusion. In other words, how do these patients look relative to "normals". The present results indicate that, in general, orthodontic treatment which includes the use of orthopedic extraoral forces as well as light Class II elastics "normalizes" the skeletal relationships. Similar results were observed earlier by Moore[16] and West.[17] On the other hand, the dental relationship at the end of the observation period was significantly influenced by the extraction decision. Specifically, the maxillary and mandibular incisors were significantly more upright and the lips more retrusive in the Class II extraction groups when compared to normals. In the nonextraction groups the incisors and lips tended to be more protrusive.

As a result, clinicians need to be aware of the long-term effects of the extraction or nonextraction decision on the dentition and profile. Such an understanding will help clinicians provide their patients with treatment plans tailored to their individual needs and would result in optimal dental, skeletal and profile relationships.

## Conclusions

From the present findings the following can be concluded:

1. Comparisons between the Class II, division 1 groups and normals indicated that pretreatment, Class II, division 1 malocclusions were associated with a larger overjet, deeper overbite, larger ANB angle and a more convex soft tissue profile.

2. Comparisons of the pretreatment measurements of subjects treated with and without extractions of first premolars indicated that in the extraction groups the upper and lower lips in

males and the lower lip in females were more protrusive relative to the Ricketts esthetic plane.

3. Following a 5-year observation period that included orthodontic treatment, there was an overall "normalization" of the skeletal relationships of the treated Class II, division 1 subjects in both the extraction and the nonextraction groups when compared to normals. On the other hand, treatment had a differential impact on the dental relationships as well as on lip prominence as a result of the extraction decision. At the end of the observation period both males and females in the extraction group had more retrusive maxillary and mandibular incisors as well as more retrusive lips than the corresponding normals. In the nonextraction groups, there was a tendency for both the incisors and the lips to be relatively more protrusive.

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**Table 7**
**Analysis of variance indicating significant differences between the three groups at the end of the observation period.**

| Variable | P-Value | Differences |
|---|---|---|
| Males | | |
| Cranial Base | | |
| NSO | .0399 | N > E |
| Skeletal | | |
| SNA | .0470 | N > E |
| NAPog | .0042 | E < N & NE |
| Ar'-Go mm | .0014 | N > E & NE |
| Pog:NB mm | .0001 | N < NE < E |
| Dental | | |
| U1:L1 | .0059 | NE < N & E |
| U1:APog mm | .0004 | E < N & NE |
| L1:NB | .0001 | E < N & NE |
| L1:FH | .0019 | E > NE |
| L1:MP | .0022 | NE > E |
| Soft Tissue | | |
| Ls:Pr-Pog' | .0001 | E < N & NE |
| Li:Pr-Pog' | .0001 | E < N < NE |
| **Females** | | |
| Cranial Base | | |
| NSO | .0069 | N > E & NE |
| Skeletal | | |
| FH:NPog | .0352 | N < NE |
| N-Ans' mm | .0122 | NE > E |
| S-Go mm | .0284 | NE > N & E |
| Pog:NB mm | .0021 | N < E & NE |
| Dental | | |
| U1:L1 | .0215 | E > N & NE |
| U1:SN | .0314 | E < N & NE |
| U1:APog mm | .0001 | E < N & NE |
| L1:NB mm | .0329 | E < NE |
| Soft Tissue | | |
| Gl-Sb-Pog' | .0085 | N > E & NE |
| Ls:Pr-Pog' mm | .0001 | E < NE < N |
| Li:Pr-Pog' mm | .0001 | E < N & NE |

P = Probability S = Group Differences
N = Normals; E = Extraction; NE = Nonextraction

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