The Dental VTO: An Analysis of Orthodontic Tooth Movement

RICHARD P. McLAUGHLIN, DDS
JOHN C. BENNETT, LDS, DOrth

Most cephalometric analyses measure maxillary and mandibular skeletal relationships in the vertical and horizontal planes, along with the position and angulation of the incisors. Few orthodontic analyses, however, provide information about the direction and amount of dental movements required during treatment within the maxillary and mandibular arches.

The Steiner analysis, for example, includes the initial positions and desired movements of the first molars, canines, and dental midlines, but is ambiguous about Class II correction and tooth movements after extractions. Without this information, the orthodontist can lose sight of the anchorage requirements of a case and thus underestimate the amount of patient cooperation and anchorage needed to reach treatment objectives.

The dental analysis presented in this article—in effect, a dental Visualized Treatment Objective—was designed to provide organized and simplified information to help in diagnosis, treatment planning, and the extraction/nonextraction decision. It should be used as an adjunct to, but not a substitute for, conventional cephalometric analyses. It takes little time to complete and occupies only a small part of the treatment card. Progress can be checked by referring to the dental VTO at the patient's regular adjustment appointments.

Method

The dental VTO consists of three charts:

Chart 1 records the initial midline and first molar positions with the mandible in centric relation.

Chart 2 measures the lower arch discrepancy, similarly to the Steiner analysis.[1] The four primary factors in each case are:

1. Space required for relief of crowding, measured from canine to midline and from first molar to midline on each side.
2. Space required for the desired correction of protrusion or retrusion of the mandibular incisors.
3. Space required for leveling the curve of Spee, measured as the deepest point on a line extending from the distal cusps of the second molars to the incisal edges of the central incisors on each side; this point is normally found in the premolar region (Fig. 1).
4. Space required for midline correction.

Four secondary factors that can sometimes provide additional space are listed, if applicable, below the primary chart:

1. Additional space from interproximal enamel reduction.
2. Additional space from uprighting or distal movement of mandibular first molars.
3. Additional space from buccal uprighting of mandibular canines and posterior teeth.
4. Additional leeway or "E" space.

According to Moorrees, the leeway space, or the difference in size between the deciduous canines, first molars, and second molars and the permanent canines, first premolars, and second premolars, is an average of 1.5mm per side in the mandibular arch and .9mm per side in the maxillary arch.[2] "E" space, or the difference in size between the primary second molar and the permanent second premolar, is an average of 2.5mm

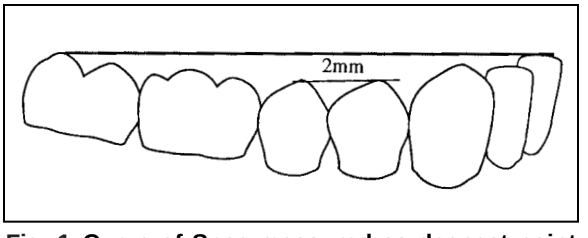
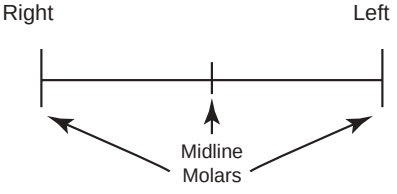


Fig. 1 Curve of Spee measured as deepest point along line extending from distal cusps of second molars to incisal edges of central incisors on each side.

Dr. McLaughlin is a Contributing Editor of the *Journal of Clinical Orthodontics* and in the private practice of orthodontics at 1831 Sunset Cliffs Blvd., San Diego, CA 92107. Dr. Bennett is in the private practice of orthodontics at 53 Portland Place, London W1N 3AH, England.

Dr. McLaughlin

Dr. Bennett



Initial Midline and Molar Position

Chart 1 with explanatory text

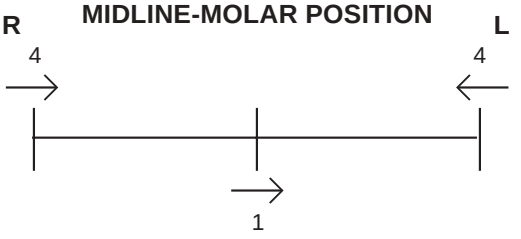
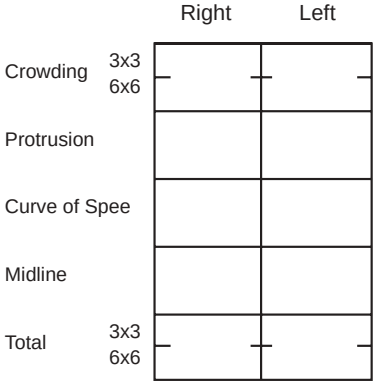


Chart 1 as it is used



Lower Arch Discrepancy

Chart 2 with explanatory text

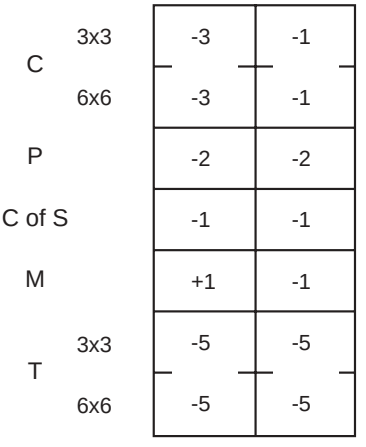
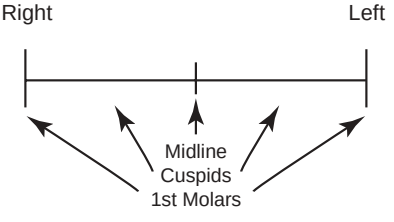


Chart 2 as it is used



Anticipated Treatment Change

Chart 3 with explanatory text

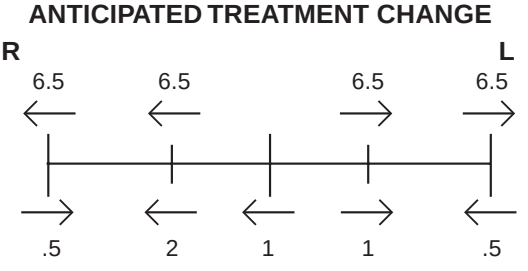


Chart 3 as it is used

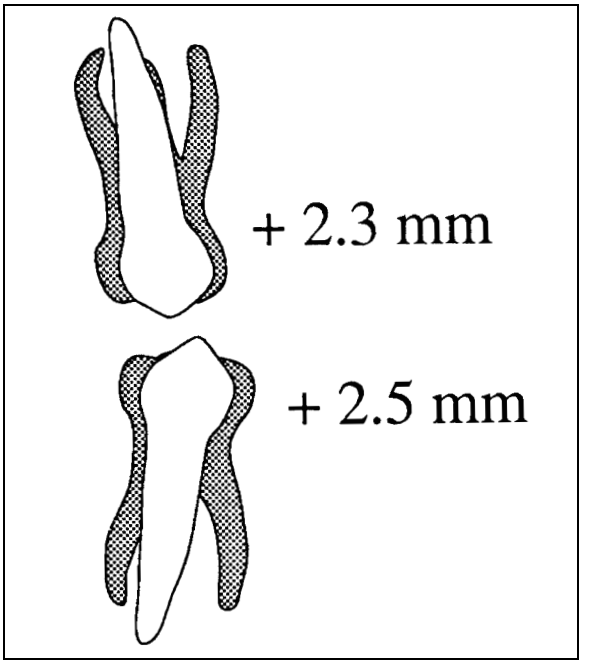


Fig. 2 Average "E" space: 2.5mm per side in mandibular arch and 2.3mm per side in maxillary arch.

per side in the mandibular arch and 2.3mm per side in the maxillary arch (Fig. 2).

The primary and secondary factors are added together at the bottom of the chart to determine the total lower arch discrepancy from canine to midline and from first molar to midline on each side.

Chart 3 records the anticipated treatment change in terms of dental movements of the first molars, canines, and midline.

Two cases are presented to show how the dental VTO can be applied.

Case 1

A 12-year-old male presented with a Class II skeletal pattern (Fig. 3). Vertically, he had a slightly high angle and a slightly long lower facial height. There were no crossbites, and the dentition was symmetrical in the transverse dimension.

The patient's dental relationships were recorded in centric relation (Chart 1). His molar

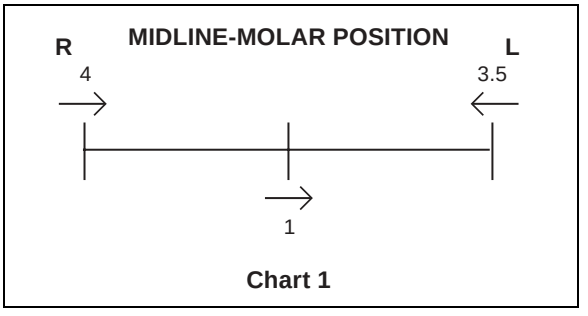


Chart 1

relationships were 4mm Class II on the right side and 3.5mm Class II on the left. The lower dental midline was deviated 1mm to the right.

The mandibular arch showed 3mm of crowding on the right side, all mesial to the right canine. Therefore, the amount of crowding from first molar to midline was the same as the amount from canine to midline (Chart 2). On the

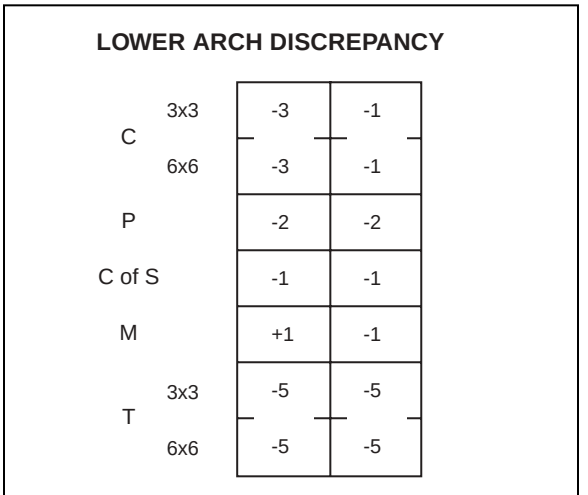


Chart 2

left side, there was only 1mm of crowding, also between the canine and the midline.

The curve of Spee was about 2mm at its deepest point. Steiner suggested that leveling a 2mm curve of Spee would advance the incisors 1mm, thus requiring 1mm of space per side for the leveling process. We have found this rule of thumb to be clinically accurate.

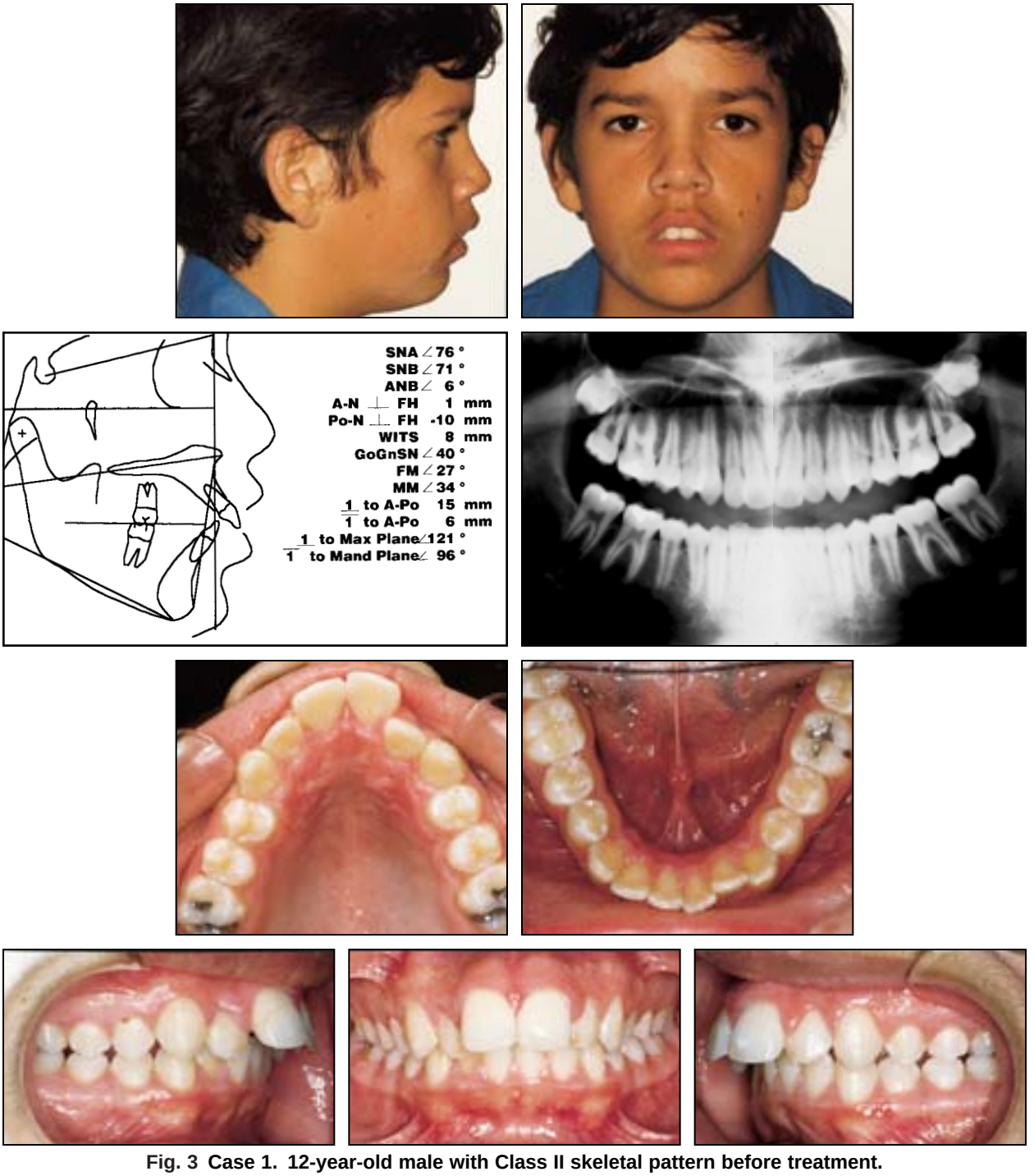


Fig. 3 Case 1. 12-year-old male with Class II skeletal pattern before treatment.

Because the lower midline was deviated 1mm to the right, the midline correction would require 1mm of space on the left side and provide 1mm of space on the right.

The mandibular incisors were inclined forward (97° to the mandibular plane) and were 6mm in front of the APo line. Without extractions, the incisors would either remain in this position or, more likely, be advanced farther. With extractions, the incisors could be retracted. Therefore, the decision was made to extract the four first premolars and retract the mandibular incisors 2mm.

The space-gaining procedures of interproximal reduction, molar uprighting, and buccal uprighting of posterior teeth were not needed in this case and were therefore not recorded in Chart 2. There was no leeway or "E" space available, since no primary teeth were present.

Anticipated treatment changes were recorded in Chart 3 using the following process:

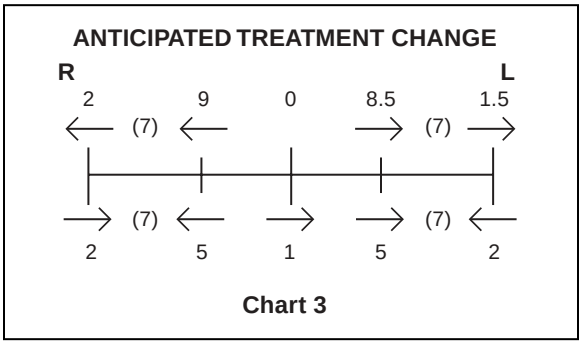


Chart 3

1. Extraction of the four first premolars produced 7mm of space in each quadrant, since there was no crowding between the canines and first molars in either arch. This was indicated by writing "(7)" in each quadrant.
2. Because the total lower arch discrepancy from canine to midline was 5mm per side, the mandibular canines needed to be retracted 5mm into the extraction sites. This was recorded on the bottom of the chart, with arrows showing the direction of movement.
3. The mandibular molars could therefore only be moved 2mm to close the remainder of the 7mm extraction spaces—also indicated with arrows on the bottom of the chart. This demonstrated a need for moderate anchorage control in the mandibular arch. A mandibular lingual arch, for example, could be considered during the first 3mm of canine retraction.
4. The mandibular midline needed to be moved 1mm to the right, as shown by the arrow on the bottom of the chart.
5. There are four possible methods of Class II molar correction in the growing patient:

a. Mesial movement of the mandibular first molars (in this case, 2mm per side).

b. Distal movement of the maxillary first molars. This is difficult in the presence of developing maxillary second and third molars, but it can be achieved. Superimposition of beginning headfilms with progress or final headfilms will inevitably show downward and forward movement of the maxillary first molars, due to the growth of the entire facial complex. Although this rotation may lead some clinicians to contend that no distalization has occurred, it does not mean there has been no dentoalveolar or skeletal change in the maxillary molar positions.

c. Limiting forward maxillary skeletal development, or retracting the maxilla. Because such changes are difficult to isolate, it is debatable how much is skeletal (above the palatal plane) and how much is dentoalveolar (below the palatal plane). Nasion normally grows forward about 1mm a year relative to sella, while A point may be maintained or retracted relative to its original position.

d. Forward mandibular rotation. This can occur in two ways:

1) Mandibular growth. The direction of overall facial growth is critical to the "expression" of mandibular growth. With more vertical patterns, there is less forward expression of mandibular growth and hence less interarch dental change. With less vertical facial growth, mandibular growth is expressed in a more forward direction, resulting in greater interarch dental change.

2) Limiting vertical maxillary develop-

ment. Although sizable claims have been made for this method, it is difficult to significantly influence the normal vertical development of the facial complex. As with forward maxillary development, vertical development is hard to measure in isolation and therefore hard to categorize as skeletal or dentoalveolar. Nevertheless, even a small limitation can greatly enhance a Class II correction.

6. In the present case, the molar relationship on the right side was 4mm Class II, and since 2mm could be corrected by mesial movement of the mandibular molar, an additional 2mm of correction was required. On the left side, an additional 1.5mm of correction was needed. These amounts were recorded on the top of Chart 3 with distal arrows.

A palatal bar and a combination high-pull and cervical-pull headgear were used to preserve maxillary anchorage in this case. If favorable mandibular growth occurred in any of the ways listed above, maxillary anchorage control could be reduced or eliminated, allowing the maxillary molars to move more mesially. This could not be predicted before treatment, however, and so the numbers in Chart 3 represent the worst-case scenario.

A functional appliance could also have been considered before fixed appliance therapy. A good response to the functional appliance might have reduced the amount of maxillary anchorage support needed later. Extractions would still have been required after the functional phase, assuming incisor retraction was still a treatment objective.

7. Taking into account the 2mm distal movement of the maxillary right molar and the 1.5mm distal movement of the maxillary left molar, the canines would have to be moved 9mm on the right and 8.5mm on the left to close the 7mm extraction spaces. This emphasizes the potential benefits of favorable growth and a favorable functional appliance response.

Leveling and alignment were carried out with an .022" edgewise appliance, beginning with light twisted wires, and proceeding to round wires and finally to .019" × .025" rectangular wires. Extraction sites were then closed with the rectangular archwires, using pull-coil springs from the first molars to archwire hooks between the lateral incisors and cuspids. Class II elastics were used as little as possible, in conjunction with the headgear, to correct the anteroposterior relationship. Detailing and finishing were carried out with .019" × .025" rectangular archwires.

With only average cooperation, total treatment time was 35 months (Fig. 4). The patient wore a tooth positioner full-time for six weeks; a maxillary Hawley retainer was then worn full-time for six months and at night only thereafter, while a fixed mandibular retainer was bonded.

Despite greater-than-average vertical development during treatment, the results were within normal limits. The occlusion was corrected from a Class II, division 1 to a Class I. The maxillary incisors were retracted from 13mm in front of NA to 4mm in front of NA, and their angulation to NA was reduced from 38° to 22°.

Case 2

A female patient age 8 years and 4 months presented with a Class II skeletal pattern (Fig. 5). Vertically, she was a low-angle patient with a normal lower facial height. There were no crossbites, and the transverse dimension was symmetrical.

The patient's molar relationship was 4.5mm Class II on the right side and 2.5mm Class II on the left (Chart 1). The dental midlines

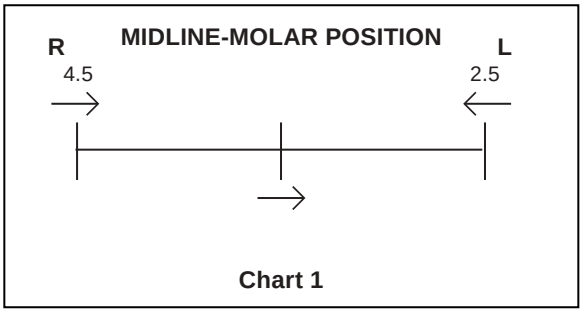


Chart 1

were properly aligned.

The mandibular arch showed 2.5mm of

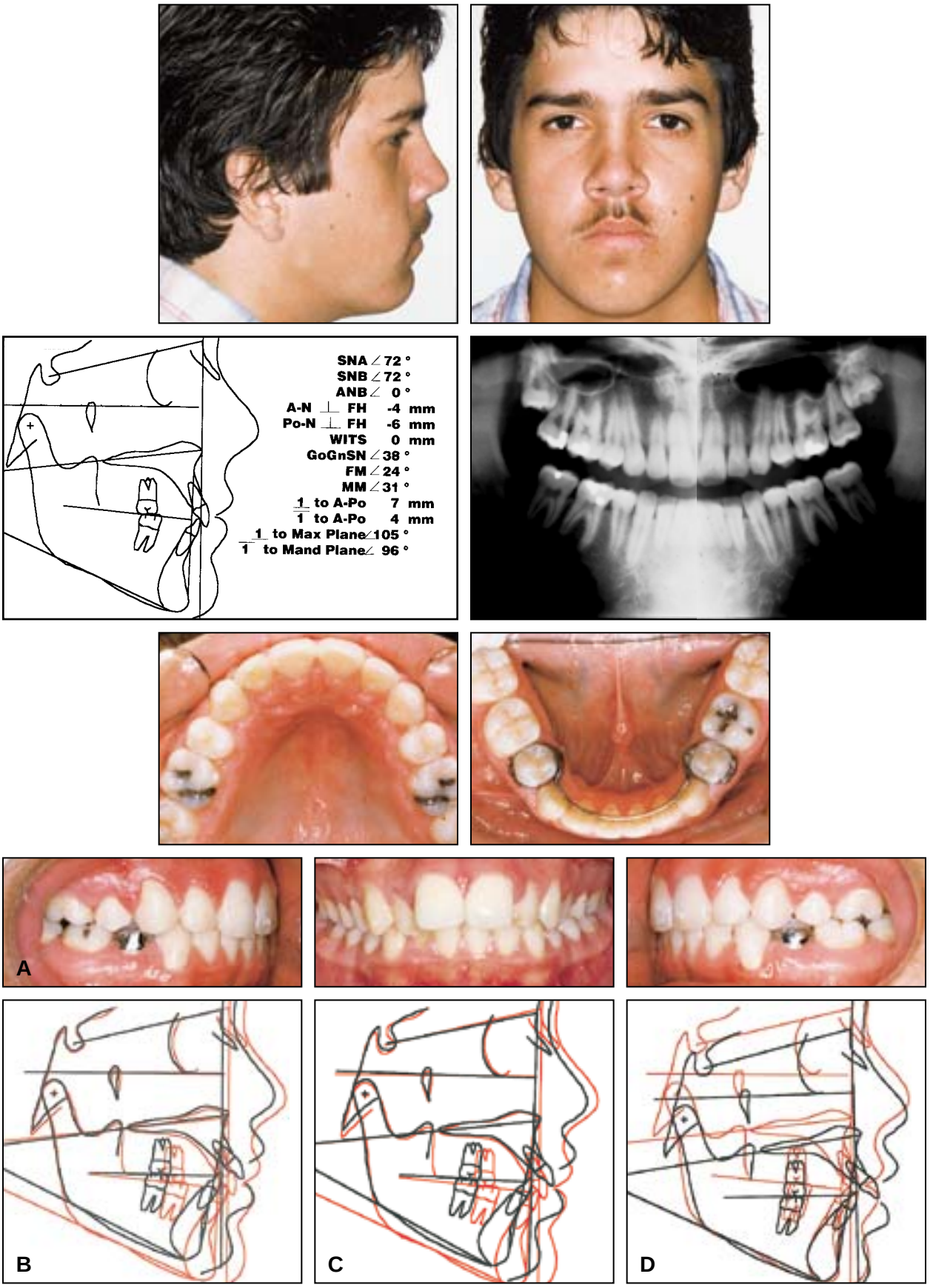


Fig. 4 **Case 1. A. After four bicuspid extractions and 35 months of treatment. B. Superimposition on SN at S. C. Superimposition on palatal plane and palatal curvature. D. Superimposition on mandibular symphysis and mandibular plane.**

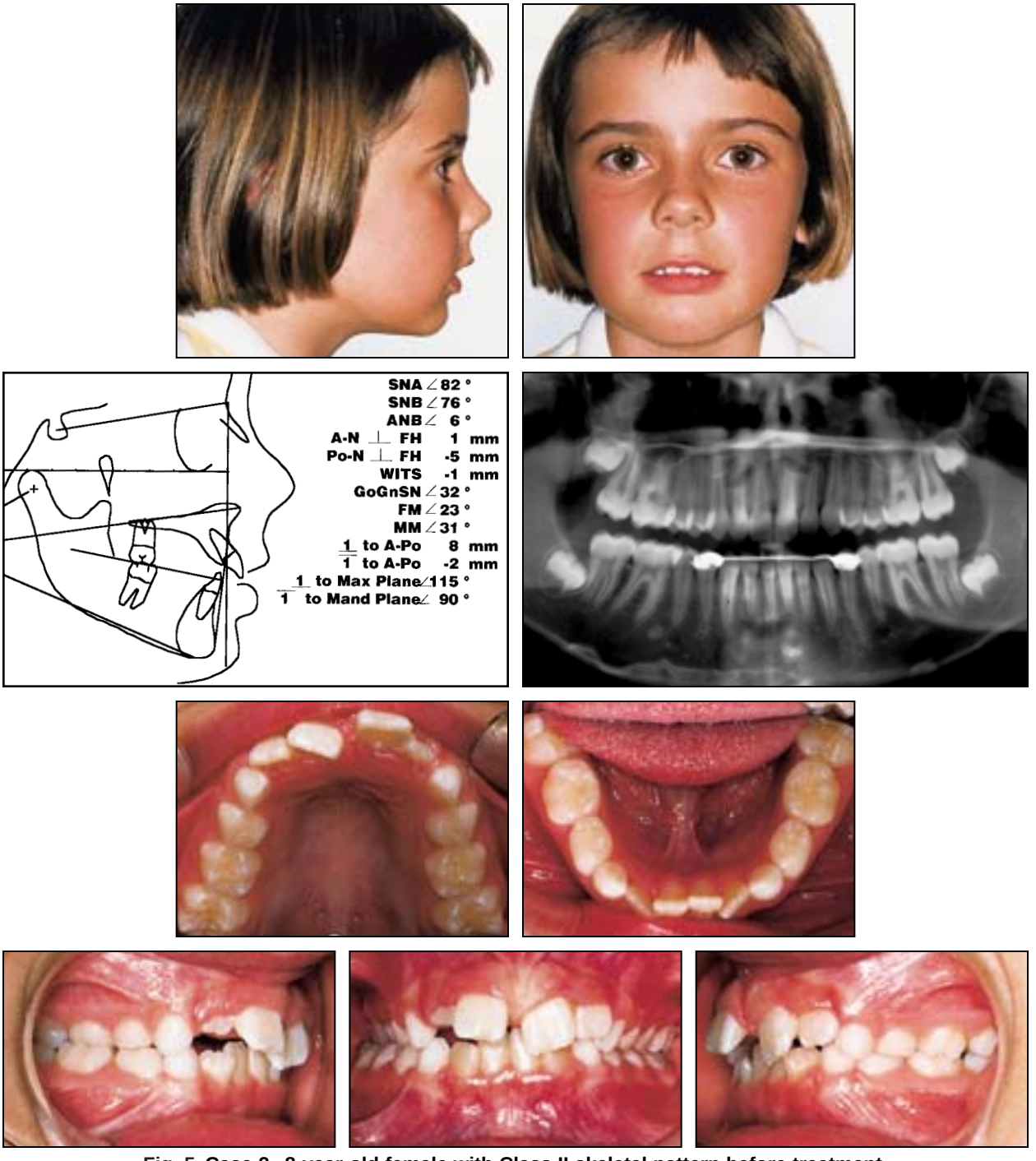


Fig. 5 Case 2. 8-year-old female with Class II skeletal pattern before treatment.

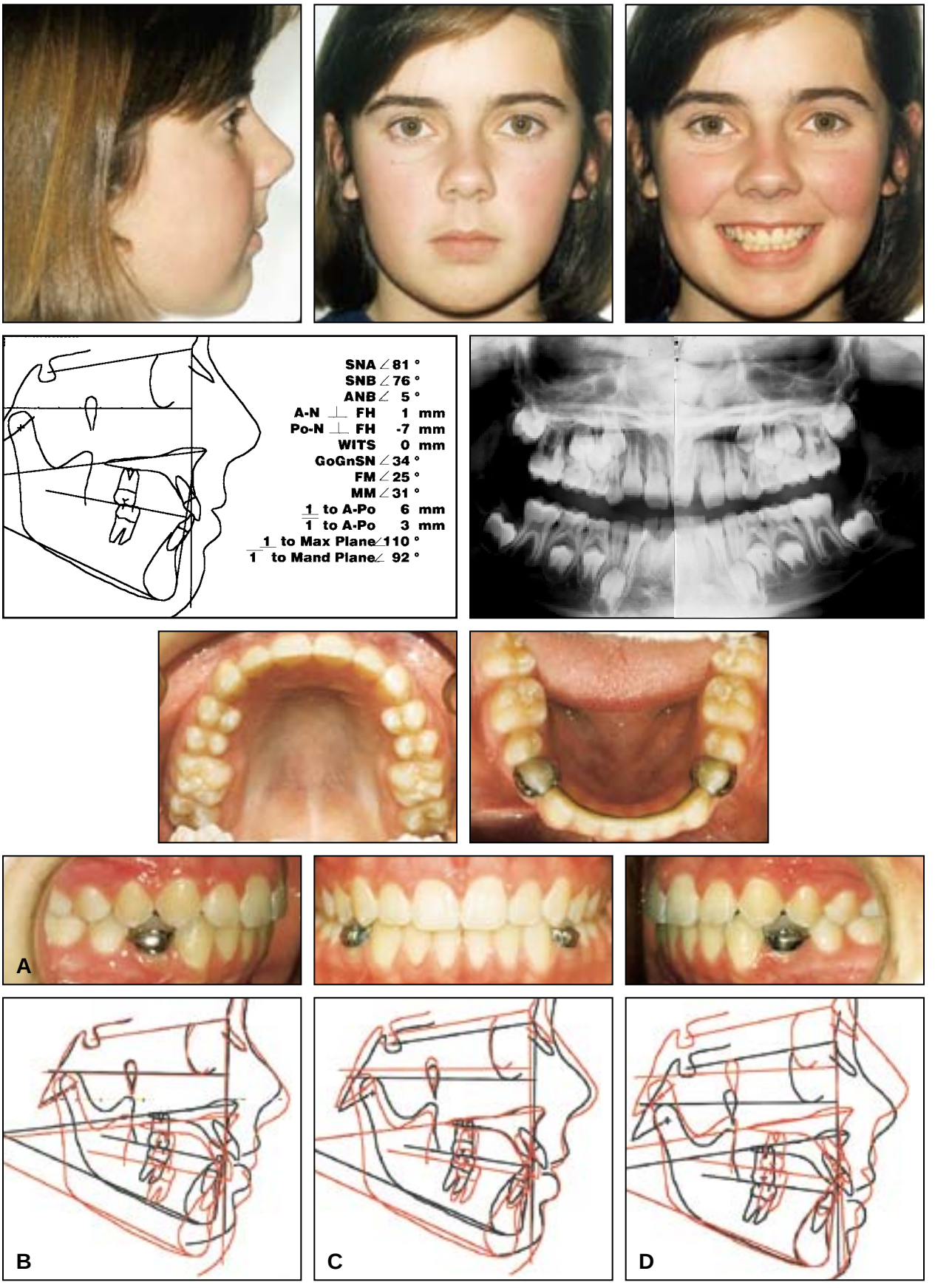


Fig. 6 Case 2. A. After two phases of nonextraction treatment. B. Superimposition on SN at S. C. Superimposition on palatal plane and palatal curvature. D. Superimposition on mandibular symphysis and mandibular plane.

crowding from the canines to the midline on each side (Chart 2). The leeway space in the mandibular arch, due to the presence of the primary canines and the first and second molars, was 1.5mm per side. The loss of these teeth would leave a total of only 1mm of crowding per side in the mandibular arch.

LOWER ARCH DISCREPANCY

C	3x3	-2.5	-2.5
	6x6	-1	-1
P		+4	+4
C of S		-.5	-.5
M		0	0
T	3x3	+1	+1
	6x6	+2.5	+2.5
Leeway Space		+1.5	+1.5

Chart 2

Because the mandibular incisors were 4mm behind the APo line and at 87° to the mandibular plane, the decision was made to advance them 4mm, providing 4mm of space per side. The curve of Spee was about 1mm deep bilaterally, requiring .5mm of space per side for leveling. No midline correction was needed.

Adding all these factors together, there was a total lower arch discrepancy of +1mm per side from canine to midline and +2.5mm per side from first molar to midline. With this space available, the mandibular canines could be advanced 1mm per side, and the molars could be advanced 2.5mm per side (Chart 3).

Thus, 2.5mm of the 4.5mm Class II correction on the right side could be achieved by mesial movement of the mandibular first molar. The remaining 2mm would have to be produced by the methods described under Case 1. On the left side, the entire 2.5mm Class II correction could by achieved by moving the mandibular first molar forward.

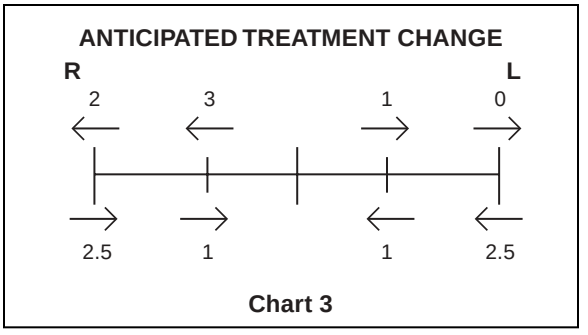


Chart 3

This patient underwent an eight-month first phase of treatment with maxillary and mandibular 2 × 4 appliances, nighttime headgear, and daytime Class II elastics. The second phase, begun at age 12, involved mainly tooth alignment for final correction, using full fixed appliances in conjunction with headgear and elastics. This phase was completed in 20 months (Fig. 6).

Retainers were a maxillary removable wraparound appliance and a mandibular fixed 4 × 4 appliance.

Conclusion

We have used the dental VTO in clinical practice for several years, and we have found this simple analysis to be most helpful as a diagnostic and treatment-planning aid and as a reference throughout treatment. It is also useful in making the extraction/nonextraction decision.

There have been few cases in which the analysis did not work. It has even been applied in some mutilated-dentition cases, and in patients where second molars were substituted for first molars, or premolars for canines.

REFERENCES

1. Steiner, C.C.: Cephalometrics for you and me, Am. J. Orthod. 39:729-755, 1953.
2. Moorrees, C.F.A.: *The Dentition of the Growing Child: A Longitudinal Study of Dental Development Between 3 and 18 Years of Age*, Harvard University Press, Boston, 1959.