Differentiated Orthodontic Mechanics for Dental Midline Correction

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Correction of midline discrepancies in orthodontic treatment is critical to the establishment of both satisfactory esthetics and a functional transverse and sagittal occlusion.[1-5] One study found that 39% of such discrepancies involved the upper midline, 62% the lower midline, 18% a mandibular shift, and 6% an underlying skeletal asymmetry.[6] This indicates that a differential diagnosis for the individual patient is a prerequisite for the satisfactory correction of a midline deviation.[7,8]

In the case of major skeletal asymmetries, surgery may be the only solution. Dental movement can only correct a dental or alveolar asymmetry or camouflage a minor skeletal asymmetry.[9] Burstone considered an apical midline deviation to be beyond the realm of orthodontic treatment, because correction would require lateral displacement of the center of resistance of the anterior teeth.[10] Most authors, however, have not considered the possibility of differential diagnosis in appliance design, and have recommended only the use of sliding mechanics in combination with Class II, Class III, and diagonal elastics or space closure and opening.[11-15]

Appliance Theory

This article will propose a more differentiated approach to the orthodontic correction of midline discrepancies, based on the determination of the necessary tooth movements in three planes of space. The theoretical backbone of the appliance design is the physical fact that for each required movement there can be only one correct force system, which, on the other hand, can be obtained by a number of different appliances.[16]

Before the appliance design is chosen, it is crucial to establish the exact nature of the correction—functional, skeletal, or dental—and to determine the necessary tooth movements within each arch. In a patient whose midline discrepancy is not caused by a forced bite, the use of intermaxillary elastics might actually be detrimental, since they could cause undesirable tooth movements and displacement of the mandible.

The clinical analysis should consider both dental and facial midlines. The dental midline discrepancy, usually determined from the occlusal view, is not an absolute value, but can vary depending on treatment options. In this article, "midline discrepancy" means the difference between the contact point of the central incisors and the desired dental midline. The facial midline can be assessed by direct observation, but should be confirmed with frontal photographs or x-rays. In patients with acceptable facial symmetry, the two midlines should coincide. If there is

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a skeletal asymmetry, however, we use the vermillion as a reference point to establish the correct position of the dental midlines.

If the midline deviation is of dental or dentoalveolar origin, it can either be the result of tipping of individual teeth or an indication that the entire anterior segment is positioned asymmetrically. The first step is therefore to determine whether the anterior teeth can be moved as a unit without any individual displacement, or whether it is necessary to apply a force independently to each tooth (Fig. 1). The second step is to estab-

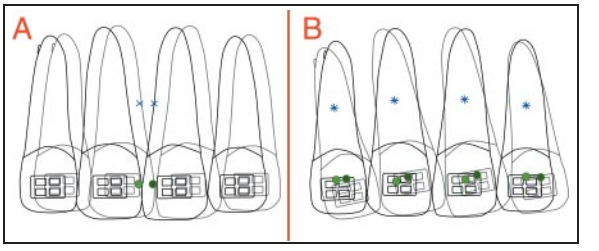

Fig. 1 Two methods of moving midline toward right side. A. Incisors moved right as a unit, so that group's center of resistance also moves right. B. Single teeth rotated independently around own centers of resistance.

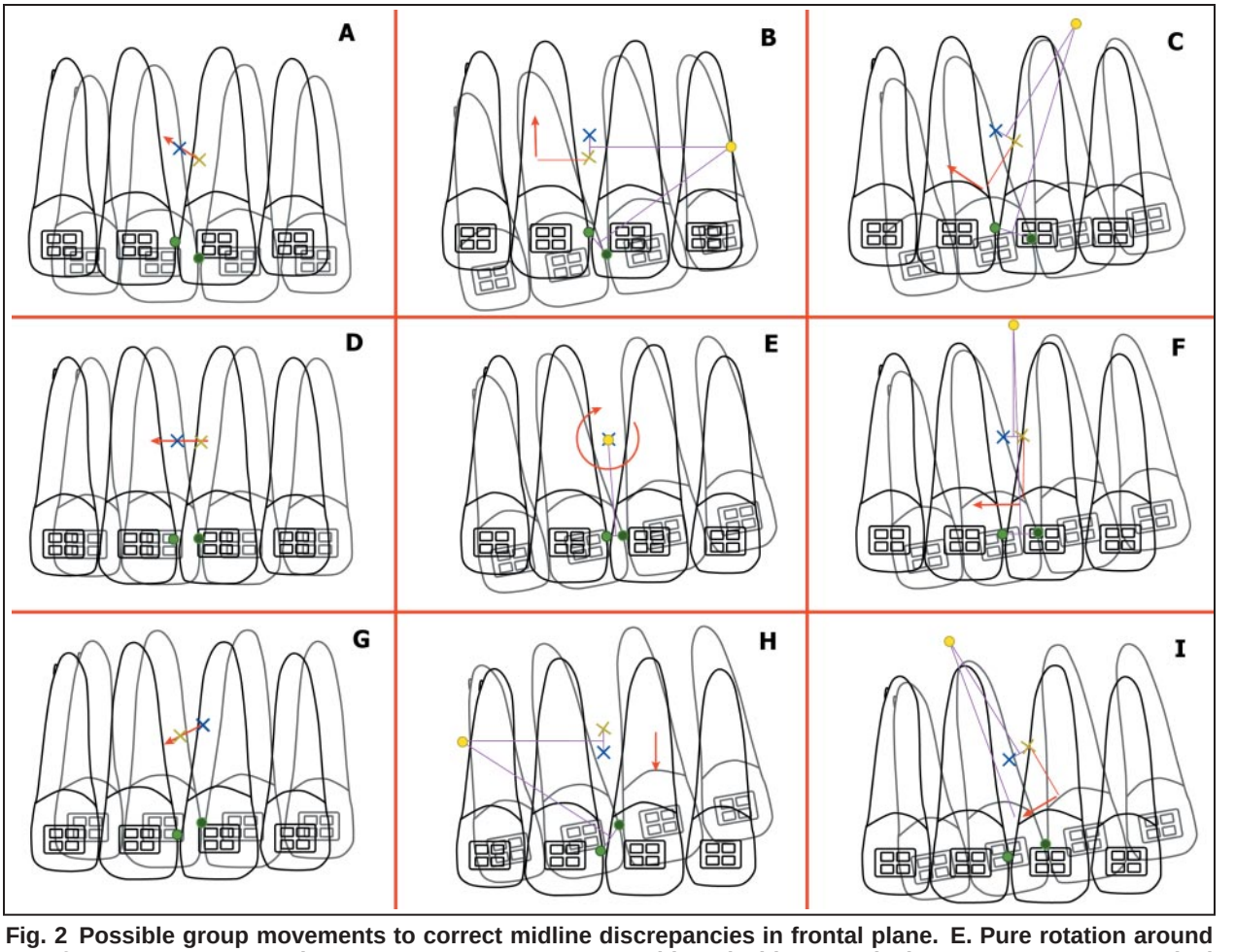

Fig. 2 Possible group movements to correct midline discrepancies in frontal plane. E. Pure rotation around CR of group. A,D,G. Translatory transverse movements, with and without vertical components. B,H. Vertical forces determine rotations and vertical movements. C,F,I. Translation and rotation due to transverse forces, with and without vertical components.

lish the type of movement needed to obtain the correction.

This article will describe only treatment of midline discrepancies by moving the anterior teeth as a unit. Without the need for individual tooth movements, the anterior teeth can be consolidated into a "macro tooth".

There are nine different categories of correction in the frontal plane, considering changes in vertical position as well as changes in inclination (Fig. 2). Furthermore, an asymmetry in the horizontal plane can involve a clockwise or counterclockwise rotation or a translation in a forward lateral or backward lateral direction (Fig. 3). Clearly, these different categories require totally different force systems and thus different appliances.

We have designed a special software system* to calculate the required force system, given the location of the center of resistance and the desired movement.[17-19] Although some of these movements can be produced with force systems acting at the bracket level, this is far from common; in fact, none of the recommended force systems can be obtained with a preadjusted appliance alone.

In Figures 2A-C and 2G-I, a vertical force component is needed. Such a force can be applied to the consolidated anterior segment directly at the bracket in Figures 2B and 2H, but in Figures 2C and 2I, the oblique line of action of the force required for tipping can be obtained more easily through a combination of horizontal and vertical force components. This is also true if the desired tooth movement is a pure horizontal translation, or if the translation follows an oblique path with a combination of vertical and horizontal movements. In such cases, the problem is more easily solved through a combination of two cantilevers.

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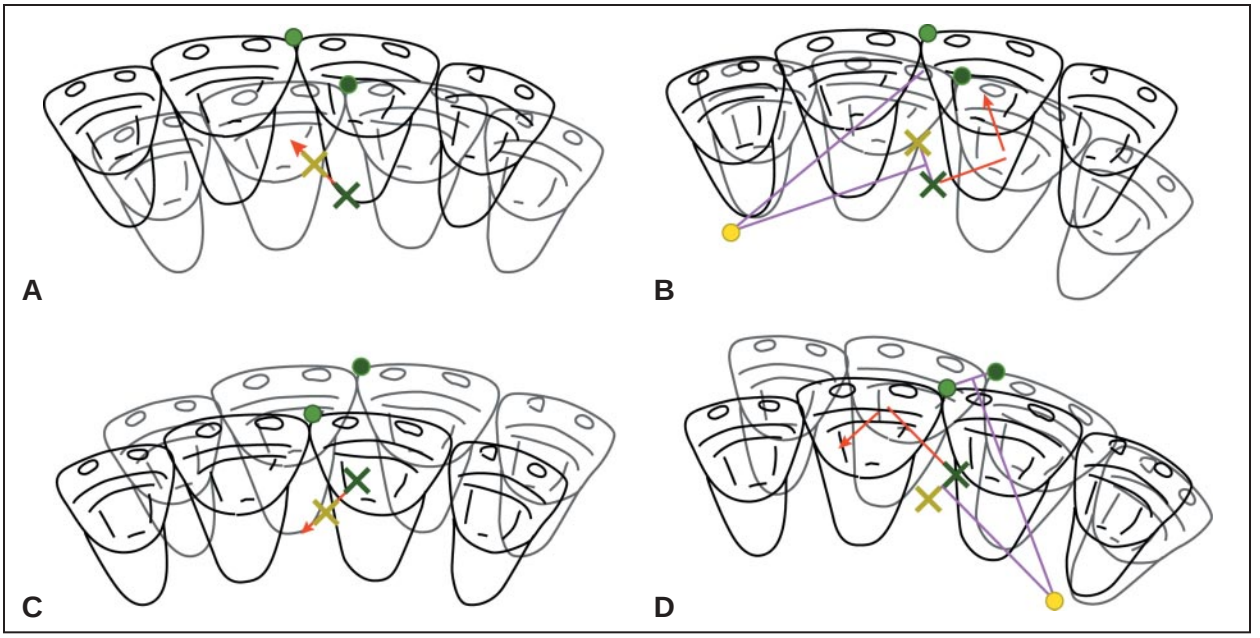

Fig. 3 Possible group movements to correct midline discrepancies with both transverse and sagittal components. A,C. Force vector passes through CR, causing pure translation. B,D. Combined translation and rotation.

Case 1

This patient's problem list included a deep bite, a midline discrepancy of the four maxillary incisors, and the need for space closure between the maxillary right canine and incisors (Fig. 4). Clinical analysis determined that moving the four incisors upward and to the right as a unit could resolve these problems. The translation required a line of action of the force passing through the center of resistance of the four anterior teeth, which could only be obtained through a combination of two cantilevers.

One cantilever delivered an intrusive force to a stiff anterior segment at the lateral aspect of the maxillary left lateral incisor. To neutralize the counterclockwise tipping of this segment, a horizontal force was added to a power arm at the level of the maxillary right lateral incisor's cantilever.

After 60 days, a significant improvement in the deep bite and midline discrepancy could be seen (Fig. 5). An undesirable canting of the occlusal plane was subsequently corrected by shortening the power arm by 3mm. This produced a clockwise moment that resulted in the generation of a moment of 240gmm in the appropriate direction at the CR. Thirty days later, the midlines were aligned, and the deep bite and spacing were corrected (Fig. 6).

Case 2

The patient's problem list included a deviation of the upper midline to the left and of the lower midline to the right, with a total midline discrepancy of 5.5mm (Fig. 7). There was a severe lack of space for the erupting maxillary left and mandibular right canines.

To correct the midline discrepancy and gain enough space, two force vectors were applied by means of cantilevers inserted in the maxillary right and mandibular left first molar tubes and ligated with one-point contacts to the anterior segment near the midline. The midlines were nearly aligned and sufficient space was created for the canines after six months of treatment (Fig. 8).

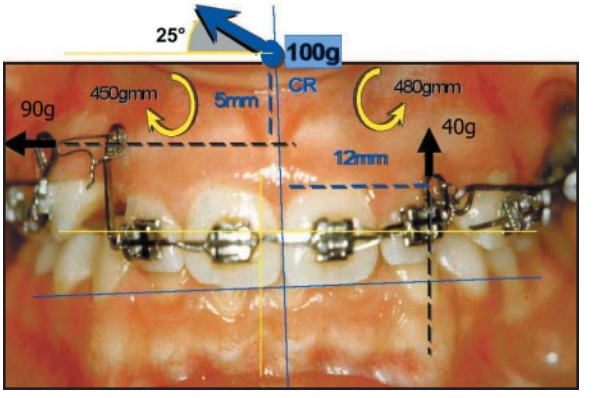

Fig. 4 Case 1. Patient requiring simultaneous intrusion and transverse movement of anterior teeth (see Fig. 2A). Calculation determined that needed force vector (blue arrow) could be split into two vectors (black arrows) that could be produced most easily by two cantilevers. Sum of two moments (yellow arrows) generated by two cantilevers is close to zero at CR.

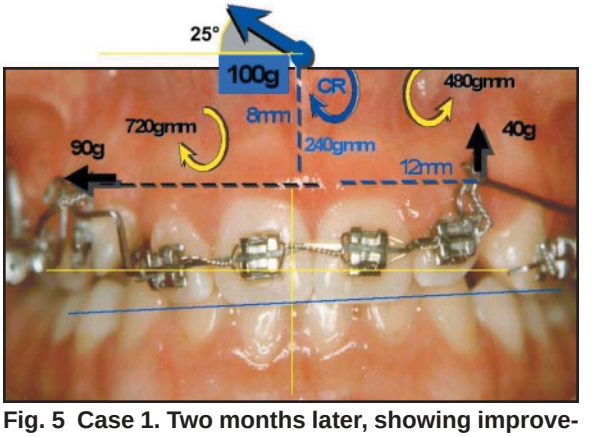

Fig. 5 Case 1. Two months later, showing improvement in both midline discrepancy and overbite. To correct canting of anterior teeth, appliance was modified by moving one-point ligature contact of right cantilever occlusally, shortening power arm (see Fig. 2C).

Fig. 6 Case 1. Complete correction of midline discrepancy and overbite after three months of treatment.

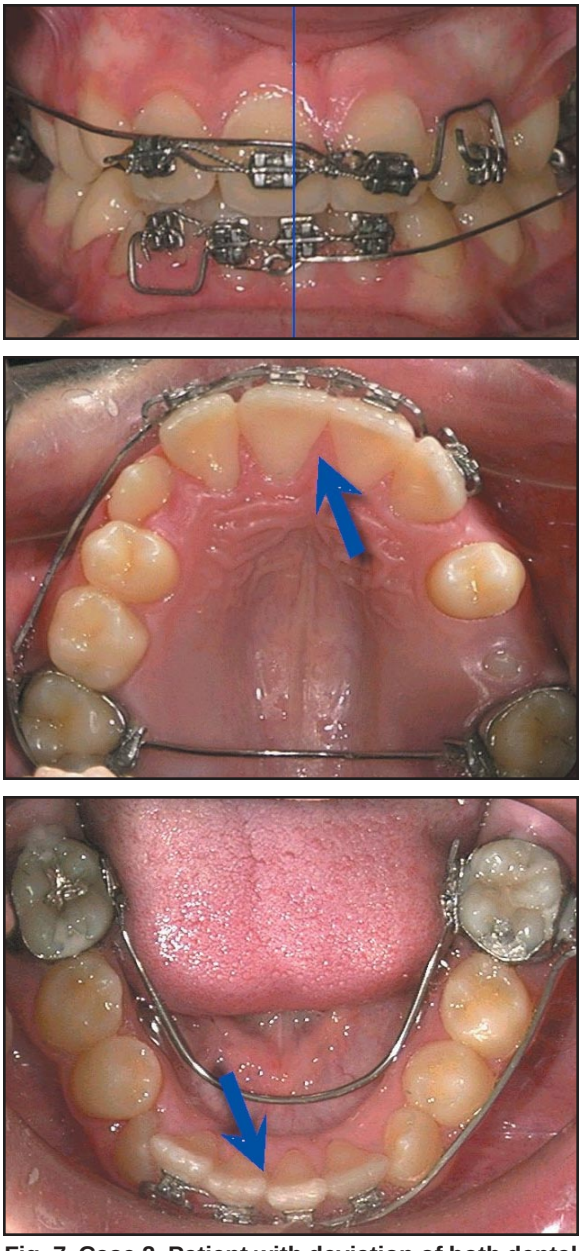

Fig. 7 Case 2. Patient with deviation of both dental midlines and insufficient space for proper eruption and alignment of maxillary left and mandibular right canines, requiring simultaneous space opening and midline correction (see Fig. 3). Force (blue arrows) was applied to anterior teeth with two unilateral cantilevers made of .017" × .025" TMA inserted into first molar tubes, ligated with single-point contacts near midline, and activated about 50g. Transpalatal and lingual arches were used for molar anchorage.**

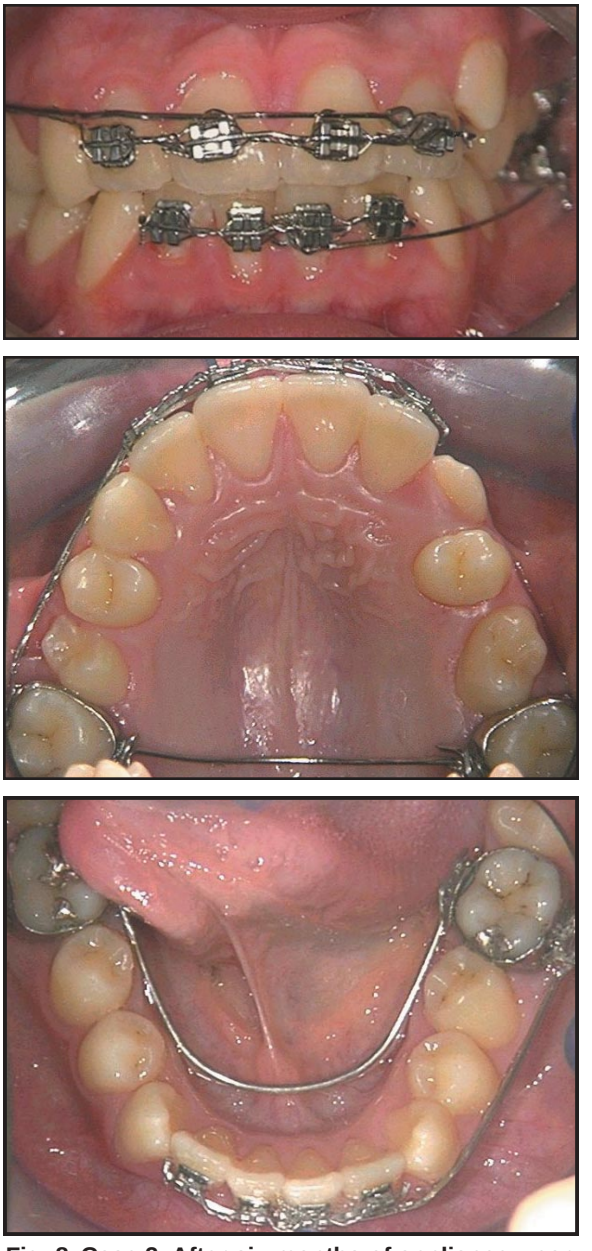

Fig. 8 Case 2. After six months of appliance wear, showing nearly complete correction of midline discrepancies in both arches, with enough space available for alignment of canines.

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Discussion

To avoid the side effect of molar rotations in cases such as this, it is critical to consolidate the posterior units in both arches by connecting the molars with transpalatal or lingual arches. The anchorage units must be carefully monitored, so that the lingual arches can be activated to counter the forces from the cantilevers.

These cantilever appliances are simple, but their effectiveness depends on a proper analysis of the required tooth movements. Both the lengths of the cantilevers and the magnitude of forces they produce must be accurately predicted and measured. With this approach, even difficult midline discrepancies can be reliably corrected, reserving the use of asymmetric elastics for the cases that need additional guidance of the mandible.

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