A reexamination of various extraoral appliances in light of recent research findings

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Abstract: The location of the center of resistance of the dentomaxillary complex has recently been identified more accurately than before. Based on this new finding, various modifications of the common facebow are presented for use in protraction therapy. Clinical applications for specific treatment objectives are also reviewed. Orthopedic and biomechanical implications of various standard retraction type extraoral appliances are also analyzed.

Key words: Extraoral appliances, Protraction headgear, Center of resistance, Maxillofacial complex

When a constrained dental structure is to be translated, only a single simple force must pass through its center of resistance.[1-3] If it does not, or if the force system acting at the center of resistance is more complex than a simple single force, rotation will occur.

Recently Dr. Kong-Geun Lee and co-workers[4] succeeded in identifying the location of the center of resistance of the maxillary dentition and its supporting osseous structure, herein referred to as the dentomaxillary complex. This finding is of clinical importance because, up to this time, with the center of resistance unknown, bilateral elastic protraction forces were applied to the dentition in an effort to alter developing Class III malocclusions. Their lines of action and points of attachment were essentially dictated by the commissure of the lips (see Figure 1A). This produces an equivalent protraction force accompanied by an undesirable counterclockwise moment at the center of resistance, shown in Figure 1B, which results in the dentomaxillary complex rotating about a point superior to its center of resistance. This is undesirable because it results in mandibular rotation and increased lower facial height. Since Class III malocclusions are generally not characterized by deep overbites, and because mandibular rotation will provide a pseudo correction of the Class III relationship, the value of this protraction force system is sometimes questionable.[5,6]

The center of resistance of the dentomaxillary complex, viewed in the sagittal plane, is positioned on a line perpendicular to the functional occlusal plane located at the distal contacts of the maxillary first molars as seen on a lateral cephalogram. It is further identified at one-half the distance from the functional occlusal plane to the inferior border of the orbit, seen in Figure 2. There are two centers of resistance of the maxillary complex when viewed in the frontal aspect (Figure 3A-B). This is because the dentomaxillary complex is essentially made up of two bones—a right and a left maxilla—each containing one-half the dental arch. Each maxillary bone articulates with the other at the median palatine suture, and relatively symmetrically on each side with the frontomaxillary suture, the nasomaxillary suture, the zygomaticomaxillary suture, and the transverse palatine suture. Because each of the protraction forces (one on each side) results in a moment that tends to stress the midpalatine suture greater at its distal area than at its anterior aspect, each half of the dentomaxillary complex acts somewhat independently. Thus, two centers of resistance are identified. However, if protraction forces are applied in the presence of a stiff .036 stainless steel transpalatal arch or a sutural expander, the left and right maxillary bones act as one unit, for the separating moments are now negated by the presence of either of these devices.

To make use of the locations of the

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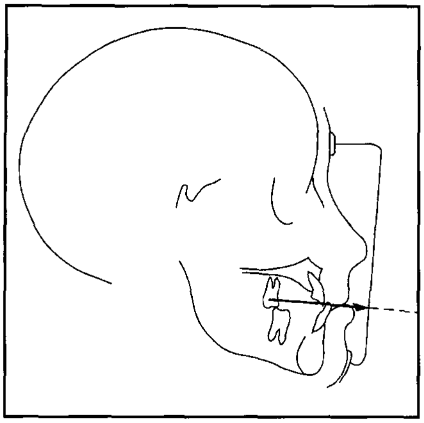

Figure 1A
Line of action of common protraction forces in the sagittal view

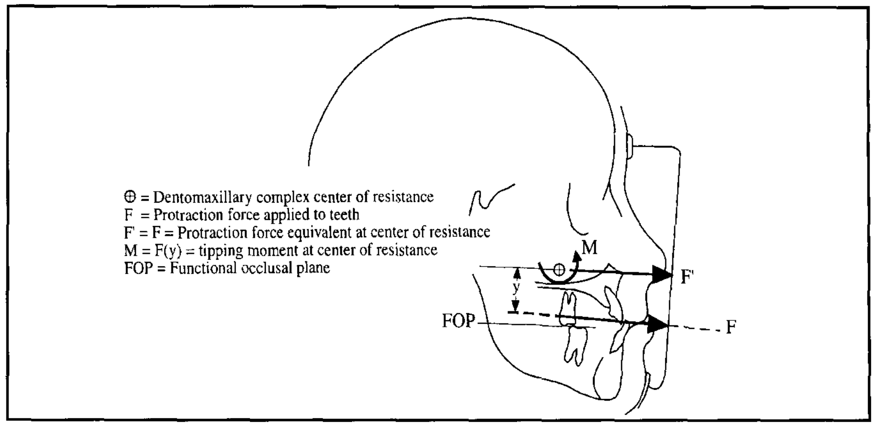

Figure 1B
Force system at center of rotation of dentomaxillary complex

centers of resistance in a clinical setting, it is important to transfer them from the cephalograms to the patient's face. This is done by holding an amalgam plugger (or equivalent) in the maxillary vestibular region while the teeth are in occlusion and the soft tissues and lips are relaxed. (The amalgam plugger handle is held in position as it exits through the commissure of the lips.) The amalgam plugger, facing buccally, is positioned at one-half the distance from the inferior border of the orbit to the functional occlusal plane and corresponding to the distal contact of the maxillary first molar. (See Figure 2) The amalgam plugger may then be easily palpated on the outer surface of the cheek and a mark made on the skin surface corresponding to it. This should be repeated bilaterally to check for reasonable symmetry in the frontal view, and if there is an obvious asymmetry, the procedure should be repeated to determine if and where an error may have occurred. This corresponds to 50% of the dimension seen on the patient's lateral cephalogram. From a clinical viewpoint, it is not necessary to factor in relative radiographic enlargement.

A standard facebow may then be contoured to insert in the maxillary molar tubes *from the distal* (see Figure 4). The outerbow is adjusted so that

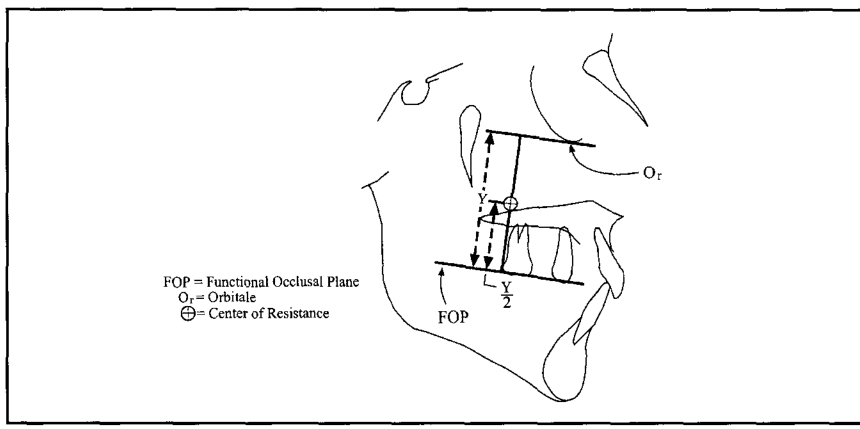

Figure 2
Center of resistance of the dentomaxillary complex, sagittal view

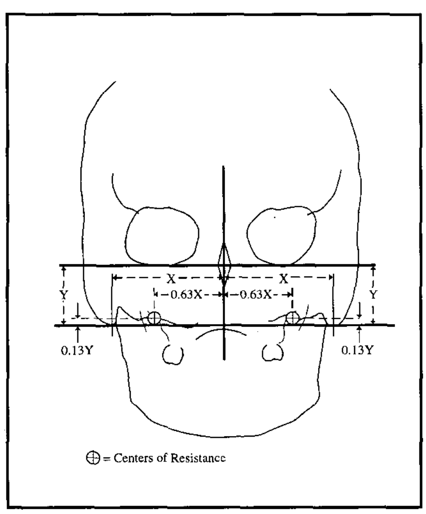

Figure 3A
Centers of resistance of the dentomaxillary complex, frontal view

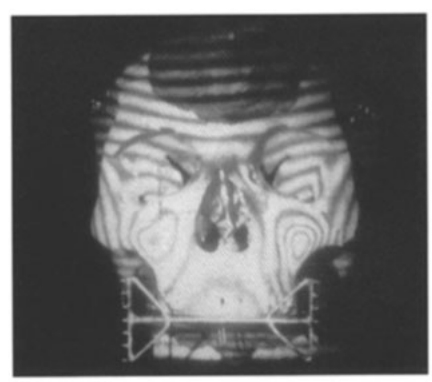

Figure 3B
Micro stress pattern of the dentomaxillary complex, frontal view

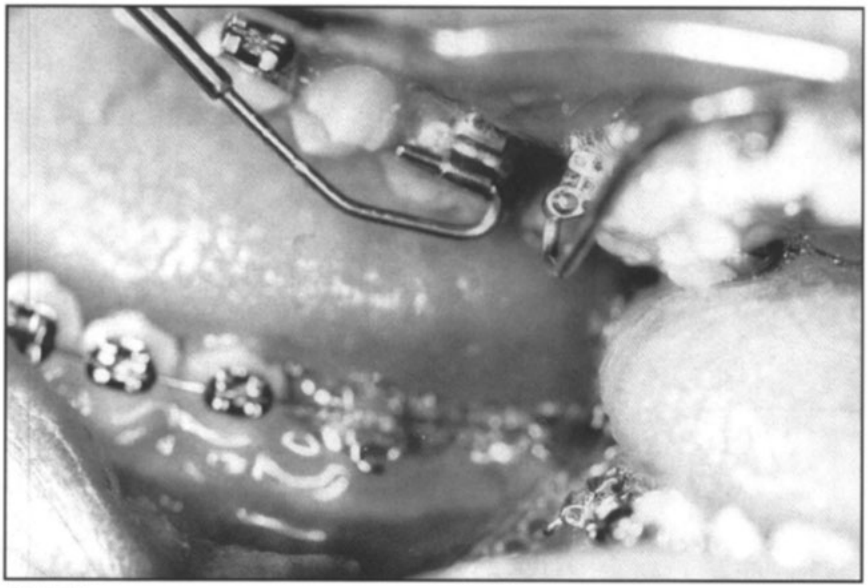

Figure 4
Inner bow contour for insertion from the distal/first molar tubes

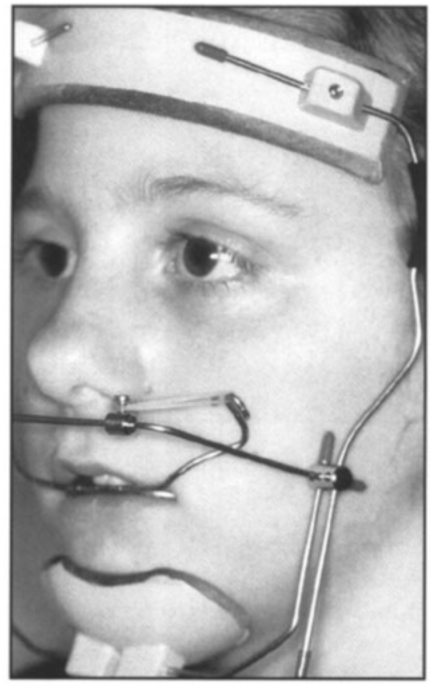

Figure 5
Outer bow contour for true protraction of the dentomaxillary complex

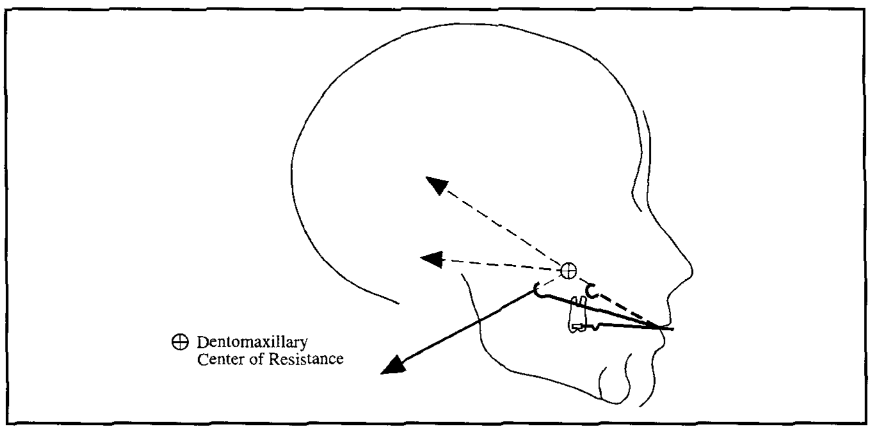

Figure 6
Orthopedic forces in relation to the dentomaxillary center of resistance

the lines of action of the protraction forces pass through the centers of resistance bilaterally, as shown in Figure 5, resulting in anteroposterior translation. The rotating moment cited above, tending to open the midpalatal suture, may be advantageous since it tends to widen the dental arch in the molar region. A protraction force of 12 ounces per side for 14 hours per day has been recommended.[7]

It is important to note that in the case of vertical maxillary excess, protraction forces passing through the facial markings in the lateral view can be designed to have an intrusive or impaction component. An extrusive component can be similarly obtained in the case of a maxillary deficiency. The protraction force may also be located above the facial markings (in the lateral view), resulting in a clockwise rotation moment accompanying the protraction force. This resulting moment has the potential of rotating the anterior portion of the maxilla downward without posterior maxillary extrusion. Consequently, it may be possible to obtain an improved incisor/lip relationship, if desired, absent mandibular rotation.

In the case of protraction therapy the clinician should consider both its appropriateness and timing. For example, if the primary cause of a Class III relationship is excessive mandibular growth (vs. maxillary deficiency), then the appropriateness and real effectiveness of initiating therapy prior to the diminution or cessation of growth is in serious doubt. In consideration of this, if the clinician were to delay initiating protraction therapy until the time when little or no additional mandibular growth remains, then the required sutural responses of the maxillary complex would be in question. If, on the other hand, the cause of a Class III relationship is a maxillary complex deficiency (in the presence of a normal mandible), then protraction therapy prior to cessation of growth may be beneficial.

It should be noted that employing protraction therapy in this instance still requires accumulation of additional clinical evidence regarding its effectiveness.

Other extraoral appliances are more commonly used to alter the naturally occurring downward and forward

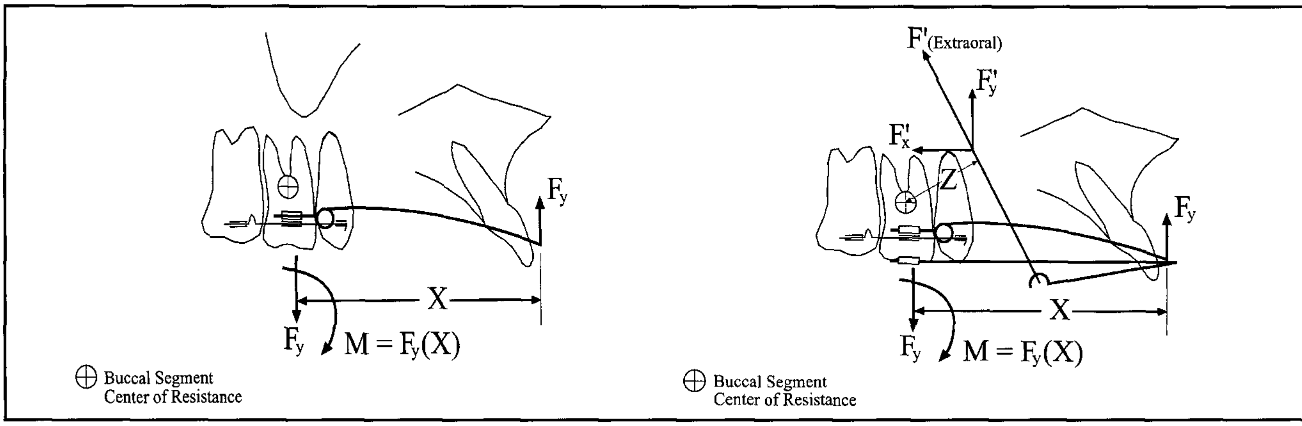

Figure 7A-B
A (left): Force system of an intrusion arch/maxillary incisors. B (right): High-pull extraoral appliance to negate reactive forces of maxillary intrusion arch

growth of the maxilla in the correction of Class II skeletal relationships.[8-12] This correction, as in the protraction facebow, is essentially orthopedic with little or no attendant dental movement. In light of the identification of the dentomaxillary complex centers of resistance, more accurate orthopedic correction may be accomplished in a variety of ways. Figure 6 illustrates various directions of forces passing through the center of resistance absent any applied moments in the sagittal view. However, the clinician may wish to adjust the outer bow to provide a force anterior to, above, or behind the center of resistance. This can provide clockwise or counterclockwise orthopedic moments in addition to intrinsic distal, intrusive, or extrusive forces as the correction of the individual malocclusion requires. It should be pointed out that the inner bows enter the molar tubes from the mesial in retractive facebows, unlike the protraction facebow.

The discussion above focuses on orthopedic applications of the extraoral appliance. However, extraoral appliances can also fulfill the additional requirement of negating or enhancing intraoral forces applied to the teeth.[13] As an example, the intrusive arch[14] shown in Figure 7A will result in a reactive moment ($M=F_y X$) and extrusive force (F_y) on the posterior teeth. These can be negated by applying a "high pull" extraoral force, as shown in Figure 7B.

Major factors have been reviewed in the appropriate design of extraoral appliances that will result in forecastable treatment outcomes. In the case of orthopedic changes, clinical identification of the centers of resistance of the dentomaxillary complex is important, whether protractive or retractive extraoral force systems are employed. The relationship of the lines of action of extraoral forces to these recently located maxillary centers of resistance, and their resulting moments and force directions, have been elucidated. Indications for various directions of forces and moments for differing clinical needs have also been described.

If the primary purpose of the extraoral appliance is to balance intraoral appliance force systems, the centers of resistance of the reactive teeth must be identified and appropriate calculations or estimates made to negate or enhance the intraoral force systems. Additionally, the clinician should be aware that balancing intraoral force systems is not without potential orthopedic effects. Finally, understanding the line of action of the extraoral force relative to an identified center of resistance is very important in achieving orthodontic treatment goals.

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