

# A New Non-Surgical Approach for Treatment of Extreme Dolichocephalic Malocclusions

## Part 1 Appliance Design and Mechanotherapy

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**F**orty years ago, Schudy posited the importance of maxillary molar extrusion in vertical facial development.<sup>1,2</sup> Other reports followed,<sup>3-5</sup> along with a cephalometric analysis centered around vertical diagnosis.<sup>6</sup> Subsequent studies identified treatment modalities that could be used to control and, to a limited extent, reduce the vertical dimension during conventional orthodontic treatment.

No investigator has published in this field as long as Pearson,<sup>7,8</sup> who has employed mandibular cervical traction,<sup>5</sup> a vertical-pull chin cup,<sup>9</sup> and vertical-pull headgear.<sup>10</sup> Others have used posterior bite blocks of varying thicknesses,<sup>11</sup> as well as spring-loaded appliances<sup>12,13</sup> and repulsive magnets.<sup>13-17</sup> Kuhn<sup>18</sup> and Thurow<sup>19</sup> proposed a high-pull headgear in conjunction with maxillary dental occlusal coverage, while DeBerardinis and colleagues used a transpalatal acrylic pad, constructed at some distance from the hard palate, to transmit an intrusive force from the tongue to the maxillary molars.<sup>20</sup> Villalobos and colleagues were able to prevent some eruption of mandibular molars with a lingual holding arch.<sup>21</sup>

The influence of soft tissue on the dolichofacial patient has also been investigated. Measurable results were obtained in young children who chewed a tough resin,<sup>22</sup> and this prompted addi-

tional study.<sup>23,24</sup> More recently, the reports of English and colleagues served as a reminder of the importance of muscle activity in the dolichocephalic face.<sup>25-27</sup>

During orthodontic treatment of these patients, an increase in the vertical dimension is generally accompanied by unfavorable changes in facial esthetics. Conventional functional appliances tend to increase anterior facial height (AFH) by encouraging mandibular molar eruption<sup>28-32</sup>; the present author developed a functional appliance that controlled AFH, but could not reduce it.<sup>33</sup> Class II elastics are likewise contraindicated in Class II patients with vertical excess, because they exert an extrusive force on the mandibular molars and maxillary incisors. Interarch compressive springs can be used in dolichocephalic facial patterns,<sup>34</sup> but still have produced no reduction in AFH.<sup>35</sup>

With the advent of skeletal anchorage, vertical control became a more realistic treatment goal. The pioneering report of Creekmore and Eklund described a case of maxillary incisor intrusion.<sup>36</sup> The onplant of Block and Hoffman<sup>37</sup> was then introduced, followed by the mini-implants of Kanomi, who demonstrated both anterior and posterior dental intrusion.<sup>38</sup> A few years later, Umemori and colleagues, using skeletal anchors, reported pronounced mandibular molar intrusion and subsequent open-bite correction.<sup>39</sup> This technique was recently described in more detail,<sup>40</sup> and a similar approach by Sherwood and colleagues intruded the maxillary molars in four adult patients with anterior open bites.<sup>41</sup> Comparable results have been obtained using miniscrews.<sup>42</sup>

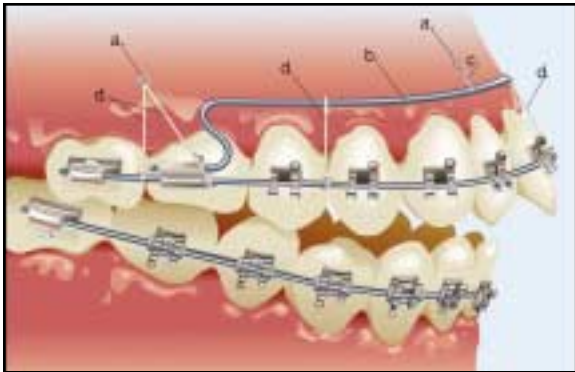
In all the reports listed above, only minor to moderate reductions in AFH and mandibular plane angle (MPA) were obtained, and these were lim-



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ited to patients with anterior open bites. When the premolars and canines were in initial contact, or when they came into contact because of molar



**Fig. 1** Maxillary Vertical Adjustable Corrector (a = skeletal anchors; b = buccal bar; c = ligature wires; d = power cords).

intrusion, further autorotation was not possible.

The Vertical Adjustable Corrector (VAC) described in this article is a natural extension of the work of Umemori<sup>39</sup> and Sherwood,<sup>41</sup> but adds a third implant in the anterior region for three-point stabilization of a large buccal bar. Thus, the VAC allows the clinician to deliver intrusive forces to any teeth in either arch, providing more precise vertical control of the entire occlusal plane.

### Appliance Design

The essential components of the VAC are the buccal bar, a trans-arch stabilizing wire, and the three skeletal implants (Fig. 1). The rigid buccal bar, made from .040" wire, is inserted into the first molar tubes and ligated to the anterior implant. A maxillary buccal bar is positioned about 1.5mm from the gingival margin and at least 3mm apical to the cemento-enamel junctions of the premolars



**Fig. 2** Buccal bars in place.



**Fig. 3** Trans-arch stabilizing appliances used with VAC. A. Maxillary. B. Mandibular. C. Rapid palatal expander later used for five months; note impaction of posterior teeth into alveolar process.

and anterior teeth; in the mandibular arch, the bar should rest slightly more occlusally (Fig. 2).

The trans-arch stabilizing wire, which is soldered to the lingual surfaces of all erupted molars and second premolars, is made of .040" resilient stainless steel (not dead-soft retainer wire) that is heat-treated after fabrication. This wire must be kept at least 5mm away from the palatal vault and 4mm from the lingual surfaces of the mandibular anterior teeth (Fig. 3). In extreme dolichofacial patients where palatal expansion is indicated, the expander can double as the trans-arch stabilizing appliance (Fig. 3C), and the skeletal implants should not be placed until expansion has been completed.

The skeletal anchors are standard mini-bone plates,\* .6mm thick, 3mm wide, and 15mm long (Fig. 4). They can have either four or five holes and need not be T-, L-, or Y-shaped; the straight I shape is adequate and less expensive. Center-drive titanium screws,\*\* 1.8mm in diam-

eter and 5mm in length, are inserted into the two most apical holes.

### Appliance Placement

The preferred location for the maxillary posterior miniplates is in the zygomatic processes superior to the maxillary sinuses, but this can be difficult to accomplish when the desired points of emergence are distal to the first molars. In my patients, some of the screws have probably penetrated the maxillary sinuses, but I have seen no complications from such placement. The posterior miniplates should emerge 2-3mm apical to the mucogingival junction and distal to the first molars (Figs. 1,4). The single maxillary anterior mini-

\*Part No. 25-304-00 or 25-316-00, KLS Martin USA, 11239-1 St. John's Industrial Parkway S., Jacksonville, FL 32246.

\*\*Eureka Orthodontics, 1312 Garden St., San Luis Obispo, CA 93401.



Fig. 4 A. Miniplate with screws before placement. B. Posterior skeletal anchors six months after placement.



Fig. 5 Maxillary and mandibular anterior skeletal anchors.

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plate should be inserted distal or mesial to the lateral incisor and should emerge at or apical to where the buccal bar will be located (Figs. 1,5).

Mandibular posterior miniplates should be attached to basal bone, apical to the roots, and should also emerge in line with the distal marginal ridges of the first molars, 1-2mm apical to the mucogingival junction (Fig. 4). The anterior miniplate can emerge at the midline or on either side of the lateral incisors, 2-4mm apical to the mucogingival junction (Fig. 5).

One to two weeks after the implants are placed, .030" power cord\*\*\* is tied from the exposed rings of the molar implants to the archwire between the first and second molars. The power cord should be tied tightly enough to produce an initial force of 300-450g, and should be replaced monthly. In the anterior and premolar areas, .025" power cord is usually attached from the buccal bar to at least an .016" x .022" continuous archwire, generating a force of 175-250g. The timing and location of attachment of the power cord to the buccal bar depends on the amount of tooth movement desired.

### Treatment Progress

Even though the trans-arch stabilizing bar is

\*\*\*Ultratuff Round Solid elastomeric thread, Glenroe Technologies, 1912 44th Ave. E., Bradenton, FL 34203.

routinely placed 5mm away from the palate, it is not uncommon for it to become embedded in the soft tissue (Fig. 6). If the large transpalatal wire is simply removed and the power cords left attached to the miniplates, rapid buccal crown torque and an increase in MPA and AFH will ensue. In this situation, therefore, the entire appliance must be removed and a new transpalatal arch constructed, even if further molar intrusion is not desired.

During active VAC treatment, which generally lasts about 12 months, the maxillary anterior teeth are usually intruded at about 1mm per month, the molars at about .6mm per month, and the premolars and canines somewhere in between, as long as their roots have appropriate torque to keep them within the alveolar trough. Palatal root torque is sometimes required for canines with prominent buccal roots, which may intrude more slowly than the molars.

Anterior root torque must be evaluated and altered as necessary, particularly in the maxillary arch. If the initial maxillary incisor to SN measurement is less than 95°, no labial root torque may be required when the .025" power cord is tied in the anterior region. If the initial value is greater than 105°, however, 15° of labial root torque should be added at the beginning of maxillary incisor intrusion, and the angulation should be closely monitored. To avoid root resorption, it is critical that the maxillary incisor roots remain in

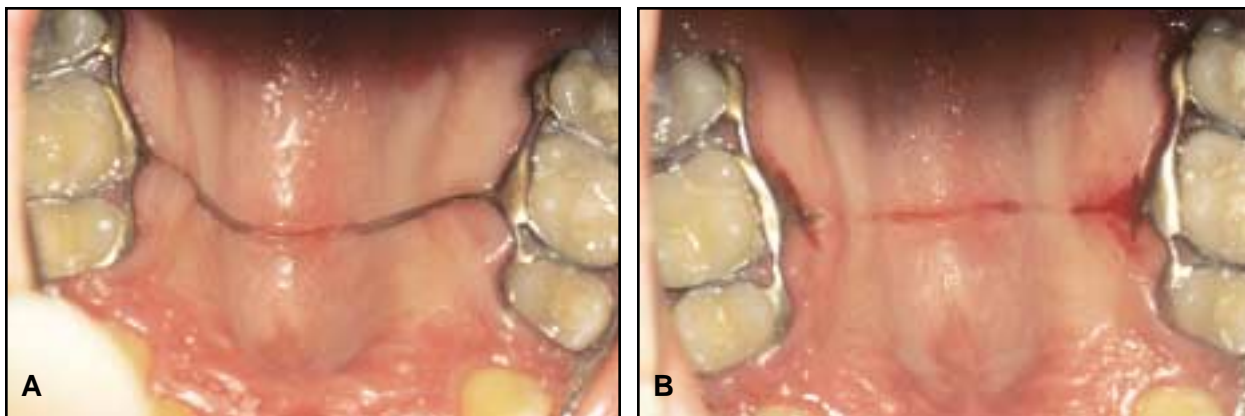


Fig. 6 A. Trans-arch stabilizing wire embedded in palate after six months of VAC treatment. B. After removal, patient ready for impression for new appliance.



the alveolar trough. Therefore, four-month progress cephalograms are mandatory.

One side is often intruded faster than the other, creating a temporary open bite (Fig. 7). The clinician should monitor treatment progress constantly to determine whether the size and location of the power cords need to be altered. If more or less distal movement of the maxillary arch occurs than is desirable, additional power cords can be placed from the posterior anchors to the appropriate teeth to create force vectors with the desired components of intrusion and sagittal movement. If the center of rotation of the maxillary occlusal plane is distal to the posterior anchor, heavy occlusion may occur on the second molars only. Because this is sometimes caused by excessive force anterior to the molar miniplates, .030" power cord should never be placed anterior to the premolars. Should more second molar intrusion be needed, a heavy power cord can be attached from the posterior anchor to the second molar, producing a strong vertical intrusive component, and a light power cord from the anchor to the canine, producing a counterbalancing horizontal distalizing component.

The posterior miniplates can also be used for anterior retraction in extraction cases (Fig. 8). Energy Chain\*\*\*\* or coil springs can be attached to continuous archwires for space closure, but if the brackets are poorly aligned, it may be necessary to



**Fig. 7** After five months of intrusion, right side has responded less than left, creating cant in occlusal plane.

disengage the second premolar or second molar from the retraction arch. A rectangular sectional archwire is then inserted only in the second molar tube, and the power cord is tied from that segment to the posterior miniplate, producing an intrusive force component on the molars.

The anterior anchors are essential, even in cases of severe anterior open bite. Without anterior anchorage, the buccal bar cannot be used and intrusion of the canines and premolars cannot occur.<sup>39,41</sup> This would limit the amount of autorotation and the reduction in AFH to the amount obtained up to the point of canine-premolar contact. A pronounced maxillary curve of Spee and a reverse smile will be produced if intrusion is continued past the vertical level of the canine-premolar region. As the desired

\*\*\*\*RMO Inc., P.O. Box 17085, Denver, CO 80217.



**Fig. 8** Extraction site closure. A. Skeletal anchors connected to nickel titanium coil springs on continuous archwires. B. Skeletal anchors connected to anterior power arms.

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degree of maxillary incisor intrusion approaches, the patient and parents should be involved in making the final decision on vertical incisor location.

When active VAC treatment has been completed, the power cords are replaced by ligature wires, and the transpalatal or lingual arches are left in place during routine finishing procedures. Four months later, the trans-arch stabilizing appliance is removed, the premolars and second molars are banded or bonded individually, and the first molars are incorporated into a new trans-arch bar. Rectangular nickel titanium wires are often used for a short time, keeping in mind that one anterior and two posterior ligatures from the respective miniplates must be replaced each time the archwire is removed. In one or two months, the standard finishing wires can be inserted for detailing. Up-and-down, Class II, or Class III elastics can be used confidently during the final stages of cases where VACs were used in both arches, as long as the ligatures to the miniplates are maintained. If additional sagittal correction is desired, either power cord from the posterior miniplates or Eureka Springs\*\* can be used.

The patient sometimes requests the removal of the buccal bar shortly after the active VAC phase has been completed. If the buccal bar is removed, an intrusion overlay wire with 1.5oz of force should be inserted in the same molar tube that housed the bar, either by first placing a DeVincenzo Insert† or by inserting the wire directly into a rectangular auxiliary tube. Occasionally, a ligature wire can be tied directly from the anterior miniplate to the archwire.

Although I have done nothing unusual during the standard retention phase of orthodontic treatment, it might be beneficial to recommend that the patient chew gum a few hours a day for six months,<sup>22-24</sup> or to stimulate occlusal forces by other means.<sup>27</sup> I have also considered placing a mandibular lingual arch during treatment with only a maxillary VAC.<sup>21</sup>

### Discussion

Shortly after Creekmore and Eklund's 1983 article appeared,<sup>36</sup> I began placing titanium bone screws at A point in adult patients. By 1992 I had

inserted eight of these screws, but five of them failed, even after waiting four to five months for osseointegration. Work then began on a new orthodontic anchor called a "stemplant"‡; more than 100 of these were placed from 1996 to the present, with reasonable success in most buccal regions (a failure rate of about 30%). All the early VAC systems, beginning in 2000, used stemplants inserted at A or B point for anterior stabilization of the buccal bar. If the implant failed, however, the subsequent orthopedic response was significantly reduced. This was the reason for experimenting with miniplates. Anterior miniplates inserted at A point failed eight out of eight times, but no miniplate that has been placed mesial or distal to the lateral incisors has failed, out of 34 VAC treatments since 2004. The anterior mandibular miniplates seem to be stable in any interdental location.

In early VAC treatments, I used Power Tube,\*\*\*\* which was replaced every four to six weeks. The rate of intrusion was slow, however, and shortening the replacement period to three weeks allowed the active phase to be completed in about a year. Switching to the power cord has permitted a return to monthly replacement while achieving more rapid intrusion.

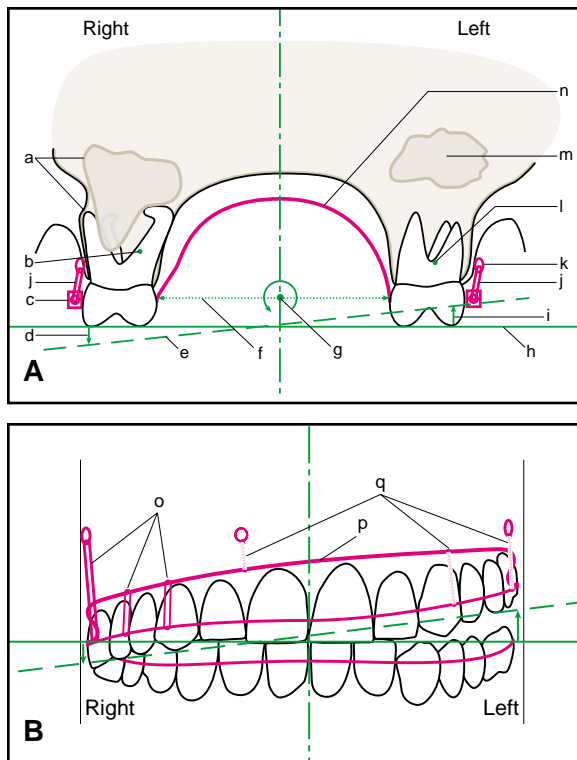
Resistance to intrusion could be attributed to a variety of factors, including root proximity to cortical bone and maxillary sinuses, root surface area and morphology, vascular supply, local and generalized individual osteoblast activity, and proximity to underlying basal bone or the mandibular neurovascular bundle. Other considerations may also come into play when groups of teeth are intruded in an effort to manipulate the occlusal plane. Some of these factors are represented in Figure 9A. In this example, the transverse center of rotation is shown at the midline, which is not necessarily accurate. Note that as transverse counterclockwise rotation occurs, the mesiobuccal root

\*\*Eureka Orthodontics, 1312 Garden St., San Luis Obispo, CA 93401.

\*\*\*\*RMO Inc., P.O. Box 17085, Denver, CO 80217.

†Part No. 47-051-22, GAC International, 355 Knickerbocker Ave., Bohemia, NY 11716.

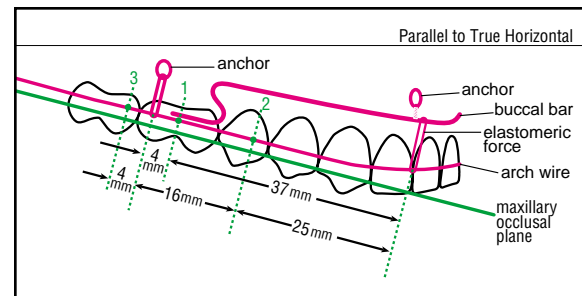
‡DeVincenzo, J.P. and Prins, S.: Subperiosteal bone anchor, U.S. Patent No. 5,853,291, 1998; DeVincenzo, J.P.: Subperiosteal bone anchor, U.S. Patent No. 6,379,154 B2, 2002.



**Fig. 9** A. Transverse view at mesial of first molars (a = cortical bone; b = right molar center of resistance; c = molar attachment; d = right molar extrusion; e = cant of occlusal plane; f = intermolar distance; g = transverse center of resistance of maxillary dentition; h = original transverse occlusal plane; i = left molar intrusion; j = equal elastomeric force on both sides; k = skeletal anchor; l = left molar center of resistance; m = maxillary sinus; n = trans-arch stabilizing appliance). B. Frontal view after several months of equal intrusive forces applied to left and right posterior teeth (o = varying force of power cord; p = buccal bar; q = ligatures to skeletal anchors and buccal bar).

of the right molar is thrust against the dense and metabolically less active cortical bone, whereas no such effect occurs with the left molar. Even if equal intrusive forces were applied to both molars, the right molar would respond much differently, partly because of this rotational effect.

When a unilateral open bite occurs, the power cords must be replaced by ligature wires on the overintruded side while intrusive force is added to



**Fig. 10** Importance of force, moment arm, and center of resistance in VAC treatment (1, 2, 3 = hypothetical centers of resistance).

the opposite side (Fig. 9B). Failure to do so can result in a shift of the transverse center of rotation.

If the center of rotation moves to the patient's left, the resulting movement could actually extrude the right molar, producing an increase in MPA and AFH. Although this rarely occurs clinically, some cases show no reduction in MPA and AFH. Unequal posterior intrusion, with the accompanying cant of the occlusal plane, is a common occurrence (Fig. 7).

The importance of the center of resistance is more obvious in the sagittal dimension. Figure 10 shows three hypothetical locations for the center of resistance. Clinically, location 1 is the most common, but with prominent canine and, occasionally, premolar roots, the center of resistance may be closer to location 2. Location 3 is the least common and is generally seen only in the mandibular arch. If the center of resistance is at location 1, a posterior moment arm of 4mm and a force of 400g would result in a clockwise moment of 1,600g-mm; an anterior moment arm of 37mm and a force of 200g would result in a counterclockwise moment of 7,400g-mm. This could cause significant intrusion of the anterior segment and even extrusion of the second molar's distobuccal cusp, with a consequent increase in anterior open bite, MPA, and AFH (Fig. 11).

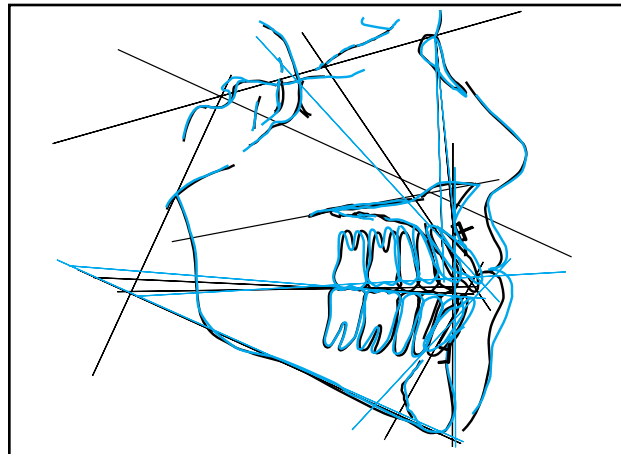
If the center of resistance is at location 2, a posterior moment arm of 16mm and a force of 400g would result in a clockwise moment of 6,400g-mm; an anterior moment arm of 25mm and a force of 200g would result in a counter-

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clockwise moment of 5,000g-mm. This would produce a net intrusive force of 600g on the entire assembly, with a clockwise couple of 1,400g-mm. All other factors being equal—an unlikely assumption based on the discussion of Figure 9—this would result in a slight posterior open bite, and the clinician would need to increase the amount of anterior force.

If the center of resistance is at location 3, a light anterior intrusive force vector will have to be employed. Clinically, this is accomplished by replacing the anterior power cord every two to



**Fig. 11** A. Patient at beginning of VAC treatment. B. After 10 months of VAC treatment, with anterior moment arm much greater than posterior moment arm. C. After 17 more months of VAC treatment, with more balance between anterior and posterior moment arms, showing vertical translation of occlusal plane.

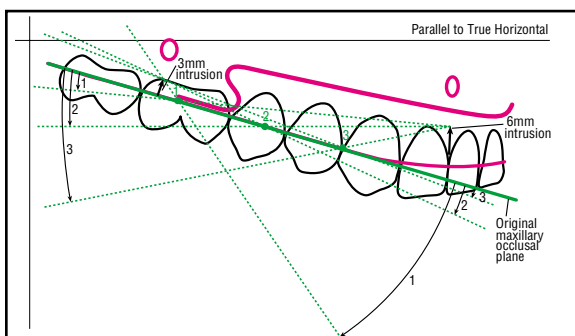


three months while replacing the posterior power cord every month.

The marked effect of changes in the location of the center of resistance emphasizes the importance of the anterior anchor and the buccal bar if intrusive translation of the occlusal plane is desired (Fig. 12). It can also explain why AFH increased in the reports of Umemori and colleagues<sup>39</sup> and Sherwood and colleagues.<sup>41</sup> As the center of rotation moves anteriorly to locations 2 and 3, the same amount of posterior molar intrusion has less extrusive effect in the anterior region.

Likewise, if the center of resistance is at location 1, an anterior intrusion of 6mm can cause second molar extrusion (Fig. 12) or at least result in insufficient posterior force to intrude the second molars (Fig. 11). As the center of resistance moves more anteriorly to locations 2 and 3, a tendency toward molar extrusion increases, along with an expected increase in AFH and MPA.

If only the first molars are banded and incorporated into the trans-arch appliance while the second molars and second premolars are bonded, considerable buccal crown tip will be exerted on the latter teeth, even when 15-25° of buccal root torque is added at insertion. Furthermore, as the molars and incisors intrude, the canine-premolar region almost always becomes the limiting factor. Sufficient buccal root torque can be delivered to the first premolar from the second premolar via the archwire,



**Fig. 12 Importance of variations in center of resistance of maxillary occlusal plane in VAC treatment. Without balancing forces, only 3mm of posterior intrusion or 6mm of anterior intrusion is obtained.**

but both premolars cannot generally receive enough buccal root torque from the first molar to overcome the strong moment generated by the force of the power cord. This problem could be related to my own mechanotherapy, since I use .018" × .025" slots with .016" × .022" finishing wires.

Trans-arch stabilizing wires smaller than .040" undergo deformation by expansion and produce lingual root torque due to the forces generated by the buccal power cord (Fig. 9). This is a result of the lever arms and accompanying large moments produced when the power cords pull from the miniplates or buccal bar to the archwire. When these buccal forces are lessened or ligature wires replace the power cords, wires smaller than .040" release the temporary deformation, causing molar constriction and extrusion. For that reason, Bantleon and colleagues have recently recommended that palatal wires be at least .045" in diameter.<sup>43</sup>

During the first three years of VAC use, I did not level and align the posterior quadrants before placing the appliance. I found that in the finishing stages, however, the posterior teeth tended to extrude when freed from the rigid trans-arch stabilizing appliance. The entire tooth could not extrude because it was ligated to the miniplate and buccal bar, but the lingual cusps did. Placing buccal root torque, at least when using .016" × .022" wires, tended to narrow the maxillary arch, causing a relapse of the original cross-bite and an increase in AFH and MPA. Leveling and aligning the posterior quadrants prior to VAC treatment reduces finishing time and helps maintain the VAC gains.

Results can be dramatic at the end of the active phase, but holding this improvement during a year or more of routine treatment and finishing can be a challenge. Premature removal of the trans-arch stabilizing wire and buccal bar will result in some degree of relapse. Torque, tip, rotations, marginal ridge height adjustments, and final sagittal corrections should all be accomplished while the miniplate and buccal bar ligature wires are in place. During the final three months of active orthodontic treatment, the ligature wires and buccal bar can be replaced by up-and-down elastics.

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