Correcting Maxillary Molar Root Angulation with the Biocreative System

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Orthodontic brackets and wires alone are often unable to generate adequate forces to properly position the clinical crowns and roots. In many cases, the challenge arises from establishing proper torque and correcting the buccopalatal angulation of the maxillary molars.[1] Although customized auxiliary appliances can facilitate the required movements, many of the conventional biomechanical techniques for adjusting maxillary molar buccal root torque are difficult to implement in an asymmetrical, controlled manner. Iatrogenic consequences such as molar extrusion and increased vertical height may also occur.[2,3]

Temporary anchorage devices (TADs) can control the vertical component in these cases while minimizing undesirable side effects. The present article describes a Biocreative torque-correcting appliance (C-TCA) for use in complicated cases involving improper maxillary molar angulation.

Biocreative Torque-Correcting Appliance

The C-TCA design and TAD insertion point are first identified from radiographs and stone casts. A 1.6mm-diameter, 8mm-long TAD* is placed in an area of sufficient palatal bone thickness near the apices of the involved teeth (Fig. 1). To avoid root contact, the TAD should be inserted in an oblique direction.

The C-TCA is a multiloop cantilever fabricated from .036" round stainless steel wire (Fig. 2). This device can be bonded directly to the target teeth by soldering it to custom pads** on the lingual tooth surfaces. The vertical dimension of the

*Jin-E screw, Jin Biomed Co., Bucheon, Korea; www.dentalvitamin.com.
**Forestadent GmbH, Pforzheim, Germany; www.forestadent.com.
***American Orthodontics, Sheboygan, WI; www.americanortho.com.


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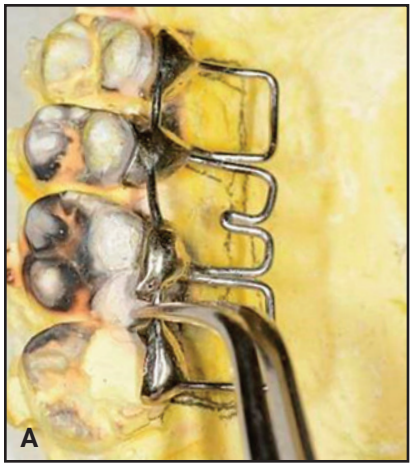
Fig. 1 1.6mm × 8mm temporary anchorage device* (TAD) inserted near apices of involved teeth.



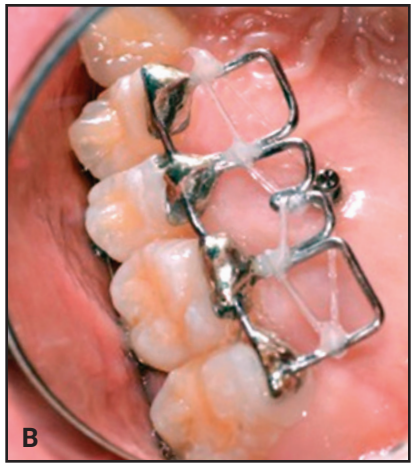


Fig. 2 A. Biocreative torque-correcting appliance (C-TCA) fabricated by bending .036" round stainless steel wire into multiloop cantilever and soldering it to lingual pads on palatal surfaces of target teeth. B. Elastic power thread*** engaged between TAD and C-TCA for activation.**

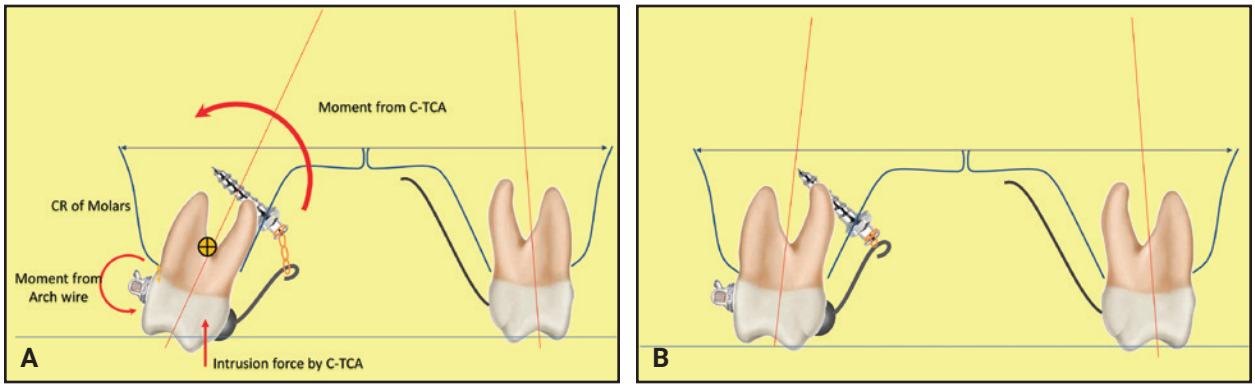


Fig. 3 Forces and moments delivered by C-TCA. A. Elastic force generates buccal root moment, inducing intrusive force on palatal cusp and extrusive force on buccal cusp (CR = center of resistance). Main archwire enhances vertical anchorage to avoid extrusion of buccal cusp. B. Buccal crown tipping corrected by moment from C-TCA; palatal cusp intruded by vertical force from C-TCA.

C-TCA depends on the amount of intrusion needed for the palatal molar cusps. Elastic power thread*** is attached between the C-TCA and TAD to generate a buccal root moment, which induces an intrusive force on the palatal cusp and an extrusive force on the buccal cusp (Fig. 3). The .017" × .025" stainless steel archwire serves as vertical anchorage to avoid extrusion of the buccal cusp. The primary result is palatal crown intrusion. Although the crown-lingual torque from the main archwire also promotes a buccal root moment, it is too weak to be effective without the C-TCA because of the small moment arm and the slot play between the molar tube and archwire.

Case 1

A 26-year-old female presented for a second opinion after 30 months of orthodontic treatment at a different office (Fig. 4). Her chief complaints were TMJ pain on the right side and mandibular shifting. Clinical examination found a 1mm anterior open bite with premature contacts of the second molars, a slight lip cant that was higher on the right side, and an upper midline shifted 1mm to the right. The tomograms were assessed by another department, which confirmed that the bite shift was not a result of sclerosis, flattening, or osteophytes of the condyles. Radiographic examination revealed severe alveolar bone and root resorption of the lower anterior teeth.

The previous orthodontist had used TADs in the lower buccal alveolar bone to retract the lower dentition and correct the Class III malocclusion (Fig. 5). This approach appeared to have been effective, but one of the TADs had fractured on the right side of the palate when a miniscrew-assisted rapid palatal expander (MARPE) was applied to correct a posterior crossbite, resulting in substantial buccal flaring of the upper right posterior segment (Table 1). The occlusal interferences had increased the anterior open bite. Superimposition of pretreatment and progress cephalometric tracings confirmed extrusion of the upper molars and bite opening, even though the lower dentition had been intruded and retracted.

A primary objective of continued treatment was to correct the crown torque of the upper right posterior teeth while maintaining the vertical dimension, thus establishing a functional stable occlusion. Because of the severely compromised periodontal condition of the lower incisors, minimal tooth movement was recommended and a fixed 3-3 retainer was planned for splinting. The application of a C-TCA would address the flared upper right posterior quadrant.

Fixed appliances placed by the previous orthodontist were left in place, and a C-TCA was

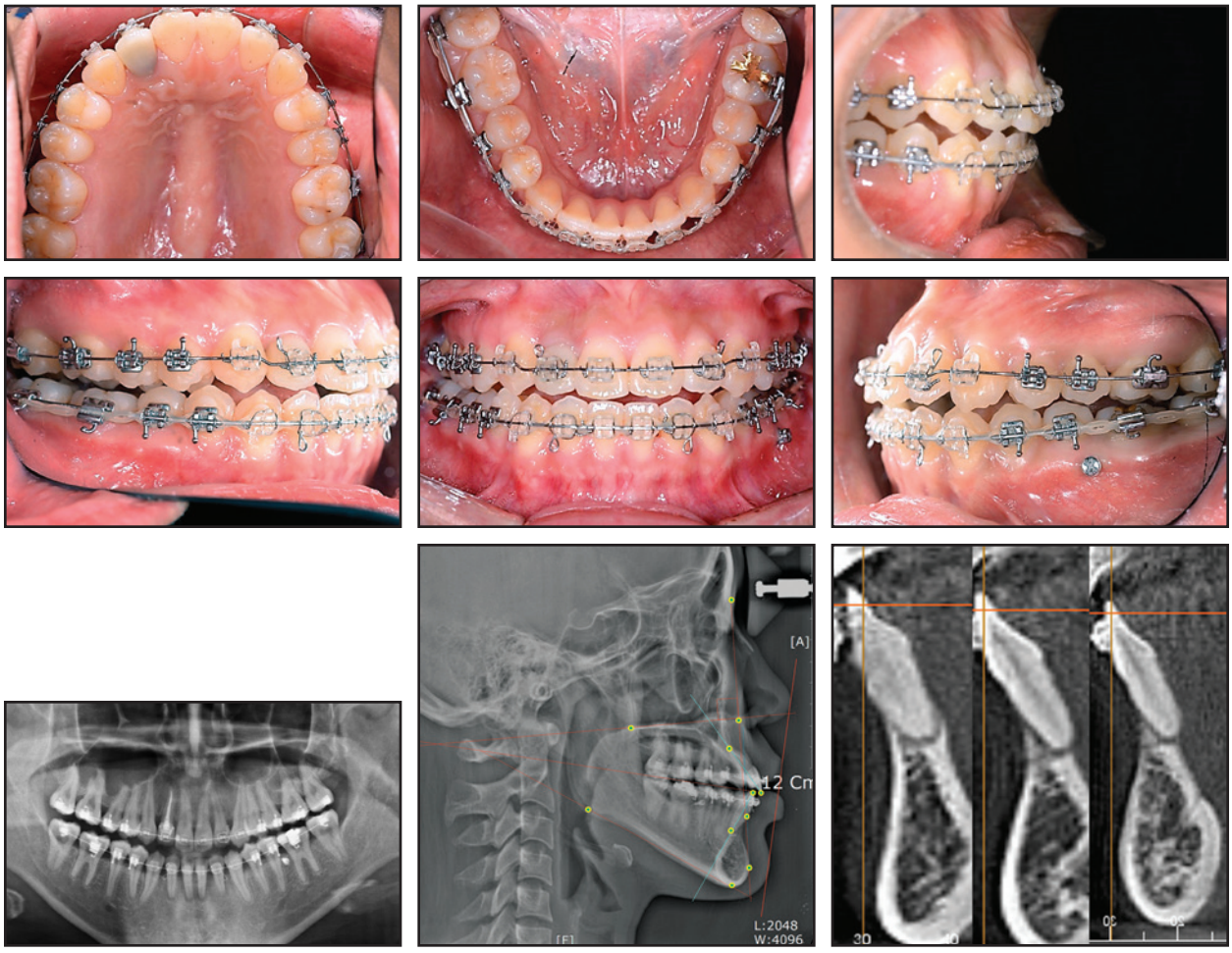


Fig. 4 Case 1. 26-year-old female patient with TMJ pain on right side, anterior open bite with premature contacts of second molars, and upper midline shifted 1mm to right after 30 months of treatment by previous orthodontist.

fabricated to control buccal torque of the upper right premolars and molars (Fig. 6). A 1.6mm × 8mm TAD was inserted palatally in the interradicular space between the upper right first molar and second premolar. RelyX† luting cement was used to bond the C-TCA. The power thread attached to the TAD was changed every three weeks to maintain light fulcrum forces, and joint pain and occlusion were checked at each visit. In the lower arch, a power chain was attached from archwire hooks to a lower left buccal TAD to improve the lower midline (Fig. 7).

After five months of treatment, with the palatal torque in the upper right posterior segment fully corrected, the C-TCA was removed (Fig. 8). The remaining fixed appliances were removed five months later, and upper and lower lingual 3-3 retainers were bonded (Fig. 9).

A Class I canine relationship was achieved,

***American Orthodontics, Sheboygan, WI; www.americanortho.com.
†Trademark of 3M ESPE Dental Products, St. Paul, MN; www.3m.com.

with canine guidance in lateral excursion, and the mandibular midline was coincident with the maxillary and facial midlines. The patient's TMJ pain was resolved with the creation of a stable occlusion. The upper right molar axis was fully corrected without affecting the upper left molar axis: the upper right first molar angulation improved from 74.2° to 77.4° and the second molar angulation from 70.7° to 75.7°, while the upper left molars displayed no substantial changes in torque (Fig. 10).

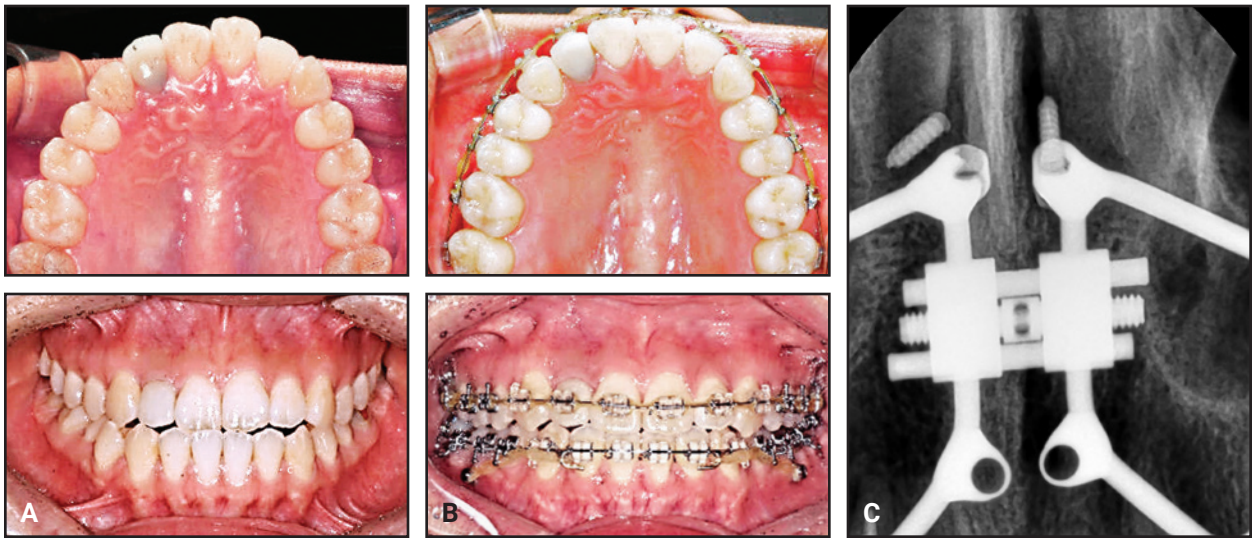


Fig. 5 Case 1. A. Patient before treatment in previous clinic. B. After 24 months of treatment in previous clinic. C. Fractured TAD on right side of palate.

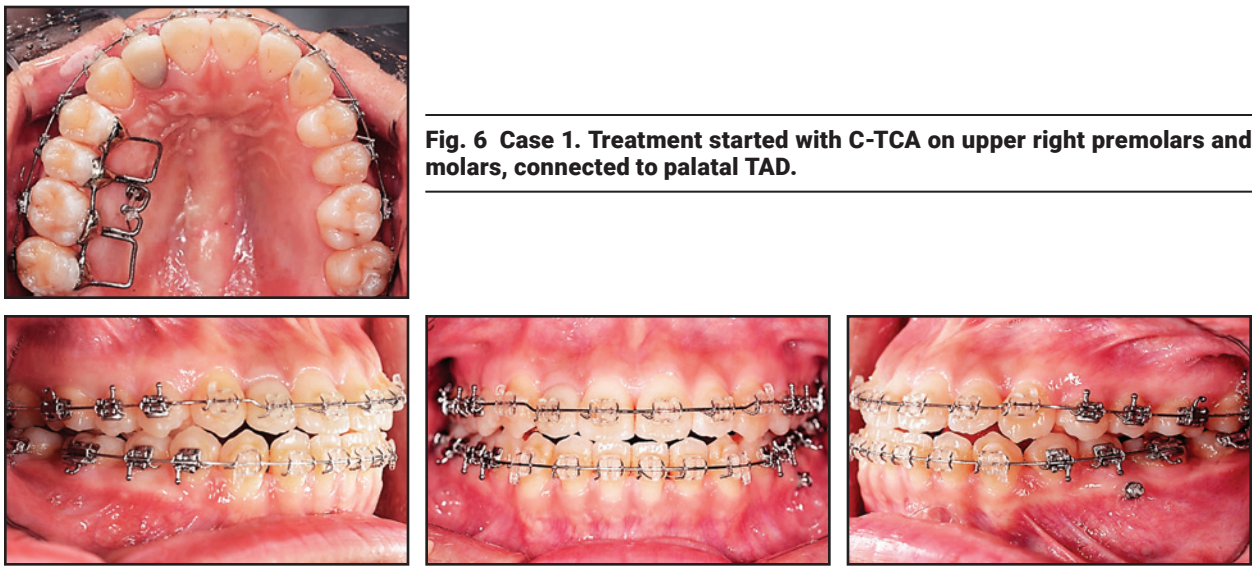
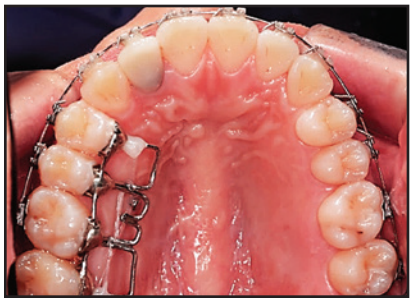
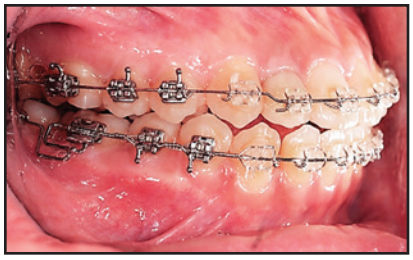


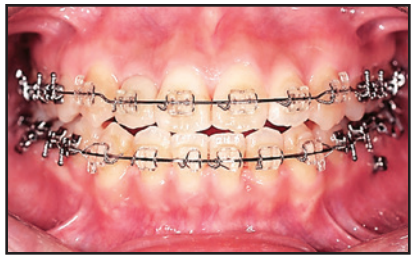
Fig. 6 Case 1. Treatment started with C-TCA on upper right premolars and molars, connected to palatal TAD.

TABLE 1
CASE 1 TWEEMAC ANALYSIS

	Mean	Pretreatment	Post-Treatment
Skeletal			
PA-PB	4.4mm ± 2.5mm	4.0mm	3.5mm
FH-PP	2.2° ± 2.3°	4.0°	4.0°
PP-MP	30.3° ± 4.3°	33.0°	32.2°
PP-Occlusal plane	11.2° ± 2.5°	11.0°	11.3°
MP-Occlusal plane	19.7° ± 3.5°	22.0°	22.5°
Dental			
U1-PP	115.3° ± 4.9°	120.0°	119.0°
IMPA	93.7° ± 7.1°	90.0°	87.0°
Dentoalveolar			
Esthetic angle	14.3° ± 5.7°	6.0°	7.5°
Soft tissue			
Superior airway width	25.6mm ± 2.7mm	20.5mm	21.3mm
Inferior airway width	11.6mm ± 3.9mm	7.3mm	11.1mm







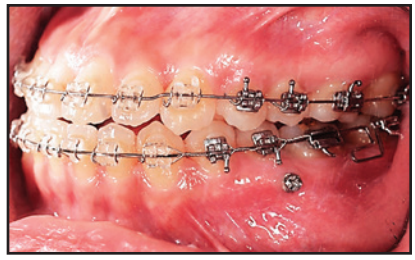


Fig. 7 Case 1. After two months of treatment.

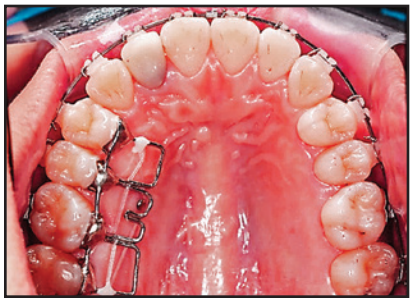
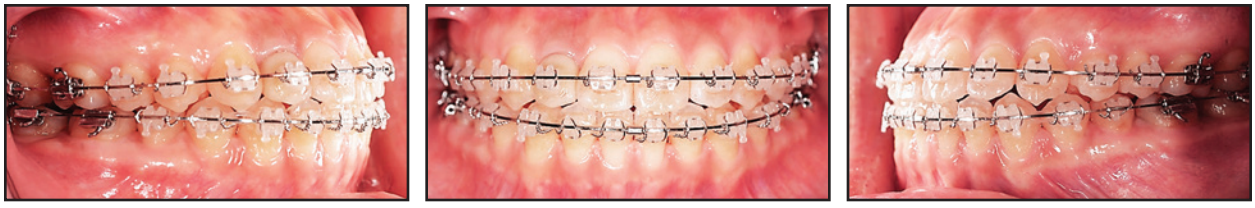
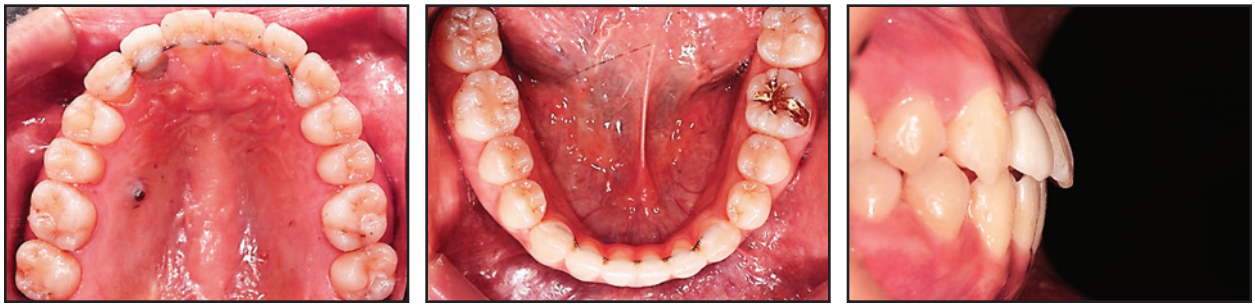


Fig. 8 Case 1. After five months of treatment.





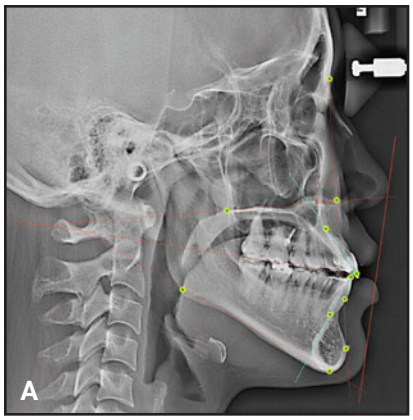


Fig. 9 Case 1. A. Patient after 10 months of treatment (continued on next page).

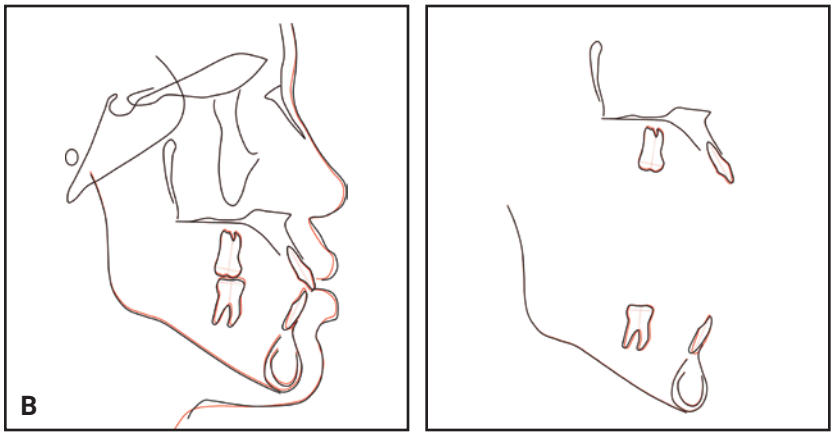
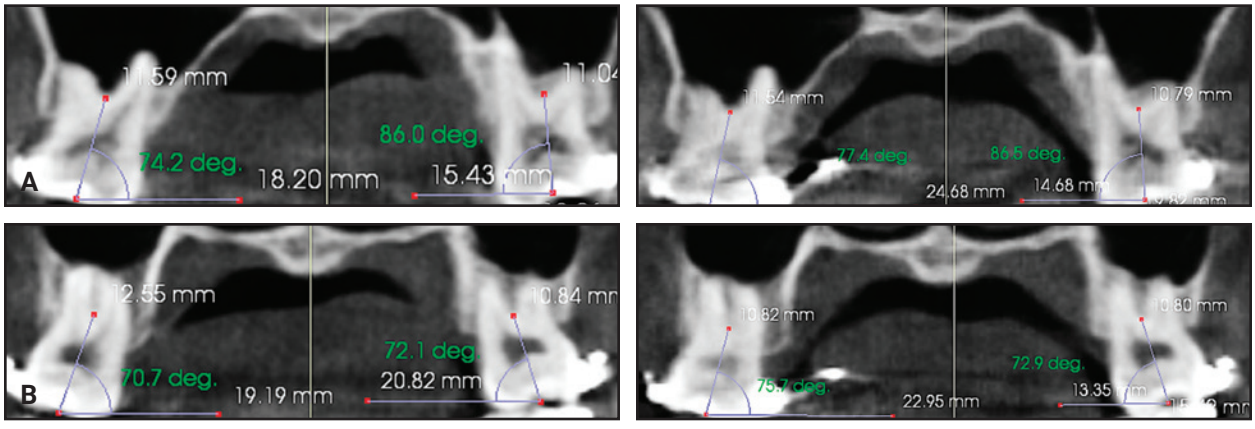


Fig. 9 (cont.) Case 1. B. Superimposition of pre- and post-treatment cephalometric tracings.



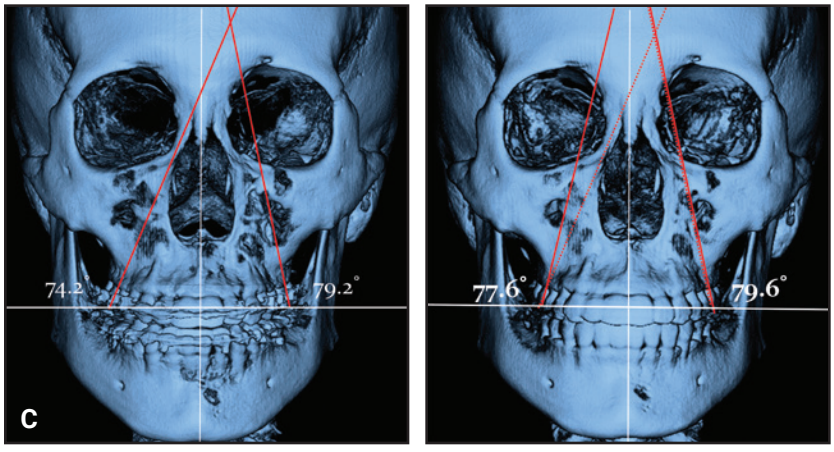


Fig. 10 Case 1 A. Improvement in upper right first molar angulation from pretreatment to post-treatment. B. Improvement in upper right second molar angulation from pretreatment to post-treatment. C. Buccopalatal improvement on right side without significant changes on left.

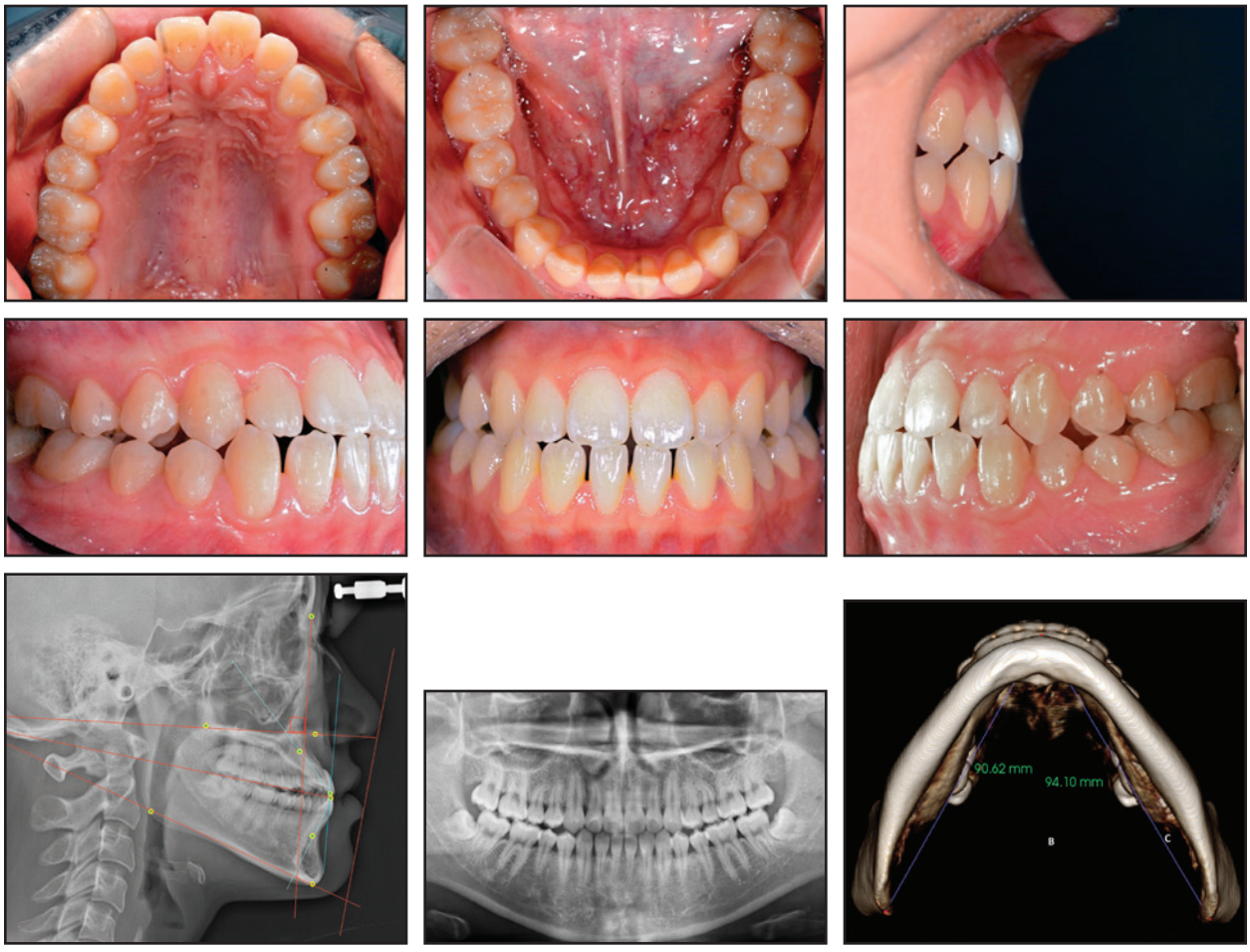


Fig. 11 Case 2. 18-year-old female patient with skeletal Class III relationship, traumatic incisor occlusion, and mandibular midline shift to right before treatment.

Case 2

An 18-year-old female presented with the chief complaints of lower anterior spacing and a protrusive chin (Fig. 11). Three-dimensional analysis indicated skeletal asymmetry and a mandibular midline shift to the right, caused by an elongated left mandible. Cephalometric analysis confirmed a skeletal Class III relationship (Table 2), which had resulted in traumatic occlusion of the incisors.

The recommended treatment plan was a "surgery-first" approach consisting of a 3mm maxillary Le Fort I advancement and 3mm posterior impaction in conjunction with a 3mm bilateral sagittal split osteotomy of the mandible and gonial reduction of 2mm. The goals were to correct the open bite, increase midfacial volume, and reduce the chin prominence. Postoperative orthodontic objectives included arch expansion, controlled tipping of the upper incisors, lower incisor intrusion to flatten the curve of Spee, and uprighting of the lower molars.

Before the bimaxillary surgery, brackets were bonded and passive archwires were inserted for surgical fixation (Fig. 12). Postsurgical dental

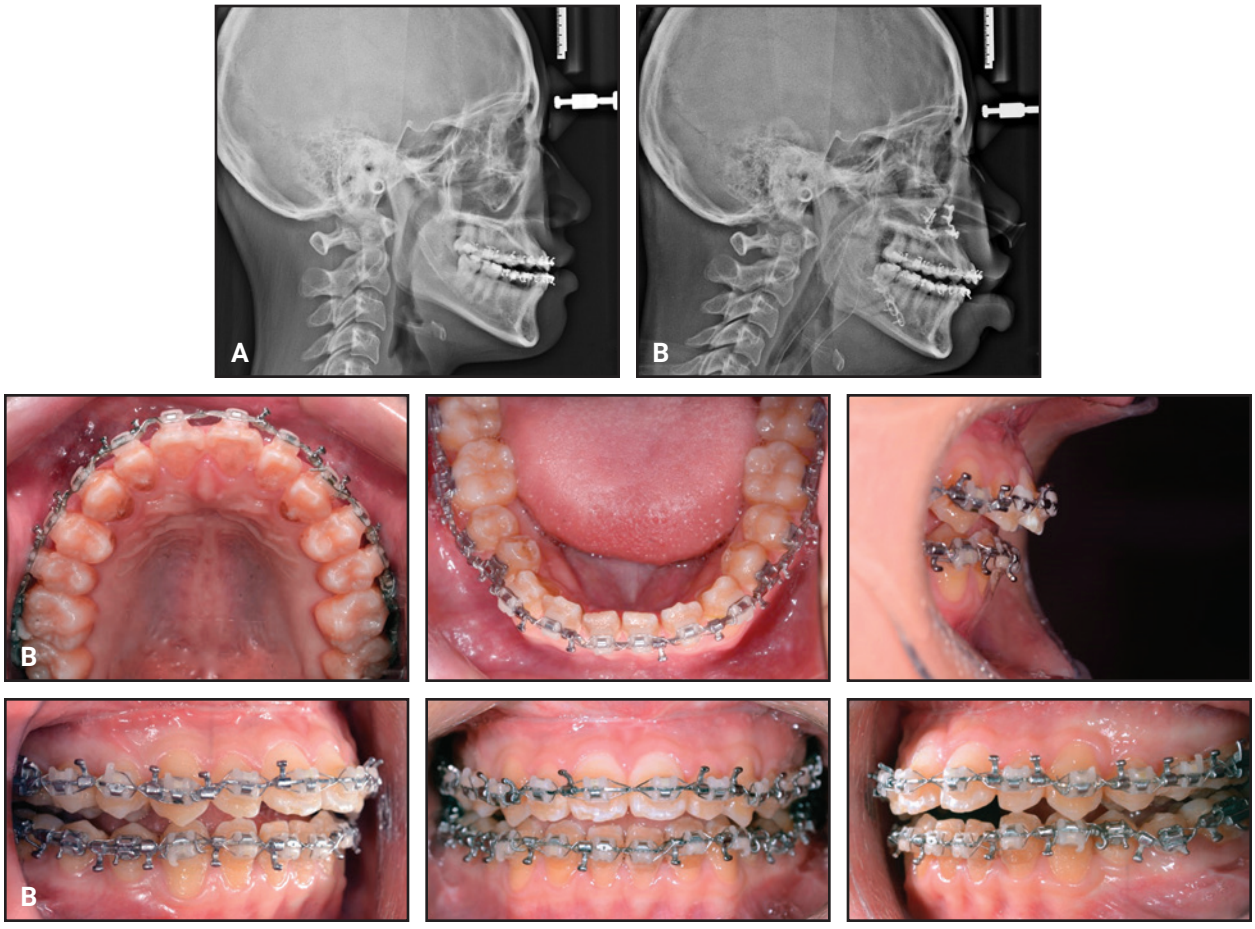


Fig. 12 Case 2. A. Before orthognathic surgery, with bonded brackets and passive archwires for surgical fixation. B. After surgery.

compensation produced flared posterior segments on both sides, which created premature contacts, and the lower midline was still deviated 1mm to the right. The patient also developed TMJ pain during the postsurgical orthodontic phase.

After four months of leveling and alignment, two C-TCAs were placed—one on each side of the upper arch, connecting the first and second premolars and first and second molars—to generate palatal crown torque for uprighting the upper molars (Fig. 13).

Four months later, the root torque of the maxillary posterior segments was significantly improved (Fig. 14), and the C-TCAs were removed. With the correction of molar angulation, the occlusion was stabilized and the patient's TMJ issues were eliminated.

The upper appliances were removed after 17 months of treatment, and a fixed lingual 3-3 retainer was bonded. Two weeks later, following additional anterior detailing, the lower appliances were removed and a bonded lingual 3-3 retainer was placed. Class I canine and molar relationships were achieved, and the upper and lower dental midlines were coincident (Fig. 15). The facial profile was improved as a result of the surgery, with a noticeable improvement in the esthetic angle (Table 2).

TABLE 2
CASE 2 TWEEMAC ANALYSIS

	Mean	Pretreatment	Post-Treatment
Skeletal			
PA-PB	4.4mm ± 2.5mm	−6.1mm	−0.2mm
FH-PP	2.2° ± 2.3°	2.5°	2.0°
PP-MP	30.3° ± 4.3°	17.4°	25.8°
PP-Occlusal plane	11.2° ± 2.5°	1.2°	6.3°
MP-Occlusal plane	19.7° ± 3.5°	16.2°	19.5°
Dental			
U1-PP	115.3° ± 4.9°	132.6°	125.2°
IMPA	93.7° ± 7.1°	88.5°	93.5°
Dentoalveolar			
Esthetic angle	14.3° ± 5.7°	0.7°	2.6°
Soft tissue			
Superior airway width	25.6mm ± 2.7mm	18.8mm	25.2mm
Inferior airway width	11.6mm ± 3.9mm	7.3mm	8.3mm

Fig. 13 Case 2. Bilateral C-TCAs placed in upper arch after four months of postsurgical orthodontic treatment.

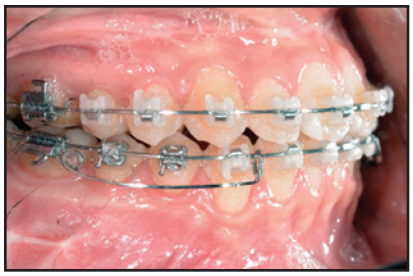


Fig. 14 Case 2. After four months of C-TCA activation.

All maxillary molar axes were fully corrected. The upper right first molar angulation improved from 76.5° to 79°, and the upper right second molar angulation from 68.7° to 71.2° (Fig. 16). The upper left first molar angulation improved from 77.7° to 80°, and the upper left second molar angulation from 72.7° to 78.3°.

Discussion

The molar axes play an important role in a functional occlusion. If an upper molar exhibits severe crown-buccal angulation, the palatal cusps will become excessively prominent, and the heavy balancing side contacts may interfere with chewing.[4-6]

Several appliance designs have been developed to correct the buccopalatal axes of the upper molars. Wirebending is a direct and simple method of adding buccal crown torque to the upper molars, but buccal root torque is difficult to achieve in this manner. In addition, because of the laws of action and reaction, the torque will inevitably be accompanied by undesirable movement of the anchor teeth.

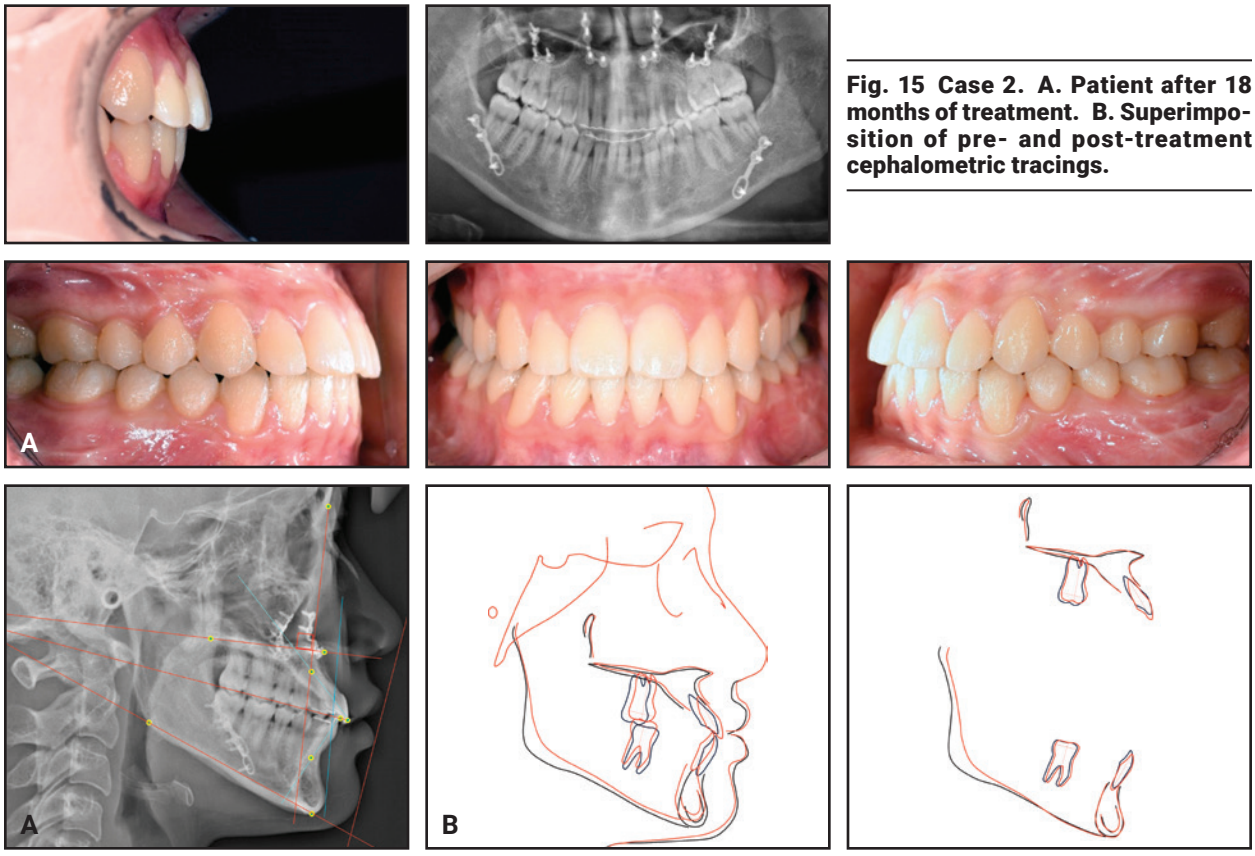


Fig. 15 Case 2. A. Patient after 18 months of treatment. B. Superimposition of pre- and post-treatment cephalometric tracings.

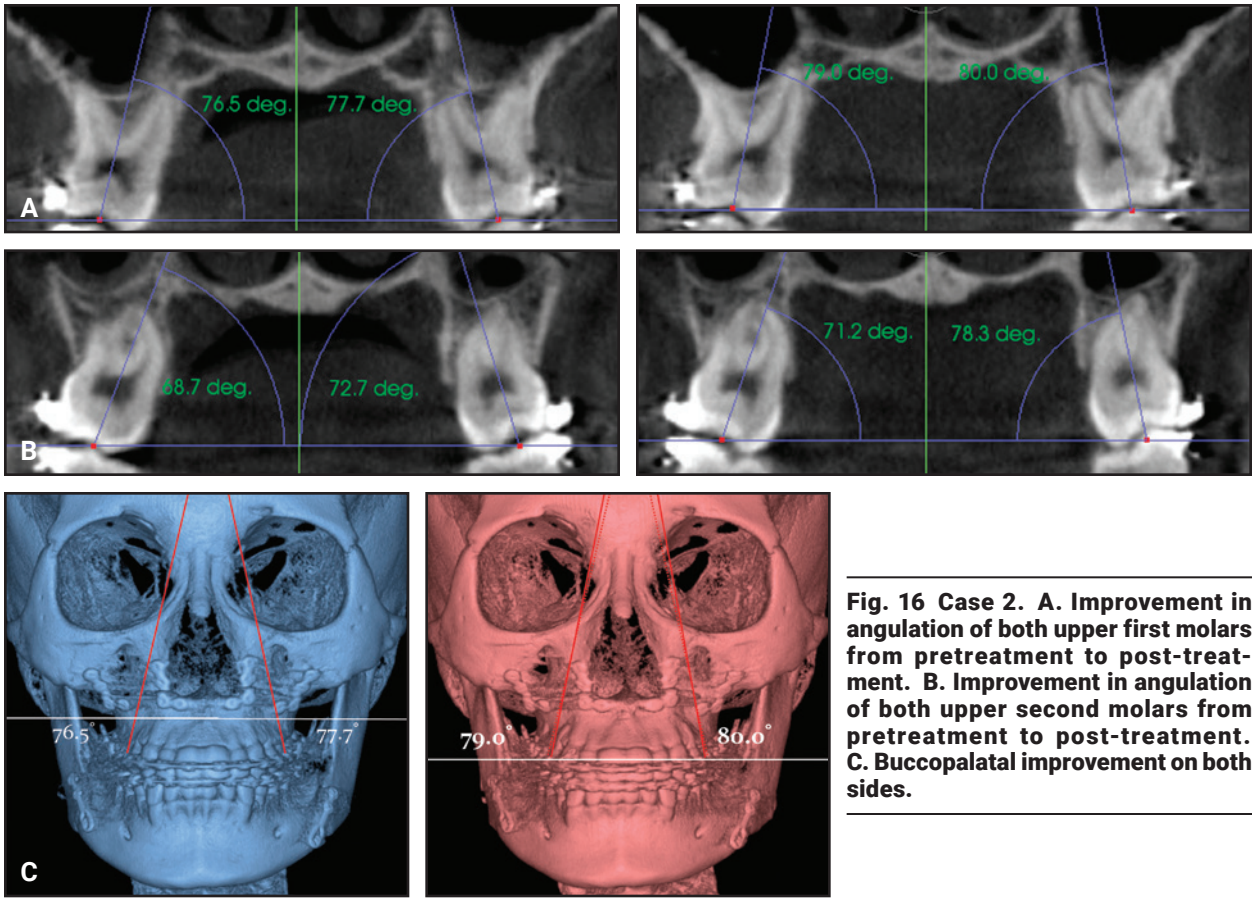


Fig. 16 Case 2. A. Improvement in angulation of both upper first molars from pretreatment to post-treatment. B. Improvement in angulation of both upper second molars from pretreatment to post-treatment. C. Buccopalatal improvement on both sides.

Although conventional rapid palatal expanders and the MARPE were intended to produce maxillary expansion without buccal crown tipping, the problem has still been reported.[7,8] Transpalatal arch (TPA) mechanics can be used to control the molar crown axes after maxillary expansion, but the application of a TPA without appropriate adjustments can result in adverse buccal crown tipping of the molar crowns, considering the distance of about 8mm between the TPA attachment and the molars' center of resistance.[9] A properly adjusted TPA can produce symmetrical buccal crown moments, but it cannot establish unilateral torque control because a vertical extrusive force will develop to balance the moment on the anchor tooth.[2] Nearly all asymmetrical mechanics generate such undesirable side effects. For example, Kucher and Weiland achieved intrusion of the upper second molar's palatal cusp while controlling buccal root torque by using a modified TPA with a soldered spur, a button bonded to the palatal surface of the second molar, and elastic chain.[3] As a result of the intrusive force on the second molar, however, an extrusive force was exerted on the first molar.

The C-TCA system was designed to improve the root and crown torques of multiple teeth in a short period of time. Because of the relative positions of the multiloop cantilever and the accompanying TAD, the force vector passes through the center of resistance of the molars,[10] enabling the C-TCA to establish buccal root torque without the need for accessories (Fig. 3). The C-TCA can achieve unilateral molar torque control without anchor tooth movement, as in Case 1.

Conventional orthodontic mechanics often require complicated appliances to reinforce anchorage. Not only is the treatment inconvenient, but the outcome can be unpredictable, and such side effects as extrusion and tipping of the anchor teeth may occur. Skeletal anchorage can be used to avoid these problems while producing targeted tooth movement.[11] The C-TCA system minimizes dental anchorage requirements with the use of a single TAD.

Successful application of the C-TCA system requires proper soldering of the wire to the lingual pads and an adequate bonding protocol to ensure that each contact point remains affixed to the tooth. The TAD must stay intact and not loosen with force application, and the activating power thread must be changed consistently. Finally, the C-TCA must be properly designed so that the force vector can be controlled upon engagement and activation.

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