Biomechanical Considerations in the Correction of Anterior Open Bite with Maxillary Skeletal Plates

S. JACK BURROW III, DDS, MS

Anterior open bite due to posterior vertical hyperplasia has traditionally been treated, depending on patient age and severity, using extraoral traction, magnets, bite plates, chin cups, functional appliances, or orthognathic surgery in conjunction with orthodontics. In recent years, temporary anchorage devices and contemporary biomechanics have afforded more effective control over tooth movements. Skeletal anchorage now makes it possible for orthodontists to intrude maxillary posterior segments without the need for orthognathic surgery.

In the case shown here, skeletal plates in the zygomatic buttress allowed us to transmit orthodontic forces from the molars to the maxilla for posterior vertical intrusion. This article will examine the orthodontic mechanics needed to control the ratio of the moment of couple (MC) to the moment of force (MF) and the load-deflection ratio, working within the range, strength, and formability of the archwires to obtain light, well-controlled biological forces.

Diagnosis and Treatment Plan

A female age 12 years, 8 months, presented with a full profile, lip protrusion, a small nose and chin, an inverse smile arc, an incompetent lip seal, inadequate maxillary incisor display, and a relatively long face (Fig. 1). Study casts showed a Class II molar relationship, upper and lower crowding, and an anterior open bite.

Cephalometric analysis (Table 1) indicated a Class II skeletal relationship (ANB = 6°) with a high FMA angle (36°), a high SN-GoGn angle (49°), and excessive total anterior facial height (130mm). The maxillary incisors were proclined (U1-SN = 115°), as were the mandibular incisors (L1-MP = 101°). Vertically, the maxillary molars were positioned inferiorly to the palatal plane (U6-PP = 26mm), with a resultant open bite and clockwise rotation of the mandible.
Biomechanical Considerations in the Correction of Anterior Open Bite

Fig. 1 12-year-old female patient with Class II molar relationship, upper and lower crowding, anterior open bite, incompetent lip seal, and inverse smile arc before treatment.
A prioritized problem list was prepared as follows.

1. Pathological concerns
   TMJ issues: popping, clicking, frequent headaches
   Left condyle short and flattened

2. Vertical
   a. Skeletal
      Excessive total anterior facial height
      Excessive lower facial height
      FMA = 36°
      Occlusal plane-SN = 24°
      SN-GoGN = 49°
      Anterior open bite
   b. Dental
      U6-PP = 26mm

3. Anteroposterior
   Class II dentoskeletal relationship (ANB = 6°)
   Proclined maxillary and mandibular incisors
   6mm overjet

4. Alignment and symmetry
   Moderate upper and lower crowding
   Bolton 12 analysis: 1.6mm mandibular excess

5. Esthetics
   Inverse smile arc
   Lip and mentalis strain upon closure
   Weak chin
   Excessive incisor display
   Full, convex profile

Two treatment options were presented to address these problems. In the surgical-orthodontic
Biomechanical Considerations in the Correction of Anterior Open Bite

controlling side effects during intrusion, six bands can make placement challenging. In this case, the bands were soldered together with lingual bars, and a TPA was fabricated to join the two posterior segments (Fig. 2). The TPA was kept 5-6mm away from the palate, so that it would not contact the palatal soft tissue as the posterior teeth were intruded.

The patient was referred to an oral surgeon for placement of Stryker single-headed titanium miniplates** in the zygomatic buttress on both sides (Fig. 3). Soft-tissue dissection to expose the lateral walls of the maxilla and zygoma was accomplished through small incisions in the vestibule. The plates were adapted, oriented, and stabilized with rigid fixation screws to the base of the buttress, with the anchors emerging through the soft tissue adjacent to the molars at the junction of the fixed gingiva and mucosa. The tissue was re-approximated with resorbable stitches.

**MBT, trademark of 3M Unitek, Monrovia, CA; www.3Munitek.com.

**Part No. 5506160, Stryker Craniomaxillofacial, Kalamazoo, MI; www.stryker.com.

The parents instead chose a nonsurgical option involving orthodontic intrusion of the maxillary posterior segments, with anchorage from temporary skeletal plates at the base of the zygomatic arch. The treatment plan was as follows.

**Vertical:** Sectional mechanics would involve leveling archwires from upper right canine to left canine and posterior sectional wires from upper second premolar to second molar. A transpalatal arch (TPA) would be used to control vertical side effects during posterior intrusion. It would also help control the transverse dimension, because the vertical forces from the posterior segments would be directed facial to the center of resistance of the segment, thus tending to tip the segment facially.

**Anteroposterior:** After extraction of all four first premolars, the maxillary incisors would be retracted more than the mandibular incisors. To procline the incisors, the MC/MF ratio would be designed to produce uprighting, and a low load-deflection ratio would be used to ensure light, consistent forces.

**Alignment and symmetry:** Part of the premolar extraction spaces would be used to alleviate the crowding.

**Esthetics:** Retracting the incisors would improve the profile and smile arc, increase the amount of incisor display, and reduce the mentalis strain upon closure.

**Orthodontic System**

After extraction of the four first premolars, the upper and lower incisors and lower second premolars were bonded with .022” brackets.* The upper second premolars, first molars, and second molars were banded. Although a rigid appliance cemented to the posterior segments is ideal for

---

*MBT, trademark of 3M Unitek, Monrovia, CA; www.3Munitek.com.

**Part No. 5506160, Stryker Craniomaxillofacial, Kalamazoo, MI; www.stryker.com.
An intrusion force was applied to the posterior sectional archwires by means of elastic thread from the skeletal plate. Four months later, some 3mm of posterior intrusion had been achieved (Fig. 4A).

Segmental posterior intrusion mechanics were continued in the maxillary arch while the lower canines were retracted using 150g nickel titanium retraction springs. Upon completion of the canine retraction, the lower incisors were bracketed (Fig. 4B). After the maxillary posterior segments had been intruded, the arch was leveled and an .018" stainless steel working archwire was placed; the upper canines were retracted individually using 150g superelastic retraction springs (Fig. 5).

**Biomechanical Considerations**

To predict and control the responses of an orthodontic system, both the physical properties of the materials and the mechanics must be well defined. Any change in materials will require a compensatory change in the system to produce the desired results. Because the principal properties of the elastic components (stiffness, range, and strength) do not vary in direct proportion to one another, a change in one can have a considerable...
Biomechanical Considerations in the Correction of Anterior Open Bite

The length of a wire segment will influence the maximum elastic load and the load-deflection ratio in several ways, depending on the design of the mechanical system. Consequently, it is important to plan the materials, brackets, loops, segments, and strategically positioned bends to systematically control the load-deflection ratio, forces, MC/MF ratio, range, and strength and thus control positioning of the teeth.

For this patient, a closing loop (CL) was designed to retract the maxillary incisors (Fig. 6). The components of an ideal CL—including the inter-bracket distance, leg length, wire size, loop shape, and type of metal—will be properly programmed to control the load-deflection and MC/MF ratios. A CL should accommodate a relatively large activation without causing patient discomfort. An off-center anterior gable bend (crown-facial/root-lingual) can be placed to control the MC/MF ratio and produce translation (MC/MF = 1), controlled tipping (MC/MF < 1), or torque (MC/MF > 1), depending on the situation. An off-center posterior gable bend (crown-distal/root-mesial) can be used to enhance posterior anchorage.

In this case, we needed a light, continuous force with an initial activation of 250g/mm. Bypassing the canine and premolar, increasing the leg length, and increasing the wire size of the CL helped increase the range and reduce the load-deflection ratio. Because we wanted to retract and upright the maxillary incisors with controlled tipping (MC/MF < 1), we did not need an off-center anterior gable bend. Nor did we need an off-center posterior gable bend, since the skeletal plate could be used for additional anchorage if required. A 3mm activation of the CL produced a load of 250g, or 62g per tooth (Fig. 7). As the CL deactivated, the force was reduced by about 80g/mm, indicating a low load-deflection ratio.

After 19 months of treatment, once incisor retraction had been completed, a new TPA was attached only to the maxillary first molars, and all remaining spaces were closed. A light elastic thread was used continuously to control the posterior vertical dimension (Fig. 8). Brackets and bands were removed after 30 months of treatment.
Burrow

Removable upper and lower retainers were fitted. The maxillary retainer, with acrylic coverage of the posterior teeth, had hooks for connecting elastics to the skeletal plate (Fig. 10). After six months of full-time wear, retainer wear was reduced to eight hours per night.

Two-year post-treatment records continued to demonstrate proper occlusion and improved dentofacial proportions, although the lateral cephalogram showed a slight increase in overbite and overjet (Fig. 11A). Superimposition of the post-treatment and two-year post-treatment cephalometric tracings indicated that the upper molars had extruded somewhat and that the upper and lower incisors were slightly proclined (Fig. 11B, Table 1). Superimposition of the pretreatment and two-year post-treatment tracings confirmed retraction and uprighting of the upper incisors and intrusion of the upper molars.

Removable upper and lower retainers were fitted. The maxillary retainer, with acrylic coverage of the posterior teeth, had hooks for connecting elastics to the skeletal plate (Fig. 10). After six months of full-time wear, retainer wear was reduced to eight hours per night.

Two-year post-treatment records continued to demonstrate proper occlusion and improved dentofacial proportions, although the lateral cephalogram showed a slight increase in overbite and overjet (Fig. 11A). Superimposition of the post-treatment and two-year post-treatment cephalometric tracings indicated that the upper molars had extruded somewhat and that the upper and lower incisors were slightly proclined (Fig. 11B, Table 1). Superimposition of the pretreatment and two-year post-treatment tracings confirmed retraction and uprighting of the upper and lower incisors and intrusion of the upper molars (Fig. 11C).

Discussion

The etiology of an anterior open bite may involve mechanical interferences as the teeth are
Fig. 9 A. Patient after 30 months of treatment. B. Superimposition of pre- and post-treatment cephalometric tracings, showing slight growth during treatment.
Fig. 10 Retainer with posterior acrylic coverage and elastic hook for application of intrusive force from skeletal plate.

Fig. 11 A. Two-year post-treatment records, showing stable results with slight increase in overbite and overjet. B. Superimposition of post-treatment and two-year post-treatment cephalometric tracings, showing little skeletal growth but slight extrusion of upper molars, consequent clockwise mandibular rotation, and proclination of upper and lower incisors. C. Superimposition of pretreatment and two-year post-treatment cephalometric tracings.
erupting, alveolar growth discrepancies, or genetic factors. An open bite may be dental, skeletal, or a combination of the two.

Various treatment modalities have been used to treat skeletal open bites caused by posterior vertical hyperplasia. Bell recommended a Le Fort I osteotomy, which was shown by Proffit and colleagues to have only a 10% chance of slight long-term relapse. Magnets and springs have also been used to intrude the posterior segments, but Lopez-Gavito and colleagues found significant relapse in 33% of the anterior open bites corrected nonsurgically.

In the case shown here, we used posterior skeletal plates as anchorage for segmental intrusion of the maxillary posterior segments, in conjunction with well-designed biomechanics. During intrusion of the posterior segments, the mandible rotated counterclockwise, which not only helped correct the open bite but reduced the anterior facial height. Retraction of the upper and lower incisors also improved the vertical dimension.

The Stryker single-headed skeletal plate required us to thread an additional orthodontic wire through the head to direct the vertical forces (Fig. 12A). This can be cumbersome and even unstable when the segment tips. We now use a Stryker T-shaped skeletal plate** that allows us to better control tipping, since vertical forces can be placed from numerous positions (Fig. 12B).

Superimposition of the pretreatment and post-treatment cephalometric tracings showed that this patient grew during the 30 months of treatment; the upper molars were intruded, the upper and lower incisors were retracted and uprighted, and the mandible rotated counterclockwise. The L6-MP measurement increased, indicating that a mandibular skeletal plate or miniscrew could have helped control the vertical position of the lower molars. In fact, a recent study reported that "skeletal open bites had more molar eruption than control groups and Class II's had more eruption of mandibular molars."

Superimposition of the post-treatment and two-year post-treatment tracings revealed some relapse. Although there was little growth during this period, the upper molars were slightly extruded and the upper and lower incisors slightly proclined, resulting in an increase in overjet and overbite. The patient wore elastics from the retainer to the skeletal plates full-time for only six months, after which retention was reduced to nighttime only and she quit wearing the elastics. In hindsight, continuing the elastic wear at night might have better controlled the vertical dimension. In addition, if a mandibular skeletal plate or miniscrew had been placed during orthodontic treatment, the minor relapse would have been easier to control. Retainer wires could also have been bonded from the maxillary skeletal plate to the upper first molars to prevent the extrusion. In any case, this molar relapse was dental and not growth-related.

---

**Part No. 9253270, Stryker Craniomaxillofacial, Kalamazoo, MI; www.stryker.com.
Conclusion

The present case demonstrates that if proper diagnostic records are obtained and orthodontic biomechanics are well designed, a stable result can be achieved in a patient with anterior open bite using skeletal plates for anchorage of posterior vertical intrusion and consequent counterclockwise rotation of the mandible.

REFERENCES