The use of miniscrews for reinforcement of orthodontic anchorage has become increasingly popular in recent years, especially in adult patients who do not want to wear extraoral appliances. Miniscrews are convenient, save time, and produce good treatment results with no need for patient cooperation. In some patients treated with miniscrews, however, mechanical factors can produce unusual changes or side effects. The present article explains these mechanical variations and provides tips for solving the problems they create in the sagittal plane. Subsequent articles will cover side effects in the horizontal and transverse planes and present relevant clinical cases.

Anchorage reinforcement is most commonly needed in patients with severe protrusion. In conventional retraction with sliding mechanics after first premolar extractions, the molars typically move forward 3.6-3.8mm. Anterior retraction with sliding mechanics is usually accomplished by placing elastomeric chain or nickel titanium springs between hooks on the anterior teeth and the second molars. The anterior and posterior segments rotate around the center of rotation, which causes bowing of the archwire. A precurved archwire can be used to prevent this side effect (Fig. 1).

Fig. 1 Usual changes during anterior teeth retraction with sliding mechanics. Anterior and posterior segment rotates around center of rotation of each segment (red dots); archwire is forced to bend near center of rotation of entire arch (blue dot). These changes can easily be prevented with precurved archwires (bottom).

Anterior retraction with sliding mechanics is usually accomplished by placing elastomeric chain or nickel titanium springs between hooks on the anterior teeth and the second molars. The anterior and posterior segments rotate around the center of rotation, which causes bowing of the archwire. A precurved archwire can be used to prevent this side effect (Fig. 1).

Fig. 2 Retraction force with miniscrew anchorage produces rotation of entire arch around center of rotation (blue dot).
The use of miniscrews for anchorage reinforcement produces somewhat different mechanics. Because the force used during retraction is not reciprocal, either the entire arch\(^4\)\(^5\) (Fig. 2) or the anterior segment (Fig. 3) will rotate around the center of rotation. In cases of severe protrusion, where absolute anchorage is required in both arches, these mechanics can produce posterior open bite and deep overbite (Fig. 4). The use of precurved archwires will result in an even stronger intrusive force on the posterior segment. Following are several possible solutions to these problems.

**Redirecting the Retraction Force**

One approach is to lengthen the archwire...
hook and raise the miniscrew insertion point to re-direct the vector of retraction force, so that it passes through the center of rotation of the anterior segment. This is located between the lateral incisor and canine roots, 6.76mm above the cervical area, or at the level of the root tip (Fig. 5). Melsen and colleagues recommended that the archwire hook extend 10mm from the main archwire, but anatomical limitations usually make this impractical.

Elastomeric chain or coil springs positioned above the bracket level may impinge on the soft tissue because of archwire curvature (Fig. 6). Furthermore, in many cases, it is difficult to place the miniscrew high enough (Fig. 7). Insertion in the mobile mucosa increases the risk of inflammation around the miniscrew and may lead to failure. Therefore, it is almost impossible to use a retraction force that passes through the center of rotation, and other methods should be considered.

**Posterior Intermaxillary Elastics**

Placing intermaxillary elastics between the posterior teeth can be a solution. Light 3/16” intermaxillary elastics, worn only at night, can prevent posterior open bite (Fig. 8). Because such elastics can extrude the posterior teeth, however, they are not recommended for patients with vertical skeletal patterns.

**Vertical Retraction Forces**

In patients with gummy smiles or other factors favoring intrusion of an entire arch, more vertical retraction forces can be used to prevent occlusal plane rotation (Fig. 9). Occlusally directed archwire hooks should be placed posterior to the canines. This method can also be used to control overbite during retraction in cases of deep overbite.

**Anterior Biteplanes**

Occlusal plane rotation due to forces of occlusion can be prevented by bonding anterior biteplanes to the lingual surfaces of the anterior teeth at the beginning of retraction (Fig. 10). Biteplanes are also helpful in preventing attrition from ceram-
Biomechanical Considerations in Treatment with Miniscrew Anchorage

Fig. 10 Anterior biteplane (red triangle) prevents occlusal plane rotation due to forces of occlusion (red arrow).

Fig. 11 A. Biteplanes built up directly with composite resin.* B. Prefabricated acrylic biteplanes bonded to central incisors.

Fig. 12 Silicone putty trays used to make biteplanes for patients with different amounts of overjet.

Fig. 13 Additional anterior miniscrews create vertical force to counteract occlusal plane rotation and maintain torque.

Fig. 14 Anterior miniscrews positioned between roots of lateral incisors and canines.

Fig. 15 Protraction force moves entire arch anteriorly, producing arch rotation around center of rotation (blue dot).

*Transbond Plus, trademark of 3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016; www.3MUnitek.com.
ic bracket wear. They can be built up directly on the teeth with composite resin,* or prefabricated acrylic biteplanes can be used (Fig. 11). The prefabricated biteplanes can be easily fabricated from silicone putty trays, saving chairtime (Fig. 12).

To minimize extrusive effects and related patient discomfort, anterior biteplanes should be placed at the level of the pretreatment overbite. If they are used after the development of posterior open bite or placed at a level that can produce posterior open bite in a vertical skeletal pattern, clockwise mandibular rotation will occur. Longer bite planes can be used in cases of significant overjet.

Additional Anterior Miniscrews

In a patient with a gummy smile or overerupted upper incisors, additional miniscrews can be placed in the upper anterior region to produce a vector of force that counteracts occlusal plane rotation and preserves anterior torque (Fig. 13). These miniscrews can be placed between either the central and lateral incisors or the lateral incisors and canines (Fig. 14). Some orthodontists prefer the area between the central incisors, but to avoid the frenum, the miniscrew must be placed submucosally with wire extensions.

If the molars are being protracted, the occlusal plane will rotate in the opposite direction, and anterior open bite can occur (Fig. 15).

REFERENCES

Biomechanical Considerations in Treatment with Miniscrew Anchorage

Part 2 The Horizontal and Transverse Planes

MIN-HO JUNG, DDS, MSD, PHD
TAE-WOO KIM, DDS, MSD, PHD

In a previous article (JCO, February 2008), we described some biomechanical variations that may occur in the sagittal plane during the retraction of anterior teeth with miniscrew anchorage. The present article covers the horizontal and transverse planes.

The Horizontal Plane

As we discussed in Part 1, bite deepening is a frequent side effect of anterior retraction with miniscrew anchorage. Buccal crossbite is seen less often (Fig. 1).

When the upper arch is observed occlusally, the center of rotation of the anterior and posterior segments can be estimated in the horizontal plane (Fig. 2). If the anterior teeth are retracted en masse, each segment moves around its center of rotation (Fig. 3), but this rotational effect can be prevented by the natural curvature of the arch, similar to the effect of precurved archwires in preventing a deepening of the curve of Spee (see Part 1).

If miniscrews are used for anterior retraction, the right and left quadrants rotate around each center of rotation, and the molars tend to tip palatally (Fig. 4). Although this rotational effect is similar in both arches, there are some differences. Because the angulation of the incisors to the occlusal plane is less in the upper arch, the distance between the retraction force and the center of rotat-
tion of the quadrant is slightly greater, which increases the amount of rotation. Also, because the root morphology of the upper molars provides less resistance to rotation, the upper molars tend to tip more than the lower molars. Furthermore, if brackets with an MBT* prescription are used, the reduced torque values for the lower molar brackets will tend to produce buccal uprighting.2-4 Upper molars usually provide less anchorage than lower molars,5 and because Class II malocclusion is more common than Class III malocclusion,6 miniscrews are used more frequently in the upper arch. All of these factors can contribute to the development of posterior buccal crossbite in some patients.

The Transverse Plane

Midline deviation is often corrected with intermaxillary elastics (Fig. 5). While these are easy to use, they do require patient cooperation, and they generate a vertical force vector. With miniscrew anchorage, on the other hand (Fig. 6), no special patient cooperation is needed, and the vector of the

Fig. 4 Retraction force with miniscrew anchorage causes rotation of arch quadrant around center of rotation.

Fig. 5 Intermaxillary elastics used to correct midline deviation.

Fig. 6 Miniscrew anchorage used for correction of midline deviation in case with vertical skeletal pattern.
Biomechanical Considerations in Treatment with Miniscrew Anchorage

Fig. 7 Patient with midline deviation and occlusal plane canting; upper and lower midlines are shifted to left and right of facial midline, respectively (horizontal dashed line = occlusal plane; vertical dashed lines = vertical midlines of upper and lower arches; horizontal solid line = true horizontal reference line; vertical solid line = midsagittal plane of face, perpendicular to true horizontal.

Fig. 8 Use of anterior midline elastics increases canting of occlusal plane.

Fig. 9 Anchorage from upper left and lower right miniscrews used to correct midline deviation and occlusal plane canting.
retraction force is usually different from that generated by intermaxillary elastics. If the side effects described in Part 1 are controlled, the midline can be corrected without adverse vertical changes.

In the patient shown in Figure 7, the upper midline is shifted to the left of the facial midline, and the lower midline to the right. Application of intermaxillary elastics between the upper left and lower right canines would worsen the canting of the occlusal plane (Fig. 8). As an alternative, miniscrews can be placed for anchorage in the upper left and lower right posterior regions to correct the midline deviation and occlusal plane canting (Fig. 9).

The patient in Figure 10 has a deviation of both the upper and lower midlines to the right of the facial midline, as well as occlusal plane canto-
Biomechanical Considerations in Treatment with Miniscrew Anchorage

Use of conventional miniscrew anchorage to correct the upper and lower midlines would result in increased canting of the upper occlusal plane (Fig. 11). Additional vertical correction is needed to resolve the problem (Fig. 12).

Discussion

Many orthodontists now prefer to use bondable tubes instead of bands in the posterior region for convenience and better hygiene. When miniscrews are used for retraction, however, it becomes difficult, if not impossible, to direct the retraction force through the center of rotation without using a transpalatal arch or lingual extension wire. Therefore, the mechanical systems shown in this article require bands on the posterior teeth and palatal miniscrew placement.

REFERENCES