Biomechanics of Skeletal Anchorage
Part 3 Intrusion

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Deep bite is usually corrected by incisor intrusion, often by means of segmented arch mechanics with molar anchorage.[1-3] With the introduction of skeletal anchorage, the molars can also be intruded to reduce lower facial height.[4] In high-angle cases, intrusion of the buccal segments may result in counterclockwise rotation of the mandible, similar to that of a Le Fort I impaction osteotomy of the posterior maxilla.[5-10] Successful outcomes have also been reported with anchorage from a combination of miniscrews and modified miniplates.[11] Temporary skeletal anchorage devices can allow the intrusion of overerupted maxillary molars before prosthetic replacement of missing mandibular molars.[12-15]

The main problem encountered during molar intrusion is buccal crown tipping. Application of a vertical force to the elastic hook on a molar tube at a distance from the center of resistance generates a moment that can produce such tipping. Additional anchorage from extra implants or extensions to other teeth may be needed to avoid these side effects.[16]

Two previous articles in this series (JCO, April and May 2006) described the biomechanics of skeletal anchorage for Class II extraction and nonextraction treatment. In the present article, we describe a new approach to intrusion that results in minimal crown tipping, with no adverse effects on adjacent teeth and little patient discomfort.

Appliance Design and Technique

We use a Bollard-type miniplate for molar intrusion (Fig. 1). Three monocortical screws attach the miniplate to the maxillary infrazygomatic crest, with the round connecting bar perforating the soft tissues near the mucogingival margin. The hollow cylindrical fixation unit contains a blocking screw. A wire with a maximum diameter of .045" is inserted through a vertical or horizontal slot at the base of the cylinder. A band is seated on the molar, with a triple tube welded parallel to the tooth's long axis. Ideally, the headgear tube should be buccal to and between the two edgewise tubes. No elastic hook is needed. To compensate for the inclination of the molar's labial surface, the inferior part of the tube should be attached at a distance from the band; a tube with a horizontal offset may be useful.

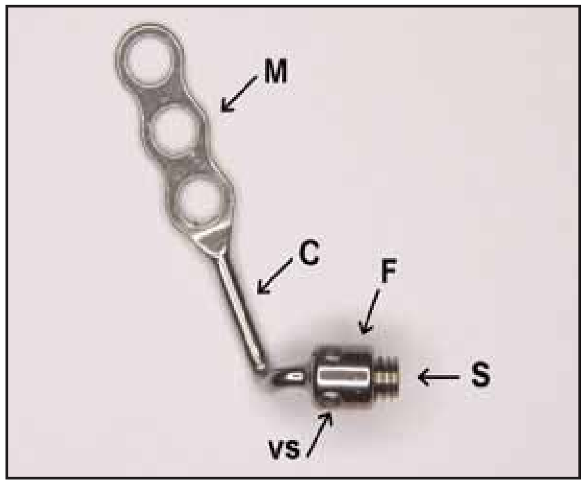

Fig. 1 Bollard-type bone anchor: miniplate (M), connecting bar (C), and fixation unit (F) with vertical slot (vs) and blocking screw (S).

Two weeks after the miniplate insertion, the tooth and bone anchor are connected with an .043" stainless steel wire. A small piece of .024" wire is soldered perpendicular to the main wire and bent to form two hooks, and the main wire is bent at a 90° angle just above the hooks (Fig. 2). The wire is first

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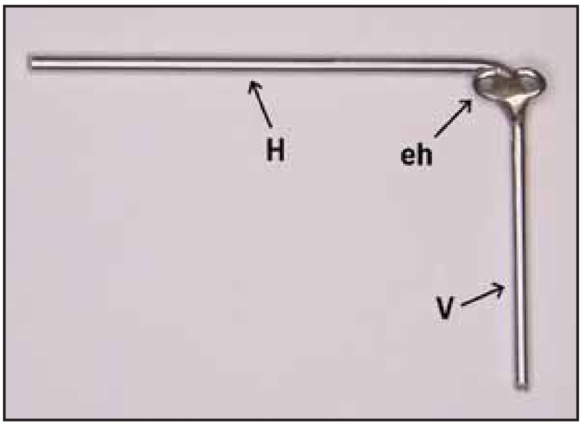

Fig. 2 Horizontal segment (H) of main wire is engaged in fixation unit, and vertical segment (V) slides through headgear tube. Two elastic hooks (eh) are soldered to top of vertical segment.

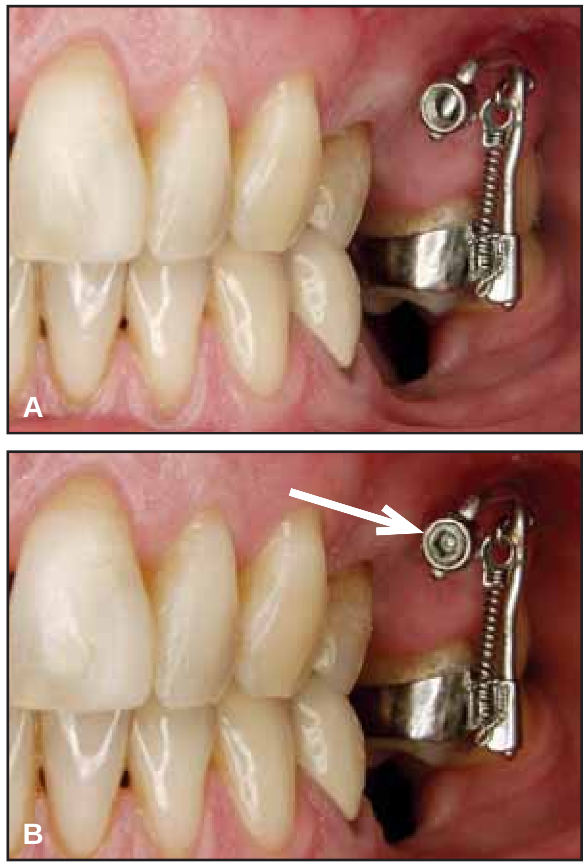

Fig. 3 A. Main wire passes through upper and lower holes of cylindrical fixation unit. B. Wire fixed with blocking screw (arrow).

inserted into the headgear tube. To avoid contact with the soft tissues, a small secondary bend can be made at a safe distance from the upper part of the molar tube, avoiding interference with the wire's entry into the tube. The horizontal segment should be raised as high as possible in the vestibule without contacting the soft tissue. A second 90° bend is made in front of the vertical slot of the fixation unit. This part of the wire passes through the upper and lower holes of the cylindrical fixation unit (Fig. 3A). Because the axis of the headgear tube and the fixation unit slot are usually not parallel, the vertical wire segment may need to be ground down to facilitate insertion. The wire is cut 1mm below the fixation unit and below the lower part of the headgear tube, and the blocking screw is tightened to secure it in place (Fig. 3B).

A 100g closed-coil spring is attached to one of the soldered hooks. The lower part of the spring is pulled down as far as possible, and the lower eyelet is fixed to the base of the triple tube with an .010" ligature wire passed through one of the two edgewise tubes. One month later, a second 100g closed-coil spring is attached between the hook and the headgear tube on the other side of the main wire. During intrusion, as the wire emerges from the headgear tube, the end must be cut every two or three months. Once traction has begun, few adjustments are needed. After the intrusion is complete, a retainer is bonded to the buccal surfaces of the adjacent teeth and kept in place until the missing lower molar has been replaced.

Fig. 4 Square wire bonded to canine and central incisor; headgear tube bonded to lateral incisor, parallel to its long axis; and closed-coil spring fixed to both sides of main wire.

A group of three teeth can be intruded using the same mechanics. The teeth are connected with an .032" × .032" wire bonded to the labial surface of the mesial and distal teeth (Fig. 4). A triple tube is bonded over the square wire on the labial surface of the middle tooth after a small notch is cut into the base of the tube. During intrusion, the three teeth are guided along the .043" wire connecting the middle tooth with the fixation unit of the bone anchor. After intrusion, permanent retention is needed, particularly in cases with periodontal breakdown.

To intrude all four upper incisors, an intrusion arch bypassing the premolars and canines is engaged in the fixation unit of the bone anchor. A horizontal force can be added by attaching an extension with a tube and a hook to the bone

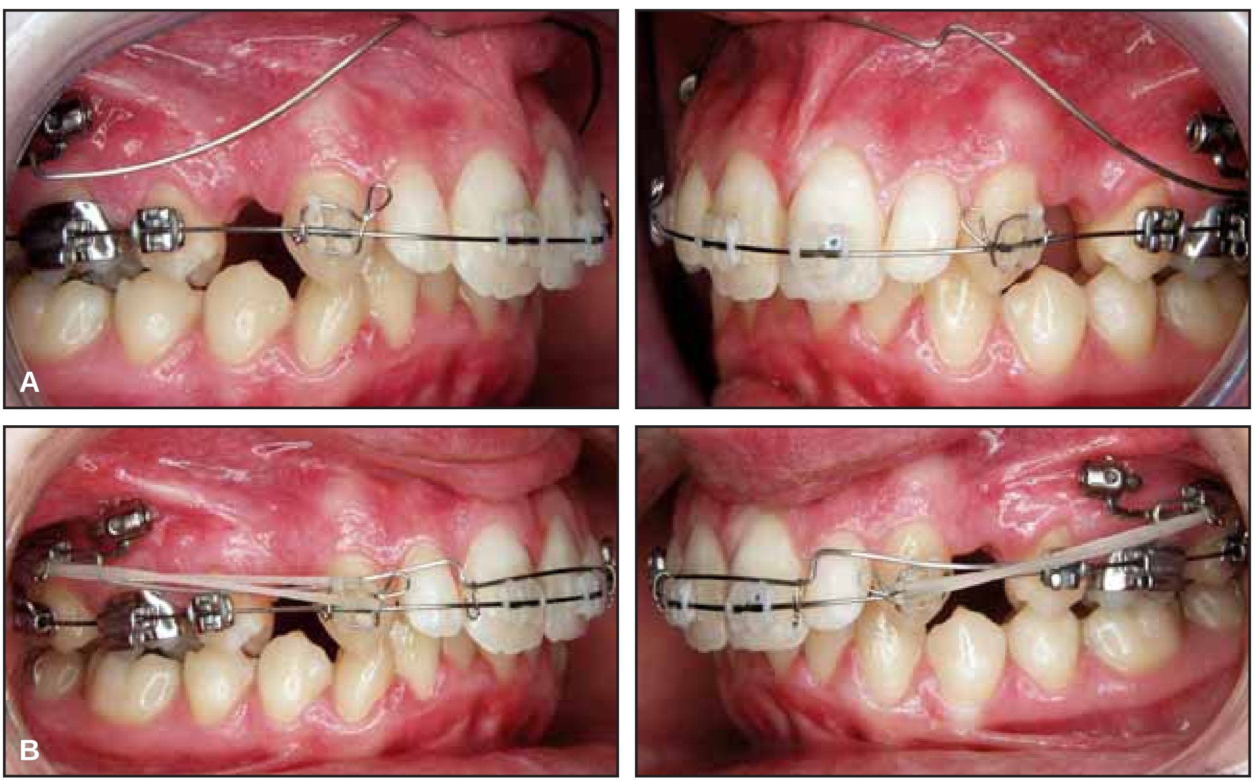

Fig. 5 A. Auxiliary intrusion wire attached to bone anchor and tied to incisors. B. Elastic fixed to bone anchor extension, allowing simultaneous canine retraction.

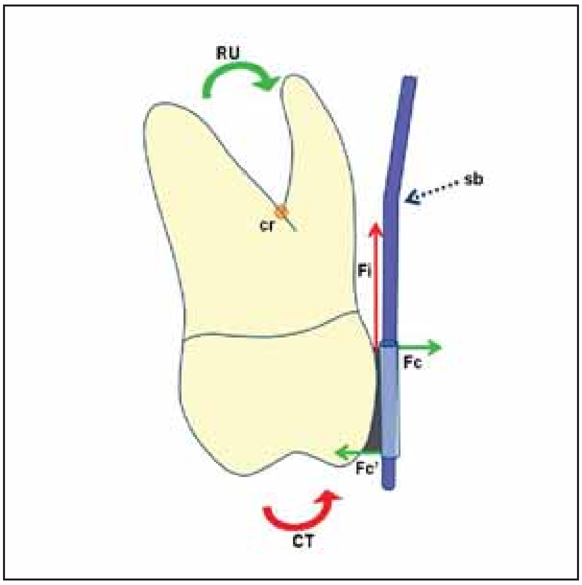

Fig. 6 Vertical force (Fi) applied away from center of resistance (cr) generates labial crown tipping (CT), and force couple (Fc and Fc') uprights roots (RU). Small secondary bend (sb) may be needed to avoid contact with soft tissues.

anchor, permitting simultaneous intrusion and retraction of the incisors (Fig. 5).

Biomechanics

The point of force application on a tooth is usually located buccal to the center of resistance. Therefore, the application of an intrusive force to a molar tube will create a moment that causes buccal crown tipping. This can be neutralized by applying a vertical force to a cleat on the palatal side of the molar, thus generating a moment in the opposite direction.[16] Traction is applied from an elastic or nickel titanium coil spring between the cleat and a second miniscrew inserted in the palate. Labial tipping can be controlled with a transpalatal arch or a biteplane covering the occlusal surfaces of the teeth.[17]

In our approach, the intrusive force is still applied at a distance from the molar's center of resistance, which will initially result in buccal crown tipping (Fig. 6). This tipping is limited to the clearance between the wire and the headgear

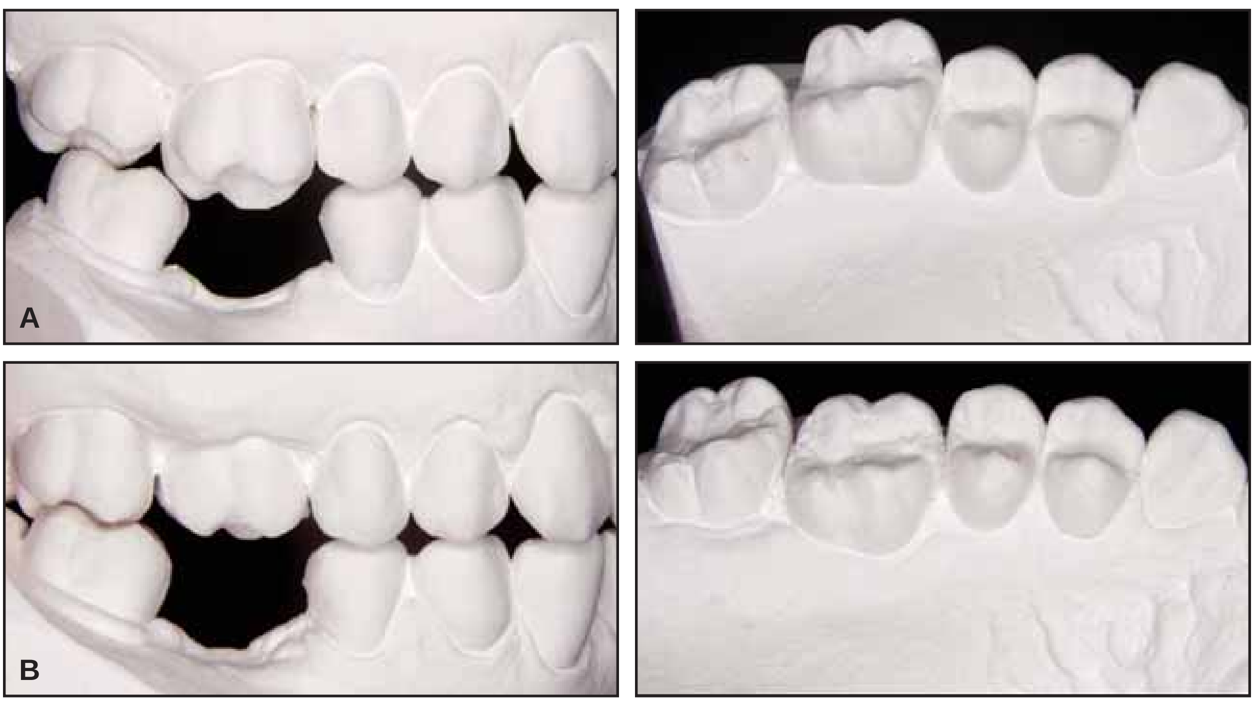

Fig. 7 Dental casts showing intrusion of maxillary first molar. A. Before intrusion. B. After intrusion.

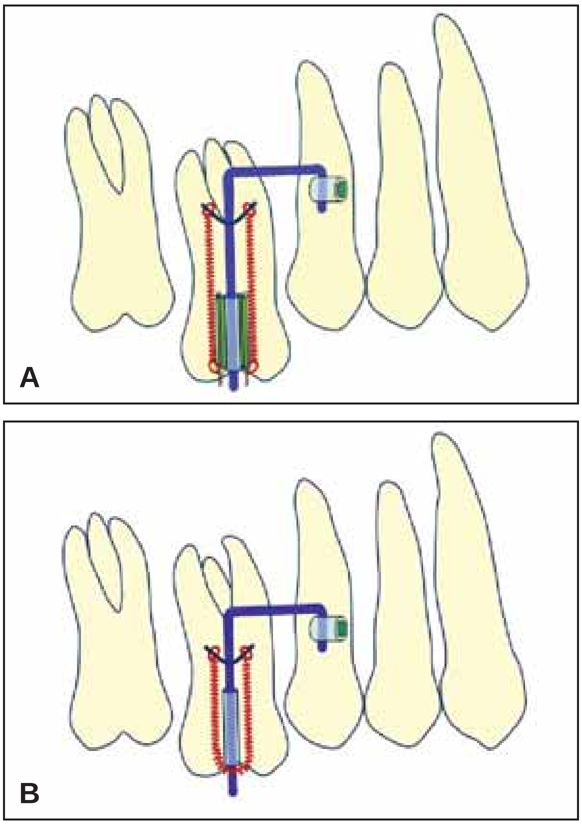

Fig. 8 A. Coil springs on both sides of tube attached with ligature through edgewise tube. B. Single coil spring connecting both hooks.

tube, however—a small distance because a nearly full-size wire is used (an .043" wire in an .045" tube). Contact between the wire and the upper labial and lower palatal sides of the tube will cause bending and slight root uprighting. Successive crown tipping and root uprighting as the tube slides along the wire will bring the tube into a position parallel to the long axis of the connecting wire's vertical segment.

The most important factor in achieving intrusion without tipping is the stability of the main wire. The initial crown tipping pulls the vertical segment of the wire buccally. Rotation around the horizontal segment of the wire is prevented by the wire's rigidity and by its attachment in the upper and lower holes of the bone anchor fixation unit's vertical slot (Fig. 3A). Intrusion of the maxillary molar is therefore accomplished with minimal labial crown tipping (Fig. 7).

In the sagittal plane, the coil spring fixed to the distal hook causes distal crown tipping. Attaching coil springs on both sides of the wire can reduce this anteroposterior tipping and overall friction (Fig. 8A). Therefore, when three teeth are intruded simultaneously, we recommend using coil springs on both sides of the headgear tube. During intrusion, however, the distance between the lower part of the headgear tube and the hooks soldered to the top of the wire may become too short to adequately stretch even the shortest available coil spring. In this case, a single coil spring can be attached from one hook to the other, passing behind the wire that emerges from the headgear tube (Fig. 8B).

When all four incisors are intruded, the use of a conventional auxiliary wire from a second edgewise tube on the molar may result in extrusion, distal tipping, and rolling of the molar. These effects can be avoided by inserting the intrusion arch into a tube welded to a rigid extension of the fixation unit. A coil spring or an elastic placed between the elastic hook of the tube and the canine can be used to retract the canine. The friction generated by the sliding of the canine along the main archwire causes slight retraction of the incisors.[18] Because the intrusion arch can slide through the soldered tube, the intrusion of the anterior segment can be combined with reduction of overjet during canine retraction.

Case 1

A 27-year-old female presented with a missing mandibular left second premolar and first and second molars due to previous extractions. Absence of occlusal support had resulted in overeruption of the maxillary first and second molars (Fig. 9A). The maxillary first molar was also extracted before orthodontic treatment because of a serious endodontic problem.

The second molar was intruded with the mechanics described above using a 100g closed-coil spring (Fig. 9B). After initial insertion of the appliance, it was removed only twice to shorten

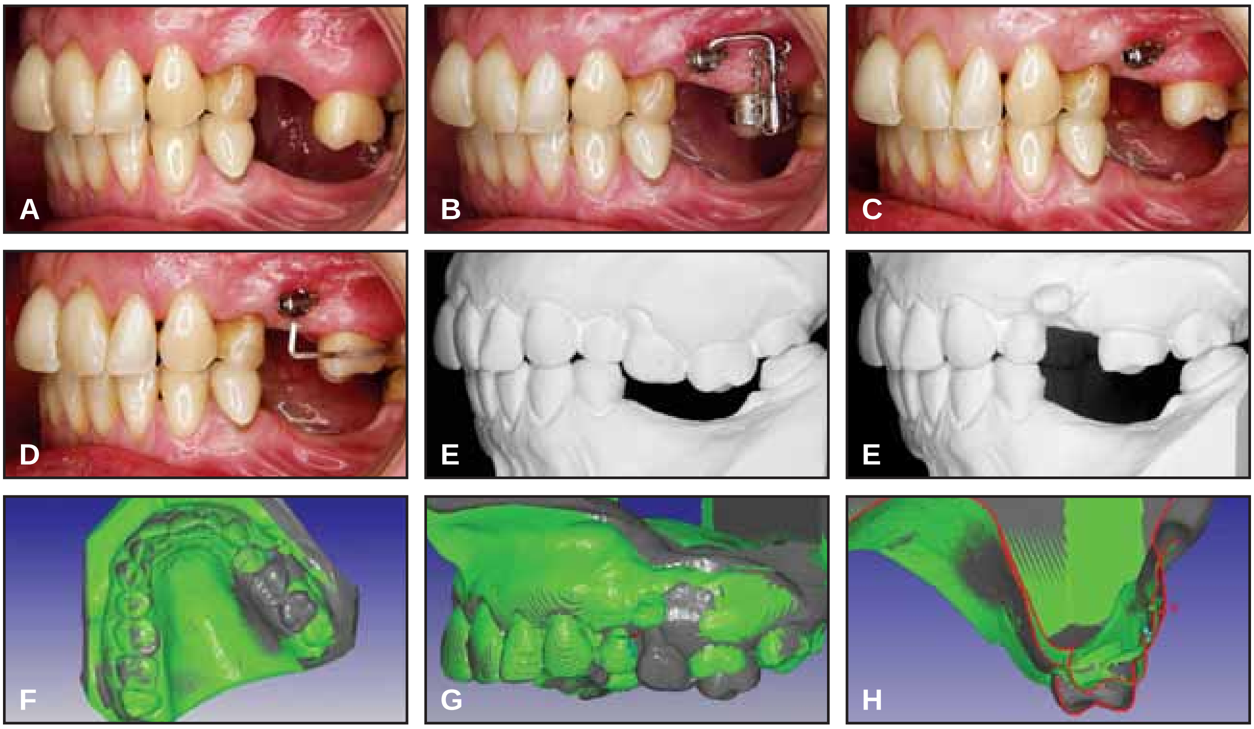

Fig. 9 Case 1. A. 27-year-old female patient with overerupted maxillary second molar after extraction of mandibular left second premolar and first and second molars. B. Intrusion with skeletal miniplate anchorage. C. After six months of intrusion. D. Square retention wire engaged in fixation unit and bonded to buccal molar surface. E. Plaster casts before and after intrusion. F. Registration of digitized maxillary model before (gray) and after (green) intrusion. G. Lateral view, showing amount of intrusion. H. Transverse section through second molar, showing little buccal crown tipping and remodeling of palatal and buccal cortical bone.

the wire emerging through the headgear tube. Intrusion was accomplished in six months, along with a leveling of the alveolar bone mesial to the second molar (Fig. 9C). After the intrusion, a segment of .032" × .032" wire was engaged in the fixation unit of the bone anchor and bonded to the buccal surface of the molar (Fig. 9D). This retainer wire was kept in place until osseointegration of the mandibular implants.

Plaster casts made before and after intrusion (Fig. 9E) were digitized and registered on all the teeth except the left first and second molars. Because none of these teeth had been loaded during orthodontic treatment, the registration was optimal (Fig. 9F), and the intrusion was plainly visible in the lateral view (Fig. 9G). A transverse section through the second molar showed little buccal crown tipping, as well as clear remodeling of the palatal and buccal bone covering the second molar (Fig. 9H).

Case 2

A 53-year-old male presented with severe periodontal disease and overeruption of the maxillary right incisors and canine (Fig. 10A). After bone loss and apical movement of the center of resistance, the maxillary right incisors and canine had initially tipped labially and then extruded until occlusal contact was restored. The main treatment goal was intrusion of these teeth. Lack of posterior anchorage prevented the use of conventional intrusion mechanics.

As described above, the three teeth to be intruded were connected with an .032" × .032" wire bonded to the labial surface of the right

Fig. 10 Case 2. A. 53-year-old male patient with severe periodontal disease and overerupted maxillary right incisors and canine before treatment. B. Before, during, and after intrusion of three anterior teeth. C. Patient after eight months of intrusion and two months of additional anterior fixed appliance treatment. D. Permanent retention with intracoronary fixed lingual retainer.

canine and central incisor (Fig. 10B). A headgear tube was bonded to the lateral incisor, covering the square wire, and two 150g closed-coil springs were attached. Except for shortening of the main wire, no adjustments were required. Instead of the expected labial tipping, the incisors were slightly uprighted during intrusion, and close contact with the labial surfaces of the mandibular incisors was maintained. After eight months of intrusion, brackets were bonded from canine to canine for an additional two months (Fig. 10C). Because of the severe periodontal breakdown and tight occlusion, an intracoronary fixed lingual retainer was bonded for permanent retention (Fig. 10D).

Discussion

After the extraction of mandibular molars, the maxillary molars lose their vertical support and will erupt until new occlusal contact is encountered. Under healthy periodontal conditions, the surrounding alveolar bone and overlying soft tissues will follow the migration of the tooth. Overeruption of the maxillary molars may make prosthetic replacement of the extracted mandibular molars difficult or impossible. Space can sometimes be regained by grinding the occlusal surfaces of the upper molars, although in some cases so much material must be removed that endodontic treatment, crown lengthening with gingivectomy, and prosthetic restoration are required.

Alveolar bone loss from periodontal disease in the incisor region causes upward movement of the center of resistance, which in turn results in labial tipping of the incisors and loss of occlusal contact with the lower teeth, followed by extrusion until vertical support has been restored. These small, alternating tipping and extrusion movements result in flaring and spacing of the upper incisors. To close the spaces, the overerupted teeth must first be intruded, which produces more labial crown tipping than under healthy periodontal conditions because of the upward migration of the center of resistance.

Skeletal anchorage now makes it possible to intrude one or more teeth. If miniscrews are used, they should be inserted at a distance from the roots, according to the amount of intrusion needed.[19] In such a location, the head of the screw is usually surrounded by mobile mucosa, which increases the risk of bacterial infiltration and local infection.[20] With modified miniplates, the screws can be inserted at a safe distance from the root apex, so that the extension will perforate the mucosa close to the mucogingival margin, causing less mobility of the surrounding soft tissues. This reduces the risks of infection, bone loss, and screw loosening.[18,21] Moreover, a connecting bar with a round section facilitates oral hygiene in the area where it penetrates the soft tissues.

Another disadvantage of using miniscrews for intrusion is the connection between the skeletal anchor and the orthodontic appliance. A closed-coil spring or elastic, attached directly between the miniscrew head and the elastic hook on the molar tube or bracket,[16] allows little control over molar crown tipping. Additional mechanics such as a second intrusive force applied on the palatal side will be required to generate a moment of lingual crown tipping to neutralize the labial crown tipping. Depending on the curvature of the palate, the horizontal component of force tends to be more critical on the palatal side than on the buccal side. This implies the need for a second miniscrew in the palate. Auxiliary appliances such as transpalatal arches or biteplanes will cause patient discomfort and may result in undesirable occlusal side effects.

In the technique presented here, only one bone anchor is needed. The best posterior location for the miniplate is the upper infrazygomatic crest. The fixation unit will often be close to the first molar, however, which complicates the insertion of the connecting wire into the molar tube. The extension of the bone anchor may also interfere with upward movement of the molar. To prevent this, the round connecting bar can be bent slightly forward during insertion at the interface between the miniplate and the connecting bar. This will place the fixation unit farther from the molar and increase the length of the horizontal wire segment connecting the fixation unit to the molar tube, facilitating adjustments and eliminating interferences between the fixation unit and molar tube during intrusion. The orientation of the vertical slot in the fixation unit prevents buccal or mesiodistal crown tipping. Rotation around the vertical segment of the connecting wire within the vertical slot of the fixation unit is still possible, but will be clinically insignificant. Because of the rigidity of the skeletal anchorage and the firm connection to the tooth with a nearly full-size wire in the headgear tube, no auxiliaries are required.

In the anterior segment, one or more teeth may be intruded along a rigid connection to a bone anchor on the paranasal ridge. When intrusion of more teeth or the complete anterior segment is needed, however, a conventional auxiliary intrusion arch should be engaged in the fixation unit of the bone anchor. This will eliminate reaction forces and unwanted movement of the posterior teeth during intrusion.

Conclusion

Use of a miniplate with a fixation unit for skeletal anchorage allows a rigid connection to a single tooth or a small group of teeth. The main advantage is maximum control of labial crown tipping during intrusion. Because no auxiliaries are needed, there are virtually no adverse effects on other teeth. Appliances can be limited to the teeth to be intruded, improving patient comfort. Few adjustments are needed, reducing chairtime and treatment costs. With proper technique, this anchorage system has little risk of local infection or loosening.

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