Creative Adjuncts for Clear Aligners
Part 2 Intrusion, Rotation, and Extrusion

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Part 1 in this series of articles (JCO, February 2015) described a number of adjuncts for improving the reliability of Class II treatment with clear aligners. This month, we will demonstrate how to perform certain difficult tooth movements with aligners. Part 3 will conclude the series with a discussion of extraction and interdisciplinary treatment.

One of the most frustrating aspects of clear-aligner treatment has been the unpredictability of tooth movements such as dental extrusion, resolution of rotations, and correction of deep overbites. For example, Chisari and colleagues reported that only 57% of the programmed movement of a single incisor was actually achieved over an eight-week experimental period. Kravitz and colleagues found only a mean 41% accuracy. As treatment progresses, this lag in tooth movement can be compounded, resulting in a “tracking error” that is usually first noticed as an “air gap” between the incisal edges of the incisors and the aligner trays. This situation may spread to other teeth, until the trays no longer fit snugly or the intended tooth movement is adversely affected. Newer plastic materials, more accurate digital scans, new attachment designs, and better programming strategies for treatment planning (including the necessity of overcorrection) have improved the predictability of outcomes. As we discussed in Part 1, however, the application of adjuncts is still indicated in some cases.

Intrusion

Intrusion of selected teeth or dental segments, as needed in patients with deep overbites, has been regarded as challenging to perform with clear aligners. In fixed-appliance treatment, mini-screws have been used to assist not only in intrusion of single posterior teeth for subsequent prosthetic restorations, but in mass intrusion to help close anterior open bites and correct deep overbites. It seems logical to extend the application of skeletal anchorage into the realm of clear aligners.

Overeruption of teeth with no opponents is commonly seen in mutilated dentitions. Intrusion of a hypererupted tooth is one way to provide sufficient clearance for prosthetic replacement. Mini-screws are ideally suited to such a task, since a variety of forces (elastic chain, coil springs, or elastics) can be applied to predictably guide the programmed intrusion without affecting adjacent teeth, even when using clear aligners (Fig. 8).

Intrusion of multiple teeth to correct deep overbites has been acknowledged as a more challenging and less predictable aspect of clear-aligner treatment. The importance of resolving deep
overbites has become more apparent in recent years with the increasing percentage of adult orthodontic patients—especially those with restricted anterior function, resulting in severe enamel attrition of both the incisal edges and the labial and lingual tooth surfaces.

Recent improvements in aligner programming have been designed to assist in leveling the curve of Spee with incisor intrusion and premolar or molar extrusion. These include biteplanes molded into the aligner trays behind the upper anterior teeth and bonded attachments used to deliver extrusive forces to the premolars. Since miniscrew anchorage has been highly dependable in correcting deep bites and “gummy smiles”, it has inevitably been applied to similar treatments with clear aligners (Fig. 9).

Rotation and Extrusion

Dental rotations and extrusion of anterior teeth seem to be the least predictable aligner movements. Kravitz and colleagues found that extrusion was the least accurate tooth movement in aligner treatment, at 29.6% effectiveness. Reasons for these difficulties, along with strategies to improve rotation control, have been proposed by Nicozisis and Humber. We have incorporated several of their common themes in the following suggestions:

![Fig. 8 Molar intrusion supported by miniscrew anchorage and elastics. A. Adult patient with missing lower right first molar and overerupted upper second premolar, initially treated with chain elastic from miniscrew to bonded button on premolar. B. During later Invisalign phase, intramaxillary triangle elastics worn from miniscrew to bonded buttons on aligners, ensuring proper tray seating and consistent leveling of occlusal plane. C. Resulting slight overcorrection provided sufficient clearance for implant in 14 weeks of treatment.](image-url)
Fig. 9 Deep-bite treatment with anterior intrusion. A. Adult male patient with mutilated dentition and deep overbite associated with significant anterior wear before treatment. B. Miniscrews inserted between roots of upper lateral incisors and canines for anchorage of intrusion elastics (continued on next page).
Bowman, Celenza, Sparaga, Papadopoulos, Ojima, and Lin

Fig. 9 (cont.) C. Elastic hook formed by placing circular extrusion in facial aligner surface with Hilliard Thermoplier Hook-Forming Pliers,§ then notching half of plastic extrusion with cutting tool. D. Improvement in overbite after 22 months of treatment and 35 pairs of aligners.

§Registered trademark of Dentsply Raintree Essix Glenroe, Sarasota, FL; www.essix.com.
1. To open sufficient space adjacent to the affected tooth, program a visible opening of .25-.5mm into the aligner treatment and/or use interproximal reduction.

2. Design appropriate bonded attachments to elicit rotational and/or extrusive forces.9,42,43

3. Program overcorrection into the aligners to account for the flexibility of the plastic.

4. Use detailing pliers such as Clear Collection’s The Vertical*** and The Horizontal*** to accentuate rotational or extrusive couples.

5. Supplement treatment with bonded buttons and elastics or even fixed appliances before or after aligner therapy.

6. Due to the inherent risk of rotational or vertical relapse, discuss the need for supracrestal fiberovery (Edwards procedure44) and long-term fixed retention as part of informed consent.

The failure of upper lateral incisors to track properly, commonly seen with Class II, division 2 malocclusions, is especially disconcerting. In some instances, the central incisors would benefit from intrusion while the lateral incisors require extrusion and rotation. Combining selective intrusion, extrusion, root torque, and rotation of anterior teeth requires more than just casual approval of a technician’s programmed treatment plan.

Failure to address the arch-length discrepancy before initiating any movement of the lateral incisors is likely to result in disappointment. If extrusion is attempted with insufficient adjacent space, iatrogenic intrusion may occur as the tooth is inadvertently “squeezed” apically. Space opening also increases the tooth-surface area for the plastic to contact—an important consideration with a small, blade-shaped lateral incisor. The addition of bonded attachments on the lingual or facial surfaces or both should be considered to increase the contact surface area and produce extrusive and/or rotational forces. If tracking is still lagging behind, other adjuncts can be considered.

Aligner Chewies§ are one of the earliest methods developed to overcome poor tracking or “aligner lag” (Fig. 10).45 Like sequential aligners themselves, these simple devices were based on the concept of the tooth positioner.46 With the trays in place, the patient bites down repeatedly on the soft Chewies, each the size of a cotton roll, for several minutes a day to help seat the aligners, especially as each new pair is started. Chewies are also prescribed when an air gap develops at the incisal edges. In that case, the Chewie should be positioned directly over the affected region to focus the chewing forces, with the patient holding the device solidly between the teeth for 10-15 seconds, releasing, and repeating for about five minutes twice a day.

Open-Bite Treatment

Passive posterior intrusion is a common issue in clear-aligner treatment. Posterior plastic can be removed to permit spontaneous settling or eruption of the posterior teeth into occlusion, and forced eruption can also be applied with intermaxillary elastics (Fig. 13).

Clever methods for using clear aligners to improve the closure of anterior open bites by intrusion of posterior teeth have been proposed by Boyd and Dayan. The underlying concept is to harness the aligners’ propensity to produce an iatrogenic posterior open bite simply as a result of holding plastic between the teeth for extended periods of time. One such strategy involves sequential intrusion of specific posterior teeth while maintaining or extruding the anterior teeth, thus creating a deeper curve of Spee. Using Chewies to exert intrusive forces on targeted pos-

Even with the best planning for clear-aligner biomechanics, aligner lag or tracking error of specific teeth can still occur, often as a result of less-than-ideal patient compliance with aligner wear. The application of adjunct elastics may assist with the extrusion of selected teeth into the aligner trays. “Bootstrap” elastics are attached to bonded buttons on the facial, lingual, or both surfaces of the lagging tooth at the gingival margin. An orthodontic elastic is stretched across the incisal surface of the seated aligner to the button, thus extruding or pulling the tooth into the tray. The gingival margin of the aligner plastic must be cut to avoid the buttons, so that the tray can seat completely. Alternatively, to avoid the need for a button on the facial side of the tooth, elastic hooks can be cut into the aligner tray (Fig. 11). Bootstrap elastics may prevent or at least delay the need to interrupt a series of aligners for the fabrication of refinement trays (Fig. 12).
Creative Adjuncts for Clear Aligners

Fig. 12 Maxillary retraction and anterior torque control supported by elastics. A. 12-year-old female patient before treatment with Invisalign TEEN™ and Class II elastics. B. After 20 months, due to progressively worsening upper left lateral incisor tracking, bonded button and bootstrap elastic added to extrude lateral incisor into aligner tray. C. Patient after completion of treatment, six months later, showing improved smile line.
Fig. 13 Forced posterior eruption supported by elastics. A. Young adult patient with anterior open bite and reverse smile line before treatment with clear aligners. B. Development of posterior open bite during aligner treatment. C. Buttons added for attachment of posterior rectangular intermaxillary elastics to assist refinement aligners in seating occlusion. D. Patient after 24 months of treatment; addressing curve of Wilson could have improved these results.


Fig. 14 Extrusion supported by elastics. A. Adult patient with poor tracking of aligner trays in anterior region. B. Buttons bonded to lingual surface of upper left lateral incisor and facial surface of lower left canine for attachment of intermaxillary elastics during refinement stage. C. Patient after 10 months of treatment.
Fig. 15 Posterior intrusion supported by miniscrew anchorage and elastics. A. Adult female patient with frank anterior open bite treated using Dayan open-bite protocol\(^48\) combined with six miniscrew implants (two each on buccal and palatal sides of posterior maxillary alveolus, two in buccal alveolus of posterior mandible). “Sling” elastics worn from palatal to buccal maxillary miniscrews, across occlusal surfaces of aligners, to support intrusion. In lower arch, teardrop notches placed at lingual gingival margin of aligners mesial and distal to first molars; elastics worn from lingual notches to buccal miniscrews, across occlusal surfaces of aligners, to support mandibular vertical control. B. Maxillary left palatal miniscrew relocated mesially; metal and esthetic attachments bonded in upper and lower arches for intermaxillary elastics (continued on next page).
terior teeth can improve the predictability of this method.

The addition of miniscrew anchorage to support biomechanics involving elastic forces for the extrusion of anterior or posterior teeth is another logical extension of their application to clear-aligner treatment (Fig. 14). An alternative type of bootstrap mechanism employs miniscrews to improve the reliability of posterior intrusion and potentially produce spontaneous mandibular autorotation (Fig. 15).47

Although there is seldom a need to extrude anterior teeth during the correction of anterior open bites,51 the combination of clear aligners with miniscrew anchorage for such treatment has been described by Lin and colleagues.36,52

(TO BE CONTINUED)

Fig. 15 (cont.) C. Rectangular intermaxillary elastics worn after sequential posterior intrusion to assist in seating occlusion. D. After 26 months of treatment, patient in refinement stage.
REFERENCES


45. Tuncay, O.: The iatrogenic crowding caused by aligner length/arch length discrepancy, Clinical Reports & Techniques (Align Technology), Fall 2005, pp. 3-5.


