The Tip-Edge Concept: Eliminating Unnecessary Anchorage Strain

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Tooth movement in any orthodontic technique is accomplished according to one of two distinct schools of thought:

1. Edgewise techniques establish and maintain the maximum anchorage potential of each tooth throughout treatment--intentionally in the case of the anchor molars, and unintentionally in the case of the teeth to be retracted. Bodily tooth movement is then used for repositioning.

2. Differential movement techniques utilize tipping of the crowns, followed by root uprighting to produce a net bodily translation.

Conventional edgewise techniques must use higher levels of force (6-16oz per quadrant) to move teeth because of the restriction produced by the bracket slots. Differential tooth movement requires only 1.5-2oz of force to trigger the biological process of tooth movement. The result is far less intraoral anchorage strain.[1]

The preangulated slots of edgewise appliance systems produce an active strain on anchorage even before any attempt is made to retract teeth. This stationary[2] or "reverse" anchorage is the result of holding the roots of all teeth to be moved at distal inclinations throughout treatment. Simple leveling with preadjusted brackets can cause undesirable mesial movement of an entire arch.[3]

The difficulty of managing this reverse anchorage potential has led to an increase in the use of extraoral forces, functional appliances, and even orthognathic surgery to correct malocclusions with relatively slight sagittal discrepancies.[4,5] In his last published article, Angle advocated angulated bracket placement that would tip the crowns of the maxillary teeth distally to correct a Class II, division 1 malocclusion[6] (Fig. 1). These angulations are the opposite of those found in today's preadjusted appliances, but they never gained widespread acceptance because of the need to remove and resolder the brackets at different angulations for finishing.

In differential tooth movement, significant anchorage strain occurs only during the final stage of treatment, *after* all spaces have been closed and the overbite and overjet have been corrected. This should not be confused with "round-tripping", which produces no net bodily repositioning.

Before 1986, only brackets with vertical slots, such as ribbon arch appliances, could be used to produce differential tooth movement. Precise mesiodistal angular control was lacking, and the vertical slots hindered archwire placement, allowing excessive tipping during retraction and making finishing difficult. These brackets also required lockpins rather than elastomeric ties. Combination brackets, with vertical slots for differential tooth movement and horizontal slots for finishing, are bulky and have the same disadvantages when the vertical slots are used.

The Tip-Edge bracket and its unique slot now make it possible to utilize differential mechanics with an edgewise appliance.[7] Even the most severe malocclusions can be successfully treated with only four straight archwires[8] (Fig. 2). Retraction and space closure are accomplished without the adverse vertical archwire distortion commonly associated with edgewise systems, allowing rapid correction of deep anterior overbite without extraoral forces.[10] Rotational control is maximized by mesiodistal wings that are concealed by the archwire (Fig. 3).

Treatment with differential tooth movement is divided into three stages, as described by Begg[11] and Proffit.[12] The stages, with goals for each listed in order of importance, are:

Stage I

1. Open or close the bite to an edge-to-edge incisal relationship while correcting any anteroposterior discrepancy.

2. Correct anterior crowding, rotations, or spacing.

3. Correct posterior crossbites.

Length: Six weeks to six months, depending on the malocclusion.

Stage II

1. Close any remaining posterior spaces using limited tipping.

2. Maintain all corrections achieved in Stage I.

Length: Six weeks to four months. In nonextraction treatment, there is usually no Stage II.

Stage III

1. Upright the roots of all teeth to ideal mesiodistal and labiolingual inclinations.

2. Maintain all corrections achieved in the first two stages.

Length: Three to six months for nonextraction treatment; nine to 12 months for extraction treatment. Force levels of more than 2oz, which could produce appreciable anchorage strain, are generally present only in Stage III.

Tipping and Uprighting

The anchorage control achieved with differential tooth movement is possible only if tipping and uprighting mechanics are distinctly separated. Although this method is commonly associated only with the Begg technique, many leading edgewise advocates have recognized limited tipping and subsequent uprighting as an efficient means of bodily tooth repositioning.[13-21]

With conventional edgewise appliances, distal crown tipping must be limited because of adverse archwire deflection and consequent bite deepening.[10] Multiple leveling archwires, segmented mechanics, or multilooped retraction archwires must often be used.

With the Tip-Edge concept, these problems are addressed by modifying the bracket slot rather than the archwire mechanics. The Tip-Edge slot eliminates archwire deflection during retraction and allows differential tooth movement without deepening the bite.[22]

Bite Opening

The establishment of an edge-to-edge incisal relationship is the single most important goal of Stage I. This procedure not only overcorrects any overbite or overjet, but also enhances the ability of mandibular growth to contribute to a Class II correction.[23] Recent research indicates that the results of sagittal correction with light, Class II elastics are essentially the same as those of conventional edgewise techniques in combination with functional appliances or extraoral forces.[24]

Four key guidelines must be strictly followed to achieve the rapid bite opening that is possible with differential tooth movement:

1. Use only light (1.5-2oz) elastics.

2. Use only the hardest, stiffest wires, with appropriate bite-opening bends.

3. Do not incorporate the premolars in the archwire until the anterior overbite has been corrected. This concentrates bite-opening forces on the anterior segments, where they are needed.

4. Use only brackets that provide 100% vertical interbracket distance by means of a one-point contact with the archwire.[7]

A one-point contact is imperative because it allows the teeth to seek the paths of least resistance through the irregular trabeculae of alveolar bone, without any interference from adjacent teeth. The same phenomenon enhances horizontal retraction on round wires and eliminates the possibility of exposing a root through the cortical plate, as can occur with rectangular archwires.[25]

The importance of maintaining the proper balance between the light elastic and archwire forces can be demonstrated on a special typodont. Initial archwires are bent from .016" Australian wire, with bite-opening bends mesial to the molar tubes. For deep overbites, the anchor bends should place the anterior portion of the archwire in the deepest part of the vestibule (Fig. 4).

With 1.5oz elastics on each side, a net intrusive force remains despite the vertical component of force delivered by the Class II elastics (Fig. 5). Such mechanics can open a deep bite quickly without adverse rotation of the occlusal plane or an increase in the

FMA angle.

If elastics of 3oz or more were used, the intrusive force of the maxillary archwire would be overpowered. These mechanics could actually deepen the anterior overbite (Fig. 6). Bite deepening can also occur if wires of insufficient stiffness or with inadequate anchor bends are used (Fig. 7).

Deferral of Anchorage Strain

With differential tooth movement, all anchorage strain is relegated to the arch that does not require retraction until after an edge-to-edge incisal relationship has been established.

With conventional edgewise techniques, the relatively strong intermaxillary elastics not only create excessive anchorage strain in the opposing arch, but also deliver significant vertical components of force that cannot be overcome by the archwires or the posterior occlusion. A deepening of the overbite and (in Class II cases) a clockwise rotation of the occlusal plane can easily occur. Therefore, use of Class II elastics is often limited, and high-pull extraoral forces may be required to maintain the vertical dimension.[12]

To minimize the vertical component of force produced by Class II or III elastics, intra-arch retraction is generally relied upon during edgewise extraction treatment. This strains the anchor units of the protrusive arch throughout canine and incisor retraction. The potential for anchorage loss is magnified by the propensity of the posterior teeth to move mesially, because of the porous bone in the extraction sites. Extraoral forces must often be employed to reinforce anchorage during retraction.

Friction-Free Retraction Mechanics

Differential tooth movement further enhances anchorage by eliminating any significant archwire binding. Except for a slight amount required to correct anterior crowding or spacing--which has no effect on anchorage--the only sliding mechanics occur when .016" or .022" round archwires pass through .036" molar tubes during the first two stages.

Friction is also minimized by the simultaneous retraction of canines and incisors. Since the archwire moves *with* the teeth, there is no friction between brackets and archwire during retraction. The common problem of distal lingual rotation of the canines is avoided as well.

The lack of friction and the elimination of anterior stationary anchorage allow rapid space closure--usually within three to four months. Continuous retraction forces are provided by elastomeric modules that are replaced as needed at regular appointments.

If molar protraction is desired, special braking mechanics are employed. Uprighting springs are used to limit the canines to bodily movement while there are still posterior spaces. For maximum protraction, a full-size rectangular wire that also limits the incisors to bodily movement is placed, and space-closing forces of 6-8oz are used to produce mesial molar movement.

Controlled Anchorage Strain

Controlled tipping and uprighting mechanics defer the anchorage strain until the third stage of treatment. At this point, any extraction spaces have been closed, an edge-to-edge incisal relationship has been established, and any crowding has been corrected without appreciable anchorage strain. The malocclusion has essentially been converted to an ideal Class I that requires only final uprighting and torquing.

Anchorage strain is much more easily controlled by delaying its occurrence. The tendency for the posterior segments to move mesially when subjected to mesially directed forces is blocked by the direct interproximal contact of the teeth throughout the arch. There is simply no space available in which anchorage can be lost (Fig. 8).

Although some mesial en masse movement of both arches occurs during Stage III, it is minor and does not affect the Class I relationship. Indeed, this small anchorage loss can be used to advantage in positioning the arches relative to the APo line.

Research studies have consistently found no significant difference in anchorage control between this technique, using only light Class II elastics, and edgewise techniques that routinely employ extraoral forces to reinforce maxillary anchorage.[26-28]

Reduced Need for Orthopedic Forces

Although attempts to induce orthopedic changes to correct Class II or m malocclusions can be helpful in correcting apical base discrepancies, such treatment is necessary far less often when differential tooth movement is used.

By eliminating the interlocking Class II dental relationship early in treatment, the Tip-Edge concept dramatically enhances the potential for mandibular growth to correct the malocclusion. It prevents the occurrence of dentoalveolar compensation, in which the teeth remain interlocked in a Class II relationship despite growth that could have moved the mandible forward.[29]

Diagnostic Criteria

In orthodontics--especially with regard to diagnosis--it is often assumed that complexity is synonymous with effectiveness. However, with the exception of severe skeletal discrepancies, a treatment plan for most patients can be determined using a simplified approach, based on the position of the incisors relative to the APo line and the ratio of required space to available space in the mandibular arch.

Gross skeletal disharmonies that might require surgery can often be identified by evaluating the patient's facial profile, Wits analysis,[30] and ANB angle. Excessive gingival display when smiling and severe open bites are common clinical indications of vertical skeletal discrepancies.

In treatment planning, it is important that qualitative aspects of each patient's malocclusion take precedence over quantitative analysis and comparison to "normal" values. This is particularly true when deciding whether orthognathic surgery will be required--a decision that ultimately must be made by the patient based on emotions and desires.

For nonsurgical treatment, the key cephalometric measurement is the position of the mandibular incisor relative to the APo line, as advocated by Williams.[31] A pleasing facial profile with well-balanced lip posture is generally achieved with the incisal edges 1-2mm ahead of the APo line. In some women or ethnic groups for whom a fuller profile might be desirable, the lower incisors can be farther ahead of APo.

This measurement, when considered along with an analysis of required and available space in the mandibular arch, will help determine whether a reduction in tooth mass is required. Such reduction can be achieved by interproximal stripping, extractions, or both.

Treatment for the following patients was planned according to these criteria.

Case 1

An 11-year-old male presented with a Class II, division 1 malocclusion with 9mm of overjet and 100% overbite. He had slight spacing of the maxillary anterior segment and mild crowding of the mandibular incisors (Fig. 9).

The facial profile was slightly convex, but the significance of this was offset by the patient's age and potential for mandibular growth (Fig. 10). The lower incisors were 2.5mm ahead of the APo line. The patient showed a Class I skeletal relationship and a Wits value of -2mm (Fig. 11).

Because of the position of the mandibular incisors, the mild lower anterior crowding, and the growth potential, the patient was thought to be a borderline extraction case. After four to six months of treatment, if the mandibular incisors were too far ahead of the APo line, the extraction of four premolars would be considered.

To shorten active treatment time, appliances were not placed until the lower permanent canines had erupted. Initial .016" Australian archwires were used in both arches, with bite opening bends and stops mesial to the molar tubes (Fig. 12A). The patient was instructed to wear light (1.5oz) Class II elastics full-time.

The premolars were not bracketed until the overbite had been corrected, and the intrusive forces of the archwires were thus concentrated on the anterior segments. The maxillary canines were not initially bracketed because they had not fully erupted.

With no posterior spaces to close, the patient proceeded directly from Stage I to Stage III. In Stage III, .022" archwires were placed in both arches. A torquing auxiliary was used to move the roots of the upper central incisors palatally, and "Side Winder" uprighting springs to upright the roots of selected teeth mesiodistally (Fig. 12B).

After just over two years of treatment, appliances were removed and a tooth positioner was delivered for retention. Only four straight archwires (two .016" and two .022") had been used for this patient.

The overjet, overbite, and Class II dental relationship were all corrected with differential tooth movement, without any extraoral forces or functional appliances (Fig. 12C). Cephalometric analysis showed the mandibular incisors remained 2.5mm forward of the APo line (Fig. 11). Although this is farther forward than is usually considered ideal for males, the facial profile was acceptable (Fig. 10).

The Class II correction was facilitated by beneficial growth, and the Wits value dropped from -2mm to -5mm during treatment. The decrease in FMA, from 23º to 18º, illustrates the level of control of the vertical dimension that is common with these mechanics.

Case 2

An 11-year-old female presented with a Class II, division 1 malocclusion and severe crowding of the upper and lower anterior segments. The maxillary right and mandibular left permanent canines were unerupted and completely blocked out. The patient had an 8mm overjet and 100% overbite, with the lower incisors occluding on the palate (Fig. 13).

The facial profile was flat with excessive lower lip curl, probably due to the deep overbite and contact of the lower lip with the lower incisors (Fig. 14). The initial cephalometric analysis showed the mandibular incisors 2mm behind the APo line, while a Wits value of +7mm indicated a pronounced skeletal Class II relationship (Fig. 15).

Even though the mandibular incisors were behind the APo line, the crowding was so severe that alignment of these teeth without extractions would have resulted in excessive proclination. Consequently, it was decided to extract the four first premolars to provide space without creating a bimaxillary protrusion.

Initial .016" Australian archwires with strong bite-opening bends mesial to the molar tubes were placed in both arches (Fig. 16A). The patient was instructed to wear light (1.5oz) Class II elastics full-time. Cooperation was poor during the first few months, but improved thereafter.

Within eight months, the overbite, overjet, and Class II molar relationship had been corrected. Stage III, delayed by the slow eruption of the maxillary second premolars, was begun after 17 months (Fig. 16B).

Eight months later, all root uprighting and torquing was complete and the appliances were removed (Fig. 16C). A tooth positioner was delivered for retention. Treatment was accomplished in about 26 months using only four straight archwires (two .016'' for Stage I and two .022" for Stages II and III).

Superimposition of pre- and post-treatment tracings showed that bite opening occurred without any opening of FMA or adverse rotation of the palatal plane (Fig. 15). The position of the upper incisors relative to APo improved from -2mm to +2mm, with a corresponding improvement in the facial profile (Fig. 14).

Case 3

A 12-year-old female presented with a Class II, division 1 malocclusion, 9mm of overjet, and 50% overbite (Fig. 17). She had mild crowding of both anterior segments, and the maxillary arch was somewhat constricted with a left buccal crossbite.

The patient showed a relatively flat profile, with lip strain apparent upon closure (Fig. 18). Although the ANB angle indicated a relatively severe Class II relationship, this was offset by a +2.5mm Wits value that pointed to a mild apical-base discrepancy (Fig. 19).

The extent of mandibular crowding, the position of the mandibular incisors directly on the APo line, and the patient's growth potential led to a decision to treat without extractions.

Fixed appliances were placed and biteopening mechanics used as in the two previous cases (Fig. 20A). Prototype nickel titanium coil springs, pulling 1.5oz per side, were used initially, but these work-hardened and broke within three days. They were replaced with conventional, light Class II elastics.

Within about three months, the overbite and overjet had been corrected (Fig. 20B). At this point the premolars were bracketed and Stage III mechanics were initiated. An .021" x .027" rectangular archwire was placed in the lower arch to reinforce anchorage.

After just over 12 months of treatment, the appliances were removed and a tooth positioner was delivered (Fig. 20C). Five straight archwires had been used (two .016", one upper .022", and two .021" x .027").

Superimposition of cephalometric tracings showed the extent to which mandibular growth contributed to the Class II correction (Fig. 19). Use of differential tooth movement with light Class II elastics produced no adverse rotation of the mandible or occlusal plane. The mandibular incisors moved from the APo line to 2mm ahead of the line, and there was a corresponding improvement in the profile (Fig. 18).

Conclusion

The results of these three cases demonstrate that treatment planning does not require complex cephalometric schemes. Except for patients requiring surgical correction, the majority of cases can be treated successfully using the diagnosis outlined in this article.

By addressing the limitations of the edgewise appliance from a fresh perspective--identifying the bracket slot as the source of anchorage problems--the Tip-Edge concept produced the first edgewise appliance to allow the use of differential tooth movement, without sacrificing the precision finishing of edgewise therapy. Major tooth repositioning and apical base corrections can be accomplished with simplified mechanics and very light intraoral forces.