Three-dimensional control during retraction of the upper anterior teeth is essential not only for facial esthetics, but also for function of the stomatognathic system and stability of orthodontic treatment. The magnitude of forces and moments applied by orthodontic appliances must be monitored to optimize tooth movement and avoid unwanted side effects.

A common orthodontic treatment goal is to combine retraction with intrusion and uprighting of the anterior teeth. To achieve this goal, clinicians often bend the continuous archwire into a shape that is expected to deliver intrusive force. Unfortunately, the many active and reactive forces produced by a continuous arch can combine to produce extrusion of the posterior teeth rather than intrusion of the incisors.¹

Controlled distribution of forces between the anterior and posterior parts of a fixed appliance can only be accomplished by dividing the arch into segments.² ³ Each segment is consolidated into a rigid unit by a section of heavy rectangular

Fig. 1 PG Universal Retraction Spring can be adjusted for canine retraction (A), uprighting of canine (B), or incisor retraction (C).
wire, with little or no play between wire and bracket slot. The anterior segment, usually including the four incisors and possibly the canines, forms the active unit, and the two posterior segments, including the premolars and molars, are the reactive units. When necessary, the reactive units are connected by a transpalatal bar to form a single rigid, multirooted entity.

The planned displacement of the anterior unit and the corresponding reaction of the posterior units are carried out by connecting the anterior and posterior units with active elements, such as retraction springs. The proper force system is then created by carefully selecting the points of force application within each segment and by precalibrating the springs to produce the desired balance of moments and forces within a certain range of activation.

A high degree of precision and standardization is required to fabricate sectional springs with the appropriate properties. Attempting to create a certain type of retraction spring by chairside wire bending, or to change the basic form of a prefabricated spring, often results in dramatic and unexpected side effects. This may explain why some clinicians are disappointed by the results of their attempts to work with segmented or sectional arches.

The PG retraction system (Fig. 1) has been designed to facilitate segmented treatment of extraction cases. The basic element of the system, which is available in right and left versions,* is a prefabricated, highly standardized, stainless steel retraction spring that is adjustable to fit both .018" and .022" edgewise appliances.

The PG Universal Retraction Spring is designed for controlled retraction of either canines or upper incisors. No clinical alteration of the spring is needed, and the force system produced is independent of interbracket distance. The spring is precalibrated to deliver predictable moment-to-force ratios in three planes of space. The magnitude of the force delivered, which is kept within desirable physiological limits, can be identified by "reading" the morphology of the spring during activation.

**Canine Retraction**

The canines are keystones of the occlusion and of crucial importance for function, stability, and esthetics. One of two types of canine retraction is generally used in edgewise mechanics:

1. A "frictional" system in which the canine is intended to slide distally, guided by a continuous wire. The main advantage of this technique is the limited possibility of unpredicted flaring and rotation. Disadvantages are lack of vertical incisor control and the need for increased anchorage (Fig. 2).

2. A non-frictional, segmented system in which the canine is moved by a buccal sectional closing loop or a retraction spring. This method avoids unwanted displacements of the incisors. Furthermore, patients appreciate the absence of visible appliances on the incisors during canine retraction.

* RMO, Inc., P.O. Box 17085, Denver, CO 80217.
**Fundamental Biomechanics**

Any type of force system delivered by a retraction spring can be separated into some combination of a force and a moment. The displacement of the canine depends on the relationship between the line of action of the force and the center of resistance. A pure force directed through CR results in a translational movement of the tooth along the line of force (Fig. 3).

Holographic studies\(^5\) and strain-gauge investigations\(^6\) have shown that the CR of a single-rooted tooth is located on the tooth axis, 35% of the distance from the marginal alveolar ridge to the apex.

Clinically, the point of force application is the bracket. If a pure force is directed distally through the bracket, the tooth will undergo a distal tipping movement—a combination of distal translation and rotation around the CR (Fig. 4). The rotation is the result of a moment of the force (\(M_p\)) produced because the force is applied at a distance (\(d\)) from CR. This moment is calculated as \(M_p = F \times d\).

If a pure translational movement of the tooth is desired, the moment must be neutralized. This can be done by calibrating the retraction spring to produce a couple at the canine bracket. An antitip moment of the couple (\(M_c\)) can be created of equal magnitude and opposite direction to the moment of force: \(M_p = -M_c = F \times d\), which can be expressed as \(M/F = d\).

Thus, translation is obtained if the moment-to-force ratio produced at the canine bracket is equal to the distance between the bracket and CR.

In the horizontal plane, a pure distal force directed through the canine bracket results in distal rotation of the tooth (Fig. 4). This distal rotation can be prevented by calibrating the retraction spring to produce an antirotation moment: \(M_c = F \times d\). In this formula, \(d\) represents the

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**Fig. 3** Center of resistance (CR) is point through which application of pure force will produce translatory tooth movement.

**Fig. 4** Pure horizontal force directed through canine bracket results in combination of translation and rotation around CR.

**Fig. 5** Antitip and antirotation moment-to-force ratios required to produce translation of canine, assuming conical root of average dimensions.
horizontal distance from CR to the center of the bracket.

The average bracket-to-CR distance of upper or lower canines with average root lengths and normal marginal bone levels is 11 mm when measured in the sagittal plane, and 4 mm when measured in the horizontal plane. Therefore, bodily movement of a normal-size canine can be produced by a retraction spring calibrated to produce an antitip M/F ratio of 11 and an antirotation M/F ratio of 4 (Fig. 5).

However, clinical experience has shown that the antirotation M/F value should be increased to 7 to compensate for deviations in root morphology and differences in buccal inclination of the roots (Fig. 6).

The optimum orthodontic force is one that provides a maximum desirable biological response, resulting in rapid tooth movement with little or no clinical discomfort. Increasing the load beyond this level can result in iatrogenic tissue damage, unwanted alteration of the M/F ratios, and anchorage loss.

The exact optimum force range has not yet been scientifically established, but reports based on clinical experience have recommended horizontal driving forces in the range of 75-260 g for canine translation. The PG spring was designed to avoid unwanted side effects and tissue damage by keeping the force magnitude within a low range—100 g in the initial activation.

A previous description of the PG spring suggested an initial activation of 160 g. However, subsequent clinical experience showed that a reduction of the initial force level to 100 g did not significantly affect the rate of tooth movement.

It is debatable whether constancy of force magnitude is desirable in stimulating the biological reactions responsible for tooth movement. The force of a retraction spring inevitably decays between activations (Fig. 7). Nevertheless, the PG spring, with a low load/deflection rate, is designed to act within appropriate physiological limits.

The PG Universal Retraction Spring

The physical characteristics of the spring.
were determined by calculation of a balance between forces and couples produced at the anterior and posterior extensions of the spring, within a certain range of activation. These measurements were made electronically with a strain-gauge device.

The spring was then precalibrated to deliver the required antitip and antirotation M/F ratios at the alpha position (the canine) to produce a controlled, bodily displacement within the desired range of activation (Fig. 8).

The prescribed initial driving force of 100g (arrows, Fig. 8) is identified by “reading” the morphology of the spring (Fig. 9). On average, 1.2mm of space closure takes place in four weeks. During this period, there is a decrease in horizontal force from 100g to 40g and an increase in intrusive force from -1g to 12g (Fig. 8A).

At the time of activation, the M/F ratio is 9 (Fig. 8B). Since the M/F ratio required for translational canine movement is 11, the initial movement is a controlled tipping. However, after only .3mm of deactivation, the antitip M/F ratio increases to 10-11. From this point on, the canine movement is translation followed by uprighting.

The curvature of the posterior extension of the spring was incorporated to produce a moment to the anchorage teeth (Fig. 10). This so-called beta moment is a desirable complement to the alpha moment, since it counteracts the extrusive forces exerted by the alpha moment at the canine. There is an equal application of beta moment at the second premolar bracket and at the molar tube.

The vertical force produced by the posterior curvature of the spring should be of a magnitude to neutralize the extrusive force generated by the alpha moment and to produce a slight intrusive

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**Fig. 8** A. Horizontal and vertical forces in grams per millimeter of space closure during canine retraction. Arrow indicates initial horizontal force of 100g. B. Antitip and antirotation M/F ratios per millimeter of space closure. Arrow transferred from A indicates 100g of initial horizontal force.

**Fig. 9** Configuration of double helix to produce 100g of horizontal driving force.
tendency at the canine bracket. According to physical laws, this modest intrusive force will be accompanied by a similar extrusive force at the posterior segment. However, the posterior extrusive force is counteracted by masticatory forces, thus avoiding undesired extrusion of the molars and an increase in lower facial height.

**Clinical Application**

1. **Alignment of the buccal teeth.** The spring is constructed to resist tendencies for tipping and rotation during canine retraction—not to correct existing rotations or extreme deviations in inclination. Therefore, the buccal segment, including the canine, second premolar, first molar, and eventually second molar, must be leveled prior to insertion of the spring.

2. **Adjustment of faciolingual loop inclination.** The correct faciolingual position of the spring (Fig. 11) is obtained by adjusting the anterior and posterior extensions before insertion (Fig. 12).

3. **Bracket engagement.** The anterior extension

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**Fig. 10 A.** Preliminary test spring with straight posterior extension. **B.** PG Universal Retraction Spring with curved posterior extension.

**Fig. 11** Correct faciolingual position of PG spring (reprinted by permission).

**Fig. 12 A.** Faciolingual adjustment of double helix. **B.** Twisting of posterior extension (reprinted by permission).
of the spring is engaged in the canine bracket. The posterior extension must be engaged in both the premolar and the molar brackets to obtain optimum transverse control of the canine and alignment of the canine, premolar, and molar (Fig. 13). The anterior extension is pulled mesially until the small circular helix contacts the distal aspect of the canine bracket (Fig. 14), and the wire is secured by bending the anterior extension gingivally.

4. Activation. The spring is activated by pulling distal to the molar tube until the two loops separate (Figs. 9, 14). The wire is secured with a gingival bend in the posterior extension. Reactivation to the initial spring configuration should be done every four to six weeks.

This amount of activation produces the recommended initial load of 100g. It is critical to avoid overactivation of the spring, because a few millimeters of overactivation will result in reduced M/F ratios (Fig. 8B) and thus unwanted tipping and rotation.

Since the average distances from the centers of the brackets to CR are identical for upper and lower canines, the PG spring works equally well for canine retraction in either arch (Fig. 15).

Deviations in anatomy or root inclination or improper clinical manipulation of the spring may result in a steepening of the mesiodistal inclination of the retracted canine. This can be corrected by uprighting the tooth after retraction. The spring is modified in the mouth by placing a V-bend in the buccal loop with a three-prong plier (Fig. 16), thus increasing the alpha moment to about 1,500g/mm, which appears to be ideal for uprighting (Fig. 17).

Minor rotations of the canine may also be noted in rare instances. These are easily corrected after retraction with lingual elastics.

Without additional anchorage support, the second premolar and first molar can be expected
to migrate mesially about half as far as the canine is retracted. Such mesial migration of the anchorage unit is often desirable, but in critical anchorage situations, it may be necessary to use a transpalatal arch and extraoral traction.

Clinical evaluation of PG Universal Retraction Springs has shown that the mesial movement of the anchorage teeth takes place as a translation. The anchorage group as a whole is not affected by unwanted side effects such as extrusion and rotation. Therefore, the magnitude of the couples and extrusive forces generated by the posterior extension of the spring should be more than offset by neuromuscular forces of occlusion.

Fig. 16 Adjustment of PG spring for canine uprighting by placing V-bend in buccal loop with three-prong plier.

Fig. 17 A. Case at beginning of canine retraction. B. After five months of space closure and two and one-half months of uprighting. Arrow indicates increased alveolar bone formation as result of uprighting.
A Universal Retraction Spring

Universal Spring has been calibrated to optimize biological reactions of the anterior teeth and to prevent unplanned side effects in the posterior segments.

Fundamental Biomechanics

Class II cases frequently have a deep bite caused by overeruption of the incisors. Orthodontic repositioning of the maxillary incisors therefore requires an upward and backward force vector (Fig. 19).

During retraction, the four incisors are united to form the anterior segment (active unit). From a biomechanical point of view, this segment can be considered a single tooth with four roots. The anterior segment is pitted against the two posterior, reactive units, each comprising the canine, second premolar, first molar, and eventually second molar. The force is delivered by a retraction spring connecting the lateral incisor bracket to the gingival molar tube (Fig. 1C).

A pure force directed through the CR of the four incisors will result in a translation of the anterior segment. The CR is located an average distance of 9-10mm gingivally and 7mm distally from the center of the lateral bracket (Fig. 20).

If a pure force F is directed distally through the lateral incisor brackets, a distal tipping movement will occur. This can be eliminated by adding

Fig. 18 A. Case with super-Class I canine relationship after canine retraction: 50-60g Class III elastic placed to promote mesial migration of buccal segment. B. Canine and buccal segment in ideal position for residual space closure 10 weeks later.

The opposite anchorage situation—overcorrection of the canine with residual extraction space—is easily corrected with light Class III elastics of 50-60g (Fig. 18).

Controlled Incisor Retraction

The position of the upper incisors has a striking effect on the esthetic appearance of the face and on an individual’s self-esteem. Patients and parents notice not only the overjet, but also the vertical position and inclination of the teeth. They may use terms such as “orthodontic face” to describe treatment results with “hanging” and steeply inclined upper incisors.

As with canine retraction, a segmented approach provides the necessary three-dimensional control of the incisors to be moved. The PG

Fig. 19 Ideal direction of force for retraction of upper incisors.
an antitip moment to the force system (Fig. 21). Bodily translation of the anterior segment occurs when the moment-to-force ratio equals the distance between the center of the lateral bracket and CR (M/F = d), or when the M/F ratio is 9-10.

The force system should be calibrated according to the root surface area of the teeth to be retracted in order to optimize the periodontal response. The combined root surface area of one maxillary central and one maxillary lateral incisor is close to that of a single canine. Therefore, the same magnitude of horizontal force can be applied for retraction of incisors and canines. The PG system uses 100g as the initial horizontal force for both.

To produce the necessary upward and backward force vector (Fig. 19), a vertically directed intrusive force must be added to the force system acting at the lateral bracket (Fig. 21). The intrusive force must be sufficient to overcome the extrusive force generated by the uprighting moment and also to produce an intrusion of the incisors. With the development of more sophisticated appliances, successful intrusion has been demonstrated in recent years.

Because the intrusive force is concentrated over a small area at the root apex, extremely light forces will produce the optimum biological reaction. An investigation of a group of patients treated with a total intrusive force of 100g at the maxillary incisors showed 18% mean resorption of the original root length. It seems reasonable to conclude that the intrusive force should be 10-25g per side.

The apically directed vertical force is accompanied by an extrusive force of the same magnitude at each of the posterior segments. This modest force is neutralized by neuromuscular occlusal forces.

**The PG Universal Retraction Spring**

The analysis and adjustment of the PG spring for incisor retraction was performed in a strain-gauge device identical to the one used to design the spring for canine retraction.

Because the magnitude of intrusive forces produced at the anterior segment are determined by the posterior curvature of the spring (Fig. 1C), this curvature was adjusted to deliver the required force magnitude of 10-25g per side. The resulting curve is close to the original design used for equal distribution of the beta moment through the premolar bracket and molar tube during canine retraction. Therefore, only minor changes were necessary to optimize the spring for both incisor and canine retraction.

As with canine retraction, the initial activation is determined by the configuration of the force system.
A Universal Retraction Spring

spring (Fig. 22). Initially, the horizontal force is 100g and the vertical force 9g (Fig. 23). Four to five weeks later, after 1.2mm of space closure, the horizontal force decreases to 30g and the intrusive force increases to 23g.

At the time of activation, the M/F ratio at the lateral bracket is 8. Since the M/F ratio required for translation is 9-10, the initial movement is a controlled tipping. After .3mm of space closure, the M/F ratio increases to 10, and the anterior segment begins to translate and upright.

Clinical Application

1. Alignment of the incisors. The PG Universal Retraction Spring can be used with any edgewise system, but triple tubes at the upper first molars are required. The occlusal tube is used for canine retraction. During the final sequence of canine retraction, the upper incisors are aligned with archwires engaged in the incisor brackets, bypassing the canine and premolar brackets (occupied by the canine retraction spring), and proceeding through the gingival molar tube.

After removal of the canine retraction spring, the canines are tied back to avoid reopening the extraction spaces. If necessary, maxillary archform can be corrected with a continuous archwire engaged in the brackets of all three segments. A vertical step is added distal to the lateral incisors to compensate for differences in the vertical level of the buccal and overerupted incisor segments (see Fig. 34).

2. Consolidation of the segments. Alignment of the incisors is followed by stabilization of the
buccal and anterior segments with heavy rectangular wires. The wire cross-section should be large enough to minimize play between wire and bracket slot. To avoid interdental spacing, the stabilizing arches, which pass through the occlusal molar tubes, are bent close to the mesial and distal aspects of the terminal brackets and tubes (Fig. 24). Notice that these bends are occlusally directed so as not to interfere with the sliding of the retraction spring.

3. Adjustment of the spring for incisor retraction. Before engagement, the spring is modified by making a 90° twist in the anterior extension, 3mm in front of the small circular loop. The twisted extension should be angulated 105° to allow for a 15° play between the wire and the vertical slot (Fig. 25).

The anterior and posterior points of force application are the centers of the lateral incisor bracket and the triple molar tube, respectively (Fig. 20). The posterior extension of the spring is always inserted in the gingival auxiliary molar tube (Fig. 24), but the anterior extension can be attached to the lateral bracket in several ways. The most practical is to use .018"X.025" lateral incisor brackets with vertical Broussard-type slots** (Fig. 26). These accommodate the .017"X.022" PG springs.

In other preadjusted systems, such as the Mini Taurus,* there is a rectangular groove between the mesial and distal tie wings of the lateral

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**For example, American Orthodontics, 1714 Cambridge Ave., Sheboygan, WI 53082.

*RMO, Inc., P.O. Box 17085, Denver, CO 80217.
incisor bracket (Fig. 27A). When the stabilizing arch is placed in the horizontal slot, the groove closes to form a vertical slot with an inner dimension that is ideal for placement of the spring (Fig. 27B).

Although a vertical slot provides excellent control of the spring’s inclination, it is not a necessity. The anterior extension can be placed behind the tie wings of a standard edgewise lateral incisor bracket and tied to the sectional arch mesial and distal to the bracket (Fig. 27C). A gingivally directed bend in the anterior extension prevents the activated spring from sliding distally.

The anterior toe-in of the spring, as calibrated for rotational control in canine retraction, establishes a good relationship between the anterior portion of the spring and the lateral incisor bracket. Horizontal adjustments for fitting the anterior extension in the vertical slot and the posterior extension in the molar tube have no significant effect on the sagittally and vertically directed force system (Fig. 26). The faciolingual inclination of the double helix is adjusted as for canine retraction (Fig. 12).

4. Bracket engagement. The posterior extension

Fig. 27 A,B. PG spring in Mini Taurus lateral incisor bracket. C. PG spring in standard edgewise lateral incisor bracket without vertical slot.

Fig. 28 Anterior extension locked into vertical slot of bracket.

Fig. 29 Mesial bend of anterior extension and activation distal to molar tube to produce morphology of double helix corresponding to 100g of horizontal force.
is placed in the gingival auxiliary tube of the molar bracket (Fig. 24). The anterior extension is placed in the vertical slot of the lateral incisor bracket, pulled as far occlusally as possible, and locked with a mesial bend (Fig. 28).

5. Activation. The spring is activated by pulling the posterior extension distally until the double helix is distorted as shown in Figure 29. This configuration will produce an initial horizontal force of about 100g. The posterior extension is secured with a gingival bend distal to the molar tube. The spring is reactivated every four to six weeks by returning the double helix to its initial configuration.

Case Reports

Case 1

A 12-year-old female displayed convexity of the soft-tissue profile and a dolichofacial growth type due to a retrognathic and posteriorly inclined mandible (Fig. 30). Use of a pacifier until age 4 was a possible factor in the development of her malocclusion. She exhibited incompetent lip closure and excessive gingival exposure in smiling.

The patient had a Class II malocclusion with an extreme overjet. The upper arch was narrow and V-shaped, while the lower arch was narrow.
and U-shaped. The upper anterior teeth were protruded and overerupted, and the lower anterior teeth were retroclined and slightly crowded.

The treatment plan involved extraction of the upper first bicuspids; transverse expansion of both arches; modest sagittal expansion of the lower arch; and retraction, intrusion, and uprighting of the upper anterior teeth. Extrusion of the buccal teeth was to be avoided to prevent any further increase in lower facial height.

The buccal segments were leveled for four weeks with .016” stainless steel Australian archwires (Fig. 31). At the same time, equal amounts of transverse expansion of the upper and lower arches were produced by a transpalatal arch attached to the upper first molars and a lingual arch attached to the lower first molars, both constructed from .036” round stainless steel wire.

The transpalatal arch was activated to deliver a moderate distal rotation of the upper first molars around their palatal roots. This rotation caused the buccal surfaces of the molars to move distally, which counteracted the mesially directed force exerted on the molars by the PG spring during canine retraction (Fig. 32).

After leveling of the buccal segments, retraction of the canines was completed in five months (Fig. 33). Notice that 2.5mm of sagittal overcorrection was obtained without any extraoral support. Because the controlled canine retraction was performed simultaneously with the distal rotation of the upper molars, the intercanine width increased gradually to normalize the shape of the upper arch. Treatment time was thus saved by

Fig. 31 Case 1. A. Leveling of buccal segments with .016” Australian wire. B. Upper transpalatal bar activated for modest expansion and slight distal molar rotation. Lower lingual arch activated for modest expansion and uprighting of molars.
eliminating the need for any additional transverse expansion.

The upper incisors were aligned within a proper archform using round, continuous stainless steel archwires of increasing cross-section (Fig. 34). Vertical steps were placed in the archwires distal to the lateral incisors to compensate for the “hanging” upper incisors. The canines were tied back to avoid reopening of extraction spaces.

Leveling and modest sagittal expansion of the lower arch were carried out during the final phase of canine retraction. To prevent an increase in lower facial height, care was taken not to eliminate the existing curve of Spee.

The buccal and anterior segments were sta-

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**Fig. 32** Case 1. Beginning of canine retraction after one month of leveling.

**Fig. 33** Case 1. After five months of canine retraction, showing elimination of V-shape in upper arch.

**Fig. 34** Case 1. Leveling of anterior segments with .016” Australian archwires (note vertical step in upper arch).
Fig. 35 Case 1. Beginning of upper incisor retraction, with lower .018” Australian archwire in place.

Fig. 36 Case 1. After four months of upper incisor retraction, with lower .020” Australian archwire in place.

Fig. 37 Case 1. One week after removal of appliances following 15 months of active treatment.
bilized with heavy rectangular wires, and the PG springs were modified for controlled incisor retraction (Fig. 35). The extraction spaces were closed in four months with an upward and backward translational movement of the anterior segments (Fig. 36).

Incisor retraction was accompanied by a mesial translation of the buccal segments, which established an optimum buccal intercuspation. Minor adjustments and artistic positioning of the occlusion were performed with continuous archwires during the following three months. The total active treatment time was 15 months (Fig. 37).

Cephalometric analysis shows the upward and backward movement of the incisors and the stability of the mandibular plane angle (Fig. 38, Table 1).

**Case 2**

Precise identification of anatomical landmarks can be difficult in lateral cephalograms because they are actually double images. The superimposition and tracing of tooth movements within the maxilla is particularly subject to error.

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**Fig. 38 Case 1.** A. Tracing of maxilla from headfilm exposed at beginning (gray) and end (black) of incisor retraction. B. Superimposition of pre- and post-treatment tracings according to Bjork and Skieller.

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**TABLE 1**

**CASE 1 CEPHALOMETRIC ANALYSIS**

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<tr>
<th>Segittal Skeletal Relations</th>
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<th>Posttreatment</th>
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<td>124</td>
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The Angle Society of Europe 1989
Cephalometric analysis of individuals who have ceased craniofacial growth is more accurate, since more skeletal structure is available for identification of landmarks. Therefore, an adult patient treated with the PG system is shown.

The upper first bicuspids were extracted, and the treatment plan was similar to that of the first case. Canine retraction was completed in six months, and incisor retraction was initiated (Fig. 39).

Space closure was accomplished in five more months (Fig. 40). No transpalatal bar or lingual arch was used, but a combi-headgear was added for anchorage support during retraction of the incisors.

All major sagittal and vertical corrections and adjustments of root inclinations were achieved during the retraction procedures. Only minor adjustment of archform and finishing were left to be completed with continuous archwires (Fig. 41). The total active treatment time was 14 months (Fig. 42).

The inclination of the lower arch remained completely unchanged during incisor retraction (Fig. 43). Correction of incisor positions was clearly achieved through an upward and backward translation, with no vertical displacement of the buccal teeth (Fig. 44).

**Conclusion**

- Three-dimensional control in the retraction of anterior teeth is made possible by segmentation of orthodontic appliances.
- Planned tooth movements can be carried out by connecting the segments with sectional springs that are precalibrated to produce the required force system.
• The standardized PG Universal Retraction Spring is experimentally designed to produce the force system required for translational movement of both canines and incisors, without changing the basic morphology of the spring.

• The force system produced by activation of the spring is independent of the distance between the anterior and posterior points of force application.

• The initial magnitude of driving force is identified from the configuration of the activated spring.

• Forces applied to the anchorage units are adjusted so that no single tooth is subjected to unwanted side effects, and undesirable changes in the occlusal plane are avoided.

• Any side effects in the buccal segments are insignificant and are neutralized by the forces of occlusion.

(continued on next page)

Fig. 42 Case 2. After 14 months of active treatment.

Fig. 43 Case 2. Headfilm exposed at beginning and end of incisor retraction.

Fig. 44 Case 2. A. Enlargement of superimposed headfilm of Figure 43. Note translational upward and backward incisor movement. B. Tracing of maxilla from same superimposed headfilm.
REFERENCES