Auxiliary springs in continuous arch treatment: Part 2. Appliance use and case reports

Bruce S. Haskell, DMD, PhD,* William A. Spencer, BSEng, DMD, and Michael Day, PhD*****
Louisville, Ky.

In the second part of this series, three clinical examples are presented to illustrate the use of auxiliary space-closure springs with clinically manageable moment-to-force ratios and new canine brackets to accommodate these springs within the framework of conventional and straight-wire 0.018-inch appliance systems. Elgiloy retraction spring models (0.1650 inch x 0.02150 inch) in the edgewise mode were developed for translational movements along a main archwire. The effects of different preactivation bends for influencing intraarch anchorage are shown for the conditions of reciprocal closure, posterior protraction, and anterior retraction. (AM J ORTHOD DENTOFAC ORTHOP 1990;98:488-98.)

Part 1 described the problems inherent in developing traditional edgewise mechanics to translate teeth with more precision in extraction environments. Spaces may be reduced by reciprocal movements of teeth toward each other or by anterior retraction/posterior protraction of individual teeth or selected segments. Unfortunately, space-closure forces are placed at a bracket that is, of necessity, located well above the center of resistance. Moments are produced that cause different degrees of tipping about a point somewhere between the tooth's center of resistance and its apex. It has been recognized that the moment of the force that causes tipping (MF) can be counteracted by application of a counter-moment (MC) that creates a couple, which may move the center of rotation to infinity.

The advantages and disadvantages of traditional techniques to provide controlled tooth movements, such as gable bends, preangulated brackets, and "segmental" mechanics, have been discussed. Segmented arch techniques developed by Burstone et al.[1-3] offer systems with controlled tooth movements and ideal moment/force ratios, but they contain numerous components that may be difficult to manipulate. In the segmented technique, no continuous arch wire is used between anterior and posterior segments of the teeth. Without the presence of this archwire, however, nothing prevents anterior and posterior segments from leaving the occlusal plane as a result of errors in the M/F ratio between segments.

From the University of Louisville,
*Clinical Professor, Department of Orthodontics, School of Dentistry
**Clinical Instructor, Department of Orthodontics, School of Dentistry
***Associate Professor, Department of Mechanical Engineering
8/1/17033

Other segmented methods such as the Ricketts technique may use a utility arch in combination with cuspid retractors not used with a main arch. Hence the Ricketts system does not necessarily prevent unwanted rotation; it also lacks the "fail-safe" approach achieved with sliding mechanics.

In view of points made in Part 1 of these reports, there is a demand for a system that incorporates the application of segmented-arch mechanics—that is, one that provides good moment/force ratios, along with the fail-safe mechanism inherent in sliding mechanics. Such a system, however, should be "user-friendly"— i.e., adaptable for use with much of the armamentarium and appliances typically associated with edgewise techniques.

APPLIANCE APPLICATION

The auxiliary spring appliance is designed to prevent unwanted tipping and rotations of teeth during its translational movement along a main 0.016 ´ 0.022-inch archwire. The system consists of specially designed 0.017 ´ 0.022-inch heat-treated Elgiloy springs (Rocky Mountain Orthodontics, Denver, Colo.), which are inserted into buccal and gingival tubes that are part of the molar and canine brackets (Fig. 1, A). Only the special canine brackets need to be substituted in existing edgewise prescriptions in cases where the first molar brackets in-

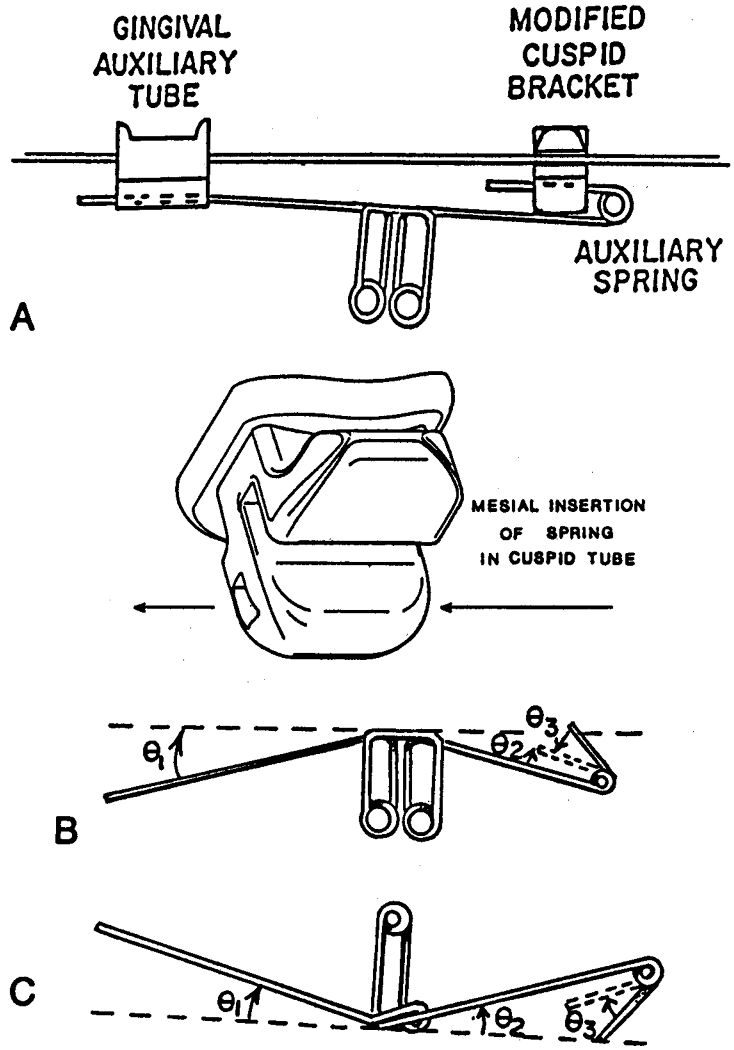

Fig. 1 A. Auxiliary spring/bracket system. Fig. 1 B. Mandibular auxiliary spring reference angles. Fig. 1 C. Maxillary auxiliary spring reference angles.

clude gingival auxiliary tubes. Other than the canine modification, the 0.018-inch edgewise Bio-progressive or Roth-type appliance is used in this report. The canine brackets have been designed to facilitate insertion or removal of springs without the necessity of retying existing ligatures. There are 0° torque and 6° tip in the mandibular canine; 0° torque and 10° tip in the maxillary canine bracket.

Notice in Fig. 1, B that the mandibular spring appears similar to traditional retraction springs except for the extra helix in the anterior (a) portion. This helix, in conjunction with the gables placed in the posterior (ß) legs of the spring provides the required couple which counters the moment produced by the closure force and allows translation of the canine or molar during space closure. The main spring helices are placed in the area of the extraction site. The maxillary spring is also shown (Fig. 1, C). There are three angles in the spring to consider θ_1 and θ_2 comprise the bends posterior and anterior to the main contraction helices, while θ_3 is the angle of the anterior leg of the helix.

The preadjusted springs are first placed in the mesial part of the auxiliary molar tube and then inserted into the mesial part of the canine tube. The excess wire at the distal side of the auxiliary molar tube is activated 2 mm by a pulling and cinching action on the wire at the end of the spring. Spaces between the teeth may be closed en masse or by separate canine-retraction methods, depending on the requirement of the clinician.

Fig. 2. Mandibular auxiliary spring in place. The main arch wire should be slightly constricted before placement to balance lateral moments.

Fig. 3. A-C. Case 1. A through C, Initial photographs of the reciprocal space-closure case with marked midline discrepancy.

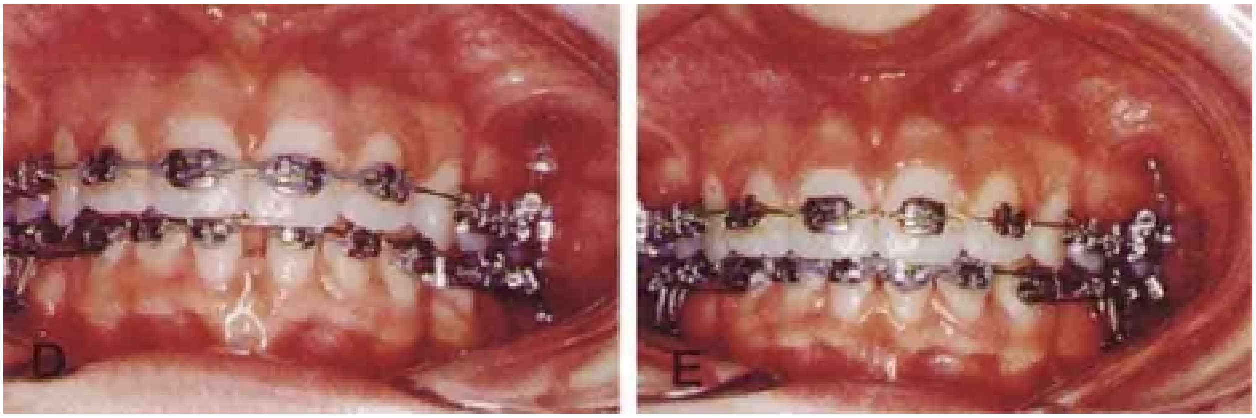

Fig. 3 (Cont'd). D-E. Case 1. D, Midline being corrected with a unilateral auxiliary bracket in place. E, both auxiliary brackets being used after anterior consolidation.

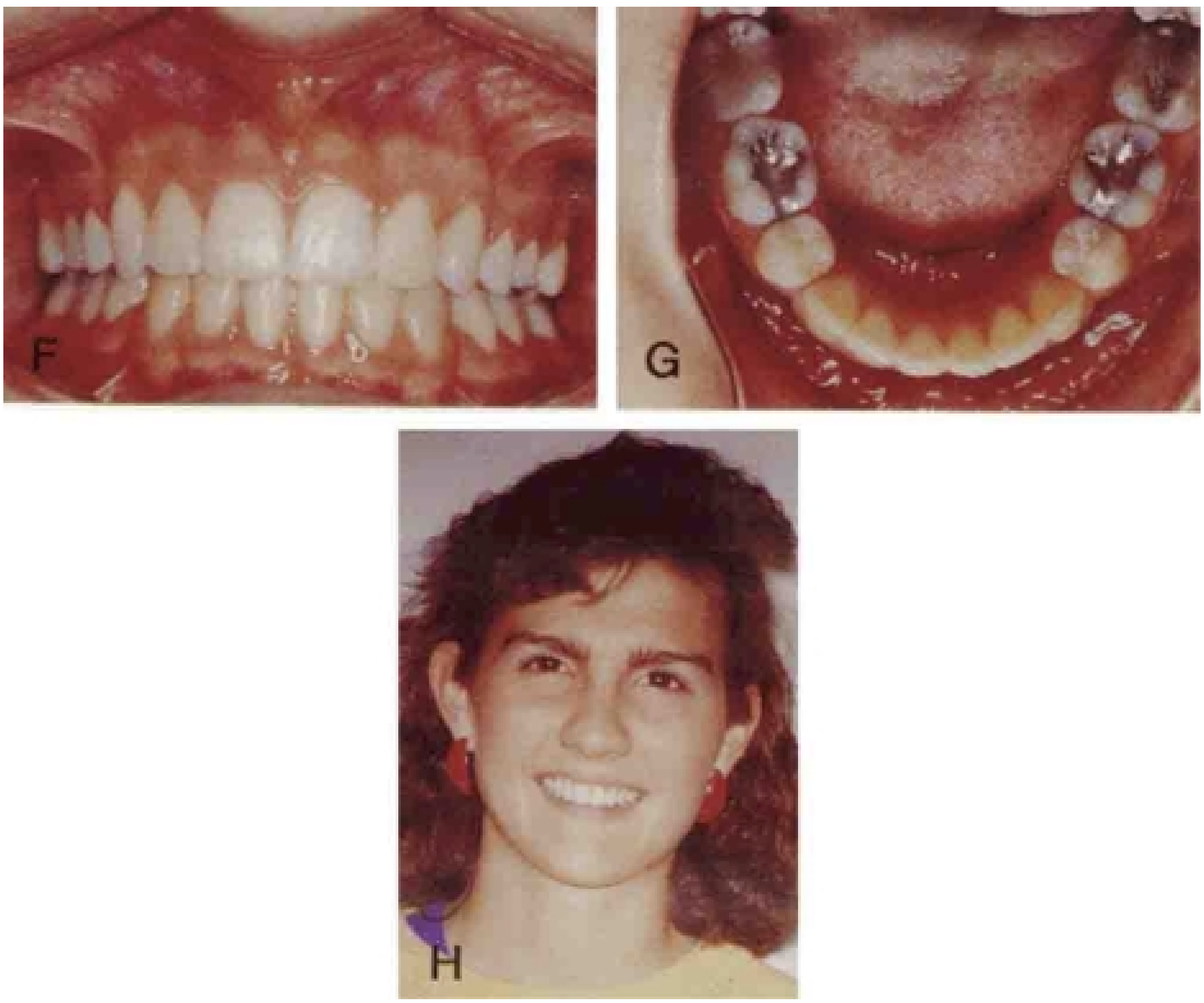

Fig. 3 (Cont'd). F-H. Case 1. F through H, Patient after treatment with midline correction and space closure completed.

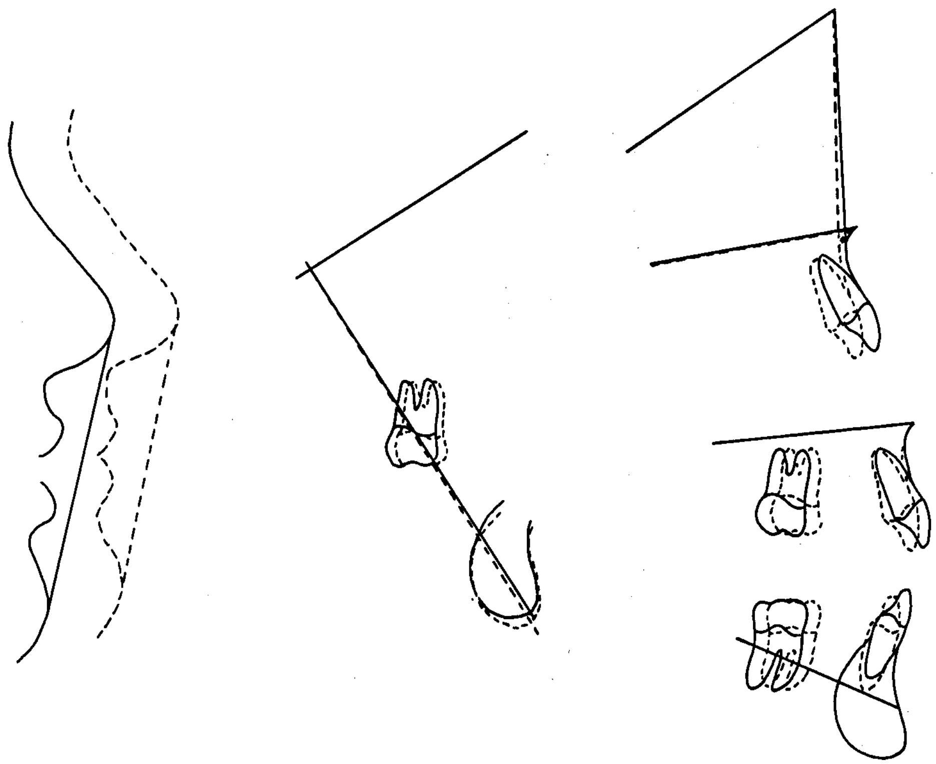

Fig. 3 (Cont'd). I. Case 1. Tooth/profile superimpositions.

All spring conditions are contoured to the arch, as are sectional wires in other techniques. The contour is usually slightly greater than the contour of the buccal segment. Moments also appear in the buccolingual plane that may be additionally controlled by adjustments of the spring and main archwire (Fig. 2). The main arch wire configuration and the proper forces and moments (moment/force ratio) are expressed by predetermined auxiliary spring activations for the most common treatment situations, including (1) reciprocal space closure, (2) maximum posterior anchorage with maximum anterior retraction, (3) maximum anterior anchorage with posterior protraction, and (4) gross shifting of the midline. The following three cases illustrate spring applications.

Reciprocal closure

In reciprocal closure, as in standard edgewise therapy, the teeth (including second molars) are bracketed, and the dental arches are leveled and aligned. Bite opening is accomplished before space closure is begun. Arches are increased in size until 0.016-inch ´ .022-inch size wires can be used. Anchorage requirements are determined and provided for. Anterior spaces are consolidated in the anterior segment from canine to canine, if en masse closure is desired, or from lateral to lateral in cases of individual canine retraction. A continuous steel ligature tie or main arch-wire stops should be placed between these teeth to assure their integrity as a unit. The springs are then adjusted and simultaneously inserted into the mesial part of the molar tube and the canine tube. The ideal preactivation configuration for reciprocal closure should be $\theta_1 = \theta_2 = 45°$ and $\theta_3 = 15°$ for the mandible, and $\theta_1 = \theta_2 = 45°$ and $\theta_3 = 30°$ for the maxilla. It is suggested that users of the auxiliaries view the anterior angular changes merely as a range for M/F ratio alterations to assist in treatment-planning goals. This spring is activated by pulling back 2 mm and cinching the wire distal to the molar tube. Activation is performed every 5 to 6 weeks until spaces are closed.

Our preference is to often retract the lower anterior teeth en masse, except in cases where the midline must first be corrected. A time-consuming task, the shifting of the midline is necessary to ensure a permanent correction without posttreatment

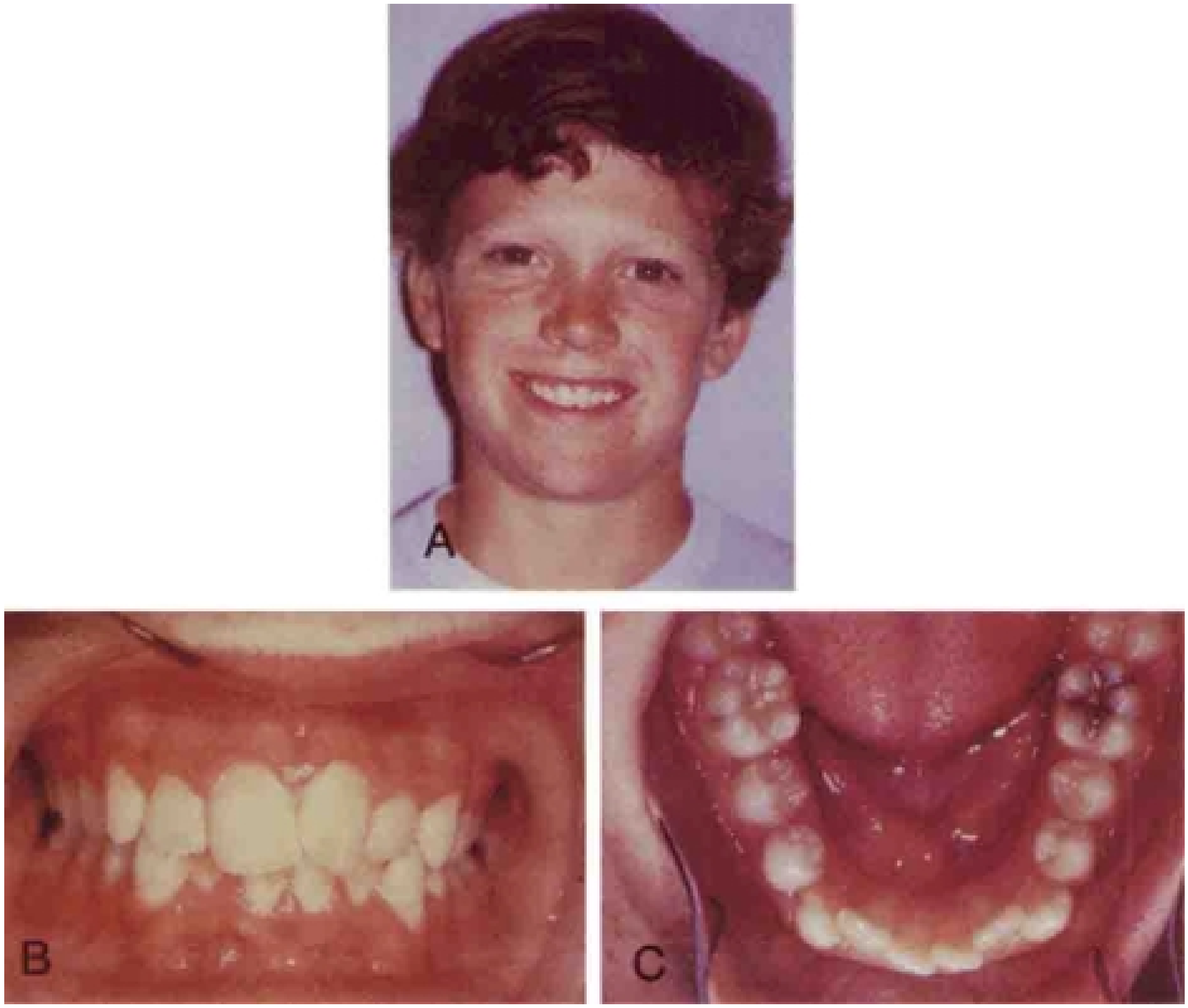

Fig. 4. A-C. Case 2. A through C, Initial photographs of posterior protraction case with deep bite and anterior crowding.

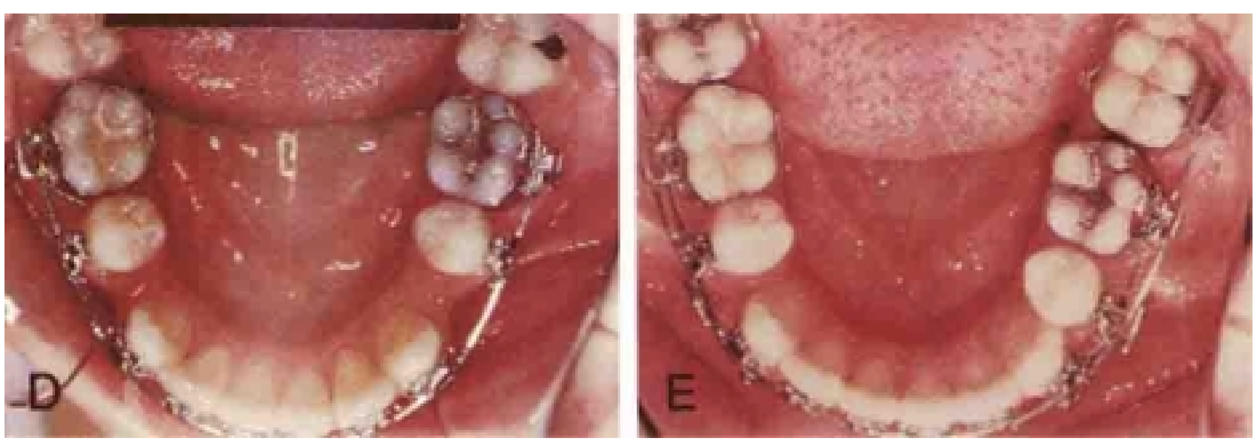

Fig. 4 (Cont'd). D-E. Case 2. D, Arch leveling with continous archwire. E, Posteruption banding of mandibular second molars during stage of partial space closure effected with spring auxiliaries.

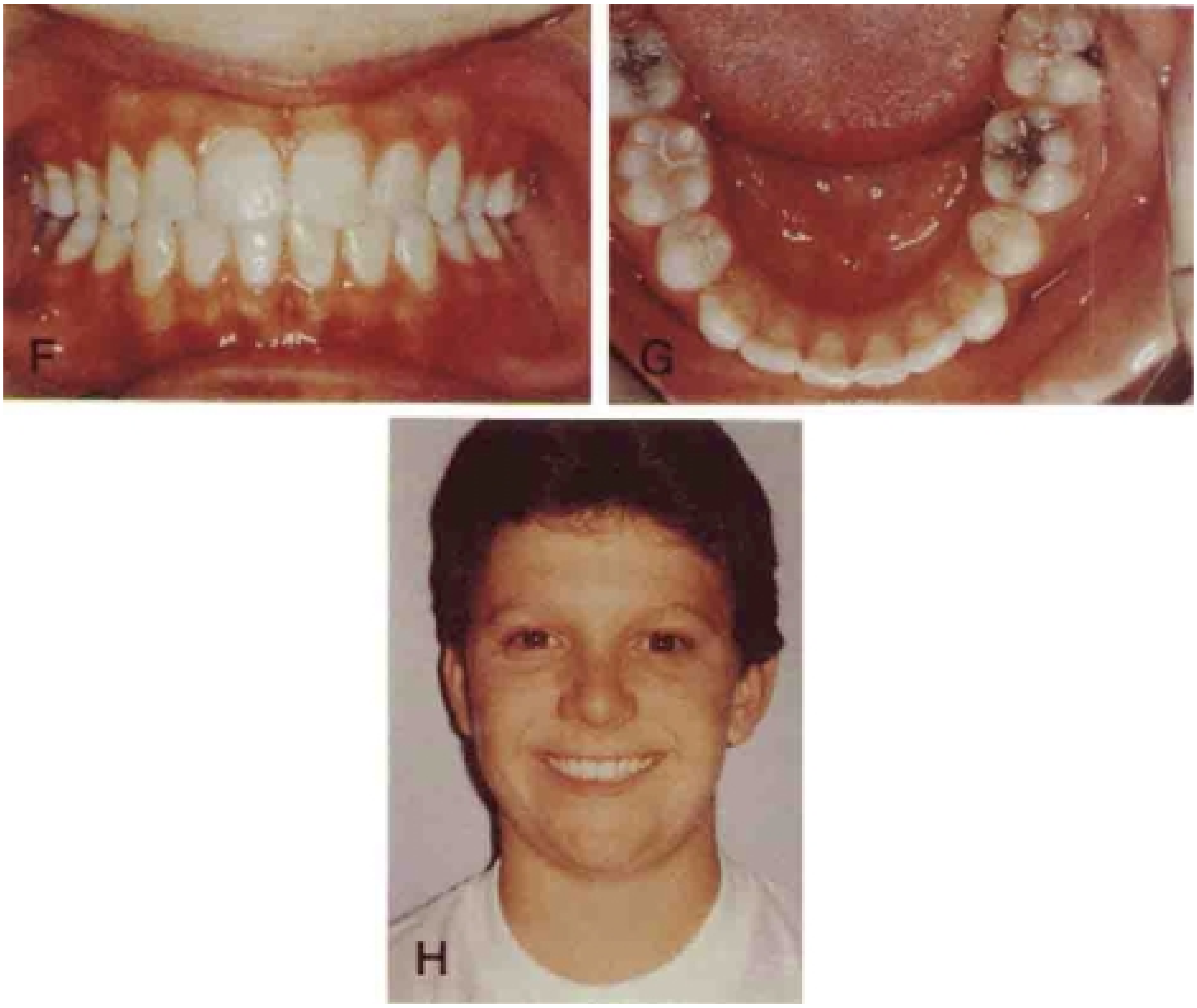

Fig. 4 (Cont'd). F-H. Case 2. F through H. Patient after treatment, with bite opening gained and space closure completed.

tipping and relapse. It is necessary first to translate the mesially shifted canine to a corrected position so that the incisors may follow. A unilaterally placed spring with a non-stopped 0.016-inch ´ 0.022-inch arch on the side is used for distal shifting. A lateral incisor may be ligated to the canine to speed the movement. The posterior anchorage should be protected until midline correction is complete and the anterior segment is consolidated. The contralateral spring is then placed and en masse closure proceeds as previously described until all remaining spaces are closed. Case 1 (Fig. 3) illustrates the use of reciprocal closure.

In the maxilla, canines may be retracted individually in lieu of en masse. It may be necessary to use Class II elastics to maintain proper anterior and posterior sagittal relationships as required in all edgewise techniques. Traditional edgewise technique suggests that teeth be ligated after space closure to prevent reopening. In the auxiliary technique it is recommended instead to leave cinched but deactivated springs in place for an additional appointment period. Leaving a cinched auxiliary with no posterior helix activation but with active residual moments from the θ_1, θ_2 and θ_3 angles will cause continued root movement because the appliance functions as a root spring with additional uprighting characteristics.

Posterior protraction

Posterior protraction in the mandibular arch is normally used for Class II occlusions, and in the

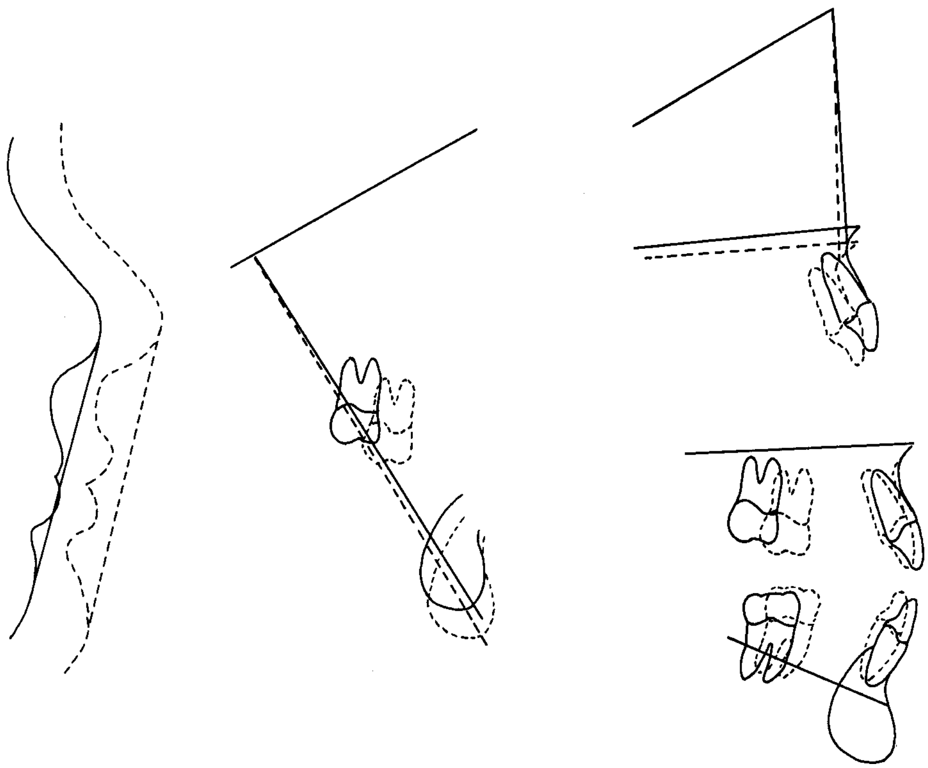

Fig. 4 (Cont'd). I. Case 2. Tooth/profile superimpositions.

maxilla for Class III relationships. As in the previous situation, it is necessary to level, align, and consolidate segments before space closure until 0.016-inch ´ 0.022-inch arch wires can be placed. It may be advantageous to extract second premolars instead of first premolars to allow for maximum protraction of the molars in classification (Fig. 2).

The following spring preactivation configurations are suggested: $\theta_1 = \theta_2 = 45°$ and $\theta_3 = 30°$ for the mandible; $\theta_1 = \theta_2 = 45°$ and $\theta_3 = 45°$ for the maxilla. In Class II posterior protraction cases, such as Case 2 (Fig. 4), Class II elastics are introduced when the lower springs are placed. Periodontal fibers usually allow the second molars simply to follow first-molar movement. Brachyfacial (low angle) and adult patients may require elastic traction and ligation from the second to the first molar if spaces develop between these teeth.

Maximum anterior retraction

Maximum anterior retraction is typically encountered in Class I bimaxillary protrusions (Case 3, Fig. 5) and in Class III dental patterns that require maximum lower anterior retraction. After arch leveling and alignment, intraarch anchorage requirements must be evaluated and used. Traditional methods, such as ligation of first and second molars and placement of transpalatal arches and modified lower lingual arches, are used in combination with the spring configurations. Individual canine retraction may be used in situations where posterior anchorage is extremely guarded, as in Class III mandibular situations.

Spring preactivation configurations are suggested as follows: $\theta_1 = \theta_2 = 45°$ and $\theta_1 = 0°$ for the mandible; $\theta_1 = \theta_2 = 45°$ and $\theta_3 = 15°$ for the maxilla.

SUMMARY AND CONCLUSION

1. As illustrated in the cases shown in Figs. 3 to 5, a great advantage of the auxiliary spring technique is its versatility. The system is self-limiting because teeth are translated on a continuous main archwire with tooth movements falling within the limitations dictated by the traditional edgewise mechanism. The main arch exists primarily to prevent anterior and posterior segments from leaving the plane of the occlusion as a result of errors in the M/ F ratio between segments. This technique is a departure from the traditional segmental technique, which generally rejects the concept of sliding me-

Fig. 5A-C. Case 3. A through C. Initial photographs of anterior retraction case with moderate lower midline shift.

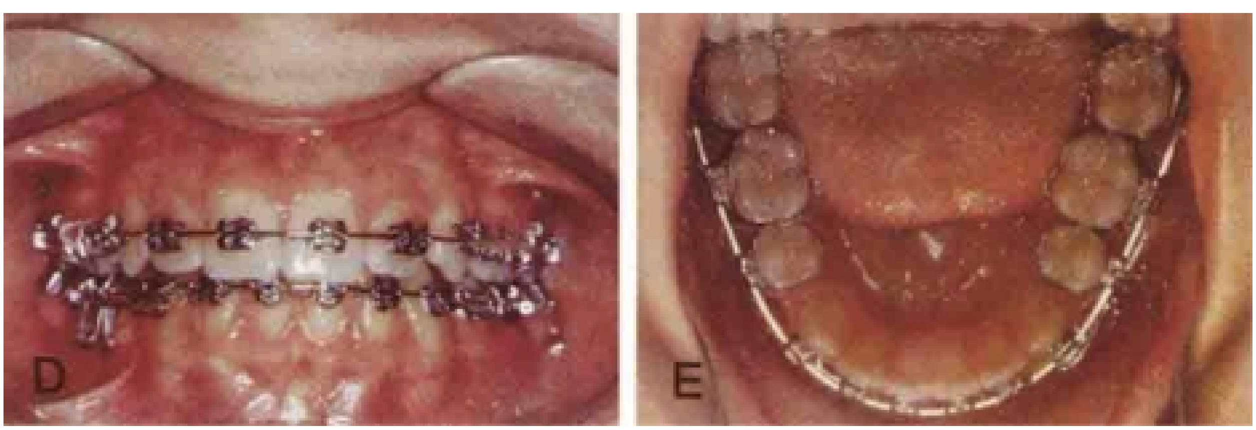

Fig. 5 (Cont'd). D-E. Case 3. D through E, Photographs taken during midline correction and before complete space closure.

Fig. 5 (Cont'd). F-H. Case 3. F thourgh H, Patient after treatment, with extraction spaces closed. Note that bite opening is maintained during the space-closure mechanics.

chanics for space closure because of archwire friction.

Too rapid a change in the moment-to-force ratio may be harsh on connective tissues and should be minimized when possible. For this reason, Bull-type loops and others with limited ranges of activation and high rates should be used with caution.[4] We believe a moderate-rate, multilooped stainless steel alloy spring represents a necessary compromise for generating the forces needed to overcome residual sliding resistance on a continuous arch.

Higher forces are also required when dental segments are translated by a combination of a force and a couple, as compared with retraction of individual teeth with light elastic forces. The stresses in the former situation are distributed in a fairly even fashion across the roots of the teeth and the periodontium with auxiliaries. More stress may actually be generated with "light" elastic forces in situations of uncontrolled tipping, because the force distribution in the tissues is uneven, with high compressive stress in the cervical and apical thirds of the ligament. Uneven stress distribution may also contribute to hyalinization of portions of the periodontium, which can impede movements and influence anchorage planning. The concept of canine retraction by means of "differential" forces may be thought of as distributing forces over a broad area of several posterior roots while reciprocally subjecting the single root of the anterior tooth to this load and employing

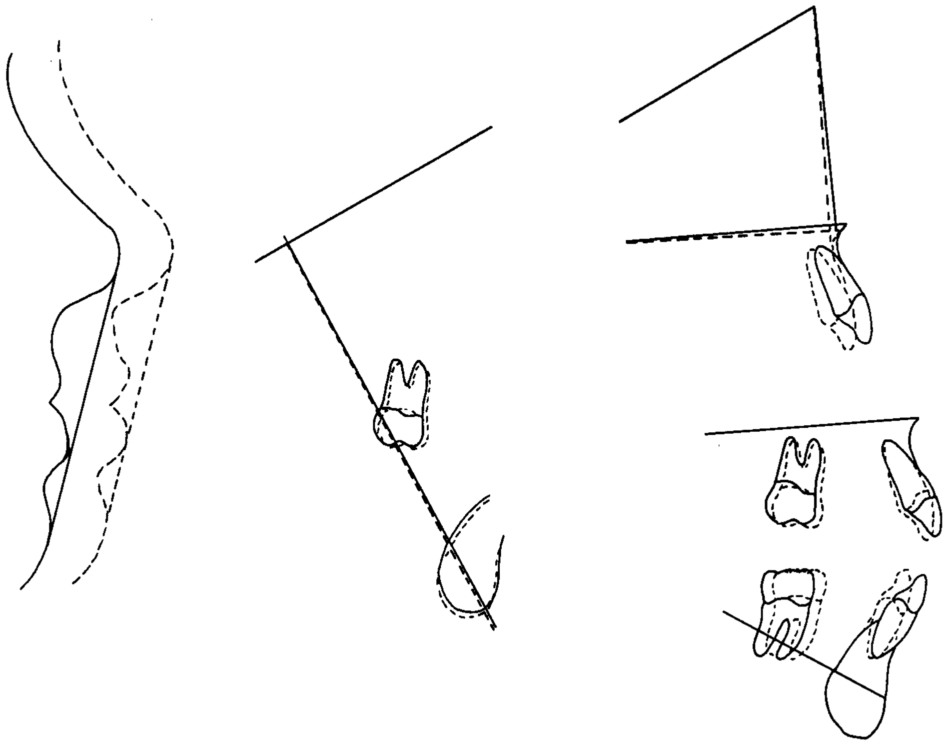

Fig. 5 (Cont'd). I. Case 3. Tooth/profile superimpositions.

tipping mechanics. In a situation of excessive force in conjunction with nontranslation mechanics, the posterior teeth may well move forward more than the anterior teeth are retracted.[5] The use of spring auxiliaries can eliminate this problem because it provides more ideal load distribution about the roots. The proper application of anterior and posterior moment/force ratios can assist in minimizing "unwanted" anterior anchorage such as that found in Class II cases. Clinical practice is rewarded by the application of simple biomechanical principles. No hiatus should exist between physics and treatment!

2. It is possible to translate either selected teeth or entire arch segments with the auxiliaries. Midline corrections are also greatly facilitated by translating mesially drifted canines.

3. The main arch wire and springs may be left in place during activations and are merely cinched at appointments. Spring and bracket designs provide the orthodontist with an easy-in/easy-out system to reduce chairtime and workload. Spring activations are predetermined and provide clinically acceptable forces and moments to accomplish the desired tooth movements. The ability to translate teeth implies greater control. Because of the use of a moderate load-deflection spring, the predetermined angular changes at the anterior bend (θ_3) needed to vary the anchorage characteristics are small and require some attention to detail. It is suggested that users view these angular changes as a range for alterations in M/F ratio to assist in treatment-planning goals. We are currently considering improvements in spring design and materials.

4. Our goal in developing the auxiliaries has been to employ the best aspects of traditional edgewise mechanics while using and simplifying segmental principles. The average clinician is not usually enthusiastic about converting patients already in treatment to new and complicated modalities at great expense and labor. With the exception of the canine bracket and closure springs, no additional armamentarium, appliance changes, or philosophy of practice are required of the clinician when the proposed method is used.

A thorough review of the segmental mechanics literature referenced in Parts 1 and 2 of this series is recommended for all persons who wish additional information concerning the concepts presented in this report.

REFERENCES

1. Burstone CJ. The rationale of the segmented arch. AM J ORTHOD 1962;48:802-21.
2. Burstone CJ. Mechanics of the segmented arch technique. Angle Orthod 1966;36:99-120.
3. Burstone CJ, Koenig HA. Optimizing anterior and canine retraction. AM J ORTHOD 1976;70:1-20.
4. Burstone CJ. The segmented arch approach to space closure. AM J ORTHOD 1982;82:361-78.
5. Quinn RS, Yoshikawa DK. A reassessment of force magnitude in orthodontics. AM J ORTHOD 1985;88:252-60.