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ORIGINAL ARTICLES

Bioprogressive therapy as an answer to orthodontic needs

Part I

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The purpose of this two-part article is to report some of the studies which have led to the development of an orthodontic treatment regime which has come to be labeled "bioprogressive therapy." It is a highly flexible, versatile, and exciting method composed of a body of principles, some of which will be introduced herein. This entire development is too extensive for even two JOURNAL articles, and is being compiled in volume form by the author.

Part I (the present article) deals with theoretical background and the logic of development of band and bracket or bonding designs organized into a practical orientation.

Part II will explain the activating mechanisms and the development of preformed arches or modules fitting together for the therapy. Concern with changes and the belief of possibilities of orthodontics is further explored in Part II in order to justify the application of these principles. The last section of Part II is primarily concerned with anchorage considerations and treatment planning based on factors available with this contemporary technique. Patient examples are shown as representative of behavior with the therapy.

Theoretical developments

This method may be considered an evolution from the edgewise technique, with features of certain light-wire methods incorporated (Figs. 1 and 2). Angle[1] described the edgewise appliance in 1925, and many papers on its use were published in the 1930's. As clinicians sought to modify the original method, a challenge to some of the practices with edgewise and forces thereof occurred in the 1940's. By the 1950's, the advantages of application of "light" force as com-

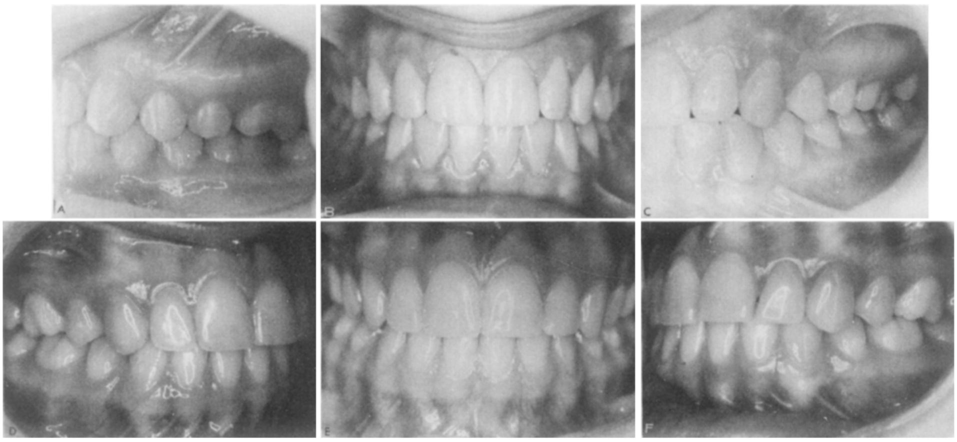


Fig. 1. A recently completed nonextraction case showing the interdigitation of teeth. Note the details in the occlusion before retainers were placed in this particular patient. **A,** Note the overtreatment of the molar occlusion in the mirrored view of the patient's right side. Note also the upper second premolar occlusion with the mesial incline of the lower first molar, which is one of the primary objectives in treatment. **B,** Progressive width increase of the arch as the arch tapers backward. Note the prominence of the first premolars. Note further the axial inclination of the canines showing normal prominence of the canine roots. **C,** Canine contact back against the lower first premolar. The distal aspect of the upper lateral is in mesial contact with the lower cuspid. **D, E,** and **F** show the results of extraction with bioprogressive therapy. The same attention is given to the detailed fit of the teeth minus four premolars. In **E** note the axial inclination of the canines and freedom for lateral function in this particular patient some years after treatment.

pared with "heavier" force to effect tooth movements were debated. Proponents of the universal technique, the Johnson twin-wire technique, the Crozat method, and other systems, such as the Begg technique, all argued the merits of "lighter" forces as compared to those which had come to be commonly employed—especially with the 0.022 by 0.028 inch edgewise bracket.

Perhaps it would be appropriate first to air some of the differences in the use of the edgewise appliance. Fortunately, I have had experience with each ramification of edgewise, as well as experience with the "ribbon" method which preceded it.

Primary Edgewise (Fig. 3)

Primary edgewise as described[1] was a fully banded technique and, because all teeth were to be brought under control or used to support a wire, there evolved an attitude that one should wait for the eruption of all canine premolar teeth before initiating treatment.[2] The technique consisted of pinching, soldering, and constructing bands to a "best fit" on each tooth. The band was then scratched or marked while in place, and the brackets were soldered onto the band in a manner to account for the correct tipping of teeth for the "ideal arch" in finishing. For making the arch wire, tooth dimensions were plotted on a card and 1/16 inch was added between the upper lateral incisors and 1/32 inch was added

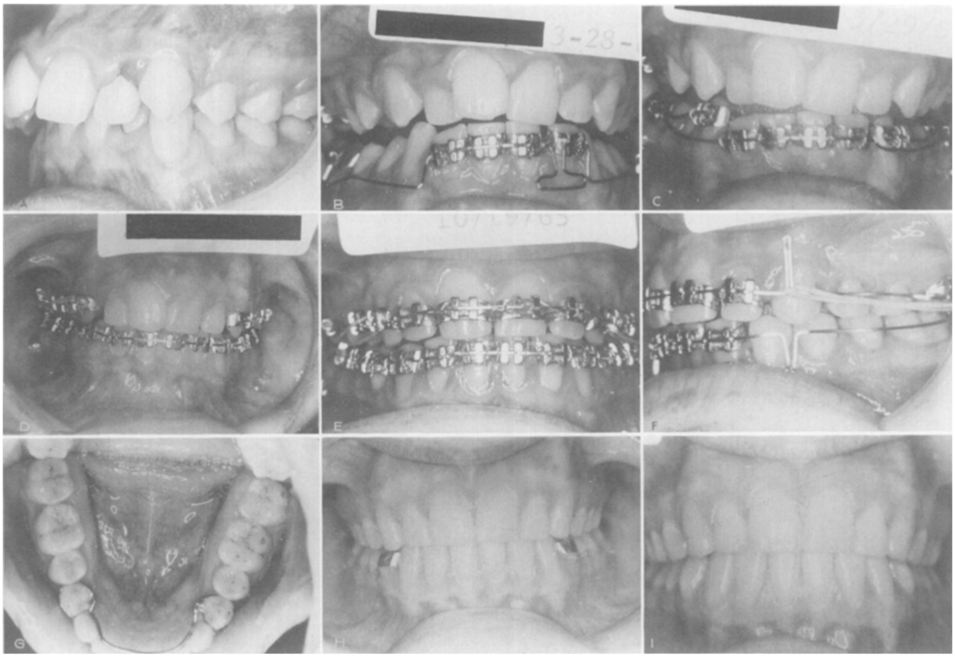


Fig. 2. Patient B. R. **A,** Before-treatment photograph showing Class II, Division 1 deep-bite with lingually displaced upper lateral incisors and lingual locking of the lower left lateral incisor and deep-bite. Note periodontal involvement. Patient was treated with biprogressive therapy. **B** and **C,** Modified utility arch in place with intrusion of the lower incisors and overtreatment of the lingually displaced lower left lateral incisor as a T loop was used to accentuate the movement. This is Stage I of the treatment. Stage II in the continuing phase includes a canine intruder. This was one of the early techniques, which has now been replaced by ligation of the canines down to the utility arch in Stage I. A stabilizing arch of 0.016 by 0.016 inch wire was placed and the section was a canine-intruding section. The headgear was continued at this phase. Further into continuing treatment the lower premolars were banded and rotated into position. Upper sections were placed, followed by intermaxillary traction as seen in **B. D, E,** and **F,** Ideal arches are in place and full Class II correction is being made with the standard bioprogressive hook-up. Overtreatment is being attempted here. **F,** Progressive stripping was being done. Note the overtreatment of the premolar and the activation of the bow loop to close band spaces as the upper arch is activated with intermaxillary elastics and the loop is activated in the lower arch. **G,** The direct 4-4 in place as a retainer in the lower arch. The spots on the teeth were for occlusal checks at this stage of treatment. **H,** The case during retention. **I,** Photograph taken about 8 years after treatment, showing the stability of the alignment, the overbite and overjet, and the healthy periodontium. All thirty-two teeth erupted into essentially ideal occlusion in this patient.

between all lateral incisors and canines. In other words, the flat "ideal" arch wire was supposed to provide normal occlusion, torque was to be placed for third-order movement, and first order was supplied by "step" bends and "bayonet" bends. Angle's original bracket was soft and was used with gold bands.

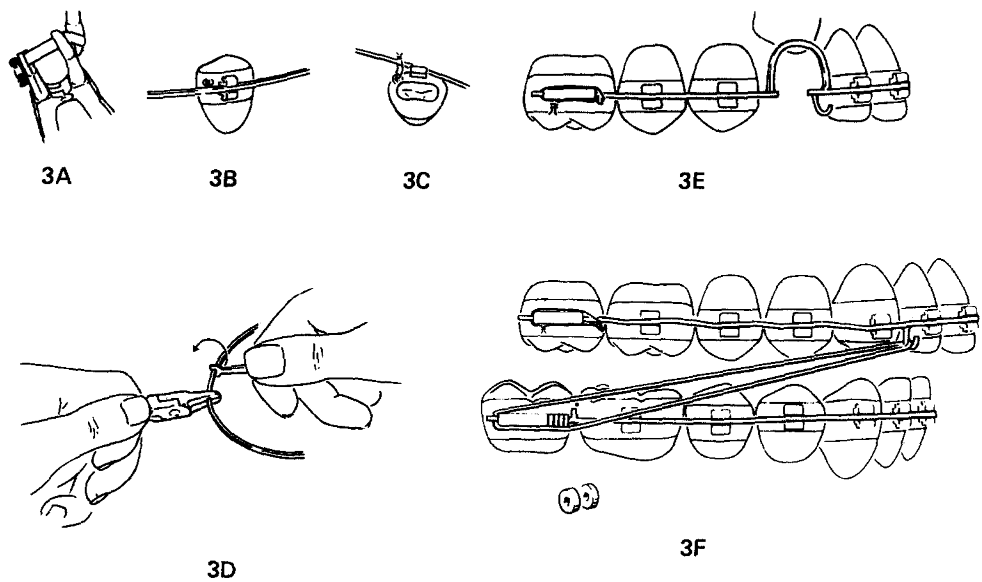


Fig. 3. Features of the primary edgewise method. **A,** The band being pinched without the the bracket being attached. **B,** The band is fitted and the bracket is soldered together with an eyelet or staple. **C,** The staple is used to promote normal rotations. **D,** The arch wire is bent by means of pliers and torquing key for first-, second-, and third-order movements. **E,** If space is to be made, loops are soldered onto the main line of the arch. Auxiliary hooks are attached and soldered onto the base arch. **F,** If spaces are present, spurs and tiebacks are used and second-order bends are placed in the arch according to the needs of the individual case. Intermaxillary elastics are employed, and if crowding is present in the arch stops are placed on the arch and washers are added at each visit in order to achieve normal movements. These are some of the essentials of the technique of primary edgewise therapy. These illustrations show some of the developments with secondary edgewise. Intermaxillary elastics were still the prime method of arch correction.

The original arch was of the 0.022 by 0.028 inch size and was also composed of soft gold. At the start, this large rectangular wire was to be adapted passively to the malocclusion after separation and band construction and cementation were all accomplished.

For treatment procedures, stops were placed to advance the arch from the molars in case of crowding (Fig. 3). For space closure, in spaced or extraction conditions, spurs for tiebacks were applied. Loops, if used, were made of 0.025 inch round wire and were soldered to the main arch wire. Ligation to eyelets was employed for rotations as rubber blocks were placed on the bracket in order to correct severe rotations. Second-order bends were activated in order to tip back the upper arch in Class II treatment as intermaxillary elastics were applied to regulate arch relation. Anchorage preparation in the lower arch usually took about 6 months. With good cooperation, severe cases were treated by students in 15 to 20 months, and sometimes the entire case was treated with the same original starting arch.[3] The main virtue was three-plane control which was possible from

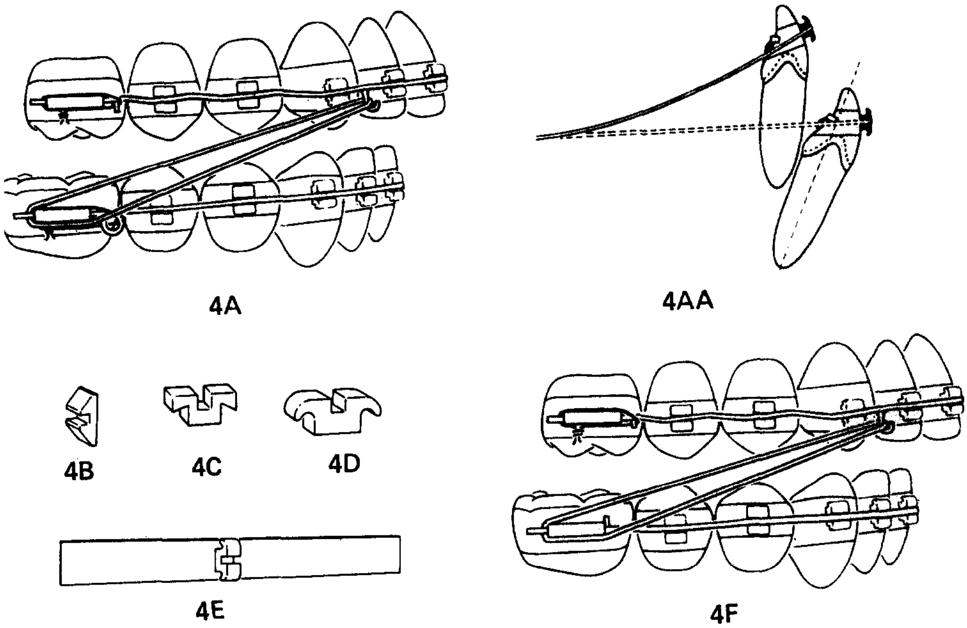


Fig. 4. A and **AA,** As seen, round arches were used to level and attempt to depress the lower incisors. This usually would tip the lower incisors forward, as shown in **AA. B, C,** and **D,** The evolution of the brackets, the last being the general form of the Steiner bracket. **E,** The premounting of the bracket on the band strip which was now a standard method. **F,** Second-order bends were employed in the same manner and 0.215 by 0.025 inch arches were more commonly used in place of 0.022 by 0.028 inch arches.

start to finish.[4] The No. 142 pliers and torquing keys were common tools with this appliance.

Secondary edgewise (Fig. 4)

Secondary edgewise emerged as clinicians sought methods to avoid the task of making the original passive 0.022 by 0.028 inch arch.[5] This development was characterized by the use of round wire in the edgewise bracket, to which some of the edgewise clinicians objected.[6] Steiner[7] designed a new bracket of harder alloy. Round wire, while being used for extraction space closure or contraction of the arches, rolled the anterior teeth inward. Uprighting was accomplished later with a rectangular wire, usually of the 0.0215 by 0.025 inch size, but now made harder or more rigid with gold alloy.

However, round wires in nonextraction conditions used for leveling and rotation often resulted in a great deal of flaring of teeth, "milking" of the arches, and loss of anchorage (Fig. 4, *AA*). Tiebacks were used to prevent forward drift of the arch, but still the lower incisor tipped forward as leveling was accomplished.

While extractions had been employed, even by Angle, the frequency of extraction seemed to increase appreciably by followers of secondary edgewise.[8] Trial treatments often led to protrusive dentures which, in turn, led to extraction as a second phase of treatment, particularly in Class II, Division 2 cases.[9]

In order to understand anchorage loss, a knowledge of cortical bone is needed, together with an analysis of applied mechanics in deep-bites treated with round wire. Suffice it to say that the *lingual plate of bone supporting the lower anterior teeth became the anchor site and the lower molars were rolled out of position in their alveolar housing.*

By now, blank cut strip forms with brackets mounted were available commercially. In pinching, the band was now positioned for the final bracket line. Some difficulty with proper bracket alignment was experienced, and all that was available was one single bracket and 0.22 by 0.028 inch tubing, which was cut and soldered onto the molar bands following the primary edgewise method. These developments occurred in the mid-1940's. In the late 1940's, round 0.045 inch tubes were also soldered on the upper molars by many edgewise users to receive a face-bow and extraoral traction.[10]

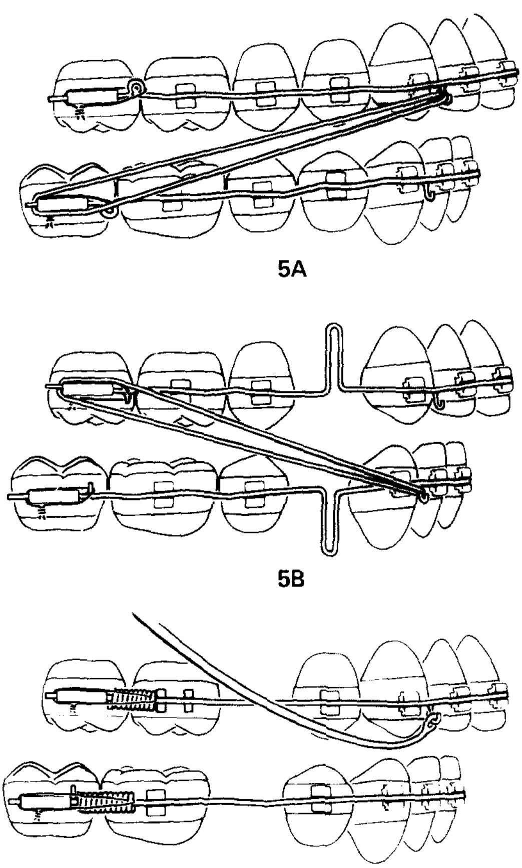
Tertiary edgewise (Fig. 5)

Tertiary edgewise might be considered the next modification from secondary, or it may be thought of as Tweed edgewise.[11] In order to avoid the "laying down" of the lower incisors with round wire and tilt of the occusal plane resulting from the pull of Class II elastic traction with lack of lower molar anchorage, astute clinicians such as Tweed advocated the application of Class III elastics with "tip-back toe-hold" anchorage for the lower arch. This was further enhanced by extraction together with extraoral traction, both of which contributed to a remarkable ability to reduce dental protrusions. Vigorous force now came to be employed. Double torquing bars were designed for use with more rigid steel wires of 0.0215 by 0.025 inch rectangular wire. Several arches were often employed and the Class II worsened initially in the attempt to gain mandibular anchorage. Space closure was accomplished by simple open loops vertically or horizontally bent into the arch or by push-coil tiebacks. Outstanding results were shown, but often at the expense of very hard work. The Nance article on limitations seemed to mark the conclusion of the day in 1947.[9]

Other factors in edgewise

All of these developments in edgewise[12] formed the background for the present bioprogressive method. By 1950, certain edgewise clinicians were becoming concerned with some of their results. Some root resorption was not uncommon. The use of the round wire in the leveling stage of deep-bite cases, as implied previously, seemed to be leading to the development of protrusive dentitions.[8] Extraction was often advocated on only therapeutic grounds. Even some patients extracted for objectives of lower incisor stability often were now found to be imbricating after treatment. This caused many clinicians to pause and examine the prevailing trend in treatment methods and inquire into the causes of some of the problems being observed. Certain breaks from the edgewise full-banded convention and technique were started.

Large, round headgear tubes were soldered on strips prior to banding because the double-tube setup on upper molars came to be commonplace (Fig. 6). Changes in attitudes of possibilities of treatment resulted from changes in arch

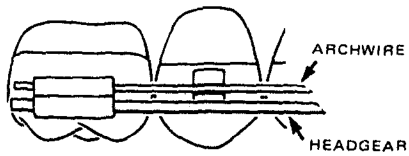


5A
5B
5C

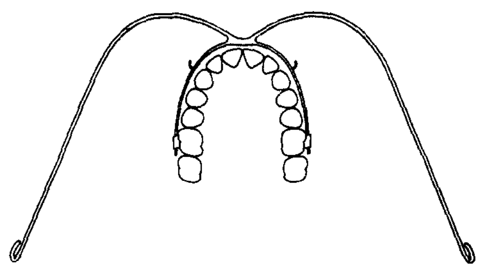
Fig. 5. Some of the moves with Tweed therapy from conventional edgewise. Extraction was used, as seen in **B.** Initially, instead of Class II elastics, Class III elastics were used to prevent the downward and forward displacement of the lower incisors. Tip-backs were incorporated in the lower arch and second-order tip-backs were likewise placed in the upper arch. Tweed incorporated loops bent into the arch in contrast to the soldered loops, and Tweed also used steel wires. In **C** note that other moves made by Tweed were the coil tiebacks for space closure in addition to the activation of a directional headgear to sustain the pull of the Class II elastics and intrude the upper incisors.

form and arch relationship observed following maxillary extraoral or headgear traction. The maxillary arch was observed to expand successfully (when permitted to do so) with a plain 0.045 inch dental bow as the Class II malocclusion was corrected. Arch-form changes in the lower arch also were noted following treatment on the upper arch only (Fig. 7). Both Kloehn and Brodie reasoned that significant environmental influences were exerted, apparently through the function of the "forces of occlusion."[10]

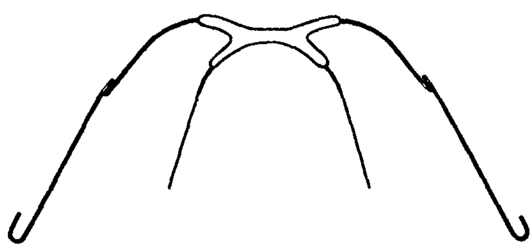
Another change which took place in edgewise was the departure from the complicated use of second-order bends in the upper arch in the treatment of Class II patients. Straight arches with sliding hooks and methods to slide teeth



6A



KLOEHN FACEBOW
6B



RICKETTS FACEBOW
6C

Fig. 6. A, The original Kloehn headgear as Kloehn soldered the dental bow onto the facebow. The head cap was used at the start and this was later changed to the cervical strap **(B)**. Originally a double tube was placed as a headgear tube to the occlusal side. For anchorage advantage to reduce some of the tipping and for ease of manipulation of the edgewise wire, the headgear tube was later placed to the gingival. **C,** A later design was made by Ricketts using plastic on the anterior so that the headgear could be brought to bear directly against the teeth as expansion was produced in the posterior.

on an arch wire were introduced to move buccal segments distally as advocated by Wright[13] in about 1949 (Fig. 8). However, elongation of the upper anterior teeth under Class II intermaxillary traction still occurred, as well as from extraoral cervical pull and "J" hooks to the arch. Both of these tended to produce "gummy" smiles in patients.

Other changes in technique were prompted by other observed effects to excite excessive mandibular rotation.[14] Several factors responsible for overrotation of the mandible accompanying treatment were investigated. The extrusion of the lower molar and the upper incisors by intermaxillary elastic pull was con-

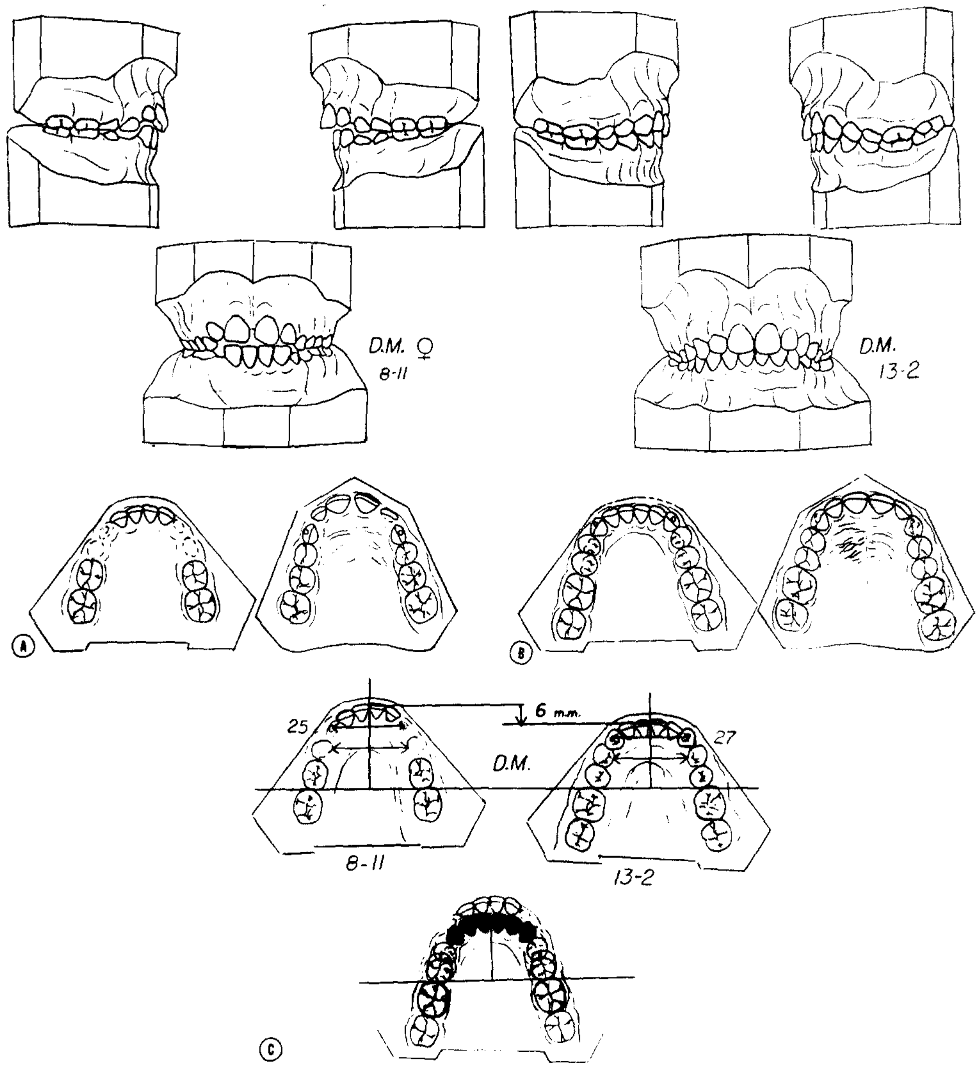


Fig. 7. A, Beginning patient D. M., age 8 years 11 months, with open-bite and thumb-sucking habit. Note the form of the lower arch and the deciduous second molars present. **B,** Same patient after headgear therapy, cervical strap, and upper utility arch only. No treatment whatsoever on the lower arch. **C,** A comparison of the beginning and end of treatment in the lower arch form. Arch depth was reduced 6.0 mm. (which is usually thought to require 12.0 mm. of arch length) the misconception stems from miscalculation of the space supplied by the second deciduous molars (which closely approximates 6.0 mm.) and first interpremolar width which provides additional space in the arch.

sidered to be the primary factor. Ricketts[15] reasoned that incisor interference was also an effective factor in causing the chin to drop during treatment. In other words, when or if incisors started to interfere in contact, the patient refused to close the jaw because of pain or a proprioceptive phenomenon, in which event the molar occlusion was prevented. The lower occlusal plane therefore ultimately

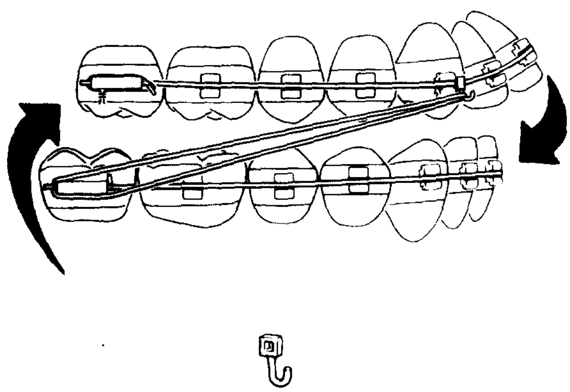


Fig. 8. In view of the complications of second order-bends, certain clinicians started using sliding hooks along the arch to aid in Class II correction. Even the use of sliding jigs still left the problem of tipping of the occlusal down in front and up in back, which tends to displace the upper incisors downward and backward and the lower molars upward and forward.

tipped upward in back and downward in front, despite the fact that teeth were tied in vigorously with a heavy ideal arch (Fig. 9). Prevention of incisor interference and holding of the lower molar downward were foreseen as factors in anchorage preservation of the entire arch, or the prevention of "dumping" of the occlusal plane.[16]

Organized studies on tooth behavior in mechanics

As the incidence of extraction increased, borderlines were unsettled. The classic work of Storey and Smith[17] in Australia in 1952 aroused many clinicians around the world to reinvestigate their application of mechanical force. New tools were developed and old ones were reapplied to measure force delivery with orthodontic mechanisms. Notable among these investigators were Reitan[18] in Europe and Burstone,[19] Weinstein,[20] Jarabak,[21] and Ricketts,[22] among others, in the United States.

In the Storey and Smith experiments, canine retraction was studied with the objective of determining rates of movement of reciprocal units. It was discovered (in those experiments, at least) that optimal translatory retraction occurred in the ranges between 150 and 300 grams of force. Exception to that work was taken later by Hixon and associates.[23]

In order properly to measure force to teeth in the line of common tooth movements, forces had to be reduced to force per unit area or, in other words, pressure. MacEwan and Stoller followed this course of inquiry with the universal appliance study clubs.[24] Pressure values were analyzed with values of anchorage estimated for different situations.

Brian Lee[25] in Melbourne, following up the work of Storey, suggested from his studies that the use of 200 grams per square centimeter of en face root surface produced movements at optimal efficiency with the Begg appliance. This was based on the pressure hypothesis that a tooth was being moved through cancellous bone in space closure.

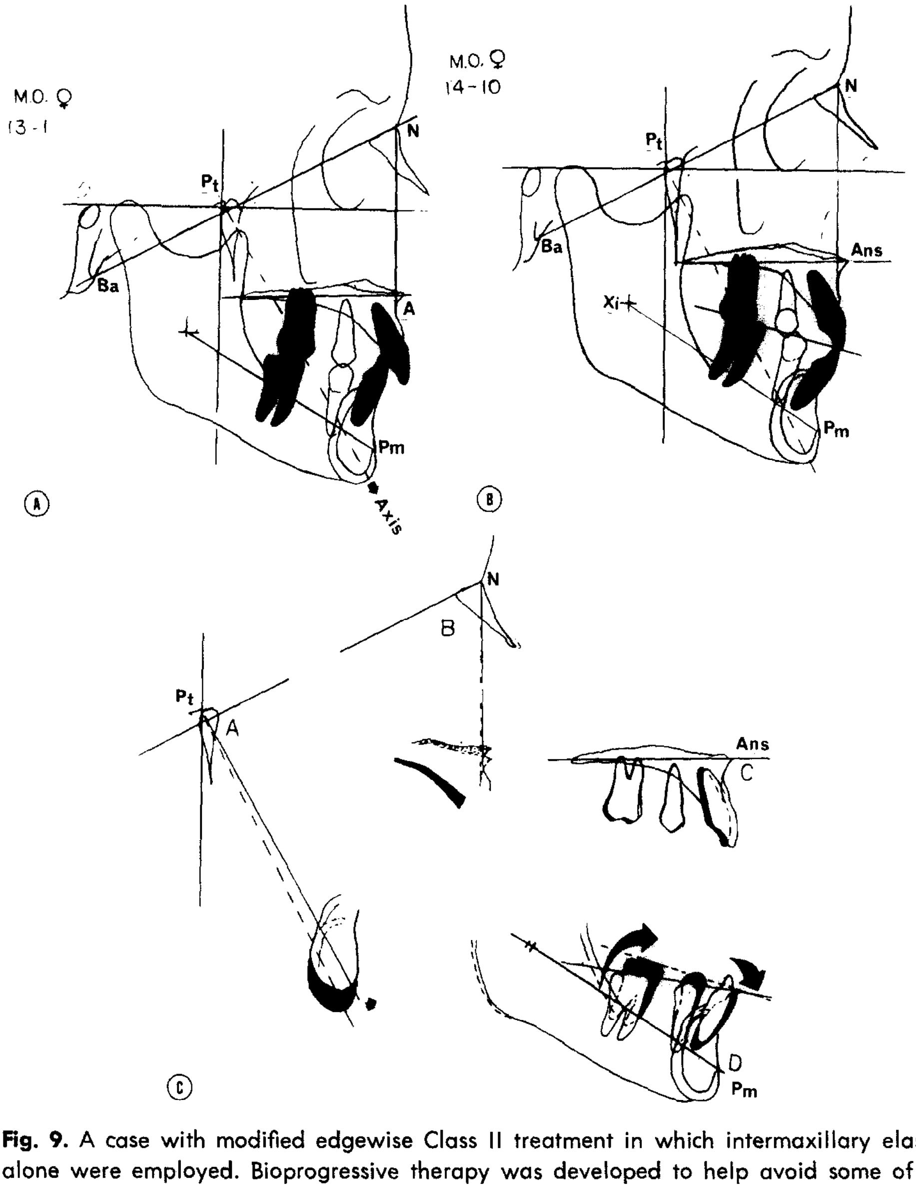
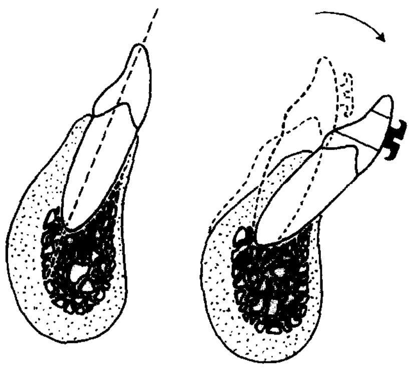
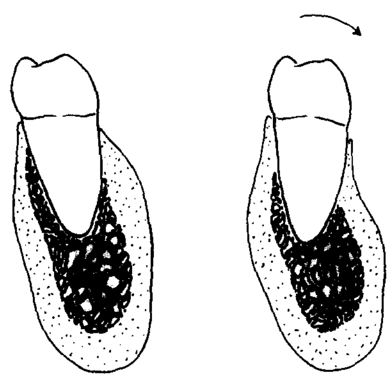


Fig. 9. A case with modified edgewise Class II treatment in which intermaxillary elastics alone were employed. Bioprogressive therapy was developed to help avoid some of the problems illustrated in Figs. 8 and 9. **A,** Patient M. O. at beginning of treatment. The facial axis, the maxillary angle at **N,** the palatal plane, and the corpus axis are used for longitudinal analysis. **B,** Tracing of patient at 14 years 10 months shows the case at retention with the lower arch moved upward and forward. **C,** The four-position analysis. The chin moved downward and backward as the lower molars were extruded. No great change in point A was seen, as moderate intermaxillary elastics were used. Only slight displacement of the upper molar was made, and the upper incisors were retracted probably as a main result of changing arch form. The lower molar was displaced upward and forward. This behavior is characteristic of prolonged use of intermaxillary traction and is the main reason for locking the lower molar under the buccal plate in bioprogressive therapy and also for the use of extraoral traction with the neck strap in the early phases to assist in anchoring the lower molar.



10A

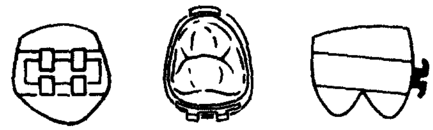


10B

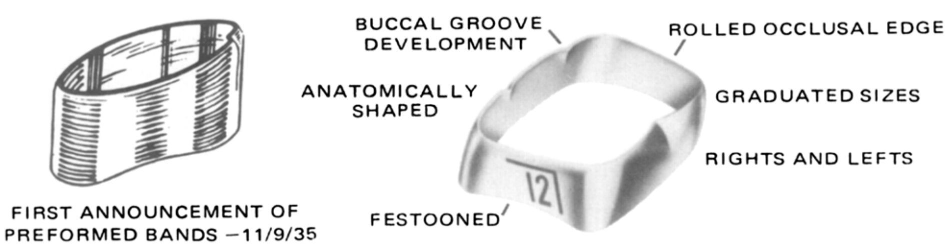
Fig. 10. A, The use of the buccal plate is demonstrated. A scheme of the difference between the character and amount of bone on the lingual aspect of the lower incisor is contrasted to the labial aspect. Note that the forward displacement of the tooth throws the apex of the root against the alveolar plane or the lingual plate and causes the lower incisor to displace forward. **B,** It will be noted for the lower molar that the distribution of the dominant bone is on the buccal rather than on the lingual, as seen for the lower incisor. Note that bone is lost and the position for mechanical advantage of the tooth is lost with the uprighting of the lower molar.

However, Ricketts pointed out that the influence of compact bone or "cortical plates" must also be recognized in the analysis of movement (Fig. 10). The external or internal bony alveolus exerts distinctly different qualities than cancellous bone when encountered in tooth movements, as had been noted by many clinicians. The study of movement against or through cortical bone therefore needed to be taken into account.

By the 1950's many clinicians had become preoccupied with extraction procedures or keeping teeth "over basal bone." Studies of anchorage, therefore, often did not pertain to other types of treatment, such as expansion or full arch correction under the pull of intermaxillary elastics, because it was not believed that molars could be moved distally. The amount of arch slippage permitted in the



ADAPTING BAND TO THE "HEIGHT OF CONTOUR"
FIG. 11-A



EVOLUTION OF PREFORMED BANDS
FIG. 11-B

Fig. 11. Development of the preformed bands. Preformed bands were announced in November, 1935. Gradual developments through the years have included not only the preformed banding but prefabrication of arches as well.

given Class II case and the subsequent changes in the environment attending the reciprocal correction of overbite were often not regarded fully because it was also believed by many clinicians that anchorage could not be estimated or predicted, even on a cursory basis.

Deliberate experiments were set up by Ricketts at the clinical chair in attempting tooth movements through, against or around heavy plates of compact bone with a variety of force. An effort toward the use of lighter forces was placed in scientific protocol in order to approach the clinical range of forces as suggested by Storey's work.

It should be understood that observations from both cephalometric and laminagraphic records were available for the monitoring of cases, together with thousands of serial intraoral photographs portraying the appliance, and all suggested that a different approach to therapy was indicated. This was pursued in the 1950's. It is estimated that some 40,000 intraoral slides have been studied in the Ricketts and Bench laboratory.

Developments toward progressive therapy

The fixed apparatus

Preformed bands. Pinching of bands required expensive, time-consuming, and customized procedures. Work with preformed chrome alloys led to narrowing and half-sizing of molar and incisor bands together with softening of material for ease of adaptation.[26] During the late 1950's premolar and canine forms were devel-

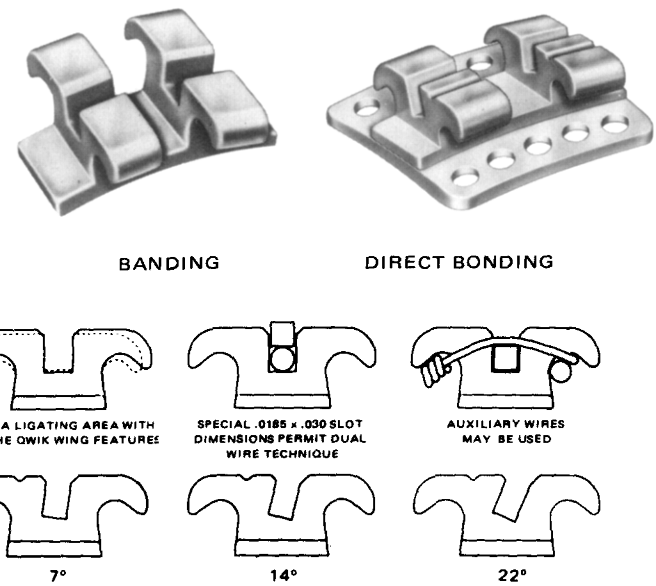


Fig. 12. The early modification of the brackets made by Ricketts. Some of the torque angulations were those designed originally by Jarabak. The Siamese is used generally throughout. The narrow, single bracket is optional with the medium Siamese in the lower incisor area.

oped. For chronologic reference, the Ricketts typodont for the American Board examination in 1958 was in fully preformed bands for all teeth. The work of banding was vastly reduced, and preformed banding with the premounted brackets and tubes was demonstrated on closed-circuit television at the 1962 meeting of the American Association of Orthodontists in Los Angeles[27] (Fig. 11).

Siamese 0.018 by 0.030 inch bracket. Increased mechanical efficiency was desired over the staple for rotation. One development was a rotating bracket. However, a double purchase on the tooth was thought to provide better control for all movements[28] (Fig. 12). Two soldered brackets had been used on molars and central incisors for great advantage in control with secondary edgewise. These were designed by Swain[29] to be milled into one gold bracket and were subsequently milled in the chrome alloys as they came into use. Therefore, a wide-flanged easy-tie 0.018 by 0.030 inch Siamese bracket was designed by Ricketts for ease of ligating and uprighting access and flexibility of elastic attachment. This design was an evolution from the original Steiner design. The narrow slot was developed in consultation with Steiner and Lang. This bracket is fabricated on bands or can be bonded directly.

Premounting of attachments and design by formula for corrections in three planes of space. One major attraction of the edgewise appliance was its control in finishing. The idea was to place bracket alignment and location so that an "ideal arch" wire would produce tooth contacts at a near-perfect, normal fit of the teeth. Angle, Brodie, Gromme, Chuck, Strang, Wright, and Tweed, as well as many others, had written on the "ideal" application. Band and bracket alignment required great attention in the "strap-up." At that time, bracket height was often measured from cusp tips.

Movements or bends in the horizontal direction to produce "bodily" movement were those referred to as "first order." "Second-order" bends or movements were those of a tipping character, such as seen in a leaning picket fence. Movements of roots while crowns remained stable were "third order" or otherwise considered "torque" movements (moments of rotation around a central axis or along a shaft or beam).

Primary edgewise strap-up

In early edgewise technique, the angulation of brackets (for second-order control in finishing) had been accomplished by either soldering the bracket at an angle or angling the band at fitting and cementation. The procedure made provision for certain factors to be "built into the appliance" for finishing the case. First-order control was relegated to the step bends and contours in the arch wire. This usually was bent by the clinician into the upper anterior and lower posterior segments.

Background for bioprogressive designs

Premounting of buccal tubes on gold strips prior to pinching ultimately led to formulas for the mounting of all tubes and the redesign of the tubes altogether.[30] With the development of standardized preformed bands, Ricketts, for the new therapy, advocated a bracket and band arrangement for alignment of band edges to marginal ridges, for the "line of occlusion" in fitting and cementation[31] (Fig. 13). This meant that brackets should be premounted in a standardized manner and that formulas for prewelding and bracket design should be worked out. These moves permitted a straight-wire approach to treatment with the exception of lower buccal torque and first-order bends.

During these years, Jarabak,[32] who was perhaps first, and also Holdaway[33] and Lee[34] began to work with "torquing" of anterior brackets to permit the use of flat rectangular or untorqued wires. It was an opportune time to start putting these developments together in one system. Andrews,[35] following this line of reasoning, proposed combinations for his "straight-wire" applications. However, Ricketts[36] took two additional important factors into account for the designs as measurements, trial and error, and continuous feedback from clinical results led to certain prescriptions for the three bioprogressive programs: First, the formulas were designed to prevent many common problems produced during treatment with untorqued brackets and, second, the designs were made to assist in sufficient overtreatment of the common malocclusions.

Development of bioprogressive set-ups

There are three combinations from which the operator may choose. Prescriptions for the fixed apparatus have been laid down for three variations, but all still use the basic bioprogressive precepts. First is the standard progressive setup; second is the full-torque bioprogressive arrangement; third is the "triple-control" bioprogressive.

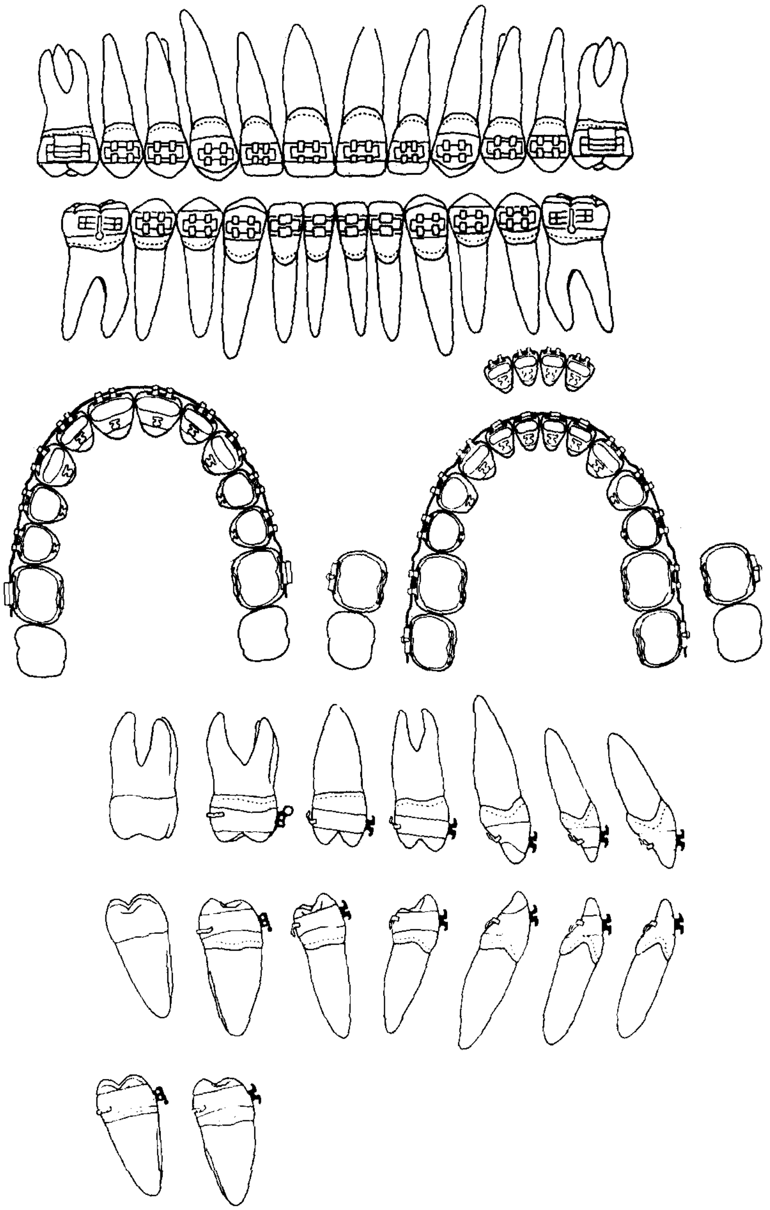


Fig. 13. The original standard bioprogressive setup shown in three different dimensions. Torque was included in the upper incisors and all four canines. Bands were designed to be placed to the marginal ridges. Torque was to be placed in the lower buccal segments, and all step bends in arch form were to be made by the operator for the original method.

Much effort, time, and expense would be required to make a perfect individual prefabricated set up in terms of torque tip and rotation for every tooth. It would possibly be a good practice if, indeed, this were the objective with the final appliance. However, in view of the need for buccal or labial inclinations for anchorage, the overcorrection of rotations, and the overtreatment of arch and jaw relationships, an absolutely straight wire finishing is not necessarily the goal and arch form is also a fundamental first-order consideration.

Individual tooth considerations are required with any technique. It is wondered, on a practical basis, how far one should go with formulas and setups in view of the complications of inventory, cost to the patient, and increased complexity of management with such a variety of attachments. Considering the beauty of intraoral adjustments with the bioprogressive therapy, particularly those of a minor nature, the gain to be experienced with absolute torque, tip, rotation bands, and brackets might be questioned.

Standard bioprogressive

As mentioned before, the edgewise appliance formed the basis for bioprogressive development. For the original bioprogressive therapy standardized tipping was studied designed, and modified over a period of years for superb clinical application (Fig. 13). Minor adjustments were left in the hands of the operator for individual conditions in treatment and it was thought advisable to tap bands into place and swage them firmly onto the teeth. This is still considered the method of choice.

Torque was built into the upper incisors and all four canines with the standard setup. Originally, the torquing of the lower buccal segment and step bends in the arch for the premolars and molars were relegated to the arch wires. Many clinicians still enjoy this setup because a series of preformed arches was designed which, when placed into inventory, could be applied in the individual situation. In effect, the preformed prefabricated band, bracket, and arch wire inventory was designed into a complete organized approach.

Full Torque

The torquing of the anterior teeth had already been made, and the only torque still to be accomplished was the lower buccal segments. Studies on patients with normal occlusion, skulls with normal occlusion, and actual practice and clinical experience led to the development of torque combinations for the lower molars and premolars. While new torque designs were made, rotation tubes were placed on the lower molars also. These were added as a first option to the original standardized bioprogressive arrangement (Fig. 14). This meant that near the end of treatment, if desired, untorqued wires could be used. Lateral step bends were needed, and even the bends were already placed in the preformed wires. In other words, all torque requirements had been eliminated in the wire except for the variations needed.

First-order provisions had been avoided because of the need for bulking-up of the brackets, the danger of esthetic and hygienic complications, and the need to prevent lever action against the band itself. However, in view of requests from students and the attraction of straight wire, designs were explored to fit the bioprogressive technique. It meant the need for three changes from the full torque appliance.

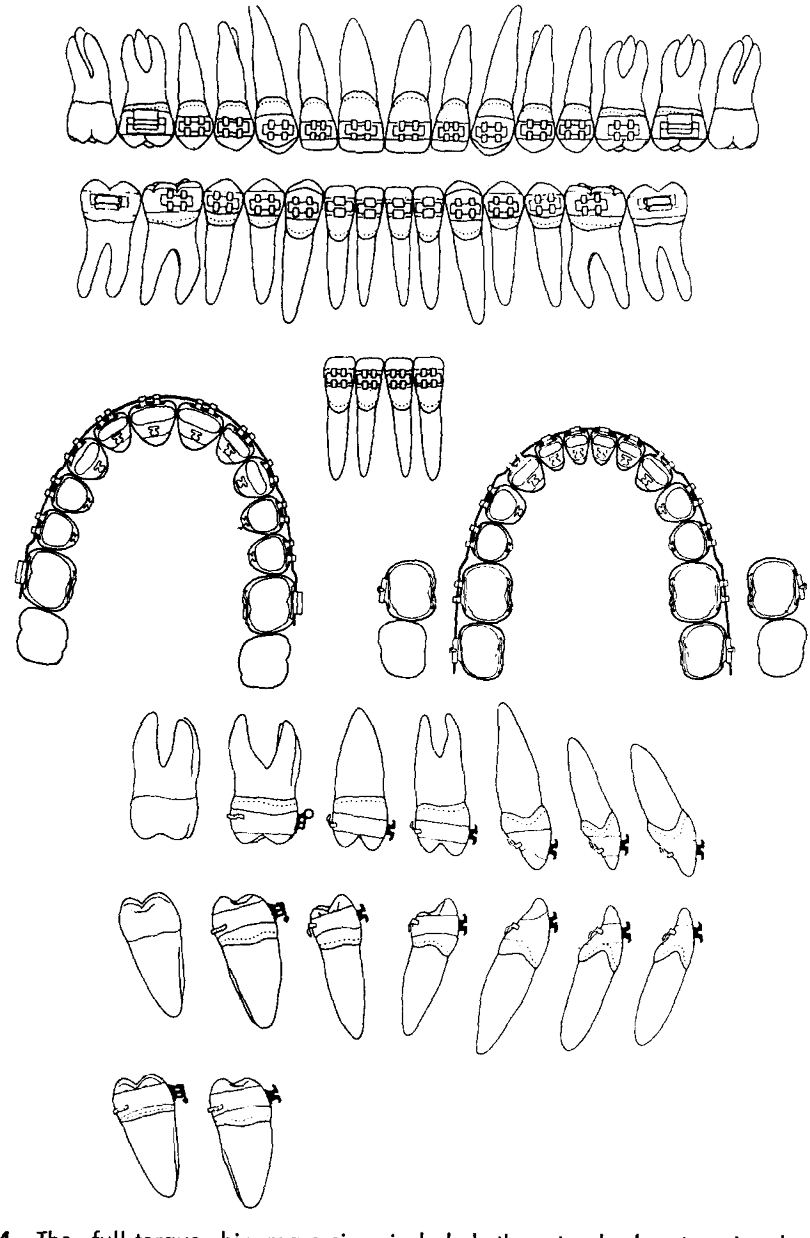


Fig. 14. The full-torque bioprogressive included the standard setup in the upper arch, but a torque-rotation tube was made on the lower molar and a torque bracket was made for the lower second premolar (see lower illustration). These were adapted for the technique and essentially eliminate excessive torquing in the wire needed for finishing stages, but they are augmented for anchorage.

Triple control setup

In order to step certain teeth outward, the adjacent teeth would need to be stepped inward (Fig. 15). First, all the canine brackets would need to be raised to produce the buccal step for the first premolars. Second, because the molar needs to be stepped buccally from the second premolars and in order to obviate

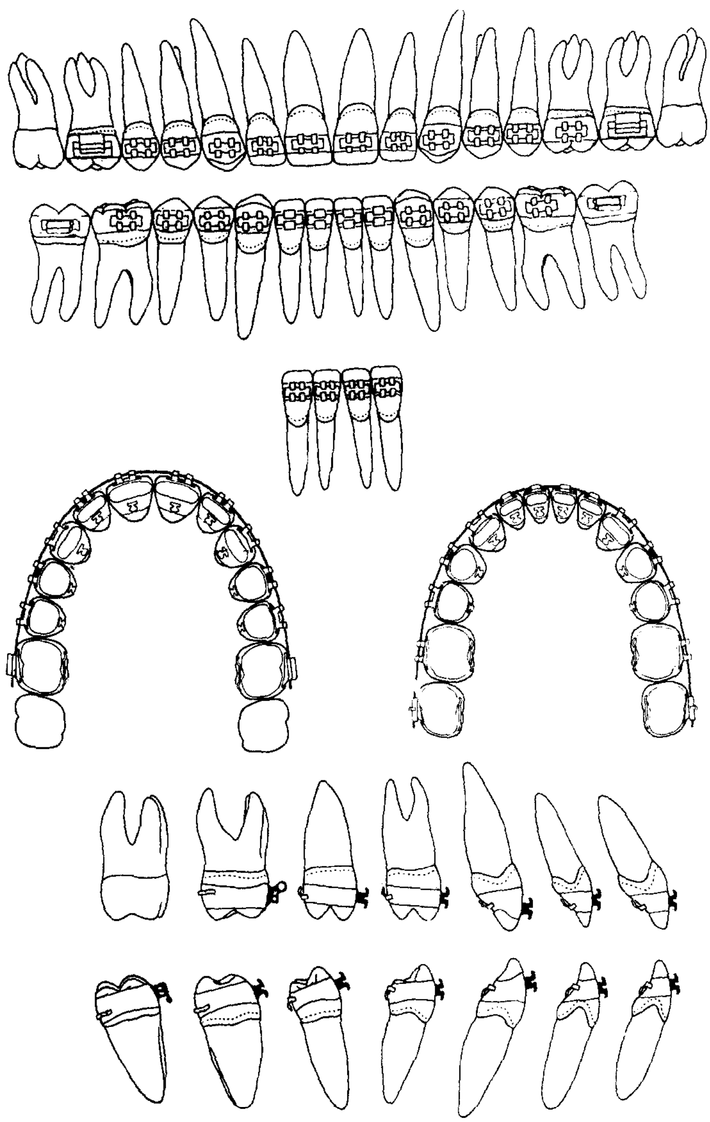


Fig. 15. A setup for the technique labeled "triple-control" bioprogressive. It includes features of overtreatment of certain torque, overtreatment of rotations, and provisions for overtreatment of upper buccal segments. The raised bracket was designed for all canines and second premolars, so that a nonstepped wire could be used at the idealization stage.

the step in the wire, the second premolar is raised so that it will be aligned lingually. The flaring of the upper molar tube to produce rotation of the upper molar was thought to produce needless extension into the buccal mucosa and complicate expansion. Many clinicians have difficulty in placing enough rotation and in remembering to adjust it at every appointment. The third move was to rotate the upper molar tube.

The options for variation in treatment still need to be avaliable, however. For instance, if the patient has a Class II malocclusion and requires extraction of upper premolars only, the upper first molars should not be rotated. In this event, for best occlusion, the buccal section has no gable or bayonet for the molar. This means that the bracket is not raised and the rotation should not be made in the upper molar. If this is the setup in the upper arch, for best fit of the teeth the step bend is not made in the lower premolar area; nor is that tooth fully rotated distally. The original standard setup is therefore superior for these unusual cases.

All this means that the individual treatment plan is needed before the orthodontist becomes concerned with which kit of bands is to be employed. There is little difficulty with the anterior teeth because all of that is essentially standardized and the minor variations required can be made very simply with intraoral adjustments. In an extraction case in the lower arch with the first premolar missing and the second premolar moved into the position in the arch normally occupied by the first premolar, a 7 degree torque bracket would be needed on that tooth, which means that the technique becomes further complicated.

Standard bioprogressive (original)

Let us now list these prescriptions, together with a certain rationale of their use. Second-order and third-order factors are built into the bracket and tubes for the anterior teeth. First-order factors will be considered later.

Provisions for tipping (second-order control) (Figs. 13, 14, and 15). The operator should be able in fitting, particularly with the band driver, to angle the band on the tooth up to 3 to 4 degrees without band distortion. The more malleable band can "draw" this much. Small angulations are too difficult to be seen with the naked eye for premounting, and therefore tipping of at least 5 degrees or more was recommended for prewelds, leaving the finer detail to the technician at cementation.

All bands therefore receive brackets parallel to the band margin except the following:

Upper lateral incisor	8 degrees down on distal
Upper canine	5 degrees down on distal
Lower canine	5 degrees down on distal
Lower first molar	5 degrees down on mesial

The tipping of the bracket (or tube) is a compensation for tooth morphology and natural fit of a band on these teeth. To reierate, by driving, the band can be adjusted and stretched 2 to 3 degrees of angulation.

Provision for torque (third-order control) (Figs. 13, 14, and 15). Some changes were made from time to time in certain angulations, but again feedback from problems in treatment and results achieved in thousands of cases led to the following prescriptions:

For standard bioprogressive, full-torque bioprogressive, and triple-control bioprogressive

Upper central incisor	22 degrees (root to the palatal)
Upper lateral incisor	14 degrees (root to the palatal)
Upper canines	7 degrees (root to the palatal)
Lower canines	7 degrees (root to the lingual)

For full-torque bioprogressive and triple-control bioprogressive

Lower second premolar	14 degrees	(root to the buccal except in first premolar-extraction case)

For full-torque bioprogressive and triple-control bioprogressive

Lower second premolar	14 degrees	(root to the buccal except in first premolar-extraction cases)
Lower first molar	22 degrees	(bracket or double-tube root to the buccal)

Comments on teeth

Incisors. Some may believe that 22 degrees of torque on the upper central incisor is excessive. However, a study of problems in initial arch placement in maxillary protrusion cases shows that first arch placement may lead to forward root movement. With the 22 degree bracket, torque is automatically treated if the square or rectangular wire is used throughout treatment. Overtreatment is most often desirable, especially in Class II, Division 2 cases, and interincisal angles at 125 degrees or less have been found to hold most successfully. This low angle also seems to allow for posttreatment physiologic and growth adjustments without bite closure (Fig. 16).

It is well to drive the upper central incisor band downward on the distal in final seating for two reasons: First, it has a rounded contour which pulls the band in at the mesial call area; second, a 1 to 2 degree tilt of the bracket ensures the slight mesial inclination to help prevent diastemas. The lateral incisor originally was 17 degrees torque and 5 degrees tip. With practical experience, this was changed to 14 degrees torque and 8 degrees tip. Again in seating, the band is driven on the distal to ensure mesial contouring up to 3 degrees or ending at 10 to 11 degrees, depending on the tooth. The entire issue is to make sure that the alignment of the bracket box is parallel to the incisal edge for function (Fig. 16).

Canines. The 7 degree torque for the canines was introduced following four studies (Fig. 17). First, 200 consecutive retained cases were photographed for occlusogram analysis. All of these were treated with conventional untorqued brackets on the canines. Thinning of labial tissue over the canines, some early recession of gingiva, and roots that appeared too prominent were noted.

Second, studies of intercanine angles were made from 60 degree oblique head films on normal occlusions. It was found that normal canines canted outward and met at 130 to 140 degree intercanine angles. The face of the crown did not possess enough curvature when the band was placed near the center third, where it is commonly located, to supply these angles routinely.

Third, studies of the position of canines during treatment, particularly in adults, indicated that buccal plate could be avoided and anchorage results improved if the roots were contained in cancellous bone. The standard straight bracket on the canine inclined the root too far to the labial and proved to make root angulation more difficult in adult extraction cases. This has also been observed in patients treated by the Begg method. This is one feature or difference in the bioprogressive and Andrews straight-wire arguments. Detorquing can be

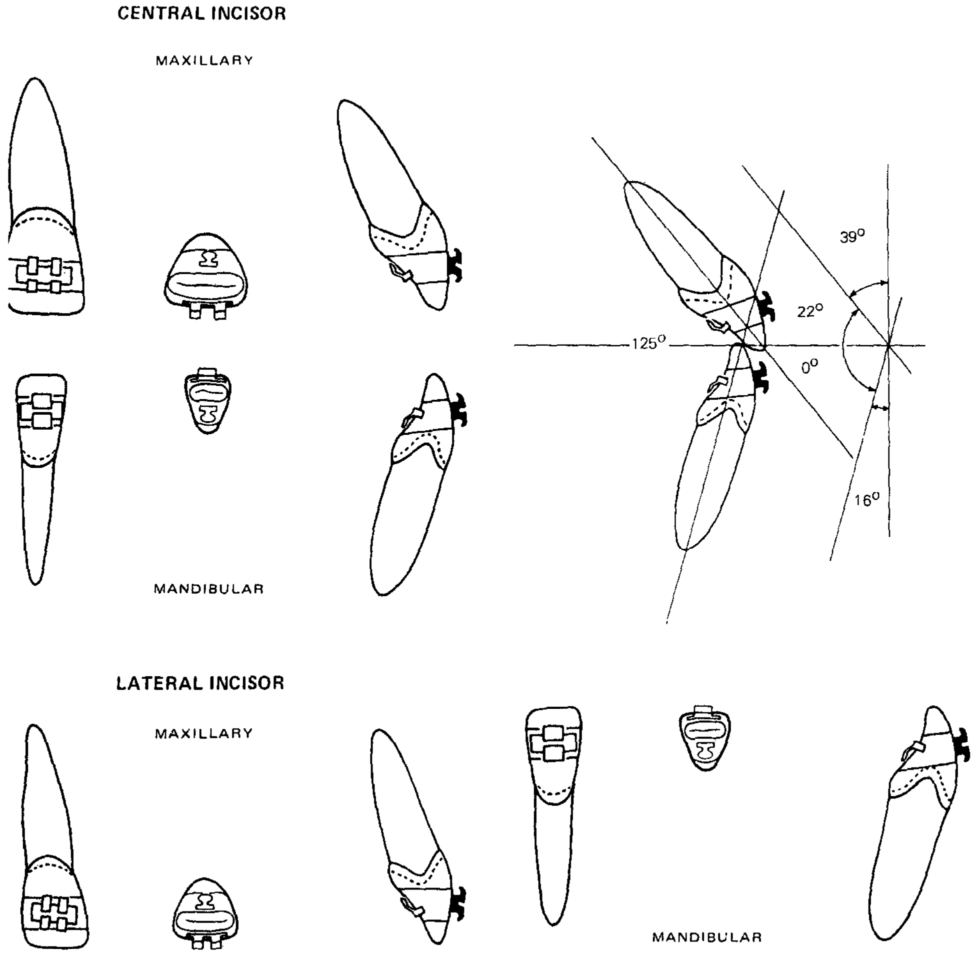
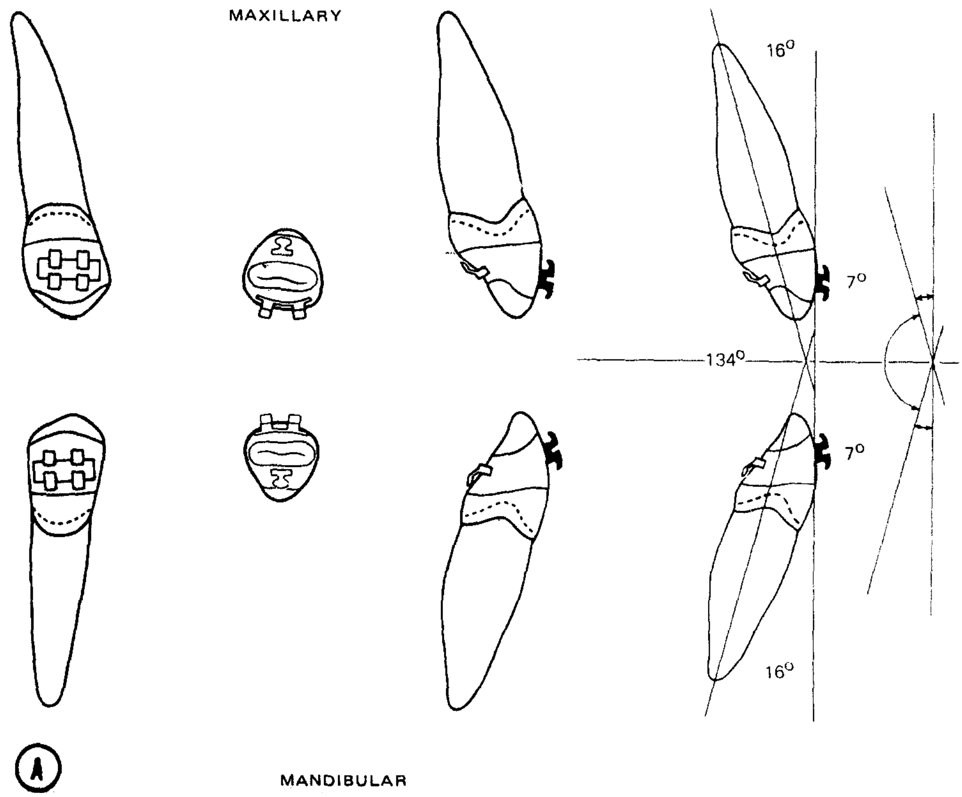


Fig. 16. Calculations for the interincisal angle at 125 degrees and the necessary requirements for the 22 degree torque bracket to achieve this by end of treatment. Note that upper incisor is canted 39 degrees off the vertical to the occlusal plane, and the lower incisor is canted 16 degrees off the vertical, totaling 180 degrees. Note 8 degree cant of upper incisor bracket.

accomplished very easily near the end of treatment by contracting with round wire if torquing of the central incisors or canines is considered excessive for the individual case. However, in my experience, this is quite rare.

The fourth study was also of normal occlusion in skulls and cephalometric frontal tracings. The normal lower canines were slightly inclined laterally outward and forward. I have never seen a condition of normal occlusion with the roots of canines labial to the crowns. In their proper angulation, they receive stress down their long axes and therefore possibly support the corners of the mouth better than if the roots are inclined more lingually.[37]

The angulation is 5 degrees standard for mesial inclination of the tooth. In the upper, driving to seat on the distal can add another 3 to 4 degrees if



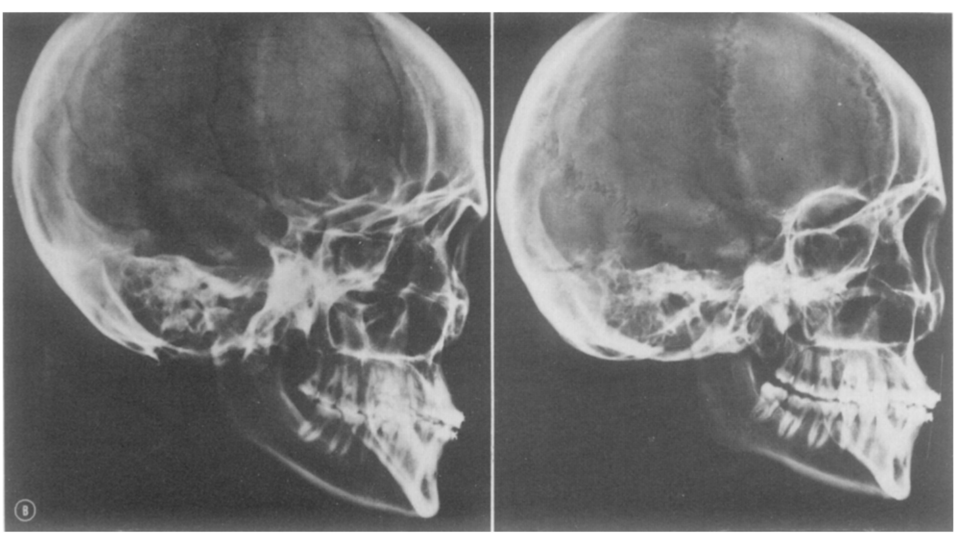


Fig. 17. A, A 7 degree torque bracket was designed for each of the canines to bring these teeth to an interincisal angle of 134 degrees on the average. This meant that a 7 degree torque bracket with the root being placed inward (or lingual root torque) was found necessary in these conditions. **B,** A skull with normal occlusion with the canines banded and a rectangular wire bent at right angles and ligated into the 7 degree torque brackets. Note that both are almost absolutely vertical in this film taken at 60 degrees oblique to show the intercanine relationship.

individual teeth warrant it. Again, the bracket box should be parallel to the mesial and distal contact areas to ensure final occlusion.

Lower posterior segments. In the lower arch in ideal normal occlusions, a progressive torque will be noted. These are quite evident in a frontal head film. Studies of sectioned normal skulls suggest that the lower first premolar crown is almost straight upright. However, a lingual crown cant starts at the second premolar. Experimentally and from a practical viewpoint, this angulation averaged about 14 degrees.

The lower first molar was found to average about 20 to 25 degrees, and a 22 degree torque for the bracket or tube was found to be acceptable. Almost a 10 degree difference was observed between the first and second molars. Individual occlusions were noted in which a tube placed on the buccal surfae of the third molar was 45 degrees. These torque positions of lower molar roots are highly significant for proper anchorage with bioprogressive therapy. The tipping of 5 degrees (down on the mesial) has been standard and worked out well for 20 years (see Fig. 13).

Provision for rotation and stepouts

First-order control with standard and full torque bioprogressive. It is supposed that rotations of teeth in line with the arch may be considered first-order control. Certain of these provisions can be built into the brackets: lower molar, 12 degrees (to the distal); lower molar tube, 12 degrees; all remaining teeth, as dictated by initial rotations.

The step-out step-in provisions in raising of selected brackets were discussed with the full triple-control wire descriptions. They were 0.6 mm. steps, on the average.

Rotation of teeth

Ligation to eyelets was needed for rotation when single brackets were used, although ligature "figure-of-eight" ties for reciprocal rotations have always been used, if available. If slight overrotation is desired with the Siamese bracket, one or all of four procedures may be considered:

1. The band may be cemented slightly off center, so that a single ligation will cause excessive rotation. This prevents the need for antirotation design on a bracket. Only one bracket need to be tied.
2. One bracket can be filled with an elastic or squashed shut with pliers to produce a block or fulcrum. It can be reopened later with a pin cutter if necessary.
3. Reciprocal ties or A-elastic chains[38] (Fig. 18) can be used with Siamese as well as single brackets.
4. Lingual cleats are placed throughout for counter moments or couples of force which now can be provided from the inside of the arch. These lingual cleats are highly efficient and are a strong argument for banding instead of direct bonding only to the labial or buccal side.

Because of the lower molar form and the need for right and left precontoured lower molar bands, it was decided to include in the lower molar tube design also a rotation of 12 degrees. This helped to further reduce arch wire manipulation

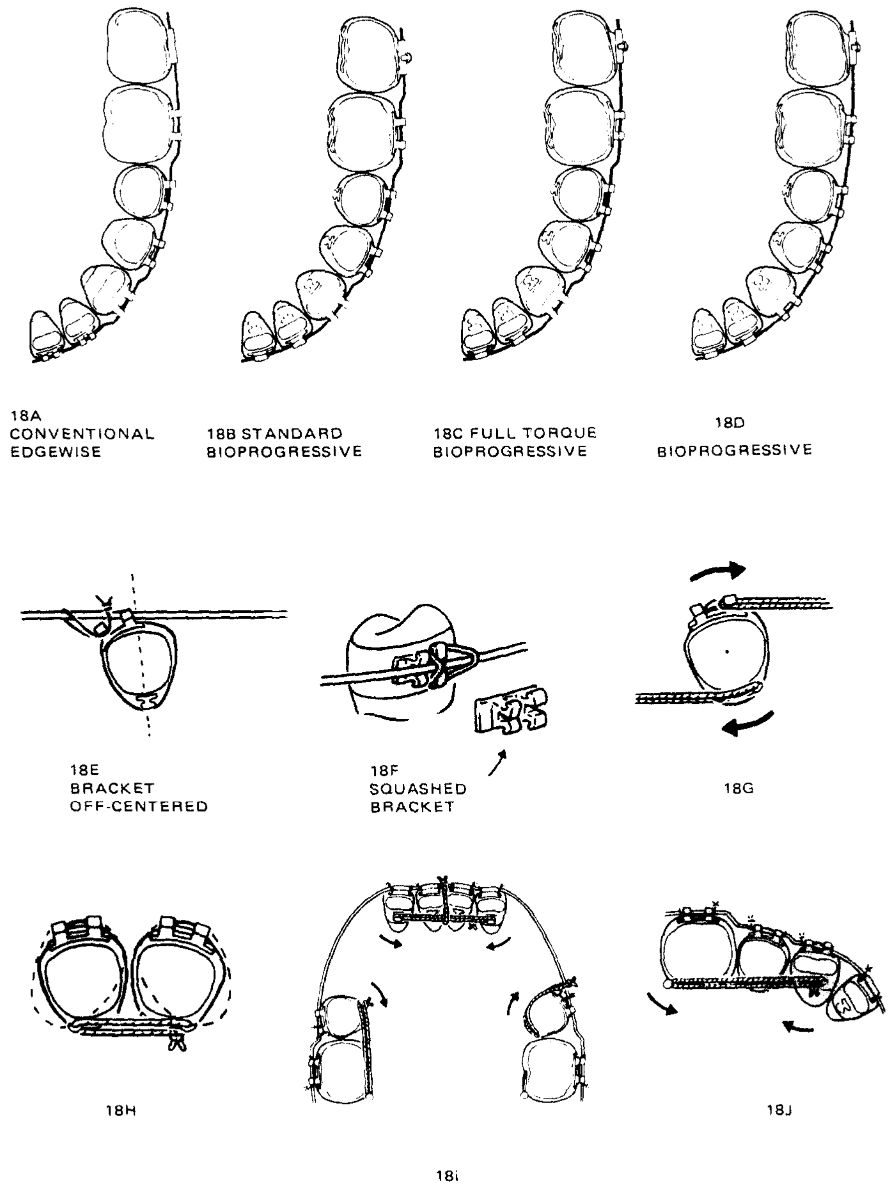


Fig. 18. Methods of rotation in finishing for different techniques. **A,** Step bends were made in the wire in the conventional edgewise appliance. **B,** Modification was made in the bioprogressive therapy to overrotate the lower molar, to step the lower lateral labially rather than lingually, and to augment the buccal step for the first premolar. **C,** The torque bracket-and-tube design is optional. **D,** The method of raising certain brackets to obviate step bends. **E,** The band may be offset for aid in rotation. **F.** One bracket can be squashed together to act as a rotation bar for purposes of overrotation with the other one tied. **G,** A coupling action can be gained by the use of threads from the labial and lingual as demonstrated. Reciprocal ties can be made in the premolars or between any two teeth, as is also demonstrated. **H, I,** and **J,** A typical tie in **J** for the mesial rotation of the canine after it had been retracted in the conventional extraction therapy and distal rotation with purchase on the labial aspect.

(Fig. 18). Again, studies of more than 100 normal and treated ideal occlusions led to this average for the typical setup. Even with this design, straight tubes are used or derotation must be put in the arch wire in one-arch extraction cases. This proves that no appliance, straight-wire or otherwise, can be completely "automatic" and that the clinician must still be in charge.

Comments on banding of second molars

There is little question that lower second molars need to be banded, used, and placed in their correct positions in the majority of cases, but it is not always necessary to band these teeth. With the bioprogressive setup, no problem is posed for picking up the second molar, as it may develop often late in treatment. Some techniques have employed a convertible bracket but, because of the need for two slots (or a double tube), this in itself is complicated. Very simply, with the progressive method a band with a bracket of choice is placed on the second molar. A separate short, straight section or looped section is then employed to rotate or level the second molar by entering the second tube from the distal aspect. This can be done without rebanding of the first molar. If, of course, the second molar is available at the start,(the tube is placed on the second molar for routine ideal arch control.

Some orthodontists make an issue of banding second molars, including the upper ones, in every case.[39] Certainly, in finishing treatment of a patient, the final occlusion of the second molar is important because the mesiolingual cusp of the upper second molar has been seen to be involved in cross-mouth interference, particularly in patients treated or developing to flat occlusions or without canine or corner guidance in function. However, studies have shown that the second molar may not reach its normal occlusion with natural development—sometimes until the age of 16 years. It is my practice, therefore, to band the upper second molar only rarely, and this is usually for cross-bites and Class III conditions. In many cases, banding the second molar complicates treatment and inhibits Class II correction and may even lead to needless extractions. Observations on thousands of postretention cases show that this tooth will usually drop into normal function on its own. The major exception is the presence of an impacted upper third molar. In this event, the third molar may be removed early or the second molar may be removed if the third molar is large, healthy, and in good position.

If the tooth is banded, a normal upper molar band is prepared, fitted, and placed. The upper second molar normally inclines slightly buccally. If Class II elastics are employed, the canting of the occlusal plane may intrude the upper first molar. In this event, banding of the second molar is advised routinely.

Summary (Part I)

The background and philosophy for development of bioprogressive therapy has been briefly explained. Organized studies leading to biologic forces needed and consequent wire sizes to be used have been reviewed.

The prefabricated fixed apparatus or bands and brackets used with this technique have been explained. Feedback from treated cases, using intraoral

photographs, study models, and particularly cephalometric analysis, has led to the gradual development of the present schemes. The standard bioprogressive set-up, the full-torque arrangement, and the triple-control formulas have been described.

Part II will deal with the activating mechanisms and the logic, rationale, and technique for application. The preforming of arches and modules or sections will be explained. Provision for first-order control is made for ideal arches. In order to prevent needless bulk of bands, help economize, simplify inventory, and remain flexible in treatment regimes, many of the first-order bends were designed originally in the preformed arch. Because of extraction or nonextraction in one arch or another, molar steps were to be placed by the operator. A new ideal arch form and detail was thought desirable following the study of relapse and posttreatment shifts of teeth. These will be explained in Part II.

With the availability of prefabricated bands and bracket designs, organized in a plan together with performed arches and modules, about 90% of the arch-wire bending at the chair has been eliminated.

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