Bracket angulation as applied to the edgewise appliance*

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An accepted procedure among orthodontists is to place edgewise brackets on bands so that they are centered on the strip of band material at right angles to the band and in turn placed on teeth that the brackets parallel the long axis of the teeth. It is the purpose of this paper to point out that, by varying slightly from the basic concept, most of the difficult mechanical procedures involved in orthodontics can be simplified. In fact, comparatively few teeth should have brackets placed upon them so that their slots are exactly at right angles to the long axis of the teeth. The basic principles underlying this treatment were laid down by Dr. Charles H. Tweed. The purpose of this article is to present certain modifications in procedures and techniques which have achieved the same results with less effort.

Most orthodontists who use the edgewise appliance agree that it is desirable to eliminate, as far as possible, those procedures in arch wire fabrication which are difficult to reproduce in subsequent arch wire changes. The replacement of arch wires having adequate second order bends, either with a new working arch wire or a heavy stabilizing arch, is a time-consuming, difficult procedure. Patients so treated always experience an undesirable amount of tooth soreness and tenderness following such changes. This is evidence that some loss of anchorage has taken place.

It is the thesis of this paper that the best anchorage is attained when the anchor units are set up in a tipped-back position, as described by Dr. Tweed. These units consist of one bicuspid and two molars on each side and in each jaw, in cases where four bicuspids must be sacrificed. However, the key anchor units are in the lower arch. When an 0.021 x 0.025 inch arch wire is adjusted to produce a coordinated tip back bend, the force exerted on the supporting structures is temporarily too severe, and even though the desired tipping is achieved, the action on the anchor units is soon lost. A more flexible, resilient arch wire, that will work through a greater range of adjustment is better tolerated by the supporting structures of the teeth in setting up the anchor units and is a more efficient mechanism for producing movement of teeth.

The presence of tip back bends, vertical offset bends, bends to upright cuspids and artistic positioning bends are also too complicated when related to other mechanical problems such as cuspid retraction and space closure. However, the effects produced by these bends must be thoroughly understood by the operator if they are to be successfully incorporated in the initial hook-up of the case through bracket angulation and placement. It is much better to have the case leveled off, anchorage set up, especially in the lower arch, and to have the arch prepared to receive an ideal arch wire, passive, and in harmony with the par-

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ticular problem at hand, but free of all bends in the vertical plane. Correct bracket angulation will also solve the problem of parallel roots in future space closure. This is not difficult to accomplish if the principle of bracket angulation is carefully applied. It will be found necessary, however, to incorporate a uniform reserve curve of Spee in the lower arch wire, but without any abrupt bends, and, if the arch wires are highly polished, they will slide through the brackets with a minimum of frictional resistance and can be easily duplicated.

The problem of bracket angulation is better understood if approached from the following clinical aspects:

A. As an aid in paralleling roots adjacent to extraction spaces.
B. As one method of setting up posterior anchorage units into tipped back or anchorage prepared positions.
C. As a means of artistically positioning teeth.

A. Paralleling Roots in Extraction Cases

Many orthodontic cases are discrepancy problems in tooth and jaw size and are therefore extraction problems. One of the glaring faults so often observed in these cases is a V-shaped area created by failing to so finish the case that the roots of those teeth adjacent to the area of extraction are parallel. In fact, a slight exaggeration is actually desirable. Careful attention must be given to the mechanics so that this unfortunate dilemma of extraction cases is not allowed to occur.

Pertinent to the problem under consideration is the following quotation from Dr. C. W. Carey's presentation, "The D.R. 11 — Light Resilient Arch for Use in Extensive Space Closure:"

"In extraction cases it is often required that we move the first tooth anterior to the space bodily to the distal, and later the other anterior teeth with the least amount of forward progress of the teeth posterior to the space. This is a challenge to our skill and ingenuity and there are few who can accomplish it successfully. I believe that it is generally accepted that our attack will be improved by tipping back the posterior teeth to enhance the stability of this anchorage unit. Next in importance is that the *distal tipping of the tooth anterior to the space, whether it be a bicuspid or cuspid, should not proceed beyond the vertical position and root movement should precede crown movement from this point.* This also applies to the incisors in turn. Occlusal interference should be reduced. Occiptal, cervical or any form of additional anchorage should be utilized to assist in the movement of these teeth."

With an arch wire of 0.022 inch thickness, the placement of brackets so that their greatest dimension parallels the long axis of the teeth would, theoretically, exactly parallel the tooth roots. However, an 0.021 inch arch wire, in an 0.022 inch bracket, allows for considerable tipping. Moreover, any orthodontic appliance is at a great mechanical disadvantage due to its position on the tooth in relation to the tooth's apical end. Every orthodontist has noticed the amount of play that exists when an 0.021 x 0.025 inch arch wire is placed in an 0.022 x 0.028 bracket. Failure to parallel tooth roots can, therefore, be the result of the basic inaccuracy of the appliance used. Certainly such procedures are frequently augmented by the following: (1) Tying rotations to an incisal or occlusal alignment staple, (2) injudicious activation of closure loops, and (3) inadequate leveling (an exaggerated curve of Spee

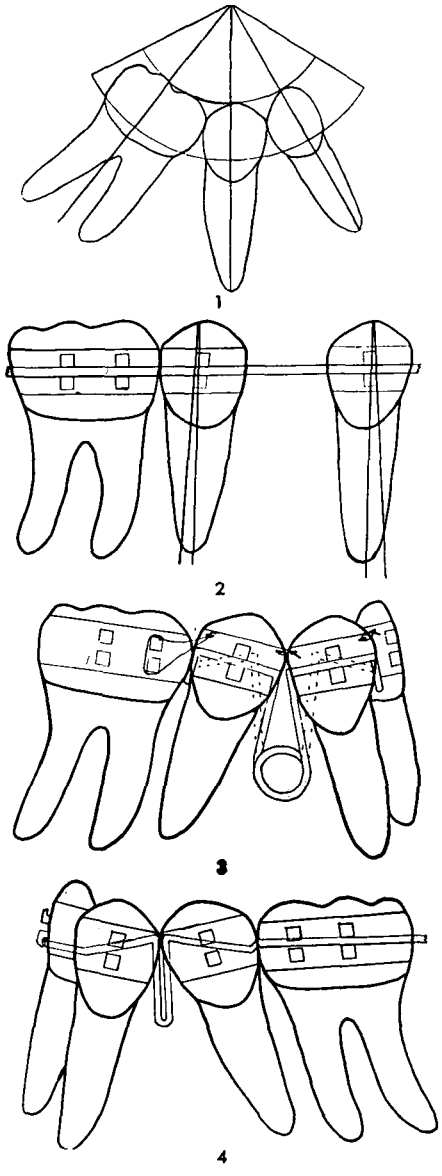
in the lower arch) which, by its very nature causes the roots to be divergent. (See Fig. 1.)

By angulating the brackets of the teeth adjacent to the extraction space 3° toward that space, the error is overcome and the space closing can proceed with parallel roots and still give the advantages of an 0.021 inch arch wire. Dr. G. H. Terwilliger has discussed the problem of resilient arches in his article, "The Development of the Edgewise Arch Mechanism and Its Place in Contemporary Orthodontics". He states:

> "It is curious to note that it was not long until orthodontists began to move unconsciously away from the desired "severe fit" so ardently sought when the soft, or 447 bracket was the only one available. They began to seek freedom of the arch wire within the bracket by the use of arches smaller than 0.022 inch by 0.028 inch in the original working dimensions of the edgewise arch. Light round steel arch wires of 0.016 inch, 0.018 inch, and 0.022 inch came into wise use for the initial stages of orthodontic treatment, and often lingered over into later stages in the hands of some operators. Many orthodontists who limited their use of round wire to the earliest stages of treatment came to use 0.021 inch by 0.025 inch arch wires for the major portion of treatment in order to reduce tissue shock. Some orthodontists are routinely using 0.020 inch by 0.028 inch arch wires in the standard 0.022 inch by 0.028 inch slot. Oddly enough, it is seldom necessary at the end of treatment to use new ideal arch wires of 0.215 inch by 0.028 inch or 0.022 inch by 0.028 inch. *Most orthodontists who use the hard or substantial bracket have learned to express their concept of tissue tolerance by a reduction in the size of the arch wire, and feel that their operating knowledge is more accurate with a known variable.*"

This "known variable" can be overcome by a 3° angulation of the brackets on those teeth adjacent to the extraction space regardless of where that space is located. (Fig. 2) This works just as well in second bicuspid extractions cases as in the usual first bicuspid extractions. In these cases it is particularly desirable to maintain tight contacts due to the functional position in the arch of the extraction site, and it is a *must* to slightly "over-correct" the root apices if this is to be achieved. It has been suggested that the resultant action on the cuspid is to set it in a position of dynamic anchorage to resist distal movement. This is certainly a true statement but not a valid objection to the use of the principle because there are so many ways to avoid this action when it is undesirable. As long as the cuspids have a forward inclination, they are best retracted without bracket engagement. Then too, it is better in the early stages of treatment to allow compensating bends in the arch wire to adjust to the malocclusion. This will eliminate the making of all kinds of gadgets (Fig. 3) and complicated arch wire fabrications (Fig. 4) near the end of treatment in order to overcome problems which never would have developed had the operator anticipated them in the initial hook-up and prevented their developing into sizeable proportions. This can be done through bracket angulation and band placement.

It is the belief of the author that in most cases, orthodontists should work toward ideal arch wires which are either flat or have a mild reverse curve of Spee in the lower arch. Duplication of such an arch wire can be accomplished with much greater precision and will thus avoid breaking down anchorage due to necessary arch wire changes.

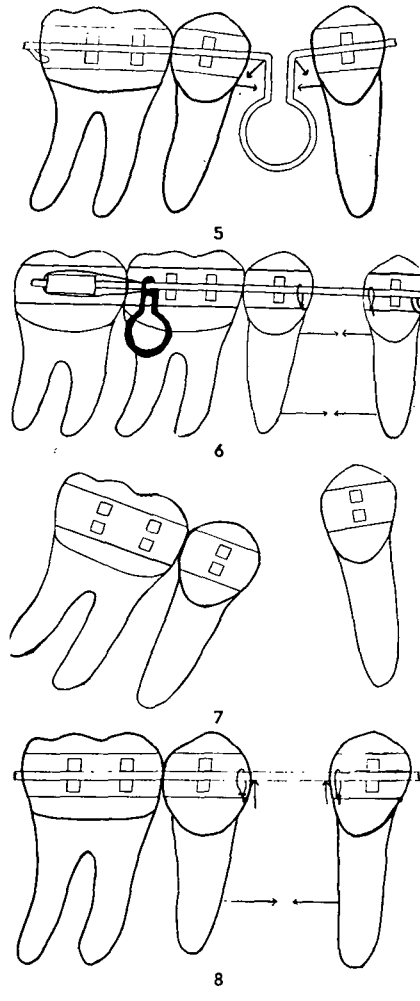


Even these changes become surprisingly few when we are working with ideal arch wires free of abrupt bends in a vertical plane.

Let us consider the importance of parallel space closure. All too often, failure to get sufficient cuspid root retraction is a factor inviting future relapse. Probably no teeth have a greater tendency to upright themselves than do the cuspids. If the cuspid bracket is so angulated that sufficient distal root movement is assured and, as a result, if the cuspids fail to be retracted as far as we should like, the anchorage problem is really brought out in the open where we can give it better attention all during treatment. Bracket angulation to secure cuspid root-end retraction, by placing them far enough distally in the apical base, will, in many cases, require more attention being paid to the anchorage problem. It doesn't require much anchorage to tip a cuspid back until it has contact with the second bicuspid, but it will not remain there. Failure to retract each cuspid root sufficiently (even if only 1-2 millimeters at the apex) could result in the crown moving forward that much during and after retention. Two to four millimeters relapse distributed among the lower incisors is too much, but a one or two millimeters distal tipping of either or both cuspids is hardly discernible. The beautiful illusion present when appliances are first removed is too frequently lost and tipped cuspids are often the reason. Evidence of this will be seen in the opening of the contact between cuspids and second bicuspids, crumpling of the lower incisors and occasionally a crowding of the upper incisors, but even more frequently observed will be a tendency for the anteriors to protrude even when open contacts distal to the cuspids are present, particularly if the uprighting action of tipped cuspids is involved. Admittedly, all inadequacies are not caused by this alone. Lack of occlusal equilibration (especially the presence of cuspid interferences) retained habit patterns, faulty musculature, impingement on the normal freeway space in vertical opening, failure to position teeth in harmony with their supporting apical base and other things play a major role in the final settling of orthodontic cases. However, before

passing off any such imperfections as factors beyond our control, we should first be certain that our mechanics cannot be improved.

There are other factors besides bracket angulation which will help to facilitate parallel space closure. (Fig. 5) (1) Cautious use of closure loops and sectional arches, if these are used at all. A continuous arch, with any of the varied types of contraction and retraction mechanisms, does a much better job of supporting the weak point in our mechanics which is the extraction site, (Fig. 6). However, friction through the brackets tends to reduce the efficiency of these mechanisms too greatly if tip back bends are present. This, too, can be overcome by the elimination of the tip back bends for setting up anchorage by doing it another way as will be discussed later in relation to anchorage preparation. There are, however, many cases in which vertical closure loops can be very successfully used, but, in nearly all cases, it is advisable to alternate the closure loop arches with ideal flat arch wires. (2) Adequate leveling: (Fig. 7) It is disastrous to begin retraction or space closure until the exaggerated curvatures and tipped teeth are corrected. (3) Proper tying to alignment staples: (Fig. 8) An eyelet placed on the bands gingivally to the arch wire is greatly to be preferred in tying teeth adjacent to extraction spaces when correcting and preventing rotations. If, in spite of everything, a mild tipping occurs, the uprighting action of the angulated bracket can be accentuated by tying reciprocal eyelets. (Fig. 9)



B. Anchorage Preparation

A consideration of any phase of the science of orthodontics inevitably includes a consideration of anchorage. The following procedure is presented for those cases where an anchorage problem exists. Its advantage is mainly the elimination of second order bends in arch wires. This means that duplication of arch wires is simplified and that arch wire changes may be made without "jiggling" the anchor unit teeth, thus greatly conserving anchorage. It is probably not the first backward tipping of an anchor tooth which causes the apparent fluidity of the supporting bone where anchorage has been lost. It is the continual altering of the root to supporting bone relationships which breaks down supporting structure and thus anchorage. Certainly, if we allow

forward tipping to occur, it is essential to stop and tip them back again. However, this is done with damage to tissue and loss of anchorage. The author has noted, with considerable satisfaction, a tendency to get away from mechanics which necessitated repeated leveling procedures, as was the case with many variations of the sectional arch. Each time the second bicuspid is submerged and elevated, anchorage is lost. When the anchor units consisting of one bicuspid and two molars are required to move back an anterior segment consisting of a long rooted, well anchored cuspid and two incisors on each side, plus the added requirement placed on them in Class II extraction cases, the conditions of dynamic anchorage stressed by Dr. Tweed must be established. Also, the degree to which it is carried must be determined by such factors as clinical judgment of the extent of the desired tooth movements, cephalometric studies—especially a Downs analysis, and a consideration of racial types. The extent to which the brackets are angulated varies from those in which it is desirable to maintain the teeth only in upright positions with 2-3° angulation, to bimaxillary protrusions and Class II cases where 10-12° bracket angulation will give best results.

The lower second bicuspids and first and second molars on each side are the key anchor units in nearly all discrepancy cases. When leveled off and tipped back, they must then be so held that they function as a single tooth or as a unit for anchorage purposes. A flat arch wire or one having a mild reverse curve of Spee placed in brackets angulated to this requirement, is ideal.

Regardless of the degree of anchorage preparation needed to properly treat the case at hand, disregarding this vital step is often the difference between a mediocre result and a beautifully treated case. Through bracket angulation there is little extra effort involved in addition to the routine leveling.

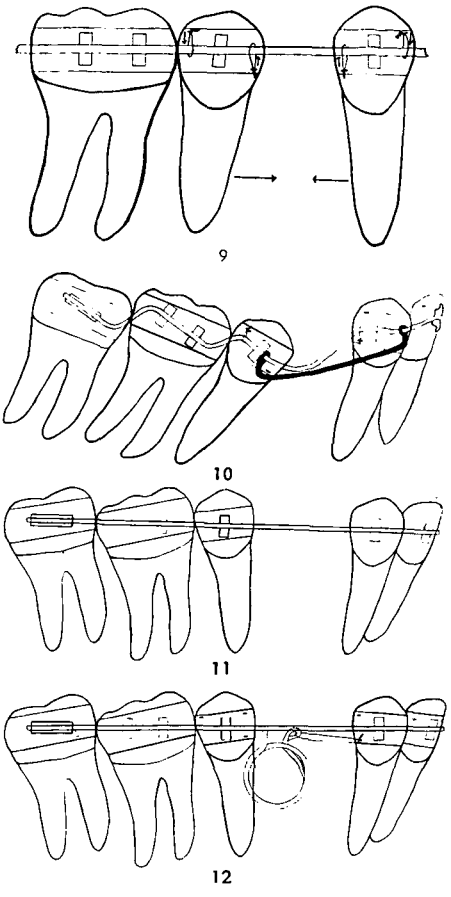
Three main procedures cover most cases in this initial stage of treatment. Variations required by an atypical case or by second bicuspid extractions will readily suggest themselves when one has had some experience with the principle of bracket angulation. First, those in which it is desirable to begin treatment with all four first bicuspids extracted in order to rapidly alleviate a crowded condition and facilitate tooth separation for band placement. Second, those extraction cases having regular but protrusive upper incisors in which band placement without extraction to begin treatment would not cause expansion of any consequence. These may also be treated the same as the first group, but, if it is suspected that headgear cooperation might be questionable, it is better to extract only the lower bicuspids until the case is leveled and anchorage prepared. One can use Class III elastics from the upper arch if this arch is free of extractions. Third, non-extraction cases.

When treatment is begun with all four first bicuspids extracted, the lower anchor units are leveled and set up by direct application of headgear to the lower arch. The force is transmitted through sliding yokes to the anchor unit at the mesial of the lower second bicuspid bracket to tip back these teeth. Angulation of brackets and tubes for the lower key anchor units is carefully determined for the case at hand. An 0.015 inch round leveling arch is tied in without headgear for two weeks, at which time it is replaced with an 0.018 inch round arch wire on which sliding yokes are placed to engage the headgear hooks at the distal of the lower lateral incisors and transmit the headgear force to the anchor units. (Fig. 10) The patient is instructed to wear the headgear fourteen hours per day, if

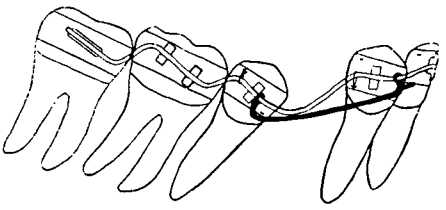
possible. This is continued for three weeks, and, at the next appointment, the 0.018 inch arch wire is replaced with an 0.020 inch round arch wire with reverse curve of Spee, and the procedure is continued for three more weeks. The same sliding yokes are transferred to the heavier arch wire. These light resilient wires are laced into the brackets in their tipped forward position, and they will gradually upright and tip back the anchor unit teeth if a suitable, distally directed force, secured from occipital or cervical anchorage, is applied. (Fig. 11)

In the upper arch, only the posterior teeth or anchor units are banded with slight angulation (2-3°) to begin treatment. These are bound together with tied-in sectional arch wires. A vertical rectangular tube is soldered on the lingual of each upper first molar band to engage a palatal acrylic appliance. This incorporates a slight bite plate to open the bite just enough to take the lower posterior teeth out of occlusion and allow them freedom to tip back without occlusal interference. From this same appliance, light finger springs are utilized to begin cuspid retraction and secure spacing of upper incisors for later band placement. These finger springs are activated at the same intervals that the lower arch wire is changed.

At the end of eight weeks the lower brackets should be fairly well lined up and ready to receive an 0.021 x 0.025 inch rectangular arch wire. In some cases, leveling is not complete and an 0.021 x 0.025 inch arch wire with considerable reserve curve of Spee may be necesary to complete leveling. Again it must be emphasized that this is the time to be certain that the lower arch is leveled off to a completely flat condition, and the anchor units properly tipped back. No depression in the second bicuspid area should be overlooked.



If crowding of the lower anterior teeth still exists, it can now be alleviated by cuspid retraction from a continuous arch wire, (Fig. 12) but without bracket engagement if the cuspid is tipped forward. When the cuspids are tipped back to a vertical position, the arch wire should be engaged in the bracket from there on. The upper anterior teeth are now banded, and, if the upper posterior teeth are in such a position that an 0.018 inch leveling arch will be activated on tying in, it is sometimes well to apply direct headgear through sliding yokes to the upper anchor units. With anchorage set up, the usual treatment procedures can continue without tip back bends in the arch wires and



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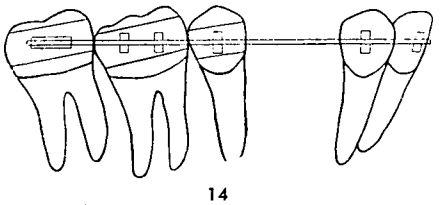

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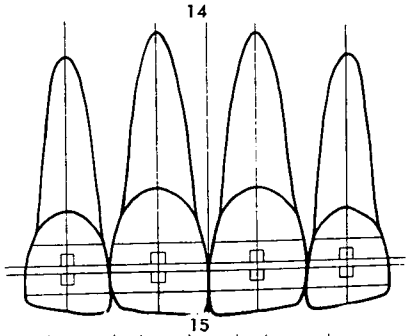

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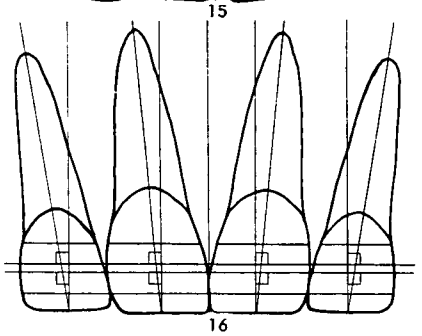

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with the assurance that the best in anchorage is available. Usually no further headgear is indicated during treatment.

Bracket angulation with headgear direct through sliding yokes to prepare anchorage in the lower arch has worked out so well that it is very seldom necessary to use any Class III elastics to the upper arch for this purpose. Occasionally, however, there are "headgear" patients who do not cooperate. If, in such a case, the upper anterior teeth can be banded without undue expansion, only the lower bicuspids are extracted to begin treatment. All teeth are banded at the beginning of treatment unless it is desirable to band only part of the lower incisors. Very mild (2°) bracket and tube angulation of the upper second bicuspisd and first and second molars is incorporated in the hook-up. Angulation of the lower key anchor units is carefully determined for the case at hand. An 0.015 inch round leveling arch for the lower and an 0.016 inch upper arch is tied in for two weeks. This is followed with a maxillary heavy stabilizing arch adapted to the brackets in their slightly tipped-forward positions with headgear hooks distal to the lateral incisors and extending distally through the upper second molar tubes far enough to allow placement of Class III elastics. Here too, an acrylic palatal bite plate is constructed to open the bite just enough to take the lower posterior teeth out of occlusion and allow them freedom to tip back without occlusal interference. At the same time, it supplements maxillary anchorage. When the 0.016 inch round arch wire is replaced with the stabilizing arch wire in the maxillary arch, a lower 0.018 inch round arch wire is tied in, on which a sliding yoke with an incorporated intermaxillary hook distal to the lower lateral incisors is placed for transmitting force to the mesial of the bracket of the lower second bicuspids. (Fig. 13) The distal eyelets must be tied to prevent rotation of the bicuspids as the force tips back the anchor units. The patient is instructed in the continuous wearing of Class III elastics and the wearing of headgear (twelve to fourteen hours per day,) to the maxillary arch. At the end of three weeks the 0.018 inch arch wire is replaced with an 0.020 inch round arch wire with reverse curve of Spee, and the same sliding yokes are transferred

to the heavier arch wire. It is often necessary at this time to add a little more to the bite plate with self-curing acrylic in order to again free the occlusion. At the end of this three week period, anchorage is usually set up in the lower arch or the anchor units are tipped back as shown in Fig. 14. The usual mechanics for cuspid retraction, space closure, and Class II treatment can now be continued from an ideal flat lower arch wire, and the upper first bicuspids can now be extracted and headgear discontinued. Even where headgear cooperation has been poor, if the lower anchorage is well established, the case is in no trouble. This is true even if the maxillary arch is displaced further forward than it was originally.

In non-extraction cases, only the lower posterior teeth have the principle of bracket angulation applied for anchorage purposes. Five to six degree angulation seems to be sufficient, but since space closing is usually unnecessary or limited, the reverse curve of Spee is accentuated on the lower anchor or second molar which gives it an additional tip back. This prevents it from interfering with distal movement of the upper second molars during Class II mechanics and increases anchorage by keeping it somewhat depressed in the alveolar process. Arch wire adjustments producing second order bends of the upper arch wire are much less objectional than those in our key anchorage area of the lower, and can be increased as dictated by the response of the teeth to Class II elastics.

Before leaving the subject of anchorage preparation, a word of warning should be added. In extraction cases requiring a maximum degree of anchorage preparation, the bracket angulation will have to be less on the second bicuspids to prevent interference with the cuspid root near the completion of space closure due to the fact that, by angulating the cuspid bracket, it has been retracted bodily, as previously emphasized. The author recalls one case in which mild resorption of all second bicuspid roots occurred. This is undoubtedly a greater fault than a failure to secure parallel space closure. If any doubt exists, the liberal use of x-rays is most certainly urged. With some practice, a degree of bracket angulation less than that used on the first molar is readily visualized which produces a workable compromise between coordinated anchorage and root interference in space closure. *I am not in favor of allowing distal tipping of the cuspids in extraction cases to coordinate their tip back with that in the anchor units.* This obviously eliminates the problem of root interference, but, if we are to have stable results, the cuspid root apex must be moved distally to a point in the apical base, allowing sufficient room for all the incisors to remain in positions of balance and stability. If this position of the cuspid necessitates a reduction in the desired amount of coordinated tip back of the second bicuspids, this is preferable to the other alternative of tipping back the cuspid.

The second bicuspid bracket should also be placed more gingivally on the tooth than the mean bracket position of the first molar. Otherwise, the larger molar teeth in tipped back positions will leave the second bicuspids out of occlusion. With brackets more gingivally placed on bicuspids and placed more to the incisal on cuspids and incisors, rare is the case which reaches completion with a deep overbite problem. Of course, if it is an open-bite problem to begin with, this must be reversed.

C. Artistic Positioning

Many orthodontists with whom the author has discussed bracket angula-

tion, use the principle for artistically positioning anterior teeth, especially on the upper lateral incisors. It would seem, however, that even though the extent of the angulation is less on the other incisors, it is well to keep it in mind in setting up cases. The reason artistic positioning bends are necessary at any time is due to the malposition acquired when brackets are positioned parallel with the long axis of the tooth, as shown in Fig. 15. It is just as easy to hook the case up with brackets angulated, as shown in Fig. 16, and thus eliminate further those arch wire bends in the vertical plane. Such bracket placement is logical because it is more in harmony with anterior tooth anatomy. If, in conventional bracket placement, it is desirable in the later stages of treatment to place artistic positioning bends to secure an angulation of the teeth which is pleasing, is it not better right from the beginning to have all bracket action gradually align the teeth in correct positions?

By way of explanation, lest anyone carry these ideas too far, it is necessary to state that the drawings have in some instances, been purposely exaggerated in order that the principles might be more obvious.

Summary

In conclusion, it should be re-emphasized that through angulation of the edgewise brackets, even though the degree may be slight, many troublesome problems solve themselves. Some of these are: parallel space closure, anchorage prepared in harmony with the requirements of the case at hand and artistically placed incisor teeth. Furthermore, all other mechanical procedures in orthodontic treatment can be more easily accomplished when arch wire bends in the vertical plane are no longer necessary due to bracket placement. It is easier to prevent problems by anticipating them in the initial hook-up than to bend arch wires into all sort of complicated designs to correct them later on.

The variations in bracket angulation which have been suggested are not to be confused with careless technique. In fact, greater care is necessary in the initial hook-up of a case to be certain that all tooth movements will be accomplished in a coordinated and orderly manner. With such care, better results are posible with less effort than is possible in conventional bracket placement.

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