An Assessment of Tandem Mechanics

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Introduction

The specialty of orthodontics has often found itself engrossed in differences over treatment philosophies, appliance designs, and therapeutic objectives. The present time has not found our contemporaries wanting in such lively discussions. Perhaps the subject of widest difference and greatest concern is the extraction of teeth. As a problem of long duration, men of stature in the profession have both lionized it and condemned it. Its employment in orthodontics has waxed and waned in regularly occurring cycles. At the present time extraction appears to be increasing due to the introduction of light-wire, differential force techniques which permit the rapid tipping of teeth into the spaces provided by the removal of teeth.

Many of those advocating a more conservative approach believe that initiating treatment in the late mixed dentition period, when a great deal of growth is expected to occur, obviates the need for the removal of teeth at the time of treatment. Since the key to extraction or nonextraction is usually dictated by the mandibular arch, this study concerns itself with the feasibility of moving lower molars distally to gain the needed arch length for the available tooth material.

Using 45° oblique cephalometric film, this study was initiated to determine 1) whether the mandibular first molar moved distally during treatment, 2) in what manner any movement took place (tipping, bodily, or combination), and 3) what stability might be expected from teeth moved in this manner. No attempt to correlate the results statistically was made, since little has been reported in the literature about measuring growth or treatment results from lateral oblique headfilms.

Thesis presented for partial requirement for a Master's degree, The Ohio State University, 1968.

Review of Literature

A review of the literature reveals that the problem surrounding the removal of teeth to gain space for the alignment of the dental arches has been recognized for two hundred years or more.

The early periods of dentistry saw extraction, without subsequent appliance therapy, as a method frequently employed to correct irregularities of teeth.[1] Duval, Talma, and Kingsley[2] recognized the importance of the dental arch integrity and urged extraction only in extreme cases.

In 1887, Isaac Davenport[1] ushered in the era that saw the greatest attempt to preserve all teeth in the arch. His elaborate treatise undoubtedly had an influence on the writings of Edward H. Angle who in that year published a pamphlet, the first edition of *Malocclusions of the Teeth.*[4]

To Angle, the human denture and Nature's plan were inviolate. Although willing to grant in his earlier writings[3,4] that extraction might be necessary to treat a very limited number of cases, he tended to regard extraction with increasing caution in later years.[5,6]

Although often regarded as an early proponent of extraction, Case[7] added his words to those of Angle in an effort to stop the general ruthless extraction of teeth. He laid down two rules: 1) "Never extract teeth for the purpose of making the operation of correction easier," and 2) "Teeth should never be extracted in orthodontia except in cases of excessive protrusion producing facial deformities—and not even then, especially in young children, unless there is every indication of an inherent protrusion that will ultimately mar the beauty of the face for life."

Tweed, on the basis of recall of some 70% of his conservatively treated patients from his first six and one-half years of private practice, felt that adherence to the full complement of teeth concept yielded only 20% success. After studying hundreds of his own clinical patients and other nontreated patients, he concluded that most malocclusions were characterized by a discrepancy between the amount of tooth material and the amount of basal bone.

In 1947, Nance[8,9] published an extensive and provocative study on the limitations of orthodontic treatment. The study consisted of an analysis and comparison of dimensions of the lower dental arch from study models at various ages of development. Nance lists the following methods for increasing mandibular arch length: 1) distal movement of mandibular posterior teeth, 2) uprighting of mandibular posterior teeth which have actually tipped forward, 3) labial movement of mandibular incisors, 4) buccal expansion, and 5) rotation of mandibular molars and premolars.

Among other things he found that the position of well-related mandibular anterior teeth must not be violated as was often the case when orthodontists attempted to develop room by rounding out the arch. Since he felt that lower molars could be uprighted permanently only in cases in which bona fide mesial drift had occurred, he concluded that permanently increasing the arch length by distal movement of mandibular posterior teeth was labor in vain. Deliberately decreasing it seemed the only solution.

Again, Nance felt that the distance from the mesial of the mandibular first molar to the mandibular midline always decreased during the transition from mixed to permanent dentitions. He therefore concluded that, with few exceptions, "this distance cannot be permanently increased through orthodontic treatment in the mixed dentition."

Miller,[10,11] although agreeing in principle with Nance's findings, believed that lower buccal teeth could be moved distally to gain arch length and that the result would be stable, at least to a significant degree. He also suggested that mesial drift of the first permanent molars in transition from mixed to permanent dentitions is not inevitable. He was convinced that a well-locked, cusp-in-groove relationship of the mandibular first molar with an axially upright maxillary first molar would be adequately maintained.

Tweed[12] was among the first to use Class III mechanics in the treatment of Class II cases. He used the distal force to the lower arch in conjunction with second-order bends in the lower archwire to tip the teeth back as a method of anchorage preparation for Class II elastics.

Holdaway[13] maintains that it is quite possible to have anterior movement of the roots of lower buccal teeth when second-order bends are used in anchorage preparation. This is particularly true when the patient is lax in wearing the Class III elastics or when the distal force is intermittent such as in the use of a lower headgear or Class III elastics used only at night against an upper headgear.

Fogel[14] in a cephalometric study of anchorage preparation, as outlined by Tweed, found that in about one half of the cases the molar roots moved mesially while the crowns moved distally. During Class II mechanics most of the crowns moved mesially while the roots showed a variety of movements. Posttreatment records indicated that the crowns were only slightly distal to their original positions and the great majority of the roots mesial.

Miller[10,11] used a system of full-time Class III mechanics against a headgear to the maxillary first molars to gain adequate space for arch alignment on a nonextraction basis and for possible preparation for Class II elastics. He cautioned against attempting to gain large increments of added arch length or expecting enormous response in older patients. He declared:

"In attempting to acquire arch length, it is much better to treat the patient at a younger age. If he can be treated before the premolars and canines erupt there is much greater likelihood of permanently increasing this arch length a slight amount by expansion or uprighting of mesially tipped lower buccal segments. By tipping the lower teeth back, one can sometimes force the premolars and canines to erupt in a more distal position."

To reinforce this last thought is a study from the Burlington Orthodontic Research Centre[15] in which a study of 45° oblique films revealed a slight tendency for the second premolar and a marked tendency for the first premolar to move distally through alveolar bone between ages six and nine. This finding, along with the great stability they found in lower first permanent molars in children with intact deciduous molars, was considered sufficient evidence to reject theories based on the forward movement of teeth, as deduced from studies of comparative anatomy.

Haas[16] uses a system of Class III mechanics in borderline cases anchored by cervical headgear in an attempt to move maxillary and mandibular arches posteriorly in unison. The term "tandem" is applied to this simultaneous movement of both arches. In the initial stage of treatment with tandem mechanics, only upper and lower first permanent molars are banded. A headgear is applied to the maxillary molars to accomplish their posterior movement and to provide anchorage for the Class III elastics. Normally the elastics are worn only when the headgear is in place to prevent forces of opposite direction from acting on the maxillary teeth in a jiggling manner. A stopped lower archwire is placed in the lower molar tubes and ligated around the necks of the incisors. A hook for the Class III elastics is maintained near the position of the lower canine by an open coil spring threaded on the lower archwire between canine and first molar. Ideally this system is used in the late mixed dentition period some twelve to eighteen months prior to the expected eruption of the maxillary canines. In this manner treatment can be a continuous process rather than having two periods of active treatment interrupted by a rest. When sufficient distal movement of the molar has occurred to allow the eruption of all permanent teeth mesial to the first molar, the tandem is abandoned in favor of conventional banding and treatment.

Several practitioners have reported distal movement of lower molars as a spontaneous response to the use of extraoral force to the maxillary arch. Asher[17] reported, in 1960, that in young, growing patients he had observed distal movement of the lower dental arch when using only cervical traction and a twin-wire appliance on the upper arch. Funk[18] related: "As a result of headgear treatment in the maxillary arch, a) mandibular teeth were tipped, uprighted, and moved distally; b) mandibular arch width was increased; c) tooth rotations were improved; and d) mandibular arch form was improved." He also reported that in many cases the mandibular molars did not drift mesially during the transition from deciduous to permanent dentitions thus allowing more space for the eruption and alignment of permanent teeth mesial to the first molar.

With regard to the stability of the result of uprighting lower molars, Holdaway[19] observed that teeth tipped distally in the lower arch tended to return around an axis near the junction of the root and crown. This resulted in only slight mesial shift of the crowns with the roots settling back toward their original positions. This occurrence was observed mostly in extraction cases. Miller[10,11] found that, in properly handled cases, tipped-back lower molars were uprighted by the forces of occlusion. There was more distal root movement than mesial crown positioning. These observations were made on conservatively managed, nonextraction cases.

An endeavor to add to the fund of information with regard to successful conservative treatment through distal movement of lower molars was made by Williams[20] in 1962. He used the conventional lateral cephalometric film to study twenty-five cases treated by Haas using tandem mechanics. His findings, recorded from the beginning of treatment to appliance removal, demonstrated that lower molars can be moved distally, but that great care must be exercised to prevent mesial movement of roots. Due to the problems of overlapping and obscuring of anatomic landmarks in lateral films, it was decided to undertake a study using the 45° lateral oblique headfilm to provide the clearest indication of the movement of the lower first molars.

Materials and Methods

The records used in this study are from cases treated by the author's brother, Dr. Andrew J. Haas, using tandem mechanics in the manner outlined in the review of literature. All were treated without extraction except for one case in which maxillary second molars were removed. The cases were completed with the edgewise appliance.

The 45° oblique cephalometric film was used to evaluate distal movement of the mandibular first molar in forty cases which were considered borderline malocclusions. The criterion of borderline was generally based on the fact that arch length was required in the lower arch in order to accommodate the full permanent dentition, excluding third molars. The right and left sides of each individual were considered separate entities since Barber and Pruzansky[21] applied the "t" test to a group of right and left films from ten individuals and found no significant differences. This made a total of eighty observations.

The lateral oblique projection is indicated wherever it is desirable to visualize either side of the dental arch without the overlapping and obscuring shadows of the opposite side. The first published reference to the oblique projection was by Margolis,[22] although little use was made of it until it was reintroduced by Cartright and Harvold[23] in 1954.

Briefly, the oriented oblique cephalometric film is obtained by rotating the headholder independent of the cassette so that the midsagittal plane of the head is at a 45° angle to the cassette. The cassette remains in its standardized perpendicular relation to the x-ray source and at the standard target-to-film distance. The head position must be maintained in the Frankfort horizontal for this projection, this consideration being more critical than for the more conventional lateral and frontal headfilms. Stuart[24] found that rotation of the head about the porionic axis in the oblique film results in the projection of any point in the skull in an elliptical path. This type of error in the relationship of various anatomic landmarks results when the head is tilted more than 5° from the plane of the ear rods. The intersection of the plane of the rods with the transverse plane of the orbits was measured on each film and those films in which the angle exceeded 5° were eliminated from the study.

In addition, there are two other precautions necessary to insure properly oriented films. First, the ear rods must be sufficiently tight to insure proper orientation in the horizontal plane, i.e., at 45° to the x-ray source. Second, and the most important consideration in the films used in this study, the head must be positioned with the side of the mandible you wish to view next to the cassette. It is possible to introduce gross errors in magnification by rotating the headholder to a point 180° from the proper position. This, of course, gives a view similar to the proper one and can only be distinguished when tracings are serially superimposed. This error in about 25% of the films used required their rejection in compiling information for the study.

Films were taken on twenty males and twenty females of which twenty-five were Class I and fifteen Class II, Division I malocclusions. No attempt was made to divide the sample according to sex or type of malocclusion, since the study was not intended to be a statistical analysis. The films were taken at four points of patient management: 1) before treatment, 2) at tandem arch removal, 3) at appliance removal and 4) in retention. Information on all patients was not available at each point, since the films are not complete in all cases, although all cases have films before treatment and either "at retention" or "in retention".

The patients ranged in age from 7.4 years to 17.1 years with a mean age of 11.1 years. Active tandem arch mechanics averaged seventeen months, while the range varied considerably, from five months to twenty-eight months. Total treatment time varied from seven to forty-seven months, the average being twenty-nine. The lengthened treatment time is characteristic of mixed dentition treatment to allow time for the eruption of teeth.

All linear measurements were made parallel and perpendicular to a base line representing the lower border of the mandible.[25] This border was defined by constructing a line between two points, one of which could be defined anatomically and the other arrived at empirically. The posterior anatomic landmark used was the most superior point in the antegonial notch. The anterior landmark was an empirical point found at the intersection of the lower border of the jaw and the ascending border of the opposite side of the mandible. A perpendicular was erected from this line tangent to the anterior border of the projected mandible and another to a point midway between the mesial and distal contacts of the first molar. A template was made of each molar from the original tracing to insure that varying tooth visualization would not affect the results. Figure 1 illustrates the anatomic landmarks and constructions used, as well as the method of taking measurements.

Since this study was concerned primarily with the possibility of "holding" or moving lower buccal segments distally, the movement of only the lower first molar was considered. Linear movement of the coronal portion of the tooth was measured from its mesial contact point to the perpendicular erected from the mandibular base line tangent to the anterior projection of the mandible. Any tooth movement that would increase the dental arch length was recorded as a plus (+); if the arch length was decreased, it was recorded as a minus (—). Linear movement of the root was measured from the most mesial point on the curvature of the mesial root of the molar to the same con-

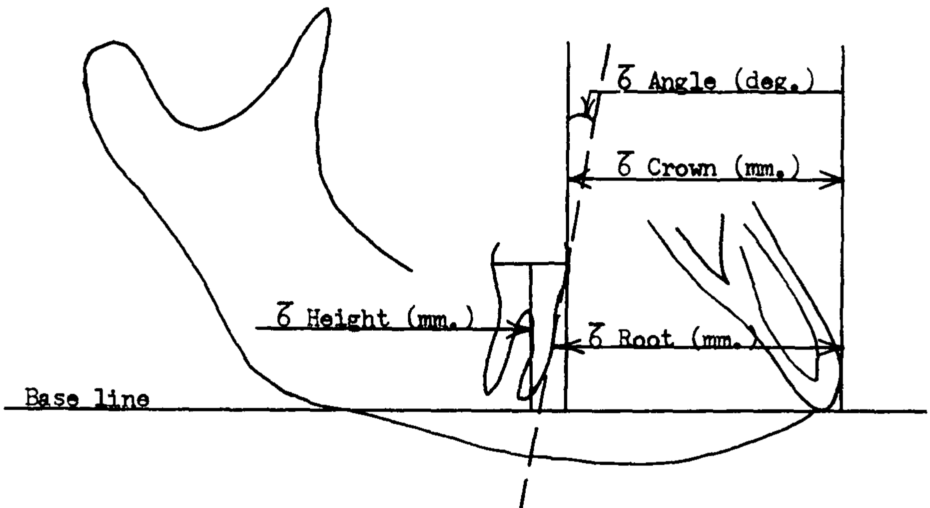


Fig. 1

structed line of the anterior mandibular projection. By measuring from this point it was felt that a truer indication of bodily movement would be recorded. A forward movement of this point was interpreted as showing primarily a distal tipping of the tooth, while a posterior movement was interpreted as showing primarily a bodily distal movement. The molar long axis was measured by the relation of a perpendicular constructed from the base line through the mesial molar contact and its intersection with a line connecting the mesial molar contact with the mesial point of the curvature of the mesial root. Molar intrusion and extrusion or alveolar growth were measured by a perpendicular erected from the base line to a point midway between the mesial and distal molar contacts.

Superpositioning of serial tracings was made by registration along the outline of the anterior and inferior borders of the projected mandible. By such comparison the magnitude and the character of the lower molar movement in each buccal segment were determined. Serial registration by this method also allowed any lengthening of the mandibular body to be seen. Although this increase in length did not appear correlated to molar response, it was of interest to observe the large increments that could be expected in patients of late mixed-dentition stage and older.

To ascertain the manner and effects of molar uprighting differently from the study of oblique films, it was decided to evaluate the Downs' profile arc[26] films on each patient. These films were selected to correspond with the four periods of treatment in which oblique films were studied. The outline of the profile (convex, straight, or concave) as well as the relation of the lower incisor to the arc was tabulated for each film. A change in the outline of the profile arc as well as a change in its relation to the lower incisor would provide some insight as to whether the arch length gain was at the expense of the lower incisor. It would also indicate whether the uprighting of the mandibular molars in retention was to the detriment of these incisors, namely, tipping them forward off their base.

As with the other measurements recorded, no attempt was made to correlate change in incisal position with uprighting of the molar. Indeed, for the most part, all statistical values such as means, standard deviations, measures of correlation, etc., were excluded. The method of measurement used in this study has not been sufficiently proven to allow such sophisticated tools to be used and also this study was intended to show the character of tooth movement with tandem mechanics. It was strongly felt that no mean value, derived from a large number of highly individual cases, would give a true indication of the usefulness of this procedure. Maximum molar movement was not needed nor desired in each case; only an amount sufficient to accommodate the permanent dentition was required. Perhaps this necessitated only a holding action of the lower molar. Apparently the required amount was attained in all cases, time being the greatest variable observed.

Findings

Measurements for this study were recorded in a manner to reflect trends of movement rather than absolute measurements. Changes of 0.25 mm or less were regarded as insignificant. Tables and bar graphs are included in certain instances to show these trends more clearly. As mentioned previously, the records are not complete for all phases of treatment studied. Of the total sample of eighty cases, the following records were available: 1) 37 records taken at tandem arch removal, 2) 27 records from tandem removal to active appliance removal, 3) 33 cases from appliance removal to the "in retention" record, 4) 55 cases from initiation of treatment to active appliance removal, and 5) 57 records from initiation of treatment to the "in retention" period. Fifteen cases had complete records at all four stages.

Molar Axis

The long axis of the molar, as previously defined, was measured to gain insight into the number of teeth that could be uprighted or tipped distally. The nature of the movement under mechanical influence was decidedly in a distal direction as evidenced by the figures in Table I. After tandem removal the tendency was for the teeth to begin uprighting, though this trend was mixed, in the retention period. The net change during active treatment was overwhelmingly toward distal movement as was the net change when the cases were studied into retention.

TABLE I
CHANGE IN MOLAR LONG AXIS

	Total Cases	Moved Distally	No Change	Moved Mesially
Tandem mechanics phase	37	36	0	1
Tandem removal to appliance removal	27	7	4	16
Appliance removal to "in retention"	33	18	1	14
Total active treatment	55	50	1	4
Start of treatment to "in retention"	57	54	0	3

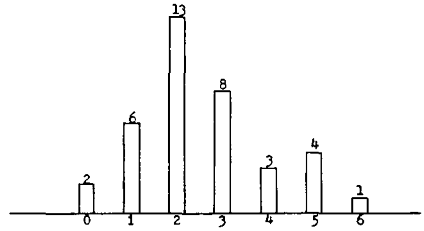
Molar Crown

In order to ascertain the change in arch length, the movement of the molar crown was surveyed. Table II summarizes the findings. These figures confirm the preponderance of distal molar crown change in response to tandem arch activation. The range of response, Figure 2, was from 0 to 6 mm with the mean change per side of 2.74 mm. Again, Table II shows there is a tendency for some of the gain to be lost during the remainder of treatment and into the retention period in about one half of the cases.

TABLE II

MOLAR CROWN CHANGES

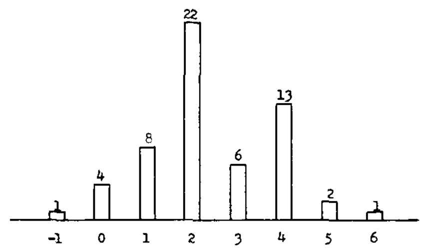
	Total Cases	Arch Length Gained	No Change	Arch Length Lost
Tandem mechanics phase	37	35	2	0
Tandem removal to appliance removal	27	6	8	13
Appliance removal to "in retention"	33	11	6	16
Total active treatment	55	53	0	2
Start of treatment to "in retention"	57	53	1	3



arch length gain per side (mm)

(the numerals above each column denote the number of cases)

Fig. 2



arch length change per side (mm)

(the numerals above each column denote the number of cases)

Fig. 3

In spite of the forward tipping of the molar after tandem activation is discontinued, the net result of treatment is still a gain of arch length. The distribution of arch length change for fifty-seven cases, which had records taken sometime after appliance removal, exhibited an average arch length change per side of 2.34 mm. Figure 3 depicts the distribution.

Molar Root

Of primary interest is the root response since this gives the best clue as to the character of molar movement and subsequent uprighting. These data are tabulated in Table III. The response during tandem mechanics was mixed, being equally divided between mesial movement, distal movement, and no change. This meant that twelve cases exhibited undesirable mesial movement of some magnitude during active tandem mechanics. Close scrutiny of these cases revealed that in each instance the root moved *distally* after tandem removal and active appliance removal. The over-all movement was not great, being about 2 mm or less in 95% of the cases observed during active treatment. The quality of root movement for

TABLE III

MOLAR ROOT MOVEMENT

	Total Cases	Mesial Movement	No Change	Distal Movement
Tandem mechanics phase	37	12	12	13
Tandem removal to appliance removal	27	6	8	13
Appliance removal to "in retention"	33	15	6	12
Total active treatment	55	13	16	26
Start of treatment to "in retention"	57	15	15	27

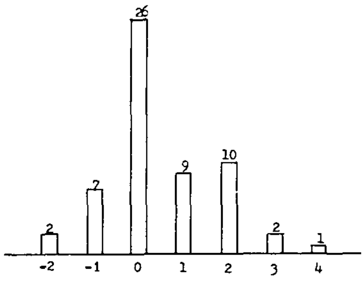


Fig. 4

those cases followed into retention is portrayed in Figure 4 and shows an 84% favorable response.

Molar Height

The change in molar height during and after the tandem phase is summarized in Table IV. The majority of cases demonstrated either intrusion or no change in molar height under the influence of the tandem arch. After tandem removal the general response was for the molar to be extruded. This trend continued on into the retention. The end result of active treatment was about an equal distribution between extrusion and intrusion with about 25% showing no change. The net result into the retention was about 84% showing gain in molar height.

TABLE IV
MOLAR HEIGHT CHANGES

	Total Cases	Intruded	No change	Extruded
Tandem mechanics phase	37	22	9	6
Tandem removal to appliance removal	27	5	5	17
Appliance removal to "in retention"	33	2	5	26
Total active treatment	55	23	13	19
Start of treatment to "in retention"	57	3	6	48

The fifteen cases having complete records at all treatment stages are given in Table V. These figures show a 100% tendency for the molar to tip distally, a mean of 8.6° when the cases are followed to the "in retention stage". All cases showed an over-all gain in arch length, the average being 2.3 mm. The molar root demonstrates a more mixed tendency though predominately in the favorable vein with nine cases moving distally and the rest showing no change or mesial movement. The net root change was a distal movement of 0.5 mm. After appliances were removed, the molars tended to recover any depression effect of the tandem with only two finishing more intruded than at the start of treatment. The average gain in molar height at the time records were taken during retention was 1.7 mm.

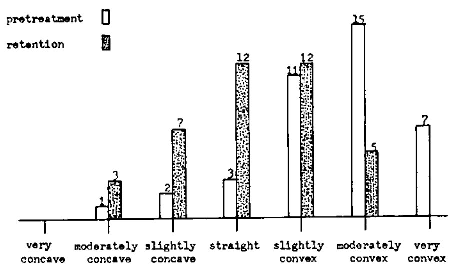
Incisal Change

In order to assess the behavior of the lower incisor during both tandem activation and in retention, the Downs' profile arc[26] films were studied during the various stages of treatment. Both facial character (convex, straight, or concave) and the relation of the lower incisor to the arc were evaluated. Of the thirty-nine patients on whom profile films were available, in no instance did the facial character become more convex (Fig. 5). Ten of the twelve cases which had serial films from appliance removal to the "in retention" recording showed no further change.

The quality of incisal change is delineated in Figure 6. The general tendency is for the incisor to become more procumbent in relation to the arc, though not alarmingly so. The twelve cases having profile films at appliance removal and into the retention period demonstrated very slight incisal changes

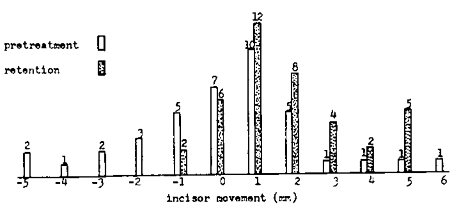
TABLE V

	MOLAR AXIS			MOLAR CROWN			MOLAR ROOT			MOLAR HEIGHT		
	Moved Distal	No Change	Moved Mesial	Gained Arch Length	No Change	Lost Arch Length	Forward Movement	No Change	Distal Movement	Intruded	No Change	Extruded
Tandem mechanics phase	15	0	0	15	0	0	4	5	6	12	2	1
Tandem removal appliance removal	5	1	9	3	6	6	3	6	6	2	2	11
Appliance removal to "in retention"	6	1	8	6	2	7	5	3	7	1	3	11
Total active treatment	14	0	1	15	0	0	5	2	8	6	4	5
Start of treatment to "in retention"	15	0	0	13	2	0	3	3	9	0	2	13



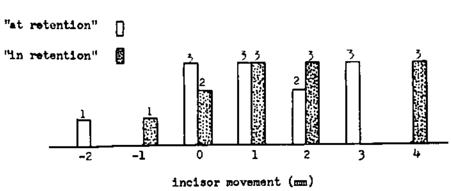
(the numerals above each column denote the number of cases)

Fig. 5



(the numerals above each column denote the number of cases)

Fig. 6



(the numerals above each column denote the number of cases)

Fig. 7

during that time (Fig. 7). Nine of the cases were well within the Downs' range, the other three only one mm above it.

To illustrate the behavior of the lower molar when tandem mechanics is employed, Figure 8 is presented. This represents the typical molar response observed in this study from the beginning of treatment to appliance removal.

Discussion

As noted in the findings there is a tendency for some of the gain in arch length to be lost during the remainder of treatment and into the retention period (Table II). This is to be expected since the molars are often overcorrected to allow for the eruption of the premolars and then allowed to tip forward to make contact after the premolars have erupted. This tipping continues after appliance removal as band spaces are obliterated. The over-all result of treatment is still a gain of arch length, hopefully to the extent required in the case. Even those cases showing little or no gain in net arch-length must be considered profitable, since holding the molars from tipping into

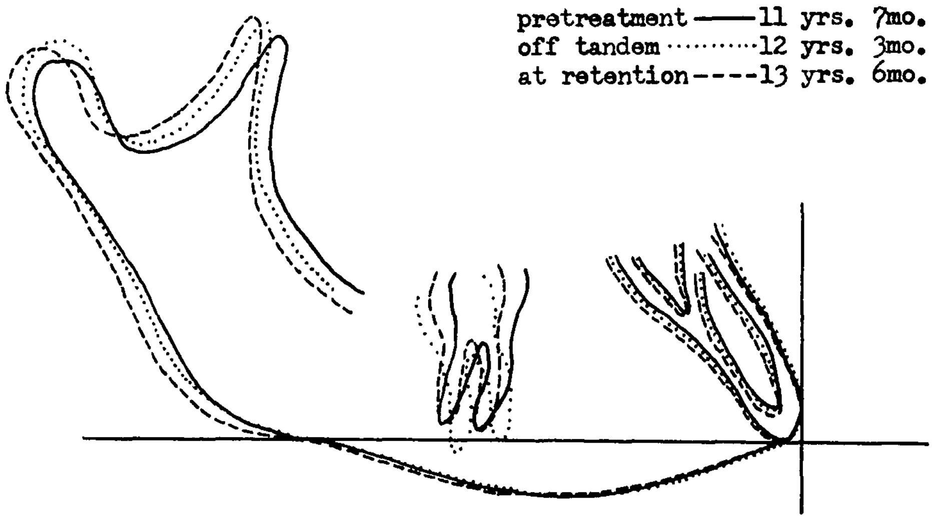


Fig. 8

the leeway space saves some 3.5 mm[8,9] from being lost.

Possibly the most important measurement regarding stability of the end result was that taken of molar root position. Cases in which there was mesial root movement would tend to have more tipping of the molar and less distal bodily movement. Those having no change and those showing distal movement would naturally tip less in ratio to the gain in arch length. The fact that about three quarters of the cases (Table III) showed no change or distal root movement during both active treatment and into retention demonstrates the success in obtaining a bodily movement. It should be added that no attempt was made to upright the tipped molar other than the use of straight archwires in the phase of treatment following tandem removal.

The over-all assessment of molar response to the tandem must be regarded as worthwhile. In only two cases out of eighty was arch length lost, and in one of these cases a unilateral response was desired. While this arch length was being gained, the majority of roots were remaining fixed or moving in the desired distal direction. This is in marked contrast to Fogel's[14] findings in which about half of the roots moved mesially following anchorage preparation as outlined by Tweed. At the end of treatment Fogel found that the great majority of roots were mesially positioned.

The reasons for the difference are quite apparent. In Tweed's philosophy molar tipping is an important concept and second-order bends are used to achieve it in a comparatively short period of time. In tandem mechanics no second-order bends are ever incorporated in the tandem arch and the procedure is expected to be more time-consuming in its course of action.

Molar uprighting tended to confirm the reports of Holdaway[19] and Miller[10,11] in that the crowns moved mesially and the roots distally apparently about an axis through the center of the cervical portion of the tooth. Such uprighting would tend to increase the stability of the end result since less strain would be placed on the lower anterior teeth than would be the case if the molars uprighted about the apices of the roots.

The study of the Downs' profile arc films revealed that in general the arc remained the same or flattened considerably. This reflects the nature of treatment, headgear to the maxillary complex, as well as the nature of growth, i.e., the profile tends to flatten with age. The ten cases which showed no further change in the arc during retention indicate either that the major part of growth had ceased or that the mechanics had the major role in the change seen in the cases during treatment. Whatever the cause of the change it becomes apparent that Case's sober advice concerning extractions in young patients must be heeded.

According to Downs the average position of the lower incisor is for "the incisal edge to fall on the profile arc with an acceptable variation of minus 2 mm to plus 3 mm according to type and soft tissue balance." Much of the apparent forward movement of the incisor in relation to the arc is due to the change of profile type as a result of growth and treatment. As the bony skeleton becomes less convex, the arc assumes a more posterior position in relation to the incisor even though the incisor remains stable. During retention there are only slight incisal changes in relation to the arc.

The change in molar height during and after the tandem phase was evaluated to see if this type of treatment might also be of value in Class II anchorage preparation. Probably the two greatest ills attributed to Class II mechanics are 1) loss of anchorage and 2) extrusion of the lower molars which results in tipping of the occlusal plane and bite opening by mandibular rotation. Distal movement of the lower molar during tandem mechanics would help offset the loss of anchorage while a depression of the lower molar would counteract the later molar extrusion. Holdaway expressed a similar idea when he contended:[19]

> "When it is anticipated that Class II elastics will be used during treatment, it is very desirable to tip the occlusal plane distally first so that there will not be an anterior cant of the occlusal plane when treatment is completed."

The extrusion seen after tandem removal may be attributed either to a recovery phenomenon or to alveolar growth, since no Class II mechanics were employed on any of the cases used in the study. A subjective appraisal of serially superimposed tracings seemed to show that the cases which had the greatest increment of alveolar growth in the posttandem period typically had the most favorable uprighting, i.e., the least amount of forward crown movement and the greatest amount of distal root movement.

Methods used to compile data for this study as well as the establishment of norms for the items measured on the oblique films await further clarification from future studies of both normal and abnormal occlusions. Establishing a normal axial inclination of lower first molars in good occlusions might possibly be an aid in determining whether a tooth is a good candidate for distal retraction in order to gain arch length. It would, of course, be interesting to follow the cases used in this study for an even longer period of time to see exactly how great the tendency is for the molar to return to its pretreatment axial position. This might shed light on Nance's contention that the leeway space will eventually be closed by mesial molar movement no matter what measures are employed to prevent it.

Orthodontists agree that the arch length condition of the lower jaw most frequently directs whether or not extraction is to be employed. Relevant to this, Haas[16] declares that "most mixed dentition treatment has practically neglected this arch, except for: a) depression of lower incisors with bite planes, b) space maintenance with a lingual arch, or c) arch lengthening by expansion and advancement of a lingual arch."

Although the jaws are normally adequately developed at birth to accommodate the deciduous dentition, the permanent teeth which follow are frequently in malocclusion. While the malocclusion may take the form of spacing between teeth, it usually is manifested as crowding of the dentition. Whatever the form, Brodie [27] feels that it is often due to various types of disharmonies between jaw growth and the eruptive pattern of the teeth.

Jaw growth has been shown by Brodie[28] to be a steady and orderly process, but variation in timing and rate exists among individuals. Tooth eruption, similarly, shows wide variation in the order of sequence and in timing. This creates a growth phenomenon in which a discontinuous variable (tooth eruption) must be correlated with a continuous variable (jaw growth) if normal occlusion is to result. While the disharmony between jaw growth and tooth eruption may resolve itself eventually, the resulting malocclusion usually remains until outside interference is employed to correct it.

While the basic underlying growth problem is recognized by most orthodontists, there is disagreement about the time for initiation of corrective therapy. Those advocating mixed dentition treatment feel that a more natural result is obtained in that the patient is guided into a proper jaw relationship with adequate space for the eruption of the permanent teeth. Those opposed to this philosophy assert that instituting treatment at this age adds nothing to the final result and only prolongs treatment. Brodie added needed insight into the problem when he pointed out:[29]

". . . the question of when a malocclusion should be treated would be the same as for almost any other abnormal condition or disease, namely, when it is seen. The objective of early interference is not treatment, but 1) the removal of factors which are slowing growth, 2) the prevention of the seemingly inevitable result of a lack of harmony between the eruption of the teeth and the growth of the jaws, and 3) in Class II cases the adjustment by growth of parts that are out of harmony in their relations to each other."

Haas affirms that there is no better time to influence the denture than in the late mixed dentition period[16] since approximately sixteen teeth will be erupting during the child's next two years and the child will be enjoying prolific jaw growth as well.

The present study was undertaken to evaluate the efficacy of a method which is most suitably employed in late mixed dentition treatment, although not wholly limited to this period. If the orthodontist can successfully position lower molars distally and maintain them in that position after appliance removal, then mixed dentition treatment can be considered useful and alternatives to mass extraction procedures can be employed more frequently and more reliably.

Summary

1. Right and left oblique cephalometric films were taken at selected times in treatment of forty Class I and Class II, Division I cases to assess the worth of tandem mechanics. Linear and angular measurements were made on serially registered tracings of the films to determine whether distal movement of the lower molar occurred.
2. No specific conclusions can be drawn, since complete records were not available in all cases and because the methods used to evaluate the results have not been sufficiently verified. Until further studies clarify

the findings only trends of movement seen are reported.

3. Predominant among the variety of molar movements demonstrated was a distal movement of the crown with little or no change in root position. This resulted in a more axially upright lower first molar.
4. The response of the lower molars to tandem treatment showed the procedure to be of value both in gaining arch length and in anchorage preparation for Class II mechanics.
5. The reaction to the headgear, inherent in the tandem set-up, was one of a flattening of the profile in all cases, at times to a marked degree.

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