Posttreatment and Postretention Changes Following Orthodontic Therapy

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Today, the changes in orthodontic therapy are many. There is constant advancement and refinement of old and new techniques. Cephalometrics has become more complex and refined in its diagnostic capabilities. However, with these advances and refinements in mechanics and diagnosis, still the ever-present and final judge of these methods is retention. Retention of the end result of orthodontic therapy has been the goal of orthodontics from its inception. The problem of retention is the stability of the teeth in a new location. This problem is not limited to the position of one tooth to another, but to the position of the teeth in the jaws. The purpose of this investigation was to answer some of the questions related to the stability of the teeth in the lower arch after orthodontic treatment.

Review of Literature

Two basic concepts have been established which reflect the retention philosophy of the orthodontic community. One is the establishment of a good occlusion which Jackson[16] and Davenport[8] first expressed in 1891, and the second is the dominance of the lower arch which Edward Angle[2] wrote about in 1899. Following these basic concepts, two other ideas were expressed and later accepted. One was the idea that teeth should be positioned over basal bone to be stable.[14,20,39] Tweed[34] made this concept the cornerstone of his treatment philosophy in 1944. The second idea was a balance of the teeth within the intra- and extraoral musculature. This concept was first introduced by Rodgers[27] in 1922, and later was enlarged upon by Dewey,[9,12] McCoy,[22,23] Webster,[37] and most recently by Brodie[6] and Strang.[32]

From these general concepts and broad philosophies came specific techniques and ideas about movement and placement of teeth within the jaws. One of the major areas of controversy in the placement of teeth within the jaws is that of establishment of arch width. McCauley,[21] Strang,[32] and Riedel[26] stated that mandibular intermolar and intercanine widths are uncompromising dimensions and should be maintained as originally presented. However, Strang[31-33] and Howes[15] felt that, if canine teeth were moved distally into premolar extraction space, they could be expanded buccally to the limits offered by their new distal location.

In recent years studies have been undertaken to evaluate the clinical observations of the preceding authors with varied results. Amott,[1] Arnold,[3] Welch,[38] Peak,[25] Shapiro,[29] and Dona[13] reported that intercanine and intermolar widths tended to return to their pretreatment dimensions. However, Walters[35,36] and Steadman[30] reported an increase in intermolar and intercanine widths could be tolerated if moderate and in balance between musculature function and growth.

Other authors[1,3,5,38] all reached an interesting conclusion with regard to extraction cases; the intermolar width decreased posttreatment, but the intercanine width retained its original dimension and did not show an increased arch width as was previously thought.

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To understand what is possible with treatment it is necessary to understand what occurs without treatment concerning the changes in the lower arch. The general concept expressed by many[4,7,17,18,24,25,28] is that there appears to be an increase in intercanine width of a significant amount between the change from the deciduous dentition to the mixed dentition. There appears to be little change in the intermolar width with growth.

From this review there emerge two views of what changes can be accomplished with treatment: one group feels that a moderate increase in intermolar and intercanine width can be tolerated, while the other group feels any change will result in relapse.

Methods and Materials

The material for this study consisted of the clinical records of 103 cases. Of these, 74 were treated nonextraction and 29 were treated with the extraction of four first premolars. There were 62 females and 41 males. All were classified in the Angle classification with 33 Class I; 52 Class II, Division 1; 5 Class II, Division 2; and 13 Class II, subdivision right or left. Thirty-four nonextraction cases began treatment in the mixed dentition while 40 began in the permanent dentition. The ages of the patients ranged from 6 years at the beginning of treatment to 27 years at the end of removal of all retaining devices. The criteria used in selecting these cases were as follows:

1. The records of each case had to be complete. Included were three sets of dental casts: pretreatment, posttreatment (immediately after band removal); and the postretention cast obtained a minimum of one year following the removal of all retention devices.

2. A minimum of one year was felt to be ample time for any relapse to occur. However, the range of postretention times varied from 1 to 13 years with a mean of 5.2 years for nonextraction and 5.3 for extraction cases.

3. The case had to have a full complement of teeth exclusive of the third molars. There were no congenitally missing permanent teeth in either the nonextraction or extraction cases. There also were no permanent teeth missing due to caries or any other reason, unless designated as one of twenty-nine four first premolar extraction cases. However, the presence or absence of decidous teeth was of concern only in the classification of mixed dentition.

4. The results of treatment had to be within acceptable limits. This was determined by subjective evaluation of the molar relationship, the presence or absence of crowding, and the degree of horizontal overjet and vertical overbite present.

5. The treatment of these cases was accomplished by the full-banded bioprogressive edgewise technique. The span of time from the first case of study to the last was from 1952 to 1970, thus encompassing all the changes and advancements made in the development of this technique.

This study was to identify the arch changes that occurred during treatment. This was done by measuring the arch widths of canines, premolars, and molars and an arch depth. These measurements were obtained from the mandibular casts only. This was done because (as Angle[2] stated in 1899), "the lower arch exerts a controlling influence over the form of the upper and the positions of the teeth therein."

The following five lower cast measurements were made with a Boley gauge equipped with a sliding bar and a vernier scale graduated in tenths of millimeters (Fig. 1).

1. Intercanine width: distance be-

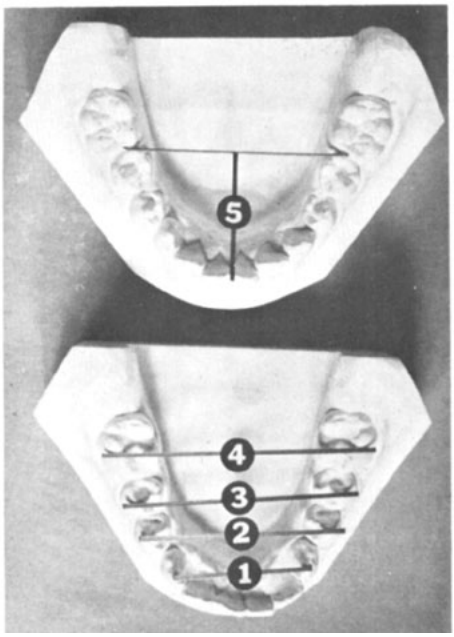

Fig. 1 Linear measurements to determine arch width and arch length changes.

tween cusp-tip center of one permanent canine to the other. When the permanent canine was not present, the measurement was either estimated, if no deciduous tooth was present, or measured from the cusp tip of the deciduous canine.

2. Inter-first premolar width: distance between the most convex buccal surfaces of the first premolars. When the first deciduous molar was present, the measurement was taken from the most convex portion of its buccal surface which was usually on the mesial buccal.

3. Inter-second premolar width: distance between the most convex buccal surface of the second premolar. However, when the second deciduous molar was present, the measurement was from the buccal surface at the buccal groove.

4. Inter-first molar width: distance between the buccal surface at the buccal groove of the first molars.

5. Incisor to molar distance: measured from a line connecting the mesial of the first molars to the most anterior lower incisor.

All measurements of deciduous teeth or estimates were noted and used to identify the mixed dentition.

Results

Table I depicts the mean and standard deviation arch distance of the five measurements of the three casts in millimeters for all cases.

Table II is a summary of the mean and standard deviation arch changes of the five measurements. The treatment changes are between the first and second casts. The postretention change represents changes between the second and third casts. The net change denotes changes between the first and third casts.

Nonextraction

The canine width showed an initial increase of 1.23 mm with a relapse of —0.72 mm leaving a net increase of .52 mm for a relapse of 58.5%. For the first premolar width there was a much larger initial increase of 2.86 mm with a relapse of only —0.39 mm for a net change of 2.47 mm for relapse of 13.6%. This small relapse may be partly due to the type of retainer used. In the technique used the majority of lower retention is accomplished with a 4 to 4 fixed retainer. In the second premolar width there was an initial increase of 1.8 mm with a relapse of —0.57 mm and a net change of 1.24 mm for a relapse of 31.5%. This width change is smaller overall than that of the first premolar with a larger percentage relapse. The molar width change showed an initial increase of 2.04 mm with a relapse of only —0.06 mm and a net change of 1.98 mm for a relapse of 2.9%. This result is interesting because of the small decrease in width after treatment. The lower mo-

TABLE I

MEAN ARCH MEASUREMENTS (mm)

		Nonextraction	Std. Dev.	Extraction	Std. Dev.
Canine	Pretreatment	25.78	1.79	25.33	2.08
	Posttreatment	27.01	1.45	27.25	1.51
	Postretention	26.28	1.63	26.12	1.85
1st Premolar	Pretreatment	37.58	2.63	37.00	3.38
	Posttreatment	40.44	1.74		
	Postretention	40.06	2.00		
2nd Premolar	Pretreatment	44.58	2.32	43.87	2.36
	Posttreatment	46.39	2.09	41.53	1.99
	Postretention	45.82	2.40	40.92	2.43
Molar	Pretreatment	50.83	2.68	50.41	2.62
	Posttreatment	52.86	2.46	48.94	2.31
	Postretention	52.80	2.42	48.97	2.71
$\bar{6}$ to $\bar{1}$	Pretreatment	24.94	1.78	25.00	2.15
	Posttreatment	23.74	1.25	18.54	1.48
	Postretention	22.75	1.39	17.69	1.18

TABLE II

MEAN ARCH CHANGES (mm)

		Nonextraction	Std. Dev.	Extraction	Std. Dev.
Canine	Treatment	1.23	1.68	1.92	2.08
	Postretention	—0.72	1.12	—1.13	1.13
	Net	0.51	1.70	0.76	1.90
1st Premolar	Treatment	2.86	2.43		
	Postretention	—0.39	1.15		
	Net	2.47	1.82		
2nd Premolar	Treatment	1.81	1.66	—2.34	1.95
	Postretention	—0.57	1.06	—0.61	1.29
	Net	1.24	1.48	—2.95	1.53
Molar	Treatment	2.04	1.76	—1.46	1.54
	Postretention	—0.06	1.14	—0.03	1.31
	Net	1.98	1.81	—1.49	1.74
$\bar{6}$ to $\bar{1}$	Treatment	—1.20	1.46	—6.45	2.23
	Postretention	—0.99	0.88	—0.86	0.85
	Net	—2.19	1.45	—7.31	1.90

lar to incisor distance showed a decrease of —1.20 mm with treatment. This would be expected because as the buccal segments were expanded, the distance from the molar to incisor should decrease. The continued decrease of —0.99 mm is also expected because the final model was taken immediately after the retention bands were removed. Thus, the continued decrease is the adjustment of band spaces.

Extraction

The canine width was increased with treatment to 1.92 mm. This would be expected in most cases. However, there was a relapse of —1.13 mm for a net change of only 0.79 mm and a relapse of 58.8%. Note the percentage of relapse is almost exactly the same as the nonextraction percentage of 58.5%. The second premolar width had an expected —2.34 mm decrease with

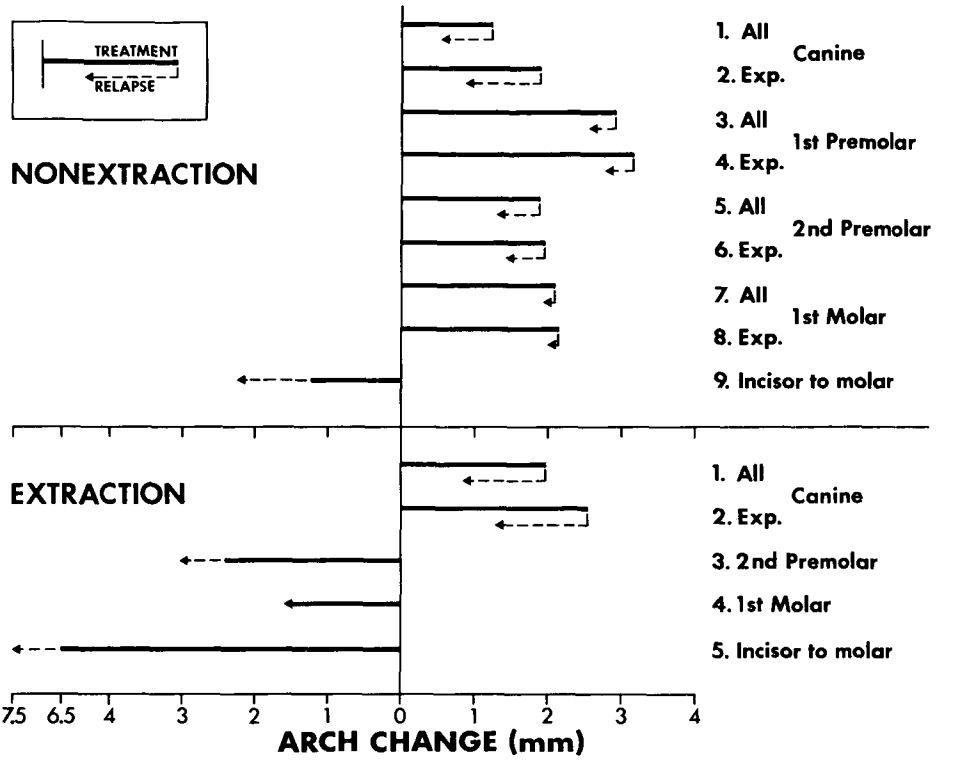

Fig. 2 Treatment and postretention changes of extraction and nonextraction cases.

treatment, but continued to decrease after treatment —0.61 mm with a net change of —2.95 mm. The molar width is most interesting, not in the initial decrease of —1.46 mm which is expected, but in the postretention change of only —0.03 mm for a net of —1.49 mm. This lack of postretention change was also noted in the nonextraction cases leading to the conclusion that the lower molar retains its width once positioned. The distance from the lower molar to the incisor decreased —6.45 mm with a continued postretention decrease of —0.86 mm and a net change of —7.31 mm.

Figure 2 is an illustration of the changes that took place in the various measurements. In the legend to the right there is a number, then the word "all" meaning all cases, or the abbreviation "exp." standing for expansion and denoting those cases with treatment changes resulting in expansion only. This group was divided to observe what changes occurred in these cases when expansion was the objective of treatment. The graph is divided into two groups, nonextraction and extraction. On the chart the solid line represents the treatment change and the broken line represents the postretention change. Every line extending to the right of zero is an increase in the arch and every line extending to the left is a decrease. Line 2, the canine width for expanded cases only, showed 56 cases with a treatment change of 1.85 mm, a relapse in postretention change of —1.08, and a net change of 0.77 mm for a relapse of 58.4%, which is the same as that for all cases. Line 4, the first premolar width for expanded cases only, showed 69 cases with a treat-

ment change increase of 3.07 mm, a relapse of —0.35 mm, and a net change of 2.72 mm for a relapse of 11.4%. This percentage was lower than the 13.6% relapse for all cases. Line 6, the second premolar width for expanded cases only, showed 66 cases with a treatment change of 1.92 mm, a relapse of —0.57 mm, and a net change of 1.35 mm for a relapse of 29.7%. This percentage of relapse was very close to that of all cases. Line 8, the first molar width for expanded cases only, showed 60 cases with a treatment change of 2.09 mm, a postretention change of 0.02 mm, and a net change of 2.11 mm for a 0% relapse. Line 2, the canine width of extraction cases for expanded cases only, showed 24 cases with a treatment change of 2.47 mm, a relapse of —1.29 mm, and a net change of 1.18 mm for a 52.2% relapse. This relapse percentage was similar to the "all" canine extraction width relapse and for the nonextraction relapse. However, the net change for the extraction expanded cases was over 1.1 mm while all the other canine width changes were less than .8 mm, a difference of .33 mm demonstrating a tendency for extraction net width changes of canine width to be slightly larger.

The next five illustrations are a breakdown of the expanded cases only. These show the percentage of relapse and number of cases that relapsed a certain percentage.

Fig. 3 is of the nonextraction canine width. There were 18 cases that relapsed 0-25% for 32.1% of the total; 7 cases that relapsed 25-50%; 10 cases that relapsed 50-75%; 4 cases that relapsed 75-100%; and 17 cases that relapsed 100% or more, for 30% and an accumulative of 100%.

Figure 4 is of the first premolar nonextraction width. There were 44 cases that relapsed 0-25%, for 63.8% of the total; 14 cases that relapsed 25-50%; 7

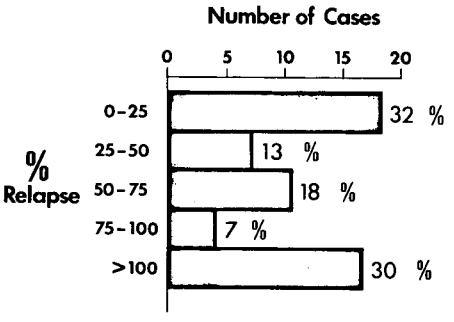

Fig. 3 Relapse of canine width changes (nonextraction-expanded only).

cases that relapsed 50-75%; 3 cases that relapse 75-100%; and 1 case that relapsed 100% or more, for 1.5% and an accumulative of 100%.

Figure 5 is of the second premolar nonextraction width. There were 31 cases that relapsed 0-25% for 48.5% of the total; 12 cases that relapsed 25-50%; 7 cases that relapsed 50-75%; 7 cases that relapsed 75-100%; and 7 cases that relapsed 100% or more, for 10.9% and an accumulative of 100%.

Figure 6 is of the first molar width. There were 45 cases that relapsed 0-25%, for 65.2% of the total; 9 cases that relapsed 25-50%; 6 cases that relapsed 50-75%; 2 cases relapsed 75-100%; 7 cases that relapsed 100% or more, for 10.2% and an accumulative of 100%.

Figure 7 is the canine width for the extraction cases. There were 6 cases that relapsed 0-25%, for 25.0% of the total; 7 cases that relapsed 25-50%; 5 cases that relapsed 50-75%; no cases

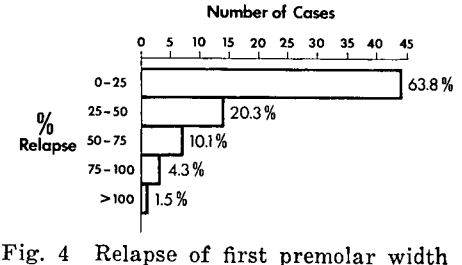

Fig. 4 Relapse of first premolar width changes (nonextraction-expanded only).

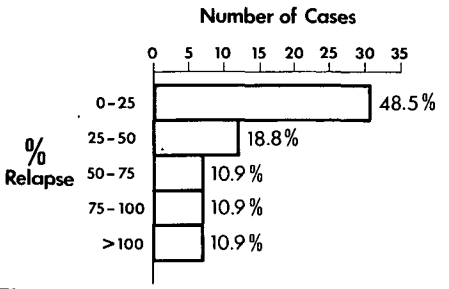

Fig. 5 Relapse of second premolar width changes (nonextraction-expanded only).

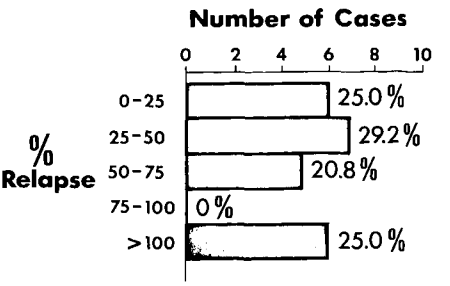

Fig. 7 Relapse of canine width changes (extraction-expanded only).

that relapsed 75-100%; and 6 cases that relapsed 100% or more, for 25% and an accumulative of 100%.

Discussion

Intercanine Width

Examination of the data representing all intercanine width dimensions discloses the following significant and related observations. First, the amount of relapse which occurs is 58%. Second, the effective net increase in width is .5 mm which is not clinically significant. The effective net increase was .8 mm for expanded cases only which is approaching clinical significance; however, because of the great amount of individual variation even this amount is not of clinical importance. Third, the type of treatment had little effect on the net change. Fourth, in those cases where the objective was to expand, there appeared to be two distinct groups: those cases where expansion was tolerated and those cases where it was not.

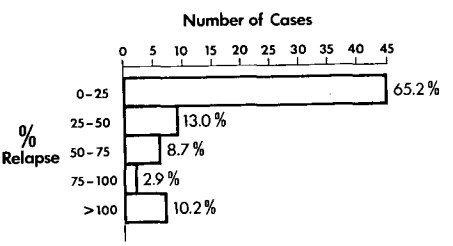

Fig. 6 Relapse of first molar width changes (nonextraction-expanded only).

The interpretation of these findings leads to the following conclusions. First, the expansion of the canines has a strong tendency to return to its original dimension independent of the type of treatment. Second, the best guide for intercanine width is the original canine pretreatment width. These conclusions agree with Shapiro,[29] Arnold,[3] Welch,[38] Amott,[1] and Dona.[13] However, Walters[36] found in the nonextraction cases an increase in canine width of +2.0 mm which he claims was maintained. He also found in the extraction cases an increase of 1.4 mm which was maintained. Strang[31] was of the opinion that the canine width could not be violated, but felt in extraction cases that the width could be increased if the canines were moved to a wider portion of the arch.

Inter-first Premolar Width

Data concerning the changes in first premolar width disclose the following observations. First, the amount of relapse is 14%. Second, the net increase for all cases was 2.5 mm, and 2.7 mm for expanded cases. This is definitely significant and useful in its clinical application. Third, 95% of cases had a net increase in width.

The interpretation of these observations leads to these conclusions. First, large amounts of expansion can be accomplished with minimal relapse. Second, gains in arch length are possible by the expansion of first premolars

without the fear of relapse. In the past the first premolars have been overlooked in the discussion of expansion to increase arch length. The canines, the primary source of study, appear to be a weak area for the use of expansion to accomplish a goal of increased arch length. What seems to be a better area is first premolar width, for it remains stable after treatment and can be expanded substantially.

The only author to study premolar width change was Amott. He found 70% of his cases had some degree of decrease postretention and only 50% retained some degree of expansion.

Inter-second Premolar Width

Observations concerning the second premolar width changes are of interest. First, the amount of relapse which occurs is 31% for nonextraction cases. Second, the net increase for nonextraction cases is 1.2 mm in all cases and 1.3 mm in expanded cases only. This smaller increase in width as compared with first premolars can be accounted for by the assumption that first premolars appear to be constricted in most of the pretreated malocclusions, while the seconds are not necessarily out of line with the ideal or functional form of the dental arch established after treatment. Consequently, the first premolars are expanded considerably to bring them to an ideal arch form, while the second premolars do not need such large increases. This can be further supported by the mean arch widths of the teeth after retention: canine 25.3 mm, first premolar 40.0 mm, second premolar 45.8 mm, the first molar 52.8 mm. From the difference between each width it can be seen that the arch form after retention is diverging fairly symmetrically. Third, 81% of the nonextraction cases resulted in a net increase in arch width. Fourth, in extraction cases there was an expected decrease indicating a continued adjustment. This finding was probably due to the adjustment of band spaces. As was stated in the results section, the posttreatment models were taken immediately after the bands were removed which would account for the continued decrease which occurred postretention in this area.

The interpretation of these findings leads to these conclusions for nonextraction cases. First, amounts of expansion can be tolerated in the area of the second premolars with minimal relapse. However, this expansion, needed to complete an ideal arch, is not as great as that of the first premolar. Second, because this width is located more posteriorly in the arch, an expansion in width would not greatly affect a change in arch length.

This area of study has been neglected in the literature with no authors reporting on the subject.

Inter-first Molar Width

The data presented concerning the first molar width changes disclose the following observations. First, the amount of relapse which occurs is 3% for the nonextraction cases. Second, the net increase for nonextraction cases was 2.0 mm in all cases and 2.1 mm in the expanded cases only. This width increase is definitely clinically significant. Third, in nonextraction cases there were 89.2% of the cases with a net increase in width. Fourth, in extraction cases the amount of change occurring postretention was zero.

In nonextraction cases it is apparent that molar width definitely can be expanded, and after the initial change or treatment change has taken place, the molar remains where it is regardless of the type of treatment.

The objective in the treatment of this group of cases was not to deliberately expand the molars, but to coordinate the two arches in this area. The reason for the expansion was due to the

use of the headgear on the upper molar teeth. The adjustment of the inner bow of the headgear is one of expansion necessary when positioning the molars and the maxilla distally to prevent posterior crossbites. Consequently, to maintain proper buccal function the lower molar has to be widened. Another aspect of the treatment is the distallization of the lower first molar accomplished by the use of "tip back" gable bends. When the molar is moved distally or uprighted, it goes into a wider portion of the arch, thus increasing the molar width.

In Welch's study, the results he found were in direct disagreement with those obtained here. He saw the molar decrease in nonextraction cases with treatment and continue to decrease postretention for a net decrease of between 2 and 3 mm. Amott reported there was an initial expansion with treatment, but in the postretention period the molar width tended to return to its original dimension. Walters, however, found results similar to ours. He observed an average increase of 1.8 mm in the molar width which maintained itself. Our results in the molar width change of the extraction cases were the same as those reported by Arnold.

Incisor to Molar Distance

The data about the incisor to molar distance reveal the following observations. First, in the nonextraction cases there was a treatment change decrease of —1.2 mm which is somewhat deceiving because it includes both the mixed and the permanent dentition cases. However, this decrease was probably due to the expansion of the buccal segments. This tended to "round out" the arch form, thus decreasing the molar to incisor distance. Second, in extraction cases there was a treatment change decrease of —6.4 mm due to the loss of the first premolars. Third, there is a continued decrease postretention in this distance of 1 mm in both the extraction and nonextraction cases. This decrease is due to the adjustment of band space. Fourth, 92% of the nonextraction cases had a decrease in distance. In almost every case the distance from the incisor to molar decreases with treatment.

Amott found similar results; most decreased in distance from molar to incisor with treatment. There was also a slight decrease after treatment. No other authors have measured this dimension in their studies of treatment and posttreatment changes.

Summary and Conclusions

This investigation was performed to determine the changes which occurred in treated orthodontic cases out of retention. The material consisted of 103 cases, of which 74 cases were treated nonextraction and 29 were treated with the extraction of four first premolars. The treatment was accomplished by the full-banded edgewise bioprogressive technique.

Five measurements were taken: intercanine, inter-first premolar, inter-second premolar and inter-first molar widths, and incisor to molar distance. The measurements were made on the mandibular arch of the pretreatment, posttreatment, and prostretention casts. The postretention model was obtained a minimum of one year after all retaining devices were removed with an average of 5.2 years.

The following conclusions were drawn from the changes in dimensions:

1. The intercanine width was expanded during treatment, but had a strong tendency to return to or close to its original pretreatment width in both nonextraction and extraction cases.

2. The inter-first premolar width showed the greatest treatment increase

in width with only a minimal amount of postretention decrease.

3. The second premolar width for nonextraction cases showed a significant amount of increase with a slight tendency for postretention decrease.

4. The second premolar width for extraction cases showed a decrease with treatment and a slight continued decrease postretention.

5. The intermolar width of nonextraction cases showed a significant increase in width with treatment. The extraction cases showed a significant decrease with treatment. However, there were no changes in either extraction or nonextraction cases postretention.

6. The incisor to molar distance decreased with treatment and had a slight tendency to continue to decrease postretention.

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