American Journal of ORTHODONTICS

Volume 80, *Number* 4 **October, 1981**

ORIGINAL ARTICLES

Dr. Little

Stability and relapse of mandibular anterior alignment–first premolar extraction cases treated by traditional edgewise orthodontics

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Assessment at least 10 years postretention of sixty-five cases previously treated in the permanent-dentition stage with first-premolar extractions, traditional edgewise mechanics, and retention revealed considerable variation among patients. The long-term response to mandibular anterior alignment was unpredictable; no variables, such as degree of initial crowding, age, sex, Angle classification, etc., were useful in establishing a prognosis. Typically, arch width and length decreased after retention, regardless of treatment expansion or constriction. Two thirds of the patients had unsatisfactory lower anterior alignment after retention. Cases that were minimally crowded before treatment usually became more crowded, while initially severe crowding cases usually moderated.

Key words: Irregularity index, relapse, alignment, postretention

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0002-9416/81/100349+17$01.70/0

Long-term postretention assessment of orthodontically treated cases has been of interest for several decades to the faculty, graduate students, and alumni of the University of Washington orthodontic program. Without regard to the quality of the long-term result, the intent has been to recall from the private practices of faculty members and from the patient pool of the University every case available at least 5 but preferably a minimum of 10 years out of retention. As a result of these continuing efforts, we have undertaken a series of descriptive and comparative studies in an effort to evaluate the validity of the rationale for our procedures, assess possible causes for relapse, search for trends, predictors, or guides, and, in short, learn from our failures as well as our successes.

The purpose of the present study was to evaluate mandibular anterior alignment, using serial long-term dental cast records of cases treated by conventional edgewise orthodontic means following removal of all four first premolars. The intent was to describe treatment and posttreatment changes and search for predictors and associations of value. A cephalometric assessment of this sample will appear in a subsequent article.

Review of the literature

Regarding extraction of permanent teeth, orthodontists of this century have been clearly divided into two camps: those who believed that mechanical alignment of crowded teeth would result in the accommodation of bones and soft tissue to this new position and those who believed that such adaptation did not necessarily follow. Unfortunately, the extraction versus nonextraction debates of the pro- and anti-Angle factions lacked the objective documentation of postretention results. Tweed was among the first to present cases of posttreatment failure; in 1940 he demonstrated the relapse of 100 cases treated initially without extraction and subsequently re-treated following first-premolar removal. The extraction camp gained many followers as a result of this dramatic presentation, but unfortunately Tweed failed to ask the next logical question: "What happened postretention to those same cases following premolar extraction and treatment? Were the cases re-treated in such a manner more stable, or did they, too, show relapse?"

Frustrated by relapse of treated cases, even after extraction of preomolars, practitioners evolved various treatment and retention strategies in an effort to reduce or minimize undesirable posttreatment changes. Most of these clinical guidelines were theories based on clinical experience and personal bias, while a few were based on documented serial review of case records.

Anxious to identify reasons for the discouraging effect of posttreatment crowding, clinicians and researchers have implicated a plethora of potential causative factors, each accompanied by clinical guidelines. Several of these theories are paraphrased below:

Apical base

"In cases of arch length deficiency, expansion of the dental arches will fail."

". . . molar width and canine width are of . . . an uncompromising nature. . ."

Patient age

"Corrections carried out during periods of growth are less likely to relapse."

Length of retention

"The longer the retention period, the better the postretention stability."

Incisors upright over basal bone

"Tip or bodily move incisors to a predetermined ideal."

"Do not change incisors from their original angular and bodily position."

Table I. Sample characteristics

	Median (yr.-mo.)	Range (yr.-mo.)
Age		
Pretreatment	13-0	7-10 to 18-2
Posttreatment	15-2	12-6 to 19-11
Postretention	30-1	25-0 to 43-4
Retention period	2-0	0-6 to 5-4
Postretention period	12-7	9-7 to 23-11

Posttreatment growth

"Late mandibular forward growth must be in concert with the remaining dentofacial complex, or crowding will result."

Third molars

"The force of third molar eruption can cause crowding."

Periodontal fibers

"Lengthy retention to allow for periodontal adaptation and/or surgical transsection of stretched fibers is critical to prvent rotational relapse."

Oral habits

"Stability is not achievable without elimination of the initial cause of the malocclusion, particularly if habit related."

"A balance of posttreatment forces labially and lingually must be through appropriate tooth movement, growth, and muscle adaptation."

Occlusion

"Stability is enhanced when ideal cusp-to-fossa interdigitation has been achieved with canine rise in lateral excursions, posterior disclusion during anterior function, and no balancing interferences."

Tooth size

"Ideal proportion of teeth intra- and interarch must be achieved to permit proper function and stability."

Normal decrease in arch dimension with time

"The normal developmental maturation process of decreasing arch dimensions inevitably results in crowding."

Unknown multiple factors

"We are in almost complete ignorance of the specific factors causing relapses and failures."

Review of postretention records can show trends and offer clues to cause-and-effect relationships, but retrospective evaluation should be classed as subordinate to experimental research in which there are proper controls and randomization of subjects. Because this potential research trap was not recognized, cause-and-effect conclusions have been erroneously reached in our own university research program and later have required reassessment. For example, in 1963 Arnold[1] stated, after reviewing twenty-nine extraction and twenty nonextraction cases, ". . . the amount of increase of intercanine width necessary to attain alignment of incisors is an index to the expected relapse." Our subsequent research tends to indicate that such relationships are not that simplistic. Seeking answers to our clinical problems can easily tempt us to exaggerate the evidence or to form

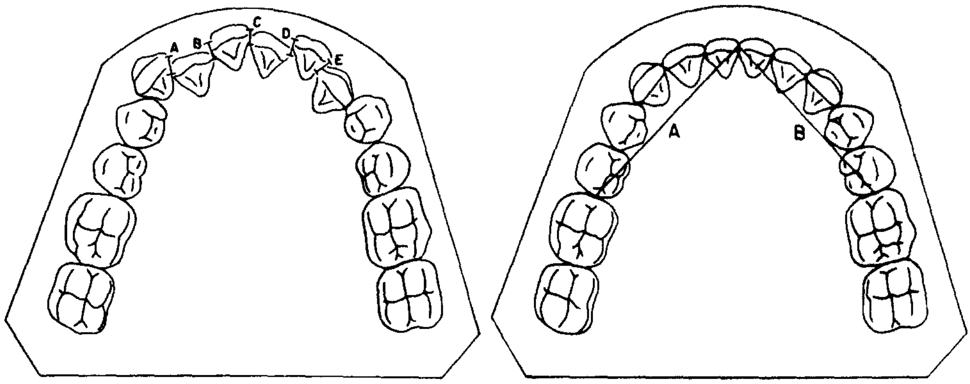

Fig. 1. Measurement technique. Irregularity index defined as the summed displacement of adjacent anatomic contact points of the mandibular anterior teeth. Arch length defined as the summed inside measurement from mandibular first permanent molars to the central incisor contact point.

inappropriate conclusions. Descriptive research can provide us with direction and possible cause but cannot lead us to the cause-and-effect conclusions of experimental research.

A second major flaw in orthodontic research has been the assumption that stability will eventually be reached, authors apparently assuming that a state of balance had been achieved at the time of their final set of records. Walter,[2, 3] in 1953 and 1962, used the term *adequate period* which, in his studies, meant a minimum of 1 year postretention. University of Washington theses, beginning with that by Kelley[4] in 1959, increased our observation time from a 1-year minimun postretention period to 2 years in Dona's[5] study, followed by theses by Arnold[1] and Welsh[6] with 5-year postretention periods. A minimum of 10 years postretention was used in Shapiro's review, and the sample size was later expanded by Gallerano[8] in 1976 and Witzel[9] in 1978. As the postretention period was extended and larger samples were collected, increased instability and individual variation became more apparent.

The second flaw is typified by an often quoted 1944 article[10] "As a result of many sad experiences we are forced to recognize that teeth will continue to settle until they ultimately reach a position where they are in balance with the forces that act upon them." We, too, have assumed that stability will eventually occur, an example being Dona's[5] statement in his 1962 thesis involving twenty-two cases out of retention 2 or more years: "In conclusion it may be stated that, in general, orthodontic cases following treatment tend to seek a state of stability or balance, and therefore the teeth are still moving following the retention period *until* they settle into a balanced state." Welch,[6] in 1965, seemed to imply that intercanine width returns to the pretreatment stage, but not beyond, as he stated: "The intercanine width of extraction cases that have been expanded during treatment and which have been free of all retaining devices for a period of 5 years or more show an exceptionally strong tendency to relapse toward the intercanine width of the original malocclusion." Perhaps, as our later data suggested, the treated case should be viewed as dynamic and constantly changing at least through the period we have studied, the third and fourth decades of life, and perhaps throughout life.

Reviewing postretention records of eleven nonextraction cases, Goldstein[11] committed

Table II. Mandibular anterior irregularity index values

	Class I		Class II-1		Class II-2		All classes	
	N	Mean ± S.D.	N	Mean ± S.D.	N	Mean ± S.D.	N	Mean ± S.D.
Pretreatment								
Male	9	8.93 ± 5.28	11	4.39 ± 2.10	3	8.46 ± 2.43		
Female	18	7.76 ± 4.81	15	8.41 ± 4.05*	5	5.02 ± 2.74*		
Pooled	27	8.14 ± 4.50	26	6.71 ± 3.88	8	6.31 ± 3.03	61	7.31 ± 4.29
Posttreatment								
Male	9	2.10 ± 0.50	12	1.62 ± 0.61	3	1.58 ± 0.19		
Female	21	1.65 ± 0.61	15	1.69 ± 0.76	5	1.88 ± 0.74		
Pooled	30	1.78 ± 0.61	27	1.66 ± 0.68	8	1.77 ± 0.59	65	1.73 ± 0.63
Postretention								
Male	9	4.79 ± 1.22	12	3.72 ± 1.36	3	4.60 ± 2.18		
Female	21	4.75 ± 2.30	15	5.24 ± 2.07	5	3.86 ± 1.30		
Pooled	30	4.82 ± 2.01	27	4.56 ± 1.92	8	4.13 ± 1.58	65	4.63 ± 1.91

*Males versus females differ significantly $p \leq 0.01$.

a third flaw of logic as he stated: "The conclusion was inescapable that in each individual there existed a certain pattern—a morphogenic pattern which limited the extent to which treatment could be carried. The patient, it seemed, had a certain potential, and if treatment could be designed to restrict movements within the possibilities and capabilities of this morphogenic pattern, then a satisfactory result would follow. If the possibilities of the pattern were transcended, however, then the spector of orthodontic failure raised its head." We have been led by our mentors to believe that if we treat a case correctly then stability will follow, whereas relapse is a sign of inappropriate treatment or evidence of misdiagnosis or incorrect mechanics. The reasoning is that good orthodontics does not fail; only poor orthodontics does so.

Fortunately, the increased sample size of more recent studies has decreased the likelihood of the fourth major error, inappropriate conclusions based on inadequate sample size. Gallerano[8] with twenty-eight and Witzel[9] with thirty-one first-premolar-extraction cases more than 10 years out of retention showed considerable patient variation as the rule, a finding in contrast to our previous reports of consistency of pattern. As an example of an inappropriate conclusion based on sample size, Riedel,[12] paraphrasing Shapiro's 1974 article, stated: ". . . there is some evidence to suggest that in the Class II, Division 2 type of malocclusion, where extraction in the mandibular arch has been performed, mandibular intercanine width may be increased and may be expected to be maintained." Unfortunately, the statement was based on only six cases, the mean data showing slight maintenance of treatment expansion, the average net gain being 1.4 mm. The standard deviation of 2.6 demonstrates the marked variation present in the small sample and should have pointed to a far weaker conclusion. Later studies with large samples showed that Division 2 cases appeared to respond with variations similar to all other Angle classes. As we reviewed our increasing body of data, previously predictable patterns of postretention change have become more varied and our rules less reliable, leading to our desire to collect even more patients of long-term postretention status. The current study should be looked upon as a provisional progress report.

Table III

		Pretreatment irregularity			
		Minimal	*Moderate*	*Severe*	
Postretention irregularity	Minimal	6	4	7	17 (28%)
	Moderate	6	8	20	34 (56%)
	Severe	2	2	6	10 (16%)
		14 (23%)	14 (23%)	33 (54%)	61

Materials and methods

The sample was limited to first-premolar-extraction cases which had undergone routine edgewise orthodontic therapy followed by retention and eventual removal of all retention devices. Sixty-five cases with complete records before treatment, at the end of treatment, and a minimum of 10 years out of retention (at least 10 years after complete removal of all retainer devices) were collected from the files of the graduate orthodontic clinic at the University of Washington and from the offices of Drs. Richard Riedel, Alton Moore, and George McCulloch (Table I). The quality of the cases postretention did not influence their inclusion or exclusion from the sample. In fact, every effort was made to ignore the final outcome as cases were collected.

Extractions were performed in the very late mixed-dentition stage or in the permanent dentition, with treatment started shortly thereafter. No ''sulcus slice'' procedures (circumferential supracrestal fibrotomy) were performed in any of these cases. Angle Class III cases were excluded because of small sample size.

With dial calipers calibrated to read hundredths of a millimeter, the following measurements were obtained for each set of casts (Fig. 1):

Irregularity index—As suggested by Little,[13] the summed displacement of the anatomic contact points of the lower anterior teeth.

Mandibular intercanine width—The distance between cusp tips or estimated cusp tips in cases of wear facets.

Mandibular arch length—The sum of the right and left distances from mesial anatomic contact points of the first permanent molars to the contact point of the central incisors or to the midpoint between the central incisor contacts, if spaced.

Overbite—Mean overlap of upper to lower central incisors.

Overjet—The distance parallel to the occlusal plane from the incisal edges of the most labial maxillary to the most labial mandibular central incisor.

To reduce examiner bias, each cast was numbered and subsequently measured in random order via a computer-generated list. Measurement error was evaluated by randomly selecting twenty-one casts, each measured on three separate occasions. The mean error in assessing irregularity was 0.30 mm, while arch width and length, overbite, and overjet averaged 0.11 to 0.19 mm.

In addition to standard descriptive statistics for the three time periods, both pooling and segregating the sample by Angle class and sex, the following routine tests were also performed[14]: Differences were assessed by Student's t test, one-way analysis of variances, ''a priori'' comparison of group means, paired differences, and percent. Association between variables was evaluated by the Pearson Product-moment correlation coefficient.

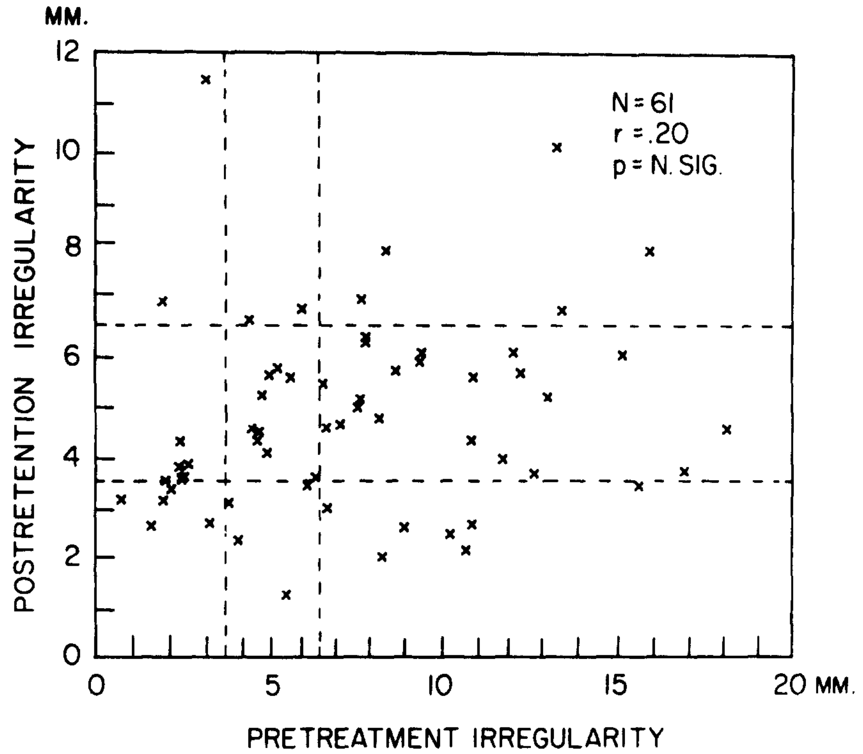

Fig. 2. Scattergram demonstrating the weak association between the degree of alignment or crowding pretreatment versus postretention.

Results

Irregularity. The mean values observed at the three time periods are shown in Table II. There was no difference in the mean pretreatment irregularity crowding score for Class II, Division 1 and Class II, Division 2 patients, but there was significantly less ($P < 0.005$) crowding in Class II (Divisions 1 and 2 pooled) than in Class I patients. While significant pretreatment differences were observed between sexes in Class II, Division 1 and Class II, Division 2 patients, when all classes were pooled, crowding in males and females did not differ significantly ($p > 0.2$). No significant differences were noted in the posttreatment or postretention crowding index between the various Angle malocclusion classes, between the sexes, or between the various combinations of sex and class.

Pooling the entire sample, more variation was noted at pretreatment and postretention stages, compared to the variation observed in the end-of-treatment records. Pretreatment crowding averaged more than 7 mm. on the irregularity index, the values having a substantial range of 17.4 mm. Postretention, the range of values was also considerable at 10.2 mm., with an average irregularity of 4.6 mm. There was no significant relationship between length of retention ($\bar{X} = 26 \pm 14$ months, range 6 to 64) and the postretention irregularity index ($r = -0.01$, $p > 0.05$). The reader should realize that removable mandibular retainers were used in some of the cases under study, the extent and degree of

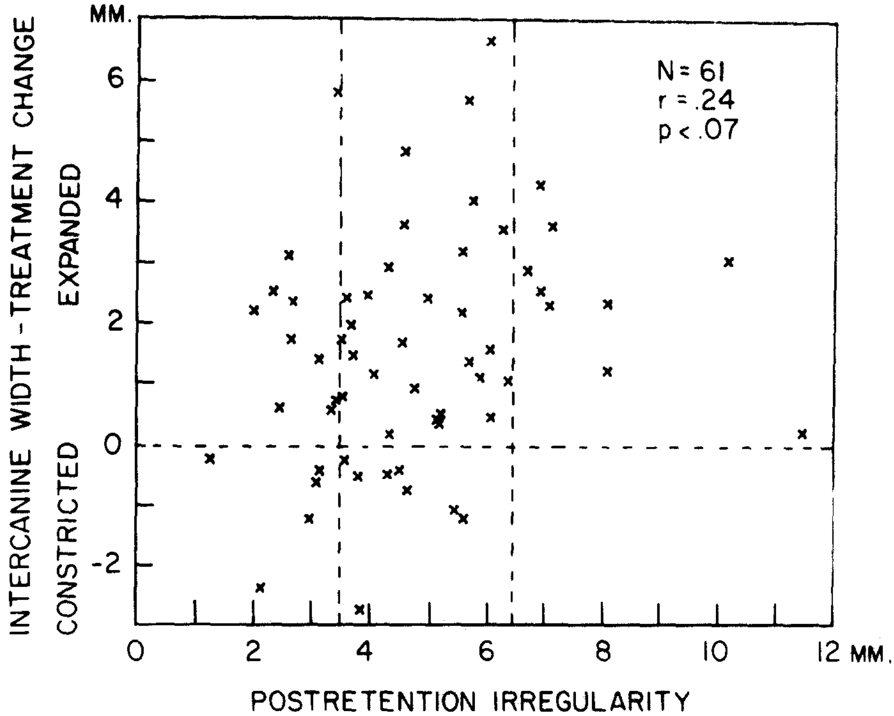

Fig. 3. Scattergram demonstrating the weak association between intercanine width change during treatment and postretention alignment.

Table IV

		Net change		
		Increased	*Decreased*	
Pretreatment irregularity	Minimal	13	1	14
	Moderate	6	8	14
	Severe	0	33	33
		19	42	61

retainer use being quite variable. Since length of retention was an estimate for those cases, interpretation of statistical results must be somewhat guarded.

Cases were arbitrarily grouped into minimal (<3.5 mm.), moderate (3.5 to 6.5 mm.), and severe (>6.5 mm.) irregularity at pretreatment and postretention stages (Table III). More than 70 percent of the cases had moderate or severe crowding prior to treatment, whereas after retention more than 70 percent were classified as showing moderate or severe crowding but in different proportions. Marked variation in postretention response characterized the sample. Of the thirty-three cases with severe crowding before treatment, six returned to the severe category, while seven had minimal crowding following treatment. In two of the fourteen cases with minimal crowding before treatment, crowding became severe postretention, although in the bulk of that group crowding either remained

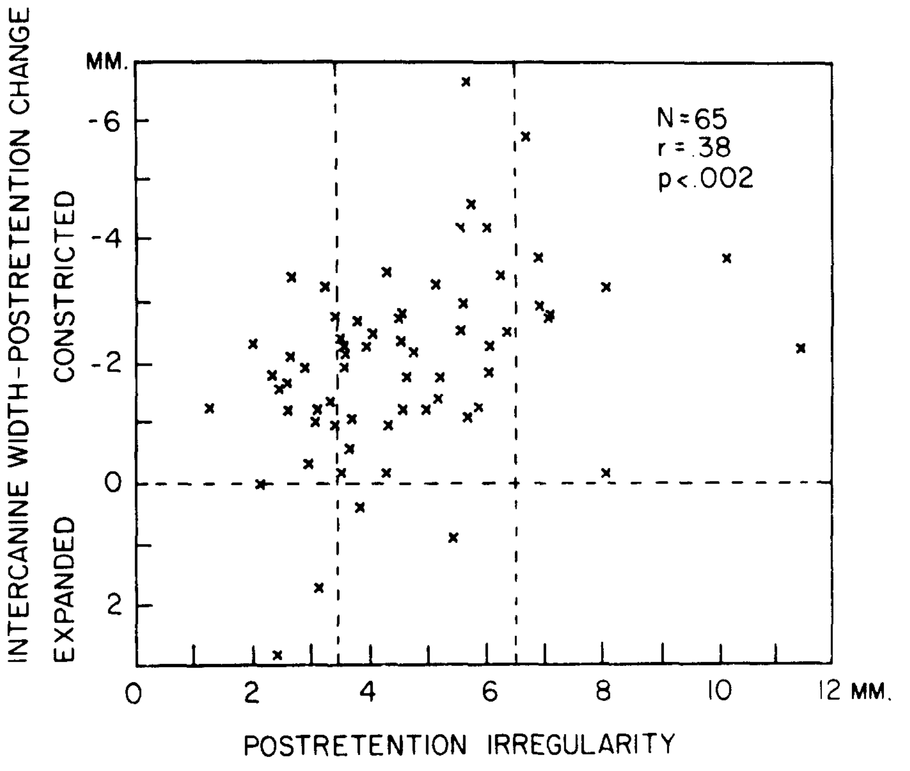

Fig. 4. Scattergram demonstrating nearly all cases constricting in width postretention, with the degree of width change weakly associated with postretention alignment.

minimal or worsened to moderate. Cases of moderate pretreatment crowding were similarly dispersed after retention. Initial crowding was a very poor predictor of long-term irregularity, the Pearson correlation coefficient being only 0.20 (Fig. 2).

Considering net change, all of the cases that were severely crowded before treatment improved to some degree, even though the end result in many cases was unacceptable (Table IV). Of the fourteen cases that were minimally crowded before treatment, all but one became worse during the postretention stage. The trend following retention was toward the moderate crowding category, initially well-aligned cases worsening and cases with very poor pretreatment alignment improving over the long term. Cases initially in the moderate crowding category tended to return to the same level after retention. Pretreatment and postretention ages were also poorly associated with long-term crowding ($r < 0.25$, $p > 0.05$).

Arch width. Although a few cases showed a decrease in arch width during treatment, more than 60 percent showed canine expansion of more than 1 mm. Sixty of the sixty-five cases showed canine constriction postretention, with most constricting more than 2 mm. ($\overline{X} = -2.02 \pm 1.57$, $p < 0.0001$). Arch width change during treatment was a poor predictor of long-term crowding, the degree of expansion or constriction having little association with postretention alignment ($r = 0.24$, $p < 0.07$, Fig. 3). The change in postretention arch width was also poorly associated with final irregularity ($r = 0.38$,

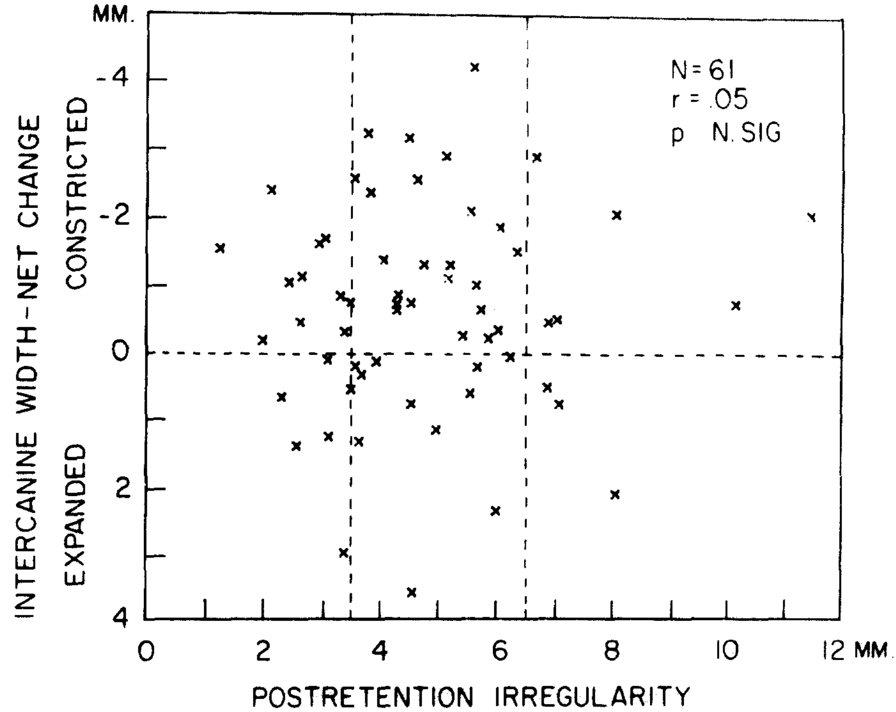

Fig. 5. Scattergram demonstrating no association between net gain or loss of arch width versus postretention alignment.

$p = < 0.002$, Fig. 4). Net change in intercanine width showed no association with long-term alignment ($r = 0.05$, Fig. 5), those showing an over-all gain in arch width having as much variation in crowding as those with a net loss in width.

Regarding the various Angle classes, no differences were noted in long-term stability of intercanine width. Class II, Division 2 patients did not show significant intercanine width expansion ($\overline{X} = 1.08 \pm 0.67$, $p > 0.1$) during treatment (presumably because of the small sample size); however, there was a significant constriction of arch width during the postretention observation period ($\overline{X} = -1.49 \pm 0.35$, $p < 0.005$).

Arch length. Since treatment involved extractions, arch length during treatment was generally decreased. During the postretention period, however, a continuing decrease in arch length typified the sample. Arch length reduction following retention averaged more than 2 mm. ($\overline{X} = -2.48 \pm 0.19$, $p < 0.001$), with one case decreasing more than 6 mm. in arch length after retainer removal. No significant differences were noted between males and females or between the Angle classes. There was a weak correlation between the degree of postretention arch length reduction and the severity of postretention crowding ($r = 0.52$, $p < 0.001$). On the basis of this r value, only 27 per cent of the variation in crowding is explained by the variation in arch length.

Overbite. Prior to treatment, overbite was greatest in the Class II, Division 2 patients ($\overline{X} = 5.74 \pm 0.67$ mm.), which differed significantly ($P < 0.001$) from the Class I patients ($\overline{X} = 3.48 \pm 0.27$ mm.) and the Class II, Division 1 patients ($\overline{X} = 3.46 \pm 0.38$ mm.). The mean overbite for all patients decreased significantly during the period of

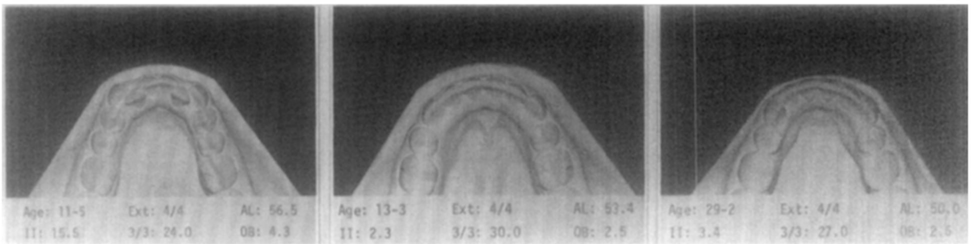

Fig. 6. Pretreatment, posttreatment and postretention casts. *Age:* Years-months. *Ext:* Four first premolars extracted. *AL:* Arch length. *II:* Irregularity index. *3/3:* Intercanine width. *OB:* Overbite.

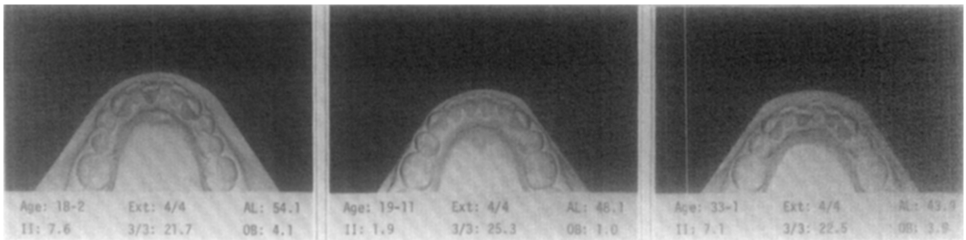

Fig. 7. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

active treatment ($\overline{X} = 1.29 \pm 0.24$, $p < 0.001$). As would be expected, Class II, Division 2 patients showed the greatest treatment decrease in overbite ($\overline{X} = -3.09 \pm 0.84$). In contrast, there was a significant increase in overbite for all cases during the postretention period ($\overline{X} = 0.76 \pm 0.15$, $p < 0.001$).

Compared to the pretreatment values, there was a significant net reduction in overbite 10 years out of retention when all patients were considered ($\overline{X} = -0.54 \pm 0.22$, $p < 0.02$). When the individual Angle classes were evaluated, Class II, Division 1 patients stood out as not significantly different from their pretreatment overbite relationships ($\overline{X} = -0.02 \pm 0.42$, $p > 0.1$), while Class I and Class II, Division 2 cases were significantly improved. There were no significant differences between the various Angle classes and the amount of overbite relapse.

There was no significant relationship between the changes in overbite and crowding from pretreatment to end-of-active-treatment measurements ($r = -0.01$, $p > 0.05$). The correlation between overbite and crowding measurements at the end of treatment and after retention, although statistically significant, was weaker than would be expected ($r = 0.46$, $p < 0.001$).

Overjet. Prior to treatment, overjet was greatest in the Class II, Division 1 patients ($\overline{X} = 8.96 \pm 0.47$ mm.), which differed significantly from the Class I patients ($\overline{X} = 4.74 \pm 0.35$ mm.) and the Class II, Division 2 cases ($\overline{X} = 4.96 \pm 0.78$ mm.). During treatment overjet decreased significantly in all three Angle classes. Overjet in Class II, Division 1 patients remained slightly greater ($p < 0.05$) over the long term than in patients of either Class I or Class II, Division 2 categories.

There were significant decreases in net overjet between pretreatment and postretention measurements in all three categories. The over-all decrease in Class II, Division 1 patients was greatest, and there were no significant postretention differences between categories.

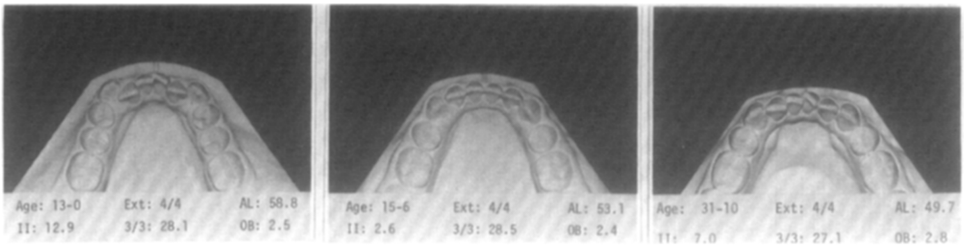

Fig. 8. Pretreatment, posttreatment, and postretention casts.

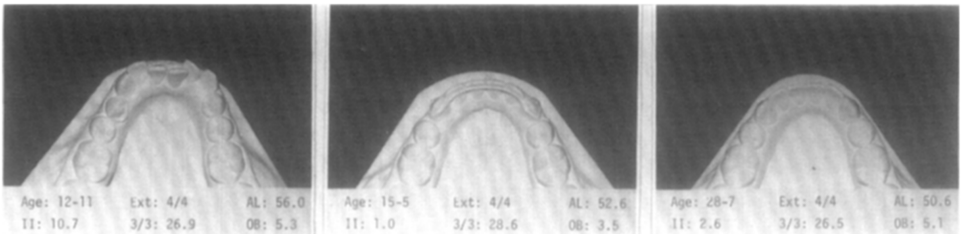

Fig. 9. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

Although the changes in means for crowding and overjet are in the same direction, there was no relationship between the amount of postretention crowding and the change in overjet either during treatment ($r = -0.08$, $p > 0.05$) or following treatment ($r = 0.23$, $p < 0.05$). The change in crowding was not related to change in overjet during treatment ($r = 0.06$, $p > 0.05$) and related only weakly after treatment ($r = 0.26$, $p < 0.05$).

Discussion

With pretreatment and end-of-treatment model data, prediction of the long-term postretention result for individual cases was not possible. Marked variation in response more aptly described the sample. Not surprisingly, those cases that were severely crowded before treatment tended to demonstrate considerable relapse, although nearly one third of them remained well aligned. A net improvement invariably occurred, but it was not possible to predict the long-term result with any degree of accuracy other than to guess that, with some exceptions, most cases with considerable initial crowding would likely relapse to at least moderate crowding (Figs. 6 to 11).

Of greater interest was the response of the initially well-aligned group. All but one showed a net deterioration over the pretreatment stage. More than one half of this group became moderate to severely crowded over the long term (Figs. 12 to 15). For those cases that were moderately crowded before treatment, the most common result was relapse back to moderate crowding, although some maintained good alignment and a few relapsed to the severe crowding category.

These variable and unpredictable results make it quite difficult to counsel patients and parents of patients both prior to treatment and at the end of active treatment. Cases that are mild before treatment usually look worse over the long term while severe cases show some net improvement, the bulk of first premolar cases treated in the permanent dentition showing substantial lower anterior crowding over a long postretention period.

Confirming Johnson's[15] report of eleven cases 6 years out of retention and the findings

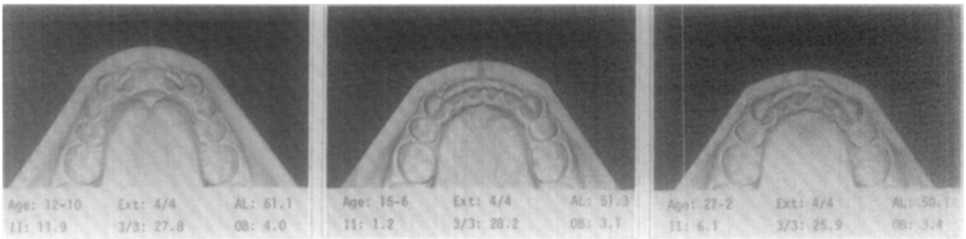

Fig. 10. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

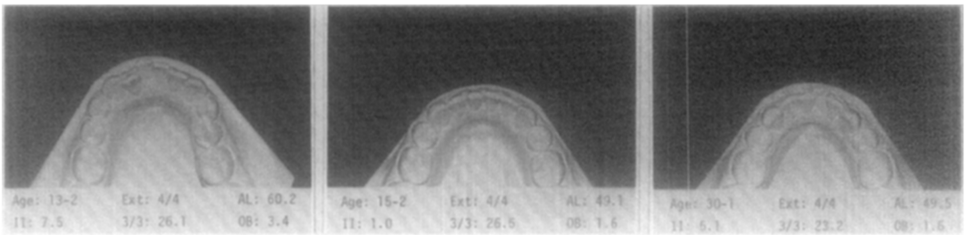

Fig. 11. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

of Gardner and Chaconas[16] which involved twenty-nine cases averaging more than 5 years out of retention, with few exceptions, postretention reduction of intercanine width was a typical finding. Of those cases in our study expanded during treatment, posttreatment constriction normally occurred (Figs. 9 and 12). Even so, many of them demonstrated a degree of net expansion over the original condition, confirming Walter's[2, 3] conclusion that some net expansion can be maintained in some cases (Figs. 6 and 7). A few cases even showed expansion of intercanine width during the postretention stage (Fig. 13). As important clinically was the startling finding that many cases had an intercanine width much less than the initial dimension. Most investigators have noted relapse in the direction of the original condition, but the high percent of relapse in this study to a width less than the original condition is disheartening (Fig. 10).

Maintenance of initial canine width during treatment had little apparent influence on the postretention crowding, as many well-treated cases without appliance expansion showed posttreatment constriction and crowding (Figs. 8, 11, and 14). Strang's precept that intercanine width should "remain inviolate" to achieve stability or Steadman's[18] view that by preventing treatment width increase one can avoid relapse did not hold true under our long-term assessment. Strang's idea that premolar extraction permits distal movement of canines into an area of greater bone width, which would allow stability of expansion, also is in conflict with these results. Our findings are also in sharp contrast with those of Lombardi[19] who, with thirty cases "several years after treatment," agreed with Peak[20] who reported on forty-three cases with postretention periods of 6 months or more. Both believed that the more cases were expanded, the more crowded they became after treatment. The results of our study demonstrate that no cause-and-effect conclusion can be made regarding width change and subsequent incisor crowding. It seems sensible to minimize treatment expansion, but maintenance of the original intercanine width is certainly no guarantee of stability.

In only two of sixty-five cases was there a postretention increase in mandibular arch

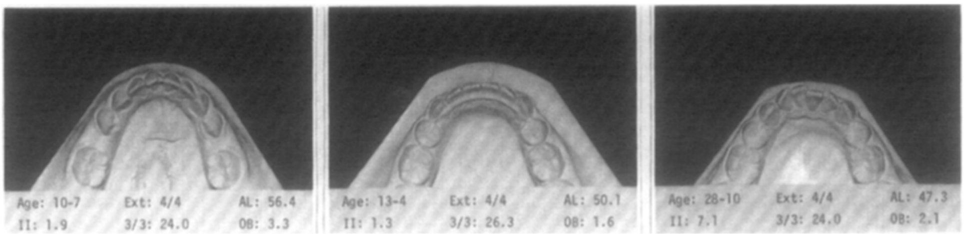

Fig. 12. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

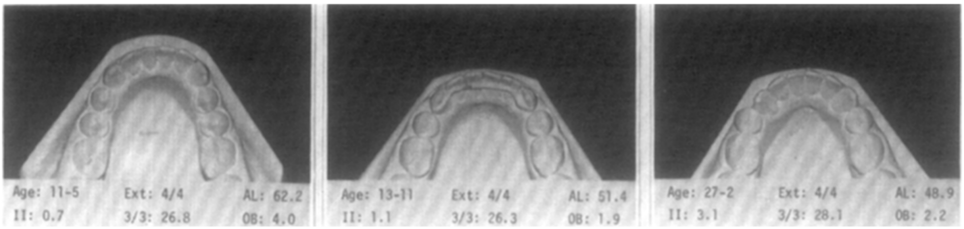

Fig. 13. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

length; all others showed varying degrees of continued loss in arch length. Variation from minimal reduction in arch length to quite severe arch loss characterized the sample, with crowding not well associated with the degree of arch length reduction. A few cases showed good incisor alignment, even with arch length loss, canines or premolars blocking labially or lingually, or anterior arch form flattening (Figs. 9 and 13). In a few cases there was no substantial loss in arch length but incisors became crowded (Figs. 10 and 11). All cases obviously lost arch length following extraction and space closure, but why shortening continued after treatment remains unclear. Does reduction in arch length cause crowding? Does crowding permit further arch length loss? It is unlikely that answers will be simple. Rather, it seems more likely that a multitude of intertwining factors are involved, the combination unique to each individual.

Overjet relapse occurred more often in Class II, Division 1 cases than in Class I or Class II, Division 2 cases, whereas variation in overbite relapse was similar for all three groups. Overbite and overjet treatment changes, as well as relapse changes, were poor predictors of incisor alignment stability. No single factor, such as sex, age, Angle class, length of retention, or treatment changes measurable on models, proved of value in establishing a reliable prognosis. Combinations of these values also proved fruitless. Cephalometric assessment of these cases will be considered in a subsequent article as we continue to search for predictors, such as posttreatment growth, tooth eruption, drift, axial inclination change, etc. Kaplan's[21] University of Washington study comparing cases in which third molars were congenitally missing versus those with third molars present will be repeated, using our larger sample size.

Numerous other possible causes for the disconcerting effects of relapse have yet to be studied. Although the method of studying muscle balance has been developed, it is not yet a part of routine record-gathering procedures. Assuming that these forces can be accurately measured, we would need records on a large sample at the three time intervals of this study.

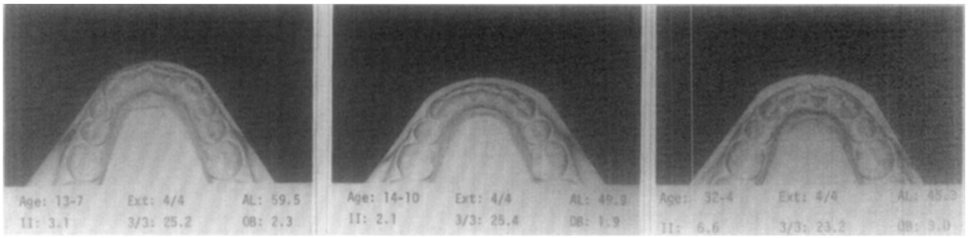

Fig. 14. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

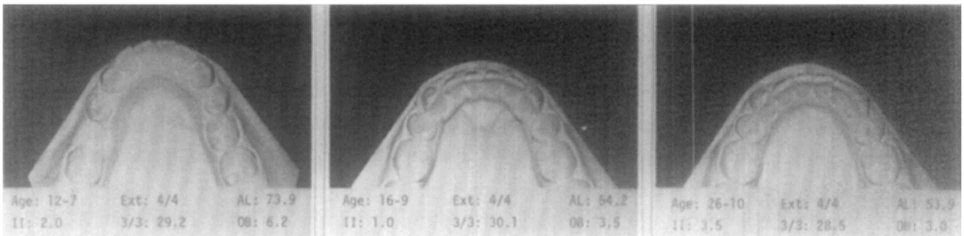

Fig. 15. Pretreatment, posttreatment, and postretention casts. (For key to symbols, see Fig. 6.)

The debate regarding the role of occlusion and function relative to stability is knotty and unresolved. Long-term records are again unavailable, while data collection, standardization, measuring techniques, and countless other problems hinder investigation. Many practitioners advocate various end-of-treatment and posttreatment procedures, but their suggestions lack the objective confirmation of retrospective research.

The findings of Fastlicht[22] and of Norderval and associates[23] suggest that wider lower incisors are more likely to crowd than are those with smaller mesiodistal width. Peck and Peck[24] advocate narrowing (reproximating) lower incisors to a given faciolingual/mesiodistal ratio to achieve stability, but their recommendations are based on a study which involved untreated rather than treated cases. They recommend that measurements be taken intraorally for an accurate determination of faciolingual dimension subgingivally, less accurate data being available from models. Long-term stability of orthodontically treated cases which also underwent enamel reproximation requires further study. Until confirmed, their suggestion remains an interesting but untested hypothesis.

Return of the original pattern of malalignment and rotations is well documented and no doubt serves as the rationale for circumferential supracrestal fiber release procedures (CSF) advocated by Edwards[25] and others.[26-30] What was surprising in our sample was the number of exceptions to this rule. Perhaps as many as half the rotations or displacements returned in a pattern different from the original condition; in none of the cases in this study was any form of posttreatment periodontal surgery performed. Recent articles by Boese[31,32] involving eighteen first-premolar-extraction cases plus twenty-two cases with other extraction patterns demonstrate considerable success. All underwent a combination of CSF plus reproximation at the end of active treatment and demonstrated excellent results 4 to 9 years posttreatment.

The preponderance of evidence in studies of untreated persons suggests that decreasing mandibular arch length and width dimensions accompanied by increasing crowding normally occurs during adolescence, early adulthood, and perhaps beyond. The focus of our current research is to document a serial sample of untreated cases to test this hypothesis. If confirmed, we will tend to agree with Horowitz and Hixon,[33] who stated: "The significant point is that orthodontic therapy may temporarily alter the course of these continuous physiologic changes and possibly, for a time, even reverse them; however, following mechanotherapy and the period of retention-restraint, the developmental maturation process resumes."

Summary

On the basis of diagnostic cast records at least 10 years postretention for cases treated with first premolar extraction and routine edgewise mechanics, the following conclusions were reached:

1. Long-term alignment was variable and unpredictable.
2. No descriptive characteristics, such as Angle class, length of retention, age at the initiation of treatment, or sex, and no measured variables, such as initial or end-of-active-treatment alignment, overbite, overjet, arch width, or arch length, were of value in predicting the long-term result.
3. Arch dimensions of width and length typically decreased after retention whereas crowding increased. This occurred in spite of treatment maintenance of initial intercanine width, treatment expansion, or constriction.
4. Success at maintaining satisfactory mandibular anterior alignment is less than 30 percent, with nearly 20 percent of the cases likely to show marked crowding many years after removal of retainers.

The authors would like to thank Dr. Joel Ivey for his advice regarding statistical interpretation during the preparation of this article.

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