Mandibular second premolar extraction — postretention evaluation of stability and relapse

By David C. McReynolds, DDS, MSD and Robert M. Little, DDS, MSD, PhD

The maintenance of dental alignment following orthodontic therapy has been, and continues to be, a challenge for the orthodontist. As Goldstein once commented on the teachings of Angle, "...the orthodontist should endeavor to establish normal occlusion and restore function to the end that physiologic balance and retentive stability could be achieved."[1] In order to meet this challenge, many philosophies and theories have been suggested but few have successfully withstood the test of postretention evaluation.

In evaluating postretention changes in the dentition, it may be helpful to understand the natural changes seen in individuals who have not had orthodontic therapy. In 1947 Nance measured arch length and determined that there is a decrease in mandibular arch length during the transition from the primary to permanent dentition.[2] DeKock, in a longitudinal study of 26 untreated individuals, found that arch length decreased from the age of 12 to 26 years with an average loss of 3.2 mm in males and 2.3 mm in females.[3] Barrow and White studied 52 untreated individuals and showed that intercanine width decreased by varying amounts after the mid-teen years.[4] Sinclair and Little evaluated 65 untreated individuals with normal occlusion and found that arch length and intercanine width decreased into early adulthood, while incisor irregularity significantly increased.[5] Little and Riedel demonstrated that generalized spacing cases also show this same trend of arch width and arch length decrease with time.[6]

Postretention studies of patients who had undergone first premolar extraction showed changes in dental arch dimension similar to those observed in untreated individuals. Shapiro[7] and Little, et al.,[8] in studies of 10-year postretention patients, found that arch length and intercanine

Abstract

The dental casts and cephalometric radiographs of 46 patients, treated with mandibular second premolar extraction and edgewise orthodontic mechanotherapy, were evaluated for changes over a minimum 10-year postretention period. The sample was divided into two groups: early (mixed dentition) extraction of mandibular second premolars and late (permanent dentition) extraction of mandibular second premolars. Results showed no difference in long-term stability between the two groups. Arch length and arch width decreased with time and incisor irregularity increased throughout the postretention period. No predictors or associations could be found to help the clinician in determining the long-term prognosis in terms of stability. The sample was regrouped according to the postretention degree of incisor irregularity. Statistically significant differences in cephalometric measurements were found between the minimally crowded group and the moderately to severely crowded group.

This manuscript was submitted July 1990. It was revised and accepted for publication December 1990.

Key Words

Postretention • Relapse • Stability • Serial extraction • Second premolars

Table 1
Sample characteristics

	Mean (yr. - mo.) Early Group	Mean (yr. - mo.) Late Group	Range (yr. - mo.) Early Group	Range (yr. - mo.) Late Group
Age				
Pretreatment (T1)	11-3	12-6	8-1 to 14-5	10-2 to 15-4
Posttreatment (T2)	15-3	15-3	12-11 to 17-6	13-3 to 17-11
Postretention (T3)	29-8	31-9	23-0 to 37-5	23-6 to 49-0
Postretention Period	14-5	16-7	9-0 to 20-6	9-4 to 33-0

	Number of patients Early Group	Number of patients Late Group
Angle class		
Class I	6	8
Class II, Division 1	6	16
Class II, Division 2	2	8
Total	14	32
Gender		
Male	3	8
Female	11	24

width decreased significantly during the postretention period. Gallerano was the first to conclude that a decrease in arch length from posttreatment to postretention is not necessarily associated with an increase in crowding postretention.[9] Little, et al., concluded that regardless of intercanine maintenance, expansion, or constriction during treatment, arch width typically decreases after retention, and in a majority of cases, restricts to less than the pretreatment dimension.[8] Patients with poor pretreatment incisor alignment showed a net improvement over the long-term while initially well-aligned cases showed more crowding at the postretention stage than at pretreatment. Moderately crowded patients at pretreatment tend to be moderately crowded 10 years postretention.

Kinne studied patients who had undergone first premolar serial extraction without subsequent orthodontic treatment and compared them to treated patients for whom first premolars had been extracted in the permanent dentition.[10] The untreated serial extraction group exhibited a substantially smaller long-term increase in mandibular anterior crowding than the treated patients who had undergone later extraction. This graduate student thesis was never published because of a possible bias. Many of the untreated patients had favorable alignment following extraction and physiologic drift and consequently may not have received orthodontic care. It is possible that these patients were not a random sample but merely the more successful results of serial extraction.

An unpublished thesis by Witzel also involved untreated patients who had undergone premolar serial extraction.[11] They were compared to treated patients who had undergone serial and/or late premolar extraction. In contrast to Kinne's findings, the untreated serial extraction sample had a higher degree of incisor crowding than the treated patients with either late or serial extractions. A recent study by Little, et al.,[12] of patients treated by either serial or late extraction of first premolars showed no difference in alignment of anterior teeth between the two groups after 10-year postretention observation.

Shields, et al.,[13] in an attempt to search for associations between long-term skeletal and dental change, performed a cephalometric appraisal of Little's postretention first premolar extraction sample. The incisor position posttreatment or postretention, as well as the amount or direction of facial growth, were found to be poor predictors of long-term mandibular incisor irregularity. Shields concluded that postretention changes of cephalometric parameters failed to explain postretention crowding and the dental cast measurements and cephalometric parameters were not interrelated.

Nonextraction treatment studies after postretention observation has further added to our knowledge of retention and relapse.[7,9,14-16] However, the lesser degree of initial crowding present in patients treated without extraction may bias these studies. Therefore, direct comparison of extraction samples and non-extraction samples must be made with caution. Shapiro studied a nonextraction sample of 22 individuals 10 years postretention.[7] Mandibular arch length and intercanine width decreased during the postretention period regardless of whether or not arch length had increased or decreased during treatment. The mean mandibular intermolar width increased during treatment and decreased during postretention in all groups with the exception of Class II division 2 patients. However, the Class II division 2 sample size was quite small, and the former conclusion is suspect given current evidence that the same sample size has been expanded. The nonextraction group experienced significantly less of a decrease in intermolar width during postretention than when premolars were extracted.

Glenn assessed the long-term stability of 28 nonextraction patients.[14] In 96% of the patients, arch length decreased significantly during an average of 8 years postretention. Likewise, 95% of the patients whose intercanine width increased during treatment showed reduction during the postretention period. Intermolar width also decreased whereas overjet and overbite showed no significant postretention change. Incisor irregularity showed only a modest increase during the postretention period, but this sample was unique in that all patients were minimally crowded before treatment and no significant arch enlargement was induced by the treatment. In observing skeletal relationships, Class II malocclusions with large ANB values and short mandibular lengths were associated with increased incisor irregularity, shorter arch length, and deeper overbites at the postretention stage. Overall, the cephalometric measures showed few changes that might contribute to or explain posttreatment relapse.

In a study by Little, et al., when arch length was enlarged during the mixed dention ("arch development"), a statistically significant and often dramatic reduction in arch width and length occurred postretention along with quite significant crowding.[17]

The evidence suggests that in nonextraction and first premolar extraction treatment, arch length and arch width dimensions decrease and incisor irregularity increases from adolesence through early adulthood. Cephalometrically, no associations seem to exist for such treatment between postretention skeletal change and dental change. Little, et al., evaluated changes in mandibular anterior alignment from 10 to 20 years postretention for 31 patients with premolar extractions.[18] Crowding continued to increase during this later phase but to a lesser degree than from the end of retention to 10 years postretention.

Joondeph and McNeill noted that early removal of mandibular deciduous second molars in individuals with congenitally absent second premolars often results in a favorable physiologic drift pattern with improved root parallelism, occlusion and contact relationship before active orthodontic treatment than in first premolar serial extraction treatment.[19] Joondeph and Riedel advocated extraction of mandibular second deciduous molars plus enucleation of second premolars because of this favorable drift pattern for cases with moderate arch length deficiency combined with an absence of dentofacial protrusion. They concluded, "The favorable dental changes associated with this approach greatly minimize future orthodontic treatment complexity and time."[20]

Intervention during the mixed dentition by serial extraction of deciduous teeth along with enucleation of second premolars or later second premolar extraction after full eruption in the permanent dentition has yet to be studied postretention. The current investigation is a descriptive and comparative study of such treatment modalities. It was our hope that such a study would further our knowledge and advance our understanding of relapse and reveal possible predictors or clinical guides.

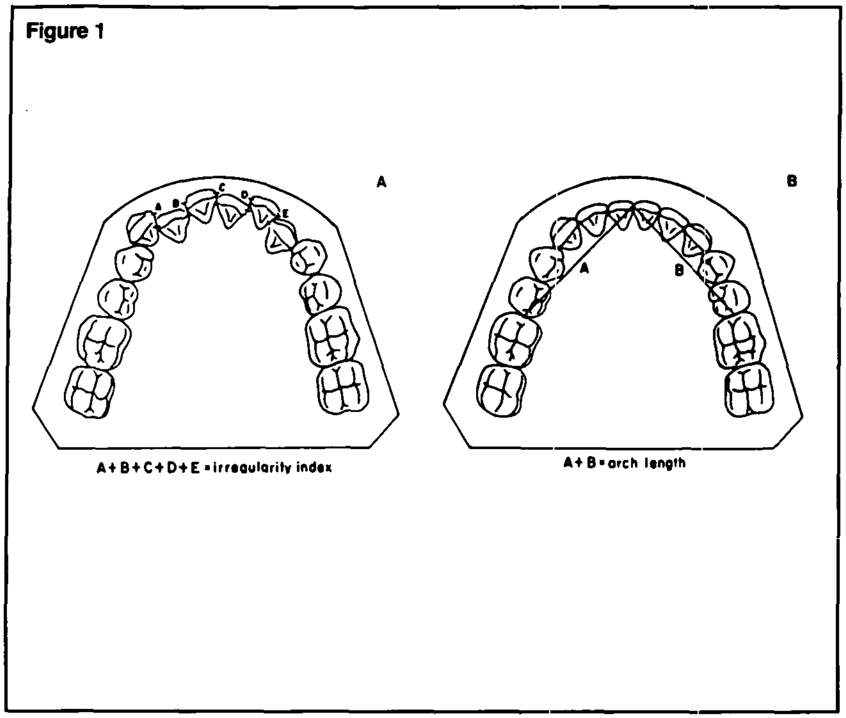
Materials and methods

The sample consisted of records for 46 patients treated with mandibular second premolar extraction. The patients were divided into the following two groups (Table 1):

a) Early (mixed dentition) extraction group (N=14) — second premolars were either congenitally missing or extracted prior to eruption. The remaining permanent teeth were allowed to undergo physiologic drift for a minimum of 1 year before comprehensive orthodontic treatment.

b) Late (permanent dentition) extraction group (N=32) — all permanent teeth anterior to the first permanent molars had erupted prior to any extractions. Active orthodontic treatment started shortly after extraction.

The patients in both groups underwent routine edgewise orthodontic mechanotherapy followed by at least 1 year of retention before removal of all retention devices. Most patients had at least 2 years of retention with a fixed mandibular canine-to-canine retainer. The records were collected from the University of Washington Department of Orthodontics, offices of faculty and offices of practitioners from the surrounding Seattle area. Patient records



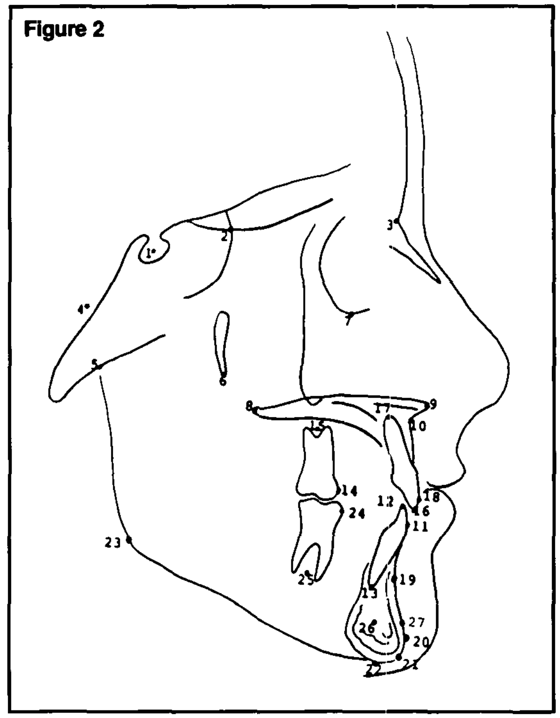


Figure 1
Measurement technique. A, irregularity index defined as the summed displacement of adjacent anatomic contact points of the six mandibular anterior teeth. B, arch length defined as the summed inside measurement from mandibular first permanent molars to the central incisor contact point.

Figure 2
Cephalometric points digitized.

were considered complete only if dental casts and cephalometric radiographs were available before treatment (T1), at the end of treatment (T2) and at the end of a minimum of 10 years out of retention (T3). The degree of postretention change did not influence inclusion or exclusion from the sample.

The average postretention period was 15 years for the early extraction group and 17 years for the late extraction group. Sulcus slice procedures (circumferential supracrestal fibrotomy) were not performed on any of the patients.

With dial calipers calibrated to .01 mm, the following measurements were obtained by a single examiner for each set of casts:

Mandibular intermolar width — the distance between the mesiobuccal cusp tips of the permanent first molars or estimated cusp tips in cases of wear facets.

Mandibular intercanine width — the distance between cusp tips or estimated cusp tips for 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 (Figure 1).

Irregularity Index — as suggested by Little,[21] the summed displacement of distances between the anatomic contact points of the mandibular anterior teeth from mesial of canine to mesial of canine (Figure 1).

Overbite — mean overlap of maxillary to mandibular 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.

Ten dental casts were randomly selected and remeasured 2 weeks later. The mean errors in assessing Irregularity Index, arch width, arch length, overbite and overjet ranged from .09 to .27 mm.

For each patient three lateral cephalometric radiographs (T1, T2, T3) were digitized. A total of 27 landmarks were identified on each film (Figure 2), to obtain 13 angular measurements, six linear measurements, and two facial proportions computed using the Dentofacial Planner software package. These data were then analyzed statistically to determine predictors or associations in the changes of dental and skeletal parameters for the three time periods.

Standard descriptive statistical calculations for the three time periods were obtained on each of the two sample groups. The statistics were also computed after segregating each sample according to the Angle classification and gender. Differences were assessed by the Student's t-test, the levels of statistical significance established at $p \leq .05$. Associations between variables were evaluated by the Pearson Product-Moment Correlation Coefficient. Regression analysis was also performed to search for associations between variables. The statistical significance level was established at $p \leq 0.05$ and a correlation value

Table 2A
Dental cast measurements — early extraction group
(Mean ± SD mm)

Variable	Pretreatment T1	End of Treatment T2	Postretention T3
Intermolar width (mm)	40.5 ± 2.6	39.0 ± 2.5 *	38.4 ± 2.3 *
Arch length (mm)	55.7 ± 5.2	48.2 ± 3.0 *	45.7 ± 2.3 *
Intercanine width (mm)	25.4 ± 1.5	26.4 ± 1.3 *	24.9 ± 1.7 *
Incisor Irregularity	4.0 ± 2.0	1.5 ± 0.4 *	3.5 ± 1.5 *
Overbite	4.3 ± 1.5	2.3 ± 0.7 *	3.0 ± 1.6
Overjet	4.7 ± 2.5	2.0 ± 0.6 *	2.5 ± 1.0

* Indicates a statistically significant difference (p<0.05) from the previous treatment period.

Table 2B
Dental cast measurements — late extraction group
(Mean ± SD mm)

Variable	Pretreatment T1	End of Treatment T2	Postretention T3
Intermolar width (mm)	41.8 ± 2.6	39.7 ± 2.0 *	38.7 ± 2.1 *
Arch length (mm)	59.4 ± 3.7	48.4 ± 2.3 *	45.5 ± 2.1 *
Intercanine width (mm)	25.8 ± 2.2	26.5 ± 1.7 *	24.7 ± 1.7 *
Incisor Irregularity	5.4 ± 3.0	1.4 ± 0.6 *	4.0 ± 1.7 *
Overbite	4.3 ± 1.8	2.4 ± 1.0 *	3.5 ± 1.2 *
Overjet	5.7 ± 3.5	2.2 ± 0.9 *	3.0 ± 1.5 *

* Indicates a statistically significant difference (p<0.05) from the previous treatment period.

(r) of 0.6 or better was considered clinically significant.

Measurement error was assessed by digitizing ten randomly selected tracings on two separate occasions. This showed an average correlation coefficient of $r = .99$ between the two trials.

Results

Dental cast data (Table 2)

Arch length. Since the sample consisted of patients who had permanent teeth extracted, arch length decreased in all instances during treatment. During the postretention period (T2 to T3), the early and late extraction groups continued to show statistically significant decreases in arch length of $\overline{X} = 2.5 \pm 1.8$ mm ($p < .001$) and $\overline{X} = 3.6 \pm 3.9$ mm ($p < .001$), respectively. No significant difference was noted between the two groups in terms of either the degree of arch length change (T2-T3) or final arch length (T3).

In assessing the changes of other dental parameters and their associations with changes in arch length, no clinically useful correlations were found for either group. A moderate association did exist between the postretnetion (T2-T3) change of incisor irregularity and postretention change in arch length in the early extraction group ($r = -.62$, $p < .01$). However, in the late extraction group the correlation was neither clinically nor statistically significant.

Arch width. Generally, intermolar width decreased during treatment except in a few instances where the increase was less than 1 mm. In the early extraction group the decrease in the intermolar width from T2 to T3 was statistically significant ($\overline{X} = -0.6 \pm 0.6$ mm, $p < .05$). The late extraction group also showed a statistically significant decrease in intermolar width ($\overline{X} = -1.0 \pm 1.3$ mm, $p < .05$), but the difference was not statistically significant between the two groups from T2 to T3, or in the final width at T3. No correlation was noted in either group between the change in intermolar width from

Table 3A
Cephalometric data — early extraction group
(Mean ± SD mm/°)

Variable	Pretreatment T1	End of Treatment T2	Postretention T3	Treatment T1 - T2	Overall T1 - T3	Posttreatment T2 - T3
SN-Pg angle	103.8 ± 4.6	101.9 ± 4.3	102.2 ± 4.2	1.9 ± 2.1	1.6 ± 2.4	-0.3 ± 2.3
ANB angle	5.8 ± 2.6	3.6 ± 1.8	3.0 ± 1.7	2.1 ± 1.7	2.7 ± 1.7	0.6 ± 0.8
SNA angle	81.4 ± 4.6	80.2 ± 4.8	79.1 ± 4.2	1.2 ± 1.8	2.3 ± 2.2	1.1 ± 2.1
SNB angle	75.6 ± 4.4	76.6 ± 4.2	76.1 ± 4.1	-1.0 ± 2.0	-0.5 ± 2.1	0.5 ± 2.2
⊥ to T angle	131.5 ±11.2	136.7 ± 7.5	136.5 ± 8.2	-5.2 ±13.7	-5.1 ±14.6	0.2 ± 5.2
Occlusal plane - SN angle	18.3 ± 5.6	18.9 ± 3.9	19.8 ± 3.9	-0.5 ± 4.8	-1.5 ± 3.2	-0.9 ± 4.1
T - MnPl angle	89.6 ± 6.3	89.2 ± 6.4	91.0 ± 7.3	0.5 ± 6.2	-1.4 ± 7.7	-1.8 ± 4.5
T - NB angle	23.8 ± 5.1	23.3 ± 4.8	23.4 ± 5.1	0.5 ± 6.3	0.4 ± 7.6	-0.2 ± 4.4
Y-axis - SN angle	68.8 ± 4.0	68.7 ± 4.5	69.1 ± 3.8	0.0 ± 2.0	-0.3 ± 2.1	-0.4 ± 2.1
Lower anterior facial height	62.9 ± 5.3	69.4 ± 8.3	72.0 ± 8.4	-6.6 ± 4.8	-9.2 ± 5.2	-2.6 ± 1.6
Upper anterior facial height	50.7 ± 2.5	54.7 ± 3.3	57.0 ± 3.2	-4.1 ± 2.6	-6.3 ± 3.6	-2.3 ± 2.4
Total anterior facial height	113.5 ± 6.6	124.1 ±10.9	129.0 ±11.1	-10.6 ± 7.0	-15.5 ± 8.3	-4.9 ± 3.3
% nasal height	45.0 ± 2.0	44.0 ± 2.0	44.2 ± 2.2	1.0 ± 1.0	0.0 ± 1.0	0.0 ± 1.0
MnPl - Sn angle	38.6 ± 6.0	37.5 ± 3.4	36.4 ± 5.6	1.0 ± 2.9	2.2 ± 2.8	1.1 ± 3.0
Lower posterior facial height	39.0 ± 3.6	45.0 ± 4.0	49.0 ± 4.3	-6.0 ± 4.3	-10.0 ± 4.6	-4.0 ± 2.6
Total posterior facial height	68.7 ± 5.7	77.2 ± 5.4	82.3 ± 5.8	-8.6 ± 5.9	-13.6 ± 6.3	-5.0 ± 2.9
TPFH : TAFH	61.0 ± 5.0	62.0 ± 5.0	63.8 ± 4.2	-2.0 ± 3.0	-3.0 ± 2.0	1.0 ± 3.0
S-Ar-Go angle	142.7 ± 7.7	144.2 ± 8.0	142.8 ± 8.2	-1.4 ± 3.6	-0.1 ± 4.5	1.4 ± 2.6
Gonial angle	132.6 ± 6.6	130.0 ± 6.0	128.7 ± 7.4	2.6 ± 2.7	3.9 ± 3.4	1.3 ± 2.6
Mn length	97.5 ± 6.8	107.9 ± 7.3	112.3 ± 7.3	-10.5 ± 6.3	-14.9 ± 6.9	-4.4 ± 1.9
Symphysis inclination	97.6 ± 8.4	88.8 ± 6.4	87.0 ± 6.8	8.8 ± 5.7	10.7 ± 5.4	1.9 ± 3.9

T1 to T2 or T2 to T3 and the postretention change in incisor alignment.

In contrast to the decrease during treatment in intermolar width, the mean intercanine width increased an average 1.0 ± 1.4 mm in the early extraction group and 0.7 ± 2.0 mm in the late group. Both distances decreased during postretention and the change for each was statistically significant (Early: $\overline{X}$ = 1.5 ± 1.2 mm, Late: $\overline{X}$ = -1.8 ± 1.1 mm). The difference between extraction groups from T2 to T3 was not statistically significant.

When comparing treatment changes and postretention changes in intercanine width, weak negative correlations were noted for both groups. Also, no correlations were found when comparing an increase in intercanine width during treatment and incisor alignment at T3. During the postretention period (T2-T3), the changes in intercanine width versus incisor alignment showed no correlation.

Irregularity index. At pretreatment there were no statistically significant differences between groups (Early: $\overline{X}$ = 4.0 ± 2.0 mm, Late: $\overline{X}$ = 5.4 ± 3.0 mm). Both groups improved to acceptable levels by the end of treatment (Early: 1.5 ± 0.4 mm, Late: 1.4 ± 0.6 mm). During the postretention period, both groups crowded and again the difference was not statistically significant (Early: 3.5 ± 1.5 mm, Late: 4.0 ± 1.7 mm).

No correlation existed between pretreatment and postretention incisor alignment for either sample group. Moreover, no associations were found during or after treatment between alignment and any other variable. Furthermore, no association was found between incisor alignment at T3 and any cephalometric measure at T1, T2, T3 or changes from T1 to T2 or T2 to T3.

The sample groups were further divided by Angle classification and gender. Only at T3 was a statistically significant association noted. The mean incisor T3 alignment of $\overline{X}$ = 4.4 ± 1.7 mm for Class II patients was significantly greater ($p<.05$) than that of $\overline{X}$ = 3.0 ± 1.2 mm for Class I patients. This difference pertained only to the late sample group, as the early sample group was too small to fairly test the differences. Gender differences did not exist in incisor alignment at any time interval for either sample group. However, after pooling the two extraction groups into one sample, males were found to have significantly more crowding than females at T3.

Overbite and overjet. Prior to treatment, the mean overjet values for the early and late sample groups were not significantly different. Over-

Table 3B
Cephalometric data — late extraction group
(Mean ± SD mm/°)

Variable	Pretreatment T1	End of Treatment T2	Postretention T3	Treatment T1 - T2	Overall T1 - T3	Posttreatment T2 - T3
SN-Pg angle	101.9 ± 3.4	100.9 ± 3.8	100.2 ± 4.2	1.0 ± 1.3	1.7 ± 2.6	0.7 ± 2.2
ANB angle	5.3 ± 2.0	3.6 ± 1.8	3.4 ± 2.5	1.7 ± 1.7	2.0 ± 2.2	0.2 ± 2.2
SNA angle	82.1 ± 3.5	80.9 ± 3.4	80.9 ± 3.7	1.2 ± 2.2	1.3 ± 2.7	0.1 ± 2.5
SNB angle	76.9 ± 3.3	77.3 ± 3.5	77.5 ± 3.8	-0.5 ± 1.3	-0.7 ± 2.5	-0.2 ± 2.5
⊥ to T angle	127.7 ±15.0	134.0 ±10.1	135.5 ±12.5	-6.2 ±11.8	-7.7 ±11.8	-1.5 ± 9.1
Occlusal plane - SN angle	15.3 ± 4.5	17.8 ± 4.56	17.3 ± 5.3	-2.5 ± 3.7	-2.0 ± 5.4	-0.5 ± 4.1
T - MnPl angle	91.8 ± 7.3	91.8 ± 7.2	91.6 ± 8.3	-0.0 ± 6.7	0.2 ± 7.0	0.2 ± 5.3
T - NB angle	24.3 ± 7.9	25.0 ± 6.2	23.4 ± 8.0	-0.6 ±6,8	0.9 ± 7.0	1.5 ± 5.4
Y-axis - SN angle	66.9 ± 3.8	67.0 ± 4.2	66.6 ± 4.6	-0.1 ± 1.4	0.3 ± 2.1	0.4 ± 1.7
Lower anterior facial height	62.0 ± 5.0	65.6 ± 4.9	67.8 ± 5.4	-3.6 ± 2.0	-5.7 ± 3.3	-2.1 ± 2.1
Upper anterior facial height	51.5 ± 3.3	53.7 ± 3.7	54.8 ± 4.1	-2.2 ± 2.3	-3.4 ± 2.9	-1.1 ± 1.7
Total anterior facial height	113.5 ± 7.3	119.3 ± 7.1	122.5 ± 8.0	-5.8 ± 3.7	-9.0 ± 5.3	-3.3 ± 2.7
% nasal height	45.0 ± 2.0	45.0 ± 2.0	44.9 ± 2.1	0.0 ± 1.0	0.0 ± 2.0	0.0 ± 1.0
MnPl - Sn angle	35.8 ± 5.7	35.9 ± 6.0	34.4 ± 6.8	-0.1 ± 1.7	1.4 ± 2.8	1.5 ± 2.2
Lower posterior facial height	41.8 ± 2.9	44.9 ± 3.9	48.4 ± 5.4	-3.1 ± 2.8	-6.6 ± 4.8	-3.5 ± 3.1
Total posterior facial height	71.0 ± 4.8	75.1 ± 5.1	79.3 ± 6.7	-4.1 ± 3.2	-8.3 ± 5.2	-4.2 ± 3.1
TPFH : TAFA	63.0 ± 4.0	63.0 ± 4.0	64.9 ± 5.3	0.0 ± 2.0	-2.0 ± 3.0	-2.0 ± 2.0
S-Ar-Go angle	141.9 ± 6.5	142.2 ± 6.8	141.2 ± 6.7	-0.4 ± 2.7	0.6 ± 3.3	0.9 ± 2.7
Gonial angle	130.8 ± 5.3	130.3 ± 5.1	129.5 ± 5.3	0.5 ± 1.2	1.3 ± 1.9	0.8 ± 1.4
Mn length	101.1 ± 4.9	106.9 ± 5.2	111.0 ± 6.9	-5.8 ± 3.2	-9.9 ± 6.0	-4.1 ± 3.3
Symphysis inclination	89.9 ± 9.6	85.1 ± 9.8	82.6 ±10.2	4.5 ± 6.0	7.0 ± 7.0	2.5 ± 3.9

jet decreased at a statistically significant level in both sample groups during treatment. Also the net decrease in overjet between pretreatment and postretention measurements was statistically significant. However, in the late extraction group, a statistically significant increase was observed in overjet ($\overline{X} = 0.8 \pm 1.3$ mm), during the postretention period. In the T1-T3 period for the early sample group, the mean change in overjet correlated with an increase in the Irregularity Index ($r = .67$, $p < .05$). No association was found for the late sample group. The amount of postretention crowding at T3 and the T2-T3 change in overjet in the early sample were also associated ($r = .62$, $p < .05$).

During the postretention period, overbite did not change significantly in the early sample group. However, the mean increase (1.1 mm, $p < .05$) in the late group was statistically significant. Overall, a net decrease in overbite between pretreatment and postretention (T1-T3) occurred in both sample groups. No association was found between postretention change in incisor alignment and postretention change in overbite. Similarly, the amount of postretention crowding was not related to the change in overbite during treatment or after treatment.

Cephalometric data (Table 3)

An effort was made to find relationships between various cephalometric measurements and the postretention change in incisor alignment for both the early and late extraction groups. The mean of each group for each time interval was tested for possible correlation with the change in incisor alignment T2-T3 and T3 alone. No significant relationship was found among any of the variables. Moreover, the cephalometric changes between the time periods (T1-T2, T2-T3, T1-T3) were not associated with the postretention change in the Irregularity Index. The difference between the early and late extraction groups was not notable in terms of mean values of the cephalometric variables.

The sample groups were combined and then regrouped according to postretention (T3) incisor alignment. One group consisted of patients with an Irregularity Index of <3.0 mm at T3 (N=14) while the other group included index values >5.0 mm (N=11). A statistically significant difference was noted in treatment change of total posterior facial height (T2-T3). The "minimally" crowded group had a mean increase of 3.3 ± 2.2 mm while the mean increase of the crowded group was 5.6 ± 3.0 mm. Lower posterior facial height changed in a similar manner,

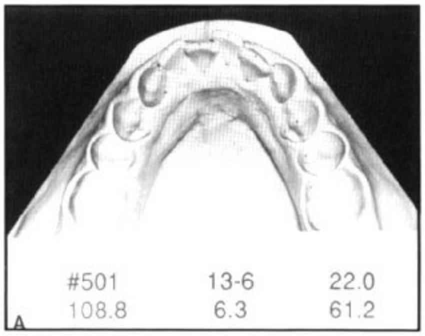


Figure 3A

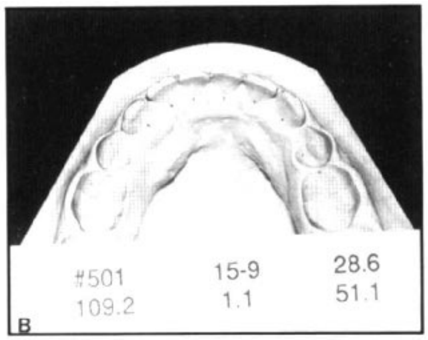


Figure 3B

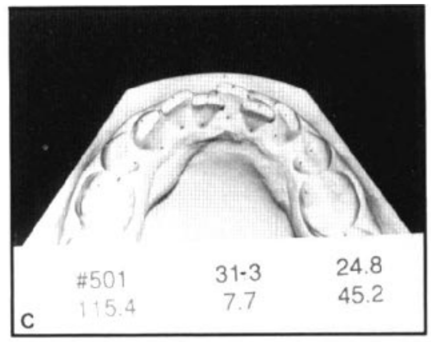


Figure 3C

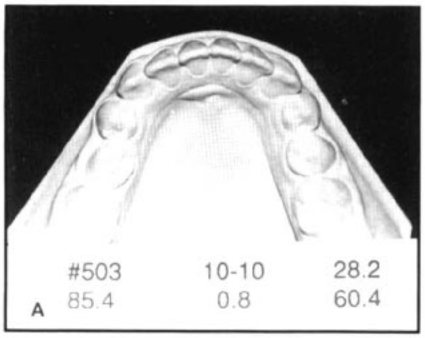


Figure 4A

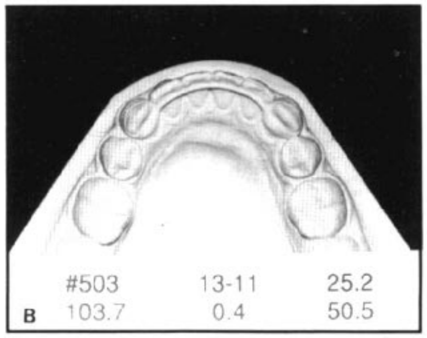


Figure 4B

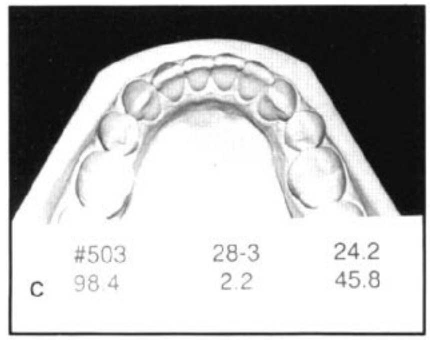


Figure 4C

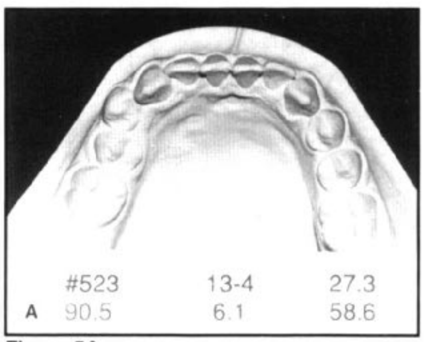


Figure 5A

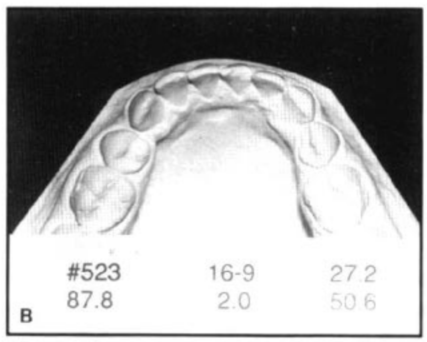


Figure 5B

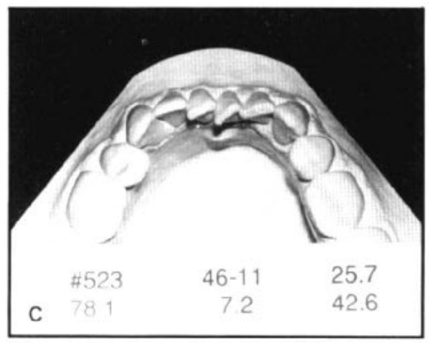


Figure 5C

Figures 3-5
Pretreatment (A), posttreatment (B), and postretention (C) casts. Data shown represent case number, age in years and months, intercanine width, inclination of mandibular incisors to MnPl, irregularity index, and arch length.

the crowded group increasing more than the minimally crowded group.

At pretreatment (T1), the mean gonial angle of the crowded group was smaller than that of the non-crowded group (X = 127.9 ± 6.1° vs. X = 133.3 ± 5.4° [$p<.05$]). The gonial angle at T2 also differed significantly, ($p<.05$) with the non-crowded group having the greater angle than the crowded group. Another notable and statistically significant difference at T2 was upper anterior facial height. The non-crowded group had a smaller mean upper facial height of 52.8 ± 2.9 mm compared to the crowded group at 55.3 ± 2.9 mm.

Finally, statistically significant differences were noted among the cephalometric variables at the final T3 stage. The minimally crowded group had a smaller upper anterior facial height when compared to the crowded group. Also, the crowded group had a greater lower posterior and total posterior facial height. Consistent with T1 and T2 findings, the gonial angle at T3 was greatest in the minimally crowded group.

Examples

Several typical examples help illustrate the variation in response during the posttreatment period.

Patient 501 (Fig. 3). Postretention crowding in combination with clinically significant arch width and arch length reduction characterized this late second premolar extraction treatment. By age 31, crowding had increased to a level greater than the pretreatment value. Intercanine width was markedly increased during treatment followed by a 4 mm postretention constriction. Arch length reduction posttreatment was also quite marked (6 mm).

Patient 503 (Fig. 4). In contrast to the previous case, relative stability characterized this late extraction case. The intercanine dimension was constricted during treatment and continued to constrict slightly postretention.

Patient 523 (Fig. 5). In spite of good pretreatment incisor alignment, this late extraction case demonstrated considerable postretention

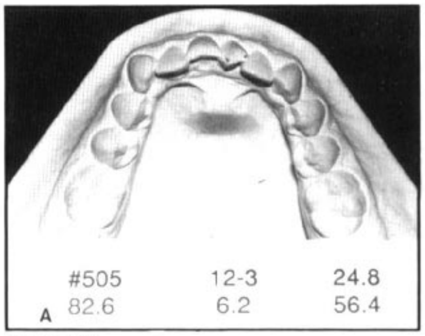


Figure 6A

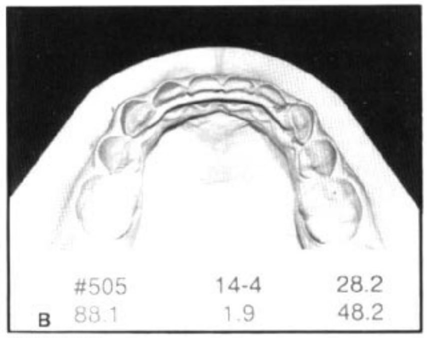


Figure 6B

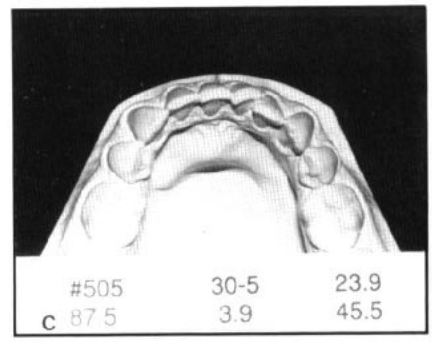


Figure 6C

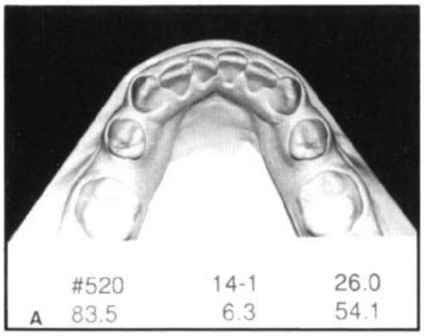


Figure 7A

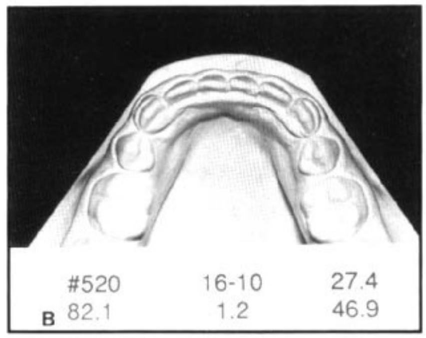


Figure 7B

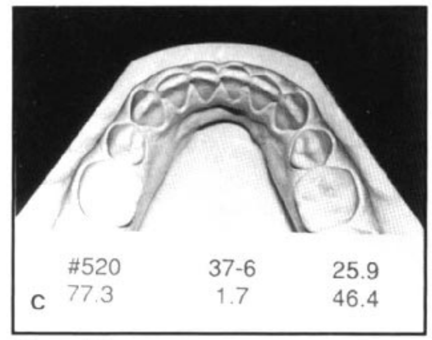


Figure 7C

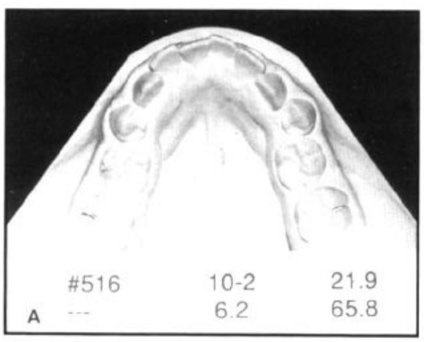


Figure 8A

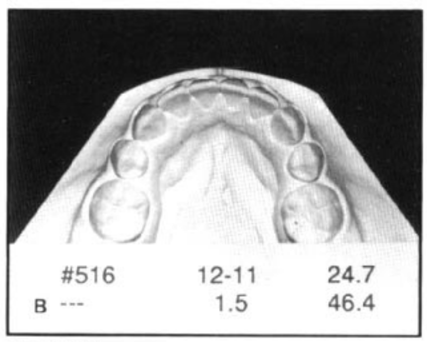


Figure 8B

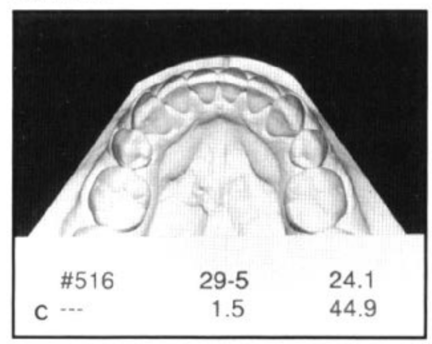


Figure 8C

Figures 6-8
Pretreatment (A), posttreatment (B), and postretention (C) casts. Data shown represent case number, age in years and months, intercanine width, inclination of mandibular incisors to MnPl, irregularity index, and arch length.

rotation of incisors. Although intercanine width was maintained during treatment, there was a reduction of both arch width and arch length postretention.

Patient 505 (Fig. 6). Postretention crowding was primarily confined to a single incisor in this late extraction case. Arch width was widened over 3 mm and then decreased to less than the pretreatment value. Fortunately, arch length decrease posttreatment was modest.

Patient 520 (Fig. 7). Minimal relapse characterized this serial extraction case. The single incisor rotation mimicked the pretreatment condition. Note that the incisor was not fully corrected during treatment. Arch width change during treatment was minimal as was postretention change. Arch length change postretention was also minimal with the unusual finding of spacing between canines and premolars.

Patient 516 (Fig. 8). Near perfection at age 29 was evident for this serial extraction case. Minimal arch width and arch length change postretention was noted. Unfortunately such fine results were unusual for both the serial extraction and late extraction samples.

Discussion

This study of mandibular second premolar extraction in the mixed and permanent dentition supports our earlier findings of postretention change. No predictors or associations were found to help the clinician in diagnosing and treatment planning for improved long-term stability. Individual variability in combination with the interaction of multiple factors muddles any simple answer. This study does not support the concept that stability is enhanced by extracting teeth before their eruption and allowing physiologic drift. Witzel,[11] and Little, et al.,[12] came to the same conclusion comparing postretention changes in patients who were treated with serial versus late extraction of first premolars.

This study agrees with previous findings that arch length appears to decrease with time posttreatment, regardless of treatment modality.[6-12,17-18] This also agrees with the maturation of untreated individuals as shown by Sinclair and Little.[5] By comparing the "extremes" of the sample, crowded and non-crowded, the detection of significant differences became more apparent in the present study. The crowded group of patients experienced a significantly greater (almost double) decrease in arch length when compared with the non-crowded group. It is interesting to note that, as in past studies, no statistically significant association was found between a decrease in arch length and an increase in incisor irregularity.

Postretention decrease in the intermolar distance was typical, a finding corroborating the findings of Shapiro pertaining to 10-year postretention extraction patients.[7] The studies of Arnold[22] and Welch[23] also support posttreatment arch width decrease.

Although postretention changes in intercanine width presented a varied response, a pattern was noted in both the early and late sample groups. An increase of intercanine distance during treatment was often followed by postretention decreases to less than the original intercanine dimension. Out of the total 46 patients, only 7 maintained posttreatment intercanine arch widths greater than their pretreatment values. The present study demonstrates the unfortunate fact that intercanine width typically decreases with time regardless of whether the patient is treated or untreated, extracted or not extracted. In agreement with Little's findings, the postretention decrease in intercanine width was not associated with an increase in incisor irregularity.[8,12,18]

The present study failed to demonstrate any correlation between pretreatment and postretention alignment, a finding similar to that of Little.[8] In agreement with Little's first premolar extraction study, the initially severely crowded patients in the present study showed a net improvement (T1-T3) in incisor alignment while the initially well-aligned cases typically became worse.

In contrast to Little[8] and Uhde,[24] the current investigation showed a significant increase in overjet from T2 to T3 in the late extraction group. One explanation for this may be that the present study had 25% more Class II patients than Little and Uhde's samples. In agreement with Little, there was a significant increase in overbite in the late extraction group during the postretention period. Despite the increase in overbite, less than 10% of the total sample had a return in overbite to an amount equal to or greater than the pretreatment value.

After evaluating the postretention changes in the cephalometric findings of the early and late extraction groups, no significant differences or useful findings were noted. No pretreatment, end of treatment or postretention cephalometric values or changes in those values during treatment or posttreatment were clinically useful.

Treatment and postretention change in the axial inclination of the teeth and the relation to incisor irregularity was highly variable. The sample included several patients whose incisor inclination was maintained during treatment, but then experienced 5° of proclination posttreatment and remained severely crowded (Figure 3). Other patients demonstrated a decrease in incisor inclination during treatment and continued to decrease during the postretention period and became severely crowded (Figure 5). Still others, who were significantly proclined during treatment, had minimal crowding at T3 (Figure 4). There was no trend in the minimally crowded sample either. The variability was such that treating to accepted cephalometric norms seems to not be a reliable predictor of postretention incisor alignment stability.

After establishing two subgroups based on postretention incisor alignment, the group of patients that had moderate to severe mandibular incisor irregularity demonstrated greater overall vertical growth in total posterior facial height during the postretention period. Upper anterior facial height and total posterior facial height were significantly greater in the crowded group at T3. In measuring direction of growth, the angles MnPl to Sn and Y-axis to Sn were used. The crowded and uncrowded groups both had similar values in the changes of these angles from T1 to T3.

Shield's study of first premolar extraction cases suggested that patients with higher occlusal and mandibular plane angles represented those more likely to have a significant decrease in postretention arch length.[13] The present study does not support this concept. The crowded group in the present study experienced arch length decreases significantly more than the non-crowded group, and had a mandibular plane angle equal to that of the non-crowded group. However, as suggested by Björk and Skieller, interpreting changes in the mandibular plane angle by conventional cephalometry is complicated by the compensating remodeling of the lower border of the mandible.[25]

Gender may be a contributing factor in postretention stability and relapse. The non-crowded group consisted of 15% males compared to 45% in the crowded group. In Sinclair and Little's study of dentofacial maturation of untreated normals, they found that females developed more crowding than males by adult years.[26] Males had significantly greater total posterior and anterior facial heights than females. In contrast to the present study, they showed gonial angles to be similar between genders. Deriving any conclusions from these differences in facial growth is difficult, yet it can be thought that facial growth may be a factor in the long-term stability of the dentition. Björk and Skieller believed that facial development may affect secondary crowding. They suggest that as the maxilla and mandible grow and rotate, compensating mechanisms can take place in the eruption of the dentition that may lead to crowding. As yet, the issue of gender differences, growth and postretention crowding remain unresolved.

Clinical implications

The clinical application of these results are quite important in the proper counseling of patients. When considering treatment increase of intercanine width, the clinician must keep in mind that a high percentage of patients treated with expansion will show postretention decrease to a width less than the pretreatment value. Therefore long-term or permanent retention may be mandatory for cases treated with intercanine width increase.

The present study demonstrates that greater long-term stability is not achieved by serial extraction of second premolars before their eruption. However, periodontal concerns, profile, treatment time, etc. may be viable indications for the early extraction of teeth.

From a clinical aspect, retention should receive high priority in the treatment planning of each patient. Patients with minimal pretreatment crowding will not necessarily have greater stability than patients with severe pretreatment incisor irregularity. Those who undergo serial extraction seem to be no more stable than those extracted after full eruption of the dentition. Owing to the fact that patients are highly variable and unpredictable in terms of long-term stability, clinicians need to inform each patient on the importance of long-term retention. Patients must realize that they play an active and vital role in the long-term maintenance of the treated result.

Acknowledgement

Unbiased collection and assessment of seria records continues to be a primary research goa of the Department of Orthodontics at the University of Washington; we are grateful to oui Orthodontic Alumni Association for its continuing financial support of this effort.

Author Address

Dr. Robert M. Little
Department of Orthodontics SM-46
School of Dentistry
University of Washington
Seattle, WA 98195

D. McReynolds is in private practice in Keller, Texas.
R.M. Little is Professor and Graduate Program Director in the Department of Orthodontics, University of Washington.

References

1. Goldstein, A.: The dominance of the morphological pattern: implications for treatment. Angle Ortho., 23:187-194, 1953.
2. Nance, H.N.: The limitations of orthodontic treatment. Am. J. Orthod., 33:253-301, 1947.
3. DeKock, W.H.: Dental arch depth and width studied longitudinally from 12 years of age to, adulthood. Am. J. Orthod., 62:56-66, 1972.
4. Barrow, G.V., White, J.R.: Developmental changes of the maxillary and mandibular dental arches. Angle Orthod., 22:41-46, 1952.
5. Sinclair, P.M., Little, R.M.: Maturation of untreated normal occlusions. Am. J. Orthod., 83: 114-123, 1983.
6. Little, R.M., Riedel, R.A.: Postretention evaluation of stability and relapse — mandibular arches with generalized spacing. Am. J. Orthod. Dentofac. Orthop., 95:37-41, 1989.
7. Shapiro, P.A.: Mandibular dental arch form and dimensions. Am. J. Orthod., 66:58-69, 1974.
8. Little, R.M., Wallen, T.R., Riedel, R.A.: Stability and relapse of mandibular anterior alignment — first permolar cases treated by traditional edgewise orthodontics. Am. J. Orthod., 80:349-364, 1981.
9. Gallerano, R.L.: Mandibular anterior crowding — a postretention study. University of Washington Master's Thesis, 1976.
10. Kinne, J.H.: Untreated first premolar serial extraction: long-term observation. University of Washington Master's Thesis, 1975.
11. Witzel, D.A.: Long-term stability of the mandibular arch following differential management of arch length deficiencies. University of Washington Master's Thesis, 1978.
12. Little, R.M., Riedel, R.A., Engst, E.D.: Serial extraction of first premolars — postretention evaluation of stability and relapse. Angle Orthod., 60:255-262, 1990.
13. Shields, T.M., Little, R.M., Chapko, M.K.: Stability and relapse of mandibular anterior alignment — a cephalometric appraisal of first premolar extraction cases treated by traditional edgewise orthodontics. Am. J. Orthod., 87:27-38, 1985.
14. Glenn, G., Sinclair, P.M., Alexander, R.G.: Nonextraction orthodontic therapy: posttreatment dental and skeletal stability. Am. J. Orthod. Dentofac. Orthop., 92:321-328, 1987.

15. Litowitz, R.: A study of the movements of certain teeth during and following orthodontic treatment. Angle Orthod., 18:113-131, 1948.
16. Walters, D.C.: Comparative changes in mandibular canine and first molar widths. Angle Orthod., 32:232-240, 1962.
17. Little, R.M., Riedel, R.A., Stein, A.: Mandibular arch length increase during the mixed dentition — postretention evaluation of stability and relapse. Am. J. Orthod. Dentofac. Orthop., 97: 393-404, 1990.
18. Little, R.M., Riedel, R.A., Årtun, J.: An evaluation of changes in mandibular anterior alignment from 10 to 20 years postretention. Am. J. Orthod. Dentofac. Orthop., 93: 423-428, 1988.
19. Joondeph, D.J., McNeill, R.W.: Congenitally absent second premolars: an interceptive approach. Am. J. Orthod., 59:50-66, 1971.
20. Joondeph, D.J., Riedel, R.A.: Second premolar serial extraction. Am. J. Orthod., 69:169-184, 1976.
21. Little, R.M.: The irregularity index: a quantitative score of mandibular anterior alignment. Am. J. Orthod., 68:554-563, 1975.
22. Arnold, M.L.: A study of the changes of the mandibular intercanine and intermolar widths during orthodontic treatment and following postretention of 5 or more years. University of Washington Master's Thesis, 1963.
23. Welch, K.N.: A study of treatment and postretention dimensional changes in mandibular dental arches. University of Washington Master's Thesis, 1965.
24. Uhde, M.D., Sadowsky, C., BeGole, E.A.: Long-term stability of dental relationships after orthodontic treatment. Angle Orthod., 53:240-252, 1983.
25. Björk, A., Skieller, V.: Facial development and tooth eruption. Am. J. Orthod., 62:339-353, 1972.
26. Sinclair, P.M., Little, R.M.: Dentofacial maturation of untreated normals. Am. J. Orthod., 88: 146-156, 1985.

Commentary: Bad news is good news

By Lee R. Boese, DDS, MSD

Little and McReynolds' latest article continues the litany of bad news concerning stability following orthodontic therapy. In a series of comprehensive long-term retrospective studies dating back to the mid 1970s, Little et al. find: arch length and arch width decrease with time; lower incisor crowding increases throughout the postretention period regardless of the length of retention; intercanine width typically decreases with time; the relationship between the axial inclination of the lower incisors before and after treatment relative to lower crowding is highly variable; treating to accepted cephalometric norms seems not to be a realistic predictor of incisor stability; and finally, no predictors or associations could be found to help the clinician in determining the long-term prognosis for posttreatment stability.

As a result of these findings, a pall of gloom and pessimism appears to envelop the orthodontic community whenever we discuss the stability of orthodontic treatment. But a paradox exists for in the seeds of bad news springs good news.

The fact that the literature now contains many excellent long-term studies dealing with posttreatment stability is indeed good news. These studies are not merely anecdotal reports; they are based on large unbiased samples of serial orthodontic records covering a long posttreatment period. From this data it becomes obvious that the current strategy for achieving posttreatment stability is flawed. Merely plodding along the paths of traditional treatment will lead us in circles, and there will be no progress. Acknowledging this simple fact will be the first step towards achieving improvements in posttreatment stability.

Little reports no statistically significant relationship existed between arch length, intercanine width, overbite, lower incisor axial position and posttreatment change in lower incisor alignment. But it is important to realize that this study provides no way of evaluating the multifactorial nature of relapse, where several factors may act together or at different time intervals. The adroit orthodontist realizes that while changes in arch length, intercanine width and lower incisor position may not be predictors of relapse, they all appear to be links in the chain of relapse that we don't quite understand.

Finally, while it may be prudent for the orthodontist to inform the patient about the unpredictability of relapse and of the patient's active role in the long-term maintenance of treatment results, the orthodontist should not abdicate responsibility for achieving posttreatment stability. As orthodontists, we must take a more proactive approach when dealing with the factors of relapse and adopt new strategies for achieving posttreatment stability. However, any new strategy must stand up to Dr. Little's methodology of using an unbiased sample and evaluating stability from long-term serial records.

Dr. Little, thank you for the bad news!