Serial extraction of first premolars — postretention evaluation of stability and relapse

By Robert M. Little, DDS, MSD, PhD; Richard A. Riedel, DDS, MS; and E. David Engst, DDS, MSD

It is true that serial extraction procedures, when properly executed, will as a rule result in self-correction or prevention of the development of irregularities in the incisal segments of both maxillary and mandibular dentures. It is also true that such procedures, excluding the existence of abnormal tongue and swallowing habits, will permit the mandibular incisors to tip and move lingually to positions of functional balance, thus giving the orthodontist a valuable clue to the correct location and inclinations of these teeth. If such information is recorded and the positions and inclinations of the mandibular incisors maintained until the conclusion of orthodontic treatment, little difficulty will be experienced during the retention period."

—Charles H. Tweed, 1966

Kjellgren's "serial extraction",[1] and Hotz's "guidance of eruption"[2] were terms that emerged simultaneously in Europe during the late 1940s. Both concepts were proposed and have evolved as a planned sequence of deciduous dentition extractions followed by certain permanent dentition extractions (usually first premolars), the rationale being a method to relieve or eliminate severe crowding. Bunon in 1743 must be credited with the original concept but Kjellgren and Hotz certainly popularized the idea. As Proffit points out in his text,[3] the practice was advocated to reduce or eliminate subsequent appliance therapy, but now is looked upon as a way of reducing the severity of a developing malocclusion, an adjunct to later treatment and a means to make comprehensive treatment easier and often quicker.

Aside from clinical efficiency and reduced mechanotherapy, the enhanced stability issue is reflected in the introductory quote lifted from Tweed's text.[4] In short, he felt that early self-alignment should result in improved stability. Many have written on the subject expressing this same optimistic bias:

Dewel: "Clinically, extraction is not a radical solution in these extreme arch reduction irregularities; instead, it can be considered a conserva-

Abstract

Case records were evaluated for 30 patients who had undergone serial extraction of deciduous teeth plus first premolars followed by compehensive orthodontic treatment and retention. Diagnostic records were available for the following stages: pre-extraction, start of active treatment, end of active treatment, and a minimum of 10 years postretention. All cases were treated with standard edgewise mechanics and were judged clinically satisfactory by the end of active treatment. Twenty-two of the 30 cases (73%) demonstrated clinically unsatisfactory mandibular anterior alignment postretention. Intercanine width and arch length decreased in 29 of the 30 cases by the postretention stage. There was no difference between the serial extraction sample and a matched sample extracted and treated after full eruption.

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Key Words

Postretention • Relapse • Stability • Serial extraction

Table I. Sample characteristics

		Median (yr. - mo.)	Range (yr. - mo.)
Age			
Preextraction	(T0)	9 - 5	8 - 2 to 12 - 4
Pretreatment	(T1)	11 - 10	9 - 11 to 13 - 7
Posttreatment	(T2)	14 - 4	12 - 7 to 18 - 0
Postretention	(T3)	29 - 1	24 - 3 to 42 - 3
Retention Period		3 - 1	0 to 7 - 11
Postretention Period		11 - 3	9 - 4 to 22 - 7

tive treatment measure if relapse and failure are to be avoided."[5]

Norman: "A properly carried out correction does not need retention. The result is always more stable than any other technique."[6]

Graber: "However, such mechanotherapy (comprehensive treatment following serial extraction) is usually of significantly shorter duration, it is likely to produce less damage, and the results are more stable."[7]

Mayne: "Retention requirements are markedly lessened in serial extraction cases."[8]

Dale: "It seems logical that if a tooth completes its formation in a site where it will remain when treatment is completed it will be more stable. Conversely, if a tooth is left in a crowded, tipped, and rotated position for several years and then is moved to a new position relatively rapidly, it will be less stable for a time and will require a longer retention period."[9]

The focus in the literature has been on various strategies of extraction, their sequence and timing; little has been written on the stability of the treated result. A University of Washington graduate student unpublished thesis by Jon Kinne gave insight to what we might expect from the extraction process alone.[10] Fifty serial extraction cases that had not undergone subsequent orthodontic treatment were evaluated 10 years post-premolar extraction. These cases showed better long-term results than cases in which first premolar extraction in the full permanent dentition was followed by full treatment.

The reason for not publishing the Kinne thesis was fear that cases may have been biased in their selection. Cases were not treated for one of several reasons — perhaps financial concerns interfered or possibly no apparent need for treatment was perceived by the parent or practitioner. It's possible the cases that did not turn out well with extractions alone were treated while those that did turn out well with extractions and physiologic drift alone were not treated. The sample may have been non-random; cases may have been unintentionally selected as representing those that reacted favorably.

Persson, et al., reported on a sample of 42 serial extraction cases that received no subsequent orthodontic treatment.[11] At the mean age of 30, "...most cases at follow-up demonstrated a redevelopment of crowding, although this was less pronounced than before." As adults, the serial extraction cases were compared to a non-treated sample of 29 cases labeled "normal occlusions" at age 13. These had been followed without any extraction or orthodontic treatment to age 31. The "normals" showed increasing crowding during this time span and were similar in degree of crowding to that of the serial extraction group.

The purpose of the present study was to evaluate long-term serial records of patients who had undergone serial extraction plus comprehensive treatment and retention. Is serial extraction the panacea for crowding of anteriors? If crowding never develops or is corrected early, will stability be assured or at least improved? Were Tweed,

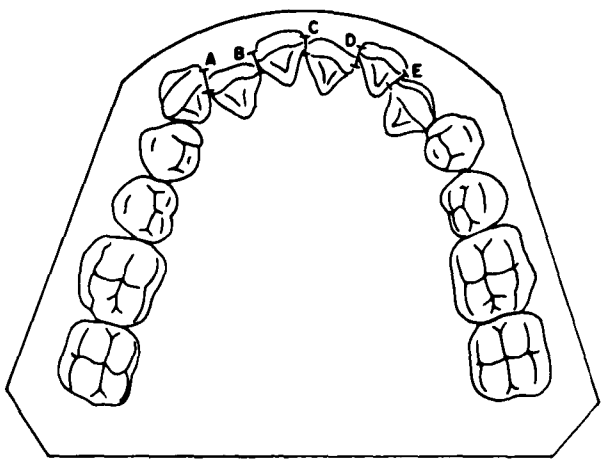


Figure 1A

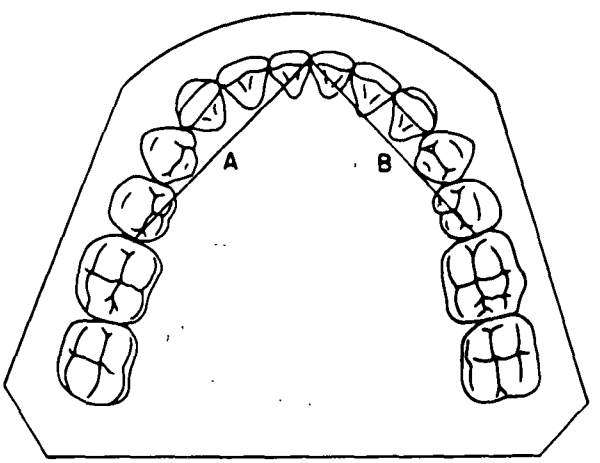


Figure 1B

Dewel, Graber, Mayne, Dale and others correct or were their views of stability too optimistic?

Materials and methods

The sample consisted of case records for individuals who had undergone a serial extraction program involving a series of deciduous tooth extractions with eventual removal of four first premolars during the mixed dentition. Following a period of physiologic drift and observation, active treatment involved fixed edgewise therapy followed by retention, usually of two years or more. Thirty cases with complete records were collected from the files of the graduate orthodontic clinic at the University of Washington and from the offices of faculty. To qualify for inclusion in the sample the last record had to be at least 10 years after discontinuing retention (range 10 to 22 years postretention).

For each case four sets of diagnostic casts were collected (Table 1): pre-extraction of premolars (T0), end of physiologic drift/beginning of active treatment (T1), end of active treatment/start of retention (T2), and a minimum of 10 years postretention (T3). Four of the 30 cases had aged to a point where an additional set of records were collected at 20 years postretention (T4). The cases were collected without consideration of the postretention quality of the result. Every effort was made to collect the sample without bias, the sole criteria being a well-treated result by the end of active care. All cases were either Angle Class I or II.

This study was a continuation of previous graduate student research by David Engst involving 30 serial extraction plus orthodontic treatment cases with a minimum 5-year postretention period.[12] This earlier sample was matched in rank order to a similar group of first premolar extraction cases that had been extracted after full eruption of the dentition and then followed to a 10-year postretention stage. The cases were matched on the basis of their original arch perimeter deficiency. The serial extraction group had a mean pretreatment arch length deficiency of 6.2 mm (range: 0.3 mm to 13.3 mm). The late extraction group had a mean pretreatment arch length deficiency of 6.7 mm (range: 0.8 mm to 15.0 mm).

To reduce examiner bias in the current study, each cast was measured in random order with similar measurement errors as in previous research (0.01 mm to 0.30 mm). A dial caliper was used to measure (at 0.01 mm) the following for each set of cases:

Irregularity Index — The summed displacement of the anatomic contact points of the mandibular anterior teeth, as described by Little (Figure 1A).[13] For the majority of the cases this value could only be determined at T2 and T3 because permanent canines usually had not yet erupted at T1.

Mandibular Arch Length — The sum of the left and right 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 1B).

Figure 1A&B Measurement technique. A — Irregularity Index was defined as the summed displacement of adjacent anatomic contact points of the six mandibular anterior teeth. B — Arch length was defined as the summed inside measurement from mandibular first permanent molars to central incisor contact point.

Table II. Mandibular anterior Irregularity Index values (mm.)

	Class I		Class II-1		Class II-2		All classes		Range
	N	Mean ± S.D.	N	Mean ± S.D.	N	Mean ± S.D.	N	Mean ± S.D.	
Pretreatment (T1)									
Male	2	3.70 ± 0.43	2	5.59 ± 1.35	1	4.01 ± 0.00			
Female	13	3.20 ± 0.98	2	6.51 ± 4.52	2	6.86 ± 3.08			
Pooled	15	3.26 ± 0.94	4	6.05 ± 2.77	3	5.91 ± 2.73	22~	4.13 ± 2.02	1.99 to 9.70
Posttreatment (T2)									
Male	3	1.03 ± 0.22*	2	2.29 ± 0.47*	1	2.33 ± 0.00*			
Female	16	1.65 ± 0.85*	4	1.78 ± 0.52*	4	2.63 ± 1.45*			
Pooled	19	1.55 ± 0.81*	6	1.95 ± 0.52*	5	2.57 ± 1.26*	30	1.80 ± 0.91*	0.49 to 4.21
Postretention (T3)									
Male	3	4.89 ± 3.27**	2	4.13 ± 1.56**	1	5.86 ± 0.00**			
Female	16	4.48 ± 1.67**	4	3.82 ± 1.14**	4	3.98 ± 1.05**			
Pooled	19	4.54 ± 1.88**	6	3.92 ± 1.14**	5	4.36 ± 1.24**	30	4.39 ± 1.64**	1.85 to 8.60

* Sig. Diff. at $p < .05$ T1 vs. T2
** Sig. Diff. at $p < .05$ T2 vs. T3
~ Irregularity Index was not determined for 8 of the 30 cases because not all 6 anterior teeth had erupted.

Mandibular Intercanine Width — The distance between cusp tips or estimated cusp tips in cases of wear facets. In most cases this value could not be measured at T1 because permanent canines were frequently not yet erupted.

Overbite — Mean overlap of upper to lower central incisors.

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

In addition to standard descriptive statistics for the four time periods and both pooling and segregating the sample by Angle class and gender, the following tests were performed: differences were assessed by the two-tailed *t* test, one-way analysis of variance and percent change. Association between variables was evaluated by the Pearson Product-Moment Correlation Coefficient. The significance level was established at $p \leq 0.05$ and a correlation value (r) of 0.6 or better was considered clinically significant.

Results

As illustrated in Table II, all 30 cases demonstrated satisfactory clinical results by the end of the active treatment record (T2), the average mandibular anterior irregularity reduced to minimal standards ($\overline{X} = 1.80 \pm 0.91$ mm). This significant reduction in crowding ($p<.05$) was followed by a significant increase by the postretention stage ($p<.05$). Average T3 postretention irregularity ($\overline{X} = 4.39 \pm 1.64$ mm) was slightly greater and not significantly different than the T1 pretreatment irregularity ($\overline{X} = 4.13 \pm 2.02$ mm). Pretreatment and postretention data showed a large range of crowding from minimal to very severe irregularity.

No significant gender differences were noted at any stage. Class I cases differed significantly from Class II cases only at T1, the Class II cases demonstrating greater pretreatment crowding. At the T2 and T3 stages there were no significant gender or Angle classification differences. Regardless of Angle classification or gender a significant treatment decrease in irregularity was followed by a significant increase postretention.

No clinically significant correlations were found comparing T3 irregularity with any other T1, T2 or T3 variable (arch length, intercanine width, overbite, overjet) or comparing T3 irregularity to change in dimension of these variables from T1 to T2 or T2 to T3.

From T2 to T3 stage, 28 of the 30 cases showed

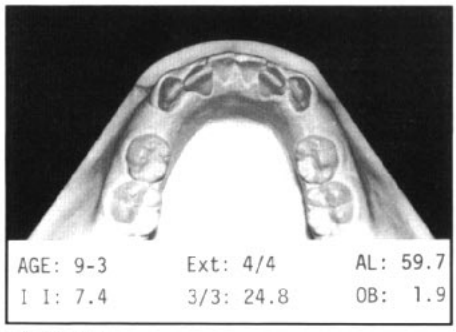


Figure 2A

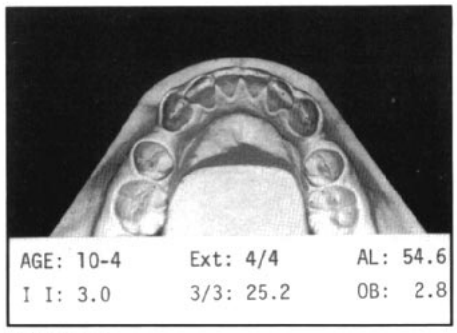


Figure 2B

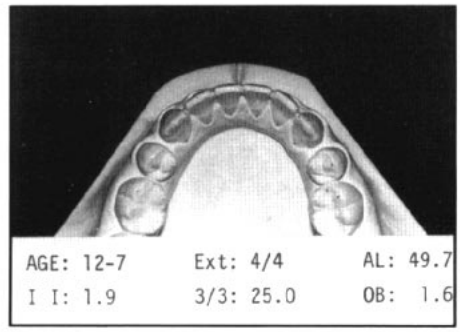


Figure 2C

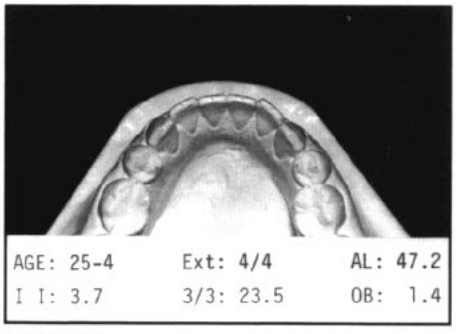
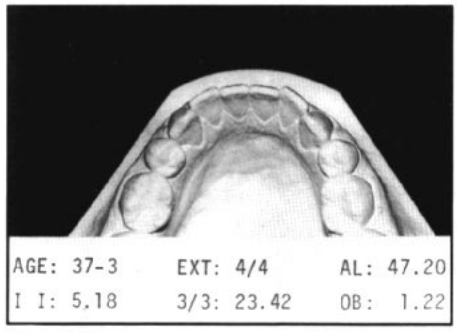


Figure 2D



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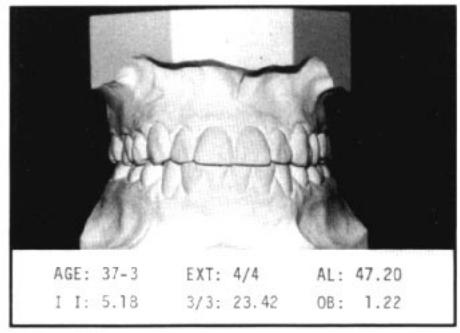

Figure 2F

Figure 2A-F
A) premolar extraction; B) end of observation stage; C) posttreatment; D) 10 years postretention; E&F) 20 years postretention

an increase in irregularity with two cases demonstrating no change. Eight cases had minimal crowding (<3.5 mm) at the T3 postretention stage while only three had severe crowding (>6.5 mm). Most were in the middle ground of moderate but clinically unacceptable irregularity (3.5-6.5 mm).

Intercanine width and arch length decreased in all but one case from T2 to T3, the unusual single case remaining essentially unchanged. During the pre-appliance stage, arch length decreased in every case. Overbite and overjet from T2 to T3 increased in most instances with a few cases showing no change or a slight decrease.

Comparing 5-year postretention serial extraction cases to the matched late extraction group, no significant differences were found in alignment of mandibular anterior teeth at the postretention stage, T3. Although there were no statistically significant nor clinical differences in postretention irregularity between the two groups there was a difference in treatment time. The average treatment time for the serial extraction cases was 12 months compared to nearly twice that figure for the late extraction treated cases. This suggests that serial extraction may require more observation visits but fewer months of active therapy.

Several typical cases will help illustrate the variation in response.

Case 1 (Figure 2). Following extraction, the mandibular anteriors responded well with a reduction in anterior irregularity from an index value of 7.4 pre-extraction down to 3.0 mm before the start of active treatment. Following treatment and retention the case did quite well by the 10-year postretention stage with an irregularity of only 3.7 mm. Arch length and intercanine width reduced during this interval. From age 25 to 37 there was increasing irregularity, each contact point that was not ideal at 25 showing increased malalignment by age 37. The case was, in general, a success and an example of what we hope for as a long-term result.

Case 2 (Figure 3). This case also responded well during the physiologic drift and observation stage following extraction. Treatment increase of intercanine width was followed by a decrease by age 27 to a point less than the pretreatment value. Also, arch length loss was significant postretention as was increased crowding. From 27 to 38 years of age the intercanine width continued to decrease as crowding increased. In spite of irregular mandibular anteriors, the maxillary incisors remained well aligned, a major factor in the minds of our patients. If the maxillary arch responded as poorly as the mandibular, one would anticipate more patient dissatisfaction. Fortunately, our study of maxillary arches, which will be submitted for publication in the future, indicates a better response in the maxillary arch than the mandibular.

Case 3 (Figure 4). During the observation stage following extraction, alignment remained unchanged. This mild crowding was decreased with very little arch form or arch width change during treatment. Postretention this case re-

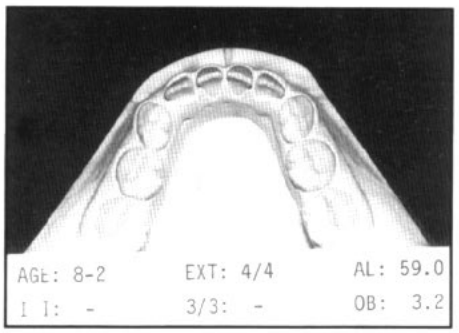

Figure 3A

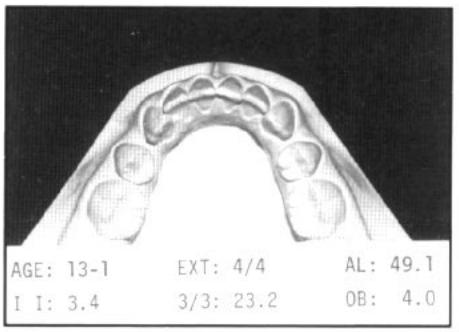

Figure 3B

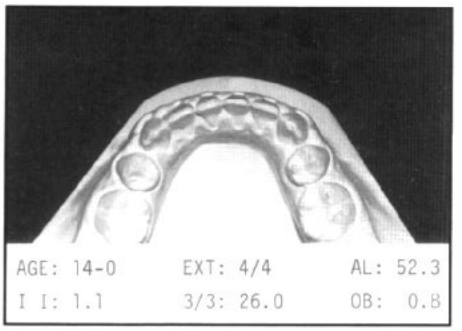

Figure 3C

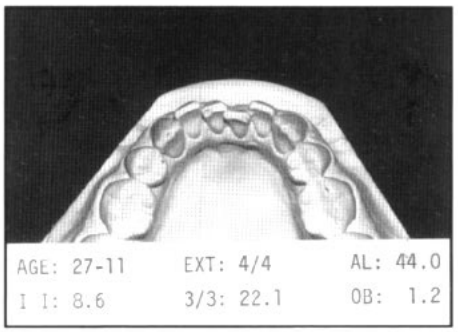

Figure 3D

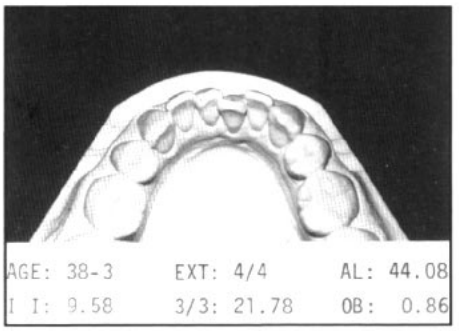

Figure 3E

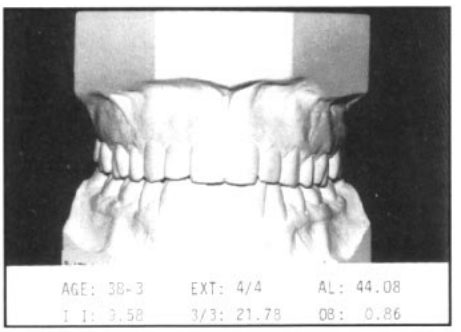

Figure 3F

Figure 3A-F
A) premolar extraction; B) end of observation stage; C) posttreatment; D) 10 years postretention; E&F) 20 years postretention

lapsed significantly and decreased in both width and arch length to age 30. From age 30 to 42 this trend of increasing anterior irregularity as well as arch width and arch length reduction continued. Although the irregularity of the mandibular anteriors was high at 9.13 mm, the maxillary arch did much better with quite good dental esthetics and a pleased patient.

Discussion

The reader should note that "crowding," arch length deficiency, and the Irregularity Index are not equal terms. The Irregularity Index measures the displaced contact points of the anterior teeth and gives an objective value to the subjective "crowding" of the case. Arch length deficiency is a clinical tool that represents the specific amount of space needed for alignment.

The Irregularity Index may be a number higher than the arch length deficiency in a given case where the anteriors are markedly displaced. Alternatively, there are examples where the anterior teeth all touch interproximally at the anatomic contact points yielding a low Irregularity Index but the pattern of anterior malalignment could be a "washboard" or "zig-zag" type that is actually inadequate in arch length.

The original study on this subject showed a fairly predictable linear relationship between subjective assessment of crowding and measured Irregularity Index scores ($r = 0.81$).[13] Approximately 65% of the variation among subjective scores is accounted for by variation in hand measurements, which indicates that the Index is a usable but not perfect predictor.

It was disconcerting to our faculty that anticipated future stability, the primary rationale for serial extraction, was not confirmed in this study. In fact, the similarity at the postretention record stage comparing the late extraction group to the serial extraction cases was quite surprising. One might anticipate that cases never allowed to crowd because of early extraction would surely be more stable than those cases that were extracted after the full eruption of the dentition, the crowding unraveled with edgewise orthodontic mechanics and then retained. Unfortunately, the reasoning that serial extraction cases would be more stable does not now seem justified.

In untreated serial extraction cases, Kinne[10] and Persson, et al.[11] consistently found relatively poor root parallelism in the mandibular second premolar/canine relationships. However, the maxillary premolar/canine root relationships were consistently satisfactory without treatment. This same phenomena was noted in the serially extracted treated cases at the start of active treatment.

Perhaps an argument could be made for improved periodontal health if anteriors were not allowed to crowd and individual incisors or canines blocked out into an area of less satisfactory gingiva. This hypothetical benefit was not assessed in this current project. Treatment time was definitely improved by the serial extraction method, but the patients did require supervision during the mixed dentition pre-appliance stage. Typically, several series of deciduous dentition

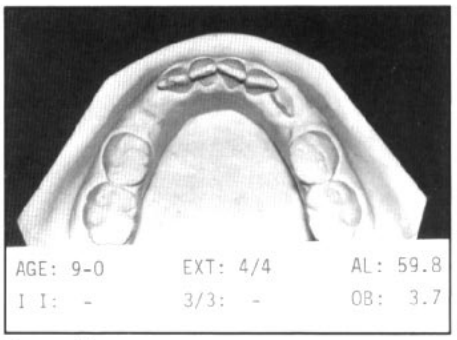

Figure 4A

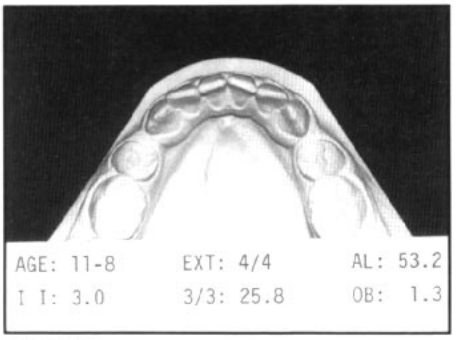

Figure 4B

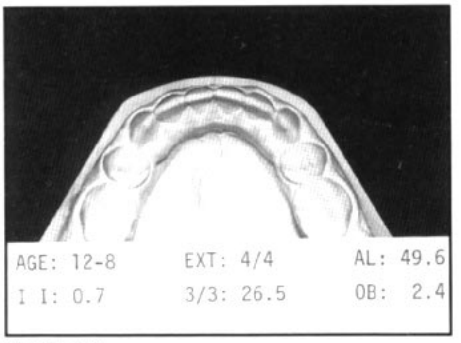

Figure 4C

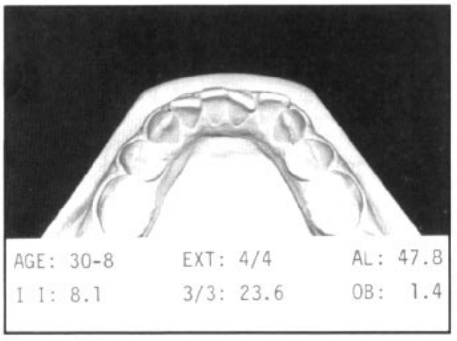

Figure 4D

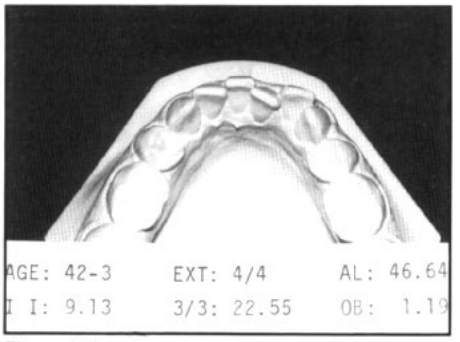

Figure 4E

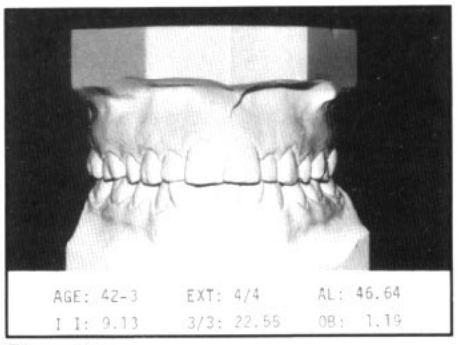

Figure 4F

Figure 4A-F
A) premolar extraction; B) end of observation stage; C) posttreatment; D) 10 years postretention; E&F) 20 years postretention

extractions were required prior to first premolar removal in the serial extraction group in order to "guide" the developing dentition compared to a single surgery in the late extraction group.

Arch length and arch width decrease along with increased crowding was the typical postretention finding in our study of orthodontically treated first premolar serial extraction cases. There was considerable variation in response from excellent results in a few cases to extremely poor results in others, most cases being in the middle ground of clinically unsatisfactory alignment. These findings are very similar to those of our previous studies, this current evidence continuing to confirm our view that postretention irregularity is an inevitable response in cases with inadequate pretreatment arch length.[14-20]

Our previous study of postretention change from 10 to 20 years and beyond would suggest that serial extraction cases will likely continue to worsen as they age but with less significant deterioration after age 30.[18] The few cases in the present study with very long-term records confirm this assumption. Permanent retention, or at least periodic use of removable retainers, perhaps for life, continues to be our suggested method of dealing with relapse. Patients and the parents of our patients need to understand our limitations and their role in maintaining the treated result. Our patients face a normal physiologic process of arch constriction and crowding and only by some artificial retention means can we guarantee success posttreatment.

Practitioners must not think that improvement of alignment during the serial extraction phase will necessarily improve the prognosis. In fact, cases that do not respond favorably during this pre-appliance time may do well or poorly in the future with no apparent way to predict the long-term outcome. Unfortunately, serial extraction is not a panacea for our postretention problems of relapse. Certainly it is better to realize that some irregularity seems to be inevitable for the majority of cases in which retention is discontinued. Realizing this fact, we should approach the problem realistically and plan means to maintain our treated results.

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

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