Mandibular incisor extraction — postretention evaluation of stability and relapse

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The extraction of teeth to resolve crowding has been an accepted treatment strategy for decades. The purpose of the present study was to assess the stability of mandibular dental alignment in patients treated with conventional edgewise mechanics following the removal of one or two mandibular incisors. The objective was to measure treatment and postretention change and to search for predictors and associations.

Nonextraction therapy in crowded cases is usually thought to lead to postretention relapse. Studies of patients treated nonextraction have demonstrated that the stability of arch length and width are variable.[1-6] Mandibular arch length and intercanine width typically decrease during the postretention period regardless of whether they increase or decrease during treatment.

Resolving arch length deficiencies with extraction treatment has not eliminated the problem of relapse.[2,7-10] A number of etiological variables have been considered, including excessive intercanine expansion, arch form change, pretreatment crowding, and the length of retention.

Gallerano[3] noted there was no correlation between a change in postretention intercanine width and postretention mandibular anterior crowding. He observed less postretention incisor irregularity in nonextraction patients than in extraction patients. However, the philosophy in vogue during the time these patients were treated meant nonextraction treatment was generally confined to those cases that had no pretreatment crowding; patients with crowding were generally treated with extraction.

In a contrasting follow-up study, Witzel[4] found that premolar extraction patients had less of a tendency to become crowded than patients treated nonextraction. He found no significant correlation between pretreatment and postretention in-

Abstract

Pretreatment, posttreatment and 10-year postretention dental cast and lateral cephalogram records of 42 patients were evaluated. Each patient had undergone edgewise orthodontic treatment following removal of one or two mandibular incisors and various maxillary teeth. Seven of 24 patients (29%) in the single-incisor extraction group and 10 of 18 (56%) patients in the two-incisor extraction group demonstrated unacceptable mandibular incisor alignment at the postretention stage. This result was considerably more favorable than the results of previously reported premolar extraction cases (70% unacceptable alignment at postretention). Intercanine width decreased during treatment and continued to decrease postretention in most cases. Overbite and overjet remained acceptable. No associations could be found to predict the amount of relapse.

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Key Words

Mandibular incisor extraction • Postretention • Relapse • Stability

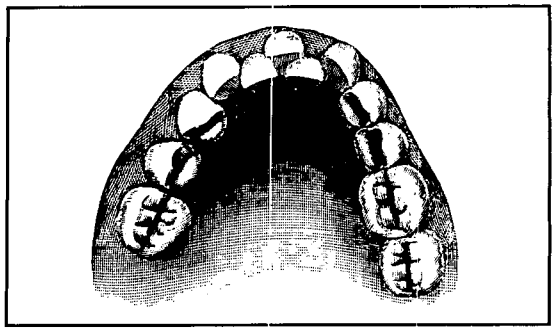


Figure 1
Illustration from 1904 textbook by V.H. Jackson.

cisor alignment, and no significant correlation between stability (or relapse) and changes in mandibular incisor position or angulation. These conclusions must be interpreted with caution because the sample had a relatively short minimum postretention time of 5 years.

Using dental casts and cephalometric records, Glenn, et al.,[5] assessed the long-term stability of a slightly crowded nonextraction sample. In these cases, the arches were enlarged slightly during treatment and responded quite favorably during the postretention stage. Intermolar width increased slightly during treatment and showed minimal decrease postretention. Cephalometric findings did not show any significant change that contributed to postretention relapse. Again, caution is needed in discussing these results since the postretention time in this study was only 3 years.

When evaluating an untreated sample with normal occlusion, Sinclair and Little[11] found that arch length and width decreased throughout the second decade of life. Little and Riedel[6] found the same trend of arch constriction in patients with generalized spacing.

It is generally agreed that patients treated with the extraction of four premolars tend to experience a decrease in mandibular intercanine width and an increase in incisor irregularity postretention, regardless of whether arch width has been expanded or constricted.[2,7-9,12] Intermolar width that was decreased during treatment continues to decrease postretention.[2,8,12]

In an effort to find predictors for the relapse of mandibular anterior crowding, Little, et al.[8] assessed 65 patients, all at least 10 years postretention, who had been treated in the permanent dentition with first premolar extraction. The long-term response to mandibular anterior alignment was unpredictable. No variables, such as degree of initial crowding, age, gender, Angle classification, etc., were useful in establishing a prognosis. Seventy percent of the patients had unsatisfactory mandibular anterior alignment in the postretention stage. Patients who were only slightly crowded before treatment usually became moderately crowded. When the same patients were analyzed cephalometrically, no predictors of long-term relapse of mandibular incisor crowding could be found.[3]

In another study, Little, et al.,[9] investigated whether a similar trend occurred from 10 to 20 years postretention. Crowding continued to increase during this later phase but to a lesser degree than during the first 10 years of postretention. Only 10% of the patients were judged to have clinically acceptable mandibular alignment at the last stage of diagnostic records. Patients responded in diverse and unpredictable manners with no apparent predictors of future success when compared to pretreatment records or to the treated result.

Riedel has suggested that in patients with severely crowded mandibular arches, the removal of one or more mandibular incisors is the only logical alternative which may allow for increased stability of the mandibular anteriors without continued retention.[14-17]

Incisor extraction to solve crowding problems is not a new idea. In his 1904 text, Jackson illustrated a case where one incisor had been previously removed and he chose to remove a second incisor because "...the three remaining ones were bunched together, the space between the cuspids being too narrow for their admission. Owing to the close occlusion, it was not considered practicable to increase the distance between the cuspids sufficiently to admit the irregular teeth."[18](Figure 1)

Dr. Milton Fisher, one of the founders of the University of Washington Department of Orthodontics, demonstrated to the early faculty several cases treated in the 1940s with a two-incisor extraction plan and no retention. Two of these cases (Figures 2, 3) with follow-up casts 4 years posttreatment illustrate acceptable stability.

Schwarz[19] reviewed 20-year postretention records of a patient who was congenitally missing two mandibular incisors. He was surprised to observe good long-term stability. After informally reviewing 10-year postretention records of patients who had two mandibular incisors removed, Riedel[16] observed that the arches in these patients appeared less crowded postretention than those of similar patients who had been treated with premolar extraction.

Riedel wrote: "The extraction of two mandibular incisors may satisfy the requirements of maintaining arch form without expansion of intercanine width."[14-17] With nonextraction or premolar extraction therapy, the original intercanine width usually must be increased in

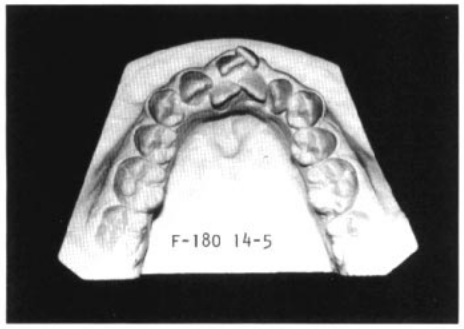


Figure 2A

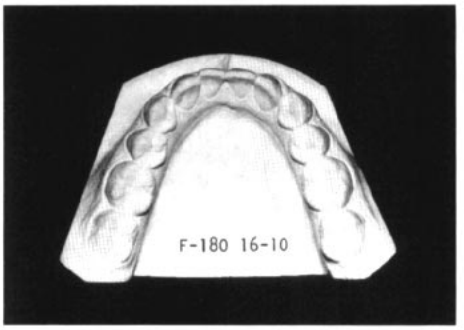


Figure 2B

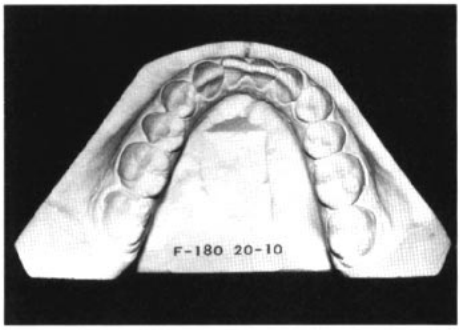


Figure 2C

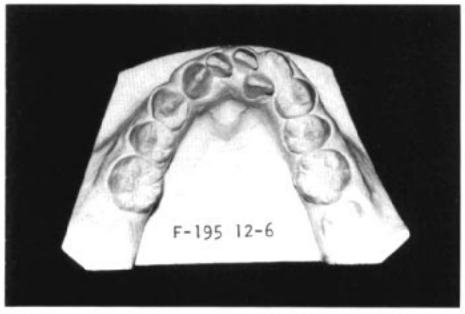


Figure 3A

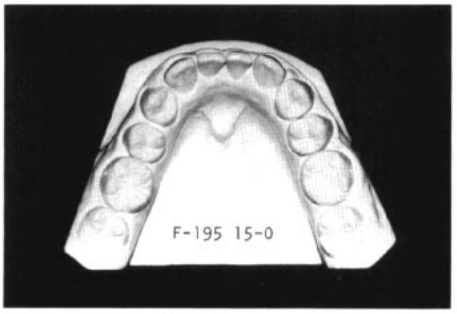


Figure 3B

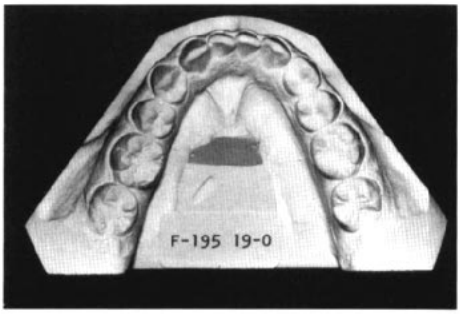


Figure 3C

order to gain adequate alignment and arch form, a strategy that might result in a more favorable result.

Extreme crowding or protrusion — conditions often accompanied by loss of gingival tissue and bone overlying the labial surface of incisor roots — may be indicators for mandibular incisor extraction. Alleged problems include possible reopening of extraction spaces in minimal crowding cases, increased overjet, increased overbite and unsatisfactory occlusion.[16]

The extraction of mandibular incisors as an appropriate treatment modality to resolve dental crowding is controversial. Salzmann,[20] reviewing Edward H. Angle's philosophy of extraction in orthodontics, noted that Angle regarded the extraction of an incisor, when the tooth was sound, to be inexcusable.

Furthermore, Angle warned that extracting one incisor, as advocated by some, would lead to less acceptable harmony between the occlusal planes of the remaining teeth, in addition to an abnormal incisor overbite.

Kokich and Shapiro[21] presented four patients who were successfully treated with extraction of a single mandibular incisor. They argued that with careful case selection, single incisor extractions may allow the practitioner to use simpler treatment mechanics and achieve good results. Riedel[14-17] has also suggested that resolving mandibular anterior crowding by means of mandibular incisor extraction(s) can reduce treatment time.

Materials and methods

The sample consisted of 42 patients treated with mandibular incisor extractions followed by edgewise orthodontic therapy (Table IA and B). Retention typically included a removable retainer worn for 2 years, although retention time varied from none at all to 6 years. The sample was divided into two groups. Group I consisted of 24 patients with one mandibular incisor extracted. The 18 patients in Group II had two mandibular incisors extracted. Patients who had a single congenitally missing incisor and were treated with an additional incisor extraction were included in the second group.

The patients were selected from the records collected in the University of Washington's Department of Orthodontics and from the private practices of faculty members. Minimum records for each patient consisted of dental casts, lateral cephalograms and a written description of the treatment plan. Except for two patients, one missing pretreatment and posttreatment cephalograms and one missing pretreatment dental casts, each patient had casts and cephalograms representing the following stages: before treatment (pretreatment T1); at the time of appliance removal (posttreatment T2); and at the end of a minimum of 6 years 6 months out of retention for Group I and 9 years 9 months out of retention for Group II (postretention T3). The average postretention change in each patient did not influence their inclusion or exclusion from the sample. None of the patients had undergone circumferential

Figure 2
Case treated by Dr. Milton Fisher in the 1940s with extraction of two central incisors.
A. Pretreatment
B. Posttreatment
C. 4 years posttreatment

Figure 3
Case treated by Dr. Milton Fisher in the 1940s with extraction of two lateral incisors.
A. Pretreatment
B. Posttreatment
C. 4 years posttreatment

Table IA
Sample Characteristics- Age (year-month)

	GROUP I N=24		GROUP II N=18		POOLED N=42	
	Mean	Range	Mean	Range	Mean	Range
Pretreatment (T1)	19-10	11-1 to 45-8	15-2	11-5 to 27-1	17-10	11-1 to 45-8
Posttreatment (T2)	22-4	13-1 to 47-7	17-2	12-7 to 29-1	20-1	12-7 to 47-7
Postretention (T3)	34-5	26-10 to 57-8	36-4	24-10 to 45-4	35-3	24-10 to 57-8
Postretention period	10-2	6-6 to 20-1	16-1	9-9 to 24-0	12-9	6-6 to 24-0

Table IB
Sample Characteristic - Angle class & gender

ANGLE CLASS	GROUP I	GROUP II	POOLED
Class I	12	9	21
Class II division 1	6	7	13
Class II division 2	6	2	8
Total	24	18	42
GENDER			
Male	9	6	15
Female	15	12	27

supracrestal fibrotomy (sulcus slice) in an effort to prevent postretention relapse.

Objective cast analysis

Digital calipers calibrated to 0.01 mm were used in measuring all cast parameters. The following measurements were obtained by a single examiner for each set of casts:

Average Irregularity Index (Av Ir In, Figure 4A): The Irregularity Index, described by Little,[22] is the summed displacement of the anatomic contact points of the mandibular anterior teeth. This quantitative method of assessing anterior dental irregularity could only be used when all incisors were present. In cases of incisors congenitally absent or extracted, a modification of the summed Irregularity Index was necessary because of the different number of contacts measured.

An Average Irregularity Index was proposed to compare the amount of crowding among groups with different numbers of mandibular anterior teeth. An arithmetic average was computed by dividing the Irregularity Index by the number of contacts in the mandibular anterior segment. In normal cases, the number of contacts would be five. For the casts with one extracted mandibular incisor, the number of contacts would be four. For cases with two-incisor extractions, premolars were substituted for canines and canines were substituted for lateral incisors, resulting in five contacts.

Intercanine width (Figure 4B): The distance between cusp tips of mandibular canines or estimated cusp tips in cases of wear facets.

Intermolar width (Figure 4B): The distance between mesiobuccal cusp tips of mandibular molars or estimated cusp tips in cases of wear facets.

Arch length (Figure 4C): The sum of the right and left distances from mesial anatomic contact points of the mandibular first permanent molars to the contact point of the central incisors. If spaced, the midpoint between the central contact was used, or if one incisor was missing or extracted, the

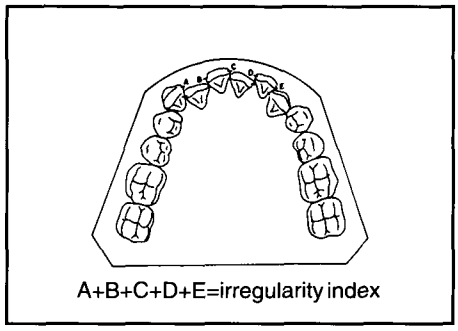
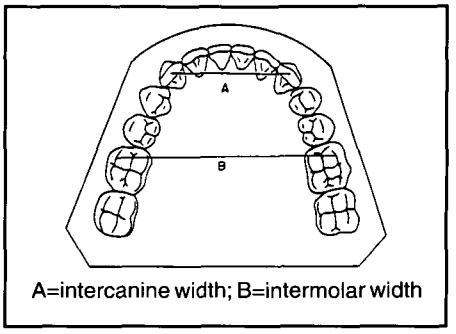


Figure 4A



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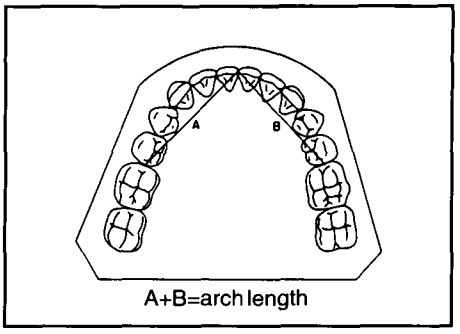

Figure 4C

center mesiodistally of the remaining central incisor was measured.

Overbite: The distance from the incisal edge of each mandibular central incisor to a point on its labial surface denoting the projection, parallel to the occlusal plane, of the incisal edge of the corresponding maxillary central incisor. Overbite was calculated as the average of the right and left measurements.

Overjet: The distance from the most labial point of the maxillary central incisor to a point on the labial surface of the mandibular central incisor along a line parallel to the occlusal plane.

In order to reduce examiner bias, the casts were numbered and subsequently measured "blind" in random order. Ten casts were measured on two separate occasions in order to establish measurement error. The mean errors in assessing incisor irregularity, mandibular intercanine width, mandibular intermolar width, arch length, overbite and overjet ranged form 0.13mm to 0.44mm.

Cephalometric analysis

Pretreatment (T1), posttreatment (T2), and postretention (T3) lateral cephalometric radiographs were digitized using the Dentofacial Planner software (Dentofacial Software Inc., Toronto, Canada). A total of 27 landmarks were identified on each film (Figure 5A) and from these points, six linear measurements, 14 angular measurements and two proportions were computed Table II). Each pretreatment (T1) cephalogram was traced by the first author and x,y coordinates were constructed (Figure 5B). The occlusal plane of the pretreatment (T1) tracing served as the x-axis, and the y-axis was represented by a line through the average mesial contact point of the mandibular first molar perpendicular to the occlusal plane.

The posttreatment (T2) and postretention (T3) cephalograms were superimposed, according to the method described by Bjork,[23] on the pretreatment (T1) tracings using the inner contour of the symphysis while obtaining a best fit of the mandibular canals and third molar tooth buds, when present (Figure 5B).

Table II
Cephalometric measurements

SN-Pg
ANB angle
SNA angle
SNB angle
Interincisal angle
Occlusal plane - SN angle
Mn incisor - Mn plane angle
Mn incisor - NB angle
Y - axis - SN angle
Lower anterior facial height
Upper anterior facial height
Total anterior facial height
% nasal height
Mn plane - SN angle
Lower posterior facial height
Total posterior facial height
Ratio TPFH : TAFH
S - Ar- Go angle
Gonial angle
Mn length
Symphysis inclination
Mn incisor - Frankfort Horizontal

The midpoint of the incisal edge and root apex of the mandibular incisors from the posttreatment and postretention cephalograms were traced on the pretreatment tracings to determine whether the mandibular incisors were intruded or extruded, proclined or retroclined during the treatment and the postretention phases. Three variables were measured:

Horizontal position of the mandibular central incisor (Figure 5B): The linear measurement from

Figure 4
Measurement technique
A. Irregularity Index
B. Intercanine and intermolar widths
C. Arch length

Figure 5
Cephalometric measurements
A. Points digitized
B. Mandibular superimposition

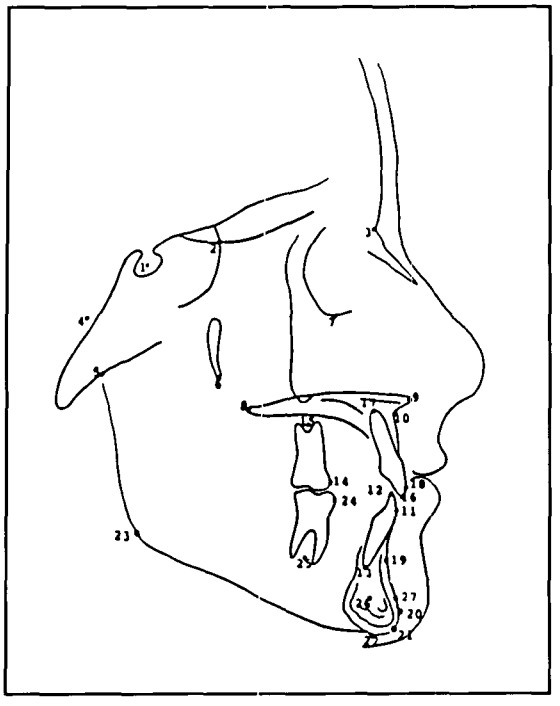

Figure 5A

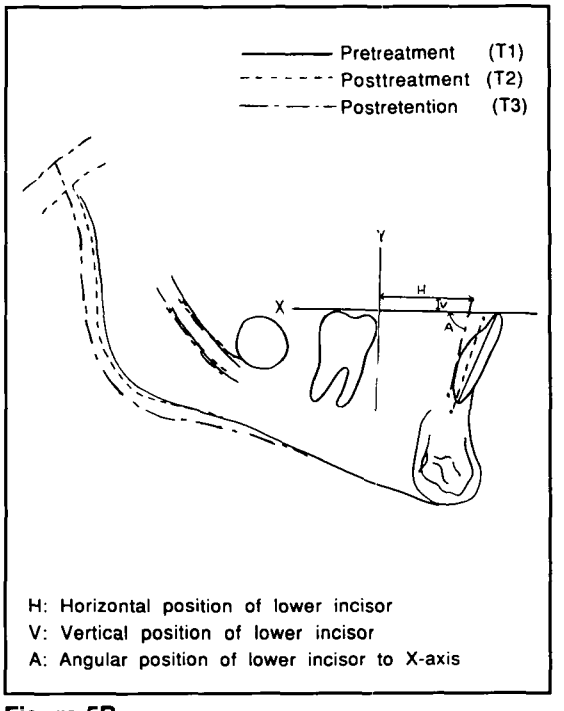

Figure 5B

the incisal edge of the mandibular central incisor to the y-axis along a line parallel to the x-axis.

Vertical position of the mandibular central incisor (Figure 5B): The linear measurement from the incisal edge of the mandibular central incisor to the x-axis along a line parallel to the x-axis.

Angulation of the mandibular central incisor to the x-axis (Figure 5B): The inner angle formed by a line from the most apical point on the root to the midpoint of the incisal edge at its intersection with the x-axis.

Digitizing error was assessed by digitizing ten randomly selected cephalograms on two separate occasions. An average correlation coefficient of r=0.95 between the two trials was determined. In order to assess superimposition error, ten randomly selected cephalograms were superimposed a second time. An average of r=0.97 was determined for the two trials.

Subjective cast analysis

Six faculty orthodontists, each with at least 10 years clinical experience, were asked to subjectively evaluate the anterior irregularity present in 30 casts to test the validity of the Average Irregularity Index. Ten casts from each of the following subgroups were selected to represent a wide range of crowding:

Subgroup A: casts with the normal six mandibular anterior teeth.

Subgroup B: casts with two incisors, two canines and two premolars (two missing incisors)

Subgroup C: casts with five mandibular anterior teeth (one missing incisor)

Each cast was subjectively ranked on a scale ranging from 0 to 10 using the following criteria, as described by Little.[22]

0	Perfect alignment
1-3	Minimal irregularity
4-6	Moderate irregularity
7-9	Severe irregularity
10	Very severe irregularity

The same six orthodontists were asked to evaluate the same 30 casts one week later to determine intraexaminer reliability. The Spearman rank order correlation coefficient was used to assess the degree of intraexaminer reliability. Examiners were quite consistent in their subjective evaluation (average r=0.95, range=0.88 to 0.99).

Data Analysis

In addition to standard descriptive statistics for the three time periods, both pooling and segregating the sample by Angle class and gender, the following routine tests were also performed: differences were assessed by Student's t-test; one-way analysis of variance, a priori comparison of group means, paired differences, and percent. The level of significance was established at $p<.05$. Association between variables was evaluated by the Pearson Product-moment correlation coefficient or the Spearman rank order correlation coefficient. The level of clinical relevance was established at $r>.7$ for correlations.

Results

Subjective cast analysis

The Spearman rank order correlation coefficient was used to compare the Average Irregularity

Table IIIA
Dental cast measurements - Group I ($\bar{X}\pm$SDmm)

Variable	Pretreatment T1	Posttreatment T2	Postretention T3	T1-T2 change	T2-T3 change
Av Ir Index	1.72 ± 0.81	0.29 ± 0.18	0.62 ± 0.30	-1.44 ± 0.77 *	+0.33 ± 0.34 *
Intercanine width	24.37 ± 2.53	22.77 ± 1.10	21.64 ± 1.41	-1.63 ± 2.22 *	-1.13 ± 0.95 *
Intermolar width	42.27 ± 2.93	42.80 ± 3.28	42.47 ± 3.21	+0.51 ± 1.40	-0.33 ± 1.51
Arch length	57.01 ± 4.38	56.71 ± 4.06	54.32 ± 4.01	-0.27 ± 2.87	-2.38 ± 1.91 *
Overbite	3.98 ± 1.72	2.43 ± 1.37	3.13 ± 1.40	-1.49 ± 2.10 *	+0.70 ± 1.27
Overjet	5.21 ± 0.66	3.58 ± 1.02	3.67 ± 1.06	-1.56 ± 3.48 *	+.09 ± 1.10

* Indicates a statistically significant difference ($p\leq 0.05$)

Table IIIB
Dental cast measurements - Group II ($\bar{X}\pm$SDmm)

Variable	Pretreatment T1	Posttreatment T2	Postretention T3	T1-T2 change	T2-T3 change
Av Ir Index	2.38 ± 0.92	0.42 ± 0.23	0.78 ± 0.27	-1.96 ± 0.85 *	+0.36 ± 0.34 *
Intercanine width	22.85 ± 3.59	17.64 ± 1.43	16.25 ± 1.23	-5.20 ± 3.14 *	-1.39 ± 1.19 *
Intermolar width	40.56 ± 3.18	41.43 ± 2.15	40.37 ± 2.53	+0.87 ± 2.12	-1.06 ± 1.42 *
Arch length	56.04 ± 4.38	50.81 ± 4.13	48.31 ± 2.62	-5.24 ± 4.18 *	-2.49 ± 2.88 *
Overbite	3.88 ± 1.20	1.59 ± 1.15	3.00 ± 1.16	-2.29 ± 1.49 *	+1.41 ± 1.43 *
Overjet	5.50 ± 2.18	2.13 ± 0.97	3.30 ± 1.20	-3.37 ± 2.62 *	+1.17 ±1.44 *

*Indicates a statistically significant difference ($p\leq 0.05$)

Index with subjective ranking of crowding. The correlation coefficients of subgroups A, B and C were .87, .83 and .91 respectively. These values indicate that 69% to 83% of the variation among subjective scores is accounted for by variation in measured Average Irregularity Index. For the purpose of this study, the amount of crowding in cases with various numbers of incisors can be objectively evaluated and compared using the Average Irregularity Index.

Objective Cast Analysis

Average Irregularity Index (Av Ir In): The mean pretreatment Average Irregularity Index was $\bar{X}$=1.72±0.81 for Group I and $\bar{X}$=2.38±0.92 for Group II (Table III). The incisor alignment was improved greatly during treatment; the mean decrease of the Average Irregularity Index from T1 to T2 was significant at -1.44±0.77 for Group I and -1.96±0.85 for Group II. During the postretention period there was a significant increase in irregularity (Group I: $\bar{X}$=0.33±0.34; Group II: $\bar{X}$=0.36±0.34 (Table IIIA & B). In spite of the significant change from T2 to T3, a net improvement between T1 and T3 was noted. At T1, 71% of Group I cases and 94% of Group II cases exhibited severe mandibular anterior crowding (Av Ir In > 1.3mm or Ir In > 6.5mm), whereas at T3, only 4% of Group I cases and none of Group II cases exhibited severe mandibular crowding (Table IVA and B, Figure 6A). At T3, 29% of Group I cases and 56% of Group II cases had an unacceptable incisor alignment (Av Ir In > .7 or Ir In > 3.5mm). When pooling the two groups, 36 out of 42 cases (86%) showed a net improvement over the three time periods, 5 out of 42 (12%) remained in the same categories, and none of the cases were worse than at T1 (Table IVA&B).

No clinically significant correlation was found when comparing pretreatment incisor irregularity with postretention change in all dental cast parameters, nor when comparing posttreatment irregularity to the pretreatment values of those

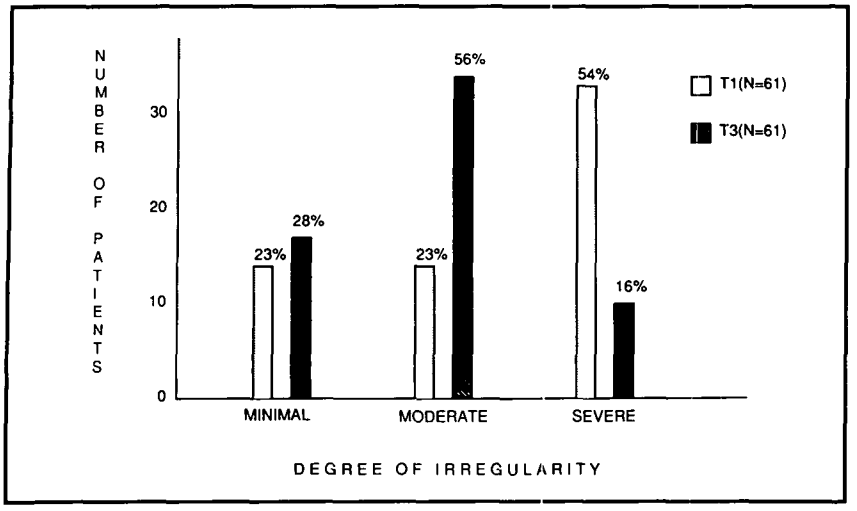

Figure 6A

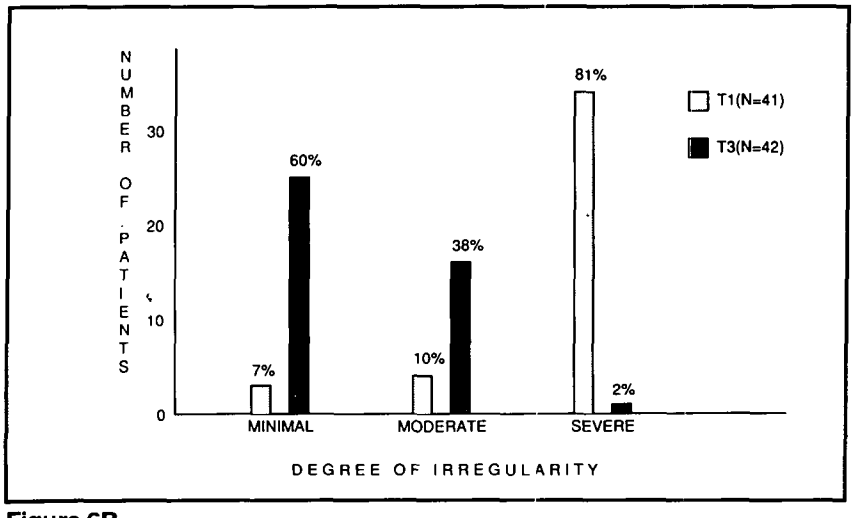

Figure 6B

Figure 6
Histograms
A. Irregularity of mandibular incisor extraction cases
B. Irregularity of premolar extraction cases

same dental cast parameters. When the sample was further divided by Angle class or by gender, or by various combinations of class and gender, no clinically significant correlations were found between these groups and the T3 or T3-T2 Average Irregularity Index.

Intercanine width: In both groups, 88% of the cases showed decreases in intercanine width during treatment. Only 5 cases, all Group I single-extraction cases, showed an increase in intercanine width. At postretention (T3), 88% of all cases showed a significant intercanine width decrease from T2 (Group I: $\bar{X}$=-1.13±0.95mm; Group II: $\bar{X}$=-1.39±1.19). There was no significant correlation between the treatment change (T1-T2) and postretention change (T2-T3) of intercanine width. There were no clinically significant correlations between the treatment change of intercanine width and the postretention change or postretention value (T3) of the dental cast measurement.

Intermolar width: During treatment, intermolar width increased in 71% of cases from both groups (67% of Group I and 78 % of Group II). During postretention, the intermolar width decreased in the same proportion of the sample (67% of group 1 and 78% of Group II). In 50% of the cases in which the intermolar width decreased during treatment, it increased postretention. There was no significant change during treatment in either group (Group I: $\bar{X}$=+0.51±1.40; Group II: $\bar{X}$=+0.87±2.12), whereas the postretention change was significant in Group II but not in Group I.

Arch length: Arch length decreased significantly during treatment in Group II but not significantly in Group I. During postretention, both groups had significant reductions in arch length (Group I: $\bar{X}$=-2.38±1.91; Group II: $\bar{X}$=-2.49±2.88).

Overbite and overjet: During treatment, overbite and overjet in both groups improved significantly. During postretention, overbite and overjet did not change significantly in Group I, but increased significantly in Group II. However, there were no significant differences in overbite and overjet at T3 between Group I and Group II. As an aside, 16 out of 18 Group II patients were treated by an orthodontist who treated deep overbite cases to zero overbite and overjet at T2. No relationship could be made between the postretention changes in overbite and overjet and the pretreatment incisor irregularity or treatment change of intercanine width.

Cephalometric analysis

In order to find predictors for the relapse of incisor alignment and changes in other dental cast parameters, cephalometric analysis was completed for all patients. The mean of each group at each stage of treatment, treatment change and postretention change were tested for correlation with the postretention change in incisor alignment and all other dental cast parameters. Even though there were several statistically significant correlations ($p<.05$), none of the correlations were clinically significant ($r>0.7$). Mandibular superimposition showed that the incisors were proclined during treatment in the single-incisor extraction group (Table V). In the two-incisor extraction group, mandibular incisors were tipped to the lingual or retracted during treatment. Even though there were no significant postretention changes (T2-T3), mandibular superimposition measurements had a tendency to return toward pretreatment values.

Case Examples

Several typical cases help illustrate the variation in response.

Case 1 (Figure 7). This single-incisor extraction case showed a very stable result 7 years

Table IVA

GROUP I		Pretreatment irregularity				
		no T1 cast	Minimal	Moderate	Severe	Total
Postretention irregularity	Minimal	1	3	3	10	17(71%)
	Moderate	0	0	0	6	6(25%)
	Severe	0	0	0	1	1(4%)
	Total	1(4%)	3(13%)	3(13%)	17(71%)	24

Minimal irregularity: < 3.5 mm. Moderate: 3.5 - 6.5mm. Severe: > 6.5mm.

Table IVB

GROUP II		Pretreatment irregularity				
		no T1 cast	Minimal	Moderate	Severe	Total
Postretention irregularity	Minimal	0	0	0	8	8(44%)
	Moderate	0	0	1	9	10(56%)
	Severe	0	0	0	0	0
	Total	0	0	1(6%)	17(94%)	18

Minimal irregularity: < 3.5 mm. Moderate: 3.5 - 6.5mm. Severe: > 6.5mm.

postretention. The intercanine width underwent moderate constriction during treatment and continued to decrease slightly postretention. The 4mm overbite and normal overjet were acceptable at postretention and unchanged from end of treatment.

Case 25 (Figure 8). This severely crowded case was typical of the average postretention relapse noted in Group I. Intercanine width and arch length increased slightly during treatment and decreased slightly postretention.

Case 36 (Figure 9). In spite of an excellent treatment result, this case demonstrated the greatest anterior alignment relapse in Group I. Arch width and length changes were typical of the group, both decreasing slightly during treatment and postretention. The overbite increased slightly postretention, but was considered acceptable at 3.7mm.

Case 17 (Figure 10). In spite of the fact that this case had the greatest pretreatment incisor irregu-

Table V
Mandibular superimpositon measurements - Mean change

	Lower incisor position	T1-T2 change	T2-T3 change
GROUP I	X coordinate (mm)	0.56	-0.48
	Y coordinate (mm)	-0.19	0.90
	Angle to X-axis (°)	-3.54*	1.50
GROUP II	X coordinate (mm)	-1.29*	0.02
	Y coordinate (mm)	-0.29	1.22
	Angle to X-axis (°)	1.33	-0.06

X coordinate: incisal tip moves anteriorly (+), posteriorly (-)
Y coordinate: incisal tip moves occlusally (+), gingivally (-)
Angle to X-axis: retroclined (+), proclined (-)
* Indicates a statistically significant difference ($p \leq .05$)

Figures 7-9
Six extraction cases. Data shown represent case number, age, extraction choice, intercanine width, arch length and overbite.
A. Pretreatment
B. Posttreatment
C-D. Postretention

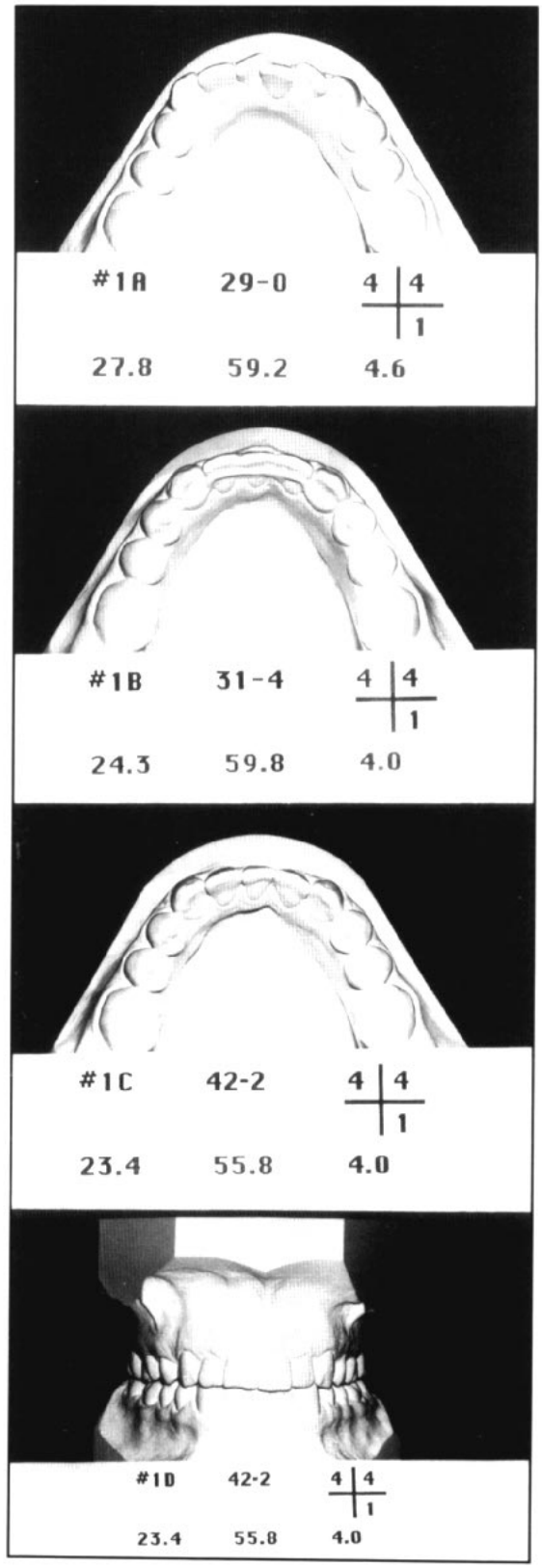

Figure 7A-D

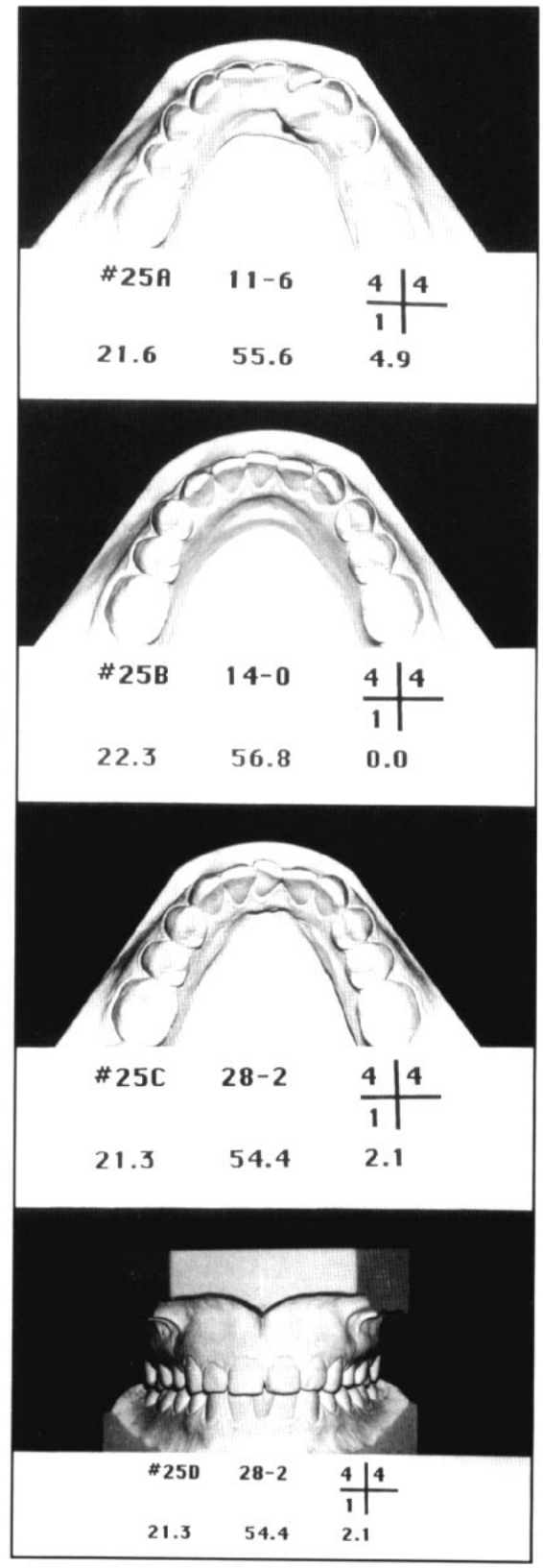

Figure 8A-D

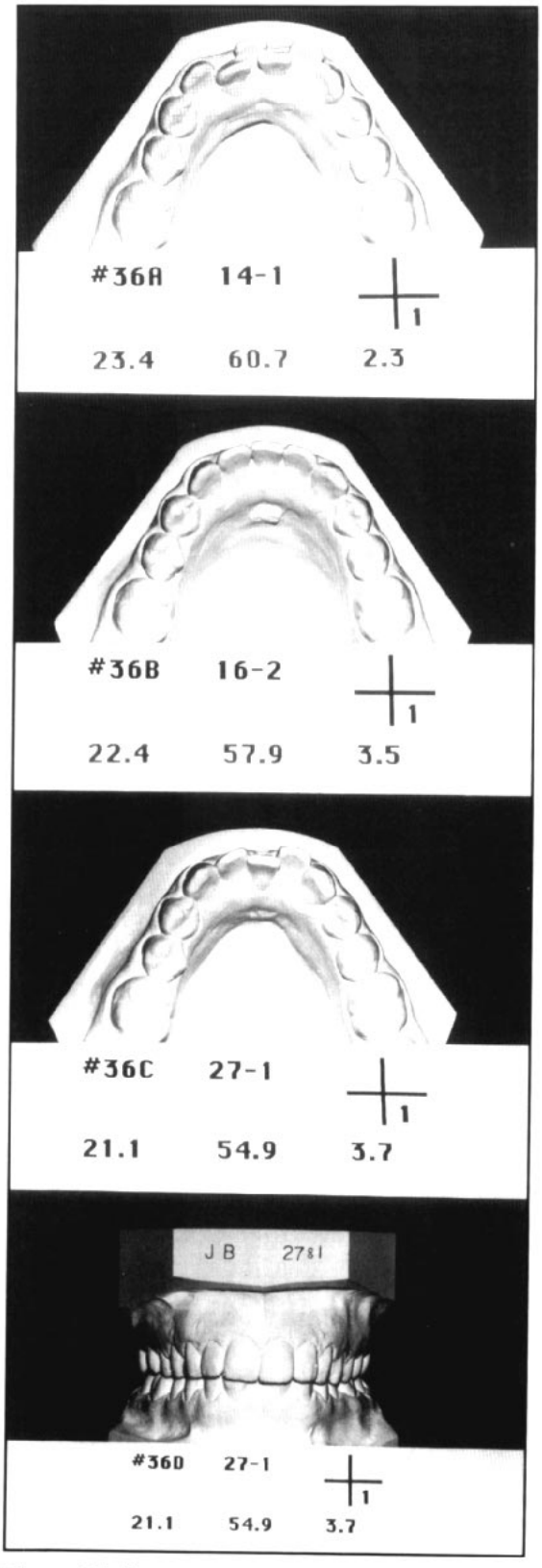

Figure 9A-D

larity in our sample, 10-year postretention records showed little change from the end of treatment record. At postretention, this was an excellent treatment result. The intercanine width was maintained during treatment and decreased by only 1mm postretention. The intermolar width increased during treatment and remained relatively stable postretention.

The incisor alignment in Case 41 (Figure 11) was very stable 10 years postretention. Intercanine width was reduced more than 5mm during treatment, but intermolar width was expanded 3mm. The overbite and overjet were ideal at T3.

Case 26 (Figure 12). In contrast to the previous two examples, this case demonstrated a clinically significant relapse in anterior alignment from T2-T3. This is the largest relapse observed in the two-incisor extraction group. Intercanine width and arch length decreased significantly postretention. The overbite deepened during the postretention period.

Discussion

Extraction of teeth has long been advocated to resolve significant arch length deficiencies. First premolars have conventionally been the extraction of choice. Riedel suggested that the removal of one or more mandibular incisors may give greater stability to the mandibular anterior dental arch in the absence of permanent retention.[14] The results of the current study suggest that this may be the case, especially for patients with severe pretreatment mandibular anterior crowding. At T1, 83% of Group I and 100% of Group II patients had moderate to severe mandibular irregularity; while at T3, only 29% of Group I and 56% of Group II patients had moderate to severe mandibular irregularity (Figure 6A). This is in contrast to Little, et al., who found in first premolar extraction cases that 70% of patients had moderate to severe crowding at T1, while 70% of patients at T3 still exhibited moderate to severe crowding (Figure 6B).[8]

In the current study, the Average Irregularity Index showed a 0.33mm postretention increase in Group I and a 0.36mm postretention increase in Group II. This change was greater than that seen in an untreated normal sample[11] and a nonextraction sample,[5] but noticeably less than that seen in a four-premolar extraction sample.[8] It should be noted that the pretreatment irregularity of the current study was greater than that of all the other samples. The mean incisor irregularity at T3 for the incisor extraction cases in the study was less than that of cases treated with four premolar extractions.[8,9,10,25,26] Care should be exercised when interpreting these results because of

Figures 10-12
Six extraction cases. Data shown represent case number, age, extraction choice, intercanine width, arch length and overbite.
A. Pretreatment
B. Posttreatment
C-D. Postretention

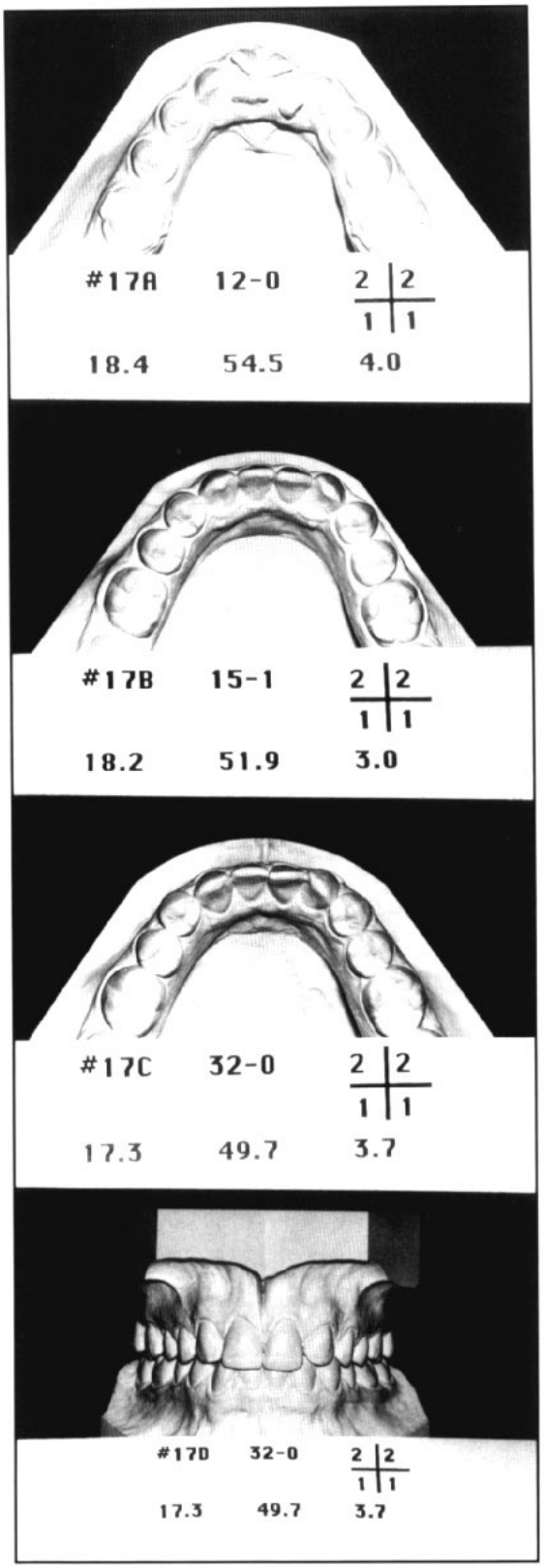

Figure 10A-D

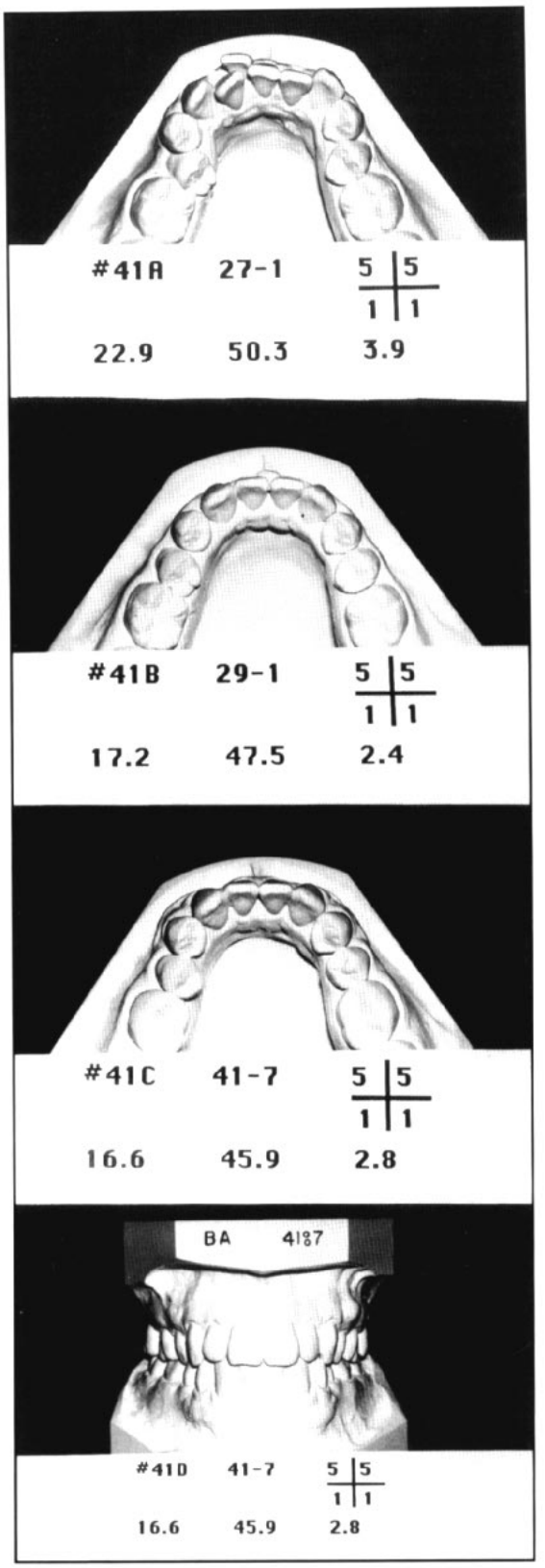

Figure 11A-D

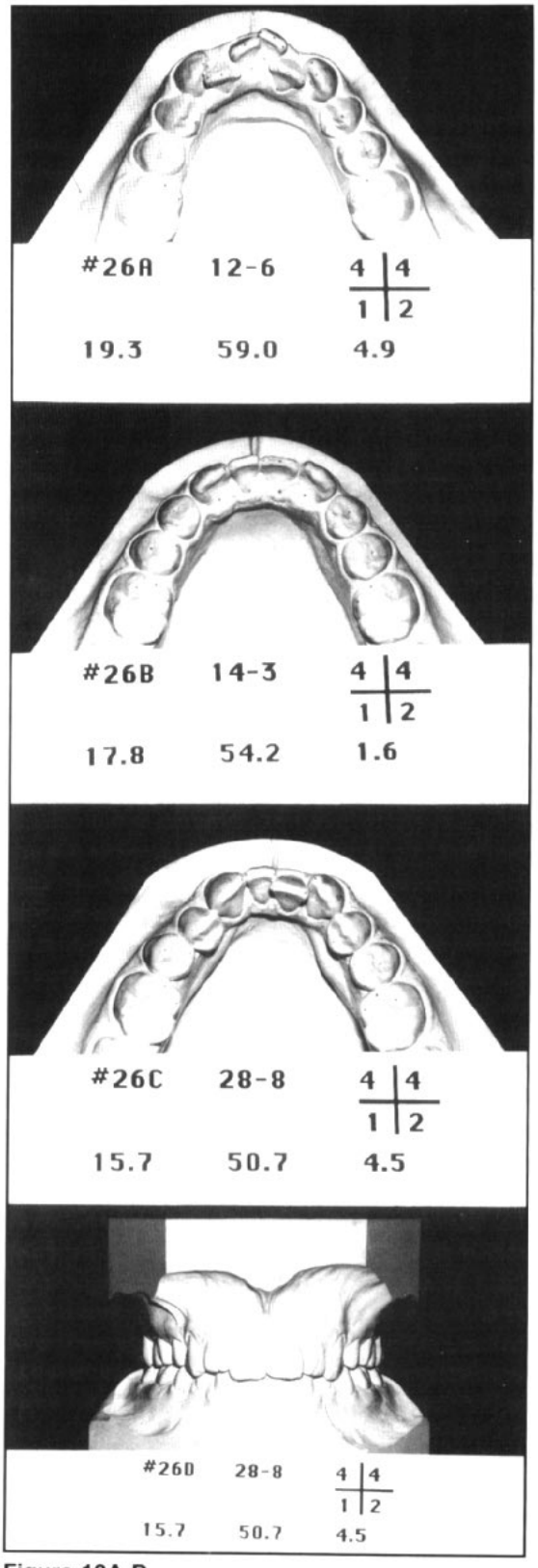

Figure 12A-D

the small sample size of the two-incisor extraction group (N=18) and the relatively short postretention period of the one-incisor extraction group (minimum of 6 years 6 months).

Others[2,7,15,25] have suspected that treatment increase of intercanine width contributes to mandibular incisor relapse and crowding. It was interesting to find that intercanine width of the incisor extraction cases decreased during treatment and continued to decrease postretention (Table IIIA&B).The postretention reduction was significantly less than that indicated in studies of late premolar extraction.[8,12,24,25] The findings from the present study suggest that simply maintaining or reducing intercanine width during treatment does not guarantee a completely stable long-term end-result, but may contribute to a lesser degree of relapse.

Salzman suggested that extracting a mandibular incisor would result in an excessive overbite.[20] In this mandibular incisor extraction sample, the mean overbite and overjet at T3 were acceptable and similar to the findings of previous studies.[5,8,9,12,13,25,26]

Kokich and Shapiro believe that the problem of increased overbite can be avoided by carefully evaluating the complete diagnostic records in selecting a suitable patient for this treatment plan.[21] For example, patients who have mandibular anterior tooth size excess (Bolton disharmony)[27] should be considered seriously for the extraction of a mandibular incisor. In addition, reproximation of maxillary anterior teeth might be needed to establish proper overbite and overjet. They also believe that in case selection, the intentional extraction of a mandibular incisor can simplify orthodontic mechanics and enhance both the occlusal and cosmetic results of treatment. Success in treatment depends upon patient selection and a mandatory "diagnostic wax set up" before making the extraction decision.

It is surprising to find that in this sample, the intermolar width changes during treatment are more similar to those of the nonextraction sample[5] than the extraction samples.[2,8,25] Even though it is an extraction plan of treatment, intermolar width increased during treatment rather than decreased as in other extraction choices (Table IIIA&B). This could be due to the mechanics used since nonextraction and incisor extraction cases have similar intact arches from canines through molars. The net changes in intermolar width from T1-T3 were similar to that of the untreated sample.[11]

In agreement with Shields, et al.,[13] and Little et al.,[8] no clinically significant correlations were

found between the long-term stability of mandibular anterior teeth and any of the cephalometric or dental cast measurements. We were unable to find any useful cephalometric and dental measurements at T1 or T2 to predict mandibular anterior alignment at T3.

Conclusions

The findings of this study suggest that the significantly crowded case may be reasonably treated by either premolar or incisor extraction, but one or two incisor extraction might yield a more stable result. This is not a recommendation to resolve all instances of mandibular crowding with mandibular incisor extraction; rather, case selection criteria[14-17] should be followed when electing this treatment option.

Further studies are needed on the stability of cases treated by various treatment options. For example, a study to compare the stability among different matched groups (untreated, nonextraction, premolar extraction and incisor extraction) with similar pretreatment irregularity and similar postretention periods would be more definitive.

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