Original Article

Assessment of Orthodontic Treatment Outcomes: Early Treatment versus Late Treatment

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Abstract: This investigation compares the treatment outcome of early treatment (in the mixed dentition) with that of late treatment (early permanent dentition) using objective evaluation criteria. Pretreatment and post-treatment records of all patients (n = 512) completed from 1998 to 2000 in the graduate orthodontics clinic at the Indiana University School of Dentistry (IUSD) were evaluated by the American Board of Orthodontics Objective Grading System (ABO OGS) and Comprehensive Clinical Assessment (CCA) method developed at IUSD. Two definitions of early treatment were used in this study: (1) all patients started in the mixed dentition with early-treatment objectives and (2) female individuals were <10 years and male individuals were <10.5 years of age when treatment began. Comparison of the final results between early- vs late-treatment groups showed that the early-treatment group had significantly longer treatment time and worse CCA scores than the late-treatment group, regardless of the definition of the early-treatment group or whether the early-debond (premature treatment termination) cases were included or not. There was no significant difference between early- and late-treatment groups regarding the ABO OGS score, which indicated that the CCA method is more sensitive in detecting compromised outcomes for patients with long treatment times. Prematurely terminated treatment was more prevalent in the early-treatment group than in the late-treatment group. In this large sample of consecutive patients (n = 512), the disadvantages of early treatment was prolonged treatment time, worse CCA score, and a higher incidence of premature termination of treatment, which was attributed to patient/parent ''burn-out.'' (*Angle Orthod* 2005;75:162–170.)

Key Words: Early treatment; Phase I; Orthodontics; University Clinic; Comprehensive clinical assessment; Objective grading system; Premature termination of treatment

INTRODUCTION

There is a lack of consensus regarding the degree of success of different treatment modalities applied during the early to late mixed dentition stages.[1–3] It is necessary to define terms, definitions, and clinical methods that are reliable in order to optimize treatment outcomes, clinical efficiency, patient/parent satisfaction, and professional communications.

The concept of ''early treatment'' is controversial. Some define it as removable or fixed appliance intervention in the primary, early mixed (permanent first molars and incisors present), or midmixed (inter-transitional period, before the emergence of first premolars and permanent mandibular canines). Others define early treatment as late–mixed dentition stage treatment (before the emergence of second premolars and permanent maxillary canines).[4]

Clinical research has focused on two prominent strategies for the timing of treatment for Class II malocclusion.[5,6] The first is intervention during the pre-adolescent years (ages 8–11 years)[7] with limited goals that include correction of the molar distocclusion, improvement of the overjet/overbite relationships and incisor alignment. This so-called early treatment is usually followed by a more definitive intervention during adolescence (ages 12–15 years)[7,8] designed to finish and detail the occlusion.

This phase I fixed appliance approach typically involves a maxillary 2 × 4 appliance, extraoral traction for Class II patients, and a lower lingual arch to hold leeway space.[8] Treatment time usually ranges from 12 to 18 months. If a second phase of orthodontic treatment is required, treatment time is usually limited to six to 18 months depending on the malocclusion, patient cooperation, and growth pattern.

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TABLE 1. Comprehensive Clinical Assessment

1. Facial esthetics:	(5)—
• Frontal symmetry: no improvement or deterioration (1–2)	
• Profile: no improvement or deterioration from ideal (1–2)	
• Smile line: no improvement or deterioration (1–2)	
2. Dental esthetics:	(5)—
• Enamel surfaces: residual bonding resin or enamel scars (1–2)	
• Dentition: embrasures, incisal edges, black triangles, and corridors (1–2)	
• Decalcifications: moderate to severe (1–2)	
3. Vertical control:	(5)—
• Growth management: no improvement or deterioration (1–2)	
• Lip competence: no improvement or deterioration (1–2)	
• Incisal exposure: no improvement or deterioration (1–2)	
4. Arch forms:	(5)—
• Symmetry: moderate to marked discrepancy (1–2)	
• Coordination: moderate to marked Mx/Mn discrepancy (1–2)	
• Dentition over basilar bone: to tonsillar pillars and apical base (1–2)	
5. Periodontium management:	(5)—
• Bone loss: moderate to severe, localized, or generalized (1–2)	
• Recession: moderate to severe, localized, or generalized (1–2)	
• Gingival clefts: moderate to severe, localized, or generalized (1–2)	
6. Root structure preservation: root resorption	(5)—
• Incisors: moderate to severe, localized, or generalized (1–2)	
• Cuspids, bicuspids: moderate to severe, localized, or generalized (1–2)	
• Molars: moderate to severe, localized, or generalized (1–2)	
7. Treatment efficiency: result attained relative to treatment time	(5)—
• Overall result: moderate to severe compromise (1–2)	
• Exceeds expected treatment time: one point per 6 mo increment (3)	
Clinical subtotal	

The key to successful phase I treatment is a comprehensive approach to early treatment.[8]

The recommendation for early treatment is most frequently based on empirical judgment rather than evidence from sound clinical research. Part of the problem is due to differences in the definition of early treatment that can include periods spanning the primary through the mixed dentition.[9] Therefore, the specific aim of this study was to compare the treatment outcomes for early treatment (started in the mixed dentition) with late treatment (adolescents in the permanent dentition). The objective was to evaluate the effectiveness of early treatment compared with delivering similar care in the early permanent dentition.

MATERIALS AND METHODS

Pretreatment and posttreatment records of all patients (n = 512) treated in the orthodontic clinic at the Indiana University School of Dentistry (IUSD), who had their treatment completed during the three years (1998, 1999, and 2000), were evaluated for final treatment outcomes. Of the 512 cases, 408 were growing children and adolescents treated in the mixed or early permanent dentition. Records included study casts, panoramic and lateral cephalometric radiographs, and extra-oral and intra-oral photographs. The study was approved by the Institutional Review Board (IRB).

The American Board of Orthodontics Objective Grading System (ABO OGS) for scoring dental casts and panoramic radiographs and the Comprehensive Clinical Assessment (CCA) developed in the IUSD Orthodontics Section were both used for a comprehensive clinical assessment of treatment outcomes.[10] The overall assessment of orthodontic treatment results was the sum of the CCA and ABO OGS scores.[11] Details of the methods have been published previously.[10]

For the CCA evaluation, there were three assessments in each category. No more than two points were deducted for each assessment with a maximum of five points deducted per category. As summarized in Table 1, the three assessments for each category were as follows.

Facial esthetics

This outcome included assessment of ''frontal symmetry, profile, and smile line.'' Pretreatment and post-treatment extra-oral photographs were compared. If there was no improvement or the facial esthetics deteriorated after the orthodontic treatment, points were deducted.

Dental esthetics

''Enamel surfaces, presence of decalcifications, and dentition form'' (embrasures, incisal edges, black triangles, and excessive dark corridors) were evaluated. Pretreatment and post-treatment intraoral photographs were compared. Points were deducted if there was any deviation from the ideal. No more than two points were deducted for each plane, with an overall maximum of five points.

Vertical control

''Growth management, lip competence, and incisal exposure'' were evaluated. Pretreatment and post-treatment extra-oral photographs and lateral cephalometric radiographs were used. In cases of no improvement or deterioration, points were deducted.

Arch forms

''Symmetry, coordination, and position of the dentition over basilar bone'' were assessed. Post-treatment study casts were evaluated. In cases of moderate to marked discrepancy, points were deducted.

Periodontium management

In cases of moderate to severe ''bone loss, gingival recession, or gingival clefts,'' points were deducted. Pretreatment and post-treatment intra-oral photographs and panoramic radiographs were used.

Root structure preservation

For cases of moderate to severe root resorption (''incisor, canine-premolar, and molar segments''), points were deducted. Pretreatment and post-treatment panoramic radiographs were compared.

Treatment efficiency

Results attained relative to the treatment time were evaluated. Points were deducted for ''moderate to severe compromise and one point for every additional six months of treatment that exceeded the expected treatment time.''

Calibration

Two examiners were trained in the use of the evaluation criteria by the clinic director. Twenty patients from the sample were graded according to the criteria by all three evaluators. Discrepancies in the scores for each patient were discussed and cases were graded repeatedly until a consensus was reached by all three evaluators.

Reliability of the evaluation criteria

To determine the examiner reliability, a randomly selected subsample of 20 cases was chosen. The dental casts were measured by two independent examiners on two occasions eight weeks apart. Differences in measurements were estimated by calculating the intraclass correlation coefficient (ICC) of reliability. This provided a single summary of reliability based on a comparison between ratings and between subjects.[12–15]

The following information was collected: patient's sex, age when the treatment started, waiting time between the two phases of treatment, age when the treatment ended, total treatment time, Angle's molar classification, year when the treatment was finished, early debond (yes/no), extraction pattern, and appliances that were used in the mixed dentition. Only the active treatment time of the early-treatment group was counted. The waiting time or the retention phase between phase I and phase II was not counted as treatment time.

Because the definition of early treatment is still controversial, two definitions of early treatment were used in this study. The first definition of early-treatment group was that phase I began in the mixed dentition and used specific appliances for mixed dentition treatment. All these patients were treated with specific mixed dentition objectives. The appliances that were used from 1998 to 2000 were the 2 × 4 appliance, headgear, lower lingual arch, Herbst, tandem mechanics, lip bumper, FR-2 appliance, palatal expander, bite plate, face mask, pendulum appliance, twin block, and FR-3 appliances.

The second definition of early treatment was that those cases that fit the first definition of early treatment and started orthodontic treatment in early childhood (<10 years in girls and <10.5 years in boys)[4] were counted as the early-treatment group. Therefore, the difference between the first definition and the second definition was defining the age at which treatment began.

The late-treatment group included those cases that did not qualify for the early-treatment group but were still growing patients (male individuals <18 years and female individuals <16 years). Intra-examiner repeatability and interexaminer agreement for the total score were assessed using ICCs. Comparisons of the model subtotal (ABO OGS), clinical subtotal (CCA), and treatment time between the early- and late-treatment groups were made using a general linear model that adjusted the influence of the Angle classification, cases finished by classes that graduated in years 1998, 1999, and 2000, extractions (yes/no), and early debond (yes/no). In this model, nongrowing patients were excluded from the sample. Statistical Package of Social Science software was used to conduct all the statistical analyses.

The early-debond cases were excluded from the data set, and then the same statistical analyses were repeated to see if the results would be different. The early-debond cases (premature termination of treatment) were defined as those patients who dropped out and signed early-termination consent forms by guarantors of underage patients or adult patients (if treatment was terminated after 18 years of age).

RESULTS

The ICC for repeatability were .97 for examiner number 1 and .98 for examiner number 2. The interexaminers error checked by ICC was .98 when comparing the 20 cases that were repeated five times by each examiner.

TABLE 2. Descriptive Analysis Between Early and Late-Treatment Groups Using the First Definition

Treatment Group		Age Started	Total Treatment Time	Clinical Subtotal	Model Subtotal	Total Score
Early-treatment group (n = 86)	Mean	10.4671	45.19	3.81	36.00	39.81
	Median	10.5000	42.00	3.00	34.00	38.50
	Standard deviation	1.07111	15.447	2.204	11.377	11.944
	Standard error of mean	0.11550	1.666	0.238	1.227	1.288
	Minimum	7.75	12	0	15	18
	Maximum	12.17	96	10	71	76
Late-treatment group (n = 322)	Mean	13.3768	33.32	2.36	34.53	36.89
	Median	13.2500	32.00	2.00	34.00	36.00
	Standard deviation	1.49904	11.700	2.260	10.209	11.082
	Standard error of mean	0.08354	0.652	0.126	0.569	0.618
	Minimum	8.33	4	0	13	14
	Maximum	17.75	88	13	76	84

TABLE 3. The Mean Total Treatment Time Categorized by the Appliances That Had Been Used in the Early-Treatment Group

Appliance	Case Number	Percentage of Cases (%)	Mean Total Treatment Time
2 × 4	48	55.2	45.31
Headgear	45	51.7	44.73
Herbst	5	5.7	47.8
Tandem mechanics	19	21.8	53.84
Lip bumper	13	14.9	43.38
FR-2	13	14.9	50.69
Expander	25	28.7	43.28
Lower lingual arch	13	14.9	33.62
Bite plate	10	11.5	49.6
Face mask	6	6.9	41.17
Pendulum	1	1.1	30
Twin block	1	1.1	53
FR-3	2	2.3	50.5

First definition of early treatment

When the first definition of early-treatment group was used (all mixed dentition starts), there were 86 early-treatment and 322 late-treatment patients (Table 2). The average age that the treatment ended in the early-treatment group (4.3 years) was earlier than that of the late-treatment group (16.2 years) ($P \leq .001$). Fifty-five cases of 86 cases (64%) had no waiting time (intertreatment interval) between the first and second phases of treatment. For those patients who had a waiting period between the two phases, the average intertreatment interval was 12.7 ± 11.1 months. The average waiting time for the cases that used any type of arch expansion in the first phase was 11.14 ± 7.18 months and ranged from 0 to 25 months.

Table 3 shows the average total treatment time for each appliance as well as the time spent in phase II treatment. Some of the patients were treated with tandem mechanics (mandibular arch expansion with a cervical headgear). Another common treatment modality was a 2 × 4 appliance (bands or bondable brackets on permanent incisors and first molars) and headgear.

The outcome at the end of phase II was significantly worse for the early-treatment group than for the late-treatment group regarding the clinical subtotal (CCA) ($P \leq .001$) and total treatment time ($P \leq .001$). Statistical analysis with general linear model further showed that only decalcification ($P = .032$) and exceeded expected treatment time ($P = .000$) contributed to the statistical significance in CCA between early- and late-treatment groups. Although the mean ABO OGS score was almost 1.5 points higher (worse) for early treatment compared with late treatment, the variance was relatively high, and the difference was not statistically significant ($P = .379$).

Second definition of early treatment

For the second definition of early treatment (start of treatment for girls <10 years and for boys <10.5 years), there were 32 in the early-treatment group and 376 in the late-treatment group. The mean and standard deviation of clinical subtotal and model subtotal, total score, and total treatment time are shown in Table 4. The CCA ($P < .001$) and total treatment time ($P < .001$) were statistically significantly greater for the early-treatment group than that of the late-treatment group. Statistical analysis with general linear model further showed that enamel surface ($P = .023$), dentition ($P = .022$), decalcification ($P = .004$), overall treatment results ($P = .038$), and exceeded expected treatment time ($P = .000$) all contributed to the statistical significance in the CCA between early- and late-treatment groups. There was no statistically significant difference in the ABO OGS score between early- and late-treatment groups ($P = .276$). On average, the CCA of the early-treatment group was about 2.53 points higher than that of the late-treatment group (Table 4). The average total treatment time of the early-treatment group was about 16.36 months longer than that of the late-treatment group (Table 4).

After excluding all the early-debond (premature termination) patients from the data, the change of sample size in each category is shown in Table 5. Table 6 shows the summary statistics for early- vs late-treatment groups using the first definition of early treatment excluding early-debond

TABLE 4. Early- Vs Late-Treatment Group by Using the Second Definition

Treatment Group		Age Started	Total Treatment Time	Clinical Subtotal	Model Subtotal	Total Score
Early-treatment group (n = 32)	Mean	9.3620	51.00	5.00	34.56	39.56
	Standard deviation	0.66989	14.822	1.849	10.680	11.213
	Minimum	7.75	30	2	15	18
	Maximum	10.42	96	9	64	69
Late-treatment group (n = 376)	Mean	13.0530	34.64	2.47	34.86	37.33
	Standard deviation	1.61479	12.584	2.252	10.465	11.324
	Minimum	8.33	4	0	13	14
	Maximum	17.75	88	13	76	84
Total (n = 408)	Mean	12.7635	35.92	2.67	34.84	37.50
	Standard deviation	1.85036	13.492	2.323	10.469	11.317
	Minimum	7.75	4	0	13	14
	Maximum	17.75	96	13	76	84

TABLE 5. Change of Sample Size in Each Category After Excluding Early-Debond Cases

		With Early Debond	Without Early Debond	Early-Debond Rate (%)
First definition of early treatment	Early-treatment group	86	65	24.42
	Late-treatment group	322	257	20.19
Second definition of early treatment	Early-treatment group	32	24	25.00
	Late-treatment group	376	298	20.74

patients. There was no statistically significant difference in ABO OGS score ($P = .89$) between early- and late-treatment groups. Pairwise comparisons showed that the early-treatment group had higher CCA score ($P = .001$) and longer treatment time ($P < .001$) than the late-treatment group. When the first definition of early treatment was used and the early-debond cases were excluded, the average treatment times were calculated for each type of mechanics (Table 7).

Using the second definition, the descriptive statistics for early- and late-treatment groups, excluding early-debond cases, are shown in Table 8. There was no statistically significant difference in the ABO OGS score between early- and late-treatment groups if the second definition of early treatment was used and the early-debond cases were excluded ($P = .155$). The early-treatment group had a statistically significantly higher CCA score ($P < .001$) and longer treatment time ($P < .001$). With early-debond cases excluded, the average treatment time for each type of appliance is shown in Table 9.

The early-debond incidence for boys (27.6%) was statistically significantly greater ($P < .002$) than that for girls (16.1%). When the first definition of early treatment was used, the early-debond rate was 24.4% in the early-treatment group. The early-debond rate in late-treatment group was 20.2%. If the second definition of early treatment was used, the early-debond rate was 25% in the early-treatment group and 20.7% in the late-treatment group.

The extraction rate was always much lower in the early-treatment group than the late-treatment group, no matter whether the first or second definition of early treatment was used or whether early-debond cases were excluded (Tables 10 and 11).

DISCUSSION

An extensive calibration of the two examiners was provided before the start of data collection, which resulted in low interexaminer and intra-examiner errors (ICC = .97–.98). These favorable errors for the methods were an important factor in establishing that the CCA method was more sensitive than the ABO OGS method for demonstrating the inferior result for long–treatment time patients who were started with mixed dentition (Tables 4 and 6).

Comparing the present data with previous studies requires careful attention to sample inclusion and exclusion criteria because the definition of early treatment varies considerably between studies. In the study at the University of North Carolina (UNC),[16,17] the pre-adolescent children in the mixed dentition group had increased overjet (>7 mm) and were within one year of peak height velocity as judged from the hand/wrist radiograph. Patients meeting these criteria were randomly assigned (in blocks of six, stratified by sex) to undergo early growth modification. As a result of the inclusion criteria, the patients' ages ranged from 7.7 to 12.4 years. It was concluded that the severity of the problem and total treatment time were not important influences on the final result, whereas variations in skeletal growth

TABLE 6. Summary Statistics for Early- Vs Late-Treatment Group Using First Definition of Early Treatment Excluding Early Debond

Treatment Group		Total Treatment Time	Age Started	Clinical Subtotal	Model Subtotal	Total Score
Early-treatment group (n = 65)	Mean	44.78	10.397	3.52	33.35	36.9
	Standard deviation	15.924	1.12	2.024	9.699	9.82
	Minimum	19	7.75	0	15	18
	Maximum	96	12.17	9	57	61
Late-treatment group (n = 257)	Mean	31.57	13.338	2.03	32.79	34.8
	Standard deviation	10.616	1.4757	2.126	8.865	9.55
	Minimum	4	8.33	0	13	14
	Maximum	76	16.58	13	59	62
Total (n = 322)	Mean	34.24	12.745	2.33	32.9	35.2
	Standard deviation	12.987	1.8397	2.187	9.027	9.62
	Minimum	4	7.75	0	13	14
	Maximum	96	16.58	13	59	62

TABLE 7. Summary Statistics for Each Appliance Used in Early Treatment by First Definition of Early Treatment Excluding Early Debond

	n	Mean Treatment Time	Standard Deviation	Minimum (mo)	Maximum (mo)
2 × 4	37	44.8	15.159	26	81
Headgear	29	45.1	17.864	23	96
Herbst appliance	1	83	—	83	83
Tandem mechanics	15	53	14.58	34	81
Lip bumper	7	38.6	12.026	26	60
FR-2	8	49.6	5.528	41	55
Expander	20	42.6	14.605	19	81
Lower lingual arch	8	30.3	6.541	19	39
Bite plate	8	49.3	24.212	27	96
Face mask	5	40.4	15.582	19	59
Pendulum	1	30	—	30	30
Twin block	1	53	—	53	53
FR-3	2	50.5	12.021	42	59
Total	405	34.2	12.985	4	96

TABLE 9. Summary Statistics for Each Appliance Used in Early Treatment by Second Definition of Early Treatment Excluding Early Debond

Appliance	n	Mean Treatment Time	Standard Deviation	Minimum (mo)	Maximum (mo)
2 × 4	35	45.03	15.279	26	81
Headgear	27	45.07	18.403	23	96
Herbst appliance	1	83	—	83	83
Tandem mechanics	13	54.08	15.097	34	81
Lip bumper	7	38.57	12.026	26	60
FR-2	6	50.33	5.317	41	55
Expander	19	42.79	14.965	19	81
Lower lingual arch	7	30.43	7.044	19	39
Bite plate	8	49.25	24.212	27	96
Face mask	5	40.4	15.582	19	59
Pendulum	1	30	—	30	30
Twin block	1	53	—	53	53
FR-3	2	50.5	12.021	42	59

TABLE 8. Summary Statistics for Early- and Late-Treatment Groups by Using Second Definition of Early Treatment Excluding Early Debond

Treatment Group		Total Treatment Time	Phase II Treatment Time	Age Started	Clinical Subtotal	Model Subtotal	Total Score
Early-treatment group	n	24	24	24	24	24	24
	Mean	50.25	28.38	9.2431	4.67	31.58	36.25
	Standard deviation	15.754	10.822	0.68318	1.786	8.871	9.128
	Minimum	30	17	7.75	2	15	18
	Maximum	96	57	10.42	9	53	61
Late-treatment group	n	298	85	298	298	298	298
	Mean	33.08	9.48	13.0266	2.14	33.01	35.15
	Standard deviation	11.924	15.497	1.59727	2.108	9.046	9.669
	Minimum	4	0	8.33	0	13	14
	Maximum	83	55	16.58	13	59	62
Total	n	322	109	322	322	322	322
	Mean	34.36	13.64	12.7446	2.33	32.9	35.23
	Standard deviation	13.028	16.54	1.83969	2.187	9.027	9.62
	Minimum	4	0	7.75	0	13	14
	Maximum	96	57	16.58	13	59	62

TABLE 10. Extraction Rate by Using First Definition of Early Treatment

Treatment Group	Early Debond	Extraction Rate (%)
Early-treatment group (first definition)	Exclude early debond	15.4
	Include early debond	14.0
Late-treatment group	Exclude early debond	31.1
	Include early debond	32.9
Total	Exclude early debond	28.0
	Include early debond	28.9

TABLE 11. Extraction Rate by Using Second Definition of Early Treatment

Treatment Group	Early Debond	Extraction Rate (%)
Early-treatment group	Exclude early debond	20.8
	Include early debond	15.6
Late-treatment group	Exclude early debond	28.5
	Include early debond	30.1
Total	Exclude early debond	28.0
	Include early debond	28.9

patterns do seem to play an important role. They concluded that a later-stage, single-phase treatment approach is preferable because of the advantages that accompany reduced treatment time.[18] These conclusions are consistent with those of this study (Tables 2, 4, and 6 through 9).

In the study at the University of Pennsylvania (UP),[4] the inclusion criteria for early treatment were a minimum of 4.5° in the ANB angle and between seven and 12.5/13 years of age. The children were grouped based on emergence or nonemergence of the permanent canines, premolars, and second molars. The change from distoclusion to neutroclusion with each appliance (FR-2 vs straight-pull headgear) was not influenced by the timing of emergence of the second premolars and permanent second molars. Thus, the optimal timing of early treatment of the Class II relationship may be considered to be in the late childhood period, which was defined in this article[4] as skeletal age $\geq$10 years in girls and $\geq$10.5 years in boys. This study also had the same finding if the second definition of early treatment was used.

In this study, two definitions of early treatment were used. According to the first definition of early treatment, the patients must have mixed dentition at the beginning of the treatment and the treatment plan should include the use of specific appliances designed to treat mixed dentition cases. For example, some cases had only second primary molars retained at the beginning of the treatment. The treatment plan was to place brackets on all the permanent teeth and wait for the primary teeth to exfoliate or be extracted. Because there were no specific phase I treatment objectives, these patients were included in the late-treatment group, although they were initially started in the late mixed dentition phase. As a result of the first definition, the patients' ages ranged from 7.75 to 12.17 years (Table 2). The chronologic age was used in this study because there were no hand/wrist films available. The second definition of early treatment further restricted the size of the group based on age at the start of treatment: boys ($<$10.5 years) and girls ($<$10 years). As a result of the second definition, the patients' ages ranged from 7.75 to 10.42 years (Table 4).

The purpose of excluding early-debond cases was because some clinicians think that the early-debond cases usually have worse treatment results, which was not the fault of the treatment regimen (early treatment or late treatment). Therefore, it is believed that early-debond patients should be excluded. Some other clinicians think that the early-debond cases should be included because the early-treatment group tends to have more early-debond cases than the late-treatment group. Then, it is the fault of the treatment regimen. The long duration of early treatment was associated with more patients desiring to quit prematurely. Because of the controversy, we wanted to know if there was any difference of treatment quality between early- and late-treatment groups. This study showed that the conclusion was still the same, no matter whether the early-debond cases were excluded or not.

Overall, this research indicates that extensive mixed dentition treatment is often counterproductive in a large university clinic. Regardless of the definition of the early treatment, or whether the early-debond cases were included or not, the conclusion was still the same. The treatment time was longer, and the outcome (CCA score) was higher (worse) for the early-treatment group compared with the late-treatment group. However, the ABO OGS score showed no statistically significant difference between the early- and late-treatment groups. This is in agreement with the results of the UP[4] and UNC studies.[17]

The purpose of this study was to compare the finishing details of the final result for early treatment (mixed dentition) and late treatment (early permanent dentition). Skeletal effects of phase I treatment and the severity of the malocclusions are important questions being addressed by additional research projects. This study showed that the final occlusion could be finished at the same quality (same ABO OGS score) between early- and late-treatment groups.

Treatment in late childhood may be more practical and cost effective because it reduces the total length of time a child is seen by an orthodontist.[4] This is in agreement with the results of this study that the treatment time was statistically significantly longer ($P < .001$) in the early-treatment

group than in the late-treatment group. This result persisted regardless of the definition of the early-treatment group or whether the early-debond cases were included or not. It can be concluded that if the treatment is started early, the treatment time may be prolonged and the treatment quality may not improve. Further research with a larger sample is indicated to determine which types of malocclusions respond best to specific early-treatment regimens, in a large university clinic with a diverse patient population and multiple supervising faculty.

By definition, two-phase treatment usually involves a waiting period (intertreatment or guidance of eruption phase) between the first phase and the second phase of orthodontic treatment. This study found that only 36% of the early-treatment group using the first definition had a waiting period between the two phases. Thus, 55 of 86 cases (64%) had a continuous treatment that extended up to 96 months. These data help explain why the total treatment in the early-treatment group was much longer than that of the late-treatment group. When the treatment time is prolonged, the patient compliance begins to decline.[10] It is more common to miss appointments, neglect oral hygiene, and fail to wear elastics or headgear. Beckwith[19] found that missed appointments, loose brackets and bands, and poor oral hygiene are all patient cooperation factors that contributed significantly to increased treatment time. Robb[20] found that the number of broken appointments and appliance repairs accounted for 46% of the variability in orthodontic treatment duration as well as 24% of the variability in treatment effectiveness. All these data indicate that patient compliance is inversely related to the length of treatment. Pinskaya[10] demonstrated that continuing the treatment of patients with long treatment times and poor compliance is counterproductive. It is in the best interest of the patients to terminate treatment rather than to continue in an attempt to improve a poor result.

Most researchers have attributed the better compliance of female individuals to an increased concern for appearance.[21] Although female and younger patients are deemed more cooperative, others have cited no difference in sex or age.[22] In this study, early treatment termination occurred more often with boys than with girls. However, the study by Ghafari et al[4] had different dropout rates. In their study, the female dropout rate with the Frankel appliance was higher in girls than in boys (42% vs 25%).

This study demonstrated that the cases where tandem mechanics were used had the longest total treatment time (~53 months) compared with FR-2/FR-3 (~50 months), bite plate (~49 months). The mixed dentition mechanics associated with the shortest treatment times were lower lingual arches (<34 months), face mask (<42 months), palatal expansion (<44 months), and lip bumper (<44 months) (Table 3). It is important to understand that these data apply to treatment delivered in a large university clinic by a series of residents. The results are not applicable to the same treatment delivered by the supervising faculty members in private practice. However, under the conditions of this study, it is clear that mixed dentition cases in a university setting should be carefully selected and rigorously supervised by expert clinicians.

CONCLUSIONS

- Disadvantages of mixed dentition (early) treatment were prolonged treatment time, worse CCA score, and higher rate of premature termination to treatment.
- In this study, the broader-based CCA scoring system was more sensitive than the ABO OGS method for detecting disadvantages of mixed dentition treatment.
- In this study, long treatment time, related to continuous phase I → phase II treatment, was associated with poor compliance during the later stages of phase II treatment.
- To avoid compliance problems due to excessive treatment times, it is recommended that early treatment with fixed appliances be limited to ~12 months of active phase I treatment and be reserved for patients where it is clearly indicated, such as developmental crossbites, functional shifts, severe crowding (≥8 mm discrepancy), and overjet ≥10 mm.

REFERENCES

1. Livieratos FA. Class II treatment: a comparison of one and two stage non-extraction alternatives. In: McNamara JA Jr, ed. *Orthodontic Treatment Outcome and Effectiveness.* 2nd ed. Ann Arbor, Mich: Center for Growth and Development, University of Michigan; 1995:163–193.
2. Keeling SD, King GJ, Wheeler TT, McGovray S. Timing of Class II treatment: rationale, methods and early results of an ongoing randomized clinical trial. In: McNamara JA Jr, ed. *Orthodontic Treatment: Outcome and Effectiveness.* Ann Arbor, Mich: Center for Growth and Development, University of Michigan; 1995:81–112.
3. Tullock JF, Phillips C, Proffit WR. Early versus late treatment of Class II malocclusion: Preliminary results from the University of North Carolina clinical trial. In: McNamara JA Jr, ed. *Orthodontic Treatment: Outcome and Effectiveness.* Ann Arbor, Mich: Center for Growth and Development, University of Michigan; 1995:113–138.
4. Ghafari J, Shofer FS, Jacobsson-Hunt U, Markowitz DL, Laster LL. Headgear versus function regulator in the early treatment of Class II, division 1 malocclusion: a randomized clinical trial [see comments]. *Am J Orthod Dentofacial Orthop.* 1998;113:51–61.
5. West EE. Treatment objectives in the deciduous dentition. *Am J Orthod.* 1969;55:617–632.
6. Graber TM, Chung DD, Aoba JT. Dentofacial orthopedics versus orthodontics. *J Am Dent Assoc.* 75:1145–1166.
7. Fulstow ED. The early treatment of Angle's Class II, division 1 malocclusion. *Dent Pract Dent Rec.* 1968;19:137–144.
8. Dugoni SA. Comprehensive mixed dentition treatment. *Am J Orthod Dentofacial Orthop.* 1998;113:75–84.
9. Ghafari J, King GJ, Tulloch JF. Early treatment of Class II, division 1 malocclusion—comparison of alternative treatment modalities. *Clin Orthod Res.* 1998;1:107–117.
10. Pinskya YB. Assessment of orthodontic treatment results and comparison between fixed lingual and labial appliances. Indiana University School of Dentistry (Masters thesis) 2001.
11. Casko JS, Vaden JL, Kokich VG, et al. Objective grading system

for dental casts and panoramic radiographs. American Board of Orthodontics. *Am J Orthod Dentofacial Orthop.* 1998;114:589–599.
12. Bartko JJ. The intraclass correlation coefficient as a measure of reliability. *Psychol Rep.* 1966;19:3–11.
13. Fleiss JL, Slakter MJ, Fischman SL, Park MH, Chilton NW. Inter-examiner reliability in caries trials. *J Dent Res.* 1979;58:604–609.
14. Fleiss JL, *Statistical Methods for Rates and Proportions.* 2nd ed. London, UK: Wiley; 1981.
15. Fleiss JL, *The Design and Analysis of Clinical Experiments.* London, UK: Wiley; 1986.
16. Tulloch JFC, Phillips C, Koch G, Proffit WR. The effect of early intervention on skeletal pattern in Class II malocclusion: a randomized clinical trial. *Am J Orthod Dentofacial Orthop.* 1997; 111:391–400.
17. Tulloch JFC, Phillips C, Proffit WR. Benefit of early Class II treatment: progress report of a two-phase randomized clinical trial. *Am J Orthod Dentofacial Orthop.* 1998;113:62–72.
18. Kluemper GT, Beeman CS, Hicks EP. Early orthodontic treatment: what are the imperatives? *J Am Dent Assoc.* 2000;131:613–620.
19. Beckwith FR, Ackerman RJ Jr, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1999;115:439–447.
20. Robb SI, Sadowsky C, Schneider BJ, BeGole EA. Effectiveness and duration of orthodontic treatment in adults and adolescents. *Am J Orthod Dentofacial Orthop.* 1998;114:383–386.
21. Lewis HG, Brown WA. The attitude of patients to the wearing of a removable orthodontic appliance. *Br Dent J.* 1973;134:87–90.
22. Nanda RS, Kierl MJ. Prediction of cooperation in orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1992;102:15–21.