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Long-term evaluation of early versus late orthodontic treatment of crowded first premolar extraction cases

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Takanobu HARUKI

叢生を伴う上下第一小臼歯抜歯の早期矯正治療と
晩期矯正治療の術後長期に渡る評価について

春木　隆伸

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ABSTRACT

The purpose of this study was to evaluate the differences in the long-term cranio facial pattern of orthodontically induced changes between early orthodontic treatment (mixed dentition) and late orthodontic treatment (permanent dentition). Cephalometric radiographs were evaluated before treatment, after treatment, and at minimum of 10 years after retention for an early orthodontic treatment group of 26 and a late orthodontic treatment group of 34. All were categorized as either Angle Class I and Class II malocclusion at pretreatment and had received routine edgewise orthodontic treatment that included maxillary and mandibular first premolar extraction. These were no significant differences between these groups at pretreatment and posttreatment except liner measurements according to age difference. Irregularity index at postretention had a statistical significant correction with the change of Gonial angle during the treatment period and the change of occlusal plane angle during the treatment period. Decreasing the Gonial angle and occlusal plane angle during the treatment period may indicate to improve long-term stability.

INTRODUCTION

Long-term stability of orthodontic treatment is one of the most important concerns of orthodontists and patients. In 1960 Richard Riedel[1] stated, "Retention is and will continue to be a problem of treatment." This sage admonition drives our search for understanding and improved treatment methods.

Early orthodontic treatment has been advocated because it may not only correct the occlusion but also may promote normal development of the dentition. Proper arch form and dental relationships in the mixed dentition may lessen the need for additional orthodontic treatment. Objectives in

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mixed dentition orthodontic therapy could include correction of dental arch irregularities, occlusal and jaw relation abnormalities, and functional interference, but does this improve stability?

There have been a number of studies to evaluate long term stability,[2-20] but no study to describe skeletal changes when comparing early versus late orthodontic treatment of first premolar extraction cases. This study investigated these differences by using cephalometric radiographs of patients who had been out of retention a minimum of 10 years.

MATERIALS AND METHODS

The sample consisted of diagnostic records for 60 patients who were categorized as either Angle Class I, Class II division 1, or Class II division 2 malocclusion at pretreatment. These cases had complete records and were selected from the Department of Orthodontics, University of Washington and from faculty practices in the Seattle area. All cases had pretreatment crowding (moderate irregularity, severe irregularity, or very severe irregularity)[21] of mandibular anteriors and no spacing in the anterior dentition. Patients with anterior openbite and/or posterior crossbites were not include in this study. Patients were divided into two groups according to the time of the initial orthodontic mechanical treatment (Table 1).

Early (mixed dentition) orthodontic treatment group (Hellman's dental stage III B[22]) (n=26) : One or more deciduous teeth remained or sequential teeth had not fully erupted at the start of treatment. Active orthodontic treatment was started during the mixed dentition immediately after extraction of first premolars. Serial extraction cases that had a period of physiologic drift after extraction were excluded. All cases had early banding of molars and bonding of incisors to gain initial alignment. In a few cases, a lingual arch was used in the mandibular arch until all permanent teeth were erupted. Full orthodontic treatment plus retention followed this early alignment phase of treatment.

Late (permanent dentition) orthodontic treatment group (Hellman's dental stage III C[22] or after) (n=34) : All permanent teeth anterior to second permanent molars had erupted prior to any treatment. Extraction or first premolars was accomplished and active treatment immediately begun.

All cases of Class II division 1 and Class II division 2 involves headgear therapy to the maxillary arch. In some of the cases, a maxillary arch bite plate was used for overbite reduction. Each patient had complete records including dental casts and cephalometric radiographs at three time periods (Table 1) : pretreatment (T1), at the end of active treatment (T2), and minimum of 10 years after removal of retainers (T3). All patients had undergone routine edgewise orthodontic treatment that included maxillary and mandibular first premolar extraciton. All four premolars were extracted either just before or soon after (within five months) the start of initial treatment. Treatment was followed by a variable period of retention, typically 1 to 3 years of a removable upper arch retainer and a lower arch canine to canine fixed retainer. No case received a "sulcus slice" (circumferential supracrestal fiberotomy) in an effort to avoid postretention rotation change. To be considered a part of the sample, a clinically acceptable result at the end of active treatment had to have been achieved and at postretention there had to be a full complement of teeth excluding extracted first premolars.

The average postretention period was 15 years for both the early and late orthodontic treatment groups. There was no statistical significant difference in posttreatment period between early and late orthodontic treatment groups.

Table 1 Sample characteristics

	Early group		Late group		Pool
Gender					
Male	8		9		17
Female	18		25		43
pool	26		34		60
Angle Class					
Class I	11		18		29
Class II div. 1	11		12		23
Class II div. 2	4		4		8
Age	Av.	S.D.	Av.	S.D.	
Pre-treatment (T1)	10y 11m	(12.22m)	13y 8m	(15.54m)	
Post-treatment (T2)	14y 4m	(14.11m)	16y 3m	(18.16m)	
Post-retention (T3)	29y 11m	(50.21m)	31y 9m	(49.24m)	
Postretention period (T2-T3)	15y 8m	(52.27m)	15y 6m	(49.44m)	

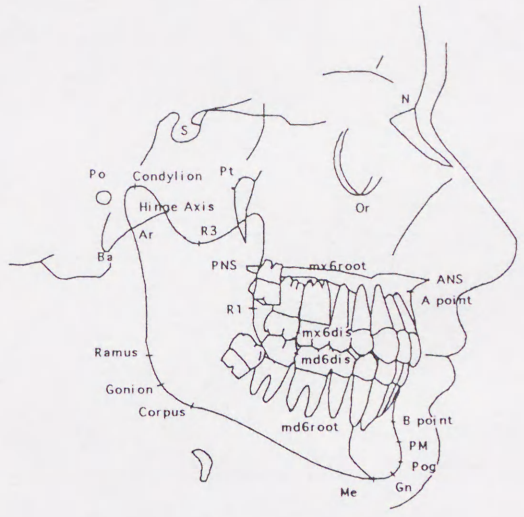

Fig. 1 Cephalometric Landmarks

Mesurements on cephalometric radiographs

To reduce examiner bias in the current study, each cephalometric radiopraph was numbered and measured in random order via a computer-generated list. Pretreatment (T1), posttreatment (T2) and postretention (T3) lateral cephalometric radiographs were traced on acetate film using a 0.3-mm lead pencil by the same trained dentist. Cephalometric landmarks were digitized with the Numonic Digitizer (Numonics Corp., Montgomeryville, Penn. USA). Using the Macintosh Quick Ceph Program (Quick Ceph Systems, San Diego, Cal. USA), the following twenty angular and eleven linear measurements were calculated :

Angular measurements :
- SNA[23]
- SNB[23]
- ANB[23]
- Upper 1 to NA[23]
- Lower 1 to NB[23]
- Occulusal plane angle[23]
- Interincisal angle[23]
- FMA[24]
- FMIA[24]
- IMPA[24]
- Saddle angle[25]
- Articular angle[25]
- Gonial angle[25]
- Upper Gonial angle[25]
- Lower Gonial angle[25]

Liner measurements :
- Upper 1 to NA(mm)[23]
- Lower 1 to NB(mm)[23]
- Wits appraisal[26-28]
- Anterior cranial base[25]
- Posterior cranial base[25]
- Ramus height[25]
- Mandibular body length[25]
- Posterior facial height[25]
- Anterior facial height[25]
- Convexity[29]
- ANS-Menton[30]

The reproducibility of the measurements was assessed by the statistically analyzing the difference between double measurements taken at least two weeks apart on 15 cephalometric radiographs selected at random. The error of the method was calculated from the equation :

$d\sqrt{2/2n}$ where d is the difference between duplicate measurements and n is the number of double measurements.

The error was calculated for each of the cephalometric measurements. The method did not exceed 0.6 mm for any of the linear variables and 1.2 degrees for any of the angular variables.

Measurements on study models

The data from study casts are noted in Table 5 and are quoted from our previous study[2),21)]. To reduce examiner bias, each cast was measured in random order. A digital caliper (Caliper Ultra-Call Mark III, Flower Co. Inc, Newton, Mass. USA) was used to measure the following values for each set of cases. Irregularity index : The summed displacement of the anatomic contact points of the lower anterior teeth as described by Little[21)]. 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[21)]. Mandibular intercanine width : The distance between cusp tips or estimated cusp tips in cases of wear facets[21)]. Deviation of the midline : The difference between maxillary and mandibular incisor midline[2)].

Data analysis

The means and standard deviations were calculated for each parameter and statistical analysis was performed by using standard methods. Groups were compared by unpaired Student's t-test for independent groups, and the significance of changes across time was determined by paired Student's t-test for paired data. Association between variables was evaluated by the Pearson product-moment correlation coefficient, discriminate analysis, and a multiple linear regression analysis.

RESULTS

Measurement of cephalometric radiograph

Mean measurement values are listed in Table 2. For angular measurement, at pretreatment (T1) there were statistically significant differences between groups on Upper incisor to NA angle, Lower incisor to NB angle, Interincisal angle, FMIA and Upper Gonial angle. At pretreatment,

Table 2 Mean angular and linear measurement on cephalometric radiographs

	T1					T2				T3			
	Early group			Late group		Early group		Late group		Early group		Late group	
	Av.	S.D.		Av.	S.D.	Av.	S.D.	Av.	S.D.	Av.	S.D.	Av.	S.D.
SNA	80.48	4.95		80.36	3.41	78.03	3.93	78.89	3.40	78.24	4.44	78.86	3.57
SNB	74.69	3.59		75.38	3.07	74.96	3.70	75.45	3.24	74.69	4.14	75.33	3.84
ANB	5.80	2.15		4.99	2.13	3.06	1.67	3.44	2.01	3.55	1.68	3.53	2.37
Up.1 to NA	20.01	9.43	*	24.20	7.38	18.47	6.06	17.02	6.84	20.96	6.95	17.75	7.98
Lw.1 to NB	24.94	7.32	*	28.04	4.99	22.35	4.47	22.93	5.27	22.03	4.63	21.93	5.28
Occl. pl. to SN	19.90	4.09		18.74	3.41	19.20	4.04	19.92	4.08	17.74	4.12	18.90	5.12
Interincisal angle	129.26	14.44	**	122.78	10.05	136.13	6.49	136.61	7.49	134.19	7.79	136.81	8.13
FMA	28.42	5.45		29.21	6.29	28.14	5.42	29.43	7.03	26.11	5.41	28.32	7.60
FMIA	58.39	8.02	**	54.77	5.78	60.94	6.08	59.92	7.23	61.75	6.24	60.74	7.18
IMPA	93.20	7.74		96.02	5.32	90.92	6.34	90.64	6.33	92.14	5.33	90.94	6.69
Saddle angle	124.93	4.51		123.81	5.07	124.91	4.30	123.82	5.16	124.91	5.07	123.87	5.74
Articulare angle	143.46	6.57		146.12	5.86	145.47	5.92	146.57	6.51	145.12	7.24	146.02	8.30
Gonial angle	128.62	5.61		126.64	7.46	126.03	5.33	126.36	7.21	124.40	5.39	125.68	7.99
Up. gonial angle	53.89	3.77	**	51.71	3.88	51.02	3.48	50.64	3.82	50.58	4.17	50.65	4.16
Lo. gonial angle	74.73	4.69		74.94	5.49	75.00	4.50	75.72	5.73	73.82	4.51	75.02	6.39
Up. 1 to NA (mm)	4.17	3.34	*	6.35	2.88	3.28	2.44	3.03	2.02	4.15	2.34	3.49	2.78
Lo.1 to NB (mm)	5.93	2.71	**	7.43	2.37	4.89	1.43	5.06	2.24	4.73	1.74	5.01	1.93
Wits appraisal	2.53	2.66		2.25	3.64	0.44	2.46	-0.24	2.55	0.83	2.61	0.95	2.41
Ant. cranial base	70.11	2.97	**	71.87	3.05	72.94	3.93	72.89	3.62	75.15	4.08	74.58	4.10
Post. cranial base	33.31	3.08	**	35.04	3.46	35.52	3.04	35.48	3.54	36.94	3.15	36.36	3.37
Ramus height	40.90	4.04	**	43.31	5.16	45.54	4.55	45.83	5.11	48.87	4.85	47.93	5.89
Mand. body length	67.23	3.51	***	71.67	5.20	72.89	4.01	73.01	5.30	75.77	4.13	74.21	5.98
Post. face height	70.38	4.96	***	74.94	6.54	77.38	5.78	77.84	7.03	81.78	6.52	80.52	7.81
Ant. face height	113.67	7.02	***	119.67	6.96	122.79	8.14	123.53	8.07	126.27	8.05	125.55	8.50
Convexity	4.91	2.65		4.29	2.43	1.71	2.06	2.71	2.64	1.04	2.53	2.22	3.23
ANS-Me.	65.58	5.24	*	68.39	5.74	70.66	6.55	70.92	6.93	72.61	6.19	71.80	7.05

* p<0.05; ** p<0.01; *** p<0.001

p-values refers to differences between subgroups at each stage

the average patient included in the sample of late treated group had a more proclined maxillary and mandibular incisors. However, there were no statistically significant differences between groups at posttreatment (T2) and postretention (T3). For linear measurement, at pretreatment there were statistically significant differences between groups on all linear measured values except Wits appraisal and Convexity. However, there were no statistically significant differences between groups at posttreatment period (T2) and postretention period (T3).

Treatment (T1-T2), posttreatment (T2-T3) and overall (T1-T3) changes are listed in Table 3. During the treatment period (T1-T2), there were statistical significant differences of changes on SNA, ANB, Upper 1 to NA angle, Occlusal plane angle, Interincisal angle, IMPA, Articular angle and Gonial angle between early and late groups. In linear measurement during the treatment period (T1-T2), there were statistical significant differences of change on all linear measured values except Wits appraisal. However, during the posttreatment period (T2-T3), there was no statistical significant difference of changes except the change of Mandibular body length between early and late groups. During the overall period (T1-T3), there were the same tendencies of the change as during the treatment period (T1-T2). There were no statistical significant difference of change on Lower 1 to NB angle and FMA during the treatment period (T1-T2), but there were statistical significant differences of changes on Lower 1 to NB angle and FMA during the overall period (T1-T3).

Treatment and posttreatment changes which were compared with zero are listed in Table 4. During the treatment period (T1-T2), the angular measures of SNA, ANB and Upper Gonial angle, and the linear measurement of Lower 1 to NB and Wits apprisal indicated significant treatment decreasing in both early and late groups. The angular measures of Gonial angle indicated significant decreasing only in the early group. The other way, the angular measures of Upper 1 to NA angle, Lower 1 to NB angle indicated significant treatment decreasing only in the late group. The linear measurement of skeletal values in early group indicated significant growth increasing.

Table 3 Treatment, post-treatment and changes on cephalometric radiographs

	Treatment(T1-T2)					Posttreatment(T2-T3)					Overall(T1-T3)				
	Early group			Late group		Early group			Late group		Early group			Late group	
	Av.	S.D.		Av.	S.D.	Av.	S.D.		Av.	S.D.	Av.	S.D.		Av.	S.D.
SNA	-2.45	2.55	*	-1.47	1.58	0.22	1.72		-0.03	1.14	-2.24	2.89		-1.50	1.80
SNB	0.27	1.34		0.08	1.02	0.46	1.18		-0.13	1.46	0.73	1.80		-0.05	1.79
ANB	-2.74	2.22	**	-1.55	1.55	-0.24	1.45		0.09	1.56	-2.98	2.42	**	-1.46	1.88
Up.1 to NA	-1.54	11.24	**	-7.18	8.80	2.49	5.80		0.73	5.13	0.95	10.32	**	-6.45	8.41
Lw.1 to NB	-2.59	7.40		-5.11	5.23	-0.32	3.51		-1.00	4.37	-2.91	6.52	**	-6.11	4.70
Occl. pl. to SN	-0.70	3.88	*	1.17	3.62	-1.47	2.73		-1.01	3.68	-2.17	4.07	*	0.16	5.03
Interincisal angle	6.87	15.36	**	13.83	10.29	-1.94	6.36		0.20	5.42	4.93	14.62	**	14.03	9.70
FMA	-0.28	2.25		0.22	1.98	-2.03	2.02		-1.11	2.11	-2.31	2.37	**	-0.89	2.95
FMIA	2.56	7.65		5.15	5.52	0.81	3.59		0.82	4.60	3.37	6.93		5.97	5.18
IMPA	-2.28	7.09	*	-5.37	5.48	1.22	3.49		0.30	4.13	-1.06	7.20	**	-5.07	5.18
Saddle angle	-0.02	1.66		0.01	1.66	0.00	1.46		0.05	2.18	-0.02	2.29		0.06	2.49
Articulare angle	2.02	3.05	**	0.45	2.86	-0.36	3.83		-0.55	3.85	1.66	3.70	*	-0.10	4.24
Gonial angle	-2.58	2.52	***	-0.27	2.14	-1.64	3.09		-0.68	3.11	-4.22	3.72	***	-0.96	3.16
Up. gonial angle	-0.60	2.03		0.18	2.14	-1.99	2.11		-1.18	2.47	-2.59	2.74	*	-1.00	3.41
Lo. gonial angle	0.27	2.17		0.78	3.30	-1.18	2.01		-0.69	2.55	-0.92	4.44		0.09	5.63
Up. 1 to NA (mm)	-0.89	4.00	**	-3.33	2.85	0.87	1.94		0.46	2.25	-0.02	3.37	**	-2.86	3.20
Lo.1 to NB (mm)	-1.05	2.40	**	-2.37	1.82	-0.15	1.44		-0.05	1.21	1.20	2.41	**	-2.42	1.83
Wits appraisal	-2.09	3.08		-2.49	2.97	0.39	1.85		1.18	1.87	-1.70	3.41		-1.03	3.41
Ant. cranial base	2.83	2.12	***	1.02	1.30	2.21	1.95		1.70	1.94	5.04	2.59	***	2.71	2.24
Post. cranial base	2.22	2.20	***	0.44	1.31	1.42	2.20		0.88	1.50	3.63	2.55	***	1.32	1.72
Ramus height	4.63	10.55	***	2.52	7.07	3.33	10.69		2.11	8.23	7.97	22.71	**	4.62	18.11
Mand. body length	5.66	9.96	***	1.34	5.08	2.88	12.40	*	1.20	6.17	8.54	21.41	***	2.54	11.80
Post. face height	7.00	13.94	***	2.90	8.77	4.40	17.89		2.68	12.06	11.40	17.90	***	5.58	25.10
Ant. face height	9.13	25.80	***	3.86	14.12	3.47	12.31		2.02	10.71	12.60	22.12	***	5.88	28.11
Convexity	-3.20	5.99	**	-1.58	2.85	-0.67	2.76		-0.49	3.75	-3.87	8.26	**	-2.07	4.83
ANS-Me.	5.08	2.53	**	2.53	5.64	1.95	4.82		0.88	6.25	7.03	17.51	***	3.41	12.90

Comparison between early and late groups

p-values refers to differences between subgroups at each period

* p<0.05; ** p<0.01; *** p<0.001

Table 4 Treatment and post-treatment changes on cephalometric radiographs

	Treatment(T1-T2)		Posttreatment(T2-T3)	
	Early Group	Late Group	Early Group	Late Group
SNA	- ***	- ***	n.s.	n.s.
SNB	n.s.	n.s.	n.s.	n.s.
ANB	- ***	- ***	n.s.	n.s.
Up.1 to NA	n.s.	- ***	n.s.	n.s.
Lw.1 to NB	n.s.	- ***	n.s.	n.s.
Occl. pl. to SN	n.s.	n.s.	- *	n.s.
Interincisal angle	+ *	+ ***	n.s.	n.s.
FMA	n.s.	n.s.	- ***	- ***
FMIA	n.s.	+ ***	n.s.	n.s.
IMPA	n.s.	- ***	n.s.	n.s.
Saddle angle	n.s.	n.s.	n.s.	n.s.
Articulare angle	+ **	n.s.	n.s.	n.s.
Gonial angle	- ***	n.s.	- *	n.s.
Up. gonial angle	- ***	- ***	n.s.	n.s.
Lo. gonial angle	n.s.	+ *	- ***	- *
Up. 1 to NA (mm)	n.s.	- ***	n.s.	n.s.
Lo.1 to NB (mm)	- *	- ***	n.s.	n.s.
Wits appraisal	- ***	- ***	n.s.	+ ***
Ant. cranial base	+ ***	+ ***	+ ***	+ ***
Post. cranial base	+ ***	n.s.	+ **	+ **
Ramus height	+ ***	+ ***	+ ***	+ ***
Mand. body length	+ ***	+ **	+ ***	+ **
Post. face height	+ ***	+ ***	+ ***	+ ***
Ant. face height	+ ***	+ ***	+ ***	+ **
Convexity	+ ***	n.s.	n.s.	n.s.
ANS-Me.	+ ***	+ ***	+ ***	+ *

p-values refers to difference between value and zero * p<0.05; ** p<0.01; *** p<0.001

However, in the late group, there was no significant growth increasing of Posterior cranial base in the treatment period, and the linear measurement of Upper 1 to NA (mm) indicated significant treatment decreasing only in the late group. During the posttreatment period (T2-T3), the angular measures of FMA and Lower Gonial angle indicated significantly decreasing. The linear measurement of all values indicated significant increasing in both early and late groups. However, the angular measures of occlusal plane angle and Gonial angle indicated significant decreasing only in the early group and the linear measurement of Wits appraisal indicated significant increasing only in the late group respectively.

In assessing the other cephalometric parameters, some clinically useful correlations were found. A weak association existed between the change of Gonial angle from pretreatment and postretention (T1-T3) and Mandibular body length at pretreatment (T1) (r=0.40), and Ramus height at pretreatment (T1) (r=0.32). A weak association existed between the change of Occlusal plane angle from pretreatment and postretention (T1-T3) and Wits apprise at pretreatment (T1) (r=0.48). A moderate negative association existed between the change of Occlusal plane angle from pretreatment and postretention (T1-T3) and the change of SNA from pretreatment and postretention (T1-T3) (r=-0.59), and the change of Upper incisal to NA angle from pretreatment and postretention (T1-T3) (r=-0.59).

Associations cephalometric radiographs and study models

In assessing the parameters of study models at postretention (T3) and cephalometric parameters, some clinically useful correlations were found. A weak association existed between the irregularity index at postretention (T3) and Gonial angle during the treatment period (T1-T2) (r=0.34), the irregularity index at postretention (T3) and Occlusal plane angle during the treatment period (T1-T2) (r=0.32), between the irregularity index at postretention (T3) and ANB at posttreatment (T2) (r=0.33). (Table 6)

ANB at postretention (T3) had a statistical significant correlation with Convexity, ANB, Wits appraisal and Overjet at pretreatment (T1) (Table 7). ANB at postretention (T3) had a statistically significant correlation with the change of FMA, occlusal plane angle and Gonial angle during the

Table 5 Mandibular measured value on Study models at T1, T2, and T3

	Early Group		Late Group		Intergroup difference
	Av.	S.D.	Av.	S.D.	
Irregularity index					
Pre-treatment (T1)	7.26	3.41	8.69	3.49	n.s.
Post-treatment (T2)	1.34	0.61	1.23	0.84	n.s.
Post-retention (T3)	2.71	1.16	4.54	2.04	**
Mandibular arch length					
(T1)	56.74	4.16	55.12	4.79	n.s.
(T2)	48.23	2.52	47.95	3.02	n.s.
(T3)	45.23	4.56	44.58	3.65	n.s.
Mandibular intercanine width					
(T1)	25.83	2.51	24.91	2.43	n.s.
(T2)	27.29	1.48	26.91	1.84	n.s.
(T3)	25.83	1.78	24.58	1.94	**
Overbite					
(T1)	3.69	1.65	3.38	1.61	n.s.
(T2)	2.76	1.06	2.91	1.65	n.s.
(T3)	2.98	1.24	3.53	1.62	n.s.
Overjet					
(T1)	5.57	2.26	6.30	2.66	n.s.
(T2)	2.93	0.55	2.91	0.76	n.s.
(T3)	3.47	0.77	3.81	1.14	n.s.
Deviation of the midline					
(T1)	1.08	0.86	1.23	1.01	n.s.
(T2)	0.34	0.40	0.36	0.43	n.s.
(T3)	0.26	0.29	0.80	0.54	**

** p<0.01

Table 6 Pearson's of correlation coefficient (r- value) between Irregularity Index at postretention (T3) and other tested variables.

variable		r	r^2	
(Overbite)	T3	0.45	0.20	***
age	T1	0.42	0.18	***
(Overjet)	T3	0.40	0.16	**
(Canine width)	T3	-0.39	0.15	**
Gonial angle	T1-T2	0.34	0.12	**
ANB	T2	0.33	0.11	*
Occlusal plane angle	T1-T2	0.32	0.10	*

( ) : model measurement * p<0.05; ** p<0.01; *** p<0.001

Table 7 Pearson's correlation coefficient (*r*- value) between ANB at posttretention (T3) and other tested variables.

variable		*r*	r^2	
Convexity	T1	0.47	0.22	***
ANB	T1	0.45	0.20	***
FMA	T2-T3	0.43	0.18	***
Occlusal plane angle	T2-T3	0.38	0.14	**
Wits appraisal	T1	0.34	0.12	**
Anterior cranial base	T2-T3	-0.32	0.10	*
Mandibular body length	T1-T2	-0.32	0.10	*
(Overjet)	T1	0.31	0.10	*
Anterior cranial base	T1-T2	-0.31	0.10	*
Age	T1	0.29	0.08	*
Occlusal plane angle	T1-T2	0.29	0.08	*
Gonial angle	T2-T3	0.29	0.08	*

( ) : model measurement * p<0.05; ** p<0.01; *** p<0.001

Other tested variables were excluded data at T2 and T3

Table 8 Pearson's correlation coefficient (*r*- value) between Mandibular body length at postretention (T3) and other tested variables.

variable		*r*	r^2	
Mandibular body length	T1	0.54	0.29	***
(Arch length)	T1	0.50	0.25	***
Anterior cranial base	T1-T2	0.43	0.18	***
Gonial angle	T2-T3	-0.43	0.18	***
ANB	T2-T3	-0.39	0.15	**
FMA	T2-T3	-0.39	0.15	**
U1 to NA (mm)	T2-T3	0.37	0.14	**
U1 to NA (degree)	T2-T3	0.36	0.13	**
ANB	T1-T2	-0.36	0.13	**
SNB	T1	0.35	0.12	**
Occlusal plane angle	T2-T3	-0.34	0.12	**
Convexity	T2-T3	-0.34	0.12	**
SNA	T1	0.34	0.12	**
SNB	T2-T3	0.32	0.10	*
Mandibular body length	T1-T2	0.32	0.10	*
Posterior cranial base	T1-T2	0.32	0.10	*
Age	T1	-0.31	0.10	*

( ) : model measurement * p<0.05; ** p<0.01; *** p<0.001

Other tested variables were excluded data at T2 and T3

posttreatment period (T2-T3) and with the change of occlusal plane angle during the treatment period (T1-T2). ANB at postretention (T3) had a statistically significant negative correlation with the change of Anterior cranial base during the treatment period (T1-T2) and posttreatment period (T2-T3). Mandibular body length at postretention (T3) had a significant negative correlation with AMB during the treatment period (T1-T2) and a statistical significant correlation with the

Table 9 Pearson's correlation coefficient (*r*- value) between Patient's age at pretretetention (T1) and other tested variables.

variable		*r*	r^2	
Posterior cranial base	T1-T2	-0.60	0.36	***
Anterior cranial base	T1-T2	-0.53	0.28	***
(Deviation of the midline)	T3	0.51	0.26	***
(Irregularity index)	T2-T3	0.45	0.20	***
Convexity	T1-T2	0.43	0.18	***
ANS-Me	T1-T2	-0.42	0.18	***
(Irregularity index)	T3	0.42	0.18	***
Gonial angle	T1-T2	0.40	0.16	**
Occlusal plane angle	T1-T2	0.39	0.15	**
ANB	T1-T2	0.35	0.12	**
Mandibular body length	T1	0.33	0.11	*
Mandibular body length	T3	-0.31	0.10	*

( ) : model measurement * p<0.05; ** p<0.01; *** p<0.001

change of Anterior cranial base, Mandibular body length and Posterior cranial base during the treatment period (T1-T2) (Table 8). The treatment and growth changes during the treatment period of decreasing of ANB, increasing of Anterior cranial base, Mandibular body length and Posterior cranial base were due to the longer Mandibular body length at postretention (T3). Mandibular body length at postretention (T3) also had a significant negative correlation with Gonial angle, ANB, FMA, Occlusal plane angle and Convexity during the posttreatment period (T2-T3) (Table 8).

The patient's age at treatment (T1) had a significant negative correlation with Posterior cranial base, Anterior cranial base and ANS-Me during treatment period (T1-T2) in Table 9. The patient's age at treatment (T1) had a significant correlation with the change of Convexity, Gonial angle, Occlusal plane angle and ANB during treatment period (T1-T2).

DISCUSSION

The ANB correction was primarily due to the decrease of SNA, suggested that the maxilla may be maintained or displaced slightly posteriorly by the effect of a face-bow in Class II patients. The decrease of SNA in the early group indicated significant greater treatment decreasing than the late group. However, there was no significant difference of SNB between early and late groups during the treatment period (T1-T2). Consequently, the angular measurement of ANB in the early group indicated greater treatment effect than the late group. During the posttreatment period (T2-T3), there was no significant difference in change of ANB among both groups (Table 3).

Most of the differences of the linear measurements between early and late groups in the treatment period (T1-T2) and the overall period (T1-T3) were probably due to the differences of the growth and development by their age at pretreatment (T1). This is the reason that there was no statistical significant difference of the linear measurements between early and late groups in the posttreatment period (T2-T3) except mandibular body length (Table 3).

The post-treatment changes on cephalometric radiographs were indicated that occlusal plane angle and Gonial angle were decreasing only in the early group (Table 4). These skeletal changes indicated that occlusal plane and mandibular plane had counter clockwise rotation during the posttreatment period (T2-T3) only in the early group. Wits appraisal for posttreatment changes indicated significant increase only in the late group. It was a very interesting finding because the Wits appraisal in the early group was stable but that in late group showed relapse.

Irregularity index at postretention (T3) had a statistical significant relationship with the change of Gronial angle during the treatment period (Table 6). Irregularity index at postretention (T3) had a statistical significant relationship with the change of occlusal plane angle during the treatment period (T1-T2). The results of the regression analyses suggested that the decreasing of Gonial angle and occlusal plane angle during the treatment period were significant predictors for the amount of incisor crowding at postretention (T3). These interesting findings in the current study suggest that we should make an effort to reduce Gonial angle and occlusal plane angle during the treatment period to improve long term stability.

ANB at postretention (T3) had a statistically significant correlation with the change of FMA, occlusal plane angle and Gonial angle during the posttreatment (T2-T3) and with the change of occlusal plane angle during the treatment period (T1-T2). These correlations indicated that counter clockwise rotation of the mandible was due to the small ANB at postretention. We could confirm the general clinical impression that a reduction in mandibular plane angle is associated with decrease of ANB. ANB at postretention (T3) had a statistically significant negative correlation with the change of Anterior cranial base during the treatment period (T1-T2) and posttreatment period (T2-T3) (Table 7). These correlations were confirmed that the smaller ANB was due to the anterior N point in general[31].

Finally, in our previous study, the patient's age at treatment (T1) had a significant negative correlation with deviation of midline at postretention (T3) and the change of Irregularity index during the posttreatment period (T2-T3) and a significant correlation with Irregularity index at postretention (T3). These significant correlation between the patient's age and relapse of model analyses were indicated the advantage of early orthodontic treatment. The current study, it is very interesting finding between the patient's age at treatment (T1) and Mandibular body length at postretention (T3) (Table 8). The younger age of treatment was the shorter Mandible at treatment (T1), while the younger age of treatment was the longer Mandible at postretention (T3). Thus, observed the patient's age of treatment time (T1) with other tested variables indicated the advantage of early orthodontic treatment of crowded first premolar extraction cases in Angel's Class I and Class II malocclusion (Table 9).

It is the goal of early treatment to minimize or eliminate skeletal, dentoalveolar and muscular problems by the end of the transition to the permanent dentition. At this time, it is hoped that skeletal imbalances and functional imbalances have been resolved easier than the permanent dentition. However, each sample demonstrates the marked variation. In clinically, we sometimes have been experienced that early intervention does not change appreciably the environment for dentofacial development. These concerns also must be considered when evaluating treatment options and we must recognize the importance of total diagnose in early dentition.

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REFERENCES

1) Riedel, A. R. : A review of the retention problem, *Angle Orthod* 30 : 179-199, 1960.
2) Haruki, T., Little, R. M. : Early versus late treatment of crowded first premolar extraction cases -Postretention evaluation of stability and relapse, *Angle Orthod* 61 : 61-68, 1998.
3) Steadman, S. R. : Change of intermolar and intercuspid distances following orthodontics treatment, *Angle Orthod* 31 : 207-215, 1961.
4) Johnson, K. C. : Cases six years postretention, *Angle Orthod* 47 : 210-220, 1977.
5) Little, R. M., Wallen, T. R., Riedel, R. A. : Stability and relapse of mandibular anterior alignment-first premolar extraction cases treated by traditional edgewise orthodontics, *Am J Orthod* 80 : 349-365, 1981.
6) Kennedy, D. B., Joondeph, D. R., Osterberg, S. K., Little, R. M. : The effect of extraction and orthodontic treatment on dentoalveolar support, *Am J Orthod* 84 : 183-190, 1983.
7) Lopez-Gavito, G., Wallen, T. R., Little, R. M., Joondeph, D. R. : Anterior open-bite malocclusion-a longitudinal 10-year postretention evaluation of orthodontically treated patients, *Am J Orthod* 87 : 175-186, 1985.
8) Little, R. M., Riedel, R. A. : Postretention evaluation of stability and relapse-mandibular arches with generalized spacing, *Am J Orthod Dentfac Orthop* 95 : 37-41, 1989.
9) Little, R. M., Riedel, R. A., Engst, E. D. : Serial extraction of first premolars - Postretention evaluation of stability and relapse. *Angle Orthod Dentfac Orthop* 60 : 255-262, 1990.
10) Ades, A. G., Joondeph, D. R., Little, R. M., Chapko, M. K. : A long-term study of the relationship of third molars to changes on the mandibular dental arch, *Am J Orthod Dentfac Orthop* 97 : 323-335, 1990.
11) Little, R. M., Riedel, R. A., Stein, A. : Mandibular arch length increase during the mixed dentition-postretention evaluation of stability and relapse, *Am J Orthod Dentfac Orthop* 97 : 393-404, 1990.
12) Artun, J., Krogstad, O., Little, R. M. : Stability of mandibular incisors following excessive proclination- a study in adults with surgically treated mandibular prognathism, *Angle Orthod* 60 : 99-106, 1990.
13) Little, R. M. : Stability and relapse of dental arch alignment, Br J Orthod 17 : 235-41, 1990.

14) McReynolds, D. C., Little, R. M. : Mandibular second premolar extraction-Postretention evaluation of stability and relapse, *Angle Orthod* 61 : 133-144, 1991.
15) Riedel RA, Little RM, Bui TD. : Mandibular incisor extraction-Postretention evaluation of stability and relapse. *Angle Orthod* 62 : 103-116. 1992.
16) Harris, E. F., Vaden, J. L., Dunn, K. L., Behrents, R. G. : Effects of patient age on postorthodontic stability in Class II, division 1 malocclusions, *Am J Orthod Dentfac Orthop* 105 : 25-34, 1994.
17) Sadowsky, C., Schneider, B. J., BeGole, E. A., Tahir, E. : Long-term stability after orthodontic treatment: nonextraction with prolonged retention, *Am J Orthod Dentfac Orthop* 106 : 243-249, 1994.
18) Fidler, B. C., Artun, J., Joondeph, D. R., Little, R. M. : Long-term stability of Angle Class II, division 1 malocclusions with successful occlusal results at the end of active treatment, *Am J Orthod Dentfac Orthop* 107 : 276-85, 1995.
19) de-la-Cruz, A., Sampson, P., Little, R. M., Artun, J., Shapiro, P. A. : Long-term changes in arch form after orthodontic treatment and retention, *Am J Orthod Dentfac Orthop* 107 : 518-530, 1995.
20) Dugoni, S. A., Lee, J. S., Varela, J., Dugoni, A. A. : Early mixed dentition treatment - Postretention evaluation of stability and relapse, *Angle Orthod* 65 : 311-320, 1995.
21) Little, R. M. : The irregularity index : a quantitative score of mandibular anterior alignment, *Am J Orthod Dentfac Orthop* 68 : 554-563, 1975.
22) Hellman, M. : Development of the face and dentition, *Am J Orthod Dentfac Orthop* 26 : 431-439, 1940.
23) Steiner, C. C. : Cephalometrics in clinical practice, *Angle Orthod* 29 : 8-29, 1959.
24) Tweed, C. H. : Was the development of the diagnostic facial triangle as an accurate analysis based on fact or fancy?, *Am J Orthod Dentfac Orthop* 49 :881-906, 1962.
25) Miyashita, K. : An atlas of roentgen anatomy and cephalometric analyses. Tokyo, 1986.
26) Jacobson, A. : Update on the Wits appraisal, *Angle Orthod* 58 : 205-219, 1988.
27) Jacobson, A. : Application of the "Wits" appraisal,

Am J Orthod Dentfac Orthop 70 : 179-189, 1976.

28) Jacobson, A. : The "Wits" appraisal of jaw disharmony, *Am J Orthod Dentfac Orthop* 67 : 125-138, 1975.

29) Graber, T. M. : New horizons in case analysis-Clinical cephalometrics, *Am J Orthod Dentfac Orthop* 38 : 603-624, 1955.

30) Coben, S. E. : The integration of facial skeletal veriants-A serial cephalometric roentgenographic analysis of craniofacial form and growth, *Am J Orthod Dentfac Orthop* 41 : 407-433, 1952.

31) McNamara, J. A., Brudon, W. L. : Orthodontic and Orthopedic Treatment in the Mixed Dentition 1st ed., USA, 1993, Needham Press Inc., 1-54.