ORIGINAL ARTICLE

Sagittal changes after maxillary protraction with expansion in Class III patients in the primary, mixed, and late mixed dentitions: A longitudinal retrospective study

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The purpose of this study was to determine the sagittal response of Class III patients in the primary, mixed, and late mixed dentition phases fitted with a protraction mask and expansion. The before-and-after cephalometric records of 112 patients divided by gender were analyzed at age groups 3 to 6, 6 to 9, and 9 to 12 years to assess the maxillary, mandibular, and intermaxillary sagittal changes. Data were correlated by means of paired *t* tests and Scheffé multiple contrasts. The study showed: (1) descriptive statistics and the before-and-after results in males and females in the different age groups; (2) the changes in males and females, disregarding age; and (3) the changes at the different ages, disregarding gender. Results show no significant differences between males and females in most of the angular and linear measurements at different ages. Greater significant changes were seen in patients treated in the primary and mixed dentition phases. Females showed highly significant changes in most linear and angular measurements between the ages of 3 and 6 years ($P < .0001$) compared with males ($P < .05$) at the same age. Significant changes were seen in the angle between the anterior part of the maxilla and the base of the skull (SNA), the maxillary depth, and the facial convexity angles, being more active in females than males. In contrast, the angle between the anterior part of the mandible and the base of the skull (SNB) showed no significant changes in all age groups, with the exception of males between 3 and 6 years. Even if correction can be achieved in all age groups, we recommend that treatment be started as soon as the diagnosis is made and cooperation allows for it. Young patients show greater and faster results in less time. Esthetics are greatly enhanced, compliance is improved, and the possible psycho-social scars can be greatly reduced. (Am J Orthod Dentofacial Orthop 2000;117:669-80)

The management of Class III malocclusion remains one of the most challenging problems confronting the practicing dentist.

Treatments in the permanent dentition can be relatively easy when the problem is confined to the alveolar bone. However, when the deformity affects basal bones, such as with a deficient maxilla, an overgrowth of the mandible, or a combination of both, then our treatment options are greatly reduced.

But when the problem is diagnosed by the parent or the dentist in the primary dentition, just to observe it worsen with time stimulated us to seek some alternatives.

LITERATURE REVIEW

For a long time, practitioners avoided early treatment because they believed the condition was caused by a mandibular overgrowth; since mandibular growth could not be controlled, surgery was inevitable. They relied on cephalometric analyses that were not designed for young children. For example an ANB angle of 3° positive could mean a Class III malocclusion in a 4-year-old vertical patient. It also was often difficult to identify the jaw that contributed to the Class III malocclusion. These variables made clinicians feel insecure, and as a result they preferred to delay treatment.

The developing Class III problem generally irreversibly affected the dentofacial appearance. These children, generally seen as "mean" or "ugly," were harassed, bullied, and rejected. Consequently, they developed negative, self-deprecating attitudes and low self-esteem, which they carried into adulthood, even after undergoing corrective surgery.[1-3]

The development of nonsurgical techniques, such as the chincup alone, has been largely abandoned, mostly because of poor long-term results.[4] For dentofacial orthopedics to succeed, treatment should be directed and correlated with growth, not against it.

In most cases, Class III malocclusions are characterized by an average of a 60% maxillary deficiency.[5-7] In this sense, it becomes logical to alter aberrant growth patterns, promoting maxillary advancement in the same physiologic maxillary displacement direction.

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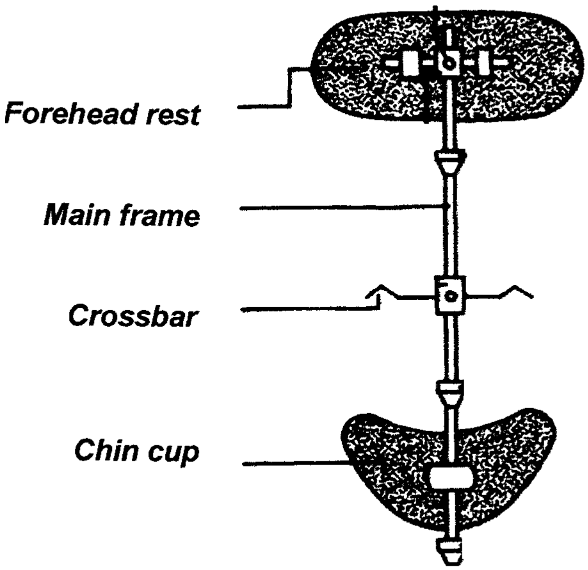

Fig 1. Different components of Petit-type face mask.

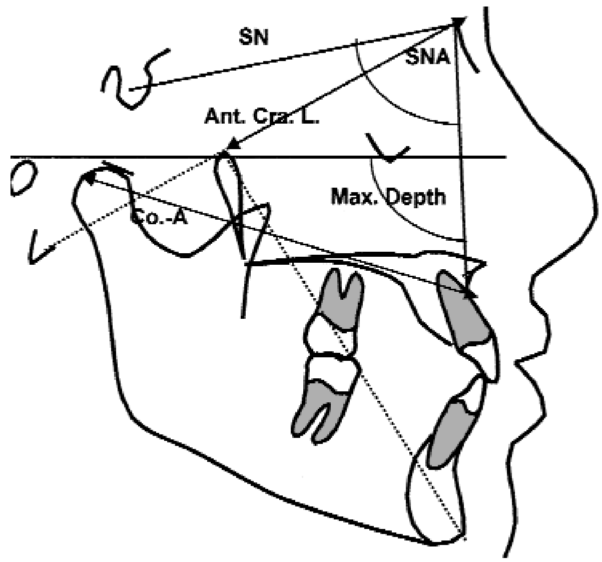

Fig 2. Cephalometric linear and angular measurements for maxillary sagittal relationships.

Even if the problem is genetic[8,9] or is caused by environmental factors,[10] treatment should be started as early as the patient cooperates, removing any factors or forces that inhibit growth and development and promoting maxillary advancement in the same physiologic maxillary displacement direction.

The use of the protraction face mask provides a directed, constant anterior force to the maxilla. With the application of constant protraction forces, several animal studies have shown a significant anterior displacement of the maxillary sutures, accompanied by histologic changes in the circummaxillary sutures.[11,12] This movement can be facilitated by rapid maxillary transverse expansion. It disrupts the sutural articulation of the maxilla to 9 other bones of the craniofacial complex, allowing for a more positive reaction to protraction forces.[13,14]

When To Treat

Cozzani[15] reported that when a child is treated at age 4 years, the direction of growth of the maxilla coincides with the direction of the protraction, creating a more stable result. Kambara[12] and Jackson[11] in animal studies suggested that it is desirable to protract the maxilla during the growth period. Gallagher[16] started treatment at a mean age of 9.8 years (range, 5.6 to 13.3 years), while Mermigos[18] treated at an average age of 8.6 years. Kapust[19] divided the patients into 3 groups: 4 to 7, 7 to 10, and 10 to 14 years and showed minimal statistical differences in the 3 age groups studied when comparing angular and linear measurements. Baik[20] and Takada et al[21] also divided the patients into 3 groups but started later, at mean ages of 8.9 years, 11.3 years, and 13.3 years, and showed no statistical differences among the results in the 3 groups. An excellent review of the literature by Kim et al[17] used meta-analysis to equate and compare results of independent studies on Class III malocclusion and evaluate the effectiveness of maxillary protraction.

Most Class III malocclusions can be detected early, in the primary dentition, but fall in the assumptions that the developing problem is associated with "pseudo" Class IIIs. The reasons to delay treatment include: fear to treat young children, lengthening the treatment period, the possibility of relapse, the hope that the problem will disappear with growth and the presence of the permanent anterior teeth. However, in 1969 Graber[22] stated that "it has been my experience that many so called "pseudo" Class III, are full blown Class III´s later on during the prolific growth period."

In 1981, Turpin[23] developed some guidelines by which one could decide when to intercept a Class III malocclusion. He charted some positive and negative factors. If the patient falls into the positive line, then early treatment ought to be considered; but if some of the patient's characteristics fall in the negative column, delaying treatment until condylar growth has ceased may be a better alternative:

Positive factors	*Negative factors*
Convergent facial type	Divergent facial type
AP functional shift	No AP shift

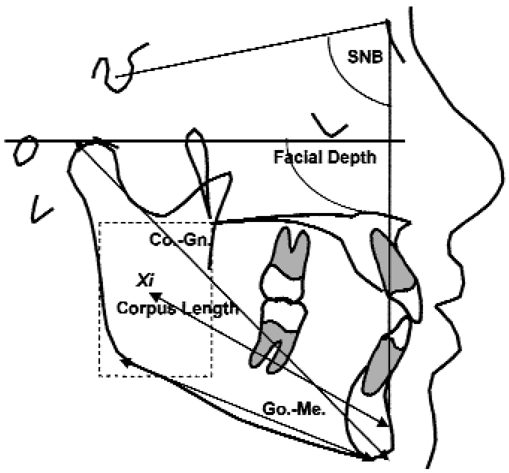

Fig 3. Cephalometric linear and angular measurements for mandibular sagittal relationships.

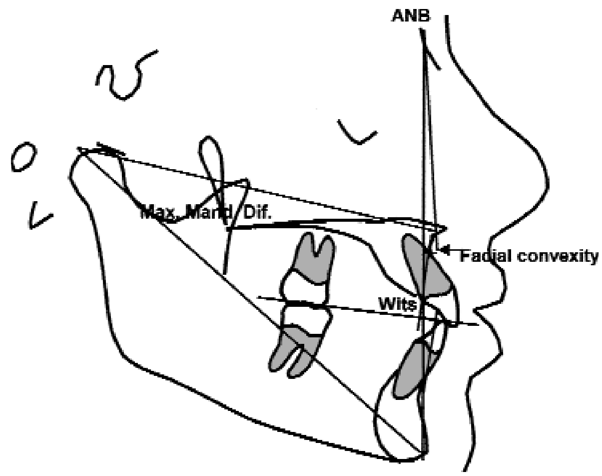

Fig 4. Cephalometric linear and angular measurements for intermaxillary sagittal relationships.

Symmetrical condylar growth	Asymmetrical growth
Young with growth remaining	Growth completed
Mild skeletal disharmony ANB <–2	Severe skeletal disharmony ANB >–2
Good cooperation expected	Poor cooperation expected
No familial prognatism	Familial pattern established
Good facial esthetics	Poor facial esthetics.

Joondeph,[24] after Turpin's thesis,[23] also pointed out the goals of early intervention:

1. Reduce the skeletal discrepancy and provide a more favorable environment for normal growth.
2. Achieve as much relative maxillary advancement as possible.
3. Improve occlusal relationships.
4. Improve facial esthetics for more psychosocial development.
5. Reduce or simplify, phase II or surgical treatment.

Sagittal Changes After Maxillary Protraction

Today, most authors agree that the treatment of choice for the interception of a Class III malocclusion is maxillary protraction.[16-23,26-33] The changes observed are summarized as follows: maxillary advancement, mandibular rotation, labial tipping of the maxillary incisors, lingual tipping of the mandibular incisors, mesial movement of the maxillary molars, and changes in ANB differences toward a more positive value.

This study shows the sagittal response of maxillary protraction therapy associated with slow maxillary disjunction in males and females at different ages.

MATERIAL AND METHODS

The material consisted of pretreatment and posttreatment lateral cephalograms of 112 consecutive patients (45 male, 67 female) seen in a private practice (M.S.), aged 3 thru 12, that were divided in the following manner: 3 to 6 years old (13 male, 25 female), 6 to 9 years old (25 male, 30 female), and 9 to 12 years old (7 male, 12 female).

All patients had been treated with a protraction face mask with transverse skeletal expansion and had no history of craniofacial anomalies; nor had they undergone prior orthodontic treatment. Most of them had Anglo-Saxon facial and skeletal characteristics.

Patients wore their face masks for an average of 6 months between the ages of 3 and 6 years, 9 months for the patients 6 to 9 years, and 12 months for patients between 9 and 12 years. They were instructed to wear the protraction mask at bedtime for children under the age of 9 and for 14 hours for children over the age of 9.

Elastics that delivered approximately 395g of force per side were fitted on all patients, who were instructed to change them daily.

The rapid maxillary expansion appliance was activated 3 times a week, even in the absence of maxillary constriction or a posterior crossbite. Activation depended on the amount of constriction but generally lasted 2 months or less.

The pretreatment radiography was generally taken 1 month before appliance insertion, and the posttreatment

Table I. Changes in cephalometric and linear measurements in anteroposterior relationships in males at different ages

	3-6 (n = 13)						6-9 (n = 25)					
Age	$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*		$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*	
Maxillary sagittal relationships												
SNA (°)	81	3.63	82.3	2.96	.046	NS	81.1	2.6	81.8	2.85	.041	*
Anterior cranial length [C.C.-N] (mm)	51	2.08	51.8	2.23	.011	*	54.1	2.82	55.2	2.64	.07	NS
SN line (mm)	64	2.7	65.2	2.97	.025	*	67.8	4.09	68.7	3.93	.0001	***
Co-A point (mm)	75	3.58	77	4.56	.012	*	80.6	3.47	81.8	3.38	.011	*
Maxillary depth [FH-NA] (°)	91	3.89	92.4	3.01	.13	NS	91	2.44	91.6	3.21	.21	NS
Mandibular sagittal relationships												
SNB (°)	80	2.66	78.2	2.79	.0017	*	79.6	2.44	79	2.59	.056	NS
Co-Gn (mm)	98	5.95	100	7.82	.022	*	108	4.21	110	4.81	.014	*
Corpus length [Xi-PM] (mm)	61	5.01	62.6	5.25	.077	NS	67	2.89	68.7	3.24	.0012	*
Go-Me (mm)	58	5.56	60.1	6.05	.025	*	64.3	4.19	65.7	3.67	.018	*
Facial depth [FH-N-Pg] (°)	89	2.53	87.9	2.65	.11	NS	89.6	2.38	89.2	2.88	.25	NS
Intermaxillary relationships												
ANB (°)	2	2.54	4.02	2.33	.0011	*	1.44	1.92	2.72	2.14	.0004	**
Wits (mm)	-4	2.27	-2.6	2.26	.039	*	-5	2.75	-4.3	3.14	.14	NS
Max-mand dif. [dif. Co-A/ Co-Gn] (mm)	2	2.64	3.96	2.42	.002	*	1.38	1.89	2.3	2.19	.006	*
Facial convexity [N-Pg to A] (mm)	23	3.88	23.3	4.59	.18	NS	27.1	2.69	27.9	3.33	.098	NS

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

Table II. Changes in cephalometric and linear measurements in anteroposterior relationships in females at different ages

	3-6 (n = 25)						6-9 (n = 30)					
Ages	$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*		$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*	
Maxillary sagittal relationships												
SNA (°)	81.3	3.18	82.66	3.34	.0001	***	81.13	3.81	82.11	3.05	.002	*
Anterior cranial length [C.C.-N] (mm)	49.6	2.46	51.26	2.52	.0002	**	51.15	2.23	52.71	2.61	.02	*
SN line (mm)	63.4	2.77	64.96	2.71	.0001	***	64.69	2.63	65.74	2.52	.0001	***
Co-A point (mm)	74.6	2.81	78.54	3.38	.0000	***	77.55	3.59	80.16	3.67	.0000	***
Maxillary depth [FH-NA] (°)	91.3	2.17	93.16	2.64	.0000	***	91.8	3.27	92.4	2.84	.24	NS
Mandibular sagittal relationships												
SNB (°)	79.3	2.58	78.61	2.82	.053	NS	79.13	2.89	78.71	2.93	.24	NS
Co-Gn (mm)	96	3.84	100.82	5.71	.0000	***	103.28	6.9	107.03	7.57	.0000	***
Corpus length [Xi-PM] (mm)	59.5	2.35	62.96	3.89	.0000	***	64.78	4.26	66.33	4.48	.003	*
Go-Me (mm)	56.3	2.84	59.89	4.59	.0004	**	62.56	4.36	64.79	4.61	.0005	**
Facial depth [FH-N-Pg] (°)	88.6	2.11	88.7	3.06	.81	NS	89.68	3.03	89.28	3.23	.28	NS
Intermaxillary relationships												
ANB (°)	2.01	1.82	4.04	2.16	.0000	***	1.99	2.65	3.39	1.98	.001	**
Wits (mm)	-3	2.3	-0.91	2.95	.003	*	-4.59	2.68	-3.21	3.04	.021	*
Max-mand dif. [dif. Co-A/Co-Gn] (mm)	2.21	1.96	3.81	2.41	.0001	***	1.98	2.75	2.9	2.18	.027	*
Facial convexity [N-Pg to A] (mm)	21.4	2.74	22.27	4.25	.16	NS	25.73	4.11	26.88	4.88	.03	*

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

radiography was done after the completion of treatment, an average of 8 to 14 months between the before and after results, depending on the age of the patients.

Treatment was discontinued when an overjet larger to normal (2 to 3 mm), Class I or II canine relationships, a mesial step or an edge-to-edge molar relationships, and an improved facial profile were achieved in the primary dentition. In the mixed dentition, treatment was discontinued when a positive overjet was achieved and no more changes were noted after 3 months. No retention appliances were used afterward.

9-12 (n = 7)					
$\bar{X}$ before	SD	$\bar{X}$ after	SD	P value	
79.1	4.99	80.5	5.1	.039	*
56.7	3.25	58.4	4.53	.096	NS
69.5	4.42	71.3	4.54	.018	*
83.2	5.98	85.4	4.3	.092	NS
91.2	3.4	91.7	3.37	.42	NS
77.9	3.62	78.4	3.52	.29	NS
113	7.16	118	7.83	.015 *	
69.8	4.16	74	4.73	.0044	*
68	5.24	72	6.03	.023	*
90.5	3.34	90.5	3.33	.96	NS
1.18	2.11	2.08	2.09	.02	*
-4.8	2.86	-2.8	2.85	.03	*
0.71	2.76	1.14	2.65	.26	NS
29.9	4.86	32.5	5.65	.016	*

9-12 (n =12)					
$\bar{X}$ before	SD	$\bar{X}$ after	SD	P value	
80.07	2.65	81.65	3.54	.004	*
55.16	2.33	55	2.75	.65	NS
68.96	2.35	69.05	2.62	.66	NS
81.2	3.81	82.74	4.98	.1	NS
90.67	2.24	91.99	2.6	.04	*
78.75	2.48	78.62	2.94	.73	NS
110.85	3.9	113	5.69	.07	NS
70.1	2.69	71.61	3.22	.06	NS
69.92	2.7	71.11	3.27	.22	NS
89.49	2	89.37	2.2	.84	NS
1.32	1.64	3	2.2	.01	*
-5.41	2.73	-2.75	2.79	.01	*
1.2	2.18	2.71	2.51	.029	*
29.67	2.64	30.26	2.48	.51	NS

Criteria for Patient Selection

All subjects included in this study had to meet all criteria in 3 different areas: dental, facial, and skeletal.

Dental. Patients with mesial step, exaggerated mesial step, Class III Angle molar occlusion, or a Class I Angle molar occlusion with lingual rotation of maxillary molars, were included. In all cases, care was taken in the assessment of molar occlusion, taking into account premature tooth loss, interproximal caries, or Bolton discrepancies.

Canine Class III relationships were difficult to assess in the primary and early mixed dentition because of the inclination of the canine slope, which maintains constant contact in most horizontal and vertical growing individuals. However, Class III canine relationships were noted in the late mixed dentition, on mandibular prognathisms, on horizontal growing patients, and unilaterally, on mandibular lateral shifts.

Generalized negative overjets or edge-to- edge anterior relationships were considered in this study. Patients with anterior functional shifts were disregarded.

During the mixed dentition the diagnosis was reinforced by using tooth measurements from the lateral head film. Upper and lower arch morphologic data were also taken into account.

Facial. The evaluation of the facial profile was possibly one of the most important items in our differential diagnosis. Flat or concave profiles, retrusive maxillas, and prominent mandibles were included. Convex profiles were only included in the presence of an increased lower face height and an increased vertical dimension associated with other skeletal and dental Class III characteristics.

Strong, or thin and acute chins were also taken into account, as were thin and poorly developed upper lips.

Skeletal. Cephalometric values were used, although we recognize that those measurements for diagnostic purposes are more realistic in older children, with a limited value in younger ones. Diagnoses, as well as estimates of treatment changes, should be interpreted with caution, because of the possibility of an anterior functional shift that can alter both the sagittal and the vertical relationships.[17]

Appliances Used for Class III Correction

Bands were fitted on second primary molars and canines in the primary dentition and on first permanent molars and first primary molars in the mixed dentition. These bands were joined by a heavy wire (0.043 inches) to the palatal plane and a midline Haas or Hyrax rapid maxillary expansion appliance.

A 0.043-inch wire was soldered bilaterally to the buccal aspects of the molar bands and canines or first primary molars, and a hook for elastic traction was extended into the canine region. A protraction face mask (adjustable Dynamic Petit-type , Orinco, Glendora, Calif) (Fig 1) was positioned just below the lower lip to provide a downward and forward pull to the maxilla of 30° to the occlusal plane.

Table III. Changes in the differences of cephalometric and linear measurements in anteroposterior relationships in males and females at different ages

	Males 3-6 (n = 13)		*Females 3-6 (n = 25)*			*Males 6-9 (n= 25)*		*Females 6-9 (n = 30)*		
Gender and ages	*Mean*	*SD*	*Mean*	*SD*	*P value*	*Mean*	*SD*	*Mean*	*SD*	*P value*
Maxillary sagittal relationships										
SNA (°)	1.5	1.71	1.37	1.67	.54 NS	0.73	1.15	0.97	2.21	.72 NS
Anterior cranial length [C.C.-N] (mm)	1.26	1.52	1.69	1.91	.48 NS	1.04	1.77	0.96	2.15	.87 NS
SN line (mm)	1.03	1.41	1.54	1.25	.25 NS	0.91	0.99	1.05	1.3	.66 NS
Co-A point (mm)	2.06	2.53	3.89	3.02	.07 NS	1.25	2.27	2.61	2.92	.06 NS
Maxillary depth [FH-NA] (°)	1.07	2.4	1.85	1.5	.22 NS	0.54	2.15	0.59	2.73	.94 NS
Mandibular sagittal relationships										
SNB (°)	-1.3	1.16	-0.66	1.62	.22 NS	-0.56	1.39	-0.41	1.92	.75 NS
Co-Gn (mm)	2.76	3.81	4.78	4.69	.19 NS	2.1	4.01	3.75	3.88	.12 NS
Corpus length [Xi-PM] (mm)	1.87	3.5	3.48	3.47	.18 NS	1.67	2.28	1.55	2.65	.85 NS
Go-Me (mm)	2.43	3.44	3.58	4.3	.41 NS	1.43	2.83	2.23	3.12	.33 NS
Facial depth [FH-N-Pg] (°)	-0.9	1.84	1.9	0.38	.14 NS	-0.41	1.79	-0.4	2.02	.97 NS
Intermaxillary relationships										
ANB (°)	2.3	1.94	2.02	1.57	.63 NS	1.3	1.59	1.4	2.21	.85 NS
Wits (mm)	1.23	1.92	2.08	3.23	.39 NS	0.69	2.3	1.37	3.11	.36 NS
Max-mand dif. [dif. Co-A / Co-Gn] (mm)	1.78	1.67	1.6	1.63	.74 NS	0.92	1.56	0.91	2.15	.97 NS
Facial convexity [N-Pg to A] (mm)	0.7	1.83	0.9	3.13	.84 NS	0.83	2.43	1.15	2.86	.66 NS

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

Table IV. Changes in cephalometric and linear measurements in anteroposterior relationships in males and females, disregarding age

	Males (n = 45)					*Females (n = 67)*				
Gender	$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*	$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*
Maxillary sagittal relationships										
SNA (°)	80.8	3.35	81.71	3.27	.0001 ***	81.0	3.38	82.23	3.22	.0000 ***
Anterior cranial length [C.C.-N] (mm)	53.5	3.37	54.7	3.56	.0000 ***	51.55	3.13	52.58	2.88	.0001 ***
SN line (mm)	67.0	4.19	68.11	4.24	.00001 ***	64.98	3.25	66.04	2.95	.00001 ***
Co-A point (mm)	79.4	4.88	80.99	4.76	.0001 ***	77.12	4.05	80.02	4.05	.0000 ***
Maxillary depth [FH-NA] (°)	91.1	3.0	91.81	3.12	.034 *	91.41	2.72	92.61	2.72	.00001 ***
Mandibular sagittal relationships										
SNB (°)	79.3	2.71	78.69	2.76	.0052 *	79.11	2.68	78.66	2.85	.03 *
Co-Gn (mm)	106.0	7.54	108.3	8.52	.0000 ***	101.93	7.37	105.78	7.86	.0000 ***
Corpus length [Xi-PM] (mm)	65.6	4.96	67.75	5.55	.0000 ***	63.75	5.09	66.02	5.03	.0000 ***
Go-Me (mm)	62.9	5.93	65.06	6.13	.0001 ***	64.54	6.01	64.09	5.88	.0001 ***
Facial depth [FH-N-Pg] (°)	89.5	2.58	89.0	2.94	.07 NS	89.25	2.57	89.08	2.99	.49 NS
Intermaxillary relationships										
ANB (°)	1.48	2.1	3.01	2.25	.00001 ***	1.88	2.19	3.56	2.09	.0000 ***
Wits (mm)	-66.0	2.63	-58.0	2.93	.002 *	-18.0	2.68	-29	3.11	.0000 ***
Max-mand dif. [dif. Co-A /Co-Gn] (mm)	1.5	2.27	2.6	2.47	.0001 ***	1.92	2.38	3.2	2.34	.0001 ***
Facial convexity [N-Pg to A] (mm)	26.2	4.21	27.3	5.04	.002 *	24.81	4.52	25.76	5.19	.01 *

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

Cephalometric Analysis

All radiographs used in the study were taken with the same cephalostat being used. Cephalograms were traced on 0.003-inch acetate paper by 2 researchers and checked for errors. Ten sets of x-ray films were measured to detect the reproducibility of the measurements. The combined method error did not exceed 0.8 mm and

Males 9-12 (n = 7)		Females 9-12 (n = 12)			
Mean	SD	Mean	SD	P value	
1.37	1.38	1.57	1.53	.77	NS
1.67	2.24	-0.16	0.36	.03	*
1.74	1.44	0.08	8.64	.002	*
2.24	2.96	1.53	3.02	.62	NS
0.45	1.41	1.31	2.04	.34	NS
0.48	1.11	-0.12	1.23	.29	NS
4.87	3.83	2.14	3.72	.14	NS
4.21	2.51	1.5	2.49	.03	*
4.01	3.53	1.19	3.19	.09	NS
0.02	1.5	-0.11	1.96	.86	NS
0.9	0.78	1.68	1.97	.33	NS
2.07	2.05	2.66	3.37	.67	NS
0.42	0.92	1.15	2.09	.21	NS
2.62	2.1	0.59	3.02	.13	NS

1.1° for any variable investigated. Tracings were digitized on a GridMaster (Numonics, Montgomeryville, Pa) digitizer connected to an IBM–PC. A computerized program (JOE 5.0, RMO Diagnostic Services, Calabasas, Calif.) used cephalometric landmarks that were incorporated from well-known analyses to provide specific information on sagittal variables (Figs 2-4).

This study analyzed: (1) changes in cephalometric and linear measurements in anteroposterior relationships in males, females, and both at ages 3 to 6, 6 to 9, and 9 to 12 years; (2) changes, disregarding gender; (3) changes, disregarding sex; and (4) changes, disregarding gender and sex.

Paired *t* tests were used to describe significant changes between pretreatment and posttreatment cephalograms. Scheffé multiple contrasts were also used to compare the multiple responses between the different age groups.

RESULTS

Tables I and II provide descriptive statistics and before-and-after results for males and for females at ages 3 to 6, 6 to 9, and 9 to 12. The comparison of changes of the differences between males and females at the different ages are shown in Table III. The changes in males and females, disregarding age, are presented in Table IV, and the changes of the differences are shown in Table V. The changes in all patients, disregarding age and gender, are shown in Table VI. The changes at 3 to 6, 6 to 9, and 9 to 12 years, disregarding gender, are shown in Table VII.

To simplify the interpretation of all the data derived from the different tables, we have provided Table VIII, which statistically summarizes the sagittal changes.

Maxillary Sagittal Changes

The changes in the angle between the anterior part of the maxilla and the base of the skull (SNA) showed a greater response between the ages of 3 and 6 and 9 and 12, with an average of 1.5° in males and 1.37° in females between 3 and 6 years, decreasing to 0.73° in males and 0.97° in females between 6 and 9 years, to increase again 1.37° in males and 1.57° in females between 9 and 12 years (Table III).

Females displayed greater significant changes ($P < .0001$) (Table II) than did males ($P < .05$) (Table I) between the ages of 3 and 6 in all angular and linear measurements (Table VIII).

These responses were also significant between 6 and 9 years, but they became mostly nonsignificant between 9 and 12 years, with the exception of SNA ($P < .05$ in males) and ($P < .001$ in females) (Table VIII). The same results can be seen in maxillary depth in females between 3 and 6 years ($P < .0001$) and between 9 and 12 years ($P < .05$). No significant changes in maxillary depth were noted in males at all ages.

No significant changes were seen between males and females at all ages in all sagittal maxillary measurements (Table III), with the exception of cranial linear measurements such as anterior cranial length and SN line and corpus length between the ages of 9 and 12 ($P < .05$) (Tables III and VIII).

Highly significant changes were seen in all measurements in all males (N = 45; $P < .0001$) and in all females (N = 67; $P < .0001$) (Table IV), and no significance was found between males and females, with the exception of the Co-A point ($P < .05$) (Table V).

Highly significant changes were observed in all angular and linear measurements for all 112 patients ($P < .0001$) (Table VI).

The comparison between the different ages showed a highly significant response between 3 and 6 ($P < .0001$), 6 to 9 ($P < .001$), and 9 to 12 ($P < .001$) with the exception of maxillary depth, which showed no significance in all 3 age groups (Tables VII and VIII).

Mandibular Sagittal Changes

Changes in the angle between the anterior part of the mandible and the base of the skull (SNB) showed a downward and backward rotation of the mandible and was greater in the younger age group and more active in males than females (Table III). The exception

Table V. Changes in the differences in cephalometric and linear measurements in anteroposterior relationships in males and females, disregarding age

	Males (n = 45)		*Females (n = 67)*			
	Mean	*SD*	*Mean*	*SD*	*P value*	
Maxillary sagittal relationships						
SNA (°)	0.92	1.35	1.23	1.82	.34	SN
Anterior cranial length [C.C.-N] (mm)	1.2	1.75	1.03	2.01	.63	NS
SN line (mm)	1.07	1.2	1.06	1.28	.95	NS
Co-A point (mm)	1.64	2.44	2.89	3.06	.02	*
Maxillary depth [FH-NA] (°)	0.68	2.1	1.19	2.26	.23	NS
Mandibular sagittal relationships						
SNB (°)	-0.6	1.38	-0.45	1.69	.61	NS
Co-Gn (mm)	2.72	3.96	3.85	4.22	.16	NS
Corpus length [Xi-PM] (mm)	2.12	2.8	2.26	3.07	.81	NS
Go-Me (mm)	2.12	3.19	2.54	3.67	.53	NS
Facial depth [FH-N-Pg] (°)	-0.47	1.75	-0.16	1.95	.39	NS
Intermaxillary relationships						
ANB (°)	1.53	1.66	1.66	1.94	.66	NS
Wits (mm)	1.06	2.17	1.87	3.19	.14	NS
Max-mand dif. [dif. Co-A / Co-Gn] (mm)	1.09	1.56	1.27	1.96	.6	NS
Facial convexity [N-Pg to A] (mm)	1.07	2.28	0.95	2.95	.81	NS

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

was noted between 9 and 12 years; males in this age group showed an anterior mandibular displacement (SNB, 0.48°) and females (SNB, –0.12°). However, the only significant change in the SNB angle was seen in males between the ages of 3 and 6 ($P < .001$) (Tables I and II). No significance was observed afterward in males or females (Tables I, II, and VIII). Other significant changes were seen in all males, disregarding age ($P < .001$), and in females ($P < .05$) (Table IV). Comparing the different ages showed a highly significant change in the SNB angle between 3 and 6 ($P < .0001$) and 6 to 9 ($P < .05$), becoming nonsignificant after age 9 (Tables VII and VIII).

Mandibular length increase (Co-Gn, corpus length, Go-Me) was more highly significant in females ($P < .0001$) than in males ($P < .05$) between the ages of 3 and 9, becoming nonsignificant in females after age 9 (Tables I and II). On the other hand, males showed a greater mandibular length response between the ages of 6 and 12 years.

Facial depth showed no significant changes in all measurements (Tables I to VII).

Maxillo-Mandibular Interrelationships

Highly significant changes were seen in the ANB angle in males and females between the ages of 3 and 9 ($P < .0001$) (Tables I and II). This change was also significant between 9 and 12 ($P < .05$). Facial convexity displayed highly significant changes in females at all ages, being more important when the girls were between 3 and 6 years of age.

The Wits appraisal was also significant in all age groups ($P < .05$), with the exception of males between the ages of 6 and 9, in whom no significant changes were observed (Tables I and II).

The maxillo-mandibular difference showed no significance in all age groups with the exception of females between 6 and 9 years ($P < .05$) and in males ($P < .05$) between 9 and 12 years (Tables I and II).

DISCUSSION

The diagnosis of Class III malocclusion in children in the primary and even mixed dentition, using the most common cephalometric analysis, should be undertaken with caution. Distinctive prognathic dental relationships, correlated with a classic Class III appearance and a possible hereditary component, are generally compared with cephalometric measurements with the assumption that negative anteroposterior cephalometric values will be present to corroborate the diagnosis. Generally, children up to 10 years of age present positive angular and linear measurements, which could mislead the practitioner into postponing treatment to watch for a further deterioration of the problem. In our sample, ANB angles were positive in all age groups and tended to decrease slightly as age progressed, with

Table VI. Anteroposterior relationships in all patients

	3-12 (n = 112)					
	$\bar{X}$ before	SD	$\bar{X}$ after	SD	P value	
Maxillary sagittal relationships						
SNA (°)	80.91	3.35	82.02	3.24	.00001	***
Anterior cranial length [C.C.-N] (mm)	52.33	3.36	53.43	3.32	.00001	***
SN line (mm)	65.81	3.78	66.87	3.65	.00001	***
Co-A point (mm)	78.01	4.52	80.41	4.35	.00001	***
Maxillary depth [FH-NA] (°)	91.3	2.83	92.29	2.9	.00001	***
Mandibular sagittal relationships						
SNB (°)	79.19	2.68	78.67	2.8	.00001	***
Co-Gn (mm)	103.4	7.62	106.8	8.19	.00001	***
Corpus length [Xi-PM] (mm)	64.5	5.1	66.71	5.29	.00001	***
Go-Me (mm)	62.1	5.99	64.48	5.98	.00001	***
Facial depth [FH-N-Pg] (°)	89.34	2.56	89.05	2.96	.1	NS
Intermaxillary relationships						
ANB (°)	1.72	2.16	3.34	2.16	.00001	***
WITS (mm)	-4.33	2.66	-2.78	3.09	.00001	***
Max-mand dif. [dif. Co-A/Co-Gn] (mm)	1.76	2.33	2.96	2.4	.0001	***
Facial convexity [N-Pg to A] (mm)	25.38	4.44	26.38	5.16	.00001	***

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

a mean of 1.48° in males and 1.88° in females. This is contradictory to the data from Chong et al,[31] Baik,[20] and Shanker et al[29] (ANB –0.28°, ANB –0.77°, ANB 0°, respectively). This result could average the craniofacial morphology of their Asian population studied. The Wits appraisal is generally a more reliable measurement for anteroposterior discrepancies, but it should take into account the direct influence derived from the vertical development of the face. Our data displayed a greater negative Wits measurement as age progressed, with a mean of –4.62 mm in males and –4.14 mm in females (Table IV). (Baik's, Chong's, and Shanker´s data were -8.14 mm, -5.32 mm, and –8.1 mm, respectively.[20,29,31]) Significant responses were noted on SNA, maxillary depth, and facial convexity, mostly in females, with a greater significant change between 3 and 6 years.

The response to appliance therapy, when compared with other studies, should take into account several factors: the age of the patients, expansion or no expansion, protraction in repaired cleft palates, elastic force application, and treatment duration in quantity and quality. All studies show a significant point A advancement, compared with that of untreated controls, that varies depending on the cephalometric reference points used.[2,16,18-21,29,31,32] These varied significantly in protraction of patients with repaired cleft lips[2] to a maxillary advancement of 2.7 mm in normal patient protracted for 16 months with no expansion[32] or 2.4 mm after 6 months of maxillary protraction with expansion.[29]

Comparing our sample with those of other studies allowed us to evaluate the effects of the protraction according to age and sex.

The amounts of change in the SNA and SNB angles were similar to the ones observed in other studies.[16,18,20,21,33] In contrast, Kapust´s study displayed greater changes,[19] with an ANB angle of 4.04° and a Wits value of 6.41 mm (compared with our data, which show an ANB angle of 1.53° in males and 1.66° in females and a Wits value of 1.06 mm in males and 1.87 mm in females, with a greater change between 3 and 6 and 9 and 12 in males and females).

In children between the ages of 9 to 12, we can appreciate no changes in the maxillary size. These are referenced by the nonsignificant change in the Co-A point and anterior cranial length. The only significant change between males and females in all age groups could be seen in the anterior cranial length and the SN line between 9 and 12 years, which suggests a greater adaptive response of the anterior cranial base to maxillary response in males than in females.

Our data show that the sagittal response was highly significant between the ages of 3 and 9 years, with a lesser response between 9 and 12 years. Females displayed more significant changes than males in all angular and linear measurements between 3 and 6 years, with the exception of SNB angle. Apparently, the major contribution for the overjet correction at this age varies between males

Table VII. Relationships at different ages, disregarding gender

	3-6 (n = 38)						6-9 (n = 55)					
Ages	$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*		$\bar{X}$ *before*	*SD*	$\bar{X}$ *after*	*SD*	*P value*	
Maxillary sagittal relationships												
SNA (°)	81.3	3.29	82.52	3.18	.00001	***	81.09	3.29	81.96	2.94	.0007	**
Anterior cranial length [C.C.-N] (mm)	49.9	2.36	51.46	2.41	.0000	***	52.83	2.9	53.83	2.88	.0004	**
SN line (mm)	63.7	2.73	65.05	2.76	.00001	***	66.11	3.69	67.1	3.54	.00001	***
Co-A point (mm)	74.7	3.05	78.01	3.82	.00001	***	78.92	3.82	80.91	3.61	.0001	***
Maxillary depth [FH-NA] (°)	91.3	2.82	92.88	2.76	.0000	***	91.45	2.92	92.02	3.02	.08	NS
Mandibular sagittal relationships												
SNB (°)	79.4	2.58	78.47	2.78	.0009	***	79.34	2.68	78.86	7.76	.039	*
Co-Gn (mm)	96.5	4.64	100.64	6.4	.0000	***	105.27	5.9	108.28	6.55	.0000	***
Corpus length [Xi-PM] (mm)	59.9	3.48	62.85	4.33	.0000	***	65.78	3.83	67.39	4.1	.0000	***
Go-Me (mm)	56.8	3.96	59.95	5.05	.0001	***	63.33	4.33	65.2	4.19	.0001	***
Facial depth [FH-N-Pg] (°)	88.7	2.23	88.43	2.92	.45	NS	89.63	2.73	89.23	3.05	.11	NS
Intermaxillary relationships												
ANB (°)	1.91	2.06	4.03	2.19	.0000	***	1.74	2.34	3.1	2.06	.0000	***
Wits (mm)	-3.3	2.3	-1.48	2.82	.0004	**	-4.76	2.69	-3.7	3.11	.0062	*
Max-mand dif. [dif.Co-A/Co-Gn] (mm)	21.8	3.18	22.62	4.33	.67	NS	26.35	3.57	27.36	4.25	.0069	*
Facial convexity [N-Pg to A] (mm)	2.2	2.18	3.86	2.38	.001	**	1.71	2.4	2.63	2.19	.0007	**

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

Table VIII. Summary of the statistical responses of Tables I through VII

	3-6 years		6-9 years		9-12 years		All patients					
Vertical relationships	*P value in M (n = 13) F (n = 25) Table I-II*	*P value between M & F Table III*	*P value in M (n = 25) F (n = 30) Table I-II*	*P value between M & F Table III*	*P value in M (n = 7) F (n = 12) Table I-II*	*P value between M & F Table III*	*P value in all M (n = 45) Table IV*	*P value all F (n = 67) Table IV*	*P value between M & F Table V*	*P value in all patiens (n = 112) Table VI*	*P value different ages in M & F Table VII*	
FMA											6-9 (n = 55)	*
M	*	NS	NS	NS	NS	NS	**		NS	***	3-6 (n = 38)	*
F	NS		*		NS			*			9-12 (n = 19)	NS
Go.-Gn.-SN											6-9 (n = 55)	NS
M	**	NS	NS	NS	NS	NS	*		NS	***	3-6 (n = 38)	**
F	*		NS		NS			*			9-12 (n = 19)	NS
Palatal-FH											6-9 (n = 55)	NS
M	NS	NS	NS	NS	NS	NS	NS		NS	NS	3-6 (n = 38)	*
F	NS		NS		NS			NS			9-12 (n = 19	NS
Facial axis											6-9 (n = 55)	**
M	**	NS	*	NS	NS	NS	**		NS	***	3-6 (n = 38)	***
F	***		*		NS			***			9-12 (n = 19)	NS
Occlusal-SN											6-9 (n = 55)	NS
M	NS	NS	NS	NS	NS	NS	NS		NS	NS	3-6 (n = 38)	NS
F	NS		NS		NS			NS			9-12 (n = 19)	*
OcclusaL-FH		*									6-9 (n = 55)	NS
M	NS		NS	NS	NS	NS	NS		NS	NS	3-6 (n = 38)	NS
F	NS	*	NS		NS			NS			9-12 (n = 19)	NS
ANS-Me											6-9 (n = 55)	**
M	**	NS	***	NS	*	NS	***		NS	***	3-6 (n = 38)	***
F	***		***		*			***			9-12 (n = 19)	**

*$P < .05$.
**$P < .001$.
***$P < .0001$.
NS, Nonsignificant.

9-12 (n = 19)					
$\bar{X}$ before	SD	$\bar{X}$ after	SD	P value	
79.71	3.58	81.21	4.08	.0003	**
55.74	2.73	56.25	3.78	.24	NS
69.17	3.16	69.87	3.5	.028	*
81.94	4.66	83.73	4.81	.01	*
90.87	2.64	91.87	2.82	.029	*
78.42	2.89	78.52	3.07	.71	NS
11.67	5.25	114.82	6.8	.002	*
70	3.2	72.5	3.9	.001	**
69.22	3.81	71.45	4.34	.012	*
89.84	2.53	89.78	2.65	.87	NS
1.27	1.77	2.66	2.15	.0017	*
-5.2	2.71	-2.75	2.73	.001	**
29.74	3.49	31.08	3.95	.054	NS
1.02	2.34	2.13	2.61	.014	*

and females. Males display a significant maxillary advancement (SNA) ($P < .05$) and a significant mandibular backward rotation SNB ($P < .001$), while females display a greater maxillary advancement ($P < .0001$) and no significant backward rotation.

Mandibular growth is more active in females between the ages of 3 and 9 years; males display major significant changes between 6 and 12 years.

The maxillo-mandibular interrelationships displayed significant changes in most angular and linear measurements at all ages, with the exception of the maxillo-mandibular difference. This linear measurement shows no significance, with the exception of females between the ages of 6 and 9 and males between 9 and 12 years. This is the result of mandibular acceleration, which apparently is not restricted with the compression existing in the chin area. Because we did not have a control sample for comparison and our data ended with subjects at a late prepubertal stage, we can only speculate that care must be taken in assuming a Class III fully resolved until facial growth has ended.

Even if at early ages females showed greater responses than males, no significant changes were noted in both groups in most linear and angular relationships, and this finding appears to grant the possibility that they may be combined in future studies. No retention is recommended after the case is corrected, which is in agreement with Delaire et al.[33] The recommendation to retain, made by Cozzani[15] and Turley,[30] may cause patient burnout and lengthen the treatment period. Our experience shows no relapse in the majority of the cases, and we tend to retain with the same appliance when minor skeletal changes are observed in the postoperative cephalogram—even in the presence of an improvement in the facial profile and occlusal relationships.

Mandibular prognathic cases were fitted with protraction masks. All of them displayed an enhanced facial profile and did not appear bi-maxillary protrusive.

Even if some authors recommend to start early,[15,19] most studies reported significant changes after protraction mask wear during the mixed dentition,[18,29] the late mixed dentition, or early permanent.[20,21,31,32] Our data show greater significant changes between 3 and 9 years, with a lesser (but significant) response between 9 and 12, which is in accordance with Kapust´s study.[19] Scheffé multiple contrasts showed no significant changes when we compared the treatment results at the 3 different ages. However, we recommend starting treatment as early as the diagnosis is made and cooperation allows for it. Young patients show greater and faster changes in less time. Esthetics are greatly enhanced. Compliance is improved, and the possibility of psycho-social scars is greatly reduced. The notions of those clinicians who recommend that treatment be started later—such things as "Class III correction is doomed to failure" or "It will lengthen the treatment period" or "I will burnout my patient" or "It is not cost-effective" or "It will relapse" or "Growth and development will modify it with no treatment"—are unfounded.

CONCLUSIONS

Once a diagnosis is established, early interception of a Class III malocclusion should be attempted. It will improve the occlusal, facial, and psycho-social relationships, promoting a more favorable environment for normal growth. A definitive reduction in treatment time is achieved when patients are treated at a very young age. This study showed the following:

1. Greater significant cephalometric changes were achieved, mostly in the primary and early mixed dentition phases.
2. Females showed greater significant changes in all linear and angular measurements between the ages of 3 and 6 years, compared with males at the same age.
3. No significant treatment responses were found between males and females at different ages, with the exception of the anterior cranial length, SN line, and corpus length between the ages of 9 and 12 years.

4. The SNA, maxillary depth, and facial convexity angles displayed significant changes at all ages and were more active in females than in males.
5. No significant changes were seen in the SNB angle, with the exception of males between the ages of 3 and 6 years.
6. The Scheffé test showed no differences in all angular and linear measurements, comparing the ages of 3 to 6 with 6 to 9, 3 to 6 with 9 to 12, and 6 to 9 with 9 to 12.

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