ORIGINAL ARTICLE

Long-term stability of skeletal Class III patients treated with splints, Class III elastics, and chincup

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Long-term results from orthopedic management of skeletal Class III malocclusions are sparse. The purpose of this study was to evaluate the stability of results after facial growth and treatment with splints, Class III elastics, and chincup (SEC III) and to investigate the main determinants of relapse. Data from pretreatment, posttreatment, and long-term (at least 3 years after retention) serial cephalograms of 52 patients who received SEC III treatment were studied: only those with long-term data when growth had ceased (women over 18 and men over 21 years of age) were selected. At the end of the follow-up period (an average of 9 years), only 6 of the 52 patients had clinical relapse (overjet ≤ 0). Low Wits appraisal, ANB angle, and overbite, and high SNB angle were the best predictors of relapse at the end of the treatment. Significantly greater decreases of the Wits appraisal and increases of ramus length during the follow-up were further associated with relapse. SEC III is a reliable treatment for skeletal Class III malocclusions. Long-term stability can be enhanced by a deeper overbite and the best possible skeletal correction. The results suggest that the correction occurs with no mandibular rotation but might be better with forward rotation. (Am J Orthod Dentofacial Orthop 2003;123:423-34)

I n a Class III malocclusion, the mandibular teeth occlude the maxillary teeth by more than one-half the width of a single cusp.[1] This dental relationship is very often associated with a skeletal Class III disharmony involving the middle and lower thirds of the face, and sometimes the cranial base.[2]

Therapeutic alternatives for dentoskeletal Class III malocclusions include orthopedic treatment in growing patients and surgery in adults. Dental compensation might be effective in treating milder cases. A main drawback of orthopedic therapy in growing subjects is its long-term failure because of additional excessive mandibular growth.

Thus, many people with Class III malocclusions wait until growth is complete to have surgery.[3] But delaying treatment until adulthood can exacerbate problems related to pain, speech, airway, anatomy, occlusion, temporomandibular joint and masticatory func-

tion, esthetics, and psychosocial factors.[4] Hence, there is an ongoing dilemma between early orthopedic treatment and late surgery in growing patients.

Although several orthopedic treatments in growing patients have been proposed,[5-25] the literature on long-term stability is minimal. Data have been mainly derived from follow-up studies on patients with growth remaining,[26-37] but the final result is seen when growth has ceased.[38-43] Furthermore, sample size is usually small because of the low prevalence of this developmental skeletal disharmony.[44] Thus, the long-term outcome for children with a skeletal Class III malocclusion is still uncertain, and stability, defined as maintaining posttreatment conditions,[45-46] is a main topic in the management of dentoskeletal Class III problems.

In the 1980s, Ferro[47] proposed a new orthopedic approach—splints, elastics, and chincup for Class III (SEC III)—to correct this skeletal malocclusion. In this approach, 2 removable splints with hooks for Class III elastics and a chincup were associated (Fig 1). The rationale was that 2 splints with a flat occlusal plane would facilitate correcting the Class III relationship, eliminating both intercuspation and aggravating factors, such as anterior tongue thrust (Fig 2). SEC III was shown to be successful at the end of the treatment and in postretention of still-growing patients.[48-52] The pur-
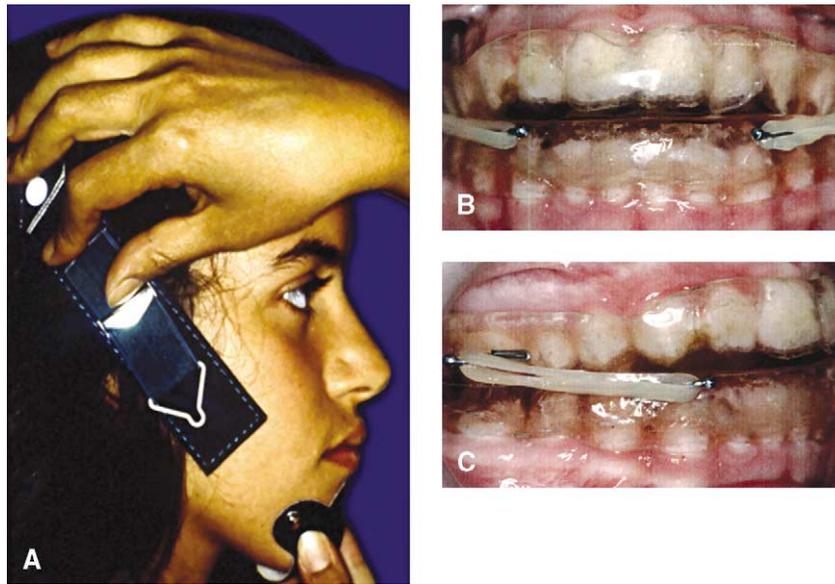
Fig 1. Splints, Class III elastics, and chincup (SEC III). **A,** Chincup: vector of force is through maxillary first molars, and total force, approximately 300-1500 g per side, is measured as 3-finger distance between 2 hooks; **B** and **C,** frontal and lateral view of 2 removable occlusal splints with hooks for Class III elastics.

Fig 2. Anterior tongue thrust: maxillary incisors are uprighted or inclined lingually, but mandibular incisors are inclined vestibularly. This tongue behavior might inhibit maxillary growth and accelerate mandibular growth.

pose of this study was to evaluate the stability of posttreatment results at the end of facial growth after successful SEC III treatment.

MATERIAL AND METHODS

For this study, patients were eligible if their Class III malocclusions had been successfully corrected to a Class I molar relationship and overjet was greater than 0 mm. Before treatment, each subject had a Class III molar relationship, less than 0 mm of overjet with involvement of all anterior incisors, an ANB angle less than 0° when SN/Go-Me angle was equal to 32° ± 5°, or less than 3° when SN/Go-Me angle was over 37°, and a Wits appraisal less than or equal to −2 mm.

Patients having only functional or dental Class III malocclusions were excluded.

Age limits were chosen to reasonably exclude patients whose facial growth was still substantially incomplete at the follow-up date[53-60]; therefore, women had to be more than 18 and men more than 21 years old at the follow-up assessment. None of the patients had undergone previous orthodontic treatment.

A minimum follow-up period of 3 years was required after retention had ceased. For each patient, 3 standardized lateral cephalograms were needed: (1) no more than 4 months before the start of the SEC III protocol, (2) no more than 1 month after the end of treatment, and (3) at least 3 years after the end of treatment. Based on these criteria, 86 patients treated between June 1987 and March 1996 were eligible for this study. Although 3 or more attempts were made to recall those who met the inclusion criteria, 34 were unavailable (7 for lack or inadequacy of baseline films and 27 for lack of follow-up films due either to denial of consent or loss to observation). Thus, the final sample included 52 patients, 22 men and 30 women. Mean ages were 9 years before treatment, 13 years after treatment, and 22 years at the follow-up assessment (Table I). Average length of follow-up was 9 years (range, 3-19 years). Mean age at the end of follow-up was 23 years for the men and 21 years for the women.

SEC III treatment protocol involves 2 phases: active

Table I. Characteristics of subjects (n = 52)

Variables	
Sex	
Male	22 (42.3%)
Female	30 (57.7%)
Age in years (mean and range)	
Before treatment	9 (4-15)
End of treatment	13 (6-20)
Follow-up assessment	22 (18-34)
Length of therapy in years (mean and range)	4 (0.3-10)
Length of follow-up in years (mean and range)	9 (3-19)

and retention. The active phase is designed to achieve occlusal sagittal correction of the Class III disharmony. Patients wear 2 occlusal splints (Fig 3) with Class III elastics and chincups. Elastics deliver a force of 150 to 700 g on each side and are attached to buccal hooks on either side of the intraoral appliance, distal to the maxillary last molars and between the mandibular canines and lateral incisors. Force levels depend mainly on splint stability. Patients are instructed to use splints and elastics for 16 to 18 hours per day and to change the elastics twice a week. The vector of the chincup force is through the maxillary first molars; the total amount of force is approximately 300 to 1500 g per side. Patients are asked to wear the appliance for an average of 14 hours per day.

The active phase should last until a positive overjet (2-3 mm) is reached. In this sample, it lasted approximately 4 years (Table I). Time differences were mainly related to a patient's age, cooperation, and severity of the problem. At the end of the active phase, if necessary, patients received supplemental treatment—eg, fixed appliances to refine the occlusion. Then patients are instructed to wear Class III elastics on the archwires, with a force of 100 to 300 g per side for 12 to 14 hours per day and a nighttime chincup delivering a force of 500 to 800 g. Thirty-two patients had a phase of fixed appliance therapy to correct residual crowding. One patient was treated by extraction of the maxillary first premolars. The retention phase aims to maintain the occlusal sagittal correction achieved during the active phase. Patients were asked to wear the chincup at bedtime only with the force vector in the direction of the condyle and force level ranges from 500 to 800 g per side, for 2 to 3 years after active treatment. Retention is indicated when stability seems tenuous, as derived by the reduction of the overbite in the post-treatment observation. Bedtime-only chincup retention was used in 18 patients for a variable period (1 to 7 years).

Cephalograms were not usually taken at the postre-tention stage; thus, the third lateral film, made at least 3 years after the end of treatment, also included changes that occurred during retention.

Cephalometric analysis

Eleven angular and 9 linear measures were considered (Fig 4): angles SNA, SNB, ANB, N-S-Ba, N-S-Ar, SN/palatal plane, SN/occlusal plane, SN/mandibular plane (Go-Me), Ar-Go-Me, maxillary incisor/SN, mandibular incisor/Go-Me, AOBO, the length of the anterior cranial base (SN), the length of the maxillary body (PNS-A projected perpendicular onto the palatal plane), the length of the mandibular body (Go-Pg projected perpendicular onto the mandibular plane), the length of the mandibular ramus (Ar-Go), the total mandibular length (both Co-Gn and Ar-Gn), overbite, and overjet.

Even though mandibular length is commonly assessed with measurements that use condylion, articulare was also involved because of its greater reliability.[61-64] Articulare-gnathion (Ar-Gn), moreover, increases at the same rate as condylion-gnathion (Co-Gn)[65] and should have a similar biological meaning.

The cephalograms were traced on 0.003-inch frosted acetate with a 0.3-mm lead pencil. Images of bilateral structures were bisected. Measurements were taken to the nearest half millimeter or degree with a protractor.

Statistical analysis

Clinical relapse was defined as reversal of positive overjet (≤ 0 mm) at the end of follow-up (T2).

The main purposes of the study were (1) to evaluate which characteristics at the end of successful treatment (baseline values) are the best predictors of relapse and (2) to determine how facial growth might affect long-term stability of results, defined as the absence of relapse at T2.

The starting point of the study was the cephalogram at the end of treatment (T1) when the baseline values were calculated; facial growth was estimated by absolute differences of cephalometric characteristics from T1 to T2, assuming that growth had ceased at that time. Under this assumption, values measured at T2 are presumed to remain stable, and absolute differences should be considered a better estimator of growth than rates per year when there is much variation of follow-up times among subjects; computing averages requires growing rates to be substantially constant throughout the whole period; this requirement is not met when follow-up includes time after growth has ceased.

For analysis, subjects were divided into 2 groups, stable and relapsed according to clinical relapse; for
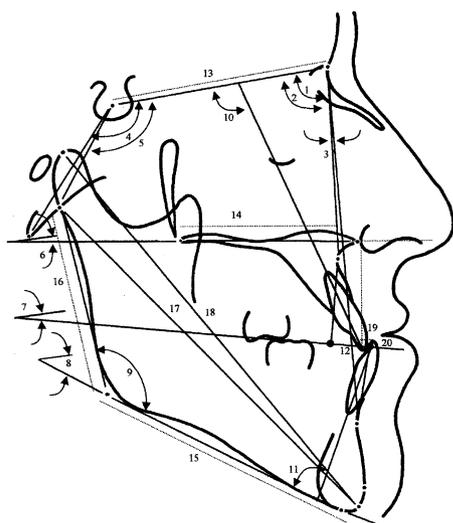
Fig 3. Lateral and occlusal views of splint.

Fig 4. Angular and linear measurements. Angular: *1*, SNA; *2*, SNB; *3*, ANB; *4*, N-S-Ba; *5*, N-S-Ar; *6*, SN/palatal plane; *7*, SN/occlusal plane; *8*, SN/Go-Me; *9*, Ar-Go-Me; *10*, maxillary incisor/SN. *11*, mandibular incisor/Go-Me. Linear: *12*, AOBO; *13*, S-N; *14*, PNS-A; *15*, Ar-Go; *16*, Go-Pg; *17*, Ar-Gn; *18*, Co-Gn; *19*, overbite; *20*, overjet.

Table II. Intraobserver consistency of cephalometric measures on random sample of 16 cephalograms

| *Measure* | *ICC* | *Intraobserver differences within subject* | |
		Mean	*Range*
Angular (°)			
SNA	0.998	−0.03	(−0.5, +0.5)
SNB	0.994	−0.16	(−1.0, +1.0)
ANB	0.983	0.00	(−1.5, +1.0)
N-S-Ba	0.996	−0.16	(−1.5, +0.5)
N-S-Ar	0.995	0.03	(−1.0, +1.0)
SN/PP	0.980	0.34	(−1.0, +1.0)
SN/OP	0.994	0.00	(−1.0, +1.0)
SN/Go-Me	0.998	0.03	(−1.0, +0.5)
Ar-Go-Me	0.997	−0.06	(−1.5, +0.5)
Max1/SN	0.996	−0.09	(−1.0, +1.0)
Mand 1/Go-Me	0.999	0.03	(−0.5, +0.5)
Linear (mm)			
AOBO	0.997	0.00	(−0.5, +0.5)
S-N	0.993	0.16	(−1.0, +1.0)
PNS-A	0.990	−0.19	(−1.0, +1.0)
Ar-Go	0.999	0.00	(−0.5, +0.5)
Go-Pg	0.998	0.19	(−0.5, +1.0)
Ar-Gn	0.999	0.13	(−0.5, +1.0)
Co-Gn	0.998	0.00	(−1.0, +1.0)
Overbite	0.984	0.00	(−0.5, +0.5)
Overjet	0.989	−0.03	(−0.5, +0.5)

ICC, Intraclass correlation coefficient; *PP,* palatal plane; *OP,* occlusal plane; *max 1,* maxillary incisor; *mand 1,* mandibular incisor.

each group, baseline values and absolute changes in cephalometric measures from the beginning to the end of follow-up were estimated and reported as means and SDs. Because of the small sample size and the highly imbalanced data (46 stable subjects and only 6 relapsed), exact *P* values were derived from Wilcoxon rank sum tests by means of the specialized software StatXact (Cambridge, Mass). Exact *P* values from the Wilcoxon rank sum tests stratified by sex were also calculated, because of the possible confounding effect of the sex on growth. The patients' characteristics at the beginning of SEC III treatment were also reported for a thorough description of the study sample.

Consistency of cephalometric measurements was assessed in a 10% random sample of cephalograms (16 of 156) by blindly repeating measures twice. The intraclass correlation coefficient (ICC)[66] was estimated

as a measure of reliability. Mean difference and range of differences of the 2 measurements from each patient were also reported.

RESULTS

The ICCs of the 2 measurements from 16 randomly sampled cephalograms are given in Table II. Mean differences and ranges of the observed differences are also shown. All ICC values are very high, showing high reliability of the measurements in the study. The main characteristics of the sample, before and after treatment, are summarized in Table III.

As defined by design, overjet was always negative

Table III. Characteristics of 52 patients before (T0) and after (T1) treatment (values expressed as mean and SD)

Variable	T0	T1
Angular (°)		
SNA	78.7 (3.6)	79.9 (3.5)
SNB	80.5 (3.8)	79.8 (3.8)
ANB	−1.9 (1.9)	0.1 (1.8)
N-S-Ba	130.3 (4.43)	131.3 (4.7)
N-S-Ar	123.9 (5.1)	126.0 (4.9)
SN/PP	10.3 (3.1)	9.9 (3.9)
SN/OP	18.5 (3.1)	14.0 (3.9)
SN/Go-Me	35.0 (5.7)	34.3 (5.1)
Ar-G0-Me	128.1 (5.5)	124.7 (5.6)
Max 1/SN	99.2 (10.8)	108.4 (10.4)
Mand 1/Go-Me	84.5 (7.3)	82.6 (7.4)
Linear (mm)		
AOBO	−6.6 (2.4)	−2.2 (2.6)
S-N	66.6 (3.5)	68.5 (3.7)
PNS-A	44.1 (2.9)	47.1 (3.3)
Ar-Go	41.1 (4.6)	45.4 (5.5)
Go-Pg	73.1 (6.4)	78.7 (6.7)
Ar-Gn	101.5 (8.8)	109.1 (10.1)
Co-Gn	107.1 (9.3)	115.0 (9.7)
Overbite	2.0 (3.0)	2.8 (1.4)
Overjet	−1.9 (1.59)	1.5 (0.8)

PP, Palatal plane; *OP*, occlusal plane; *max 1,* maxillary incisor; *mand 1,* mandibular incisor,

Table IV. Baseline values of variables immediately after treatment (T1) according to clinical relapse (overjet ≤ 0 at T2) (values expressed as mean and SD)

Variable	Relapse (n = 6)	Stable (n = 46)	P*	P**
Female	1 (16.7%)	29 (63.0%)	.05†	-
Male	5 (83.3%)	17 (37.0%)		
Age (y)	12.2 (2.5)	12.9 (3.5)	.62	.46
Length of therapy (y)	3.0 (1.8)	3.9 (3.0)	.56	.66
Angular (°)				
SNA	81.2 (3.7)	79.8 (3.5)	.19	.26
SNB	82.5 (4.2)	79.5 (3.6)	.04	.04
ANB	−1.3 (1.7)	0.3 (1.7)	.06	.02
N-S-Ba	130.2 (3.3)	131.4 (4.8)	.42	.86
N-S-Ar	127.7 (3.6)	126.0 (5.1)	.48	.34
SN/PP	10.4 (1.4)	9.8 (3.6)	.54	.78
SN/OP	12.3 (5.0)	14.2 (3.8)	.41	.52
SN/Go-Me	31.9 (6.7)	34.7 (4.9)	.27	.29
Ar-G0-Me	124.4 (7.7)	124.8 (5.4)	.98	.85
Max 1/SN	114.0 (10.3)	107.6 (10.2)	.19	.18
Mand 1/Go-Me	87.0 (7.0)	82.0 (7.3)	.08	.09
Linear (mm)				
AOBO	−4.5 (2.3)	−1.9 (2.5)	.04	.006
S-N	70.2 (2.8)	68.2 (3.8)	.20	.89
PNS-A	49.0 (3.0)	46.8 (3.3)	.13	.59
Ar-Go	46.6 (7.3)	45.3 (5.4)	.74	.76
Go-Pg	83.2 (6.9)	78.1 (6.6)	.12	.37
Ar-Gn	113.4 (12.9)	108.5 (9.8)	.37	.91
Co-Gn	119.4 (12.6)	114.4 (9.3)	.33	.75
Overbite	1.4 (1.7)	3.0 (1.3)	.03	.01
Overjet	1.2 (0.7)	1.6 (0.9)	.52	.74

*Exact *P* values from Wilcoxon rank sum test.
**Exact *P* values from Wilcoxon rank-sum text stratified by sex.
†Mid *P* value from Fisher exact test.
PP, Palatal plane; *OC*, occlusal plane; *max 1,* maxillary incisor; *mand 1,* mandibular incisor.

at the beginning of treatment with an average value of −1.9 mm and a range of −9.0 to −0.5 mm. ANB angle was −1.9° on average, with a range between −7° and 2.5°. SNA angle was 78.7°, and the SNB angle was 80.5°.

Wits appraisal was −6.6° on average, with a range of −12.5° to −2°. The anterior cranial base (SN), maxillary body (PNS-A), and mandibular body (Go-Pg) lengths were 66.6, 44.1, and 73.1 mm, respectively; according to Schwarz's table,[67] the first 2 were relatively short and the third longer. Overbite showed an average value of 2.0 mm, with a range of −5.5 to 13 mm.

As defined by design, overjet was always positive at T1, with an average value of 1.5 mm and a range of 0.5 to 4.5 mm. ANB angle was 0° on average, ranging from −5° to 3.5°. At T1, ANB angle improved in 47 patients, was unchanged in 3, and worsened in 2. SNA angle increased by 1.2°, and SNB angle decreased by 0.7° on average. Cranial base angle N-S-Ar opened by 2° and N-S-Ba angle by 1° on average.

SN/palatal and SN/mandibular angles were unchanged, but the SN/occlusal angle and the gonial angle closed by 4.5° and 3.4°, respectively. The maxillary incisors proclined by 9.2°, and the mandibular incisors were slightly retroclined. After treatment, Wits appraisal was −2.2° on average, with a range of −8° to 3.5°. This measurement improved in 50 patients, was unchanged in 1, and worsened in another; positive values were reached in 11 patients.

Lengths of the anterior cranial base (SN), maxillary body (PNS-A), mandibular body (Go-Pg), mandibular ramus (Ar-Go), and total mandibular length (both Co-Gn and Ar-Gn) increased. However, the mandibular linear measurements had the greatest increases.

Overbite increased and was always positive, with an average value of 2.8 mm (1.46) and a range of 0 to 5.5 mm.

Baseline values of variables at T1, grouped according to clinical relapse (defined as an overjet value ≤ 0 at T2), are given in Table IV. At T2, 6 of 52 patients relapsed (11.5%). Representative series for both stable and relapsed subjects are shown in Figures 5 and 6.
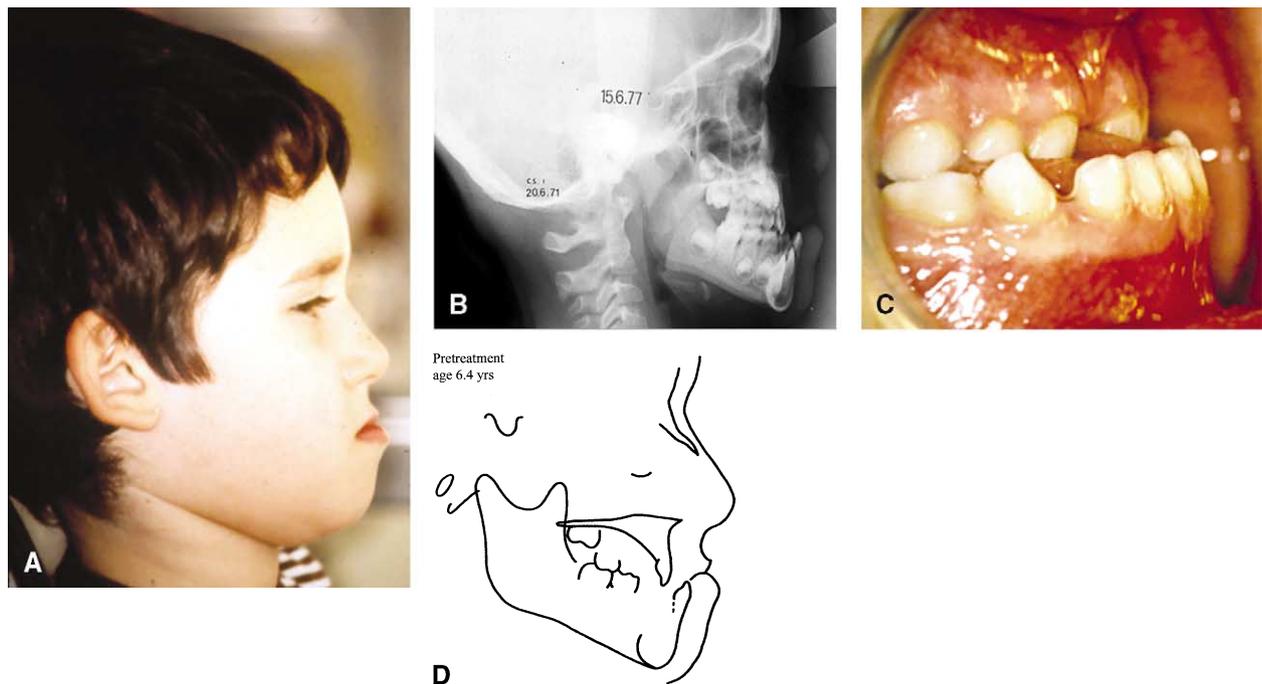
Fig 5. Patient treated whith SEC III whose treatment result remained stable. **A-D**, pretreatment; **E-H**, end of treatment; **I-L**, follow-up.

The stable and the relapsed groups did not differ in age and length of therapy at T1, but a significant association was found for sex (mid *P* values equal to 0.052 in the Fisher exact test). Just 1 of 30 women relapsed compared with 5 of 22 men. Because of the possible confounding effect of sex, all results are reported after stratification by sex. Few baseline characteristics were significantly associated with relapse; the results were all confirmed after stratification by sex.

Wits appraisal was significantly greater in the stable group than in the relapsed group (−1.9° vs −4.5° on average, *P* = .04), whereas SNB angle was significantly smaller (79.5° vs 82.5° on average, *P* = .04). In the stable group, overbite and ANB angle values at T1 were significantly greater than in the relapsed patients (3.0 vs 1.4 mm, *P* = .03, and 0.3° vs −1.3°, *P* = .06, respectively).

Absolute differences of cephalometric variables from T1 to T2 are grouped according to clinical relapse and shown in Table V. Clear differences were observed only for Wits appraisal and length of mandibular ramus. The absolute decrease of Wits appraisal was smaller in the stable than in the relapsed group (−0.3 vs −2.9 mm on average, *P* = .02).

Conversely, the mandibular ramus length increased more in the relapsed than in the stable group (12.3 vs 5.8 mm, *P* = .01). The absolute changes in total

mandibular length were no longer statistically significant after adjustment by sex. Overjet changes were highly different by design.

DISCUSSION

The purpose of this study was to examine the long-term stability at the end of facial growth after successful SEC III treatment. The specific goals were (1) to evaluate which characteristics at T1 (baseline values) were the best predictors of relapse and (2) to analyze how facial growth might affect long-term stability of results (absolute variations).

These results suggest that successful SEC III treatment (with post-SEC III orthodontic treatment) has a lasting impact on the occlusal sagittal correction of Class III malocclusions in a high percentage of patients. Only 6 (11.5%) of 52 patients showed a clinical relapse, defined as an overjet value less than or equal to 0 at T2.

Low Wits appraisal, ANB angle, and overbite, and high SNB angle seemed to be the best predictors of relapse at T1. Male gender was significantly related to relapse, but age and length of therapy at T1 did not affect the stability of the results. Furthermore, long-term stability was mainly affected by posttreatment growth of the mandibular ramus. These findings are particularly important because all patients were recalled at the end of growth. Age limits (18 for women and 21
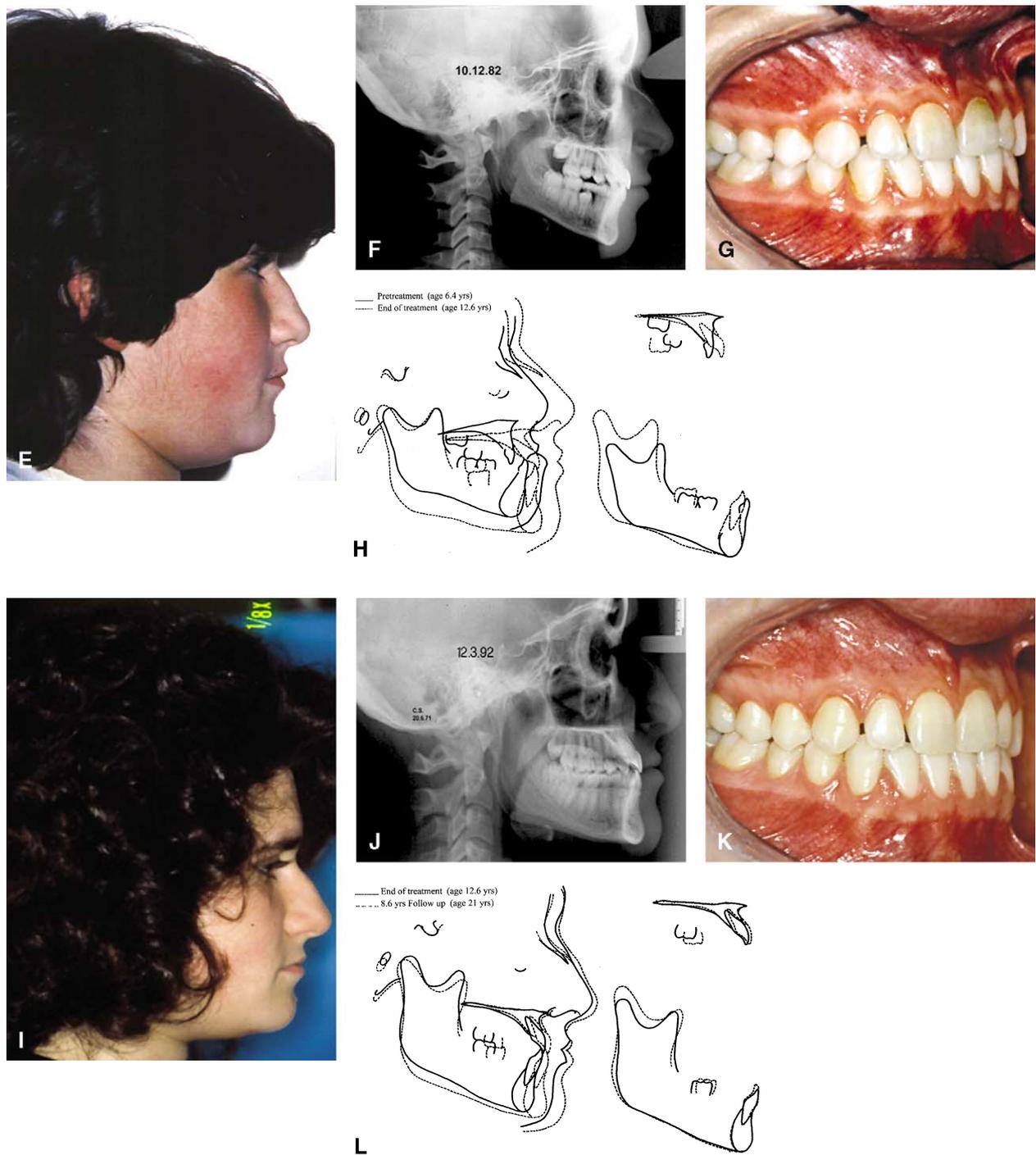
Pretreatment (age 6.4 yrs)
End of treatment (age 12.6 yrs)

End of treatment (age 12.6 yrs)
8.6 yrs Follow up (age 21 yrs)

Fig 5. Continued

for men) were chosen to reasonably exclude patients whose facial growth was still substantially incomplete at the follow-up date.[53-60]

In girls, Björk[53-55] suggested that maxillary growth is essentially complete by the age of 15, and mandibular growth ceases approximately by the age of 17. However, a more recent implant study suggested that the horizontal component of the maxilla remains active until 18 years of age.[56] In boys, approximately 98% of facial growth is usually considered complete at the age of 18 years.[57-59] However, Class III subjects can have considerable mandibular growth from 16 to 21 years.[60]

Table V. Absolute differences of cephalometric characteristics from end of treatment (T1) to follow-up assessment (T2) according to clinical relapse (overjet ≤ 0 at T2)

Variable	Relapse (n = 6)	Stable (n = 46)	P*	P**
Angular (°)				
SNA	0.7 (3.2)	1.0 (5.1)	.82	.93
SNB	2.8 (2.7)	1.8 (5.1)	.18	.32
ANB	−2.1 (1.1)	−0.7 (1.7)	.06	.09
N-S-Ba	1.3 (2.7)	0.6 (2.2)	.43	.49
N-S-Ar	−0.2 (4.0)	1.4 (2.3)	.30	.40
SN/PP	−0.2 (1.8)	0.6 (1.5)	.21	.38
SN/OP	−1.8 (2.4)	−1.7 (3.6)	.89	.79
SN/Go-Me	−4.4 (2.3)	−2.8 (3.4)	.19	.45
Ar-G0-Me	−4.4 (3.2)	−3.9 (3.7)	.72	.89
Max 1/SN	−1.6 (6.7)	−1.3 (8.6)	.69	.54
Mand 1/Go-Me	2.2 (4.3)	2.1 (5.3)	.75	.98
Linear (mm)				
AOBO	−2.9 (1.5)	−0.3 (2.8)	.02	.006
S-N	3.7 (2.6)	1.9 (2.0)	.08	.27
PNS-A	3.8 (2.8)	3.0 (2.7)	.47	.73
Ar-Go	12.3 (5.0)	5.8 (5.7)	.01	.07
Go-Pg	8.6 (4.7)	6.0 (5.4)	.27	.53
Ar-Gn	14.8 (6.6)	7.3 (8.2)	.03	.11
Co-Gn	14.6 (5.1)	8.8 (8.0)	.06	.20
Overbite	−0.5 (2.7)	−0.3 (1.5)	.90	.79
Overjet	−2.2 (1.2)	−0.5 (0.8)	-	-

*Exact *P* values from Wilcoxon rank sum test.
**Exact *P* values from Wilcoxon rank sum text stratified by sex.
PP, Palatal plane; *OP,* occlusal plane; *max 1,* maxillary incisor; *mand 1,* mandibular incisor.

All patients in our study had true skeletal Class III malocclusions as confirmed by follow-up variations of Wits appraisal and ANB angle. Our definition of clinical relapse was conservative, including overjet values equal to zero.

Comparison with other studies is difficult because of different appliances, skeletal patterns, ages of the subjects, duration and time of day for wearing the appliance, length of treatment, or method of analysis. Moreover, findings derived from different ethnic groups[40,68] and stability at the end of growth is controversial.

Sugawara et al[38] showed that the chincup greatly improved the skeletal profile of 63 Japanese girls during the initial stages of therapy, but these changes were often not maintained thereafter.

Battagel and Orton[39] reviewed 28 children with skeletal Class III malocclusions who were successfully treated with a combination of maxillary incisor proclination and headgear to an intact mandibular dentition. Two years after retention, when most growth had ceased, many treatment effects had been reversed.

Yoshida et al[43] studied the combined effects of the maxillary protraction appliance and chincup therapy in 28 Japanese girls with skeletal Class III malocclusions. The follow-up of 13 subjects until the age of 19 showed that, although a slight relapse had occurred, the effects on the maxilla persisted, but changes in the mandible reverted almost completely for an excessive rebound-like growth.

Deguchi and Kitsugi[40] showed that using a chincup with a Mershon lingual arch and fixed appliances produced effects lasting until 18 years of age in 24 Japanese girls with moderately severe mandibular prognathism and a follow-up of 4 years. In a 5-year follow-up of 36 Japanese girls at 18 years of age, Deguchi et al[41] reported that long-term use of the chincup brought about improvements even in severe dolichofacial skeletal Class III malocclusions associated with posterior crossbite.

Satravaha and Taweesedt[42] examined the skeletal changes after activator treatment in 28 children with skeletal Class III malocclusions. After about 6 years, at 17 years of age, a lasting skeletal effect was reported. A few selection criteria used in these studies, however, are worth considering. The patient selection of Deguchi and Kitsugi[40] was not based on cephalometric analysis. Therefore, not all patients had skeletal measurements consistent with a skeletal Class III malocclusion; they had nonprominent skeletal Class III profiles at rest and edge-to-edge bites on posterior guide position of the mandible.

In the study of Deguchi et al,[41] patient compliance was required, and treatment included either occipital or high-pull chincups associated with rapid palatal expansion in 21 patients and extraction in 17 patients, followed by fixed appliances. On the other hand, in the study of Satravaha et al,[42] only patients suitable for Class III activator therapy were selected.

A likely explanation for the high percentage of stability we observed is that SEC III treatment allowed a Class III correction without mandibular rotation as shown by the unchanged SN/Go-Me angle.

The follow-up variations showed a forward mandibular rotation (SN/Go-Me) in both the stable and relapsed groups, but it was more marked in the latter. As described by Björk and Skieller[61] and also observed by Battagel and Orton,[39] forward mandibular rotation is a natural growth tendency in late adolescence. It cannot be categorized as posttreatment rebound because, during SEC III treatment, no mandibular rotation was observed.

We believe that it is important to work with and not against facial growth. But when the correction is achieved through a backward mandibular rotation, the
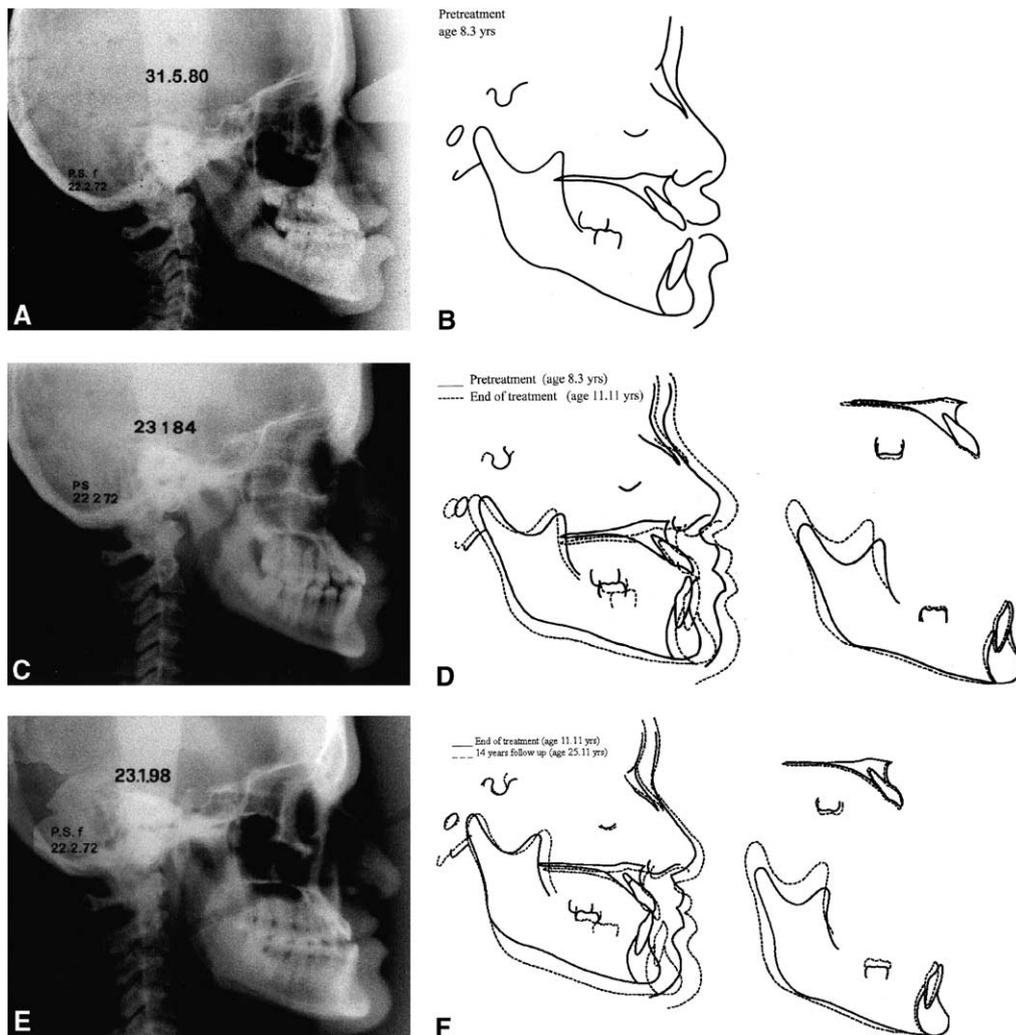
Fig 6. Headfilms and tracings of patient who relapsed. **A** and **B**, pretreatment; **C** and **D**, end of treatment; **E** and **F**, follow-up.

physiologic pattern of growth in forward rotation tends to return—thus, the relapse described by Behrents.[60]

Hence, a backward mandibular rotation, even though useful in correcting the Class III relationship, should be carefully evaluated. A Class III malocclusion should be corrected with no rotation or, better, with a forward mandibular rotation. Exhausting the potential mandibular growth in forward rotation during treatment limits or avoids relapse later. Avoiding backward rotation of the mandible also helps to keep the overbite positive. Previous studies stressed that this is very important to control relapse.[39,69-71] We found relapse in patients with a significantly reduced overbite at the end of treatment.

The other significant predictors of relapse are low Wits appraisal and ANB angle and high SNB angle at the end of the treatment. These suggest that the degree of the skeletal correction is also important. The treatment should therefore aim for both occlusal and skeletal correction. Better control of mandibular growth should be planned to reduce SNB angle and to increase Wits appraisal and ANB angle.

In addition, for a better skeletal correction, dentoalveolar compensation such as proclination or retroclination of incisors should be avoided. The average proclination of the maxillary incisors of about 9°, observed in this study, was probably due to a technical error during the cast of the splints. Therefore, we recommend care in this step of the procedure.

Some investigators hold that the stability of the results is a function of good intercuspation.[40,72-76] Here, all patients had good intercuspation at the end of

treatment, half spontaneously and half for post-SEC III procedures designed to refine the occlusion. Thus, the intercuspation might contribute to stability but cannot guarantee it. Relapse occurred even with good intercuspation.

During the follow-up, relapse was significantly affected by growth of the mandibular ramus. This finding, also seen by Yoshida et al,[43] confirmed that the risk is in the ramus and not in the body growth of the mandible. We found that the ramus growth was remarkable only in patients with reduced overbite, low Wits appraisal and ANB angle, and high SNB angle. Because mandibular growth might be genetically determined, a deeper overbite and better skeletal correction could control mandibular ramus growth and perhaps reduce relapse.

CONCLUSIONS

Analysis of longitudinal data from 52 patients with dentoskeletal Class III malocclusions treated with the SEC III appliance showed the following:

1. The SEC III appliance achieved a long-term Class III occlusal correction in a high percentage (88.5%) of successfully treated patients. Thus, SEC III treatment is reliable at least at the end of the facial growth, as defined by age.
2. At the end of treatment, the best predictors of relapse seem to be low Wits appraisal, ANB angle, and overbite, and large SNB. No backward mandibular rotation was observed.
3. After treatment, forward mandibular rotation occurs.
4. Mandibular forward rotation cannot be considered a rebound because during treatment no mandibular postrotation was seen.
5. Relapse appears to be affected by increased growth of the mandibular ramus.

The likelihood of long-term stability of skeletal Class III correction can be enhanced by a deeper overbite and the best possible skeletal correction. The results suggest that the correction occurs with no mandibular rotation but might be better with forward rotation.

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