

# Early Treatment of Class III Patients To Improve Facial Aesthetics and Predict Future Growth

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**ABSTRACT** The objective of this study is to determine the profile changes in Class III patients treated with protraction facemask and propose the use of serial cephalometric radiographs and a Growth Treatment Response Vector (GTRV) analysis to predict excessive mandibular growth. Serial cephalometric radiograph of 40 Class III patients who were treated with protraction facemask were included in the study. Cephalometric radiograph was taken at the initiation of treatment (T1) and 6 months after maxillary protraction (T2). Changes in skeletal and soft tissue profiles were determined using well-known cephalometric analyses. Data were analyzed using a Student t test. To determine the GTRV ratio for the successfully and unsuccessfully treated cases, post-treatment records were used to divide patients into successfully and unsuccessfully treated groups. The criteria for successful treatment included a positive overjet of greater than 1 mm at the follow-up visit. Horizontal growth changes of the maxilla and mandible were determined by superimposition of the follow-up radiograph on the post-treatment radiograph. The GTRV ratio was calculated using the formula  $GTRV = \text{Horizontal growth changes of the maxilla} / \text{Horizontal growth changes of the mandible}$ . Results show that early treatment with protraction facemask can improve the skeletal and soft tissue facial profiles. The lip posture was improved. The normal incisal relationship (overjet) that was achieved had a significant impact on the soft tissue overlying both the upper and lower incisors, resulting in improved lip competence and posture. The mean GTRV ratio for the successful group was found to be 0.49 with a range of 0.33 to 0.88. Class III patients with mild to moderate skeletal malocclusion and a GTRV ratio that falls within this range can be successfully camouflaged with orthodontic treatment. The mean GTRV ratio for the unsuccessful group was found to be 0.22 with a range of 0.06 to 0.38. Patients with excessive mandibular growth together with a GTRV ratio that falls below 0.38 should be warned of future need for orthognathic surgery.

## Introduction

The occurrence of Class III malocclusion is believed to be hereditary although environmental factors such as

habits and mouth breathing may play a role<sup>1,2</sup>. The prevalence of Class III malocclusion varies among different ethnic groups. The incidence in Caucasians ranges between 1-4% depending on the method of classifying the malocclusion and the age group evaluated<sup>3-5</sup>. In Asian societies, the frequency of Class III malocclusion is higher due to a large percentage of patients with maxillary deficiency. The incidence of this malocclusion ranges between 4-13% among the Japanese<sup>6</sup> and 4-14% among the Chinese<sup>7</sup>. Few studies separate skeletal Class III malocclusion from pseudo Class III malocclusion. According to a study by Lin<sup>8</sup>, the prevalence of pseudo and true Class III malocclusion in Chinese children age 9 to 15 was 2.3% and 1.7%, respectively.

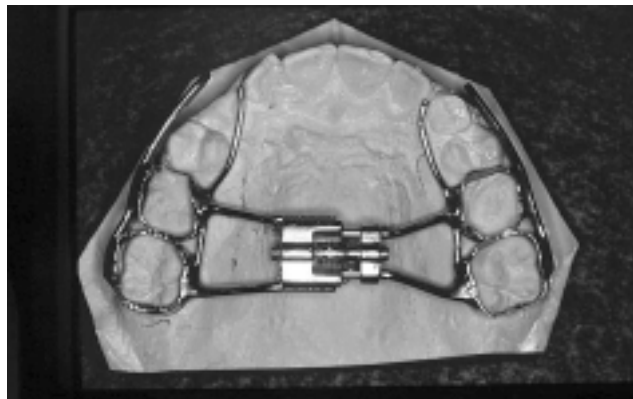
Individuals with Class III malocclusion may have combinations of skeletal and dentoalveolar components. Consideration of the various components is essential so that the underlying cause of the discrepancy can be treated appropriately. According to Guyer *et al*<sup>9</sup>, 57% of the patients with either a normal or prognathic mandible showed a deficiency in the maxilla.

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**Figure 1** Anchorage system consisted of a banded expansion appliance with wire soldered on the buccal aspects of the bands and extended anteriorly to the canine area for protraction with elastics.

Protraction facemask has been advocated in the treatment of Class III patients with maxillary deficiency<sup>10-12</sup>. The dental and skeletal effects of this appliance are well documented in the literature<sup>10,13-17</sup>. However, the profile and aesthetic changes with this treatment modality have not been emphasized. In a study by Lew<sup>18</sup>, patient with a concave profile and a prognathic mandible was found to be least acceptable by the public. Early treatment of these patients can improve the profile and self-image of these child patients during the growth years<sup>19-20</sup>.

One of the reasons clinicians are reluctant to render early orthopedic treatment in Class III patients is the inability to predict mandibular growth<sup>21</sup>. Patients received early orthodontic or orthopedic treatment could wind up having surgical treatment at the end of the growth period. The ability to predict mandibular growth early in life can help clinicians to plan for future orthodontic care or the need for surgical treatment. Bjork<sup>22</sup> used a single cephalogram to identify 7 structural signs of extreme mandibular growth rotation occurring during growth. The 7 signs are related to the inclination of the condylar head, the curvature of the mandibular canal, the shape of the lower border of the mandible, the width of the symphysis, the interincisal angle, the intermolar angle, and the anterior lower face height. Discriminant analysis of long-term results of early treatment identified several variables that had predictive values. Franchi *et al*<sup>23</sup> found the inclination of the condylar head, the maxillomandibular vertical relationship together with the width of the mandibular arch could predict success or failure of early Class III treatment. Ghiz *et al*<sup>24</sup> found that the position of the mandible, the ramal length, the corpus length, and the gonial angle can predict successful outcomes with 95% accuracy. However, this method can only predict unsuccessful outcome with only 70% accuracy. The objective of this study is to determine the soft tissue profile changes in Class III patients treated with protraction headgear and propose the use of serial cephalometric radiographs and a Growth Treatment Response Vector analysis to predict excessive mandibular growth.

## Methods and Materials

Serial cephalometric radiographs of 40 Class III patients



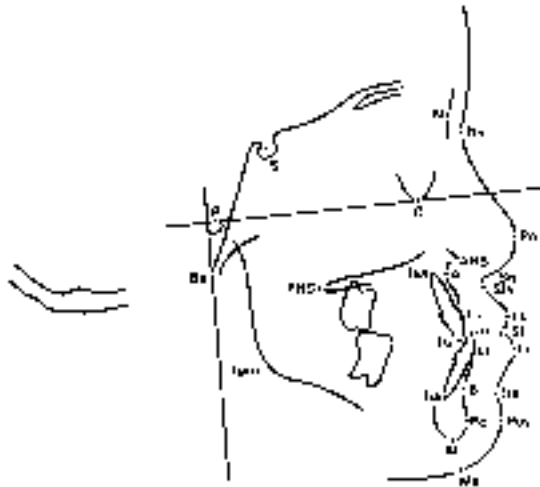
**Figure 2** Protraction facemask with an adjustable anterior wire and hooks to accommodate a forward and downward pull of the maxilla with elastics.

(21 males, 19 females) who were treated with maxillary protraction headgear were included in the study. There were 25 Chinese and 15 Caucasian patients. The criteria for selection included: 1) patients who had an anterior crossbite and a skeletal Class III malocclusion, 2) patients who had no previous orthodontic treatment other than protraction facemask treatment to correct the anterior crossbite and 3) patients who had pre-treatment, post-treatment, and a minimum of 3 years of follow-up orthodontic records after facemask treatment. The average age of the patients was  $8.9 \pm 2.1$  years.

### Appliances for Class III Correction

The Hyrax rapid palatal expansion appliance was constructed by placing bands on the posterior teeth (Figure 1). Bands were fitted on the maxillary primary second molars and permanent first molars. These bands were joined by a heavy wire (0.043-inch) to the palatal plate, which had a jack screw in the midline. The appliance was activated twice daily (0.25 mm per turn) by the patient for 1 week. In patients with a constricted maxilla, activation of the expansion screw was applied for 2 weeks. An 0.045-inch wire was soldered bilaterally to the buccal aspects of the molar bands, and extended anteriorly to the canine area for elastic protraction.

The facemask was a one-piece construction with an adjustable anterior wire and hooks to accommodate a downward and forward pull of the maxilla with elastics (Figure 2). The protraction elastics were attached near the maxillary canines with a downward and forward pull of 30 degrees to the occlusal plane. Elastics that delivered 380 g per side as measured by a gauge were used. The patients were instructed to wear the facemask for 12 hours a day. At the end of the facemask treatment, a functional retainer such as a Frankel III appliance or a



**Figure 3** Cephalometric landmarks for skeletal and soft tissue analysis.

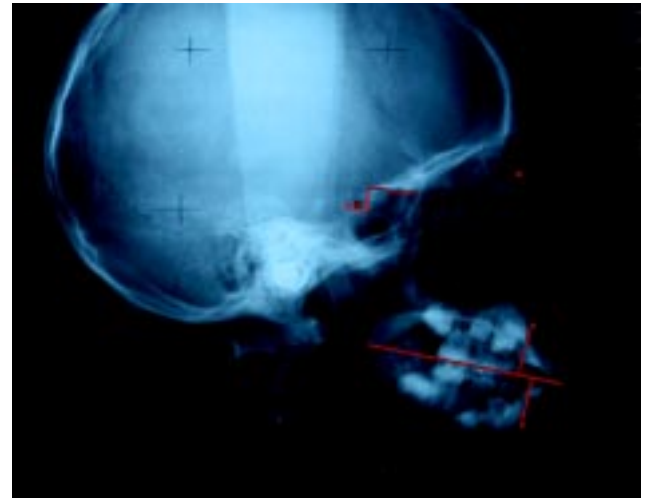
Class III activator was worn by the patient nighttime for one year.

Cephalometric Analysis to evaluate Soft Tissue Changes

For each patient, a cephalometric radiograph was taken at the initiation of treatment (T1) and 6 months after maxillary protraction (T2). A computerized cephalometric appraisal was developed, incorporating variables from different well-known cephalometric analyses and introducing some new measurements (Figure 3). Our analysis was based on a reference system consisting of horizontal (HP) and vertical (VP) planes developed by Coben<sup>25</sup>. The Frankfurt horizontal plane was used as the best estimate for the HP and a line perpendicular to this plane through basion, represented the VP, as suggested by Coben. Both HP and VP served as a grid in which sagittal and vertical distances were measured as projections from these planes. Data were analyzed using a Student t test. Improvement in facial esthetics was evaluated by changes in soft tissue facial convexity, lower face height, soft tissue thickness and lip morphology before and after treatment.

Growth Treatment Response Vector (GTRV) Analysis

Post-treatment records were divided into two groups of 20 patients in each group. The first group comprised of patients who were successfully treated with the protraction headgear based on the follow-up record and the second group comprised of patients who were unsuccessfully treated with the protraction headgear. The criteria for successful treatment included a positive overjet of greater than 1 mm at the follow-up visit. Table 1 shows the mean age of the patients in the two groups at pre-



**Figure 4** The horizontal growth changes of the maxilla and the mandible between the post-treatment radiograph and the follow-up radiograph were determined by locating the A point and B point on the first radiograph. The occlusal plane (O) was constructed by using the mesial buccal cusp of the maxillary molars and the incisal tip of the maxillary incisors as landmarks. The line AO and Bo were then constructed by connecting A and B point perpendicular to the occlusal plane.

treatment, post-treatment and follow-up visit. There were 11 males and 9 females in the successful group and 10 males and 10 females in the unsuccessful group.

The horizontal growth changes of the maxilla and the mandible between the post-treatment radiograph and the follow-up radiograph were determined by locating the A point and B point on the post-treatment radiograph (Figure 4). The occlusal plane (O) was constructed by using the mesial buccal cusp of the maxillary molars and the incisal tip of the maxillary incisors as landmarks. The lines AO and BO were then constructed by connecting point A and B perpendicular to the occlusal plane.

The first tracing was superimposed on the follow-up radiograph using the stable landmarks on the mid-sagittal cranial structure (Figure 5). The A point and B point on the follow-up radiograph was located and the lines AO and BO were then constructed by connecting point A and B of the follow-up radiograph to the occlusal plane of the first tracing. The distance between the A point of the two tracing along the occlusal plane represented the growth changes of the maxilla and the distance on the occlusal plane of the B point represented the growth changes of the mandible.

The GTRV ratio was calculated by using the following formula:

$$\text{GTRV} = \frac{\text{Horizontal growth changes of the maxilla}}{\text{Horizontal growth changes of the mandible}}$$

**Table 1.** Mean age of patients in the successful and unsuccessful groups before treatment, post-treatment and follow-up visit.

	Successful Group		Unsuccessful Group	
	Mean	SD	Mean	SD
Pre-Treatment	8.4	1.8	9.3	2.0
Post-Treatment	9.2	1.9	10.4	2.2
Follow-up Visit	12.4	2.1	13.6	2.4



**Figure 5** The first tracing was superimposed on the follow-up radiograph using the stable landmarks on the mid-sagittal cranial structure. The distance between the A point of the two tracing along the occlusal plane represented the growth changes of the maxilla and the distance on the occlusal plane of the B point represented the growth changes of the mandible. GTRV ratio was then calculated using the formula as depicted in the text.

For inter-rater reliability, each measurement was performed by two researchers. For intra-rater reliability, each measurement was measured twice with an interval of 3 weeks apart. Significant differences between the GTRV ratios of the two treatment groups were determined using a Student t test.

## Results

### Sagittal skeletal and soft tissue changes

Tables 2 and 3 show the skeletal and soft tissue changes with maxillary protraction, respectively. A more orthognathic profile was obtained after treatment. The maxilla was protracted significantly forward ( $SNA = 1.3^\circ$ ,  $p < .001$ ),

while the mandible was positioned backward significantly ( $SNB = -1.7^\circ$ ,  $p > .001$ ) giving an ANB difference of  $3.0^\circ$  ( $p < .001$ ). The corresponding soft tissue changes displayed a significant decrease in soft tissue pogonion ( $Ns-Pos = -2.7$  mm,  $p < .01$ ), facial angle ( $Ns-Pos/FH = -1.7^\circ$ ,  $p < .001$ ) and angle of convexity ( $Ns-Sls/Sls-Pos = 6.4^\circ$ ,  $p < .001$ ).

### Vertical skeletal and soft tissue changes

Vertical changes included a significant increase in lower face height ( $Ans-Me = 3.1$  mm,  $p < .001$ ), mandibular plane angle ( $Tgo-M/SN = 1.9^\circ$ ,  $p < .001$ ) and occlusal plane angle ( $OL/SN = -2.0^\circ$ ,  $p < .001$ ). There was a corresponding increase in soft tissue lower face height ( $Sn-Ms = 2.2$  mm,  $p < .01$ ) and total face height ( $Ns-Ms = 4.9$  mm,  $p < .05$ ).

### Soft tissue thickness

A significant decrease in thickness was noted in the upper lip ( $Ls-U1 = -1.8$  mm,  $p < .001$ ) while an increase was found in the lower lip ( $Li-L1 = 1.6$  mm,  $p < .001$ ).

### Lip Morphology

The inclination of the lower lip was decreased ( $Li-Ils/FH = -3.6^\circ$ ,  $p < .01$ ). However, its curvature ( $Ils-Pos-Ls = 0.6^\circ$ ) was increased as indicated by an increase in the distance of point inferior labial sulcus to the plane  $Pos-Ls$ . The inclination of the upper lip became flatter with treatment ( $Sn-Ls/FH = -0.7$ ) but the changes were not statistically significant.

### GTRV Analysis

Significant differences were found between the GTRV ratios for the two treatment groups ( $p < .05$ ). The mean GTRV ratio for the successful group was  $0.49 \pm 0.14$  with a range of 0.33 to 0.88. The mean GTRV ratio for the unsuccessful group was  $0.22 \pm 0.10$  with a range of 0.06 to 0.38. The interrater reliability was  $0.08 \pm 0.05$  and the intrarater reliability was  $0.06 \pm 0.04$  for the two researchers.

**Table 2.** Sagittal and vertical skeletal changes in 20 patients treated with protraction facemask before treatment ( $T_1$ ) and 6 months after treatment ( $T_2$ ).

	$T_1$		$T_2$		$T_2 - T_1$	
	Mean	SD	Mean	SD	Mean	SD
Maxillary position (SNA)	80.9	3.7	82.3	3.4	1.3	1.3***
Mandibular position (SNB)	81.1	2.7	79.4	2.5	-1.7	1.2***
Sagittal jaw relation (ANB)	-0.2	2.2	2.8	2.0	3.0	1.2***
Palatal plane angle (Ans-Pns/SN)	9.4	3.3	8.4	3.2	-1.0	1.8*
Mand plane angle (Tgo-M/SN)	34.6	4.0	36.5	4.0	1.9	1.4***
Lower face height (Ans-Me)	59.9	3.1	63.0	3.5	3.1	1.9***
Occl plane angle (OL/SN)	22.6	3.9	20.6	3.4	-2.0	3.0***
Max incisal angle (Isi-Isa/SN)	104.8	11.0	108.2	9.0	3.4	7.8
Mand incisal angle (Iii-Iia/Tgo-M)	90.7	9.2	85.6	6.6	-5.2	5.6***
Interincisal angle (Isa-Isa/Iii-Iia)	129.4	14.5	129.0	10.5	-0.3	10.6
Maxillary length (Co-A)	77.6	3.7	79.9	3.7	2.3	1.2***
Mandibular length (Co-Gn)	104.0	5.2	105.2	5.3	1.2	0.9***
Maxillo-mandibular diff	26.4	3.6	25.2	3.7	-1.2	1.5***
Wits analysis	-7.9	4.2	-3.46	2.3	4.5	3.3***

NS = not significant; \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ ;

## Case Report

A typical case was reported to illustrate the profile changes with treatment and the use of the GTRV ratio to predict excessive mandibular growth. Figure 6A shows an 8 years, 2 months old Chinese girl presented with a skeletal Class III malocclusion and a concave facial profile. Clinical examination revealed an anterior crossbite with a mesial step molar relationship. The inclination of her maxillary incisors was within normal limit but the mandibular incisors were proclined. Cephalometric radiograph revealed a deficient maxilla and a prognathic mandible.

Patient was treated with a maxillary expansion appliance together with a protraction facemask for 8 months. A positive overjet was established after 8 months of treatment (Figure 6B). Patient was given a

Frankel III regulator for night time wear as retention. Figures 6C and D show the changes in soft tissue and skeletal relationship two years and four years after completion of maxillary protraction, respectively.

The radiographs on Figures 6B and D were used to calculate the GTRV ratio using the method and formula depicted previously. The ratio of 0.2 indicated excessive mandibular growth that may warrant surgical treatment when growth is completed.

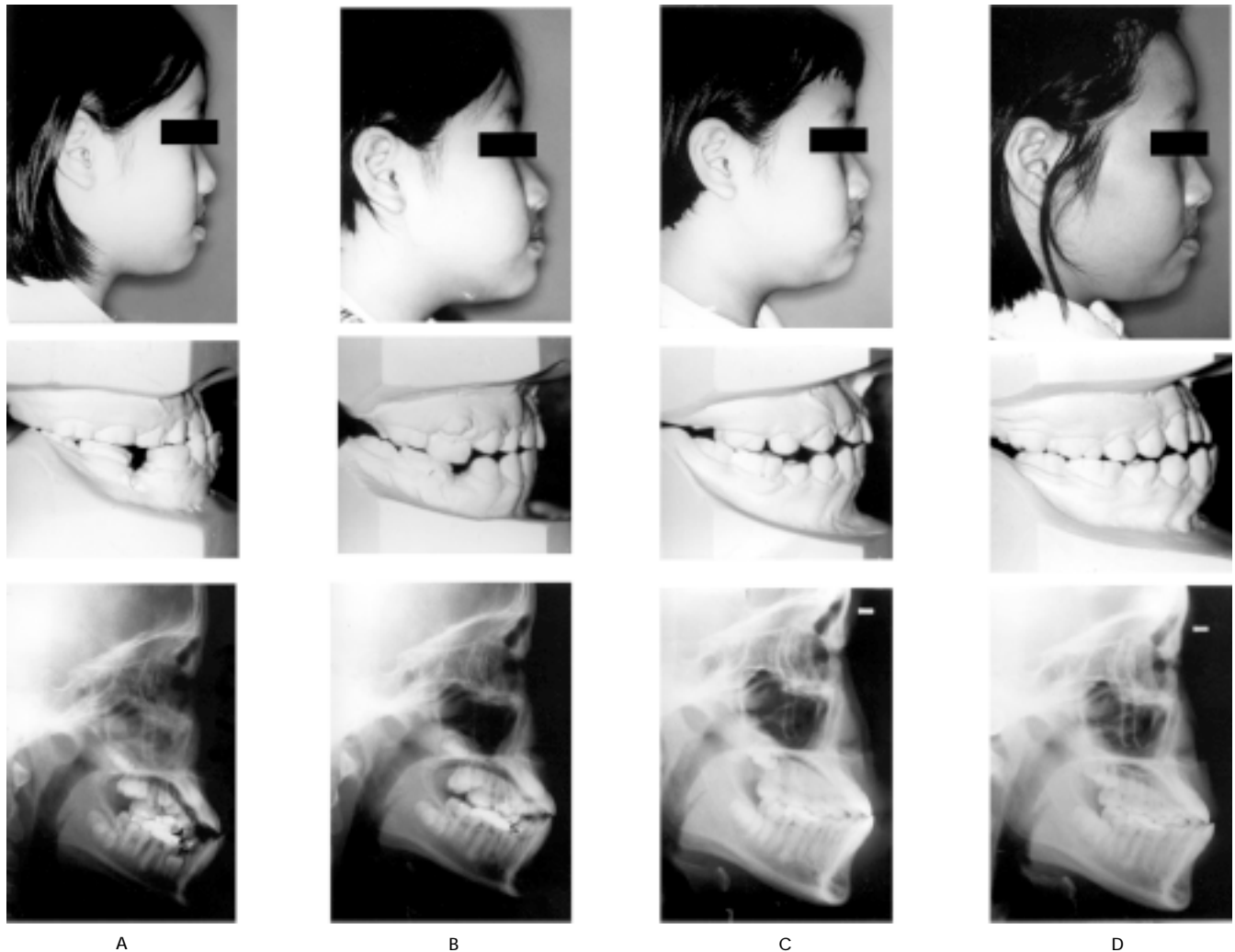
## Discussion

Clinically, patients with skeletal Class III malocclusion often present with a concave facial profile, a retrusive nasomaxillary area, and a prominent lower third of the face. The lower lip is often protruded relative to the

**Table 3.** Sagittal and vertical soft tissue changes in 20 patients treated with protraction facemask before treatment ( $T_1$ ) and 6 months after treatment ( $T_2$ )

Variables	$T_1$		$T_2$		$T_2-T_1$	
	Mean	SD	Mean	SD	Mean	SD
<b>Sagittal relationship of soft-tissue profile</b>						
Ns-Pos/FH (deg)	91.3	2.5	89.6	2.6	-1.7	1.0***
Ns-Sls/Sls-Pos	-4.8	6.4	-11.2	4.2	-6.4	3.9***
Ls/Pn-Pos (mm)	0.5	2.2	2.6	1.5	2.2	1.4**
Li/Pn-Pos (mm)	3.6	2.2	3.4	1.5	-0.2	1.7
Pn/Ns (mm)	14.9	3.4	15.9	3.0	1.0	1.0
Ns/Sn (mm)	3.8	3.5	5.2	2.9	1.4	1.3
Ns/Sls (mm)	3.3	3.6	4.8	2.8	1.5	1.4
Ns/Lss (mm)	10.0	4.0	11.5	3.7	1.5	1.7
Ns/St (mm)	4.8	3.8	4.5	3.8	-0.4	2.1
Ns/Li (mm)	19.2	16.8	8.8	4.1	-10.4	14.6**
Ns/lls (mm)	3.1	4.4	0.9	4.4	-2.2	1.6***
Ns/Pos (mm)	2.3	4.6	-0.4	4.5	-2.7	2.0***
<b>Vertical relationship of soft-tissue profile</b>						
Sn-Ms (mm)	63.6	3.5	65.9	3.8	2.3	2.2**
Sn-St (mm)	21.0	1.9	22.3	1.7	1.3	2.0
St-Ms (mm)	42.3	2.4	42.8	3.1	0.5	2.3
St-lls (mm)	16.0	2.5	15.5	2.8	-0.5	1.9
Ns-Ms (mm)	116.3	4.4	121.6	12.2	5.3	11.5*
Ns-Sn (mm)	52.7	2.6	53.6	2.4	0.9	1.7
Soft tissue thickness						
Sn-A (mm)	12.5	1.5	12.4	1.1	0.0	1.0
Ls-U1 (mm)	15.0	1.6	13.1	1.9	-1.8	1.6***
Li-L1 (mm)	12.4	1.9	14.0	1.4	1.6	2.2**
Pos-Pog (mm)	12.4	2.3	12.8	2.4	0.4	1.5
Sis-A (mm)	12.0	1.5	12.1	1.2	0.1	1.0
lls-B (mm)	11.8	1.9	12.8	2.0	1.0	2.5
<b>Lip morphology</b>						
Sn-Ls/FH (deg)	112.9	8.4	112.2	6.8	-0.7	6.3
Li-lls/FH (deg)	51.5	9.6	47.8	8.8	-3.6	9.5**
Sls-Ls (deg)	6.6	2.1	6.8	2.0	0.2	1.0
lls-Pos-Ls (deg)	1.8	1.36	2.4	1.0	0.6	0.8
Li/Pos-Ls (deg)	-3.4	1.4	-1.9	1.1	1.5	1.3*

NS = not significant; \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$



**Figure 6** A. 8 years 2 months old Chinese girl with an anterior crossbite and a skeletal Class III malocclusion. B. Patient was treated with maxillary expansion and protraction facemask. Note the positive overjet after 8 months of treatment. C. Two years post-treatment follow-up record showing changes in soft tissue profile and molar relationship. D. Four years post-treatment follow-up record showing a reverse overjet and a Class III molar relationship.

upper lip. The upper arch is usually much narrower than the lower arch, and the overjet and overbite can range from reduced to reverse. Early treatment with maxillary expansion and protraction can improve the skeletal and soft tissue facial profiles as demonstrated in this clinical study. The lip posture was improved after treatment. The normal incisal relationship (overjet) that was achieved had a significant impact on the soft tissue overlying both upper and lower incisors, resulting in improved lip competence and posture.

One of the reasons why clinicians are reluctant to perform early orthopedic treatment for Class III patients is the inability to predict mandibular growth<sup>21</sup>. The use of a single lateral cephalometric radiograph has limitation in its ability to predict excessive mandibular growth<sup>22</sup>. Prediction equations based on long-term clinical results with chincup and protraction facemask can predict successful cases with 95% confidence. However, the accuracy in predicting unsuccessful cases is only 70%<sup>23-24</sup>. We propose the use of a Growth Treatment Response Vector (GTRV) analysis to warn

clinicians of excessive mandibular growth after early orthopedic or facemask treatment. Treatment with protraction facemask in the primary or mixed dentitions can help in the correction of anterior cross bite and elimination of any centric occlusion/centric relation discrepancy to reveal the true underlying skeletal discrepancy. The facemask treatment also maximizes the growth potential of the maxilla. The follow up radiograph (2-3 years after facemask treatment) superimposed on the post-treatment radiograph provides information on patient's individual growth pattern. The horizontal growth of the maxilla and mandible can then be used to generate a GTRV ratio. Clinicians can use this information at the time of phase II treatment (early permanent dentition) to decide whether the Class III malocclusion can be camouflaged by orthodontic treatment or a surgical treatment is warranted.

In this study, the mean GTRV ratio for the successful group was found to be 0.49 with a range of 0.33 to 0.88. Class III patients with mild to moderate Class III skeletal pattern and a GTRV ratio that falls within this range can

**Table 4.** Calculated GTRV ratio of patients in the successful and unsuccessful treatment groups.

		Successful Group	Unsuccessful Group
<b>GTRV RATIO</b>	Mean	0.49	0.22
	SD	0.14	0.10
	Range	0.33-0.88	0.06-0.38

be successfully camouflaged with orthodontic treatment. The mean GTRV ratio for the unsuccessful group was 0.22 with a range of 0.06 to 0.38. Class III patients with excessive mandibular growth together with a GTRV ratio that falls below 0.38 should be warned of future need for orthognathic surgery. Clinicians should note that the sample population is derived from a mix of Chinese and Caucasian patients. It should be pointed out that the GTRV measurement reflects only the discrepancy between maxillary and mandibular growth and does not differentiate between deficient maxillary growth and excessive mandibular growth which may coexist in the patient.<sup>9</sup> In addition, GTRV is based on a number of constructed points rather than on identifiable landmarks. The measurements AO, BO can be influenced by the rotation of the maxilla and mandible<sup>26</sup>.

## Conclusions

Early treatment of Class III patients with maxillary deficiency using appliances such as protraction facemask can improve facial esthetics during the growing years. The facemask treatment can be used as a tool to predict excessive mandibular growth. A follow-up lateral cephalogram can be taken 2-3 years after completion of protraction facemask treatment to calculate the Growth Treatment Response Vector (GTRV) ratio. This ratio can help clinicians to decide whether the Class III malocclusion can be compensated by orthodontic treatment or a surgical treatment is warranted.

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