Original Article

Photogrammetric Comparison of Facial Soft Tissue Profile before and after Protraction Facemask Therapy in Class III Children (6-11 Years Old)

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KEY WORDS
Class III malocclusion;
Dental photographs;
Removable orthodontic
Appliance;

ABSTRACT

Statement of the Problem: Achieving a normal soft tissue facial profile is considered to be the main concern of class III patients and the goal of most class III treatments.

Purpose: The purpose of this study was to investigate the effects of facemask treatment on profile with photogrammetric method.

Materials and Method: Before (T0) and after (T1) treatment photograms of 40 class III patients profiles (20 male and 20 female individuals) treated with protraction face mask that met the inclusion criteria were digitized and analyzed using Aesthetic Analyzer software. Selected linear and angular measurements were performed for each patient and the changes were noted.

Results: An increase in inferior facial height ($p< 0.001$) and inferior facial angle ($p< 0.001$) was observed. Nasal prominence and upper lip prominence also increased significantly ($p< 0.001$). Advancement of sub nasal area was observed to be significant in females ($p< 0.05$) in contrast to males.

Conclusion: Remarkable advancement in the middle face and consequent fullness in the soft-tissue profile can be achieved by using protraction face mask. The response to treatment is not different between males and females.

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Introduction

Treatment of patients with class III malocclusion is considered to be one the most challenging ones in orthodontics. The prognosis of such treatments is particularly limited, especially in cases of skeletal malocclusion with genetic determinants. [1-3] A wide range of prevalence has been reported for class III malocclusion in different populations, i.e. from 1-5% in Caucasians to as high as 15% in Asian population. [4-6] In Iranian population, this prevalence seems to be between 2.1 to 7.8 %. [7-9] Class III malocclusion can be diagnosed with variety of skeletal and dental signs including maxillary retrognathism, mandibular prognathism, retruded maxillary teeth, protruded mandibular teeth, or a combination of these. [3, 10]

Traditional strategies for orthopedic correction of class III malocclusions include chin cup therapy and the protraction facemask protocol, either with or without rapid maxillary expansion. [11-12]

Two thirds of the skeletal class III malocclusions are caused to either by maxillary retrognathism or by a combination of maxillary retrognathism and mandibular prognathism. [13] Patients suffering from these two types of class III malocclusion, with maxillary retrusion, will greatly benefit from early treatment that includes maxillary protraction. [14] Class III patients whom have missed the opportunity for early growth modification have to go through their teenage years with a socially and functionally undesired malocclusion, which is shown to be the least favored of all profiles in teenagers.

[12, 15-16] Therefore, early treatment could at least provide such patients with a higher quality of life throughout the years they are most vulnerable by how they look like. [17-18]

As class III patients' profile is their main chief complaint, the main objective of an early treatment of such patients always includes facial profile correction, which leads to an improvement in psychosocial well-being and appearance of patient, especially during their teenage years. The dentoskeletal effects of maxillary protraction therapy have been extensively investigated, while studies on their effects on soft tissue profile changes are limited. [19] Just a few authors investigated the profile and soft tissue changes in response to face-mask therapy. Most of them have employed cephalometric radiography to measure both soft and hard tissues, and to relate them to facial profile changes.

Kilic *et al.* [19] investigated the soft tissue profile changes in class III patients following a course of maxillary protraction treatment. They used pre- and post-treatment cephalometric views of 24 female subjects and compared them with a control group of 15 untreated females of the same age during same period of time. Soft tissue landmarks visible on a lateral cephalogram were chosen and subsequent linear and angular measurements were analyzed. They concluded that after maxillary protraction therapy, the maxilla and its surrounding soft tissues showed significant anterior movement ($p< 0.001$), whereas the mandible and its surrounding soft tissues showed a backward and downward rotation. The improvement in facial profile predominantly resulted from changes in maxillary soft tissue and mandibular hard tissue. The concave soft tissue profiles of the class III subjects were corrected by anterior movement of the maxilla and a concomitant increase in the fullness of the upper lip. The concave skeletal profiles, however, were corrected mainly by backward and downward rotation of the mandible. [19]

Kiliçoĝlu *et al.* [20] investigated the profile changes in female patients with class III malocclusions after Delaire mask therapy. They stated that following maxillary protraction therapy the maxilla was displaced anteriorly while the mandible rotated in a clockwise pattern. Furthermore, the mandibular plane angle and anterior lower and total facial heights increased in magnitude. Dentally, they observed a retrusion in lower incisors in contrast to the significant anterior movement of the upper incisors. They concluded that the class III concave profile became more balanced, with the upper lip area becoming more marked. [20]

Evaluation of soft tissue changes following face-mask therapy has been performed previously using lateral cephalograms [19]; however, radiographic analysis for this purpose is not recommended due to variable visibility of the soft tissue and dose exposure of patients. To the best of our knowledge, the soft tissue facial profile changes caused by facemask therapy have not been quantified previously using facial photographs. [21] While some authors have suggested the evaluation of facial profile by photogrammetric method, [22-24] but there has been no research focused on photogrammetric method to evaluate and quantify the soft tissue profile changes after maxillary protraction therapy. Furthermore, because the ultimate aim of facemask therapy is the improvement of the patient’s soft tissue profile, if it can be proven that photographs can be used satisfactorily for the evaluation of treatment outcome, they can replace lateral cephalograms taken for this purpose. This substitution results in a dose reduction of x-ray to growing children. Therefore, we conducted this study to determine the improvement of the soft tissue profile after facemask treatment in male and female patients diagnosed with maxillary skeletal retrusion with the aid of photogrammetric analysis.

Materials and Method

In this retrospective study we analyzed the pre- and post-treatment profile photographs of 40 randomly chosen recently treated patients with skeletal Class III malocclusion (20 male patients and 20 female patients) who were accepted for treatment in the private practices of two senior orthodontists in the city of Shiraz, Iran. The sample size was based on similar studies in the field of maxillary growth modification. [19-20] For this purpose the total number of Class III patients whom had received face mask therapy were designated with a number and random allocation was ensured using a calculator. The age of the patients at the time of protraction facemask treatment ranged from 6 to 11 years.

Criteria for patient selection

For diagnosis of Class III malocclusion in preteen patients, factors such as the overall facial profile, chin position, maxillary position and mandibular repositioning were considered. Patients with a concave profile, a retrusive maxilla with or without mandibular protrusion that had a negative overjet as well as specific cephalometric criteria (Table 1), indicating a class III skeletal pattern, were included in the study. Patients with previous orthodontic treatment and those who were older than 11 years before the start of treatment were excluded from the study, as were patients who were non-compliant with the treatment modality. The excluded patients were replaced by the next randomly selected patient of the same gender.

Table 1: Angular and linear cephalometric criteria for patient selection

Measurements	Angular	ANB < 2º N-Pog to FH > 90º Sum of Bjork < 400º 1 to SN < 110º
	Linear	Wits Appraisal < -1mm Jarabak > 60% 1 to NA < 6mm

Appliances for class III correction

The palatal expansion appliance (to provide the attachment for facemask elastics) was constructed by retention clasps on the posterior teeth, acrylic for the palatal coverage and posterior bites, and a jack screw for midline expansion (Dentaurum; Ispringen, Germany). The appliance was activated 1 turn, twice weekly (0.25 mm per turn) by the patient him/herself for the duration of treatment as prescribed equally by the treating orthodontist. The face mask was a premade one-piece construction with adjustable anterior wire and hooks to accommodate a downward and forward pull of the maxilla with elastics (American Orthodontics; Sheboygan, Wisconsin, USA). To avoid occurence of open bite, as the maxilla was repositioned, the protraction elastics were attached near the maxillary canines with a downward and forward pull of 30° to the occlusal plane.

Maxillary protraction has been recommended with 400-500 g per side. [19] In this study, similar 8 oz elastics were used for all patients, in a similar way that delivered 350-400 g of force per side, as measured by a gauge. Patients were instructed to wear the facemask 12 hours a day to obtain an optimal skeletal effect, but with a minimal amount of tooth movement.

Photographs

The photographic set-up consisted of a tripod that held a SLR camera (Canon Eos 400D, Japan) with an external flash. The height of the camera on the tripod was adjusted according to the subject's height to ensure the correct horizontal position of the optical axis of the lens (Macro; Sigma, Japan). A 70 mm focal lens was selected in order to maintain the natural proportions.

An external flash was attached to the tripod by a lateral arm at a distance of 27 cm from the optical axis of the camera and 75 degrees from the upper right angle to avoid light spots or red-eyes in the photographs. A secondary flash, placed behind the subject. The latter's function was to light the background and eliminate undesirable shadows from the contours of the facial profile. A slave cell allowed synchronization with the main flash.

The camera was used in its manual position. The shutter speed was 1/125 per second and the opening of the diaphragm was set for f/11. Each subject was positioned on a line marked on the floor, and framed alongside a vertical scale divided in 5-cm segments. From the scale hung a plumb line held by a thick black thread that indicated the True Vertical (TV). The scale allowed measurements at life size. Small white square plastic cards 2 cm - 2 cm were placed on the forehead and on the flat surfaces of the right and left cheeks, the camera lens being perpendicular to the square. The purpose of the card was to be able to express linear measurements as centimeters rather than pixels. On the opposite side of the scale and outside the frame, there was a vertical mirror, approximately 110 cm from the subject. In order to take the records in NHP, the subjects were asked to walk a few steps before standing at rest facing the camera and near the scale. They were asked to look into their eyes in the mirror and place their arms at their side. The lips should also be relaxed, adopting the position they normally show during the day. Of course, glasses had been removed and the operator ensured that the patient's forehead, neck, and ears were clearly visible during the recording.

Digitalization

The photographic records were saved in TIFF image format. After transfer of the images into the software, the desired landmarks were identified by an orthodontist on each photograph in the Aesthetic Analyzer software. The program was customized with the landmarks that were used in this investigation in order to perform the

Table 2: The landmarks and their respective definitions.

Landmark	Definition
Trichion (Tri)	The sagittal midpoint of the forehead that borders the hairline
Glabella (G)	The most anterior point of the middle line of the forehead
Nasion (N)	The point in the middle line located at the nasal root
Pronasal (Prn)	The most prominent point of the tip of the nose
Columella (Cm)	The most inferior and anterior point of the nose
Subnasal (Sn)	The point where the upper lip joins the columella
Labial superior (Ls)	The point that indicates the mucocutaneous limit of the upper lip
Stomion superior (Sts)	The most inferior point of the upper lip
Stomion inferior (Sti)	The most superior point of the lower lip
Labial inferior (Li)	The point that indicates the mucocutaneous limit of the lower lip
Supramental (Sm)	The deepest point of the inferior sublabial concavity
Pogonion (Pg)	The most anterior point of the chin
Menton (Me)	The most inferior point of the inferior edge of the chin
Tragus (Trg)	The most posterior point of the auricular tragus
Alar (Al)	The most lateral point of the alar contour of the nose
sTV	Superior point of the TV
iTV	Inferior point of the TV
Ort	The point joining the TV and the TH

required measurements. The aforementioned software has been developed by the author of the present study and its validity and reliability proven previously. [25] The validity and reliability of software measurements has been shown in existing literature. [26]

Photographic analysis

For each patient, the first profile photograph was taken before the initiation of facemask treatment (T0). A second photograph was taken 6 months after protraction facemask treatment (T1). This way, (T1−T0) represented the effects of appliance therapy and each patient served as his/her own control (T0-T0). For the purpose of this study, a computerized photogrammetric appraisal was used. This software incorporates variables from different well-known cephalometric analyses. Our analysis was based on a reference system consisting of true horizontal (THP) and true vertical (TVP) planes. The profile photogrammetric analysis included 18 soft tissue landmarks; by using these landmarks the desired linear and angular variables were measured.

Landmarks and measurements

The landmarks that were used in digitization and soft tissue linear and angular measurements are summarized in Table 2 (Figure 1).

The following reference lines were used:

- TV, sTV-iTV (inferior and superior points on plumb line)
- TV in N (N-Ort), parallel to TV through N
- TH, Trg-Ort, perpendicular to TV through Trg

The following vertical linear measurements (parallel to TV) were used:

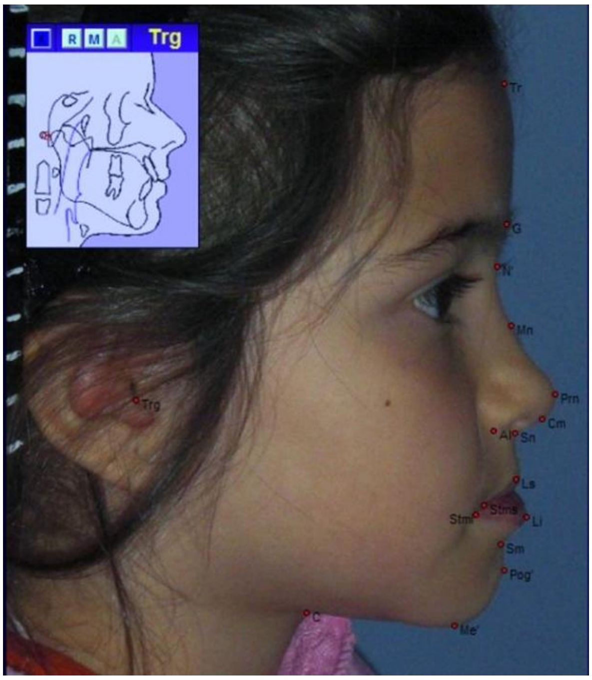

Figure 1: The landmarks used for photogrammetric analysis.

- 1.Superior facial third, Tri-G
- 2.Middle facial third, G-Sn
- 3.Inferior facial third, Sn-Me
- 4.Nasal length, N-Sn
- 5.Length of upper lip, Sn-Sts
- 6.Interlabial gap, Sts-Sti
- 7.Length of lower lip, Sti-Sm
- 8.Vermilion of upper lip, Ls-Sts
- 9.Vermilion of lower lip, Li-Sti
- 10.Height of chin, Sm-Me
- 11.Height of nasal tip, Sn-Prn

The following linear horizontal measurements (parallel

Table 3: Minimum, maximum, mean and standard deviations of pre-treatment measurements in each gender

Landmark	Pre-treatment Male (n= 20)				Pre-treatment Female (n= 20)			
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD
1 SFT	39.10	48.71	43.51	3.22	45.850	59.38	52.25	5.24
2 MFT	51.81	69.73	61.96	6.07	51.26	70.95	58.18	7.06
3 IFT	46.49	78.93	60.18	11.63	53.71	64.44	57.21	4.07
4 NL	40.19	54.12	46.80	4.54	15.56	51.50	37.36	12.27
5 LUL	14.09	27.29	19.56	5.27	11.71	20.06	17.44	3.01
6 IG	1.49	3.72	2.86	.95	.93	2.87	2.05	.76
7 ILL	8.77	21.81	13.59	4.54	8.11	39.85	17.54	11.63
8 VUL	2.72	8.40	4.78	2.03	2.08	5.55	4.35	1.29
9 VLL	.54	6.68	3.69	2.64	.46	4.09	1.49	1.36
10 HC	19.49	28.93	24.18	3.15	18.86	30.44	23.24	4.05
11 HNT	9.20	13.12	10.92	1.53	6.94	13.50	10.44	2.28
12 FD	95.93	123.61	107.33	9.39	90.78	122.10	102.06	11.46
13 ND	19.17	27.53	22.37	3.00	17.86	23.22	20.20	2.14
14 NP	13.77	19.17	16.44	1.85	-1.22	17.43	11.78	6.92
15 SD	-.39	7.59	2.61	2.77	-2.32	9.53	3.86	4.04
16 MD	-14.75	-1.37	-6.68	4.51	-11.95	2.82	-5.71	5.25
17 PUL	-5.84	5.13	.29	4.28	-3.79	6.76	1.21	3.78
18 PLL	-5.06	4.92	1.29	3.53	-5.21	10.69	1.08	5.60
19 PC	-13.98	-1.32	-6.75	4.20	-13.39	3.37	-5.58	6.12
20 CNP	7.64	12.61	11.08	1.84	8.73	11.61	10.15	1.00
21 CPUL	-.99	5.78	2.04	2.28	1.03	3.83	2.93	1.02
22 CPLL	3.06	7.85	5.31	1.57	1.94	7.80	4.41	2.10
23 CPP	.41	4.47	2.45	1.38	.08	4.08	1.95	1.51
24 NFA	134.19	166.93	150.42	11.01	135.21	160.98	148.23	9.84
25 VNA	20.20	30.04	25.08	3.29	17.86	30.32	24.09	4.96
26 NLA	99.85	142.49	124.06	14.54	111.41	120.47	115.49	3.13
27 MLA	134.05	150.71	142.51	7.45	132.58	161.71	147.02	11.81
28 NA	83.44	99.81	91.51	6.24	83.86	98.25	89.71	4.88
29 AND	178.38	186.98	182.99	3.74	170.65	183.53	177.06	5.61
30 CMA	83.18	89.20	86.94	2.24	84.87	98.00	92.51	4.56
31 AMFT	23.55	26.61	24.91	1.11	21.22	24.22	23.03	1.13
32 AIFT	28.06	38.37	34.72	3.96	30.88	36.52	33.23	1.89
33 AHP	72.65	78.91	75.40	2.51	71.83	83.54	76.94	3.99
34 AFC	160.57	172.91	166.97	4.06	164.27	174.02	169.90	3.68
35 ATFC	137.17	146.19	140.67	3.30	136.04	149.20	143.64	5.35

to TH) were used:

- 12.Facial depth, Trg-Sn
- 13.Nasal depth, Al-Prn
- 14.Nasal prominence, Prn to N-Ort line
- 15.Subnasal depth, Sn to N-Ort line
- 16.Mentolabial depth, Sm to N-Ort line
- 17.Prominence of upper lip, Ls to N-Ort line
- 18.Prominence of lower lip, Li to N-Ort line
- 19.Prominence of chin, Pg to N-Ort line

Angular measurements of the analysis (clockwise) included:

- 20.CNP, canuts nasal prominence;
- 21.CPUL, canuts prominence of the upper lip;
- 22.CPLL, canuts prominence of the lower lip;
- 23.CPP, canuts prominence of the pogonion;
- 24.N–G–Prn, nasofrontal angle;
- 25.N–Prn/N–Ort, vertical nasal angle;
- 26.Cm–Sn–Ls, nasolabial angle;
- 27.Li–Sm–Pg, mentolabial angle;
- 28.Sn–Cm/N–Prn, nasal angle;
- 29.N–Mn–Prn, angle of the nasal dorsum;
- 30.G–Pg/C–Me, cervicomental angle;
- 31.N–Trg–Sn, angle of the medium facial third;
- 32.Sn–Trg–Me, angle of the inferior facial third;
- 33.Trg–Ort/Sn–Sm, angle of the head position;
- 34.Angle of facial concavity;
- 35.Angle of total facial concavity;

Statistical analysis

Descriptive indices such as mean and frequency were used to summarize the data. A paired t-test was employed to compare average of landmarks before and after intervention. We also used a student t-test to compare changes in landmarks between two genders.

Results

Descriptive statistics, including mean, maximum, minimum, and standard deviations for pre-treatment photogrammetric linear and angular measurements are shown

Table 4: Minimum, maximum, mean and standard deviations of post-treatment measurements in each gender

Landmark	Post-treatment Male (n= 20)				Post-treatment Female (n= 20)			
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD
1 SFT	38.07	51.00	44.96	5.00	43.83	59.85	53.13	5.55
2 MFT	50.72	62.48	58.68	4.37	48.72	61.78	56.21	5.61
3 IFT	44.11	75.04	57.20	10.24	51.58	70.66	60.85	6.34
4 NL	38.72	51.47	43.88	4.45	18.43	47.78	36.07	10.26
5 LUL	14.12	27.17	19.72	4.41	9.54	22.82	18.50	4.78
6 IG	.43	2.21	1.32	.59	.61	5.29	2.69	1.58
7 ILL	8.91	17.32	12.71	3.23	8.12	40.11	18.09	11.85
8 VUL	2.91	6.16	4.60	1.11	5.82	7.72	6.85	.63
9 VLL	.74	4.58	2.53	1.26	.14	5.59	1.98	2.05
10 HC	18.11	28.54	23.15	3.80	21.94	27.66	24.51	2.25
11 HNT	9.73	13.48	11.56	1.42	5.43	14.78	9.87	3.12
12 FD	94.81	119.68	104.45	8.55	91.16	116.22	102.05	8.31
13 ND	16.81	28.31	20.95	3.99	16.69	24.21	19.95	2.64
14 NP	13.05	22.44	17.34	3.30	-.30	17.69	12.84	6.85
15 SD	-2.37	12.42	3.72	5.12	-.60	11.44	5.80	4.32
16 MD	-20.97	.84	-6.55	8.15	-12.99	5.19	-7.07	7.05
17 PUL	-6.37	9.92	2.69	5.74	1.18	11.13	5.20	3.47
18 PLL	-11.90	8.31	1.19	7.53	-1.67	12.33	3.04	4.97
19 PC	-20.47	.80	-6.42	7.92	-14.32	3.38	-6.97	6.83
20 CNP	5.64	13.17	10.15	2.54	4.31	11.83	8.76	2.71
21 CPUL	3.08	5.00	4.23	.73	4.78	7.18	5.68	.92
22 CPLL	3.18	6.43	4.72	1.27	4.06	6.72	5.72	1.12
23 CPP	1.30	5.13	2.92	1.36	-.62	6.09	3.43	2.26
24 NFA	136.53	173.46	151.03	13.72	135.59	161.18	148.03	10.79
25 VNA	21.29	34.70	28.20	4.99	19.28	37.57	27.17	6.55
26 NLA	96.08	140.28	116.85	15.42	92.80	122.85	104.99	10.41
27 MLA	122.47	153.12	140.92	10.77	128.70	161.57	141.42	11.67
28 NA	74.38	97.82	87.35	8.35	72.81	99.46	82.07	9.56
29 AND	170.55	187.33	180.28	5.63	163.81	184.74	176.70	7.83
30 CMA	85.97	93.41	90.01	2.76	82.98	106.59	95.37	8.82
31 AMFT	22.91	26.11	24.24	1.20	20.06	23.76	22.38	1.70
32 AIFT	29.05	39.64	34.23	3.46	33.91	40.57	37.67	2.90
33 AHP	67.87	81.59	73.57	5.07	67.01	83.29	73.70	6.45
34 AFC	149.05	171.64	163.94	8.22	157.31	171.14	163.88	4.60
35 ATFC	129.68	145.07	136.96	5.37	135.26	144.56	139.73	3.11

in Table 3. Post-treatment results are shown in Table 4. The paired t-test analysis showed that there was statistically significant difference between mean pre-treatment and post treatment values of SFT, MFT, IFT, NL, VUL, FD, ND, NP, SD, PUL, CNP, CPUL, CPP, VNA, NLA, NA, CMA, AMFT, AIFT, AHP and AFC ($p< 0.05$) (Table 5). There was a significant increase in lower facial third length of the patients; however, the angle of inferior facial third increased in total. Nasal prominence, prominence of upper lip increased in both genders and in total, but the prominence of lower lip was not changed significantly. Subnasal area moved forward in the female group while changes in the male group were not significant. Mean changes and *p* values of landmarks in each gender are shown in Table 5.

Discussion

The soft tissue facial profile has been considered by patients and orthodontists as an important factor to seek orthodontic treatment, especially in patients with a concave facial profile and Class III malocclusion. [20] The main focus of this study was to determine the changes in soft tissue angular and linear measurements in profiles of those undergoing protraction facemask treatments and to compare these changes between the two genders. The objectives of this study were achieved through photogrammetric method, which is accepted globally as a gold standard method for such studies. [25-27]

In this study, we used the standardized photogrammetric records that were taken in NHP before and after treatment. Malcok *et al.* [28] described that NHP presents individuals as they appear in real life. Consequently, lateral profile photographs recorded routinely in NHP would be more clinically meaningful. NHP has been celebrated as the best position to study profile by many researchers. [22, 29-32]

Several facial analysis systems and landmarks have been introduced. [22, 29-30, 33-37] Most of these

Table 5: Mean differences and *p* values of each landmark

Landmark	Female (n= 20)		Male (n= 20)		Total (n=40)	
	Mean difference	*p* value	Mean difference	*p* value	Mean difference	*p* value
1 SFT	-.88200	.068	-1.456000	.147	-1.16900	.033
2 MFT	1.97800	.189	3.28200	.000	2.63000	.003
3 IFT	-3.64200	.000	-2.98000	.004	-3.3110	.000
4 NL	1.29400	.159	2.92400	.000	2.10900	.000
5 LUL	-1.06200	.018	-.15200	.771	-.60700	.076
6 IG	-.63800	.035	1.53600	.000	.44900	.108
7 ILL	-.55800	.362	.88400	.260	.16300	.742
8 VUL	-2.49400	.000	.18200	.542	-1.15600	.001
9 VLL	-.48600	.097	1.15400	.076	.33400	.357
10 HC	-1.27000	.066	1.02600	.003	-.12200	.762
11 HNT	.57000	.024	-.64000	.010	-.03500	.852
12 FD	.01200	.991	2.87200	.000	1.44200	.026
13 ND	.25600	.650	1.41600	.000	.83600	.015
14 NP	-1.05800	.000	-.89600	.014	-.97700	.000
15 SD	-1.93600	.000	-1.10600	.053	-1.52100	.000
16 MD	1.35200	.080	-.12800	.899	.61200	.329
17 PUL	-3.98600	.000	-2.40800	.000	-3.19700	.000
18 PLL	-1.96000	.001	.09200	.921	-.93400	.093
19 PC	1.38400	.195	-.32600	.751	.52900	.470
20 CNP	1.38800	.040	1.21400	.005	1.30100	.001
21 CPUL	-2.74800	.000	-2.05100	.000	-2.39950	.000
22 CPLL	-1.31200	.002	.59000	.010	-.36100	.163
23 CPP	-1.48200	.004	-.45900	.000	-.97050	.000
24 NFA	.19800	.698	.03850	.984	.11825	.905
25 VNA	-3.08000	.000	-2.89300	.000	-2.98650	.000
26 NLA	10.50200	.000	7.09550	.000	8.79875	.000
27 MLA	5.60600	.286	1.76700	.194	3.68650	.167
28 NA	7.63800	.000	4.06450	.000	5.85125	.000
29 AND	.35600	.640	2.41150	.213	1.38375	.178
30 CMA	-2.85800	.025	-2.73300	.000	-2.79550	.000
31 AMFT	.65400	.013	.64900	.000	.65150	.000
32 AIFT	-4.43800	.000	.51900	.297	-1.95950	.001
33 AHP	3.24600	.001	1.75650	.031	2.50125	.000
34 AFC	6.01600	.000	2.45200	.026	4.23400	.000
35 ATFC	3.91000	.000	3.33150	.001	3.62075	.000

systems however; except for those that are photographically based, require expensive equipment and complex procedures and provide data that are difficult to evaluate mathematically. [38] The ultimate compensator of facial contour relationships are the soft tissues, and most plastic surgeons concerned with total facial aesthetics work primarily from photographs or patients themselves, not roentgenograms. [39]

There is no argument about the reliability of lateral cephalometric analysis; however, a desirable skeletal pattern does not imply desirable facial aesthetics, nor does an undesirable skeletal pattern imply undesirable facial aesthetics. [39] Many orthodontists carry out soft tissue analysis mainly in a subconscious and unstructured manner. However in the present study, soft tissue facial analysis is presented as a necessary procedure in order to facilitate orthodontists to carry out more quantitative evaluation and make disciplined decisions.

Photogrammetric analysis offers many advantages using human profile analysis. First, with photogrammetric analysis, linear measurements are not affected by enlargement as happens in cephalometric views. [28] Thus, the technique can be used clinically for both pretreatment planning and evaluation of a patient's postoperative results. Second, every profile point can be moved freely on a computer monitor using the cephalometric software program or a photogrammetric analyzer to determine the most appropriate profile points. Third, angular photogrammetric profile analysis does not require expensive equipment and complex procedures, and it offers digitized results that can be easily evaluated. Furthermore, the collected data can be arranged in unified charts.

The results of the current study presents that facemask therapy induced a forward and upward rotation of maxilla. Forward movement of the basal maxilla, upper lip and nose also occurred. The findings of the present study are almost in agreement with those of

Arman *et al.* [40-41] who investigated the effects of MP with RME in growing children (mean age 11 years and 6 months). Kilic *et al.* [19] also investigated the soft tissue profile changes after maxillary protraction and found that the maxilla and surrounding soft tissues showed significant anterior movement.

Due to some previous studies we know that the center of resistance of the maxilla is between the root apices of first and second premolars, [42] so protraction forces at the level of the occlusal plane produces upward and forward rotation of maxilla. [43] It is also shown that with facemask therapy, significant posterior rotation of palatal plane and extrusion of posterior teeth occurs which induces a downward and backward movement of the mandible and surrounding soft tissues (lower lip and soft tissue pogonion). [20, 40-41, 44-46] In this study, the angle of inferior facial third increased significantly and the height of inferior facial third increased, which produces clockwise rotation of mandible and a more vertical growth pattern looking profile. These results were compatible with the results of previous studies. [19-20, 47]

Protrusion of the upper lip, which is related to the increased inclination of the maxillary incisors, was observed in the present study in both genders. This somehow compensates the concave profile of class III patients, and corrects the incisor relationship; especially in patients with reverse overjet. Kiliçoĝlu and Kirlic [20] and Kim *et al.* [48] also observed a protrusion in maxillary incisors after protraction facemask therapy in class III patients.

In the current study, the position of lower lip was not changed significantly. However, some previous studies, such as the studies enrolled by Merwin *et al.* [1] and Kiliçoĝlu and Kirlic [20] showed a more retruded lower lip after facemask therapy. Their observations were most probably due to a decrease in mandibular incisors angle with mandibular plan (IMPA).

No specific statistically significant difference was found in how the two genders would respond to the treatment, in terms of linear and angular soft tissue variables. However, a well-controlled prospective study with larger sample size might be needed to evaluate the differences between males and females properly.

There are some known limitations for to the photogrammetric method that some of them cannot be eliminated. For example alterations in lighting intensity and/or direction produce unwanted variation in the measurements between two photographs taken from a single person. Another limitation is the head posturing. In normal cephalograms, the use of head or nose rests together with the ear rods produces a well-controlled head position; however, in photograms head positioning is not controlled very well. [26] There are also limitations that can significantly influence measurements obtained from facial photographs. These factors are known as “subject posturing” and “differential magnification". Subject posturing greatly influences the measurements obtained from frontal photographs that were no used in this study, but differential magnification is due the fact that objects closer to the camera lens tend to be larger in photograms. Such errors would most likely affect some of the measurements on frontal photographs. Since most landmarks on the lateral photographs are at the midline, this problem should minimally affect these measurements. [26] Furthermore, the present study does not include a class III untreated control group and therefore, fails to take in to account the effect independent facial changes associated with normal growth in class III patients. Such a draw back significantly affects the results obtained from this study and any other evaluation of appliances used for skeletal growth modification. The reason that this limitation could not be addressed is the ethical issues involved with deciding not to treat diagnosed patients. Another limitation of this study is the control of patient compliance with the face mask treatment. While an effort was made to exclude patients with records of non-compliance with the treatment, such records were mainly due to reports by the parents of the patients or the patients themselve which may not be totally reliable. While the monitoring of patient compliance is favorable, we could not find any studies focusing on this issue.

Conclusion

A significant increase in the length of the lower facial third and in the angle of inferior facial third was observed. The prominence of the upper lip increased while the prominence of the lower lip did not demonstrate a significant change. Apart from the forward movement of the subnasal area which was only significant in females, the responses to treatment were similar in both genders.

Conflict of Interest

None to declare.

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