Original Article

Profile Changes Associated with Different Orthopedic Treatment Approaches in Class III Malocclusions

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Abstract: The aim of this study was to evaluate and compare the soft tissue effects of chincup (CC), chincup plus bite plate (CC+P), and reverse headgear (RHg) therapies with each other and with an untreated control group (C). The material consisted of lateral cephalometric and hand-wrist films of 59 Class III cases and 20 nontreated control subjects. Thirty-one cases were treated with CC, 14 with CC+P, and 14 with RHg, and Class I relation was achieved. The mean pretreatment ages were approximately 11 years and the observation period was one year. The cephalometric films were analyzed according to the structural superimposition method of Björk. All tracings were double digitized, and the measurements were calculated by a computer program (PORDIOS). Treatment and control changes within the groups and the differences between the groups were analyzed statistically. Forward positioning of the maxilla was significant in the RHg group, whereas the mandible was positioned backward significantly in all the treatment groups. Posterior rotation of the mandible was significant in the CC+P and RHg groups. The overjet increased and the overbite decreased significantly in all the treatment groups. Forward movement of soft tissue A and upper lip was significant in all groups, whereas more pronounced in the CC+P group. The soft tissue changes in the mandibular region were significant in the CC and CC+P groups, whereas in the maxillary region more significant and similar improvements were obtained by CC+P and RHg treatments. Long-term studies are required to confirm the stability of these changes. (*Angle Orthod* 2004;74:733–740.)

Key Words: Class III; Chincup; Reverse headgear; Maxillary protraction; Soft tissue profile

INTRODUCTION

The final goal of any orthodontic treatment should be not only to obtain good function but also to improve facial attractiveness. The main focus of concern for the Class III patient, presenting a concave facial profile, a retrusive nasomaxillary area, and a protrusive lower face and lip, may be the profile rather than the occlusion. However, achieving a harmonious soft tissue profile is sometimes difficult because a Class III malocclusion is one of the most challenging problems confronting the orthodontist.

The Class III malocclusion can exhibit a variety of skeletal and dental components including a large or protrusive mandible, deficient or retrusive maxilla, protrusive mandibular dentition, retrusive maxillary dentition, and combinations of these components.[1–4] Although most Class III patients have excess mandibular development, there is some degree of maxillary deficiency (30–40%), enough to make the maxilla a significant part of the problem.[1–5]

Early treatment is commonly indicated for Class III individuals because if left untreated they will ultimately comprise a substantial percentage of patients seeking orthognathic surgery as adults. Therapeutic regimes designed to influence the facial morphology during the growth period include functional approaches,[4,6–8] chincup therapy,[9–23] extraoral traction to the mandibular dentition,[24–26] reverse headgears, or facemasks.[27–42]

The skeletal and dentoalveolar effects of various orthopedic approaches used in Class III malocclusions have been reported extensively, whereas available literature comparing the soft tissue responses to treatment[6,25,31,36,43] and comparison of effects of different treatment applications is limited.[7,20,26] The purpose of this study was to evaluate the treatment effects of chincup, chincup plus removable bite plate, and reverse headgear therapies on the soft tissue profiles of

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TABLE 1. Chronological Age Distribution and Duration of Observation Period (y)

	CC[a] (Mean ± SEM)	CC+P (Mean ± SEM)	RHg (Mean ± SEM)	C (Mean ± SEM)	*F*-test
Beginning of treatment-control	11.0 ± 0.24	11.1 ± 0.49	11.6 ± 0.61	10.5 ± 0.24	NS
Duration of treatment-control	1.0 ± 0.15	1.2 ± 0.15	0.9 ± 0.09	1.0 ± 0.09	NS

[a] CC indicates chincup; CC+P, chincup + bite plate; RHg, reverse headgear; C, control; and NS, not significant.

subjects having Class III skeletal malocclusion and to compare the changes in the three groups with each other and with an untreated control group.

MATERIALS AND METHODS

The material consisted of lateral cephalometric and hand-wrist films of 59 patients treated at the Department of Orthodontics, Faculty of Dentistry, Ankara University, and of 20 nontreated control subjects from a previously collected longitudinal growth study. The first radiographs (T1) were taken before appliance delivery, and the second radiographs (T2) were taken after achieving a positive overjet or Class I occlusion (or both) but before second-phase fixed appliance treatment. The records included in the treatment groups were selected retrospectively. All had skeletal Class III malocclusions, reversed overjet, and normal or increased overbite values at the beginning of the treatment period. The control subjects were matched according to skeletal maturation stage and chronological ages and displayed Class I or Class III skeletal relationships with positive overbite values. The mean ages at the beginning (T1) and treatment-control periods are shown in Table 1. To evaluate the maturational stage, hand-wrist radiographs were used. All the treatment and control subjects were between PP_2 and MP_{3cap} developmental stages[44] at the beginning of the treatment-control period.

The first treatment group of 31 patients (22 girls, nine boys) was successfully treated with only chincup (CC) applied to the mandible with a force of 500 g. The direction of the applied force was toward the condylar head of the mandible.

The second group of 14 patients (six girls, eight boys) was treated with a chincup and removable bite plate appliance (CC+P). The intraoral appliances were applied to the upper arch in 10 patients and to the lower arch in 4 patients. The posterior bite plates were prepared at a minimum thickness sufficient to open the bite to an edge to edge incisal position. After placement of the appliance, maximum cusp contacts were attained by occlusal adaptation. Finger springs or screws were incorporated to five of the maxillary appliances for protrusion, slow maxillary expansion, or minor dental corrections.

The third group of 14 patients (11 girls, three boys) received maxillary protraction therapy through a reverse headgear (RHG) applied with rapid maxillary expansion appliances. Delaire or Petit-type face masks were used. The protraction elastics were attached near the maxillary canines and a force of 400–600 g per side was applied. All patients were instructed to wear their chincups and facemasks at least 14 hours per day.

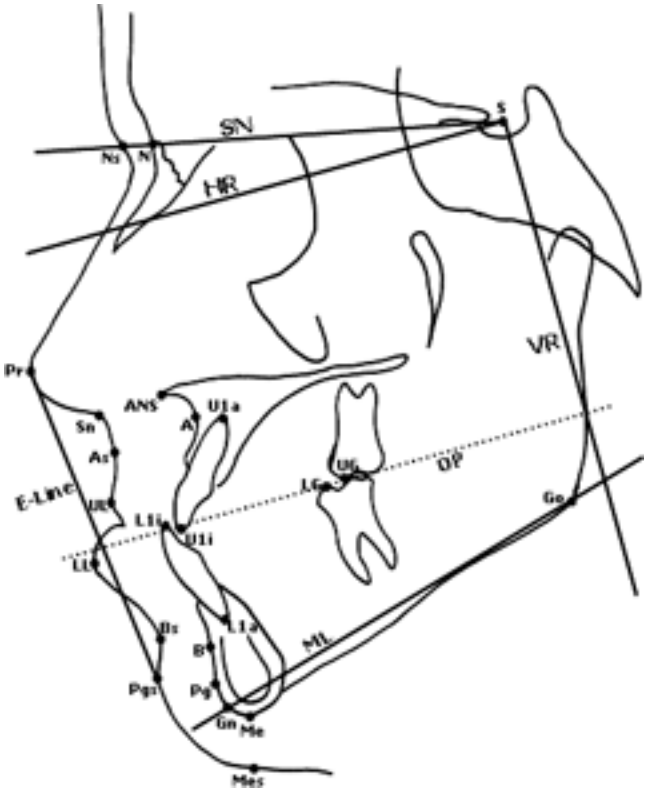

FIGURE 1. Reference landmarks and reference planes used in the study. VR: vertical reference plane constructed perpendicular to the occlusal plane (OP) of the first tracing (T1) from point sella (S) of T1. HR: horizontal reference plane drawn perpendicular to VR from sella point (S) and parallel to OP of T1. SN: sella (S)-nasion (S) line. OP: occlusal plane. ML: mandibular plane constructed between gonion (Go) and gnathion (Gn) points. E-line (E): Ricketts' esthetic line constructed between Pr and Pgs.

Cephalometric analysis

The cephalometric radiographs were obtained with the lips in a habitual posture at a film-focus distance of 155 cm with a midsagittal plane to film distance of 12.5 cm. The cephalograms were traced and the reference points (Figure 1) were marked simultaneously on the two films of each subject to be able to obtain maximal agreement in the marking. The cephalometric films were superimposed according to the structural method of Björk.[45] The second film (T2) was superimposed on the first one oriented to obtain max-

imal coincidence for (1) the contours of the anterior wall of sella turcica, (2) the anterior contours of the median cranial fossa, (3) the intersection of the anterior contour of sella and tuberculum sella, (4) the inner surface of the frontal bone, (5) the contours of the ciribriform plate, (6) the contours of the bilateral frontoethmoidal crests, and (7) the contour of the median border of the cerebral surfaces of the orbital roofs. Control of the superimposition was made by checking the changes of the frontoparietal suture, occipital bone, and points articulare and pterygomaxillare.[45]

The horizontal (HR) and vertical reference planes (VR) were transferred from the first tracings (T1) to the second (T2) according to the superimposition. The VR was constructed perpendicular to the occlusal plane (OP) of the first tracing from point sella (S_1) of the first tracing (T1), and the HR was drawn perpendicular to VR from sella point (S_1) and parallel to the OP of the first tracing (Figure 1). Using these reference planes, the projective distances of the reference landmarks were measured. The ± coordinates of the reference landmarks were recorded using a Houston Hipad Digitiser of 0.125 mm resolution with a double-digitizing procedure. The PorDios (Purpose on request Digitizer input-output system, Institute of Orthodontic Computer Science, Arhus, Denmark) cephalometric analysis program was used, and no corrections were made for the standard magnification.

Statistical method

The data were examined by multivarious statistical analysis. Paired *t*-tests were performed to analyze the changes that occurred during the treatment-control periods. Analysis of variance and Duncan tests were used for comparison of cephalometric measurements at the beginning of treatment-control period and the changes due to treatment or normal growth in the three treatment and control groups.

Method error

Landmark identification, superimposition, and digitization procedures were repeated for 20 subjects by the same investigator one month after first measurements. Intraclass correlation coefficients were performed to assess the reliability of the cephalometric measurements. The reliability of measurements was found to be within 0.90–0.99, and the method was found to yield sufficient reliability.

RESULTS

The craniofacial morphology of all subjects and the statistical evaluation of intergroup differences at the beginning of the treatment-control period (T1) are given in Table 2. Table 3 shows the changes in all measurements, statistical analysis of intra- and intergroup differences in all study groups from T1 to T2.

Skeletal measurements

Mandibular prognathism (SNB), sagittal intermaxillary relationship (ANB, (A-VR)-(B-VR)), and the facial convexity angle (NAPg) were significantly different in the treatment groups compared with the control group at T1 ($P < .001$) (Table 2). The ANB angle and Witts measurement ((A-VR)-(B-VR)) also was significantly different between the CC and RHG groups ($P < .001$).

Significant skeletal changes were seen with all treatment approaches (Table 3). Protraction of the maxilla (SNA) was significantly larger in the RHg group ($P < .01$), whereas the mandible was positioned backward significantly in all treatment groups (SNB). The ANB angle and Witts appraisal increased significantly with a concomitant increase in the facial convexity angle (NAPg) in all treatment groups ($P < .001$). The anterior and posterior facial heights increased significantly in all groups; however, the increase in total anterior face height (N-Me) was more pronounced in the CC+P and RHg groups ($P < .05$). Posterior rotation of the mandible (ML.SN) was significant in the CC+P and RHg groups ($P < .05$), whereas no significant difference was noted among the study groups.

Dental measurements

The overjet value, vertical position of the upper incisors (U1i-HR) and lower incisors (L1i-HR), inclination of lower incisors (L1.HR), and interincisal angle (U1.L1) demonstrated significant differences among groups at T1 (Table 2).

The overjet increased ($P < .001$) and overbite decreased significantly by means of all treatment approaches (Table 3). When compared with the control group, the change in overjet was significantly different in all treatment groups, whereas the decrease in overbite was significantly different in CC+P and RHg groups. The maxillary incisors showed significant protrusion (U1i-VR) in all study groups, whereas extrusion of upper incisors (U1i-HR) was significant in the control group ($P < .001$). The maxillary incisal angulation (U1.HR) increased significantly, representing proclination in all treatment groups. The mandibular incisors, on the other hand, were significantly retruded in all treatment groups, whereas significant protrusion was noticed in the control group (L1i-VR). The retroclination of the lower incisors was significant in the CC and RHg groups (L1.HR), and vertical movement of lower incisors was significant in all groups (L1i-HR).

Soft tissue measurements

The upper lip E-line distance, sagittal lip relationship (UL-VR)-(LL-VR), vertical position of soft tissue A (As-HR), soft tissue convexity angle (Ns.Sn.Pgs), and upper lip thickness measurements presented significant intergroup differences at the beginning of the treatment-control period (T1) (Table 2).

TABLE 2. Mean Values of Measurements at the Beginning of the Treatment-Control Period and Comparison of Groups With ANOVA and Duncan Tests[a]

Parameter	CC (1) (Mean ± SEM)	CC+P (2) (Mean ± SEM)	RHg (3) (Mean ± SEM)	C (4) (Mean ± SEM)	*F*-test	1-2	1-3	1-4	2-3	2-4	3-4
Skeletal measurements (sagittal)											
SNA (°)	78.0 ± 0.49	78.4 ± 1.12	76.6 ± 0.79	78.4 ± 0.83							
SNB (°)	79.4 ± 0.54	80.8 ± 0.95	80.3 ± 0.77	76.3 ± 0.84	***			***		***	***
ANB (°)	−1.3 ± 0.34	−2.4 ± 0.42	−3.7 ± 0.71	2.2 ± 0.45	***		***	***		***	***
(A-VR)-(B-VR)	−7.4 ± 0.55	−8.0 ± 0.39	−10.7 ± 0.83	−2.3 ± 0.51	***		***	***		***	***
NAPg (°)	−3.4 ± 0.89	−6.0 ± 1.16	−9.1 ± 1.81	3.2 ± 1.06	***			***		***	***
Skeletal measurements (vertical)											
N-Me	113.1 ± 1.20	114.2 ± 2.29	119.7 ± 2.66	115.1 ± 1.44							
ANS-Me	63.2 ± 1.12	62.3 ± 1.62	67.2 ± 1.84	64.5 ± 1.21							
S-Go	70.4 ± 0.76	70.6 ± 1.72	73.3 ± 1.73	71.4 ± 1.23							
ML.SN (°)	33.8 ± 1.00	33.7 ± 1.12	35.9 ± 1.21	34.7 ± 1.27							
Dental measurements (sagittal + vertical)											
Overjet	−2.0 ± 0.25	−3.1 ± 0.28	−3.2 ± 0.52	2.1 ± 0.45	***			***		***	***
Overbite	2.2 ± 0.43	3.7 ± 0.73	1.5 ± 0.72	2.1 ± 0.44							
U1i-VR	77.5 ± 0.84	77.6 ± 1.56	76.1 ± 1.05	79.7 ± 0.99							
U1i-HR	54.1 ± 0.79	57.4 ± 1.55	58.4 ± 1.62	53.6 ± 1.39	**		**				**
U1.HR (°)	119.9 ± 1.06	121.0 ± 1.43	119.6 ± 0.99	120.4 ± 1.12							
L1i-VR	79.5 ± 0.84	80.7 ± 1.56	79.3 ± 0.96	77.7 ± 0.92							
L1i-HR	51.9 ± 0.69	53.7 ± 1.85	56.9 ± 1.73	51.5 ± 1.35	**		**				**
L1.HR (°)	75.4 ± 1.30	74.0 ± 1.06	80.1 ± 2.16	71.4 ± 1.14	***		***		***		***
U1.L1 (°)	135.5 ± 1.65	133.0 ± 2.33	140.5 ± 2.31	131.0 ± 1.73	*						*
Soft tissue measurements (sagittal)											
As-VR	86.7 ± 0.72	87.1 ± 1.42	86.0 ± 1.00	88.0 ± 0.97							
UL-VR	91.0 ± 0.87	90.7 ± 1.40	89.6 ± 1.03	90.8 ± 0.97							
UL-(E)	−3.6 ± 0.38	−5.4 ± 0.63	−6.8 ± 0.73	−3.0 ± 0.44	***	***	***			***	
LL-VR	93.6 ± 0.99	94.6 ± 1.64	93.5 ± 1.09	91.4 ± 1.00							
LL-(E)	0.2 ± 0.38	−0.1 ± 0.70	−1.9 ± 0.84	−0.7 ± 0.50							
Bs-VR	89.0 ± 1.02	89.5 ± 1.44	90.2 ± 1.34	86.3 ± 0.89							
Pgs-VR	91.5 ± 1.09	92.2 ± 1.53	93.7 ± 1.55	88.7 ± 0.95							
(UL-VR)-(LL-VR)	−2.6 ± 0.27	−3.9 ± 0.40	−4.0 ± 0.33	−0.5 ± 0.33	***	***	***	***		***	***
Soft tissue measurements (vertical)											
As-HR	36.0 ± 0.68	40.5 ± 1.51	40.5 ± 1.36	36.1 ± 1.61	**	**	**			**	**
UL-HR	43.8 ± 0.66	47.4 ± 1.79	47.2 ± 1.56	43.5 ± 1.63							
LL-HR	56.6 ± 0.83	59.5 ± 2.01	59.7 ± 1.79	55.2 ± 1.74							
Bs-HR	68.1 ± 0.96	72.6 ± 2.37	71.6 ± 2.14	67.1 ± 1.85							
Pgs-HR	78.6 ± 1.01	81.3 ± 2.60	83.0 ± 2.44	78.2 ± 1.89							
Ns-Mes	121.8 ± 1.33	123.0 ± 2.52	128.0 ± 2.60	123.8 ± 1.54							
Sn-Mes	67.9 ± 1.12	66.7 ± 1.52	70.0 ± 1.69	70.2 ± 1.20							
Ns.Sn.Pgs (°)	11.1 ± 0.94	9.8 ± 1.34	7.1 ± 1.38	16.2 ± 1.01	***			***		***	***
Soft tissue measurements (thicknesses)											
A-As	16.3 ± 0.30	16.6 ± 0.68	17.2 ± 0.77	15.4 ± 0.39							
U1i-UL	17.1 ± 0.46	16.6 ± 0.52	17.7 ± 0.49	15.2 ± 0.36	**			**			**
L1i-LL	15.1 ± 0.36	15.2 ± 0.42	14.7 ± 0.53	14.3 ± 0.50							
B-Bs	12.1 ± 0.50	11.7 ± 0.52	12.3 ± 0.60	12.5 ± 0.61							
Pg-Pgs	12.6 ± 0.60	12.2 ± 0.46	12.7 ± 0.49	12.5 ± 0.60							

[a] ANOVA indicates analysis of variance; CC, chincup; CC+P, chincup + bite plate; RHg, reverse headgear; and C, control.
* $P < .05$, ** $P < .01$, *** $P < .001$.

The soft tissue measurements illustrated that a more orthognathic profile was achieved after treatment with orthopedic approaches (Table 3). Soft tissue A and upper lip moved forward significantly in all groups (As-VR, UL-VR), although this movement was more significant in the CC+P group compared with the CC group ($P < .05$). The lower lip retracted in both CC groups but was significant only in the CC group according to VR (LL-VR) and in both CC groups according to the E-line (LL-(E)). The sagittal change in the lower lip position in CC and CC+P groups was different from the control group. Soft tissue B moved backward significantly in all treatment groups (Bs-

TABLE 3. Changes in the Treatment-Control Groups, Significance of Changes in Each Group (*t*-test), and Comparison of Changes in Treatment-Control Groups With ANOVA and Duncan Tests[a]

Parameter	CC (1) D ± S_D *t*-test	CC+P (2) D ± S_D *t*-test	RHg (3) D ± S_D *t*-test	C (4) D ± S_D *t*-test	*F*-test	1-2	1-3	1-4	2-3	2-4	3-4
Skeletal measurements (sagittal)											
SNA (°)	0.2 ± 0.17	0.5 ± 0.41	1.9 ± 0.60**	0.1 ± 0.16	***		***		***		***
SNB (°)	−1.7 ± 0.26***	−1.9 ± 0.38***	−1.1 ± 0.31**	0.2 ± 0.19	***			***		***	***
ANB (°)	1.8 ± 0.24***	2.4 ± 0.36***	2.9 ± 0.66***	−0.1 ± 0.13	***			***		***	***
(A-VR)-(B-VR)	3.0 ± 0.34***	3.6 ± 0.46***	3.4 ± 0.71***	−0.1 ± 0.22	***			***		***	***
NAPg (°)	3.8 ± 0.87***	4.7 ± 0.75***	5.7 ± 1.25***	−0.4 ± 0.28	***			***		***	***
Skeletal measurements (vertical)											
N-Me	2.9 ± 0.51***	4.6 ± 0.59***	4.7 ± 0.79***	2.8 ± 0.26***	*	*	*			*	*
ANS-Me	2.4 ± 0.43***	3.1 ± 0.38***	3.7 ± 0.53***	1.5 ± 0.25***	*						*
S-Go	1.5 ± 0.41***	2.1 ± 0.66**	2.0 ± 0.73*	2.3 ± 0.30***							
ML.SN (°)	0.5 ± 0.33	0.9 ± 0.39*	1.3 ± 0.56*	−0.2 ± 0.27							
Dental measurements (sagittal + vertical)											
Overjet	5.0 ± 0.29***	5.6 ± 0.39***	6.3 ± 0.75***	−0.1 ± 0.21	***			***		***	***
Overbite	−0.8 ± 0.40*	−2.2 ± 0.54**	−1.8 ± 0.55**	0.2 ± 0.16	**					**	**
U1i-VR	1.9 ± 0.31***	3.4 ± 0.55***	4.3 ± 0.67***	0.9 ± 0.23**	***					***	***
U1i-HR	0.6 ± 0.23*	1.0 ± 0.65	0.7 ± 0.55	2.0 ± 1.16***	**			**		**	**
U1.HR (°)	2.4 ± 0.65***	4.8 ± 1.68*	4.5 ± 1.06***	−0.7 ± 0.50	***			***		***	***
L1i-VR	−3.1 ± 0.36***	−2.2 ± 0.44***	−2.0 ± 0.51**	1.0 ± 0.28**	***			***		***	***
L1i-HR	1.4 ± 0.44**	3.2 ± 0.55***	2.5 ± 0.62**	1.8 ± 0.20***							
L1.HR (°)	3.1 ± 1.04**	1.1 ± 0.93	3.2 ± 1.26*	0.0 ± 0.51							
U1.L1 (°)	0.7 ± 1.18	−3.7 ± 2.10	−1.4 ± 1.98	0.8 ± 0.76							
Soft tissue measurements (sagittal)											
As-VR	1.3 ± 0.29***	2.9 ± 0.61***	2.6 ± 0.58***	1.5 ± 0.34***	*	*					
UL-VR	1.4 ± 0.36***	3.2 ± 0.65***	2.6 ± 0.60***	2.7 ± 0.41**	*	*					
UL-(E)	1.0 ± 0.23***	1.6 ± 0.54**	1.6 ± 0.59*	0.5 ± 0.34							
LL-VR	−1.2 ± 0.46*	−0.6 ± 0.71	0.1 ± 0.52	2.2 ± 0.42***	***			***		***	
LL-(E)	−0.8 ± 0.25**	−1.0 ± 0.45*	−0.3 ± 0.52	0.5 ± 0.38	*			*		*	
Bs-VR	−1.7 ± 0.42***	−1.3 ± 0.52*	−1.0 ± 0.52	1.0 ± 0.36*	***			***		***	***
Pgs-VR	−1.5 ± 0.45**	−1.3 ± 0.55*	−0.8 ± 0.54	1.3 ± 0.39**	***			***		***	***
(UL-VR)-(LL-VR)	2.5 ± 0.23***	3.8 ± 0.53***	2.6 ± 0.60***	0.5 ± 0.16**	***			***		***	***
Soft tissue measurements (vertical)											
As-HR	0.7 ± 0.39	1.7 ± 0.49**	0.8 ± 0.65	0.9 ± 0.30**							
UL-HR	0.8 ± 0.39	2.4 ± 0.46***	1.6 ± 0.68*	0.7 ± 0.28*	*	*				*	
LL-HR	1.4 ± 0.46**	3.2 ± 0.62***	2.5 ± 0.81**	2.9 ± 0.36***							
Bs-HR	1.0 ± 0.50	1.8 ± 1.27	2.3 ± 0.51***	3.3 ± 0.65***							
Pgs-HR	1.2 ± 0.66	3.7 ± 1.13**	2.7 ± 0.90**	3.6 ± 0.78***							
Ns-Mes	2.9 ± 0.56***	4.2 ± 0.85***	4.6 ± 0.81***	3.5 ± 0.44***							
Sn-Mes	2.6 ± 0.40***	3.8 ± 0.51***	4.0 ± 0.72***	2.3 ± 0.41***	*						*
Ns.Sn.Pgs (°)	3.7 ± 0.53***	6.2 ± 1.13***	5.2 ± 1.00***	0.5 ± 0.52	***			***		***	***
Soft tissue measurements (thicknesses)											
A-As	0.4 ± 0.21*	1.1 ± 0.45*	0.6 ± 0.42	0.7 ± 0.32**							
U1i-UL	−0.5 ± 0.33	−0.9 ± 0.39*	−1.7 ± 0.74*	2.3 ± 0.34***	***			***		***	***
L1i-LL	1.8 ± 0.27***	1.5 ± 0.38*	2.1 ± 0.57**	1.5 ± 0.38**							
B-Bs	0.9 ± 0.32*	1.3 ± 0.50*	1.0 ± 0.36*	−0.4 ± 0.43	*			*		*	*
Pg-Pgs	1.3 ± 0.55*	1.1 ± 0.45*	1.0 ± 0.45	−0.4 ± 0.51							

[a] ANOVA indicates analysis of variance; CC, chincup; CC+P, chincup + bite plate; RHg, reverse headgear; C, control; D, differences; and S_D, standard error of differences.

* $P < .05$, ** $P < .01$, *** $P < .001$.

VR), whereas the soft tissue chin was positioned backward significantly in CC and CC+P groups (Pgs-VR). The treatment changes in this region were significantly different from the control group ($P < .001$). The sagittal lip relationship and convexity (Ns.Sn.Pgs) improved in all groups, and the treatment changes were statistically different from the control changes ($P < .001$).

The downward displacement of soft tissue point A was significant in the CC+P and control groups (As-HR) ($P < .01$). The upper lip's downward movement was significant

in the CC+P, RHg, and control groups, and the differences between CC+P and CC and CC+P and control groups were statistically significant ($P < .05$). The lower lip positioned downward in all groups (LL-HR), soft tissue B lowered significantly in RHg and control groups (Bs-HR), and finally the soft chin moved downward significantly in CC+P, RHg, and control groups (Pgs-HR). These mandibular vertical soft tissue changes were statistically similar in all study groups. The total and lower soft tissue facial height increased significantly in all groups (Ns-Mes, Sn-Mes). Increase of the lower facial height in the RHg group was significantly greater than in the control group ($P < .05$).

A significant decrease in the thickness occurred in the upper lip (U1i-UL) in the CC+P and RHg groups, whereas a significant increase was found in the control group, and the difference was statistically significant ($P < .001$). The lower lip thickness (L1i-LL) increased significantly in all groups. Soft tissue chin thickness (Pgs-Pg) increased significantly in both CC groups ($P < .05$). Statistical significance was found between CC groups and control.

DISCUSSION

Today, a large number of clinicians feel that mandibular prognathism has a genetic potential that cannot be altered by orthopedic treatment. On the other hand, a successful orthopedic treatment can prevent the problem from becoming more severe. It can eliminate or reduce the need for a comprehensive surgical approach and will improve the psychosocial well-being and appearance of the patient during teenage years, which are the most important formative years of their lives.

The basis of choice between a surgical and orthodontic-orthopedic treatment depends a great deal on the patient's or family's decision as well as the esthetic aspect. Moreover, achieving an acceptable facial profile in skeletal Class III patients is very critical and sometimes ''acceptable'' may not be sufficient. Therefore, the potential changes in the soft tissue profile due to different treatment approaches should be considered in the development of a treatment plan. In this study, the soft tissue profiles were evaluated, but patients do not see themselves in profile in a mirror. This is a handicap of the cephalometric method and the retrospective study design.

Not all skeletal Class III malocclusions can benefit from early orthopedic intervention; therefore, case selection should be made carefully. The facial growth pattern and amount of pretreatment overbite are factors to consider for prognosis and also for prevention of relapse.[18,23,25] For that reason, patients presenting normally directed vertical growth patterns with normal or deep overbite were included in the study sample.

The treatment effects of three different orthopedic approaches were evaluated and compared with an untreated control sample matched according to skeletal maturation criteria. The control subjects mostly presented skeletal Class I relationships for ethical purposes; thus, statistical differences in some of the parameters between control and treatment groups were noted at T1 (Table 2). Previous studies have examined the effect of growth in Class III patients and demonstrated that the magnitude of growth increment in the maxilla and the mandible was not significantly different between skeletal Classes I and III.[22]

Assessment of the results demonstrates that considerable facial changes and improvements took place after one year of treatment with all three orthopedic approaches. It was seen that forward movement of the maxilla was significant in the RHg group ($P < .01$), whereas the mandible was positioned backward, and intermaxillary relationship (ANB) was improved significantly in all treatment groups. In previous studies, a significant amount of maxillary forward movement was found with maxillary protraction appliances.[30–37] Several studies indicated that a chincup effects and stimulates anteroposterior growth of the maxilla,[9–15,17,22] whereas some demonstrated no significant effect.[16,20] Clinical and experimental studies have also revealed redirection, inhibition of mandibular growth, and backward repositioning of the mandible both with chincup[13,14,18,19] and maxillary protraction devices.[20,28–33]

Many authors have shown significant downward and backward rotation of the mandible both with chincup and maxillary protraction appliances.[18,20,29,31,41] In this study, the posterior rotation of the mandible was significant in the CC+P and RHg groups ($P < .01$), but no significant difference was found when the groups were compared. Facial heights increased significantly in all the groups. However, increases in the total anterior facial height (N-Me) were more pronounced in the CC+P and RHg groups compared with CC and C. Increases in the total anterior facial height were mainly due to increases in the lower anterior facial height in the treatment groups, whereas increase in ANS-Me measurement reflects approximately half of the anterior facial height increase in the control group.

Protrusion of the upper and retrusion of the lower incisors were significant, the overjet increased, and the overbite decreased significantly in all treatment groups compared with the control. Similar dentoalveolar findings were reported in studies regarding both chincup and facemask or reverse headgear effects.[15,17,18,20,30,31]

The major intent of this study was to evaluate the effects of different orthopedic treatment approaches on the soft tissues of Class III patients. Any attempt to predict soft tissue responses is difficult because there are too many factors to consider. The soft tissue overlying the teeth and bones shows significant individual variations in its thickness and tension. There is a strong but complex relationship between hard and soft tissue changes.[46] Because soft tissue facial components are supported directly by anterior teeth, any dental changes will have a direct impact on their position. Many orthodontists have examined the interrelationship between incisal

movement and lip response during orthodontic treatment.[47–51] In addition, measurements related to soft tissues tend to be less reliable than those of hard tissues and show large deviations, potentially obscuring significant changes.

When the soft tissue changes in the maxillary region were examined, soft tissue A point and the upper lip moved forward significantly in all the groups, but this movement was more pronounced in the CC+P group. The thickness of the upper lip decreased significantly in the CC+P and RHg groups, whereas a significant increase was found in the control group ($P < .001$). The difference between the treatment and control groups was significant ($P < .001$). These changes demonstrate that the soft tissue outcomes of CC+P and RHg treatments are similar in the maxillary region. It is more likely that bilabial improvements will be found when treatment is directed toward both arches.[6,26] Therefore, as the biteplate appliance disengages the occlusion, the upper arch is no longer trapped within the lower and an effect similar to the RHg is achieved in the maxillary region.

No significant differences were found regarding the sagittal soft tissue changes in the mandibular region among the treatment groups, but the changes in the treatment groups were significantly different from the control group. The soft tissue chin was positioned backward significantly in the CC and CC+P groups ($P < .05$). The lower lip retruded significantly in the CC group ($P < .05$), whereas significant protrusion was found in the control group ($P < .001$). The thickness of the lower lip increased significantly in all the groups, whereas the soft tissue chin thickness increased in the two chincup groups ($P < .05$). It is apparent that chincup treatment is more effective in the mandibular soft tissue region. The sagittal lip relationship ((UL-VR)-(LL-VR)) improved significantly in all the groups, but the changes in the treatment groups were statistically different from the control group ($P < .001$). The soft tissue convexity (Ns.Sn.Pgs) also increased significantly with all treatment approaches ($P < .001$). Allen et al[17] reported significant lower lip retraction with a chincup similar to our findings. Ngan et al[31] recorded significant protrusion of the upper and retrusion of the lower lip, decreases in the soft tissue pogonion, and decrease in the upper and increase in the lower lip thickness with maxillary protraction. Significant forward movement of the upper lip by maxillary protraction forces was also found in other studies.[26,35]

Vertical soft tissue measurements reflect the vertical skeletal changes and significant downward movement in all the soft tissue parameters, and increases in soft tissue facial heights were found in all groups.

The treatment approaches evaluated in this study had significant effects on the profiles of skeletal Class III patients. Besides the skeletal and dentoalveolar effects, the soft tissue improvements gained by CC+P and RHg were more pronounced and similar. The clinical implication suggests directing treatment to both jaws instead of a single jaw. Using a chincup together with a removable bite plate appliance may be a preferred treatment alternative more easily accepted by the patient as compared with a face mask, although they reveal comparable effects.

This study provides information regarding the short-term profile effects of orthopedic approaches in Class III treatment. However, long-term results are needed to evaluate the success and stability of early orthopedic intervention of Class III individuals because significant relapse potentials of skeletal and dentoalveolar variables have been reported in studies evaluating the long-term effects of both chincup and maxillary protraction appliances.[13,16,18,21,22,35,41,42] However, the data reported in this study only describe significant profile changes and improvements that are obtained with these orthopedic approaches. The important questions are whether or not these improvements are sufficient and are the facial profiles at the end of the treatment acceptable? Answers to these questions can be given with further studies.

CONCLUSIONS

- Significant dentoskeletal changes and improvements in dentofacial profile were achieved with all the orthopedic treatment modalities.
- Soft tissue profile improvements in the maxillary region were more prominent and similar in CC+P and RHg groups.
- In the mandibular region, the soft tissue changes were pronounced in CC and CC+P groups.
- Long-term studies are required to confirm the stability of these changes.

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