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Class III camouflage treatment: What are the limits?

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Introduction: The purpose of this study was to determine the skeletal, dental, and soft-tissue changes in response to camouflage Class III treatment. **Methods:** Thirty patients (average age, 12.4 ± 1.0 years) with skeletal Class III malocclusions who completed comprehensive nonextraction orthodontic treatment were studied. Skeletal, dental, and soft-tissue changes were determined by using published cephalometric analyses. The quality of orthodontic treatment was standardized by registering the peer assessment rating index on the pretreatment and posttreatment study models. The change in the level of gingival attachment with treatment was determined on the study casts. The results were compared with a group of untreated subjects. Data were analyzed with repeated measures analysis and paired *t* tests. **Results:** The average change in the Wits appraisal was greater in the treated group (1.2 ± 0.1 mm) than in the control group (–0.5 ± 0.3 mm). The average peer assessment rating index score improved from 33.5 to 4.1. No significant differences were found for the level of gingival attachments between the treatment and control groups. The sagittal jaw relationship (ANB angle) did not improve with camouflage treatment. A wide range of tooth movements compensated for the skeletal changes in both groups. The upper and lower limits for incisal movement to compensate for Class III skeletal changes were 120° to the sella-nasion line and 80° to the mandibular plane, respectively. Greater increases in the angle of convexity were found in the treated group, indicating improved facial profiles. Greater increases in length of the upper lip were found in the treated group, corresponding to the changes in the hard tissues with treatment. **Conclusions:** Significant dental and soft-tissue changes can be expected in young Class III patients treated with camouflage orthodontic tooth movement. A wide range of skeletal dysplasias can be camouflaged with tooth movement without deleterious effects to the periodontium. However, proper diagnosis and realistic treatment objectives are necessary to prevent undesirable sequelae. (Am J Orthod Dentofacial Orthop 2010;137:9.e1-9.e13)

A developing skeletal Class III malocclusion is one of the most challenging problems confronting an orthodontist. The prevalence of Class III malocclusion in the United States was approximately 1%.[1] However, approximately 16% of patients aged 4 to 10 referred to an orthodontist have a diagnosis of Class III malocclusion.[2]

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Young patients who are diagnosed early with this problem can be treated orthopedically with a chincap or protraction facemask to normalize the underlying skeletal discrepancy. Patients with no growth remaining must be camouflaged by orthodontic tooth movement or fixed appliances. Camouflage treatment is the displacement of teeth relative to their supporting bone to compensate for an underlying jaw discrepancy.[3] It implies that growth modification to overcome the basic problem is not feasible. The technique to camouflage a skeletal malocclusion was developed as an extraction treatment and introduced into orthodontics in the 1930s and 1940s.[3] During that era, extraction to camouflage a skeletal malocclusion became popular because growth modification had been largely rejected as ineffective, and surgical correction had barely begun to develop. The strategy to camouflage a Class III malocclusion usually involves proclination of the maxillary incisors and retroclination of the mandibular incisors to improve the dental occlusion, but it might not correct the underlying skeletal problem or facial profile. Studies have shown an increase in the ANB angle, little or no change in the vertical dimension, and decreased concavity of the facial

Table I. Starting craniofacial morphology of treated and control samples

		Skeletal and dental measurements						
		Treated		*Control*				
	Variable	*Mean*	*SD*	*Mean*	*SD*	*Difference*	P *value*	*Sig*
Sagittal (mm)								
Skeletal	Olp-A	70.67	5.83	67.8	4.14	2.87	0.03	*
	Olp-B	75.69	7.87	72.72	5.83	2.97	0.1	NS
	Olp-Pg	79.69	9.09	76.20	6.45	3.49	0.09	NS
	Wits	–7.16	2.81	–6.14	2.31	–1.02	0.12	NS
	Co-ANS	89.46	7.05	86.69	4.8	2.77	0.08	NS
	Co-Pg	113.34	9.37	109.45	6.46	3.89	0.06	NS
Dental	Is/Olp	78.57	6.89	75.84	5.28	2.73	0.09	NS
	Ii/Olp	76.4	6.48	73.90	5.64	2.5	0.11	NS
	Overjet	2.11	2.12	1.92	1.91	0.19	0.71	NS
	Ms/Olp	49.38	5.77	46.92	4.13	2.46	0.06	NS
	Mi/Olp	53.06	5.9	51.73	4.43	1.33	0.33	NS
	Molar relationship	–3.7	2.01	–4.82	1.94	1.12	0.03	*
Vertical (mm)								
Skeletal	N-A	50.22	4.68	48.27	3.18	1.95	0.06	NS
	ANS-Me	63.58	6.43	62.2	4.76	1.38	0.34	NS
Dental	Is-NL	26.71	2.82	26.14	2.56	0.57	0.41	NS
	Ii-ML	36.68	4.36	35.96	2.56	0.72	0.43	NS
	Overbite	1.1	2.15	0.48	1.74	0.62	0.22	NS
	Msc-NL	21.49	2.54	20.93	2.31	0.56	0.37	NS
	Mic-ML	28.98	3.25	27.8	2.2	1.18	0.1	NS
	ILG	4.3	5.09	0.93	1.65	3.37	0.001	†
Angular (°)								
Skeletal	SNA	79.56	3.54	74.32	3.79	5.24	0.0001	†
	SNB	80.1	4.11	75.17	4.49	4.93	0.0001	†
	ANB	–0.46	2.74	–0.85	2.19	0.39	0.55	NS
	ANL-ML	33.68	6.16	32.97	5.74	0.71	0.64	NS
	SNL-OL	17.36	4.82	17.54	5.52	–0.18	0.89	NS
	SNL-NL	7.66	3.75	7.52	3.45	0.14	0.87	NS
Dental	Is/SNL	107.36	6.93	103.32	5.9	4.04	0.01	*
	Is-FH	118.03	6.77	114.36	4.53	3.67	0.01	*
	Ii/ML	89.05	7.79	84.22	6.34	4.83	0.01	*
	U1-NL	114.63	6.9	111.19	4.97	3.44	0.03	*
	U1-L1	129.91	10.61	119.7	7.33	10.21	0.0001	†

NS, No significant difference between the means of the treatment and control groups at T1; *Sig,* significance.
*$P < 0.05$; †$P < 0.001$.

profile with Class III camouflage treatment.[4-9] However, little information is available on possible tooth movements to camouflage this type of skeletal malocclusion. Our objective in this study was to determine the skeletal, dental, and soft-tissue changes in response to camouflage Class III treatment. The null hypothesis was that there are no significant differences in the skeletal, dental, and soft-tissue changes between treated and control Class III samples.

MATERIAL AND METHODS

Forty-one patients, selected from the office files of an author (D.R.M.), had completed Class III camouflage treatment. The criteria for selection included (1) Class III molar relationship or mesial step in the mixed dentition, (2) concave facial profile, (3) Wits appraisal <–1.5 mm or ANB angle <1.0°, (4) a reduction in peer assessment rating (PAR) score >30%, (4) nonextraction comprehensive orthodontic treatment, and (5) high-quality pretreatment and posttreatment orthodontic records. Exclusion criteria included (1) dentofacial anomalies such as cleft lip and palate, (2) extracted or missing teeth, and (3) periodontal disease. Four patients were eliminated because they had extraction treatment; 5 were eliminated because of inadequate reductions in PAR scores; 2 were eliminated because there were no control subjects of similar age, sex, and craniofacial morphology to match them. No patient was eliminated because of poor records. The final sample consisted of 30 white patients (11 boys, 19 girls; average age, 12.4

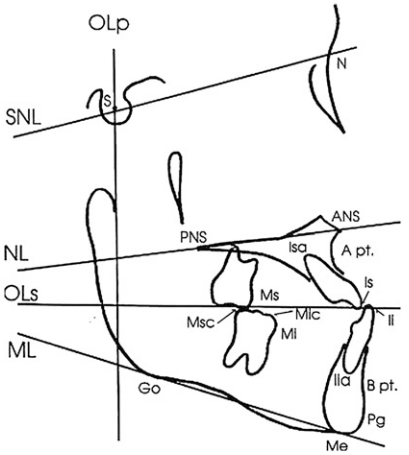

Fig 1. Cephalometric landmarks used for hard-tissue measurements on lateral cephalograms.

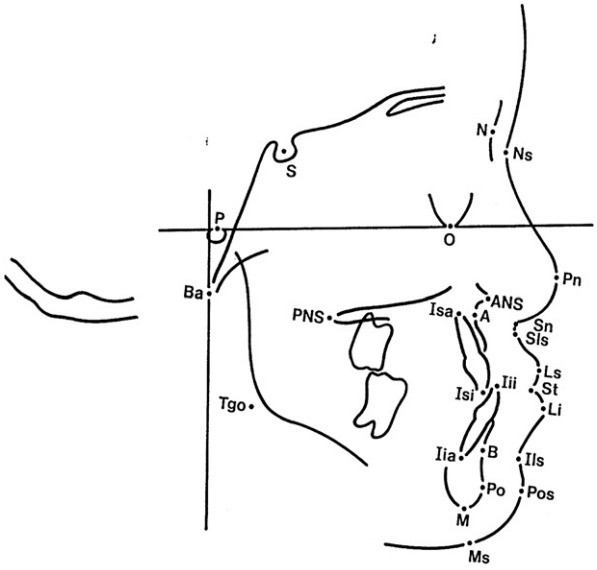

Fig 2. Cephalometric landmarks used for soft-tissue measurements on lateral cephalograms.

± 1.0 years). The mean treatment time was 2 years 2 months ± 7 months. Lateral cephalometric radiographs were taken before treatment (T1) and after treatment (T2). The cephalometric analyses used to evaluate skeletal, dental, and soft-tissue changes were described in the literature.[10-13] The quality of orthodontic treatment was standardized by registering the PAR index on the pretreatment and posttreatment dental casts. Certified PAR calibration was obtained from Ohio State University, Columbus, Ohio, before this project. The change in the level of gingival attachment with treatment was measured on the study casts.

The control group consisted of serial radiographs of 30 white subjects (11 boys, 19 girls) from the Bolton-Brush Study in Cleveland, Ohio, who were matched by age, sex, and craniofacial morphology to the experimental sample. There were no significant differences in skeletal age between the treated and the control groups. A selection of cephalometric records describing the initial craniofacial morphology of the control and treated subjects is shown in Table I. Significant differences were found with variables OLp-A, molar relationship, SNA, SNB, ILG, Is/SNL, Is/FH, Ii/ML, U1-NL, and U1-L1.

The PAR index was used in this study to evaluate the quality of camouflage orthodontic treatment. The index was originally developed to assess how well orthodontic treatment reduces the severity of malocclusion.[14] A score was assigned based on various occlusal traits that make up a malocclusion. The total score represents the degree to which a person's occlusion deviates from normal alignment. The difference in scores between pretreatment and posttreatment reflects the improvement or success of the treatment. According to Feghali et al,[15] a reduction in the PAR score of 22 or more points indicates "great improvement," a reduction of 30% indicates an "improved condition," and a reduction of less than 30% indicates "no improvement." In this study, only patients who had a 30% or greater reduction in their PAR scores were included.

To assess the periodontium with the study casts, we measured the change in the level of gingival attachment with an electronic caliper (Ultra-Cal Mark III, Fowler-Sylvec, Boston, Mass) and a cephalometric protractor (3M Unitek, Monrovia, Calif) for the 4 mandibular incisors. Crown height was measured from the deepest point of the curvature of the facial vestibulogingival margin to the incisal edge of the incisors. Measurements were made to the nearest 0.1 mm with a Boley gauge. A paired *t* test was used to evaluate treatment changes (T2-T1) in the treated group and growth changes between the serial radiographs (t2-t1) in the control group. A repeated measures analysis was used to assess the differences between the treated and the control groups (T2-T1)-(t2-t1).

Cephalometric changes during treatment were evaluated on the lateral cephalometric radiographs taken at T1 and T2 for the treated sample and at t1 and t2 for the control sample. All radiographs were analyzed by using a combination of landmarks from various traditional cephalometric analyses (Figs 1 and 2).[10-13] Analysis of the sagittal skeletal and dental changes were recorded along the occlusal plane (OL) and to the occlusal plane perpendicular (OLp) obtained from the radiographs at t1 and T1. The OL and the OLp from the t1 and T1 tracings

Table II. Sagittal, vertical, and angular skeletal and dental measurements at T1 and T2 for subjects in the treated group

			Skeletal and dental measurements									
			T1				*T2*					
	Variable	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*T2-T1* P *value*	*Sig*
Sagittal (mm)												
Skeletal	Olp-A	70.67	5.83	59.9	83.5	72.48	6.24	61.3	88	1.81	0.0004	‡
	Olp-B	75.69	7.87	60.8	92.3	77.63	8.53	62.6	95.5	1.94	0.0006	‡
	Olp-Pg	79.69	9.09	65	96.9	82.89	10.1	64.9	102.3	3.2	0.0001	‡
	Wits	–7.16	2.81	–12	–1.5	–5.98	2.92	–12	1	1.18	0.002	‡
	Co-ANS	89.46	7.05	69.9	110.6	93.66	7.91	75	113.8	4.2	0.0001	‡
	Co-Pg	113.34	9.37	91.6	133.6	119.46	11.2	96.9	119.46	6.12	0.0001	‡
Dental	Is/Olp	78.57	6.89	65.9	91.1	80.28	6.91	68.4	94.8	1.71	0.03	*
	Ii/Olp	76.4	6.48	54.1	87.1	78.38	7.2	66.6	92.1	1.98	0.002	†
	Overjet	2.11	2.12	–5.5	6	2.03	1.28	–2.6	3.8	–0.08	0.53	NS
	Ms/Olp	49.38	5.77	37.1	60.2	53.02	5.31	43.4	63.8	3.64	0.0001	‡
	Mi/Olp	53.06	5.9	40.9	64	56.33	6.02	46.3	69.1	3.27	0.0001	‡
	Molar relationship	–3.7	2.01	–12.5	–1.1	–3.3	1.57	–6.1	2.2	0.4	0.42	NS
Vertical (mm)												
Skeletal	N-A	50.22	4.68	42.9	63.1	52.57	4.61	43.6	66.2	2.35	0.0001	‡
	ANS-Me	63.58	6.43	53.1	74.1	67.4	6.9	55.4	77.8	3.82	0.0001	‡
Dental	Is-NL	26.71	2.82	20.6	31.6	27.66	3	22.7	32.8	0.95	0.002	†
	Ii-ML	36.68	4.36	23.1	42.7	39.27	3.64	33	45.4	2.59	0.0001	‡
	Overbite	1.1	2.15	–5.2	5.3	1.04	0.87	–0.8	3	–0.06	0.85	NS
	Msc-NL	21.49	2.54	15.4	26.1	23.5	2.45	18.9	28.8	2.01	0.0001	‡
	Mic-ML	28.98	3.25	22.7	36.4	30.88	2.74	25.5	36.6	1.9	0.001	‡
	ILG	3.61	3.67	0	13.9	0.41	1.47	0	7.4	–3.2	0.0003	‡
Angular (°)												
Skeletal	SNA	79.56	3.54	70	87	78.38	4.23	70	89.0	–1.18	0.32	NS
	SNB	80.1	4.11	69.5	89	79.33	4.69	67.5	90	–0.77	0.06	NS
	ANB	–0.46	2.74	–7	4	–1.26	2.09	–7	2	–0.8	0.04	*
	ANL-ML	33.68	6.16	21	53	33	7.55	20.5	58	–0.68	0.69	NS
	SNL-OL	17.36	4.82	10	28	16.68	5.49	8	32	–0.68	0.3	NS
	SNL-NL	7.66	3.75	0	14	8.08	4.47	–2	18	0.42	0.24	NS
Dental	Is/SNL	107.36	6.93	91	123	108.91	6.77	96.5	127	1.55	0.14	NS
	Is-FH	118.03	6.77	108	138	120.1	6.91	109	138	2.07	0.07	NS
	Ii/ML	89.05	7.79	74	105	89.76	8.54	74	106	0.71	0.48	NS
	U1-NL	114.63	6.9	99	134	116.31	6.76	107	134	1.68	0.15	NS
	U1-L1	129.91	10.61	109	148	128.2	10.09	108	144	–1.71	0.28	NS

NS, No significant difference between the means at T1 and T2; *Min,* minimum; *Max,* maximum; *Sig,* significance.
*$P < 0.05$; †$P < 0.01$; ‡$P < 0.001$.

formed the reference grid for all sagittal measurements between OLp and the cephalometric landmarks. The grid was then transferred to the radiographs at t1 and T2, superimposing the tracings on the sella-nasion line (SNL) and along the anterior cranial base structure. The distance between OLp and the cephalometric landmarks were measured. Overjet and molar relationship were then calculated by summing the skeletal and dental contributions. A matched-pairs test was used to evaluate the significant treatment changes between T1 and T2 for the treated sample and t1 and t2 for the control sample. A repeated measures analysis was performed to evaluate the changes between the 2 samples (T2-T1)-(t2-t1).

RESULTS

Errors in locating, superimposing, and measuring the changes of the landmarks were calculated. Cronbach's correlation coefficient of reliability showed that all sagittal, vertical, and angular measurements and time periods were greater than 0.97; this indicates high reliability.

Sex differences were determined on all the tested variables. Significant differences were found only for the variable SN-NL and soft-tissue variables Ls-U1 and Ns-Ls/FH (data not shown). Male and female subjects were then combined for subsequent analyses. Table II shows the sagittal, vertical, and angular

Table III. Sagittal, vertical, and angular skeletal and dental measurements at t1 and t2 for all subjects in the control group

		Skeletal and dental measurements										
		t1				*t2*				*t2-t1*		
	Variable	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	P *value*	*Sig*
Sagittal (mm)												
Skeletal	Olp-A	67.8	4.14	60.2	77.8	70.52	5.3	60.9	83.5	2.72	0.0001	‡
	Olp-B	72.72	5.83	62.2	85.2	76.7	6.92	61.7	89.8	3.98	0.0001	‡
	Olp-Pg	76.2	6.45	64.6	89.5	81.04	7.67	66.1	94.2	4.84	0.0001	‡
	Wits	–6.14	2.31	–12.3	–2.8	–6.67	2.68	–12.7	–1.4	–0.53	0.2	NS
	Co-ANS	86.69	4.8	77.3	95.4	90.99	4.86	83.9	102.3	4.3	0.0001	‡
	Co-Pg	109.45	6.46	97.5	123.8	116.38	6.43	106.3	131.7	6.93	0.0001	‡
Dental	Is/Olp	75.84	5.28	67.2	88.5	79.14	6.36	66.7	92.6	3.3	0.0001	‡
	Ii/Olp	73.9	5.64	62.6	86.7	77.72	6.56	66.7	93.3	3.82	0.0001	‡
	Overjet	1.92	1.91	–2.5	8.3	1.39	2.34	–3.8	8	–0.53	0.03	*
	Ms/Olp	46.92	4.13	39.6	57.1	50.55	6.13	39.8	65.5	3.63	0.0001	‡
	Mi/Olp	51.73	4.43	42.9	60	55.65	6.27	46.4	70.7	3.92	0.0001	‡
	Molar relationship	–4.82	1.94	–9.2	–2	–5.08	2.05	–10.2	–2.3	–0.26	0.49	NS
Vertical (mm)												
Skeletal	N-A	48.27	3.18	43.4	54.6	51.07	3.95	44.9	60.1	2.8	0.22	NS
	ANS-Me	62.2	4.76	50.7	70.6	66.16	6.2	55.3	80.3	3.96	0.0001	‡
Dental	Is-NL	26.14	2.56	19.3	30.5	26.84	2.89	20.5	32.2	0.7	0.007	†
	Ii-ML	35.96	2.56	28.2	42.1	38.35	3.28	32.2	46.9	2.39	0.0001	‡
	Overbite	0.48	1.74	–3.9	6.5	0.22	0.86	–1.3	1.9	–0.26	0.43	NS
	Msc-NL	20.93	2.31	14.9	25.1	23.09	2.57	17.8	28.1	2.16	0.0001	‡
	Mic-ML	27.8	2.2	23.6	32.8	29.95	3.2	24.5	38.5	2.15	0.0001	‡
	ILG	0.93	1.65	0	6.7	0.62	1.2	0	4.6	–0.31	0.4	NS
Angular (°)												
Skeletal	SNA	74.32	3.79	64.2	82.1	74.96	3.45	65.6	81.2	0.64	0.07	NS
	SNB	75.17	4.49	63.2	82.1	76.53	4.28	64.2	85	1.36	0.0001	‡
	ANB	–0.85	2.19	–8.5	3.8	–1.56	2.33	–7.6	2.8	–0.71	0.01	*
	ANL-ML	32.97	5.74	24.5	44.4	31.72	6.58	20.8	48.1	–1.25	0.03	*
	SNL-OL	17.54	5.52	8.5	34	15.2	4.27	8.5	22.7	–2.34	0.001	†
	SNL-NL	7.52	3.45	1.4	14.2	7.87	3.79	0	16	0.35	0.33	NS
Dental	Is/SNL	103.32	5.9	89.7	113.3	105.11	7.08	88.7	118	1.79	0.04	*
	Is-FH	114.36	4.53	105.7	122.7	116	6.65	99.1	131.2	1.64	0.08	NS
	Ii/ML	84.22	6.34	70.8	93.5	83.12	5.94	69.9	93.5	–1.1	0.1	NS
	U1-NL	111.19	4.97	97.2	122.7	113.07	6.03	99.1	129.3	1.88	0.03	*
	U1-L1	119.7	7.33	107.6	136.9	120.17	8.06	104.8	135.9	0.47	0.7	NS

NS, No significant difference between the means at t1 and t2; *Min,* minimum; *Max,* maximum; *Sig,* significance.
*P <0.05; †P <0.01; ‡P <0.001.

measurements at T1 and T2 for all subjects in the treated group. Significant differences were found in 10 of 12 variables in the sagittal measurements, 7 of 8 variables in the vertical measurements, and 1 angular measurement. Table III shows the sagittal, vertical, and angular measurements at t1 and t2 for all subjects in the control group. Significant differences were found in 10 of 12 variables in the sagittal measurements, 5 of 8 variables in the vertical measurements, and 6 angular measurements. Table IV compares the skeletal and dental changes between the treated and control groups. For sagittal changes, significant differences were found for the variables OLp-B, Wits, Is/OLp, and Ii/OLp. Greater forward movement of the mandible was found in the control group (P <0.01). The Wits appraisal was decreased in the treatment group (–7.16 to –5.98) but increased in the control group (–6.14 to –6.67), P <0.002. The average maxillary incisor inclination was retroclined with treatment but proclined with growth in the control group (P <0.02). The average mandibular incisor inclination was proclined with treatment but retroclined with growth in the control group (P <0.03).

No significant differences were found in overjet between the treated and control groups (Fig 3). The average changes in overjet in the treated and control groups

Table IV. Comparison of skeletal and dental changes between the treated and control groups (T2-T1)-(t2-t1)

	Skeletal and dental measurements		
	Variable	P *value*	*Sig*
Sagittal measurements (mm)			
Skeletal	Olp-A	0.13	NS
	Olp-B	0.01	†
	Olp-Pg	0.06	NS
	Wits	0.002	†
	Co-ANS	0.92	NS
	Co-Pg	0.57	NS
Dental	Is/Olp	0.02	*
	Ii/Olp	0.03	*
	Overjet	0.29	NS
	Ms/Olp	0.99	NS
	Mi/Olp	0.48	NS
	Molar relationship	0.28	NS
Vertical measurements			
Skeletal	N-A	0.29	NS
	ANS-Me	0.86	NS
	Is-NL	0.5	NS
	Ii-ML	0.72	NS
	Overbite	0.67	NS
Dental	Msc-NL	0.74	NS
	Mic-ML	0.69	NS
	ILG	0.0009	‡
Angular measurements			
Skeletal	SNA	0.32	NS
	SNB	0.0001	‡
	ANB	0.85	NS
	SNL-ML	0.07	NS
	SNL-OL	0.08	NS
	SNL-NL	0.88	NS
Dental	Is/SNL	0.85	NS
	Is-FH	0.76	NS
	Ii/ML	0.14	NS
	U1-NL	0.89	NS
	U1-L1	0.27	NS

NS, No significant difference in the means changes over time between the treatment and control groups; *Sig,* significance.
*P <0.05; †P <0.01; ‡P <0.001.

were –0.19 and –0.74 mm, respectively. However, large variations in skeletal and dental changes were found in both groups that contributed to the changes in overjet (Figs 4-11). The changes ranged from 2 to 8 mm in the maxillary base and 3 to 9 mm in the mandibular base in both groups. A similar distribution was found in both groups. A wide range of incisal changes was also noted in both groups to compensate for the skeletal changes. The changes in mandibular incisor inclinations ranged from –10° to 15° in the treated group and –10° to 6° in the control group. The changes in maxillary incisor inclinations ranged from –6° to 12° in the treated group and –3° to 12° in the control group. No significant differences were found in molar relationships between the 2 groups. The average changes in molar relationship for the treated and control groups were 0.37 and –0.27 mm, respectively.

For vertical changes, significant differences were found between the treated and the control groups for interlabial distance (ILG). A greater decrease in ILG was found in the treated group.

For angular changes, significant differences between the treated and control groups were found for the variable SNB. The forward movement of the mandibles (SNB) was less in the treated group compared with the control group.

Table V shows the sagittal, vertical, and angular soft-tissue measurements at T1 and T2 for all subjects in the treated group. Significant differences were found in 2 of 11 sagittal soft-tissue profile variables, 5 of 6 variables in vertical measurements, and 2 of 6 variables in soft-tissue thickness measurements. Table VI shows the sagittal, vertical, and angular soft-tissue measurements at t1 and t2 for all subjects in the control group. Significant differences were found in 4 of 11 variables in soft-tissue thickness measurements, 5 of 6 variables in vertical measurements, and 4 of 6 variables in soft-tissue thickness measurements. No significant differences were found in the lip-structure measurements. Table VII compares the soft-tissue changes between the treated and control groups. For soft-tissue profile changes, significant differences were found for the variables Ns-Sls/SLs-Pos, Ls/Pn-Pos, Ns-St, Ns-Li, and Ns-Pog. A greater increase in facial convexity was found in the treated group compared with the control group. For vertical changes, significant differences were found for the variable Sn-St. A greater increase in upper lip length was found in the treated compared with the control group.

Table VIII shows the changes in the level of gingival attachment for the 4 incisors from T1 to T2 for all subjects between T1 and T2 in the treated group. Significant differences were found with the mandibular right and left lateral incisors. Table IX shows the changes in the level of gingival attachment in the control group. Significant differences were found between t1 and t2 for all 4 incisors. Table X compares the changes in the level of gingival attachment between the treated and control groups; no significant differences were found.

DISCUSSION

This study had several limitations. This was a retrospective study with a sample from a private orthodontic practice. The sample was not uniform in skeletal age, age at T1, and treatment period. An attempt was made

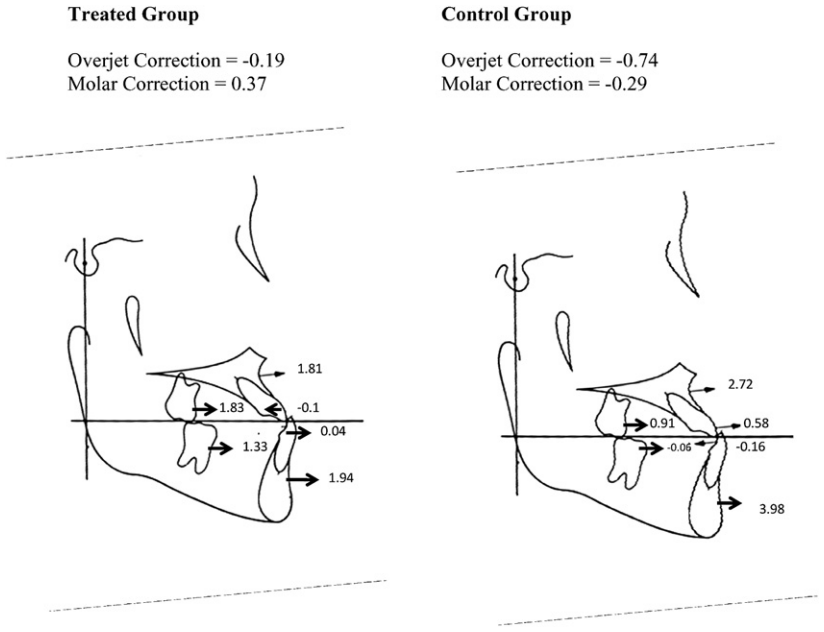

Fig 3. Sagittal skeletal and dental changes in the treated and control groups.

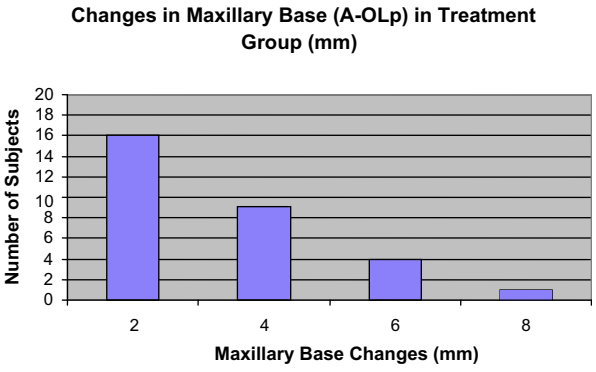

Fig 4. Changes in the maxillary base in the treated group (mm).

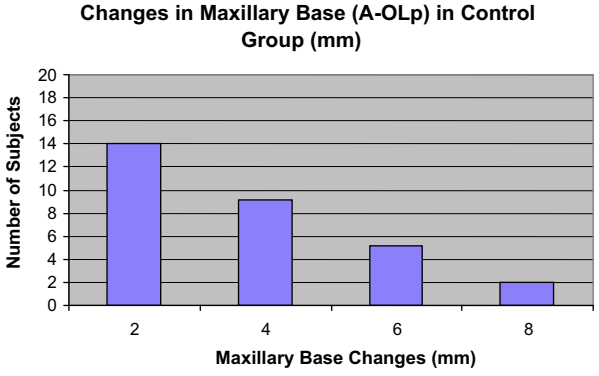

Fig 5. Changes in the maxillary base in the control group (mm).

to match the starting craniofacial morphology of the treated and the control groups. The skeletal differences (ANB) in both groups were similar. However, the starting SNA and SNB angles were greater in the treated sample. Maxillary and mandibular incisor proclinations were greater in the treated group compared with the control group. Long-term data on these patients were not available to show whether camouflage tooth movement was stable after growth.

Camouflage treatment did not result in improvement in the sagittal jaw relationship. In both groups, the jaw relationships became worse with treatment because of disproportional growth of the maxilla and the mandible. Most patients in this study started treatment at the beginning of the growth spurt (cervical vertebral maturation stage 2 or 3). It is therefore not surprising that skeletal dysplasia became worse after camouflage treatment.

Most patients who received camouflage orthodontic treatment were followed for several years after correction of any centric occlusion-centric relation discrepancy to evaluate the changes in Wits appraisal with growth. Stellzig-Eisenhower et al[16] reported that the Wits appraisal was the most discriminative in determining whether the developing Class III malocclusion should be treated by camouflage treatment or surgery. The average Wits appraisal for patients who were successfully treated with camouflage treatment was

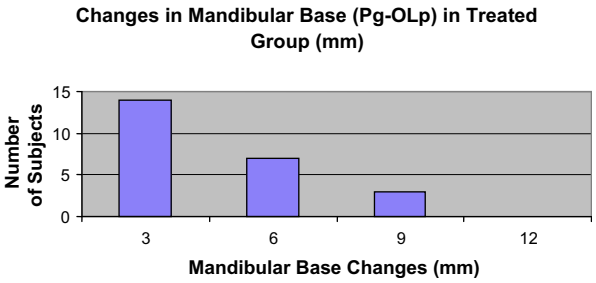

Fig 6. Changes in the mandibular base in the treated group (mm).

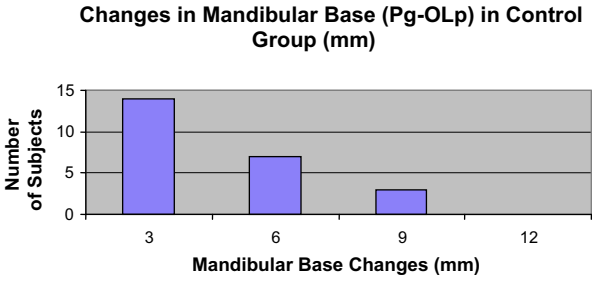

Fig 7. Changes in the mandibular base in the control group (mm).

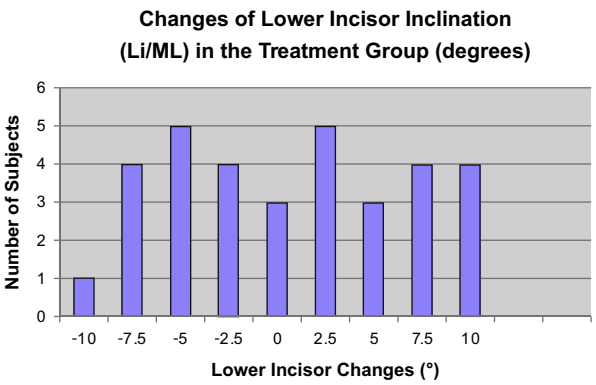

Fig 8. Changes in mandibular incisor inclinations in the treated group (°).

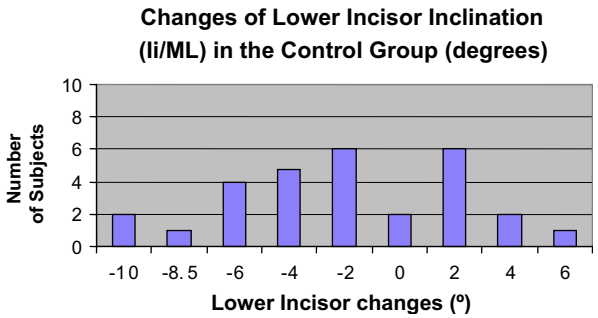

Fig 9. Changes in mandibular incisor inclinations in the control group (°).

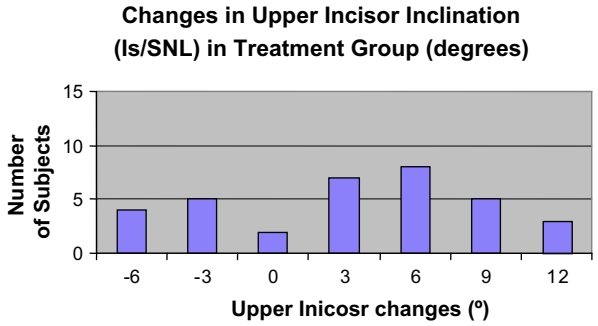

Fig 10. Changes in maxillary incisor inclinations in the treated group (°).

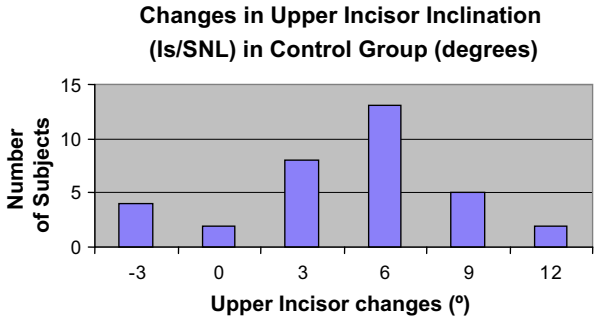

Fig 11. Changes in maxillary incisor inclinations in the control group (°).

-4.6 ± 1.7. In our study, patients who had a Wits appraisal better than –5.0 had camouflage orthodontic treatment.

A greater improvement in the Wits appraisal was found in the treated group. This can be attributed to a decrease in the occlusal plane inclination with Class III treatment mechanics, resulting in a decreased SNB angle, extrusion of the posterior molars, and an increased mandibular plane angle. The average overjet remained relatively unchanged in both groups, but many skeletal and dental changes were observed in these groups. In the control group, the maxillary incisors were proclined, and the mandibular incisors were retroclined to compensate for the skeletal changes during the studied period. In the treated group, the maxillary incisors were retroclined, and the mandibular incisors were proclined with treatment, decreasing the dental compensation to skeletal discrepancies. The

Table V. Sagittal, vertical, and angular soft-tissue measurements at T1 and T2 for all subjects in the treated group

	Total soft-tissue measurements										
	T1				*T2*				*T2-T1*		
	Mean	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	P *value*	*Sig*
Sagittal relationship of soft tissue profile											
Ns-Sls/ Sls-Pos(mm)	–4.89	8.05	–22	15.6	–7.12	6.3	–20.6	9	–2.23	0.09	NS
Ls/Pn-Pos (mm)	81.67	10.21	62.6	100.4	81.74	10.55	62.6	105.9	0.07	0.93	NS
Li/Pn-Pos (mm)	80.08	15.47	15.5	103.6	82.76	11	63.4	106.5	2.68	0.37	NS
Pn/Ns (mm)	26.56	4.77	17.8	38	28.08	5.24	20.3	39.7	1.52	0.0005	‡
Ns-Sn (mm)	–12.41	6.77	–25.5	11.7	–11.33	14.73	–24.5	65	1.08	0.54	NS
Ns/Sls (mm)	–11.41	6.77	–25.7	11.9	–11.87	7.03	–24.2	15.7	–0.46	0.32	NS
Ns/Ls (mm)	–16.04	8.4	–31.8	18.3	–15.44	6.84	–29.8	7.6	0.6	0.33	NS
Ns-St (mm)	–11.06	6.53	–26.3	11.1	–10.07	6.09	–25.1	1	0.99	0.17	NS
Ns/Li (mm)	–17.21	8.36	–35.3	15.8	–16	8.63	–33.7	18.8	1.21	0.02	*
Ns/Ils (mm)	–12.27	7.58	–31.4	16	–12.03	6.55	–30.4	1.8	0.24	0.72	NS
Ns-Pog (mm)	–17.31	8.01	–38.5	8.5	–17.35	8.61	–39.3	9.7	–0.04	0.93	NS
Vertical relationship of soft tissue profile											
Sn-Ms (mm)	69.68	6.54	60	82.2	72.89	6.43	61	84	3.21	0.0001	‡
Sn-St (mm)	18.55	2.83	12.9	23.4	21.59	2.53	13.7	25.7	3.04	0.0001	‡
St-Ms (mm)	47.73	5.28	37.8	58.2	50.52	5.33	39.8	60.9	2.79	0.0001	‡
St-Ils (mm)	16.88	2.47	12.1	21.5	17.4	2.34	12.1	22.1	0.52	0.18	NS
Ns-Ms (mm)	120.23	10.11	103.2	142.4	125.03	10.31	105.4	145.3	4.8	0.0001	‡
Ns-Sn (mm)	53.2	5.68	43.2	66.5	55.26	5.86	45.8	71.2	2.06	0.0001	‡
Soft-tissue thickness											
Sn-A (mm)	15.81	2.95	9.9	23	17.33	2.79	10.2	23	1.52	0.006	†
Ls-U1 (mm)	13.27	2.51	8.9	19	13.36	2	9.7	17.2	0.09	0.81	NS
Li-L1 (mm)	14.3	2.37	9.1	19.5	14	2.29	10.7	22.7	–0.3	0.41	NS
Pos-Pog (mm)	11.68	1.72	7.7	16.4	11.59	1.9	8.5	15.9	–0.09	0.73	NS
Sls-A (mm)	14.99	3.1	8.1	21.9	16.25	2.55	9.1	21.2	1.26	0.01	*
Ils-B (mm)	11.27	1.83	7.7	15.6	12.05	2.32	9	21.1	0.78	0.11	NS
Lip structure											
Ns-Ls/FH (°)	100.51	4.89	93	115	99.34	5.57	77	108	–1.17	0.31	NS
Li-Ils/FH (°)	52.65	14.44	17	81	53.1	11.24	24	71	0.45	0.84	NS
Ils-Pos-Ls (°)	–17.6	9.69	–32	17	–17.65	5.12	–26	–10	–0.05	0.97	NS
Li/Pos-Ls (°)	1.93	5.54	–7	12	0.75	4.77	–9	13	–1.18	0.18	NS

NS, No significant difference between the means at T1 and T2; *Min,* minimum; *Max,* maximum; *Sig,* significance.
*$P < 0.05$; †$P < 0.01$; ‡$P < 0.001$.

results for the control group agree with studies showing that skeletal Class III compensation tends to worsen with age without treatment.[17,18] The results for the treated group contrast with those of Troy et al.[9] In their study, the maxillary incisors after camouflage treatment were more proclined or compensated, and the mandibular incisors were more retroclined than at pretreatment. The main difference was that all subjects in their study had already experienced their growth spurt (cervical vertebral maturation stage 4, 5, or 6), whereas, in our study, all subjects were experiencing their growth spurt (cervical vertebral maturation stage 2 and 3). Long-term data from our study will confirm whether tooth movements are similar when growth is completed.

Variability in growth and response to treatment were also observed in this study. The average mandibular incisor angulation (Ii/ML) with treatment was 90.2°, which is close to the norm. However, variations in individual responses ranged from –10° to 10°, equivalent to a range of Ii/ML from 80° to 106°. The average maxillary incisor angulation (Is/SNL) with treatment was 108°, which is close to the norm, but variations in individual responses ranged from –6° to 12°, equivalent to a range in Is/SNL of 102° to 120°. In a study of adult Class III patients (average age, 26.7 years) camouflaged with orthodontic treatment, the mean maxillary incisal angulation (U1-SN) after treatment was 112.1° (range, 95°-132°), and the mandibular incisal angulation (L1-MP) was 82.4° (range, 65°-100°).[19] Casko and

Table VI. Sagittal, vertical, and angular soft-tissue measurements at t1 and t2 for all subjects in the control groups

	Total soft-tissue measurements										
	t1				*t2*				*t2-t1*		
	Mean	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	P *value*	*Sig*
Sagittal relationship of soft-tissue profile											
Ns-Sls/Sls-Pos(mm)	–9.6	4.9	–22	2.5	–7.46	6.92	–25.2	15	2.14	0.06	NS
Ls/Pn-Pos (mm)	76.55	7.69	63	94	80.98	8.94	60.4	97.9	4.43	0.0001	†
Li/Pn-Pos (mm)	77.76	8.67	60.9	97.2	82.66	9.57	62.2	100.9	4.9	0.0002	†
Pn/Ns (mm)	27.55	8.33	15.3	66.6	28.09	4.52	19.4	36	0.54	0.75	NS
Ns-Sn (mm)	–13.67	3.83	–25.6	–5.1	–13.98	4.77	–26.6	–6.8	–0.31	0.58	NS
Ns/Sls (mm)	–12.66	3.77	–25.1	–4.3	–13.27	4.56	–25.3	–5.9	–0.61	0.31	NS
Ns/Ls (mm)	–16.44	4.07	–30	–8.8	–17.01	4.94	–30.6	–9.8	–0.57	0.30	NS
Ns-St (mm)	–11.15	4.2	–24.8	–2.4	–12.01	4.77	–23.9	–4.7	–0.86	0.1	NS
Ns/Li (mm)	–17.52	4.96	–32.4	–7.6	–18.46	5.68	–32.1	–7.3	–0.94	0.1	NS
Ns/Ils (mm)	–12.95	5.12	–26.3	–2.4	–14.42	5.78	–26.5	–2.9	–1.47	0.03	*
Ns-Pog (mm)	–16.17	5.97	–28.7	–3.7	–18.61	6.77	–31.1	–4.9	–2.44	0.0003	†
Vertical relationship of soft-tissue profile											
Sn-Ms (mm)	66.02	4.7	59.7	76	70.32	5.4	59.8	84.1	4.3	0.0001	†
Sn-St (mm)	18.14	2.19	12.8	22.8	18.71	2.82	14.8	25.2	0.57	0.32	NS
St-Ms (mm)	47.02	3.44	40.9	55.9	51.14	4.04	41.9	61.7	4.12	0.0001	†
St-Ils (mm)	16.77	2.57	11.9	22.5	18.37	2.7	13.9	24.4	11.6	0.02	*
Ns-Ms (mm)	120.94	12.53	107.2	178.2	126.58	7.52	114	143	5.64	0.03	*
Ns-Sn (mm)	56.17	4.09	47.7	64	59.29	4.5	49.1	66.7	3.12	0.0001	†
Soft-tissue thickness											
Sn-A (mm)	15.98	2.04	12	19.8	16.92	2.61	12.4	22.8	0.94	0.01	*
Ls-U1 (mm)	12.07	1.63	8.9	15	12.8	1.84	9.3	16.3	0.73	0.02	*
Li-L1 (mm)	12.93	1.93	8.9	15.6	13.07	2.06	8.9	18.9	0.14	0.69	NS
Pos-Pog (mm)	10.45	2.03	6.6	14.3	11.55	2.11	7.8	16	1.1	0.01	*
Sls-A (mm)	15.8	1.83	11.4	19.2	16.68	2.36	13.3	22.4	0.88	0.01	*
Ils-B (mm)	11.35	1.93	7.5	15.2	11.63	1.99	6.6	14.6	0.28	0.47	NS
Lips structure											
Ns-Ls/FH (°)	95.39	4.8	83.1	105.7	95.81	4.94	86.8	107.6	0.42	0.55	NS
Li-Ils/FH (°)	53.33	7.57	36.8	67	55	10.44	32.1	79.3	1.67	0.39	NS
Ils-Pos-Ls (°)	–13.02	3.77	–18.9	–4.7	–14.88	4.75	–22.7	–6.6	–1.86	0.07	NS
Li/Pos-Ls (°)	3.08	3.57	–5.7	10.4	1.98	4.38	–6.6	14.2	–1.1	0.16	NS

NS, No significant difference between the means at t1 and t2; *Min,* minimum; *Max,* maximum; *Sig,* significance.
*$P < 0.05$; †$P < 0.001$.

Shepherd[20] reported on the cephalometric values of a sample of adults with normal occlusion and found variations in skeletal and dental parameters that were far beyond mean values. Dietrich[21] and Guyer et al[22] also reported variability of skeletal Class III relationships using cephalometeric analysis. Several Class III patients in this study had a positive overjet because the underlying skeletal malocclusion was compensated by retroclination of the mandibular incisors. The objective of camouflage treatment in these patients was to normalize the underlying skeletal discrepancies and place the incisors in the medullary trough to prevent bony dehiscence. It has also been shown that overjet is not a good predictor of sagittal relationship in Class III subjects.[23]

As for vertical changes, a decreased distance between the upper and lower lip (ILG) was observed in the treated group. The improvement in lip competency agrees with other studies that demonstrated that a decrease in facial concavity improved the posture of the lips.[6,24] Although the following variables were not significant, our results showed a trend that the maxillary and mandibular incisors, as well as the molars, had more extrusion in the treated group than in the control group; this can be explained by the use of Class III elastics. There was counterclockwise rotation of the occlusal plane in the treated group. Lin and Gu[6] reported similar results and found that the relative extrusion of the mandibular incisors in relation to the maxillary molars during Class III traction of elastics seemed to contribute to the counterclockwise rotation of the occlusal plane. The increase in mandibular plane angulation in the treated group could be attributed to the extrusion of the mandibular molars.

Table VII. Comparison of soft-tissue changes between the treated and control groups (T2-T1)-(t2-t1)

Soft-tissue measurements	P *value*	*Sig*
Sagittal relationship of soft-tissue profile		
Ns-Sls/Sls-Pos	0.01	†
Ls/Pn-Pos (mm)	0.0003	‡
Li/Pn-Pos (mm)	0.49	NS
Pn/Ns (mm)	0.57	NS
Ns-Sn (mm)	0.46	NS
Ns/Sls (mm)	0.84	NS
Ns/Ls (mm)	0.15	NS
Ns-St (mm)	0.04	*
Ns/Li (mm)	0.006	†
Ns/Ils (mm)	0.07	NS
Ns-Pog (mm)	0.003	†
Vertical relationship of soft-tissue profile		
Sn-Ms (mm)	0.19	NS
Sn-St (mm)	0.0012	†
St-Ms (mm)	0.14	NS
St-Ils (mm)	0.16	NS
Ns-Ms (mm)	0.73	NS
Ns-Sn (mm)	0.15	NS
Soft-tissue thickness		
Sn-A (mm)	0.36	NS
Ls-U1 (mm)	0.2	NS
Li-L1 (mm)	0.38	NS
Pos-Pog (mm)	0.01	NS
Sls-A (mm)	0.54	NS
Ils-B (mm)	0.41	NS
Lip structure		
Ns-Ls/FH (°)	0.25	NS
Li-Ils/FH (°)	0.68	NS
Ils-Pos-Ls (°)	0.29	NS
Li/Pos-Ls (°)	0.94	NS

Repeated measurements analysis was used for testing the interaction effect.

NS, No significant difference in the mean changes over time between the treatment and control groups.

*$P < 0.05$; †$P < 0.01$; ‡$P < 0.001$.

As for angular changes, patients in the control group had a more forward position of the mandibular base angle in relation to the cranial base (SNB). The difference might be explained by the Class III treatment mechanics, which have a tendency to extrude the molars, increase the mandibular plane angle, and decrease the SNB angle. These changes were not observed in the control group, which experienced a decrease in mandibular plane angle.[24] Maxillary incisor position and inclination were found to be greater in the control group. Proclination of the maxillary incisors in response to either growth or treatment in Class III patients was reported by Baccetti et al,[25] Lin and Gu,[6] Moullas and Palomo,[26] and Daher and Caron.[27] No studies have compared treated and untreated samples. In our study, the maxillary incisors in the control group compensated for the skeletal discrepancy and thereby continued to procline with growth. The use of Class III elastics in the treated group provided forward movement of the maxillary molars, decreasing the incisors' proclination. Mandibular incisor inclination in relation to the mandibular plane (Ii-ML) was greater in the treated sample. The treated sample also had a greater interincisal angle (U1-L1). An increase in the interincisal angle usually means less proclination of the incisors. In the present study, camouflage treatment results in decompensation or more upright maxillary and mandibular incisors than the control group. Although proclination of the maxillary incisors may still takes place during treatment, it is less pronounced than those resulted from growth alone. Studies have shown that skeletal Class III discrepancies worsen with age.[18-20] Thus, the difficulty in treating a developing Class III malocclusion successfully increases with time. If the skeletal discrepancy worsens with age, then the interincisal angle will decrease over time. With the advent of temporary anchorage devices, intermaxillary elastics can be replaced by these devices and intra-arch mechanics. This will minimize extrusion of the molars and opening of the mandibular plane.

For sagittal soft-tissue changes, the angle of convexity (Ns-Sls/Sls-Pos) increased in the control group and decreased in the treatment group; this indicates improved facial esthetics in the treated sample. The treated group also had a higher mandibular plane angle (Sn-ML) than the control group; this can also contribute to an esthetic profile change. Decreases in convexity were also found by Lin and Gu[6] and Daher and Caron,[27] who attributed the changes mostly to the changes in mandibular plane angulation.

For vertical soft-tissue changes, the length of the upper lip (Sn-St) in the treated group was longer than the control group. A study with facemask treatment also found an increase in the length of the upper lip in the treated group, but it was not significant.[24] A possible explanation could be that, since the treated group had less incisor proclination than the control group, the length of the upper lip was greater, assuming that the position of the teeth influences the position of the soft tissues.

The average loss of attachment in the treated group was similar to the control group. This was even though the average inclination of the mandibular incisors in the treated group was more proclined than in the control group. Individual variation in response to treatment was noted in both the range of incisor movement and the response. These results suggest that camouflage treatment can be successful in various tooth movements without deleterious effects to the periodontium.

Table VIII. Change in level of gingival attachments from T1 to T2 for all subjects in the treated groups

	Periodontal measurements										
	T1				*T2*				*T2-T1*		
Variable	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	P-*value*	*Sig*
IL-ML	89.05	7.79	74	105	89.76	8.54	74	106	0.71	0.48	NS
LR2	8.11	0.88	6.6	9.8	8.73	0.88	6.8	9.8	0.62	0.0001	*
LR1	8.37	0.76	6.6	9.8	8.56	0.88	6.6	9.7	0.19	0.16	NS
LL1	8.44	0.88	6.6	10	8.64	0.88	6.9	10	0.2	0.15	NS
LL2	8.15	0.85	6	10	8.82	0.92	7.2	10.4	0.67	0.0001	*

NS, No significant difference between the means at T1 and T2.
*$P < 0.05$.

Table IX. Change in level of gingival attachment from t1 to t2 for all subjects in the control group

	t1				*t2*				*t2-t1*		
Variable	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	P *value*	*Sig*
IL-ML	84.22	6.34	70.8	93.5	83.12	5.94	69.9	93.5	–1.1	0.1	NS
LR2	8.41	1	6.7	10.4	8.74	0.98	6.8	10.6	0.33	0.1	*
LR1	8.55	1.05	6.1	10.7	8.85	1.06	6.4	10.6	0.3	0.04	*
LL1	8.54	1.05	6.2	10.7	8.89	1.12	6.4	11.2	0.35	0.01	*
LL2	8.36	0.9	6.6	9.8	8.84	0.92	6.7	10.5	0.48	0.0001	†

NS, No significant difference between the means at t1 and t2; *Min,* minimum; *Max,* maximum; *Sig,* significance.
*$P < 0.05$; †$P < 0.001$.

Table X. Comparison of the periodontal changes between the treated and control groups (T2-T1)-(t2-t1)

Angular measurements		
Variable	P *value*	*Sig*
IL-ML	0.14	NS
ii/Olp	0.03	*
LR2	0.09	NS
LR1	0.58	NS
LL1	0.4	NS
LL2	0.28	NS

Repeated measurements analysis was used for testing the interaction effect.
NS, No significant difference in the mean changes over time between the treatment and control groups; *Sig,* significance.
*$P < 0.05$.

However, clinicians should be cautioned that, in this study, both groups had significant growth changes during the study period. When treating a Class III patient, the clinician should monitor the patient so that he or she does not grow out of the range of successful camouflage treatment. If camouflage treatment is planned with the irreversible step of extraction of premolars, verification that the goals of treatment can be achieved with nonsurgical treatment approach is essential. Frequently, a nonextraction preliminary orthopedic stage—eg, 4 to 6 months of therapeutic treatment with rapid palatal expansion, Class III traction, and maxillary anterior braces—eliminates the mandibular functional shifts that are frequently present and make the Class III problem look worse than it is.[28] In addition, patients should be followed for periodontal health after camouflage treatment. Increased morbidity in long-term evaluations measured by gingival recession has been reported in Class III patients camouflaged by greater dental compensations.[19]

CONCLUSIONS

The null hypothesis that there are no significant differences in skeletal, dental, and soft-tissue changes between the treated and control groups was rejected. Most differences were attributed to tooth movement to reduce dental compensation of the skeletal malocclusion and improve the facial profile. The range of skeletal and dental changes in response to orthodontic treatment suggests that a wide range of skeletal dysplasia can be successfully camouflaged with tooth movement without deleterious effects to the periodontium. However, proper diagnosis and the establishment of realistic treatment objectives by the clinician and the patient are

necessary to prevent undesirable sequelae in camouflaging a mild to moderate skeletal Class III malocclusion.

REFERENCES

1. Proffit WR, Fields HW, Moray LJ. Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from the NHANES III survey. Int J Adult Orthod Orthognath Surg 1998;13:97-106.
2. Musich DR, Busch MJ. Early orthodontic treatment: current clinical perspectives. Alpha Omegan 2007;100:17-24.
3. Profitt WR, Fields HW, Sarver DM. Contemporary orthodontics. 4th ed. St Louis: Mosby; 2007. p. 6-14, 300-309.
4. Ngan P. Treatment of Class III malocclusion in the primary and mixed dentitions. In: Bishara SE, editor. Textbook of orthodontics. Philadelphia: W.B. Saunders; 2001. p. 375-6.
5. Costa Pinho T, Torrent J, Pinto J. Orthodontic camouflage in the case of a skeletal Class III malocclsuion. World J Orthod 2004;5:213-23.
6. Lin J, Gu Y. Preliminary investigation of nonsurgical treatment of severe skeletal Class III malocclusion in the permanent dentition. Angle Orthod 2003;73:401-10.
7. Chang HF, Chen KC, Nanda R. Two-stage treatment of a severe skeletal Class III deep bite malocclusion. Am J Orthod Dentofacial Orthop 1997;111:481-6.
8. Rabie ABM, Wong RWK, Min GU. Treatment in borderline Class III malocclusion: orthodontic camouflage (extraction) versus orthognathic surgery. Open Dent J 2008;2:38-48.
9. Troy BA, Shanker S, Fields HW, Vig K, Johnston W. Comparison of incisor inclination in patients with Class III malocclusion treated with orthognathic surgery or orthodontic camouflage. Am J Orthod Dentofacial Orthop 2009;135:146.e1–9.
10. Bjork A. The face in profile: an anthropological x-ray investigation of Swedish children and conscripts. Lund, Sweden: Berlingska Boktrycheriet 1947;47:58.
11. Pancherz H. The mechanism of Class II correction in Herbst appliance treatment, a cephalometric investigation. Am J Orthod 1982;82:107-13.
12. Holdaway RA. Soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. Am J Orthod 1983;84:1-28.
13. Legan HL, Burstone CJ. Soft tissue analysis for orthognathic surgery. J Oral Surg 1980;38:744-51.
14. Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Jones R, Stephens CD, et al. The development of the PAR index (peer assessment rating): reliability and validity. Eur J Orthod 1992;14:125-39.
15. Feghali R, Nelson S, Hans MG. Comparing orthodontic treatment outcome of two geographically different clinic samples [abstract]. J Dent Res 1997;76:1181.
16. Stellzig-Eisenhauer A, Lux CJ, Schuster G. Treatment decision in adult patients with Class III malocclusion: orthodontic therapy or orthognathic surgery? Am J Orthod Dentofacial Orthop 2002;122:27-38.
17. Enlow DH. Facial growth. 3rd ed. Philadelphia: W.B. Saunders; 1990. p. 200-21, 434-443.
18. Sugawara J, Mitani H. Facial growth of skeletal Class III malocclusion and the effects, limitations, and long-term dentofacial adaptations to chincap therapy. Semin Orthod 1997;3:244-54.
19. Sperry TP, Speidel TM, Isaacson RJ, Worms FW. The role of dental compensations in the orthodontic treatment of mandibular prognathism. Angle Orthod 1977;47:293-9.
20. Casko JS, Shepherd WB. Dental and skeletal variation within the range of normal. Angle Orthod 1984;54:5-17.
21. Dietrich UC. Morphological variability of skeletal Class III relationships as veiled by cephalometric analysis. Cong Eur Orthod Soc 1970:131-43.
22. Guyer EC, Ellis EE, McNamara JA, Behrents RG. Components of Class III malocclusions in juveniles and adolescents. Angle Orthod 1986;56:7-30.
23. Zupancic S, Pohar M, Farcnik F, Ovsenik M. Overjet as a predictor of sagittal skeletal relationships. Eur J Orthod 2008;30:269-73.
24. Ngan P, Hägg U, Yiu C, Merwin D, Wei SH. Soft tissue and dentoskeletal profile changes associated with maxillary expansion and protraction headgear treatment. Am J Orthod Dentofacial Orthop 1996;109:38-49.
25. Baccetti T, Franchi L, McNamara J. Growth in the untreated Class III subject. Semin Orthod 2007;13:130-42.
26. Moullas AT, Palomo JM. Nonsurgical treatment of a patient with a Class III malocclusion. Am J Orthod Dentofacial Orthop 2006;129(Suppl 4):S111-8.
27. Daher W, Caron J. Nonsurgical treatment of an adult with a Class III malocclusion. Am J Orthod Dentofacial Orthop 2007;132:243-51.
28. Musich DR, Busch MJ. Clinical management of the Class III growing patient. Informationen aus Orthodontie & Kieferorthopädie 2008;40:13-26.