Late Growth Period Orthopedic Therapy Versus Bimaxillary Surgery for Correction of Skeletal Class III

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Objective: To compare the effects of late orthopedic therapy with orthognathic surgery in skeletal class III cases.

Materials and Methods: The subjects of the study were divided into 2 groups. Group 1 comprised 15 patients (8 females and 7 males) with a mean age of 14 years 6 months (range, 12 y 10 mo to 15 y 6 mo) and treated with maxillary expansion and a modified maxillary protraction appliance (MMPA). Group 2 comprised 11 patients (6 females and 5 males) treated with bimaxillary surgery (BMS) with a mean age of 23 years (range, 18 y 2 mo to 28 y 4 mo). Lateral cephalometric films were taken before (T_1) and after orthopedic therapy (T_2) in the MMPA group and before surgery (T_1) and after fixed orthodontic therapy (T_2) in the BMS group. Study groups were compared by analysis of variance and Tukey tests at the beginning and at the end of the treatment.

Results: Maxillary forward displacement ($P < 0.01$) and the increase in ANS-Me distance ($P < 0.05$) were higher in the BMS group than in the MMPA group. The mandible exhibited significant posterior rotation in MMPA group ($P < 0.01$). Mandibular effective length decreased in the BMS group and increased in the MMPA group. Soft tissue profile (G-Sn-Pg) improved in both groups ($P < 0.05$) and labiomental angle reduced in the BMS group, whereas an increase was observed in the MMPA group.

Conclusions: Orthognathic surgery can be more effective in patients with increased mandibular length, more anteriorly positioned mandibles, and increased vertical dimensions.

Key Words: Orthopedic therapy, bimaxillary surgery, soft tissues, hard tissues

(*J Craniofac Surg* 2010;21: 741–747)

Class III malocclusion is one of the most challenging skeletodentofacial anomalies in orthodontics and must be diagnosed well for appropriate treatment planning. If significant skeletal discrepancy exists between the mandible and the maxilla, the treatment choices are growth modification and orthognatic surgery.[1–3] Treatment decisions and their success or failure depend highly on the future growth potential of the patient with class III occlusion.[4–13]

If skeletal maturation is used as the criterion for case selection, class III malocclusions can be corrected by orthopedic appliance during growth spurt, and the surgical repositioning of jaw segments can be achieved after termination of craniofacial growth.[1,2,6,10,11] However, disagreement arises about deciding the suitable treatment plan, especially in borderline cases at which few growth potential remains.

There is no absolute consensus in the orthodontic literature about the proper treatment option for patients in the postpubertal growth period. The effects of orthopedic therapy for adolescents[14–26] and orthognathic surgery for adults in skeletal class III correction have been reported extensively.[27–32] However, few reports have been published in the literature, all evaluating the effects of different treatment applications for postpubertal patients and comparing the effects of orthopedic therapy and orthognathic surgery.

Therefore, this study was designed (1) to compare the effects of orthopedic therapy in patients with class III malocclusion in the postpubertal growth period with orthognathic surgery cases at the end of the postpubertal growth period and (2) to assess the various hard and soft tissue outcomes of 2 groups of patients with different treatment modalities and with different growth periods.

MATERIALS AND METHODS

Materials for this study consisted of lateral cephalograms and hand-wrist radiographs that were taken before and after the treatment from 26 patients successfully treated for skeletal class III malocclusion and obtained from the archive of Department of Orthodontics, Faculty of Dentistry, and University of Ankara. The criteria for case selection were as follows:

- Noncleft, nonsyndromic white patients with skeletal (ANB < 0 degrees) and dental class III malocclusion and negative overjet
- Normal vertical growth pattern
- Minimum or moderate crowding in both dental arches
- No previous orthodontic treatment
- Skeletal and dental class I occlusion with normal overjet and overbite and acceptable soft tissue profile at the end of treatment

This study was performed on 2 groups. The first group consisted of 15 patients (8 females and 7 males) treated with maxillary expansion and a modified maxillary protraction appliance (MMPA) designed by Altug and Arslan.[22] Elastics were attached between maxillary hooks to the horizontal bar of the mandibular plate (Figs. 1 and 2). A protraction force of 500*g* per side with an anteroinferior force vector of 20 to 30 degrees to the occlusal plane was applied. Patients were instructed to use the mini maxillary protractor for at least 18 h/d. When a minimum 2-mm overjet with a class I or class II dental arch relationship was achieved, orthopedic therapy was terminated. Mean age at pretreatment in the MMPA group was 14 years 6 months, ranging between 12 years 10 months and 15 years 6 months. The duration of appliance wear was 10 months for each patient.

The second group comprised 11 patients (6 females and 5 males) who underwent bimaxillary surgery (BMS)—Le Fort I

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Received September 25, 2009.
Accepted for publication December 18, 2009.
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The authors report no conflicts of interest.

ISSN: 1049-2275
DOI: 10.1097/SCS.0b013e3181d7a98e

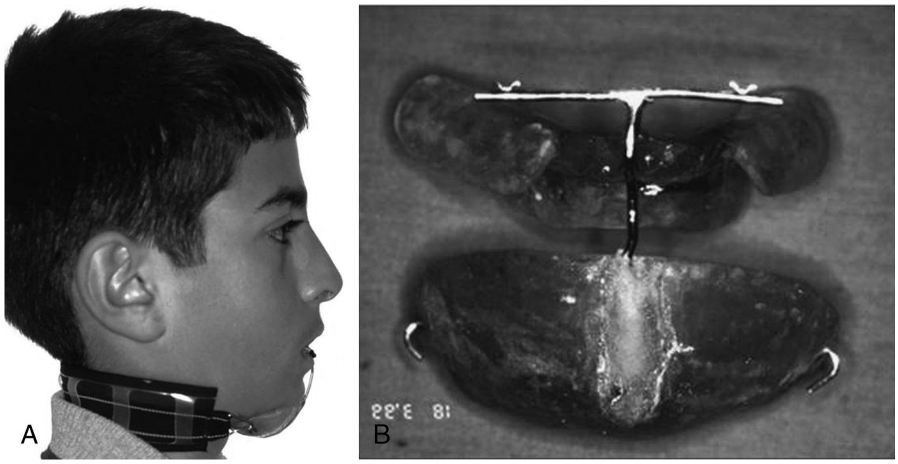

FIGURE 1. Extraoral view (A) and intraoral part (B) of the MMPA.

osteotomy with maxillary advancement and sagittal split ramus osteotomy with mandibular setback. All operations were performed by the same surgeon, and all orthodontic treatments were achieved by one of the authors (H.G.). Mean age at pretreatment in the BMS group was 23 years, ranging from 18 years 2 months to 28 years 4 months, and mean duration of treatment was 27 months.

The skeletal growth potential and skeletal age were assessed by hand-wrist radiographs according to the Greulich and Pyle atlas.[33] At the beginning of the treatment, patients in the MMPA group completed 96.2% of their skeletal growth maturation, whereas the BMS group all consisted of adult subjects who have completed their skeletal growth maturation.

Cephalometric Analysis

The cephalometric records were obtained under standardized conditions by the same technician. Lateral cephalometric films obtained taken before the start and at the end of the orthopedic therapy for the MMPA group. In the BMS group, lateral cephalometric films were obtained before surgical orthodontic treatment and at the end of the fixed orthodontic therapy after the surgery. Lateral cephalograms were traced by pencil on orthodontic 0.003 matte acetate papers. Twelve hard and 10 soft tissue points were double-digitized on the PORDIOS computer program (Purpose on Request Digitizer Input Output System; Institute of Orthodontic Computer Science, Arhus, Denmark; Fig. 3) by one of the authors (V.G.), and 10 hard (Fig. 4) and 11 soft tissue measurements (Fig. 5) were done.

Statistical Method

Descriptive statistics, including means and SDs, was analyzed for each study group. Study groups were compared by analysis of variance and Tukey tests at the beginning and at the end of the treatment.

RESULTS

The comparison of initial cephalometric values of the MMPA and the BMS groups is presented in Table 1. Three hard tissue measurements (GoGn/SN, ANS-Me, Co-Gn) were significantly

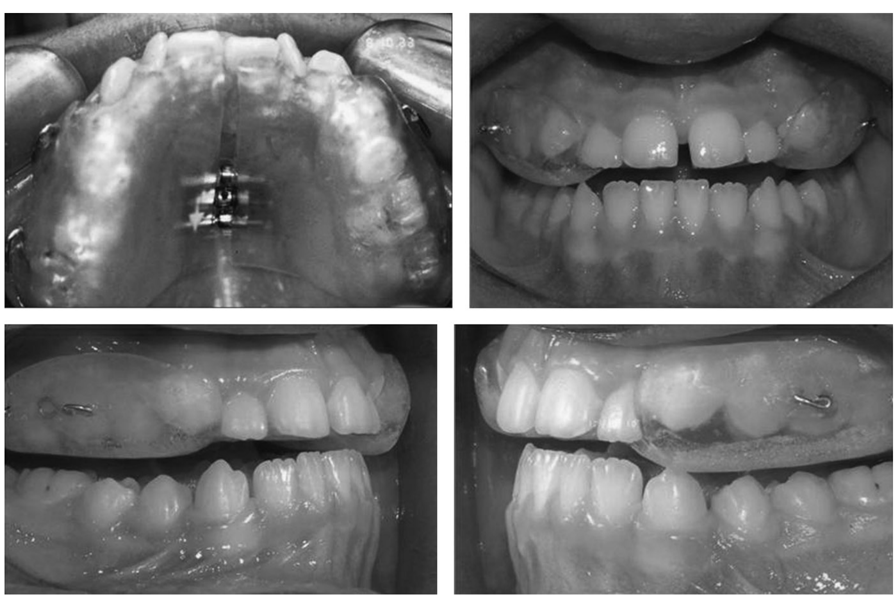

FIGURE 2. Intraoral view of the MMPA.

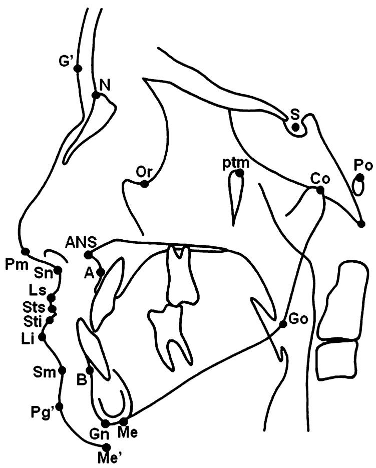

FIGURE 3. Hard and soft tissue points on the lateral cephalogram.

higher in the BMS group than in the MMPA group ($P < 0.01$). Two of the soft tissue measurements (Li-Sm-Pg′ and Sts-Sti) were significantly different between the groups (Table 1).

Skeletal Measurements

In both treatment groups, the sagittal maxillary dimension (Co-A) increased ($P < 0.05$), maxilla (SNA) positioned anteriorly ($P < 0.05$), and the ANB angle increased ($P < 0.05$; Table 2), but the forward displacement of the maxilla (NaPerp-A) was significant only in the BMS group. Although a reducing tendency exists for the variables describing the anteroposterior position of the mandible (SNB and NaPerp-B), no statistically significant differences were observed in the MMPA and in the BMS groups at the end of the treatment (Table 2). However, sagittal mandibular dimension (Co-Gn) decreased significantly in the BMS group ($P < 0.01$), and significant increases were observed both in the mandibular plane angle (Go-Gn/SN) and in the lower anterior facial height (ANS-Me) in the MMPA group ($P < 0.01$; Table 2).

The comparison of differences after treatment between the MMPA and the BMS groups showed that maxillary forward displacement (SNA, $P < 0.05$; NaPerp-A, $P < 0.01$) in the BMS group was significantly higher than that in the MMPA group (Table 3). The increase in ANS-Me distance showing anterior vertical skeletal dimension was higher in the MMPA group ($P < 0.05$). The mandible exhibited posterior rotation (GoGn-SN) in the MMPA group and anterior rotation in the BMS group, and the difference of effects of the 2 treatment groups was significant ($P < 0.01$). A significant difference ($P < 0.01$) was found between the decrease in the BMS group and the increase in the MMPA group after treatment in mandibular effective length (Co-Gn; Table 3).

Soft Tissue Measurements

When soft tissue data were evaluated after the treatment, significant changes in the soft tissue profile were observed (Table 2). Vertical upper lip length (Sn-Sts) significantly increased ($P < 0.05$) and upper lip tip moved anteriorly (SnPerp-Ls) in both groups ($P < 0.05$). Lower lip (SnPerp-Li) and soft tissue pogonion (SnPerp-Pg) moved posteriorly in both groups ($P < 0.05$). Because of these changes, soft tissue profile (G-Sn-Pg) improved in both groups ($P < 0.05$).

Interlabial distance (Sts-Sti) reduced in the MMPA group, whereas an increase was noted in the BMS group, and the difference was significant ($P < 0.01$). Labiomental angle (Li-Sm-Pg′) reduced in the BMS group, whereas an increase was seen in the MMPA group, and the difference was also significant ($P < 0.01$; Table 3).

DISCUSSION

The main objective of the present study was to compare effects of the late-phase orthopedic therapy and orthognathic surgery outcomes of skeletal class III by cephalometric films. Assessment of the treatment outcomes demonstrated considerable facial profile changes and skeletal improvements by both late-phase orthopedic therapy and orthognathic surgery. Because of both treatment approaches, more orthognatic soft tissue profile was achieved and the lips-chin relationship improved.

At the beginning of the treatment, both groups had similar skeletal and soft tissue parameters except skeletal vertical dimension (ANS-Me), mandibular length (Co-Gn), and 2 soft tissue parameters (Li-Sm-Pg′ and Sts-Sti). Skeletal vertical dimension and mandibular length were increased in the BMS group at the beginning of the study. The differences between the groups can be attributed to the differences between the mean ages and the remaining growth potential of the groups. Deguchi et al[34] showed the worsening of the class III skeletal characteristics with growth due to

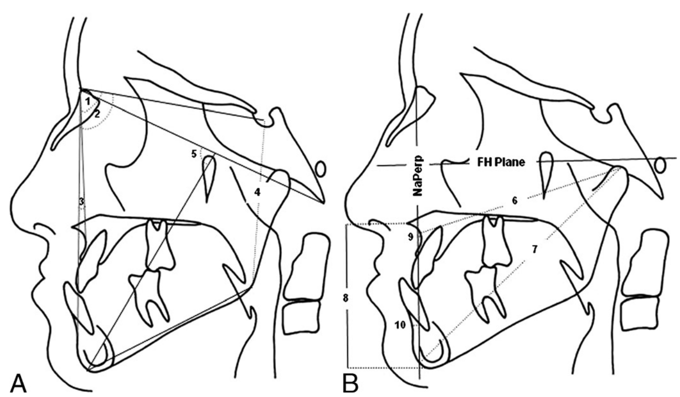

FIGURE 4. Hard tissue measurements made on lateral cephalograms. A, Angular measurements: (1) SNA, angle describing the position of the maxilla; (2) SNB; angle describing the position of the mandible; (3) ANB, angle describing the maxillo-mandibular relation; (4) GoGn/SN, angle describing the vertical change of the mandibular plane; and (5) NaBa-PtmGn, angle showing the rotation of the mandible. B, Linear measurements: (6) Co-A, maxillary length; (7) Co-Gn, mandibular length; (8) ANS-Me, anterior lower facial height; (9) NaPp-A, length describing the sagittal change of the maxilla; and (10) NaPp-B, length describing the sagittal change of the mandible.

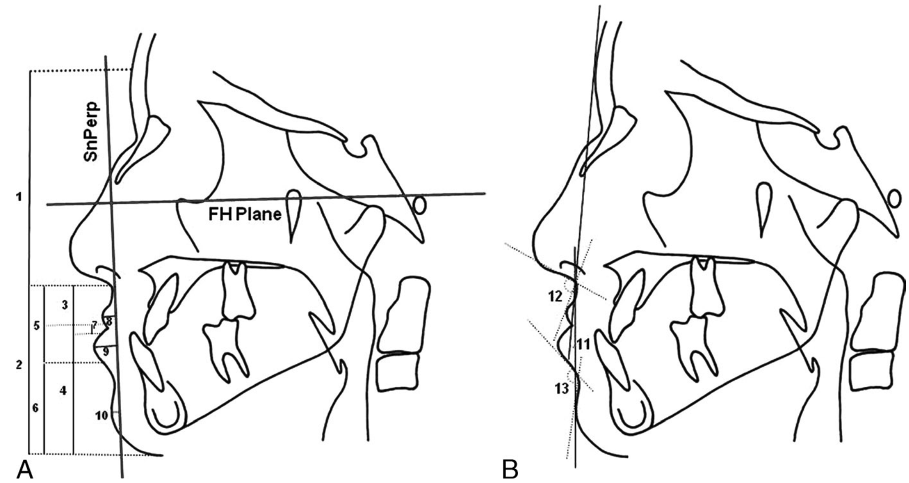

FIGURE 5. Soft tissue measurements. A, Linear measurements: (1) G-Sn, upper facial height; (2) Sn-Me, lower facial height; (3) Sn-Sts, upper lip length; (4) Sts-Me: length describing the vertical change of the upper lip; (5) Sn-Li, length describing the vertical change of the lower lip; (6) Li-Me, lower lip length; (7) Sts-Sti, interlabial gap; (8) SnPerp-Ls, length describing the sagittal change of the upper lip; (9) SnPp-Li, length describing the sagittal change of the lower lip; and (10) SnPerp-Pg, length describing the sagittal change of the soft tissue chin. B, Angular measurements: (11) G-Sn-Pg, facial convexity angle; (12) Pm-Sn-Ls, nasolabial angle; and (13) Li-Sm-Pg′, labiomental angle.

TABLE 1. Comparison of the Pretreatment and Posttreatment Cephalometric Values for the MMPA and BMS Groups

	Pretreatment (T_1)					Posttreatment (T_2)				
	MMPA		BMS			MMPA		BMS		
Parameters	**Mean**	**SD**	**Mean**	**SD**	***P***	**Mean**	**SD**	**Mean**	**SD**	***P***
Hard tissue measurements										
SNA, degrees	77.20	3.84	77	2.09	NS	79.07	3.43	81.36	5.18	NS
SNB, degrees	80.27	4.15	80.73	3.25	NS	78.73	4.39	80.55	4.59	NS
ANB, degrees	−3.07	1.71	−3.73	2.49	NS	0.33	1.59	0.82	1.33	NS
GoGn-SN, degrees	35	4.97	39.64	5.28	*	36.67	4.58	38.27	4.31	NS
Facial axis angle	91.20	3.53	94.64	5.43	NS	92.80	3.97	94.27	4.01	NS
Co-A, mm	82.93	3.65	82.36	3.98	NS	85.40	3.68	85.27	5.93	NS
Co-Gn, mm	118.13	6.39	128.55	6.39	*	118.93	5.93	125.36	4.96	*
ANS-Me, mm	67.40	6.28	77.82	7.67	*	70.60	6.29	78.27	5.14	*
NaPerp-A, mm	−5	4	−7	2.53	NS	−3.60	3.60	−1.73	4.01	NS
NaPerp-B, mm	−2.13	7.81	−3.45	8.17	NS	−4.60	8.59	−3.91	5.56	NS
Soft tissue measurements										
G′-Sn/Sn-Me′, mm	1.02	0.18	1.02	0.18	NS	0.98	0.18	0.97	0.09	NS
Sn-Sts, mm	21	3.68	22.09	3.21	NS	22.8	3.45	23.27	2.57	NS
Sn-Sts/Sts-Me′, mm	0.40	0.06	0.37	0.04	NS	0.42	0.05	0.41	0.04	NS
Sn-Li/Li-Me′, mm	0.56	0.09	0.54	0.08	NS	0.60	0.08	0.60	0.09	NS
Sts-Sti, mm	0.27	0.59	−0.91	0.30	†	0.13	0.35	−0.27	0.47	†
SnPerp-Ls, mm	1.27	1.94	0.55	3.75	NS	1.73	2.02	2.36	2.73	NS
SnPerp-Li, mm	2.57	3.14	2.64	5.26	NS	−0.70	3.40	1	3.44	NS
SnPerp-Pg′, mm	−2.87	4.37	−1.45	8.45	NS	−6.27	6.09	−5.82	5.84	NS
G′-Sn-Pg′, degrees	6.07	4.59	2.73	9.42	NS	10.50	6.46	8.27	6.29	NS
Pm-Sn-Ls, degrees	123	7.85	118.55	19.26	NS	120.80	9.60	115.73	9.52	NS
Li-Sm-Pg′, degrees	141.87	10.34	155.64	10.04	*	142.93	8.71	143.55	12.79	NS

NS, nonsignificant.
*$P < 0.01$.
†$P < 0.05$.

TABLE 2. Comparison of Pretreatment and Posttreatment Cephalometric Measurements in the MMPA and BMS Groups

	MMPA					BMS				
	T_1		T_2			T_1		T_2		
Parameters	Mean	SD	Mean	SD	P	Mean	SD	Mean	SD	P
Hard tissue measurements										
SNA, degrees	77.20	3.84	79.07	3.43	*	77	2.09	81.36	5.18	*
SNB, degrees	80.27	4.15	78.73	4.39	NS	80.73	3.25	80.55	4.59	NS
ANB, degrees	−3.07	1.71	0.33	1.59	*	−3.73	2.49	0.82	1.33	*
GoGn-SN, degrees	35	4.97	36.67	4.58	†	39.64	5.28	38.27	4.31	NS
Facial axis angle	91.20	3.53	92.80	3.97	NS	94.64	5.43	94.27	4.01	NS
Co-A, mm	82.93	3.65	85.40	3.68	*	82.36	3.98	85.27	5.93	*
Co-Gn, mm	118.13	6.39	118.93	5.93	NS	128.55	6.39	125.36	4.96	†
ANS-Me, mm	67.40	6.28	70.60	6.29	†	77.82	7.67	78.27	5.14	NS
NaPerp-A, mm	−5	4	−3.60	3.60	NS	−7	2.53	−1.73	4.01	†
NaPerp-B, mm	−2.13	7.81	−4.60	8.59	NS	−3.45	8.17	−3.91	5.56	NS
Soft tissue measurements										
G′-Sn/Sn-Me′, mm	1.02	0.18	0.98	0.18	NS	1.02	0.18	0.97	0.09	NS
Sn-Sts, mm	21	3.68	22.8	3.45	†	22.09	3.21	23.27	2.57	†
Sn-Sts/Sts-Me′, mm	0.40	0.06	0.42	0.05	†	0.37	0.04	0.41	0.04	†
Sn-Li/Li-Me′, mm	0.56	0.09	0.60	0.08	†	0.54	0.08	0.60	0.09	†
Sts-Sti, mm	0.27	0.59	0.13	0.35	NS	−0.91	0.30	−0.27	0.47	NS
SnPerp-Ls, mm	1.27	1.94	1.73	2.02	†	0.55	3.75	2.36	2.73	†
SnPerp-Li, mm	2.57	3.14	−0.70	3.40	†	2.64	5.26	1	3.44	†
SnPerp-Pg′, mm	−2.87	4.37	−6.27	6.09	†	−1.45	8.45	−5.82	5.84	†
G′-Sn-Pg′, degrees	6.07	4.59	10.50	6.46	‡	2.73	9.42	8.27	6.29	‡
Pm-Sn-Ls, degrees	123	7.85	120.80	9.60	NS	118.55	19.26	115.73	9.52	NS
Li-Sm-Pg′, degrees	141.87	10.34	142.93	8.71	NS	155.64	10.04	143.55	12.79	*

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

continuous advancement of the mandible. Battagel[35] investigated patients with class III and showed that facial development remained active in these individuals and that facial changes continued after the age of 15.

Assessment of the treatment outcomes demonstrated considerable skeletal and soft tissue profile improvements in both groups. The most pronounced skeletal results among the groups were achieved in the BMS group. The maxillary advancement (NaPerp-A = 5.27 mm), maxillary anterior positioning relative to the cranium (SNA = 4.36 degrees), and mandibular set back (Co-Gn = −3.19 mm) resulted in larger improvements in the BMS group. Mandibular plane angle (GoGn/SN = 1.67 degrees) and lower anterior facial height (ANS-Me = 3.20 mm) increased in the MMPA group after treatment. Maxillary impaction procedure and the surgical repositioning of jaw segments enabled to control the vertical skeletal dimensions in the patients from the BMS group. Patients in the MMPA group exhibited significant forward movement (Co-A) and backward rotation (GoGn/SN) of the mandible in relation to the cranial base. The vertical changes observed in the present study were harmonious with those in previous studies.[16,17,19–22]

Significant soft tissue changes were achieved with both treatment modalities in this study. Upper lip protruded, lower lip and chin retruded significantly in both groups, and balanced facial profile was obtained. Similar to our findings in the MMPA group, Allen et al[36] reported significant lower lip retraction with chin cup therapy. Ngan et al[37] recorded significant protrusion of the upper lip and retrusion of the lower lip and showed decrease in both soft tissue pogonion and upper lip thickness and increase in the lower lip thickness with maxillary protraction. Significant forward movement of the upper lip and retrusion of lower lip by maxillary protraction forces were also found in previous studies.[38–40] Patients in the BMS group showed a significant increase in interlabial distance (Sts-Sti) and a significant decrease in labiomental angle (Li-Sm-Pg′). The greater labiomental angle reduction in the BMS group was most likely due to the larger maxillary and mandibular base movements.

Although the MMPA group only had 3.8% of skeletal growth potential at the beginning of the treatment, hard and soft tissue findings of the current study demonstrate that it is possible to reach successful treatment outcomes with the orthopedic treatment not only in the early growth period but also in the late growth period with a proper treatment protocol and with patients who cooperate well. Generally, depending on treatment modality, response ranges for the latest recommended orthopedic therapy were 13.8 years for females[41–43] and 15 years for males[44] chronologically and coincide with 97% completion of skeletal growth potential for patients with class III malocclusion in the literature.[11] Pancherz[10] suggested orthopedic treatment in the postpubertal patients and stated that growth-adaptive therapy with the Herbst appliance is possible even after the age of 20 and that this could thus replace surgery

TABLE 3. Changes That Occurred in Each Group During Treatment and the Comparison of the Changes Between the MMPA and BMS Groups

	T_2–T_1				
	MMPA		BMS		
Parameters	Mean	SD	Mean	SD	*P*
Hard tissue measurements					
SNA, degrees	1.87	1.96	4.36	4.80	*
SNB, degrees	−1.54	1.84	−0.18	4.11	NS
ANB, degrees	3.40	1.35	4.55	2.62	NS
GoGn-SN, degrees	1.67	1.79	−1.37	3.10	†
Facial axis angle	1.60	2.41	−0.37	5.12	NS
Co-A, mm	2.47	2.16	2.91	4.52	NS
Co-Gn, mm	0.80	2.62	−3.19	4.33	†
ANS-Me, mm	3.20	2.30	0.45	4.27	*
NaPerp-A, mm	1.40	1.72	5.27	4.54	†
NaPerp-B, mm	−2.47	4.35	−0.46	8.52	NS
Soft tissue measurements					
G′-Sn/Sn-Me′, mm	−0.04	0.02	−0.05	0.08	NS
Sn-Sts, mm	1.80	1.82	1.18	3.40	NS
Sn-Sts/Sts-Me′, mm	0.02	0.03	0.04	0.06	NS
Sn-Li/Li-Me′, mm	0.04	0.03	0.06	0.04	NS
Sts-Sti, mm	−0.14	0.38	0.64	0.42	†
SnPerp-Ls, mm	0.46	1.30	1.81	2.71	NS
SnPerp-Li, mm	−3.27	1.90	−1.64	4.43	NS
SnPerp-Pg′, mm	−3.40	3.22	−4.37	6.66	NS
G′-Sn-Pg′, degrees	4.43	3.14	5.54	7.01	NS
Pm-Sn-Ls, degrees	−2.20	7.78	−2.82	8.45	NS
Li-Sm-Pg′, degrees	1.06	9.18	−12.09	15.45	†

*$P < 0.05$.
†$P < 0.01$.

especially in milder skeletal class II cases. On the contrary, some authors advocated early surgical intervention during a period of decreasing growth velocity.[4,5,45] They believe that there were psychologic and practical advantages associated with surgery in adolescence patients and that late growth changes after surgery do not affect the stability of adolescent surgical changes.[9]

In patients with borderline class III malocclusion, several other factors must be taken into consideration while deciding the treatment process. One of these factors is patient's cooperation. An important part of orthopedic treatment in class III malocclusion is the use of extraoral appliances. In many cases, patients would prefer to undergo surgical correction rather than to use the extraoral appliances during the desired time.[29,30] Altuğ and Arslan[22] showed that, although it is an extraoral appliance, MMPA therapy is well tolerated by patients because of its comfortable design, and this improves the patient's cooperation. The other factor is patient's expectation from the orthopedic treatment. For this reason, the exact nature of patient's complaints and expectations must be carefully evaluated. The type of treatment should initially be based on the patient's chief complaint. The third factor is the benefit-risk ratio of the possible treatment approaches. Patients should be evaluated regarding the risks and benefits and projected outcomes of each type of treatment. The risks of surgery must always be taken into consideration. Not surprising is that most people may prefer minimally invasive methods to solve their problems. The last factor is the financial part of the treatment approaches. Orthognathic surgery has certainly increased in total cost compared with orthopedic treatment. When comparing orthognathic surgery with orthopedic therapy, the risks and costs associated with surgery are obviously much greater than those of the other treatment option.[29,30]

The objective of the present study was to compare data obtained from different treatment modalities performed in different growth periods. When the patient with mild or moderate class III malocclusion associated with skeletal discrepancy was in the late growth period, some authors recommend waiting until the end of skeletal growth. However, others suggest performing the surgery immediately while the patient has not completed his/her skeletal growth. Each approach mentioned above has some advantages and disadvantages. If the patients have little growth potential owing to the late phase of the growth and do not desire orthognathic surgery, results of the present study demonstrate that MMPAs can be successfully used to achieve harmonious and aesthetically balanced hard and soft tissue structures.

CONCLUSIONS

1. Posterior rotation of the mandible was observed in the orthopedic appliance group, so BMS can be used in patients with increased vertical dimensions.
2. Patients in the BMS group exhibited greater reductions in the mandibular length and in the labiomental angle, so orthognatic surgery is more eligible in patients with increased mandibular length and with more anteriorly positioned mandibles.
3. Modified maxillary protraction appliance can be a preferable alternative to orthognathic surgery especially in borderline mild to moderate skeletal class III cases if the condition of a patient is diagnosed well.

ACKNOWLEDGMENT

The authors thank Dr Ayşegül Dalkıran Arslan for her participation in the study with the cases treated by MMPA.

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