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Comparison of the effects of Twin Block and activator treatment on the soft tissue profile

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SUMMARY The aim of this study was to evaluate and compare the effects of activator and Twin Block (TB) appliances on the soft tissue profile. The study included 50 skeletal Class II patients (25 girls and 25 boys, mean age: 11.9 ± 0.16 years) who were randomly allocated to one of two functional appliance treatment groups. The control group included 25 untreated skeletal Class II patients (13 boys and 12 girls, mean age: 10.11 ± 0.91 years). Data were obtained from standardized lateral cephalograms taken at the beginning (T0) and end (T1) of appliance wear. The mean treatment time was 9 months for the activator group and 8 months for the TB group. The observation period of the control group was 8 months. Soft tissue profile changes were evaluated by means of 12 linear and five angular measurements. The groups were compared at T0 and T1 using analysis of variance, and treatment/observation differences (T1–T0) were evaluated with the Kruskal–Wallis test.

Treatment changes in both appliance groups differed significantly ($P \leq 0.001$) from those in the control group, except for Ss–γ, Ls–γ, Li–E, and A–γ measurements in the TB group and Ls–γ, Li–E, nasolabial angle, and A–γ measurements in the activator group. When the effects of the two appliances were compared, significant differences were observed only for SS–γ ($P \leq 0.05$), Ss–E ($P \leq 0.05$), Si–E ($P \leq 0.05$), and nasolabial angle ($P \leq 0.01$). The effects of the activator and TB appliances on the soft tissue profile were similar; both significantly changed the soft tissue profile.

Introduction

Aesthetic improvement is highly valued by patients seeking orthodontic treatment (Dann *et al.*, 1995). Subjects with a Class II malocclusion are a good example of patients who are referred to orthodontists primarily for aesthetic improvement (Dann *et al.*, 1995).

In growing patients, two-phase treatment of Class II skeletal malocclusions, which includes growth modification with functional appliances followed by orthodontic treatment with fixed appliances, has been advocated as an appropriate treatment approach (Keeling *et al.*, 1998; Tulloch *et al.*, 2004). As with all orthodontic treatment modalities, the primary goals of growth modification are both to correct the skeletal discrepancy and to achieve optimal facial aesthetics.

One of the most widely used functional appliances for orthopaedic correction of Class II skeletal malocclusions is the activator, which was introduced by Andresen in 1935 (Graber, 2005). The skeletal and dentoalveolar effects of activators have been well documented (Harvold and Vargervik, 1971; Calvert, 1982; Pancherz, 1984; Vargervik and Harvold, 1985; Lux *et al.*, 2001; Başçiftçi *et al.*, 2003).

Another popular functional appliance is the Twin Block (TB). Due to its simple design and ease of use, the TB can be worn 24 hours a day and takes full advantage of all the functional forces applied to the dentition, including those of mastication. Another advantage of the TB is that it can be used with fixed appliances (Clark, 1982, 2002).

The purpose of this study was to assess and compare the soft tissue profile changes produced by the TB and activator appliances, both with each other and with the changes resulting from natural growth alone.

Subjects and methods

The sample size for the groups was calculated based on a significance level of 0.05 and a power of 80 per cent to detect a clinically meaningful difference of 1 mm (±1.5 mm) for the distance of the lower lip to E plane between the three groups. The power analysis showed that 18 patients in each group were required. To compensate for withdrawals or dropouts, it was planned to include at least 20 patients in each group.

Fifty Class II division 1 children (25 boys and 25 girls) with a mean age of 11.9 ± 0.16 years were chosen from the patients attending the Department of Orthodontics, Gazi University, and randomly assigned to either the TB or activator treatment group for first-phase orthodontic treatment. Twenty-four pairs consisting of a boy and a girl were formed. A random numbers table and balanced randomization method with a block of eight was used to achieve approximately equal number of boys and girls in each group. The remaining boy and girl were allocated to one of the two treatment groups by tossing a coin. Finally, there were 12 boys and 13 girls in the TB group and 13 boys and 12 girls in the activator group. The patients and their

parents were informed about the aim of the study, two-phase orthodontic treatment and the appliances, and consent was obtained.

Inclusion criteria for the treatment groups were as follows:

1. Class II molar relationship and overjet ≥5 mm.
2. Skeletal Class II pattern (ANB > 4) with retrognathic mandible (SNB<78°).
3. Optimal mandibular plane angle (GoGn/SN: 32 ± 2°).
4. Subjects exhibiting maximal pubertal growth at the beginning of treatment and
5. No previous history of orthodontic therapy.

The control group comprised 13 boys and 12 girls with a mean age of 10.11 ± 0.91 years that met the criteria but who refused treatment with either appliance. These patients were placed on the department's waiting list for one-phase orthodontic treatment.

Maximum pubertal growth was defined on hand-wrist radiographs (the MP3 cap stage, the epiphysis of the middle phalanx of third finger caps its diaphysis) (Hägg and Taranger, 1982). Hand-wrist radiographs are included in the standard clinical records when treatment with growth modification is planned.

The working bites for both activator and TB appliances were taken with the incisors in an edge-to-edge relationship and 3–4 mm bite opening between the central incisors. The appliances were fabricated in the same laboratory. The patients were instructed to wear the TB full-time and the activator for 12 hours per day. Treatment was discontinued when a Class I molar relationship was achieved. The mean treatment time was 9 months for the activator group and 8 months for the TB group. The observation period of the control group was 8 months. After the first-phase treatment/observation period, orthodontic treatment with fixed appliances was initiated.

The soft tissue changes were evaluated in all groups on standardized lateral cephalograms taken with the same cephalostat before (T0) and after (T1) functional appliance therapy. All subjects were positioned in the cephalostat with their sagittal plane at a right angle to the path of the X-rays, their Frankfort horizontal plane parallel to the floor, their teeth in occlusion, and their lips in a relaxed position.

The lateral cephalograms were traced on acetate paper using a 0.3 m diameter lead pencil. All tracings and measurements were made by the same investigator (SKV). The cephalometric lines and angles used are shown in Table 1 and the landmarks and linear and angular measurements in Figures 1 and 2. All the measurements were recorded to the nearest 0.5 degree and 0.5 mm.

Statistical analysis

Ten randomly selected cephalograms from each group were retraced 10 days after the first tracing and Dalhberg's (1940) formula was used to determine the method error, which did not exceed 1 mm and 1 degree.

Table 1 Cephalometric lines and angles used to evaluate changes in soft tissue profile.

Lines	
y-axis (PMV plane)	A line passing through the intersection of the greater wings of the sphenoid with the floor of the anterior cranial fossa (Se point) and the inferior, and most posterior point on the anterior outline of the pterygomaxillary fissure (ptm point)
E line	Aesthetic line of Ricketts, extending between the nose tip and soft tissue pogonion
Profile line	Line tangent to the soft tissue chin and most prominent lip
Mandibular plane	Plane running through gonion and menton
Frankfort horizontal plane	Horizontal plane running through porion and orbitale
Axial inclination of maxillary incisor	
Axial inclination of mandibular incisor	
Angles	
Nasolabial angle	Angle formed by the intersection of a line originating from subnasale, tangent to the lower margin of the nose and a line between Sn and labrale superior
Labiomental angle	
Z angle	Inner inferior angle formed by the intersection of the Frankfort horizontal plane and profile line
U1–APog	Angle formed by the intersection of the APog line and maxillary incisor axis
L1–Apog	Angle formed by the intersection of the APog line and mandibular incisor axis
IMPA	Angle formed by the of the mandibular incisor axis and mandibular plane
U1–SN	Inner inferior angle formed by the maxillary incisor axis and SN line

As there were no significant differences between genders for any of the measurements, their data were pooled. All the measurements were tested for group differences with respect to their T0 and T1 values and T1 − T0 (difference) values. The groups were compared at T0 and T1 with analysis of variance. When differences were found, Tukey's HSD method of multiple comparisons was used to test the significance of individual groups. Treatment/observation differences between the three groups were analyzed by Kruskal–Wallis, as T1−T0 values revealed asymmetric distribution. When a statistically significant difference was determined, a multiple comparison test was used. The significance level was set at $P < 0.05$.

Results

Comparison of the groups at T0 and the differences between T0 and T1 values are shown in Table 2.

Analysis of variance revealed that there were no significant differences between the groups at T0, except for Li–E measurement. Comparison of the groups at T1 showed

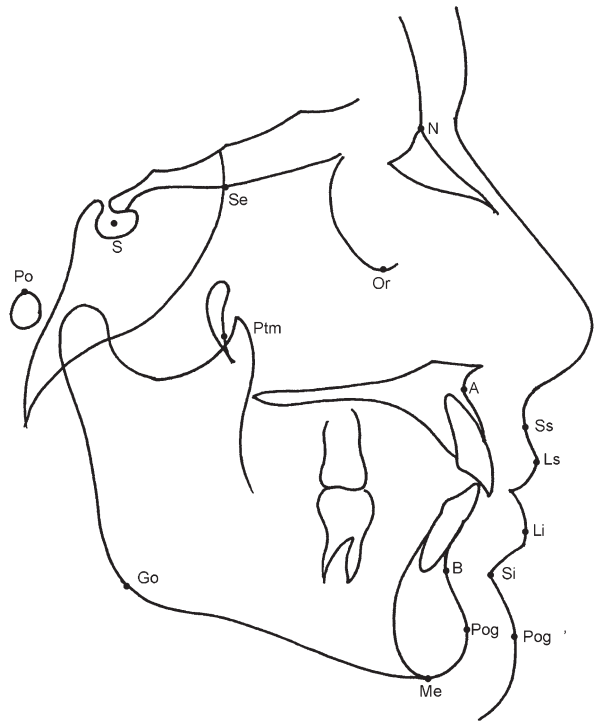

Figure 1 Landmarks used in the study: S = sella, Na = nasion, Or = orbitale, Ss = sulcus superior, Ls = labrale superior, Li = labrale inferior, Si = sulcus inferior, Pog' = soft tissue pogonion, A = point A, B = point B, Pog = pogonion, Me = menton, Go = gonion, Po = porion, Se = intersection of greater wings of the sphenoid with the floor of the anterior cranial fossa, and ptm = inferior and most posterior point on the anterior outline of the pterygomaxillary fissure.

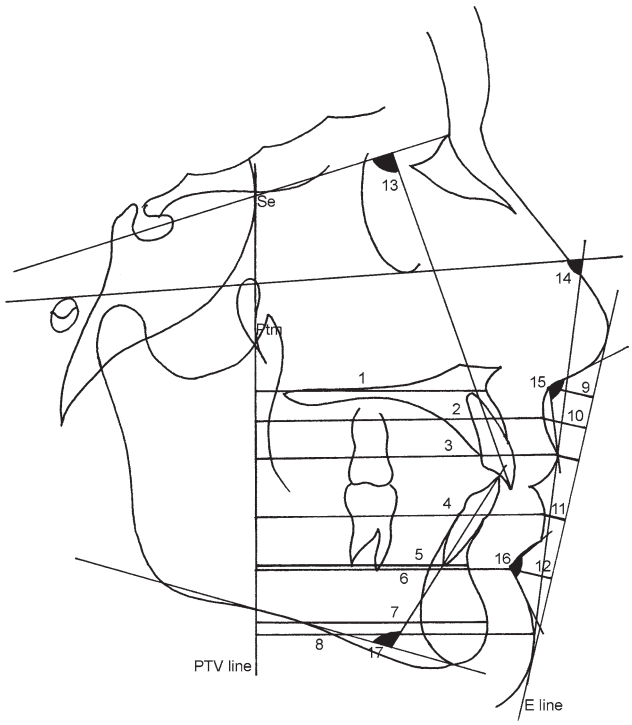

Figure 2 Linear and angular measurements: (1) A–y, (2) Ss–y, (3) Ls–y, (4) Li–y, (5) B–y, (6) Si–y, (7) Pog–y, (8) Pog'–y, (9) Ss–E, (10) Ls–E, (11) Li–E, (12) Si–E, (13) U1–SN, (14) Z angle, (15) nasolabial angle, (16) labiomental angle, (17) IMPA.

that the activator and control groups significantly differed from each other when Si–y, Pog'–y and B–y, Ss–E, Ls–E, B–y, and Pog–y measurements were taken into consideration. These measurements were greater in the activator than in the control group. In addition, Ss–E, Ls–E and Pog–y measurements and labiomental angle were significantly greater in the TB group than in the control group. No significant difference was found between the activator and TB groups at T1.

Comparison of the changes in the variables (T1−T0) resulting from growth in the control group and treatment in the TB and activator groups are shown in Table 3.

Sulcus superior moved forward significantly ($P \leq 0.01$) in the activator group but remained unchanged in the control and TB groups. When the treatment/observation changes were compared, sulcus superior in the activator group was significantly different from the changes in the control and TB groups ($P \leq 0.01$ and $P \leq 0.05$, respectively).

The distances between the vertical reference line and the labrale superior (Ls–y) and the labrale inferior and aesthetic plane (Li–E) remained unchanged in all three groups. Sulcus inferior, pogonion, and soft tissue moved significantly forward with respect to the vertical reference line in both treatment groups ($P \leq 0.001$). These changes were significantly different from the control group ($P \leq 0.001$), but no difference was observed between the treatment groups. Labrale inferior also moved forward with respect to the vertical reference line, both in the activator and TB groups ($P \leq 0.01$). No difference was seen between the treatment groups when changes due to treatment were considered; however, both were significantly different from the control group ($P \leq 0.001$).

Sulcus superior and labrale superior moved backwards relative to the aesthetic plane in both treatment groups (TB: $P \leq 0.001$ and activator: $P \leq 0.01$). A significant difference was found between the changes in both treatment groups and the control ($P \leq 0.001$) and between the two treatment groups ($P \leq 0.05$). Sulcus inferior moved backwards relative to the aesthetic plane only in the TB group ($P \leq 0.001$). When the differences between the changes were evaluated, significant differences were observed between the control group and both treatment groups (TB: $P \leq 0.001$, activator $P \leq 0.05$) and between the TB and activator groups ($P \leq 0.05$).

The nasolabial angle increased significantly only in the TB group ($P \leq 0.05$). When the treatment/observation changes were compared, the control and TB groups ($P \leq 0.05$) and the TB and activator groups ($P \leq 0.01$) were significantly different.

Table 2 Pre- and post-treatment/observation values of each group. Differences between the three groups at T0 or at T1 were examined by one-way analysis of variance.

Measurement	T0							T1						
	Control (C), $n=25$		Twin Block (TB), $n=25$		Activator (A), $n=25$		Significance	C		TB		A		Significance
	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD	
Ss–y	60.7	3.5	60.7	3.0	61.21	4.1	NS	60.8	3.2	61.6	3.3	62.5*	3.9	NS
Ls–y	63.2	4.5	62.5	3.1	64.4	3.6	NS	63.6*	4.6	63.9	3.2	65.0	3.6	NS
Li–y	58.8	4.8	56.2	3.8	58.5	4.9	NS	59.3	4.8	59.5**	4.9	61.5*	5.0	NS
Si–y	46.2	4.3	45.8	3.7	47.9	4.2	NS	46.9	4.1	50.3***	4.1	52.7***	4.5	A–C**
Pog'–y	48.0	4.6	47.8	3.7	49.5	5.5	NS	48.6	4.4	52.3***	4.1	54.4**	6.5	A–C*
Ss–E	−6.3	1.6	−6.7	1.6	−6.3	2.4	NS	−6.0	1.4	−8.2**	1.2	−8.9***	2.2	TB–C,** A–C***
Ls–E	−0.6	2.1	−0.9	2.2	−1.4	4.5	NS	−0.5	2.0	−3.2***	2.1	−3.0	2.9	TB–C*, A–C*
Li–E	1.0	2.1	−1.4	2.3	−1.2	2.9	*MB–C	0.7	2.0	−1.5	2.1	−1.0	3.0	NS
Si–E	−7.4	1.5	−8.3	1.8	−7.3	2.7	NS	−7.4	1.5	−7.2*	1.3	−6.8	2.7	NS
Nasolabial angle	108.9	11.8	108	14.4	111	13.1	NS	109.1	11.7	114	7.9	110.4	9.9	NS
Labiomental angle	91.4	22.2	92.4	15.7	91.3	22.3	NS	92.2	22.2	109**	11.7	107.4***	16.8	TB–C*
Z angle	66.1	5.4	67.6	4.4	66.4	5.5	NS	66.4	5.1	73.0*	9.7	71.5***	7.2	NS
IMPA	96.8	2.7	96.3	3.5	96.5	2.3	NS	96.8	2.9	98.1***	3.3	99.3***	3.0	NS
U1–SN	106.3	6.7	103.9	4.7	104.6	5.2	NS	106.5	6.6	101.3***	4.3	94.8	26.4	NS
A–y	45.8	2.4	45.6	2.8	46.1	3.4	NS	45.6	2.5	46.8*	3.8	46.3	3.1	NS
B–y	34.7	4.9	34.8	3.6	35.5	4.7	NS	35.1	4.3	39.1**	5.2	40.2***	5.8	A–C*
Pog–y	35.5	5.4	37.4	4.9	37.4	5.9	NS	36.4	4.9	40.5***	5.4	42.1***	6.7	A–C, *TB–C*

*$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$; NS, not significant.

Labiomental angle, Z angle, and IMPA increased significantly in both treatment groups ($P \leq 0.001$). Changes in all three angles in both treatment groups were significantly different from the control ($P \leq 0.001$).

The angle between the sella–nasion plane and the maxillary central incisor decreased significantly in the TB group ($P \leq 0.001$). When the changes in the three groups were compared, both treatment groups showed a significant difference from the control group ($P \leq 0.001$).

Point A moved significantly forward only in the TB group ($P \leq 0.05$) and treatment/observation changes did not differ significantly. Point B moved forward in both the activator and TB groups ($P \leq 0.01$ and $P \leq 0.001$, respectively). Changes in both treatment groups were significantly different from the control group ($P \leq 0.001$), but no difference was observed between the treatment groups.

Discussion

The aim of this study was to evaluate and compare the effects of TB and activator appliances on the soft tissue profile. The results showed that both functional appliances had a pronounced effect.

Nanda *et al.* (1990) studied longitudinal growth changes in the soft tissue profile between the ages of 7 and 18 years and found that most soft tissue growth changes at the nose, lips, and chin showed sexual dimorphism. They reported that growth of upper lip was completed in 93 per cent of girls and in 82 per cent of boys by 7 years of age. The rates for the lower lip were 89 and 85 per cent, respectively. In the present study, no change was observed in these measurements in the control group. This lack of facial growth was probably due to the short observation time.

The most pronounced effects of the activator and TB appliances were the significant forward movement of the mandibular landmarks with respect to the vertical reference line. Evidently, mandibular advancement was the primary reason. Additionally, significant proclination of the mandibular incisors at the end of functional appliance use or the pre-treatment distance of the maxillary incisors to the lower lip at T0 (Veltkamp *et al.*, 2002), might have contributed to forward movement of the lower lip. In several studies concerning soft tissue profile effects of Class II functional appliances, similar changes have been reported (Bishara and Ziaja, 1989; Kasai, 1998; Morris *et al.*, 1998; McDonagh *et al.*, 2001; Cozza *et al.*, 2004; Sharma and Lee, 2005; Quintão *et al.*, 2006).

Upper lip adaptation to incisor retraction is still controversial. Roos (1977) reported a mean ratio for maxillary incisor retraction to upper lip retraction of 2.24:1. The same ratio was found to be 2.24:1 by Perkins and Staley (1993), 2.38:1 ± 1.67 by Kasai (1998), and 1:0.70 ± 0.05 by Ramos *et al.* (2005). These studies used linear measurements to determine positional changes of the incisors. In the present investigation, 1–SN angle value was used. In both activator and TB groups, a decrease in 1–SN angle indicated

Table 3 Differences between the groups during the treatment/observation period (T1−T0) examined by Kruskal–Wallis test.

Measurement	Control (C), $n=25$		Twin Block (TB), $n=25$		Activator (A), $n=25$		Group difference		
	Mean	SD	Mean	SD	Mean	SD	C–TB	C–A	TB–A
Ss–y	0.08	0.41	−0.3	2.48	1.28	1.90	NS	**	*
Ls–y	0.28	0.70	1.50	3.22	0.23	2.41	NS	NS	NS
Li–y	0.23	1.03	3.10	3.35	3.35	4.48	***	***	NS
Si–y	0.45	1.37	4.13	3.21	4.60	3.62	***	***	NS
Pog'–y	0.33	1.89	4.58	3.17	4.98	4.29	***	***	NS
Ss–E	0.18	0.67	−1.60	1.73	−2.65	1.79	***	***	*
Ls–E	0.03	0.44	−2.23	1.75	−1.45	3.91	***	***	NS
Li–E	−0.20	0.55	−0.03	1.94	0.20	1.86	NS	NS	NS
Si–E	0.03	0.44	1.35	1.32	0.20	2.68	***	*	*
Nasolabial angle	0.10	0.48	6.23	3.10	−0.80	2.83	*	NS	**
Labiomental angle	0.50	1.45	16.35	15.95	16.87	14.26	***	***	NS
Z angle	0.28	0.82	5.68	6.50	5.60	4.06	***	***	NS
IMPA	0.04	0.46	1.86	0.95	2.71	1.38	***	***	NS
U1–SN	0.25	0.47	−2.61	0.91	−2.82	0.90	***	***	NS
A–y	−0.14	0.53	1.21	1.91	0.14	3.05	NS	NS	NS
B–y	0.39	1.53	4.37	4.30	4.68	3.57	***	***	NS
Pog–y	0.65	1.74	3.65	5.74	0.65	1.74	***	***	NS

*$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$; NS, not significant.

significant maxillary incisor retraction; however, soft tissue points related to the upper lip (labrale superior and sulcus superior) did not reveal a change relative to the vertical reference line (Table 2). Sulcus superior moved forward in the activator group but did not change significantly in the control or TB groups. According to Ramos *et al.* (2005), translatory retraction of the incisors results in more upper lip retraction. Incisor retraction in the present study was accomplished mostly by retraction of the incisal edge, with a slight backward displacement of the cervical point. Probably this tipping movement resulted in less change in the upper lip. Morris *et al.* (1998) also did not find a significant change in upper lip landmarks after Bass, bionator, and TB therapy. Similarly, Lange *et al.* (1995) reported only a minimal change in the upper lip following bionator treatment. However, this finding differs from that of Sharma and Lee (2005) who showed that maxillary incisor retraction was followed by advancement of the upper lip after treatment with TB and mini-block appliances. Hershey (1972) noted great variability in upper lip movement as a function of incisor retraction.

The purpose of using the E plane as a reference was not to quantify the changes but to determine whether a desirable lip relationship was achieved when the change in soft tissue pogonion was considered. At T1, the mean value of the Li–E plane in both appliance groups was very close to its normal value (Table 2; Athanasiou, 1995).

For a balanced soft tissue profile, the nasolabial angle should be in the range of 90–120 degrees (Sarver, 1998). In the present study, the nasolabial angle was close to normal at T0 in all the groups and increased slightly in the TB group. These alterations were either due to a change in the nasal base or upper lip position; therefore, the unchanged values for nasolabial angle could be explained by the fact that upper lip position did not change significantly with respect to the vertical reference line. Similarly, Lange *et al.* (1995) and Quintão *et al.* (2006) did not find a statistically significant change in nasolabial angle after treatment with TB appliances. Morris *et al.* (1998) reported an increase in the nasolabial angle which was not statistically significant after treating Class II patients with three different functional appliances. Nanda *et al.* (1990) reported a mean value for the mentolabial angle of 125.3 ± 8.4 degrees and 136 ± 11.6 degrees at 7 years of age and 125.1 ± 12.9 degrees and 127.1 ± 12.9 degrees at 18 years of age for boys and girls, respectively. In the present study, due to eversion and trapping of the lower lip below the upper incisors, T0 values for the labiomental angle were low. Reduction of the overjet resulted in the uncurling of the lower lip, which in turn led to a significant increase in the labiomental angle in both activator and TB groups.

The significant difference in the Z angle observed in both the TB and activator groups was the result of anterior movement of soft tissue pogonion. Z angle values for the treatment groups at T1 were close to the mean value of 78 ± 5 degrees (Bishara *et al.*, 1985).

At T1, significant differences were seen between the activator and control group for Si–y, Pog'–y, Li–y, Ss–E, Ls–E, B–y, and Pog–y measurements. In addition, significant differences were observed between the TB and control group for Ss–E, Ls–E and Pog–y measurements and labiomental angle (Table 2). The treatment changes

(T1−T0), which were very similar in both treatment groups, seemed to generate different effects on the T1 values. One reason might be that at T0, although no significant difference was found, Si–y, Pog–y, and B–y values were greater in the activator group and the labiomental angle was greater in the TB group.

When the changes in the two treatment groups were evaluated, the measurements, which revealed statistically significant differences, were SS–y, SS–E, and Si–E measurements (Table 3). The most pronounced treatment changes were approximately 3.5–4.5 mm and were observed at the mandibular soft tissue landmarks. This difference might seem of little importance; however, according to profile studies, a change of a few millimeters in one feature can alter the aesthetics of the rest of the face (Romani *et al.*, 1993; Bowman and Johnston, 2000). Relatively high standard deviations of treatment change values for mandibular soft tissue landmarks reflected a large variation in individual patient response. This variation might have been due to differences in soft tissue thickness.

The stability of the results achieved by functional appliance therapy has been a major concern. Continued skeletal growth can affect the skeletal and dental changes, which could result in soft tissue alterations. For this reason, efficient orthopaedic retention should be used. For the patients in this study, the first phase of treatment was directly followed by a second phase of fixed orthodontic treatment; therefore, an orthopaedic retention protocol was not used. At the end of the second phase, retention with either Hawley retainers or bonded lingual retainers was initiated. Nevertheless, it should be borne in mind that even if a patient has a straight profile at the end of treatment, during the post-adolescent growth period, the lower facial profile may become increasingly concave due to differential growth of the nose, lips, and chin (Formby *et al.*, 1994; Bishara *et al.*, 1998).

Conclusions

1. Growing Class II division 1 patients revealed significant profile changes after TB and activator treatment.
2. The effects of activator and TB treatment on the soft tissue profile were similar; they both significantly changed the soft tissue profile. Among the evaluated measurements, their effects differed from each other only for the measurements Ss–y, Ss–E, and Si–E and nasolabial angle.
3. The most pronounced effects of both appliances were forward movement of mandibular soft and hard tissue landmarks.
4. Values defining the differences between T0 and T1 (Table 3) were subject to a large range of values, demonstrating a large variation in individual response.
5. Longitudinal studies are required to evaluate the stability of the observed soft tissue changes.

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