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Three-dimensional bimetric maxillary distalization arches compared with a modified Begg intraoral distalization system

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SUMMARY The purpose of this study was to compare the dentofacial effects of two intraoral molar distalization techniques [three-dimensional bimetric maxillary distalization arches (3D-BMDA) and a modified Begg intraoral distalization system (MBIDS)] in subjects requiring maxillary molar distalization. Twenty-one patients (12 females and 9 males, mean age pre-treatment: 14.7 ± 1.50 years) were treated with the 3D-BMDA and 17 (14 females and 3 males, mean age pre-treatment: 14.4 ± 1.43 years) with the MBIDS. Measurements were recorded from lateral cephalometric radiographs taken at two different points in time: at the start of treatment for the MBIDS group and prior to distalization for the 3D-BMDA group (T_1) and post-distalization (T_2). Student's *t*- and paired *t*-tests were used to determine differences between and within the groups.

The total amount of distalization for the 3D-BMDA and MBIDS groups was similar (3.55 and 3.27 mm, respectively). However, there were statistically significant differences in the length of the distalization period (3.4 and 6.5 months, respectively) and the amount monthly of distalization (1.11 and 0.54 mm, respectively). The most significant differences were observed in the mandibular dental arches and vertical facial dimensions. Anchorage loss in the mandible was greater in the 3D-BMDA group, whereas increases in facial dimensions were greater in the MBIDS group. Both 3D-BMDA and MBIDS techniques were found to be effective to obtain distal movement of the maxillary molars. In order to achieve successful results, the side-effects of each treatment modality on dentofacial structures need to be taken into consideration.

Introduction

Three-dimensional bimetric maxillary distalization arches (3D-BMDA) was introduced for the correction of Class II malocclusions by Wilson (1978) and Wilson and Wilson (1980, 1984, 1987, 1988). With this system, the maxillary molars are distalized using an open coil spring and Class II elastics (Wilson and Wilson, 1987, 1988).

The dental and skeletal effects of the 3D-BMDA have been previously evaluated (Muse *et al.*, 1993; Yuksel *et al.*, 1996; Rana and Becher, 2000; Ucem *et al.*, 2000; Altug-Atac and Erdem, 2007); however, there are no publications evaluating the effects of the 'modified Begg intraoral distalization system (MBIDS)'. The purpose of this study was to introduce a MBIDS and compare the effects of the 3D-BMDA and the MBIDS on dentofacial structures in subjects requiring maxillary molar distalization.

Subjects and methods

The subjects were randomly selected from among those referred to the Department of Orthodontics of Ankara University. Informed consent was obtained from each patient or his/her parent prior to treatment.

The inclusion criteria were as follows:

1. Skeletal Class I or Class II malocclusion and a dental Class II relationship on both sides;
2. Non-extraction treatment plan;
3. SN/GoGn angle less than 40 degrees;
4. No/minimal crowding in the mandibular dental arch;
5. Erupted maxillary and mandibular second molars in occlusion.

Table 1 shows the gender and age and the distalization periods of the subjects in each treatment group. Although 50 patients were initially selected for inclusion in the study, 12 were later excluded due to problems of non-cooperation during treatment. The patients were randomly selected and distributed to the treatment groups without regard for gender. As a result of both randomization and dropout, although the number of females in each group were similar (3D-BMDA = 12 and MBIDS = 14), the number of males varied significantly (3D-BMDA = 9 and MBIDS = 3).

In the 3D-BMDA group, a full-bonded mandibular dental arch was used as an anchorage unit for Class II elastics (Figure 1a–c), with a 0.019 × 0.025 inch lower archwire to increase anchorage. The elastic load reduction principle (Wilson and Wilson, 1988) was modified for each patient, with an initial elastic force of approximately 175–185g applied by adjusting the load until the 3D-BMDA was seated inside the 0.022 inch straight wire bracket slot. The patients were examined at 10 day intervals, and the elastic loads were checked and adjusted at each visit.

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Table 1. The mean (X), standard errors (Sx), and minimum (min) and maximum (max) values of the age, gender, and distalization periods of the subjects in the treatment groups.

	n		Pre-distalization chronological age (year)				Distalization period (year)			
			X	Sx	Min	Max	X	Sx	Min	Max
Three dimensional bimetric maxillary distalizing arches	21	F: 12 M: 9	14.70	1.50	12.67	16.25	0.28 3.4 months	0.10	0.16	0.5
Modified Begg intraoral distalizing system	17	F: 14 M: 3	14.40	1.43	12.00	16.58	0.54 6.5 months	0.17	0.25	0.83

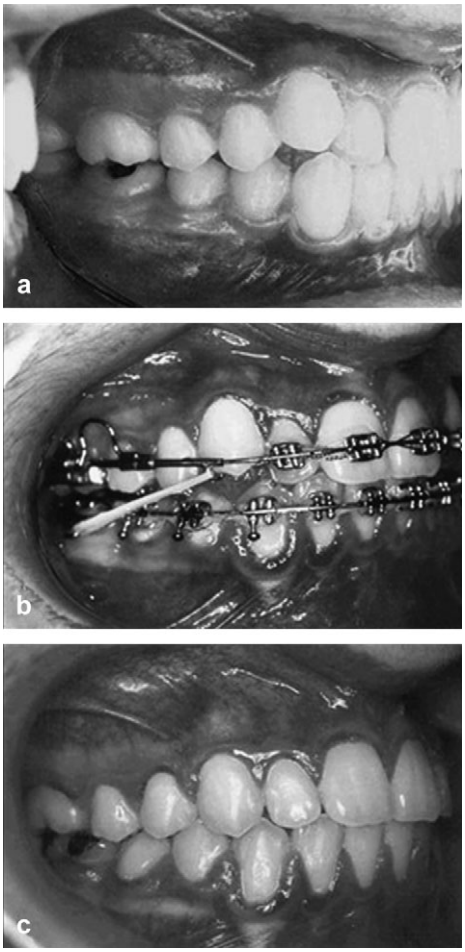


Figure 1 Three-dimensional bimetric maxillary distalization arches (3D-BMDA); in a 16-year-old female patient treated by 3D-BMDA. (a) Occlusion before maxillary molar distalization, (b) 3D-BMDA in place supported by intermaxillary Class II elastics, and (c) occlusion after 3D-BMDA therapy.

In the MBIDS group, both maxillary and mandibular dental arches (including mandibular second molars) were banded and bonded with Begg fixed appliances. The maxillary distalization arch was prepared using a 0.018 inch special plus Australian wire (TP Orthodontics, La Porte, Indiana, USA) consisting of bilateral vertical loops with two helixes resting mesial to the maxillary molar tubes. A plain mandibular archwire (0.018 inch) bent with anchorage bends to reinforce the molar anchorage was used. Uprighting springs were also added to the mandibular first and second premolars to prevent mesial drift of the mandibular molars from the Class II elastics (Figure 2a–d). For each patient, an initial elastic force of approximately 80–85g was applied by adjusting the load until the distalization arch was seated inside the Begg bracket slot.

Lateral cephalometric radiographs were taken for both groups at two different time points: at the start of treatment for the MBIDS group and just prior to distalization for the 3D-BMDA group (T_1) and after molar distalization was complete (T_2).

A total of 11 angular and 25 linear parameters were measured in order to determine differences in the effects of the 3D-BMDA and the MBIDS. Total structural superimpositions were used to evaluate craniofacial and soft tissue changes (Björk and Skieller, 1983). Reference planes were drawn on T_1 and transferred to T_2 radiographs, using sella–nasion (S–N) plane as the horizontal reference plane and the perpendicular to SN through point S as the vertical reference plane. Maxillary and mandibular local superimpositions were used to evaluate dentoalveolar changes. Maxillary local superimpositions were established along the palatal plane (ANS–PNS) registered at ANS (Broadbent, 1937). Mandibular local superimpositions were performed based on the structural methods of Björk and Skieller (1983). Reference planes were transferred from T_1 to T_2 radiographs using these superimpositions. Total (Figure 3a,b), maxillary (Figure 4a) and mandibular (Figure 4b) measurements were recorded from the total vertical and horizontal and local vertical and horizontal reference planes.

Statistical analysis

The mean and standard error of the mean were calculated for each variable. Student's *t*-tests were used to compare differences in pre-treatment measurements between the groups (Table 2). Paired *t*-tests were used to determine significant changes between pre- (T_1) and post (T_2)-treatment measurements within each group (Table 3). Student's *t*-tests were also used to compare differences in the amount of change between the groups (Table 3).

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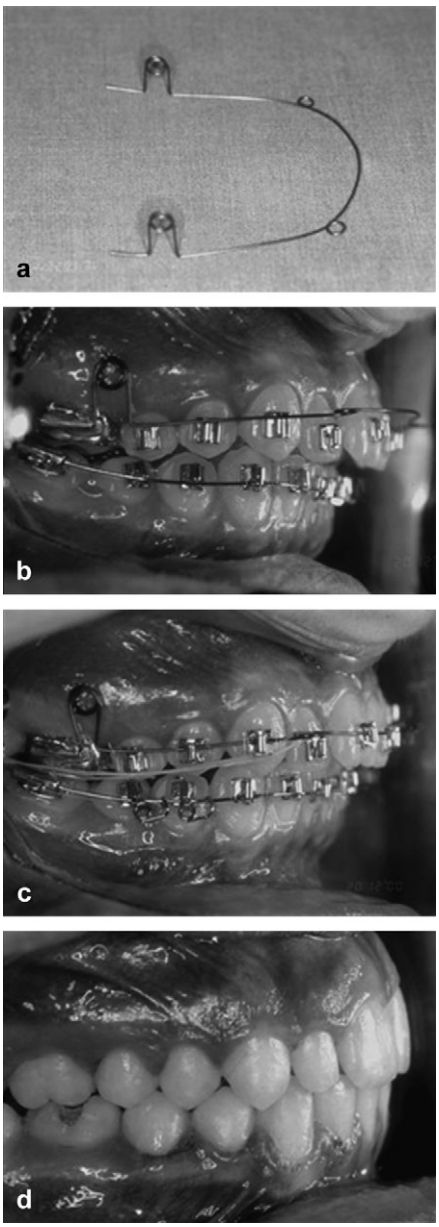


Figure 2 Modified Begg intraoral distalization system (MBIDS); (a) maxillary 0.018 inch Australian wire distalization arch with bilateral double-twisted single vertical loop; (b) the distalization arch positioned one loop width anterior of the maxillary incisors; (c) the uprighting springs to reinforce the mandibular anchorage and activation of the arch with intermaxillary Class II elastics; and (d) occlusion after MBIDS therapy.

Error study

Twenty randomly selected cephalograms were retraced by the same author (ATA-A) after a period of 1 month. No significant differences were found between the two series. Reliability coefficients (r) ranged from 0.93 to 0.99.

Results

Cephalometric measurements for the 3D-BMDA group prior to molar distalization and of the MBIDS group at the beginning of fixed appliance therapy are shown in Table 2 and comparison of the treatment changes in Table 3.

A Class I molar relationship was achieved in 3.4 months in the 3D-BMDA group and in 6.5 months in the MBIDS group (Table 1).

Sufficient distalization of the maxillary molars was achieved in both intraoral distalization groups. However, as Table 3 shows, the rate of distal molar movement was significantly greater in the 3D-BMDA group (1.11 ± 0.13 mm/month) than in the MBIDS group (0.54 ± 0.17 mm/month, $P < 0.001$).

The mean amount of distalization, intrusion, and distal tipping of the maxillary molars was similar in both groups. However, first and second maxillary molar intrusion (U6t–max.HR and U7t–max.HR: $P < 0.05$) and mandibular molar extrusion were greater in the MBIDS group (L6t–mand.HR: $P < 0.01$).

Mesial tipping of the mandibular first molars was significantly greater in the 3D-BMDA group (L6/mand. HR), whereas proclination of the mandibular incisors was significantly greater in the MBIDS group (L1/mand.HR and L1i–mand.VR, $P < 0.001$).

Increases in the occlusal plane angle and decreases in overbite were also significantly greater in the MBIDS group ($P < 0.01$ and $P < 0.001$, respectively).

The decrease in ANB was statistically significant ($P < 0.05$) in the MBIDS group, whereas the increase in SNB was statistically significant ($P < 0.05$) in the 3D-BMDA group. However, the changes in these angles did not differ significantly between the groups. There were significant differences ($P < 0.05$) between the groups with respect to changes in A–max.VR, which decreased significantly ($P < 0.01$) in the 3D-BMDA group, but not in the MBIDS group.

SN/GoGn angle remained stable in the 3D-BMDA group, despite statistically significant changes in the vertical position of the molars, whereas in the MBIDS group this angle significantly increased ($P < 0.05$). Co–Gn, Co–Go, and S–Go increased significantly in both groups.

N–Me and ANS–Me increased in both the MBIDS and 3D-BMDA groups; however, the increases were significantly greater in the MBIDS group in comparison with the 3D-BMDA group ($P < 0.001$ and $P < 0.01$, respectively).

The lower lip protruded significantly in both groups; however, protrusion was significantly greater in the MBIDS group ($P < 0.01$).

Discussion

Anchorage maintenance

Although intraoral molar distalization techniques are looked upon positively because they do not rely on patient co-operation for their effects, they unfortunately result in anchorage loss in different areas of the dental arches. With

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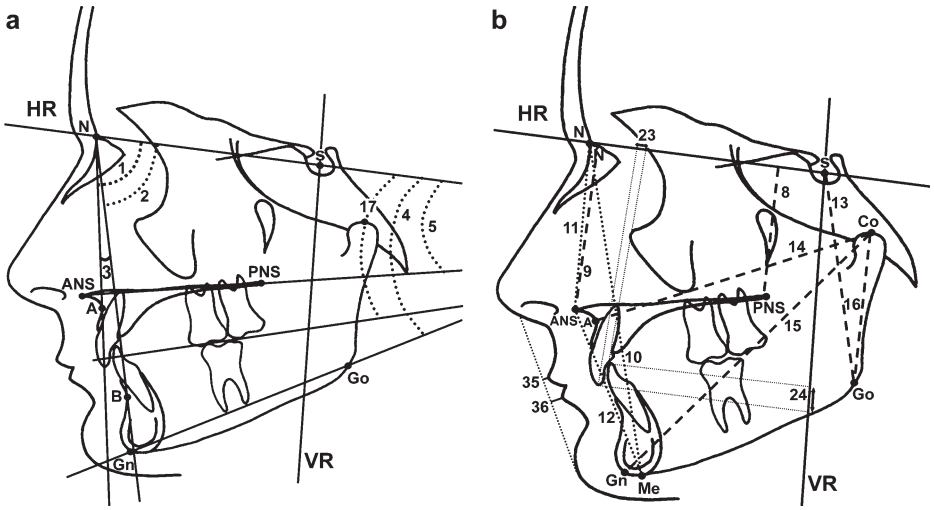


Figure 3 Angular (a) 1: SNA, 2: SNB, 3: ANB, 4: SN/GoGn, 5: SN/PP, 17: SN/Occ and linear (b) 8: PNS–HR, 9: ANS–HR, 10: N–Me, 11: N–ANS, 12: ANS–Me, 13: S–Go, 14: Co–A, 15: Co–Gn, 16: Co–Go, 23: overjet, 24: overbite, 35: Ls–(Steiner), 36: Li–(Steiner) measurements on total tracings.

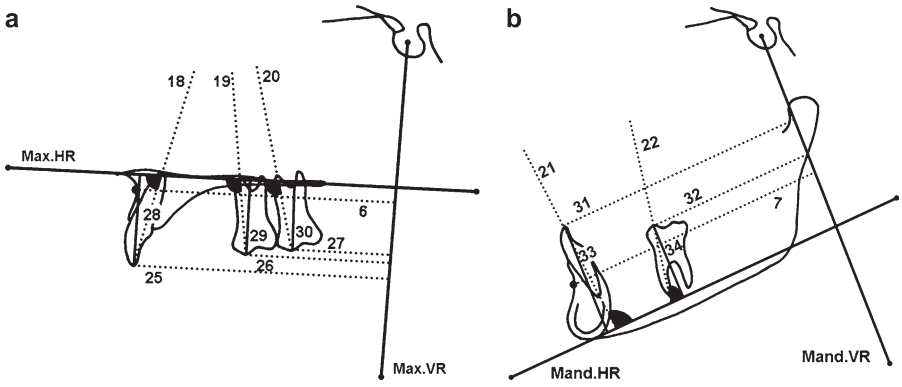


Figure 4 (a) Measurements on maxillary 6: A–max.VR, 18: U1/max.HR, 19: U6/max.HR, 20: U7/max.HR, 25: U1i–max.VR, 26: U6t–max.VR, 27: U7t–max.VR, 28: U1i–max.HR, 29: U6t–max.HR, 30: U7t–max.HR and (b) mandibular 7: B–mand.VR, 21: L1/mand.HR, 22: L6/mand.HR, 31: L1i–mand.VR, 32: L6t–mand.VR, 33: L1i–mand.HR, 34: L6t–mand.HR. local tracings.

the use of intramaxillary intraoral techniques, e.g. magnets (Blechman and Smiley, 1978), superelastic NiTi coils (Gianelly *et al.*, 1991), pendulum (Hilgers, 1992), Jones jig (Jones and White, 1992), and distal jet (Carano and Testa, 1996), anchorage loss is frequently observed in the maxillary anterior region. In intermaxillary intraoral techniques (e.g. 3D-BMDA and MBIDS), significant anchorage loss has been observed in the mandibular dental arch as a result of the intermaxillary Class II elastics used as part of the system (Reddy *et al.*, 2000; Ucem *et al.*, 2000). In the present study, a Class I molar relationship was successfully achieved using both 3D-BMDA and MBIDS. Although the maxillary molars were distalized significantly in both groups, mesial movement of the mandibular molars due to anchorage loss caused by the intermaxillary Class II elastics affected the final results. These results show that the traditional full-bonded mandibular arch is insufficient for controlling anchorage, even when reinforced by lingual crown torque in the 3D-BMDA group and by uprighting springs in the MBIDS group. A 4.40 mm proclination of the mandibular incisors was observed in the MBIDS group, indicating anchorage loss in the anterior region. However, it should be noted that the elimination of anterior crowding only accounts for part of this anterior movement. There was also less mesial movement of the mandibular molars observed in the MBIDS group in comparison with the 3D-BMDA group. This finding supports the assumption that all facets of anchorage loss in the MBIDS group were lower than in the 3D-BMDA because of the use of uprighting springs on the premolars and the use of the mandibular second molars as anchorage units for intermaxillary elastics.

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Table 2. Comparison of the initial values of three-dimensional biometric maxillary distalization arch (3D-BMDA) prior to molar distalization and the modified Begg intraoral molar distalization group (MBIDS) at the beginning of fixed appliance therapy (X, mean and Sx, standard error of the mean, and Sd, standard error of the differences) by Student's *t*-test.

Parameters	3D-BMDA group ($n=21$)			MBIDS group ($n=17$)			Test
	X	Sd	±Sx	X	Sd	±Sx	
Maxilla							
SNA (°)	80.37	4.50	0.96	77.92	2.86	0.69	
A–max.VR (mm)	69.44	4.43	0.98	68.97	3.70	0.90	
SN/PP (°)	8.27	3.93	0.84	9.82	3.57	0.87	
Co–A (mm)	88.35	5.99	1.4	90.07	3.20	0.78	
N–ANS (mm)	56.84	3.07	0.69	55.87	2.44	0.59	
ANS–HR (mm)	56.55	3.00	0.67	55.53	2.45	0.60	
PNS–HR (mm)	48.71	2.79	0.68	45.49	2.23	0.54	**
Mandible							
SNB (°)	76.20	4.55	0.94	73.70	2.69	0.65	*
B–mand.VR (mm)	95.86	5.66	1.2	91.54	4.15	1.0	*
SN/GoGn (°)	33.41	4.83	1.1	32.98	4.65	1.1	
Co–Gn (mm)	115.68	6.05	1.5	115.66	4.79	1.2	
Co–Go (mm)	59.14	5.18	1.0	59.49	3.78	0.92	
N–Me (mm)	124.94	4.77	1.2	122.11	4.03	0.98	
S–Go (mm)	82.19	4.80	1.2	78.01	3.11	0.75	**
Maxillomandibular							
ANB (°)	4.17	1.72	0.37	4.22	1.08	0.26	
SN/Occ (°)	15.78	4.83	1.1	17.22	4.41	1.1	
ANS–Me (mm)	70.41	4.20	1.1	68.69	4.34	1.1	
Dentoalveolar							
U1/max.HR (°)	69.33	7.18	1.1	73.73	7.04	1.7	*
U6/max.HR (°)	97.19	5.67	1.4	97.39	7.06	1.7	
U7/max.HR (°)	109.79	5.62	1.1	106.36	6.96	1.7	
L1/mand.HR (°)	97.62	5.33	0.99	97.48	6.95	1.7	
L6/mand.HR (°)	77.08	4.40	1.2	86.36	6.17	1.5	***
U1i–max.VR (mm)	73.54	5.65	1.1	71.27	5.15	1.3	
U6t–max.VR (mm)	42.97	5.08	0.92	41.06	4.42	1.1	
U7t–max.VR (mm)	29.92	4.59	0.87	29.95	4.48	1.1	
U1i–max.HR (mm)	29.73	2.90	0.73	30.68	2.53	0.61	
U6t–max.HR (mm)	24.29	2.08	0.51	24.18	1.68	0.41	
U7t–max.HR (mm)	21.22	2.14	0.48	20.74	1.95	0.47	
L1i–mand.VR (mm)	94.39	5.45	1.2	90.16	3.49	0.85	**
L6t–mand.VR (mm)	67.40	4.60	1.0	64.22	4.33	1.0	*
L1i–mand.HR (mm)	42.73	2.25	0.57	41.83	2.58	0.63	
L6t–mand.HR (mm)	32.16	1.76	0.49	30.25	2.21	0.54	*
Overjet (mm)	4.00	2.20	0.47	3.37	1.66	0.40	
Overbite (mm)	3.73	1.64	0.37	6.44	1.30	0.32	***
Soft tissues							
Ls–(Steiner), mm	−0.98	1.63	0.39	−1.00	2.01	0.49	
Li–(Steiner), mm	0.37	2.02	0.38	−0.98	2.96	0.72	

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

Mandibular rotation

The posterior rotation of the mandible was not significant in the 3D-BMDA group (mean 0.01 degrees), but was significant ($P < 0.01$) in the MBIDS group (mean 0.81 degrees). The difference between the groups was also statistically significant ($P < 0.05$). However, even in the MBIDS group, rotation was less than 1 degree, which is acceptable in patients treated with continuous Class II elastics. Interestingly, in both groups, the relative lack of mandibular rotation was accompanied by significant extrusion of the mandibular molars, which previous reports have shown to cause significant rotation (Reddy *et al.*, 2000; Ucem *et al.*, 2000). This contradiction may be explained by the compensatory increase in posterior face and ramus heights in both groups occurring as a result of condylar growth, which is indicated by the significant increases in Co–Gn and Co–Go in both groups.

Maxillary changes

A–max.VR remained nearly stable in the MBIDS group, but decreased significantly in the 3D-BMDA group (–0.85 mm, $P < 0.01$). This posterior movement of point A could be explained by the backward movement of the maxillary incisor roots. While the intermaxillary elastics inhibited

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Table 3. Comparison of the means of differences (D) and standard error of the differences (Sd) between the three-dimensional bimetric maxillary distalization arches (3D-BMDA) and the modified Begg intraoral distalization system (MBIDS) groups by Student's *t*-test.

Parameters	3D-BMDA group ($n=21$)		MBIDS group ($n=17$)		Test
	D	±Sd	D	±Sd	
Maxilla					
SNA (°)	−0.01	0.23	0.05	0.15	
A–max.VR (mm)	−0.85**	0.29	0.03	0.21	*
SN/PP (°)	0.50	0.28	0.18	0.17	
Co–A (mm)	0.08	0.50	−0.19	0.51	
N–ANS (mm)	0.53*	0.26	0.73***	0.13	
ANS–HR (mm)	0.57*	0.26	0.71***	0.12	
PNS–HR (mm)	−0.16	0.16	0.15	0.20	
Mandible					
SNB (°)	0.53*	0.23	0.38	0.20	
B–mand.VR (mm)	−0.21	0.17	0.1	0.72	
SN/GoGn (°)	0.01	0.24	0.81**	0.27	*
Co–Gn (mm)	1.72**	0.46	2.03**	0.54	
Co–Go (mm)	2.12***	0.33	1.90**	0.56	
N–Me (mm)	0.88**	0.25	2.60***	0.38	***
S–Go (mm)	1.06**	0.26	1.68***	0.36	
Maxillomandibular					
ANB (°)	−0.54	0.26	−0.34*	0.16	
SN/Occ (°)	4.38***	0.68	7.94***	0.70	**
ANS–Me (mm)	0.56	0.32	1.85***	0.35	**
Dentoalveolar					
U1/max.HR (°)	−0.87	1.38	−2.20	1.2	
U6/max.HR (°)	5.51***	1.08	5.41**	1.4	
U7/max.HR (°)	4.38***	1.04	7.37***	1.2	
L1/mand.HR (°)	9.53***	1.39	11.92***	0.82	***
L6/mand.HR (°)	6.06***	1.16	1.73	1.1	***
U1i–max.VR (mm)	0.06	0.47	0.45*	2.14	
U6t–max.VR (mm)	−3.55***	0.38	−3.27***	0.65	
U6t–max.VR (monthly, mm)	−1.11	0.13	−0.54	0.17	***
U7t–max.VR (mm)	−2.86***	0.34	−3.22***	1.31	
U1i–max.HR (mm)	1.60***	0.37	2.17***	0.29	
U6t–max.HR (mm)	−0.70**	0.20	−1.23***	0.16	*
U7t–max.HR (mm)	−0.78**	0.21	−1.46***	0.17	*
L1i–mand.VR (mm)	2.82***	0.44	4.40***	1.47	***
L6t–mand.VR (mm)	2.16***	0.28	1.40**	1.41	***
L1i–mand.HR (mm)	−0.93**	0.31	−2.52***	1.51	***
L6t–mand.HR (mm)	1.60***	0.23	2.35***	1.10	**
Overjet (mm)	−2.16**	0.54	−1.73**	0.42	
Overbite (mm)	−1.58**	0.53	−4.21***	0.39	***
Soft tissues					
Ls–(Steiner), mm	−0.10	0.28	0.23	0.35	
Li–(Steiner), mm	1.66***	0.24	2.75***	0.31	**

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

protrusion of the incisor crowns (0.06 mm), the incisor roots showed a slight palatal movement, resulting in a –0.85-mm movement of point A.

Maxillary incisor extrusion

Intermaxillary Class II elastics were found to have caused significant maxillary incisor extrusion in both treatment groups. Extrusion of the maxillary incisors is a common finding in studies involving intermaxillary Class II elastics (Muse *et al.*, 1993; Doganay, 1996; Rana and Becher, 2000).

Lower lip

The lower lip protruded in both groups; however, this protrusion was greater in the MBIDS group ($P < 0.01$). These findings are consistent with the movements of the maxillary and mandibular incisors.

Conclusions

1. Both 3D-BMDA and MBIDS techniques are effective in distalization of the maxillary molars.

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2. In addition to the distalization of the maxillary molars, the mesial movement of the mandibular molars contributed to the achievement of a Class I relationship in both groups of patients.
3. The rate of distal molar movement was significantly greater in the 3D-BMDA group than in the MBIDS group.
4. Moderate anchorage loss in the mandibular dental arch was observed in both groups; however, this was less in the MBIDS group.
5. Full-bonded dental arches are not sufficient for supporting mandibular anchorage.
6. The effects of treatment modality on dentofacial structures need to be taken into consideration for each individual patient in order to achieve successful results with either of these techniques.

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