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CLINICAL INVESTIGATION

Asymmetric Maxillary First Molar Distalization with the Transpalatal Arch

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Abstract: The purpose of this study was to determine the dentoalveolar and skeletal effects of a Goshgarian transpalatal arch (TPA) in unilateral maxillary first molar distalization. The treatment group consisted of 15 patients (6 females and 9 males) between 10.8 and 12.1 years of age. The maxillary first molars, which were in a dental Class I relationship (anchorage molars), were the anchorage units, while the molars in Class II relationship (distalized molars) were distalized using a TPA with 150 g. of force. Lateral head films, study models and clinical photographs of all the patients were taken before and after distalization. The differences between the measurements were evaluated with a paired samples t test. The mean unilateral molar distalization was 2.067 mm, with 3.733° distal tipping and 4.800° distopalatal rotation. Anchorage molars were mesialized 0.367 mm with 0.400° mesial tipping and showed a mesiobuccal rotation of 9.400°. The distalized molars and anchorage molars were extruded 0.267 mm and 0.533 mm, respectively. A 0.467 mm buccal movement was observed in the distalized molars; however, the expansive movement of the anchorage molars was not statistically significant. The results showed that the TPA was effective in the asymmetric distalization of the maxillary first molars.

Key Words: Unilateral, asymmetric, molar distalization, transpalatal arch

Introduction

The treatment of Class II malocclusions frequently requires the distalization of maxillary molars and it has been shown in a number of studies that maxillary molars can be effectively distalized with various non-compliance treatment modalities (1-9). However, these methods can also cause mesial movement of the maxillary premolars and canines. In addition, the loss of anterior anchorage often leads to relapse of the maxillary molars during the correction of the canine relationship, overbite, and overjet. On the other hand, the transpalatal arch (TPA) is a widely used appliance in orthodontic treatments and, besides several other functions including stabilization and anchorage (10), correction of molar rotations (11), vertical molar control (12-14) and treatment of unilateral molar crossbites (15,16), it is also an alternative to the other treatment regimen for the correction of the molar relationship when the maxillary molars present a slight unilateral Class II discrepancy (17,18).

Lemons and Holmes (19) indicated that mesial

rotation of the maxillary first molars is typical in the majority of Class II cases and a gain of 1-2 mm arch length per side could be achieved following the correction of mesial rotation of these teeth. Early loss of the upper second deciduous molars increases the severity of the mesial rotation and causes maxillary first molars to seem as if they were in a Class II relationship, from a buccal aspect. However, since the mesiolingual cusps of maxillary molars still fit in the central fossae of mandibular molars, a Class I relationship can be obtained with just the correction of molar rotation. The biomechanical principles of the TPA are adequate for the correction of molar rotations, and limited distalization of the maxillary molars can also be achieved through sequential activation of the appliance (17,18). Since the introduction of TPA there have been few articles in the orthodontic literature that have dealt directly with the clinical management of this type of appliance. Studies dealing with the distalization effects of the TPA are even rare. Modifying Cetlin's (20) technique, Mauderino and

Balducci (18) demonstrated unilateral distalization of the maxillary molars with 0.032" TMA bars, which are more elastic and resilient than the stainless steel used in the conventional Goshgarian arch. However, they suggested extraoral force at nights to reinforce anchorage. The objective of this study was to evaluate the efficiency of the conventional Goshgarian TPA in unilateral maxillary first molar distalization and to determine the dentoalveolar and skeletal effects of the appliance.

Materials and Methods

The study comprised 6 females and 9 males, with an average age of 11.2 years. The patient selection criteria were as follows:

- 1- Class I malocclusion with a normal vertical pattern,
- 2- Unilateral Class II molar relationship (need for first molar distalization not exceeding 1.5-2.5 mm),
- 4- Correct lower dental midline,
- 5- Late mixed or early permanent dentition,
- 6- Normal overjet and overbite.

Maxillary first molars in the treatment group were distalized unilaterally with transpalatal arches bent from 0.9 mm stainless steel wire. Lateral cephalograms, orthodontic models and clinical photographs of the patients were taken before and after the distalization period.

Construction of the TPA

Buccal tubes and palatal sheaths (0.9 mm x 1.8 mm) were spot welded to appropriate molar bands. Sheaths were attached to the lingual aspects of the molar bands at the same occluso-gingival height and in the same mesiodistal position as the tubes. Tubes and sheaths were soldered to the molar bands, and an alginate impression was made with the bands in place. The bands were transferred to the impression and a study model was obtained. The TPA was bent so that the loop was 4 mm above the palatal mucosa with the bend facing the distal. The ends of the arch were formed according to the modified technique of Mauderino and Balducci (18). One of the doubled-over ends of the TPA was inserted passively from the distal into the sheath of the maxillary first molar used as anchorage (AnM), and from the mesial into that of the maxillary first molar to be distalized (DiM) (Figures 1a-c). The appliance was held with pliers beneath

the doubled-over end at the side of the AnM and the arm was pushed distally until a 150-g force was produced on the DiM (Figure 1d). The force was measured by pulling back the DiM end of the arch to the level of the lingual sheath, using a dentaurem gauge (006-013-00) (Figure 1c). Approximately 30° of the buccal root torque was incorporated in the doubled-over end, which was inserted into the AnM sheath.

Clinical Management

A slight expansion bend was incorporated in the appliance during the first appointment to prevent an edge-to-edge relationship with the DiM. The patients were seen monthly and the TPA was reactivated by bending distally beneath the end inserted from the distal. The mean distalization period was 5 months and all the records were repeated after the patients attained a bilateral Class I molar relationship. The orthodontic treatments of the patients were then carried out with fixed edgewise appliances. Excessive rotations and undesired tipplings of the maxillary first molars were corrected with finishing Ni-Ti archwires (0.017" x 0.025") and blue elgiloy uprighting springs (0.016" x 0.022"). Intraoral photographs of a patient before and after unilateral molar distalization are shown in Figures 2 a-c and 3 a-d.

Cephalometric Evaluation

Radiography was performed with the Frankfort Horizontal plane parallel to the floor. Individual guiding markers (0.017" x 0.025" blue elgiloy) were used to distinguish the AnM and DiM on the lateral head films. Straight markers indicated the AnM (Figure 2b) while the hooked markers indicated the DiM (Figure 2c). The markers were placed in the rectangular double buccal tubes of molar bands and oriented vertically before obtaining the initial cephalograms. Then they were removed and kept for the final use after distalization. The radiographies were traced by 1 investigator with verification of anatomic outlines and landmarks by the other 3. The structures in question were retraced to the mutual satisfaction of the investigators. A single average tracing was made in instances of bilateral structures. The parameters were measured by each investigator twice, at different times, to eliminate measurement errors and the mean findings were evaluated statistically. The angular and linear measurements used in lateral cephalograms are presented in Figure 4.

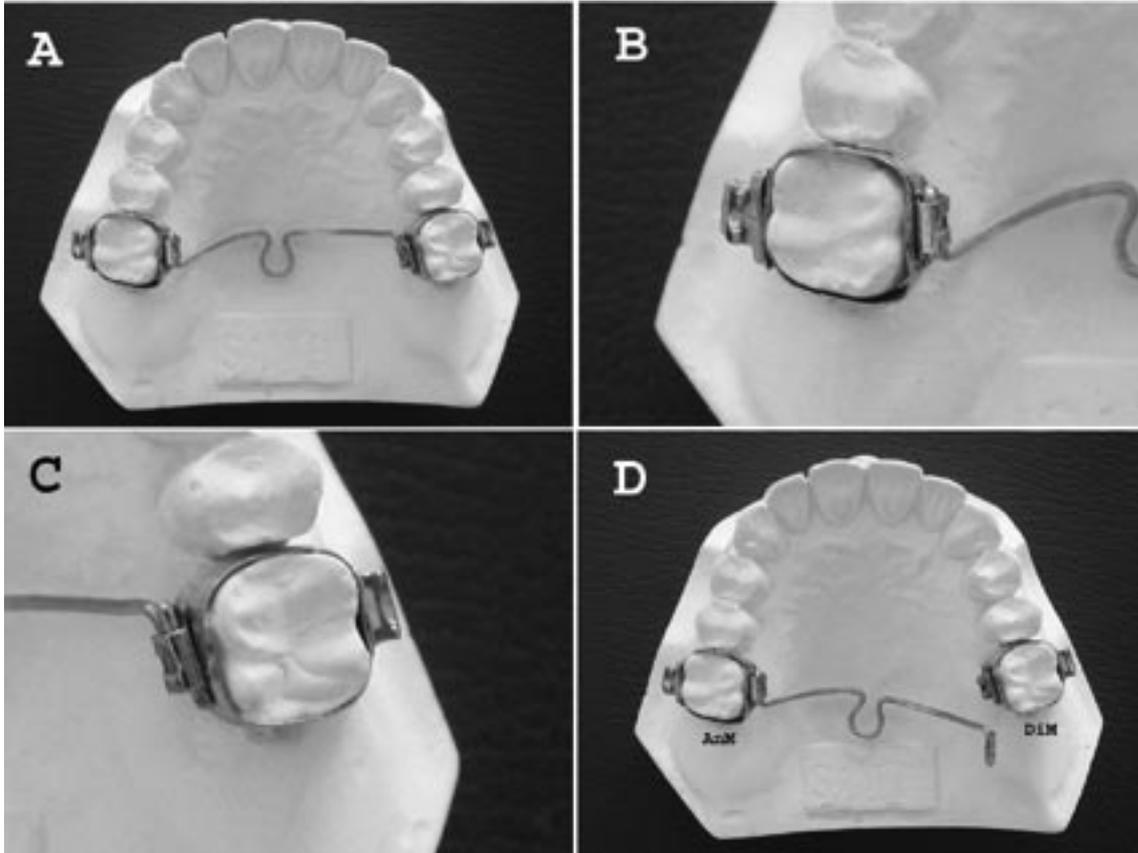


Figure 1. The doubled-over ends of the AnM (b) and DiM (c) and active form of the TPA (d).



Figure 2. Intraoral photographs of a patient before distalization.

Model Analysis

Model analysis was carried out to determine maxillary first molar rotation and changes in intermolar distance. The midpalatal sutures and the tips of molar cusps were defined with a 0.5 mm pointed drawing pencil on study models. Model photocopies were obtained as described by Champagne (21). On model photocopies, a midline was drawn along midpalatal suture and 2 diagonal lines were drawn between the cusptips of the first molars and their

intersection point was marked. The intersection points on the AnM and DiM were defined as IPAn and IPDi, respectively.

Rotation of the first molars was found by measuring the angle between the midline (ML) and the diagonal line passing through the mesiobuccal (MB) and distopalatal (DP) cusptips. The changes in the intermolar distance were found by measuring the perpendicular distances from IPAn to ML and from IPDi to ML (Figure 5).

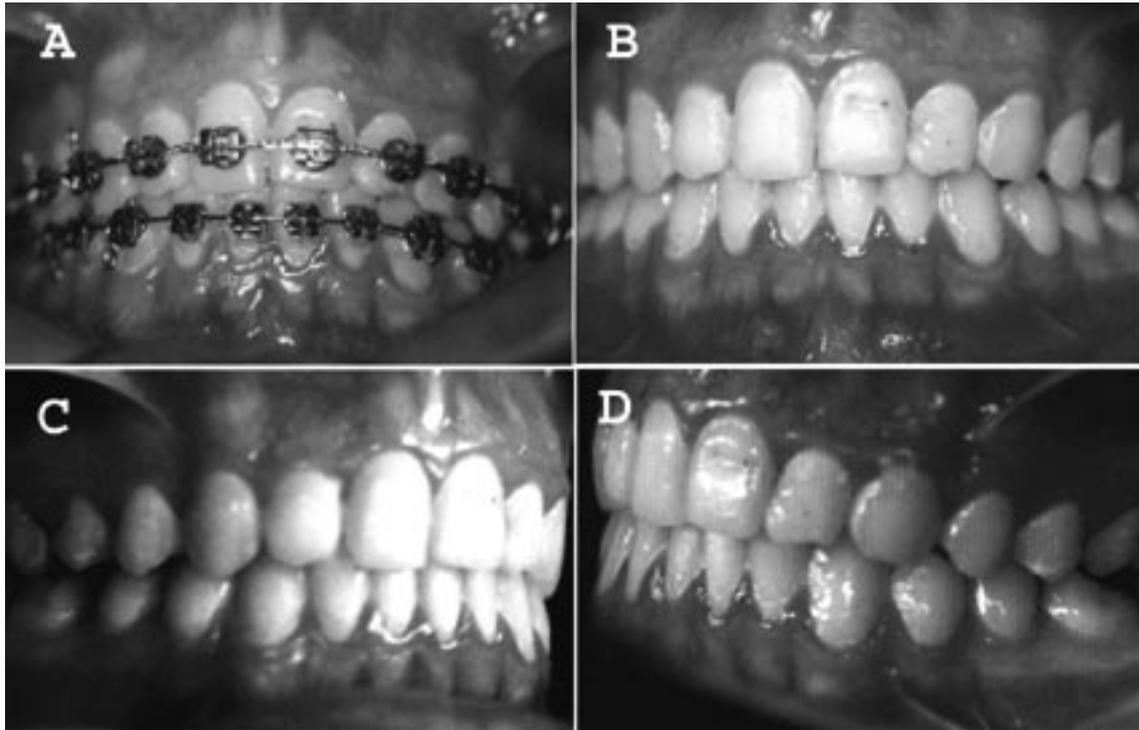


Figure 3. Intraoral photographs of the patient during fixed treatment (a) and after (b-d) orthodontic treatment.

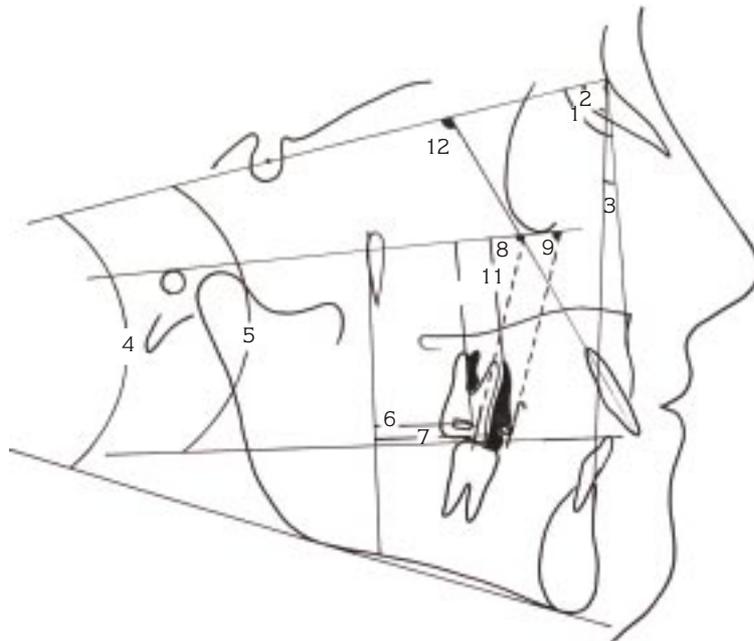


Figure 4. Angular and linear measurements used in cephalometric analysis. (1) SNA° , (2) SNB° , (3) ANB° , (4) MP° , (5) OP° , (6) AnM-PtV (mm): the perpendicular distance from the inserting point of the AnM marker to the buccal tube to PtV, (7) DiM-PtV (mm), (8) AnM/FH° : the angle between the marker of AnM and FH, (9) DiM/FH° , (10) AnM-FH (mm): the perpendicular distance from the inserting point of the AnM marker to the buccal tube to FH, (11) DiM-FH (mm), (12) $U1/SN^\circ$: the angle between the long axis of the maxillary incisor and SN.

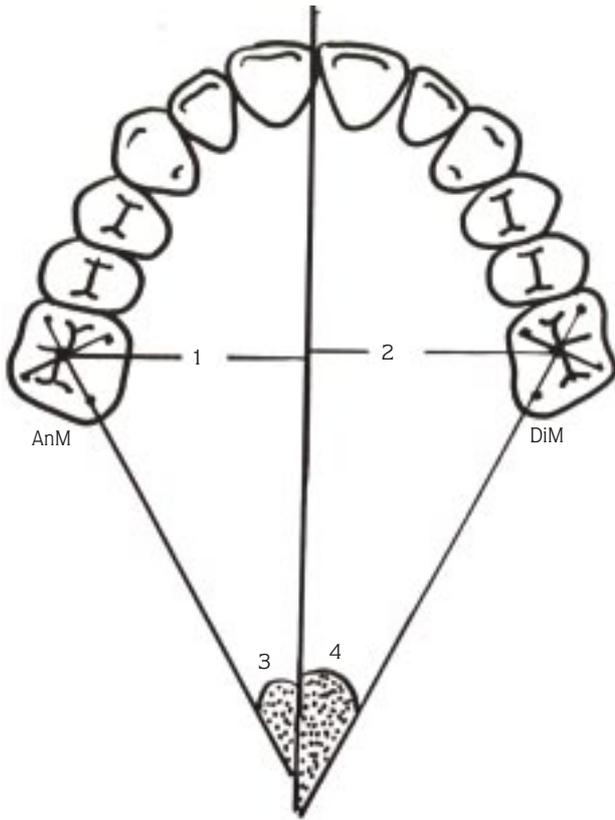


Figure 5. Angular and linear measurements used in study model analysis. (1) IpAn-ML (mm): the perpendicular distance from IpAn to ML, (2) IpDi-ML (mm), (3) MB-DPAN/ML°: the angle between the line connecting the mesiobuccal and distopalatal cusps of the first molar and ML, (4) MB-DPDi/ML°.

Statistical Method

Statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA) and the results are shown as mean \pm standard deviation. After the parametric assumptions were tested to see if the variables were suitable for parametric tests, the differences between the 2 measurements were evaluated with a paired-samples t test. P values less than or equal to 0.05 were considered as statistically significant.

Results

Cephalometric Findings

The first molars in a Class II relationship (DiMs) were distalized 2.067 mm ($P < 0.001$) on average with a distal tipping of 3.733° ($P < 0.001$), while the anchorage first molars (AnMs) were mesialized 0.367 mm ($P = 0.006$)

with a distal tipping of 0.367° ($P = 0.022$). The DiMs and AnMs were extruded 0.533 mm ($P = 0.003$) and 0.267 mm ($P = 0.027$), respectively. When skeletal changes were evaluated, a significant increase was observed at the SNB angle of 0.466° ($P = 0.010$) (Table 1).

Study Model Findings

The distance between the DiMs and the midline was increased by 0.467 mm ($P = 0.014$) however the distance between the AnMs and the midline did not change significantly. The DiMs showed distopalatal rotation of 4.800° ($P < 0.001$) while a mesiobuccal rotation of 9.400° ($P < 0.001$) was observed in the AnMs (Table 2).

Discussion

The TPA can be activated to deliver clinically useful forces and couples to move and/or rotate maxillary molars in all 3 planes of space. However, it must be kept in mind that in instances of asymmetric activation the associated equilibrium forces of a couple can be the source of undesired clinical surprises. Moreover, it is also well known that asymmetric molar distalization, regardless of which method is used, causes undesirable side effects that need to be resolved after the distalization. In order to keep the side effects of the asymmetric force to a minimum, a 150-g force was used in patients who required 1.5-2 mm unilateral maxillary first molar distalization.

Cetlin's (20) method, with the toe-in bend applying a mesiobuccal rotation to the maxillary molar on the side of anchorage, was reliable in terms of anchorage loss but is considered time-consuming (18). In our study, the TPAs were bent according to Mauderino and Balducci's (18) modified technique because the authors (18) asserted that this technique would reduce treatment time and improve the efficiency of unilateral maxillary molar distalization. The TPA in the case report by Mauderino and Balducci (18) was made from the same 0.032" TMA bars used to construct Pendulum springs (5), which were more elastic and resilient than stainless steel. They activated the TMA arch by bending the end inserted from the distal about 30° . However, we used conventional TPAs in this study, incorporated a buccal root torque at the doubled-over ends inserting from the distal and activated the appliances just beneath the end.

Table 1. Statistical evaluation of cephalometric measurements before (T1) and after (T2) distalization.

Measurements	T1		T2		ΔT1-T2		Significance
	Mean	St.D.	Mean	St.D.	Mean	St.D.	
SNA°	80.067	2.815	80.267	2.520	-0.200	1.521	NS
SNB°	77.267	3.218	77.733	3.029	-0.467	0.611	*
ANB°	2.733	1.033	2.503	1.798	0.230	1.735	NS
MP°	33.000	2.420	33.333	2.350	-0.333	0.617	NS
OP°	18.933	2.282	19.400	2.131	-0.467	0.916	NS
AnM-PtV (mm)	22.200	2.042	22.567	1.850	-0.367	0.442	**
DiM-PtV (mm)	22.000	2.449	19.933	2.685	2.067	0.704	***
AnM/FH°	75.467	4.138	75.867	4.442	-0.400	0.604	*
DiM/FH°	75.400	4.014	71.667	4.385	3.733	0.961	***
AnM-FH (mm)	41.600	2.165	41.867	2.240	-0.267	0.417	*
DiM-FH (mm)	42.200	2.145	42.733	1.945	-0.533	0.582	**
U1/SN°	101.800	3.668	102.133	3.583	-0.333	0.724	NS

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

Table 2. Statistical evaluation of the study model findings before (S1) and after (S2) distalization.

Measurements	S1		S2		ΔS1-S2		Significance
	Mean	St.D.	Mean	St.D.	Mean	St.D.	
IpAn-ML (mm)	24.600	1.957	24.800	1.821	-0.200	0.414	NS
IpDi-ML (mm)	24.067	1.981	24.533	2.066	-0.467	0.639	*
MB-DPAn/ML°	27.400	3.396	36.800	2.651	-9.400	2.746	***
MB-DPDi/ML°	27.067	2.987	31.867	3.181	-4.800	1.935	***

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

Dahlquist et al. (11) and Ingervall et al. (15) demonstrated that buccal root torque at the anchorage side worked well in the treatment of unilateral molar crossbites. On the other hand, Baldini and Luder (23) found that the moment-to-force ratio was dependent on the height and width of the TPA and indicated that when low TPAs were used, the application of buccal root torque might lead to initial buccal crown tipping, whereas the same amount of torque, when applied by means of high arches, would bring the desired buccal root tipping. However, the patients were not classified according to their palatal heights and widths in our study and approximately 30° of buccal root torque was applied to the AnM in every patient.

The intrusive effect and mesially and distally directed forces caused by the tongue on the TPA have been shown in a number of studies (14,22). Ney and Goz (22) observed that the omega loop facing the mesial caused mesial tipping movement of the molars during deglutition while the loop facing the distal predominated distally directed moments. Chiba et al. (14) investigated tongue pressure on the loops of the TPAs with varying heights (2, 4 and 6 mm) from the palatal mucosa and found significant differences between 2 and 4 mm, and 2 and 6 mm. Based on these findings, we bent the loops facing the distal and 4 mm above the palatal mucosa and considered the use of the effect of the tongue as an auxiliary mechanism to stabilize the AnM.

An interesting finding of our study was the increase in the SNB angle (0.467°). When the average age of the sample was considered, this was related to the growth potential of the patients. The mean unilateral molar distalization was 2.067 mm on average. The DiMs also showed 3.733° distal tipping and 4.800° distopalatal rotation. The mean distalization was of course considerably less than in other distalization techniques (1-9); however, it was efficient enough to attain a bilateral Class I molar relationship since the need for molar distalization was minimal. The AnMs were affected by a force couple: a buccal root torque due to activation of the double-over end and a rotational force due to activation of the arm. The torque movement increased the resistance of the AnM to rotational, mesially directed and expansive forces. It was observed that the AnMs were mesialized 0.367 mm with 0.400° mesial tipping and showed a 9.400° mesiobuccal rotation. The anchorage loss was clinically acceptable, indicating that the anchorage value of one of the first maxillary molars was enough to distalize the other one. Although we constructed omega loops 4 mm above the palatal mucosa, it was not efficient enough to control the molars vertically and both maxillary first molars were extruded. However, the extrusion movement of the AnMs (0.267 mm) was less than that seen in the DiMs (0.533 mm). The DiMs were expanded 0.467 mm; however, expansion was not

observed in the AnMs, showing the effectiveness of buccal root torque in unilateral molar expansion with the TPA. This was consistent with the findings of Dahlquist et al. (11) and Ingervall et al. (15).

These results show that the TPA can be used in the unilateral distalization of maxillary molars without using extraoral forces or other intraoral techniques when appropriate cases are selected. It is a simple, hygienic and cheap technique to perform when sagittal discrepancy in the maxillary molars is minimal. The mesial movement of the anchorage molars was clinically acceptable. This was evaluated as an advantage; however, anchorage molars showed a serious mesiobuccal rotation, which had to be corrected at the end of the treatment. Although it is a widely used appliance in orthodontic treatments, studies related to the distalization effects of TPA are limited. We think that modifications of this appliance would improve its distalization effects.

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