ORIGINAL ARTICLE

A new approach in maxillary molar distalization: Intraoral bodily molar distalizer

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The objectives of our study were to achieve bodily molar distalization, avoid distal tipping of molars, eliminate the need for patient cooperation (no headgear, no elastics, and no esthetic and social concern), and finally to minimize the treatment period and maximize the treatment efficiency. The study was carried out on 5 males and 10 females, a total of 15 patients. Mean age for the study group was 13.53 years. Dentally, all the patients had Class II molar relationship on both sides. The patients were in permanent dentition, second molars were erupted, and the lower dental arch was well aligned. Patients showed normal or sagittally directed growth pattern. Lateral cephalograms and study models were taken and analyzed before and after molar distalization. In the present study, in order to achieve maxillary molar distalization, a new intraoral appliance was developed. The intraoral bodily molar distalizer (IBMB) was composed of 2 parts: the anchorage unit and the distalizing unit. The anchorage unit was a wide Nance button, and the active unit consisted of distalizing springs. The springs had 2 components: the distalizer section of the spring applied a crown tipping force, while the uprighting section of the spring applied a root uprighting force on the first molars. A total of 230 g of distalizing force was used on both sides. After the distal movement of the first molars, the cephalometric results of 15 patients showed the following. Maxillary first molars were moved distally by an average of 5.23 mm ($P < .001$) without tipping or extrusion. Maxillary first premolars were moved 4.33 mm mesially ($P < .001$), tipped 2.73° distally ($P < .05$), and extruded by 3.33 mm ($P < .001$). Maxillary central incisors were proclined by an average of 4.7 mm ($P < .001$) and tipped 6.73° labially ($P < .01$). Model analysis showed that maxillary first molars were not rotated, and intermolar distance did not change after distal movement of molars. In conclusion, unlike most of the other molar distalization mechanics, this newly developed device achieved (1) bodily distal movement of maxillary molars and (2) eliminated dependence on patient cooperation and did not require headgear wear for molar root uprighting. (Am J Orthod Dentofacial Orthop 2000;117:39-48)

Over the past few years, nonextraction treatment and noncompliance therapies have become more popular in correction of Class II malocclusions. Treatment of Class II cases usually requires distal movement of maxillary molars in order to achieve Class I molar and canine relationship. However, if the maxillary molars are not distalized bodily and adequate anchorage is not established to move premolars and canines distally, anchorage will be lost very easily. In the literature, various types of devices have been developed for molar distalization. For years headgear was used routinely for distal movement of maxillary molars.[1-3] A combination of headgear and removable appliance was used by Cetlin and Ten Hoove.[4] In this approach, the headgear wear time was reduced to 14 hours per day. Wilson and Wilson[5] developed molar distalization mechanics and used mandibular arch as anchorage for the use of Class II elastics. However, these approaches partially or totally relied on patient cooperation, which could reduce treatment success and increase treatment duration.

Headgear is rejected by many patients because of esthetic and social concerns.[6] The difficulties of headgear wear and dependence on patient cooperation stimulated many investigators to develop new intraoral devices and techniques for distal movement of molars. In 1978 Blechman and Smiley,[7] in 1988 Gianelly et al,[8] in 1992 and 1994 Bondemark and Kurol[9,10] used magnets for molar distalization. In 1991, Gianelly et al[11] used super-elastic Ni-Ti coil springs for distal movement of maxillary molars, followed by Hilgers[12] who developed the pendulum appliance in 1992 for the same purpose. In 1997, Erverdi and Koyutürk[13] used magnets and Ni-Ti coil springs for correction of Class II molar relationship. All the intraoral molar distalization mechanics, which were described previously,

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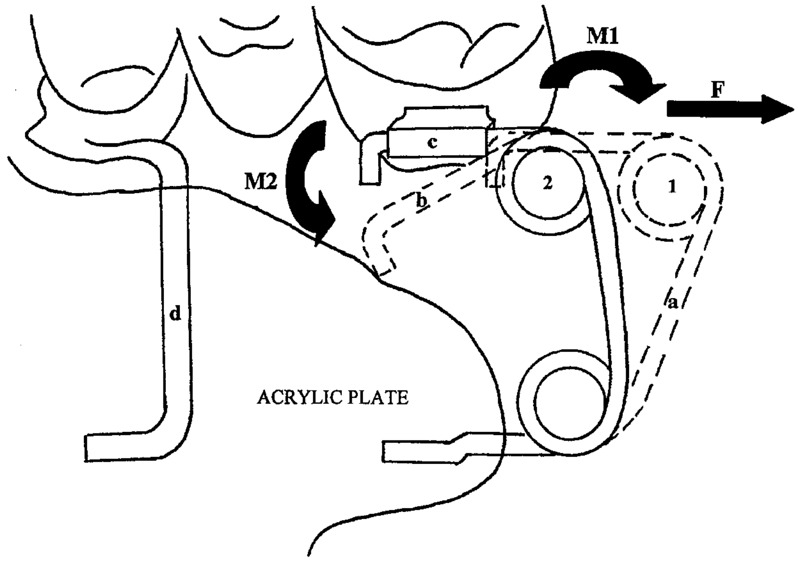

1= Inactive stage of the spring
2= Active stage of the spring
a= Distalizing component of the spring
b= Uprighting component of the spring
c= Palatal hinge-cap attachment
d= Retaining wire of the Modified Nance
M1= Moment generated by the distal force (clockwise direction)
M2= Moment generated by the uprighting component of the spring (counter-clockwise direction)
F= Distal force
Moment **M1** = Moment **M2**
Moment **M1** – Moment **M2** = 0
No moment = No tipping of first molars

Fig 1. Biomechanics of the distalizing spring.

could not achieve total bodily distal movement of molars and crown tipping could not be avoided.

The aim of our study was to develop an intra-oral appliance, which would:

1. Achieve bodily distal movement of molars without tipping
2. Eliminate patient cooperation (no headgear wear, no elastics, or no removable intra-oral appliances)
3. Minimize the treatment time and maximize the treatment efficiency

MATERIAL AND METHODS

Case Selection

In the present study, 10 females and 5 males were selected. The age of the male patients ranged from 10.8 to 15.1 years with an average age of 13.1 years old. The age of the female patients ranged from 11 to 15.8 with an average of 13.8. Mean age for the study group was 13.53 years old.

The criteria for patient selection were as follows: (1) Class II molar relationship, (2) permanent dentition, (3) maxillary second molars erupted, (4) well-aligned lower dental arch, (5) sagittally directed or normal growth pattern.

Appliance Construction

Maxillary first molars and premolars were banded. On the palatal side of the first molar bands, 0.032 × 0.032 inch slot size hinge cap palatal attachments were welded, and a maxillary impression was taken. On the model, a wide acrylic Nance button was constructed and attached to the first premolar bands with 0.045 inch in diameter stainless steel retaining wires. The acrylic button was constructed that covered the palatal

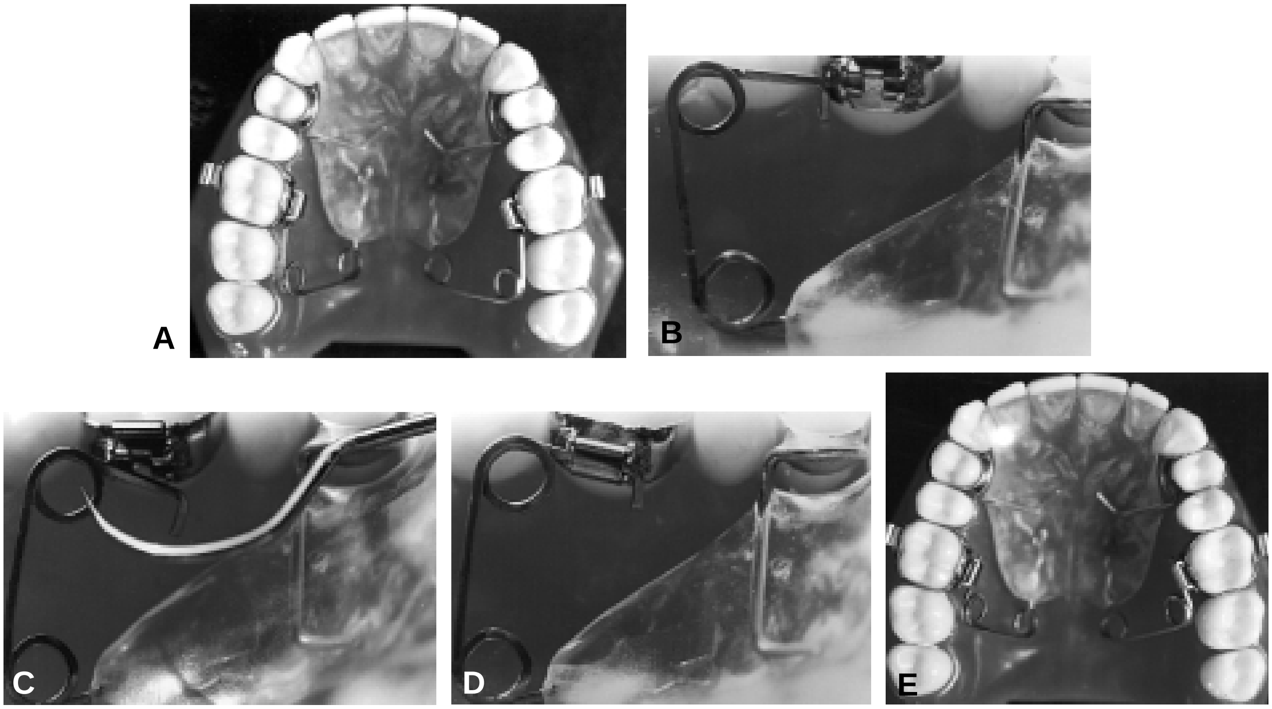

Fig 2. A, Design of appliance before activation; **B**, activation stages of the spring (before activation); **C**, activation stages of the spring (activation of the distalizing component of the spring); **D**, activation stages of the spring (activation of the uprighting component of the spring); **E**, design of appliance after activation.

aspect of the incisors and functioned as an anterior bite plane to disclude the posterior teeth and enhance molar distalization. For molar distalization, 0.032 × 0.032 inch size TMA springs were bent and oriented from the acrylic. The springs had 2 components. The distalizer section of the spring applied a crown tipping force, whereas the uprighting section of the spring applied a root uprighting force to the first molars (Fig 1). The intraoral bodily molar distalizer (IBMD) was cemented to the first premolars without the springs engaged (Figs 2*A* and *B*). After the cementation, the hinge caps on the molar bands were opened. Activation of the springs was accomplished by pulling from distal to mesial with the help of a Weingart plier and then seating into the slot of the palatal hinge cap attachments (Figs 2*C*, *D*,and *E*). A total of 230 g of distal force was applied and measured with the force gauge when the distalizer section of the spring was activated toward the palatal attachment. Most of the cases needed only initial activation. However, in some cases, the spring was reactivated during the treatment with the help of a Weingart plier if more distal molar movement was needed. After distal movement of molars, to attain the Class I molar relationship, they were stabilized by a conventional Nance appliance. This appliance was attached to the

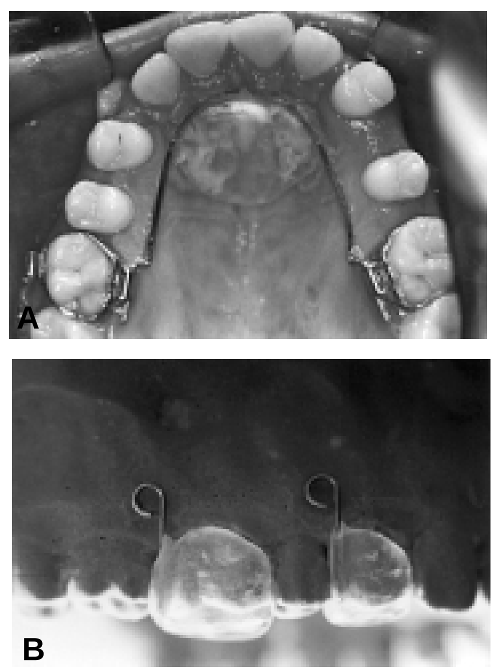

Fig 3. A, Nance button was engaged to the hinge cup attachments right after the distal movement of the molars; **B**, wire markers for lateral cephalometric analysis.

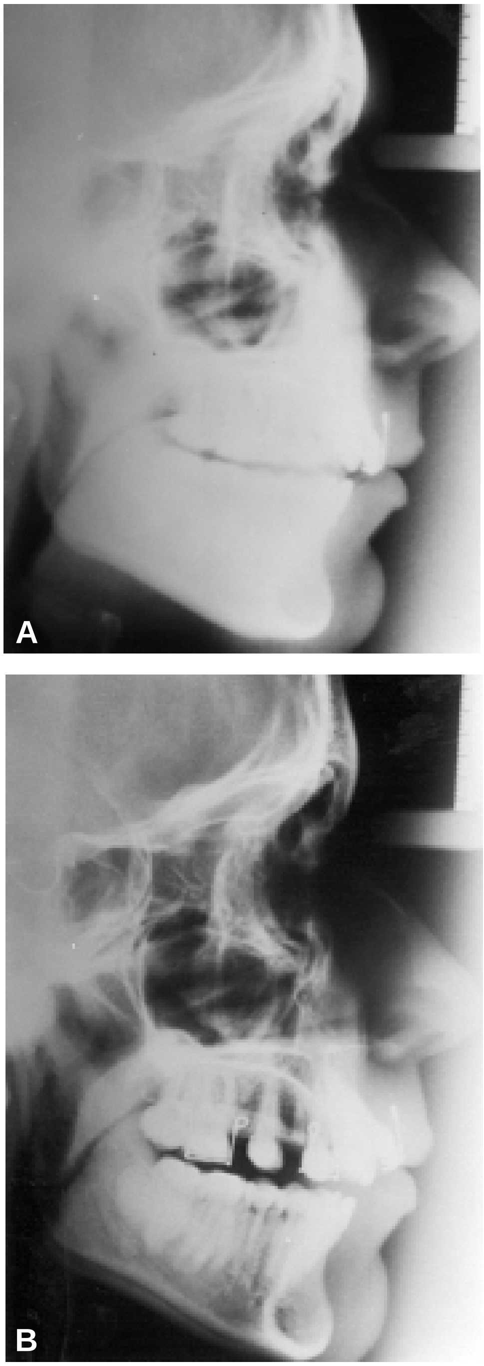

Fig 4. A, Lateral cephalometric radiograph of a patient with the wire markers cemented temporarily before the distalization; **B**, lateral cephalometric radiograph of a patient with the wire markers cemented temporarily after the distalization.

hinge caps on the molars for 2 months before the second phase of orthodontic treatment. This would allow the orthodontist to remove the Nance button by opening the hinge caps without any difficulty for cleaning

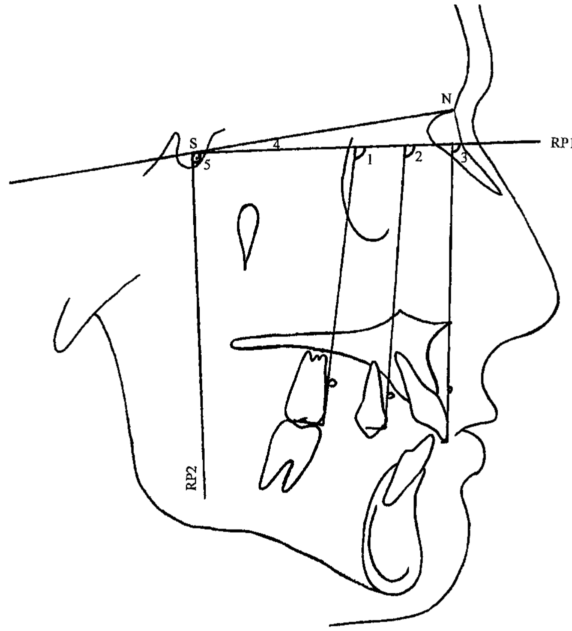

Fig 5. Angular measurements for maxillary dental changes.

and in case of irritation. After 2 months, the rest of the maxillary teeth were bonded, and the Nance button was maintained until Class I canine relationship was achieved (Fig 3*A*).

Cephalometric Analysis

To analyze the parameters related to the maxilla other than the dental changes, conventional lateral cephalometric radiographs were taken before and after the molar movement. To analyze the parameters related to the maxillary dental changes, a new method was developed. Most of the time it is difficult to identify the inclination of the right and left molars and premolars on cephalometric radiographs because of the superimposition of the right side on the left side. Wire markers (0.032 inch) were oriented vertically and retained in acrylic caps, which were made for maxillary first molars, first premolars, and right central incisor (Fig 3*B*). On the right side, the tip of the wires was bent distally and mesially on the left side. On the right side, the markers were oriented vertically from the distal and on the left side from the mesial in order to prevent the superimposition of these markers on the cephalograms. The markers were cemented temporarily to the molars, premolars, and right central incisor, respectively. Lateral cephalometric radiographs were taken and analyzed before and after molar distalization (Figs 4*A* and *B*). The cephalometric parameters used in our study are presented in Figs 5-7.

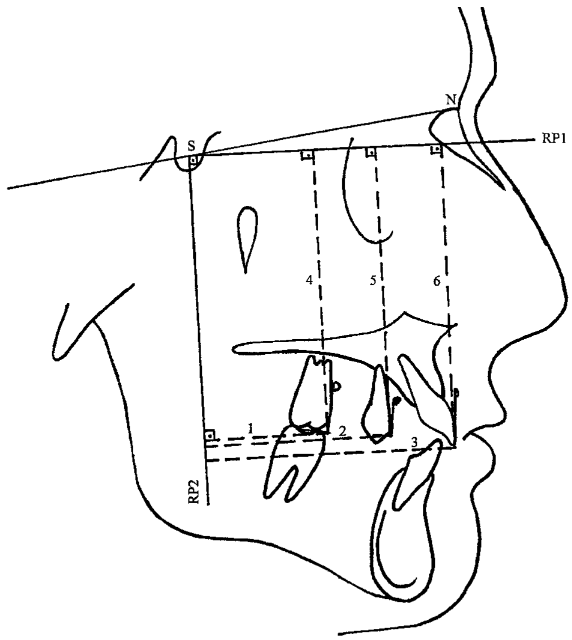

Fig 6. Linear measurements for maxillary dental changes.

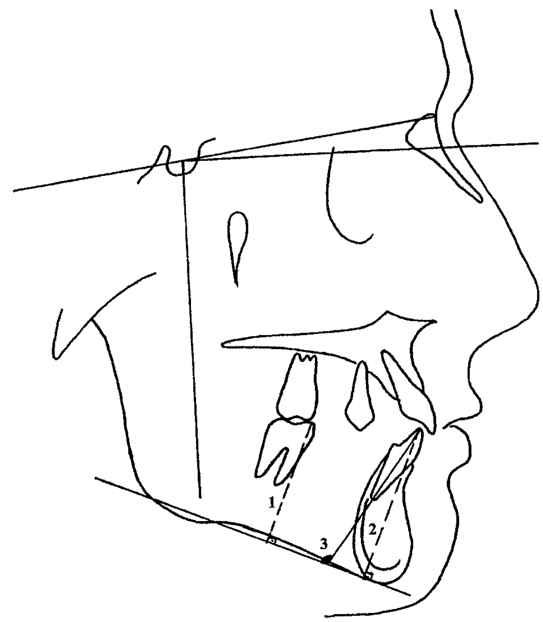

Fig 7. Linear and angular measurements for mandibular dental changes.

Model Analysis

In order to determine the rotations of the maxillary first molars and changes in intermolar distance, model analysis was carried out. The median palatal suture of the study models was defined by tracing with a 0.5 mm pointed drawing pencil. To evaluate the location of the first molars before and after the treatment, the cusp tips of these teeth were marked as well. Model photocopies were obtained as described by Champagne.[14] On model photocopies, a midline was drawn along medial palatal suture. For the first molars, 2 diagonal lines were drawn between the cusp tips of the first molars and their point of intersection was marked. The following measurements were analyzed on the model occlusal photocopies (Fig 8).

Rotation of the maxillary first molar. The angle between the midline and the line passing through the mesiobuccal and distopalatal cusp tips of the maxillary first molars.

Intermolar distance. The distance between the intersection of the two diagonal lines passing from the cusp tips of the maxillary first molars.

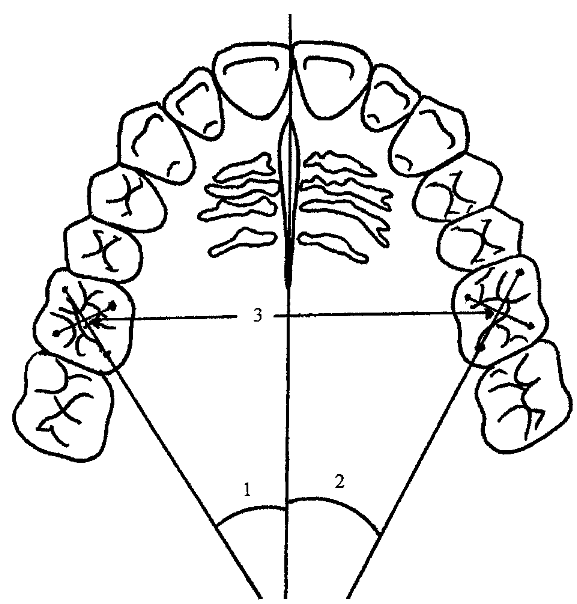

Fig 8. Maxillary model photocopy measurement.

Statistical Method

Nonparametric Wilcoxon sign rank test was used for statistical evaluation. Method error was calculated with correlation analysis.

RESULTS

The results of the present study showed that maxillary first molars were distalized bodily 5.23 mm ($P < .001$) on average. Maxillary molar extrusion was not observed after distalization. Class I molar relationship was achieved in an average period of 7.5 months. Maxillary first premolars moved forward 4.33 mm ($P < .001$), were extruded 3.33 mm ($P < .001$), and tipped 2.735 distally ($P < .05$). A 4.77 mm protrusion ($P < .001$) and 6.73° proclination ($P < .01$) of the incisors were observed. The overjet was increased by 4.1 mm

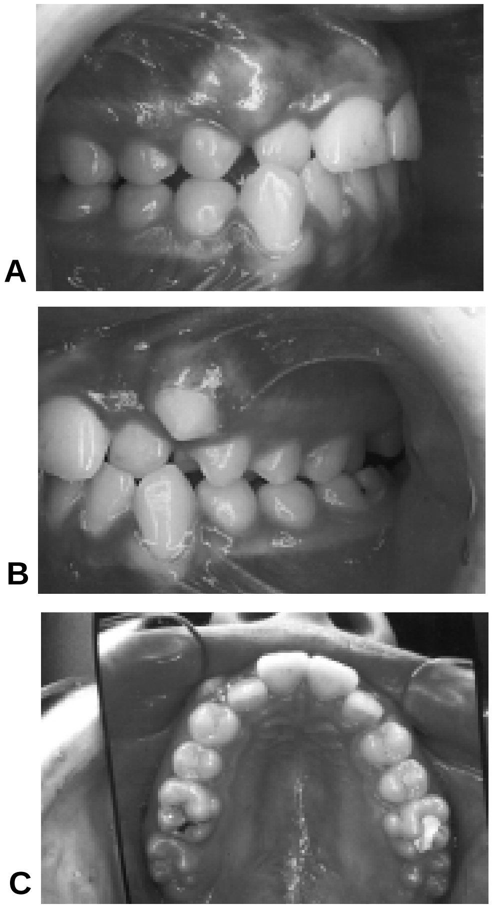

Fig 9. Intraoral view of patient 1 before the distal movement of the molars (**A**, right; **B**, left; **C**, occlusal).

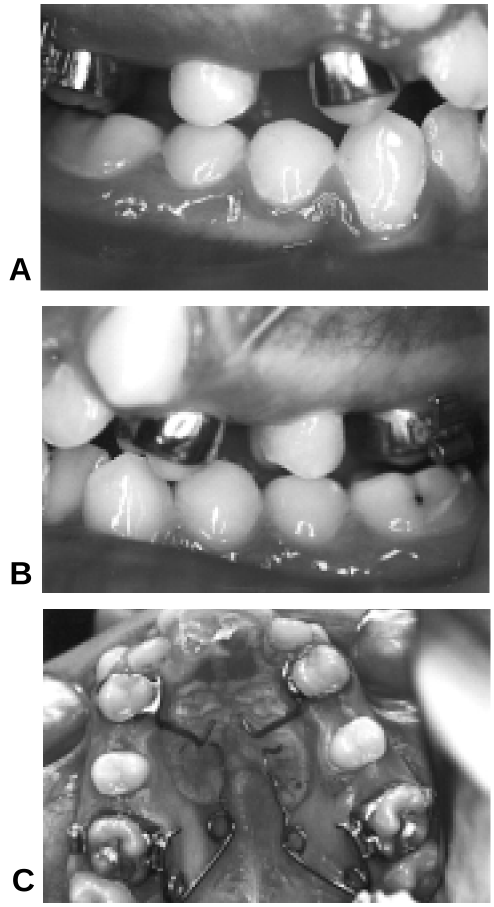

Fig 10. Intraoral view of patient 1 after the distal movement of the molars (**A**, right; **B**, left; **C**, occlusal).

($P < .001$), whereas the overbite was reduced by 2.63 mm ($P < .001$). Mandibular first molars were extruded by 1.53 mm ($P < .001$). Intraoral pictures of one of the patients before and after distalization and also at the end of the second phase treatment are shown in Figs 9, 10, and 11. The model analysis showed that maxillary molars did not rotate and intermolar distance did not change after distalization. If we look at the skeletal changes, SN/GoMe, SN/Occ plane angle, and SN/Palatal plane angle increased by 1.26° ($P < .01$), 1°($P < .05$) and 0.43°($P < .05$), respectively. Anterior lower face height to total face height ratio was increased by 0.95 mm ($P < .001$). SNA increased by 1.56° ($P < .01$), whereas ANB angle increased by 1.66° ($P < .01$). After the removal of IBMD, incisor protrusion and mesial migration of premolars spontaneausly relapsed distally (Figs 12 and 13). The cephalometric and model analysis results are presented in Table I and II. The cephalometric superimposition, which was drawn from the mean values, represented the effect of IBMD on maxillary dentition (Fig 14).

DISCUSSION

A Class II malocclusion, which requires maxillary molar distalization, can be difficult to treat. Several methods were introduced for molar distalization. However, patient cooperation (headgear, Class II elastics, removable appliance) is a major requirement for the success of the treatment. Noncompliance treatment modalities eliminate the dependence on patient cooperation, however, bodily molar distalization has not been achieved with most techniques.

Our results showed that maxillary molars were distalized bodily without any rotation. The IBMD does not depend on patient cooperation and does not require headgear for root uprising.

In our study, 15 patients were treated with an average age of 13.53 years old ranging from 11 to 16 years old. Second molars were present in all the

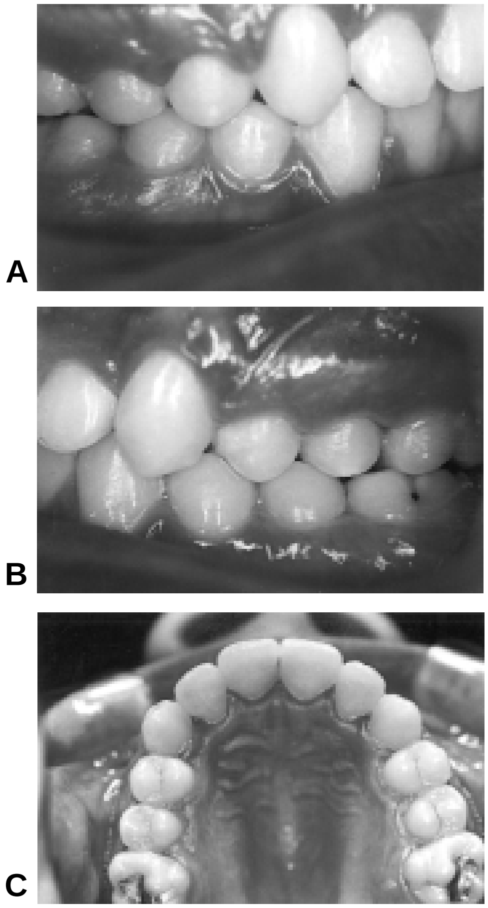

Fig 11. Intraoral view of patient 1 at the end of the orthodontic treatment (**A**, right; **B**, left; **C**, occlusal).

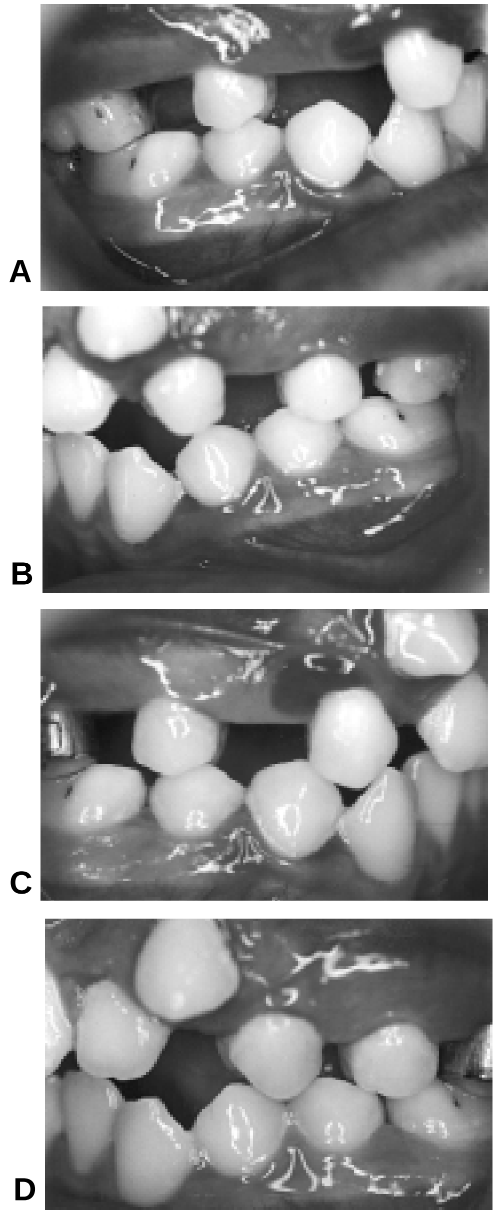

Fig 12. Intraoral view of patient 2 right after the distal movement of the molars (**A**, right; **B**, left). Intraoral view of patient 2 after 1 month of stabilization period by Nance button (distal drift of the maxillary first premolars) (**C**, right; **D**, left).

cases. According to Ghosh and Nanda,[15] there were no statistically significant differences in first molar distalization as well as anchorage loss between patients with erupted and unerupted maxillary second molars.

The purpose of using a wide plate was to get support from a wider palatal tissue to increase the anchorage. According to Ghosh and Nanda,[15] the pendulum appliance anchorage loss could possibly be reduced if the anchor unit was adequately reinforced by full palatal coverage. In our appliance design, maxillary first premolars were banded and connected to the acrylic plate with the retaining wires as described by Gianelly et al[8] and Bondemark and Kurol.[9] The acrylic button had an anterior bite plane, which was effective in deep bite correction and also enhanced the distal movement of maxillary molars by disoccluding the posterior teeth. The purpose of using square sectioned springs for distal movement of molars was to have a better transverse control. In the inactive stage before engaging the spring into the slot, the uprighting section of the spring was being positioned at the same height, parallel, and distal to the palatal cleat (Fig 2*B*). Based on the elastic properties of the TMA, the spring's distalizer section was activated mesially without plastic deformation and engaged into the hinge cap attachment. Unlike the Pendulum appliance, the springs moved the maxillary

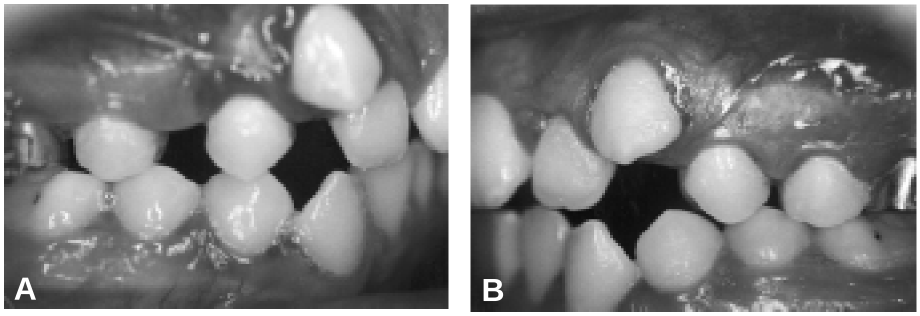

Fig 13. Intraoral view of patient 2 after 2 months of stabilization period by Nance button (distal drift of the maxillary first premolars) (**A**, right; **B**, left).

Table I. Mean, standard deviation, and minimum and maximum values for changes in cephalometric skeletal and dental measurements

Measurement	*Mean*	*SD*	*Minimum*	*Maximum*	*P value*	*Probability*
Skeletal						
SN-mandibular plane angle (°)	1.26	0.96	0	3	.0022	**
SN-occlusal plane angle (°)	1	1.29	–2	3	.0167	*
SN-palatal plane angle (°)	0.43	0.62	0	2	.0277	*
SNA (°)	1.56	1.42	0	5	.0022	**
SNB (°)	–0.1	0.91	–2	1.5	.7213	NS
ANB (°)	1.66	1.50	–0.5	5	.0021	**
ANS-Me/N-me (ratio)	0.95	0.59	0.1	2	.0007	***
Dental–Angular (°)						
Maxillary first molar-RP1	1.15	6.46	-10	14	.3525	NS
Maxillary first premolar-RP1	2.73	6.71	–15.5	15.5	.0196	*
Maxillary incisor–RP1	6.73	5.98	–3.5	19	.0023	**
Mandibular incisor–mandibular plane	1.2	1.59	–2	4	.0218	*
Dental–Linear (mm)						
Maxillary first molar-RP2	5.23	1.89	1.5	11	.0000	***
Maxillary first premolar-RP2	4.33	2.66	–1.5	12	.0000	***
Maxillary incisor–RP2	4.7	2.15	1	8	.0007	***
Maxillary first molar-RP1	0.26	1.31	–2.5	2	.2158	NS
Maxillary first premolar-RP1	3.33	1.89	–2	7	.0000	***
Maxillary incisor-RP1	1.06	2.56	–4.5	5.5	.1026	NS
Mandibular incisor tip–mandibular plane	–0.33	0.69	–2	0.5	.0796	NS
Mandibular first molar mesial cusp tip mandibular plane	1.53	0.63	0	2	.0010	***
Overjet	4.1	1.71	1	7	.0007	***
Overbite	–2.63	0.87	–4	–1	.0007	***

*Implies significance at $P < .05$.

Table II. Mean, standard deviation, and minimum and maximum values for changes in transverse measurements and maxillary first molar rotation

Measurement	*Mean*	*SD*	*Minimum*	*Maximum*	*P value*	*Probability*
Between maxillary first molars' center (mm)	0.53	1.91	–3.5	3	.2934	NS
Maxillary first molar-median of palate (°)	0.78	10	–20	20	.5538	NS

*Implies significance at $P < .05$; ** implies significance at $P < .01$; *** implies significance at $P < .001$
NS = Nonsignificant.

first molars distally toward the direction where the springs were in a inactive stage (Fig 2*A* and *B*). In our appliance design, approximately 230 g of force was applied to the first molars. In the literature the optimum force ranges from 100 to 230 g for molar distal movement of molars.[4,5,7-11]

In all the cases, Class II molar relationship was corrected and Class I molar relationship was achieved by means of 5.23 mm bodily distal movement of molars. Distal tipping and extrusion of molars were not statistically significant. Maxillary molars were distalized bodily. Ghosh and Nanda[15] evaluated the effect of pendulum appliance. According to their findings, molars were moved distally by 3.37 mm with 8.36° distal tipping.[15] As they claim, the stability of distally tipped molars is not certain and their use as an anchorage to retract the anterior teeth is questionable.[15] After distalization, the position of the first molars was retained with either the Nance button or utility arches. They suggested that posterior anchorage may be improved by uprighting the molars with headgear.[15]

According to Gianelly et al,[16] after distalization the molars needed to be stabilized in their new positions for at least 3 to 6 months while being uprighted with a passive 0.016 × 0.022 inch arch wire with stops at the molars and a high-pull headgear. Therefore, the use of headgear does not allow us to classify the pendulum appliance or the Gianelly et al technique as noncompliance therapy. The cases that Gianelly et al[8,11] presented with open coil springs and magnets showed distal tipping of molars.[8,11] Bondemark and Kurol[9] found in their study with magnets that molars moved 4.2 mm distally with 8° distal tipping. After this study, they conducted another study[10] with repelling magnets versus superelastic Ni-Ti coil springs. They reported that with the modification of the appliance and extending a wire from the Nance through the palatal tube of the first molar bands, first and second molars were distalized with minimal tipping. This arrangement achieves molar distalization with sliding mechanics; nevertheless, minimal distal tipping and distobuccal rotation of molars were still observed.

If we look at the dental changes related to the first premolars and incisors, maxillary first premolars moved 4.33 mm mesially and were extruded by 3.33 mm with the use of IBMD. Maxillary incisors were protruded by 4.7 mm with 6.73° labial tipping.

By using a pendulum appliance, Ghosh and Nanda[15] showed 2.55 mm of premolar mesial movement with 1.29° mesial tipping and 1.7 mm extrusion. Thus, for every millimeter of distal molar movement, the premolars moved mesially 0.75 mm. Nevertheless, this anchorage loss was seen in conjunction with 8.36° molar distal tipping. Our findings showed that for every millimeter of molar distalization, 0.82 mm anchorage loss was seen, but no distal tipping of molars was observed. This would explain why bodily molar distalization requires more anchorage. During the stabilization period with Nance button for 2 months, premolars drifted distally and overjet was reduced spontaneously without any orthodontic therapy (Figs 12 and 13). We believe that the removal of IBMD eliminated mesially directed force on premolars and incisors; as a result, the anchorage unit relapsed distally.

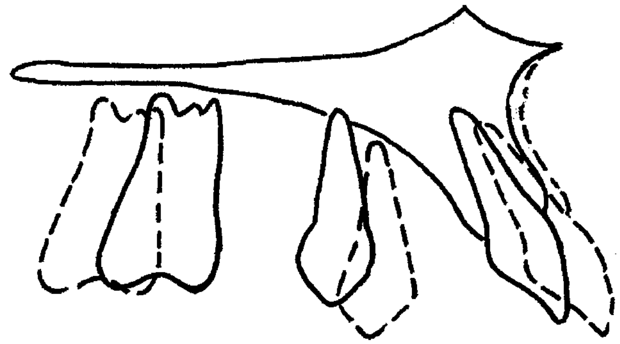

Fig 14. Cephalometric superimposition shows effects of IBMD appliance on maxillary dentition.

Model analysis showed that intermolar distance was increased by 0.53 mm. However, this result was not statistically significant. Molar rotation was not observed after the distal movement of molars. Overjet was increased by 4.1 mm, and overbite was reduced by 2.63 mm. Mandibular molars were extruded by 1.53 mm, SN/GoMe plane angle increased by 1.26°. Anterior lower face height to total face height ratio was increased by 0.95 mm ($P < .001$). The reduction of the overbite, the increase of SN/GoMe and the increase of lower face height to total face height ratio could be related to the mandibular molar extrusion and cuspal interference. SNA increased by 1.56° ($P < .001$), whereas ANB angle increased by 1.66° ($P < .01$). SNB did not change after distal molar movement. The increase of SNA angle could be related to the proclination of incisors and the remodeling of A point.

CONCLUSION

The IBMD is a very effective appliance to distalize molars bodily without using any extraoral appliance or other intraoral mechanics. Class I molar relationship was established in a period of 7.5 months on average. The appliance was fixed and did not depend on patient cooperation. In a few patients, the palatal mucosa was inflamed. However, the tissue recovered within a week after the removal of the appliance. Molar distalization cost some anchorage loss. However, during the stabilization of maxillary molars with Nance button for 2 months, the lost anchorage was regained by distal relapse of premolars without any orthodontic therapy. After the removal of the appliance, hinge cap palatal attachments were used on the first molars for fixation of the Nance appliance. It is hypothesized that bonding the second premolars and canines and using the entire buccal segment would decrease the anchorage loss while distalizing the molars. Perhaps, distoplalatal activation of the spring would derotate the molars before distalization and enhance the distal movement of molars. Further studies are needed to be done at the end of the second stage of orthodontic treatment in order to examine the stability of distally translated molars when correcting the Class II canine relationship and reducing the overjet.

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