European Journal of Orthodontics 28 (2006) 361–365
doi:10.1093/ejo/cji118
Advance Access publication 28 April 2006

Unilateral molar distalization with a modified slider

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SUMMARY Although there are numerous publications on bilateral non-compliance molar distalization appliances, there is limited information on problems such as asymmetrical unilateral Class II malocclusions. The aim of the present investigation was to examine the distalization of molars unilaterally in patients with a unilateral Class II molar relationship utilizing a Keles Slider, designed without a bite plane. Ten girls (mean age 13.94 ± 2.13 years) and seven boys (mean age 13.12 ± 1.51 years) comprised the study material. Following insertion of the appliance, the patients were seen monthly and the screw was reactivated every 2 months. After a super-Class I molar relationship was achieved, the appliance was removed and the molars were stabilized with a Nance appliance for 2 months before the second-phase of orthodontic treatment. The Nance appliance was maintained in the palate until the end of canine distalization. Lateral cephalometric radiographs were obtained before and immediately after insertion of the molar distalizer.

The results showed that the maxillary first molars were distalized bodily on average by 2.85 mm. The maxillary first premolars moved forward bodily 2 mm and were extruded 2.03 mm. In all, 1.32 mm of protrusion, 1.12 mm of extrusion, and 1.79 degrees of proclination of the upper incisors were observed. The mandibular incisors and mandibular molars erupted 0.83 and 0.95 mm, respectively. The unilateral Keles Slider distalized molars successfully to a Class I molar relationship.

Introduction

Since current trends in orthodontics have shifted towards non-extraction therapy, molar distalization mechanics and treatment modalities have become increasingly popular. The use of headgear for molar distalization was followed by easier to use non-compliance intraoral appliances (Gianelly *et al.*, 1989, 1991; Hilgers, 1992; Reiner, 1992; Bondemark *et al.*, 1994; Erverdi *et al.*, 1997; Bussick and McNamara, 2000; Brickman *et al.*, 2000; Keles and Sayinsu, 2000; Keles, 2001; Bolla *et al.*, 2002; Karaman *et al.*, 2002; Keles *et al.*, 2003). In subjects with a unilateral Angle Class II molar relationship the asymmetrical force created by the unilateral headgear often resulted in a crossbite of the distalizing molar, which was why this treatment approach was avoided by orthodontists most of the time (Yoshida *et al.*, 2001).

Although there are numerous publications on bilateral non-compliance molar distalization systems, there is limited information on problems such as asymmetrical unilateral Class II malocclusions. The literature on unilateral distalization comprises mostly case reports, showing the effects of an appliance in a few patients (Reiner, 1992; Keles and Işguden, 1999; Karaman *et al.*, 2002). An intraoral Nance appliance was modified for unilateral molar distalization by Reiner (1992), who reported distalization of 0.19 mm/week. Keles (2001) studied 15 patients who had undergone orthodontic treatment with a unilateral intraoral Keles Slider appliance. The rate of tooth movement was 4.9 mm in 6.1 months. That author concluded that bodily tooth movement occurred with minimal anchorage loss.

The aim of the present investigation was to determine the rate of distalization and anchorage loss, and identify dental changes on the non-distalizing side in patients with a unilateral Class II molar relationship when using a Keles Slider appliance, designed without a bite plane.

Subjects and methods

This research was approved by the Ethical Committee of Yeditepe University.

Subject selection criteria

Ten females (mean age 13.94 ± 2.13 years) and seven males (mean age 13.12 ± 1.51 years) who had registered for orthodontic treatment at the Yeditepe University Orthodontic Clinic were enrolled in the study. All were in the permanent dentition, had a normal vertical growth pattern, a Class I skeletal sagittal relationship with a Class II molar relationship on one side, and a well-aligned mandibular dental arch. None had an overjet of more than 3 mm.

Appliance construction

Appliance construction was executed according to Keles (2001) with few modifications. The maxillary first molars and premolars were banded and the bands were transferred to the maxillary alginate impression. On the model, a 1.3-mm diameter tube (Dentaurum, Pforzheim, Germany) was soldered on the palatal side of the first molar bands. First premolar bands were attached with 1.1-mm diameter

stainless steel retaining wires to the Nance button. Different from the original Keles Slider, the acrylic button did not include an anterior bite plane. A 1.2-mm diameter stainless steel wire was embedded into the acrylic Nance button at the anterior part of the appliance, which then passed through the gingival molar tube and was orientated parallel to the occlusal plane (Figure 1). For molar distalization, a heavy Ni–Ti coil spring (Leone C1214-55, Firenze, Italy), 11 mm in length and 0.055 inch in diameter, was placed between the gurin lock screw (3M Unitek, Monrovia, California, USA) on the wire and the tube in full compression. The amount of force generated with full compression of the 11-mm open coil was approximately 150 g. This system allowed the application of distal force around the level of the centre of resistance of the first molars. The patients were seen monthly and the screw was reactivated every 2 months with a special screwdriver. After a super-Class I molar relationship was achieved, the appliance was removed, and the molars stabilized by a Nance appliance for 2 months before the second-phase of orthodontic treatment. The mean treatment duration for the group was 6.03 months (6.35 months for females and 5.57 months for males).

Cephalometric analysis

Conventional lateral cephalometric radiographs in natural head posture were obtained with a Trophy Ortho Slice 1000 C (Eastman Kodak Company, Harrow, Middlesex, UK) before insertion and immediately after removal of the distalization appliances. To analyse the related maxillary dental changes, a further cephalometric radiograph was obtained using the method of Keles and Sayinsu (2000). Because of superimposition of the right side on the left side, it is sometimes difficult to identify the inclination of the right and left molars and premolars on cephalometric radiographs. Wire markers (0.032 inch) were orientated vertically and retained in acrylic caps, which were made for the maxillary first molars, first premolars, and right central incisor. On the right side, the tip of the wires was bent distally and on the left side mesially. On the right side, the markers were orientated vertically from the distal aspect of the teeth and on the left side from the mesial in order to prevent superimposition of these markers on the cephalograms. The cap markers were temporarily cemented to the teeth while the radiographs were taken. Radiographs were scanned at 300 dpi into Dolphin Imaging Software 9.0 (Los Angeles, California, USA). The skeletal and some dental (IMPA, overjet, overbite, L6–MP, L1–MP) parameters were calculated by the software program, whereas dental parameters measured from the acrylic caps were traced, measured, and registered by hand with conventional methods (KS). Linear measurements were read to the nearest 0.5 mm, and all angular measurements were obtained with a standard protractor and read to the nearest 0.5 degree. The reference planes and dental measurements used are shown in Figures 2 and 3.

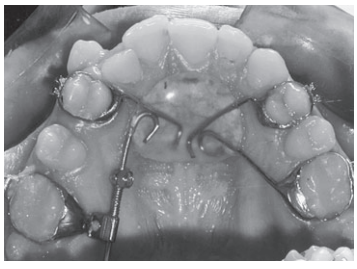

Figure 1 Maxillary occlusal view of a patient at the end of distalization with the appliance *in situ.*

Statistical method

A non-parametric Wilcoxon signed rank test was used to determine intra-group changes. The method error was examined by retracing 10 randomly selected radiographs 1 week after the first measurement (KS). The paired *t*-test did not reveal any errors of more than 0.5 mm and 0.75 degrees in the linear and angular measurements.

Results

The results showed that there were no marked changes in the skeletal parameters (Table 1). The maxillary first molars were, on average, distalized bodily 2.85 mm ($P < 0.001$). The maxillary first premolars moved forward bodily 2 mm ($P < 0.01$) and were extruded 2.03 mm ($P < 0.001$). In all, 1.32 mm of protrusion ($P < 0.01$), 1.12 mm of extrusion ($P < 0.001$), and 1.79 degrees of proclination ($P < 0.01$) of the upper incisors were observed (Table 1). On the non-distalizing side the first premolars were extruded by 1.47 mm ($P < 0.05$; Table 2). The mandibular incisors and molars erupted 0.83 and 0.95 mm (both $P < 0.01$), respectively (Table 1).

Discussion

Several methods have been introduced for molar distalization in the treatment of dental Class II malocclusions. Among these, non-compliance intraoral appliances are gaining popularity because they minimize the dependence on patient co-operation.

The appliance used in this study differed in a few details from the original Keles Slider. The appliance had no bite plane and the palatal wire had a wider diameter in order to increase rigidity. Although the acrylic button had no anterior bite plane, the inter-arch space created by the rest position of the mandible should have eliminated the necessity of disoccluding the posterior teeth for the enhancement of the distal movement of maxillary molars. The results, on the other hand, showed that this smaller Nance button, which did not cover the palatal surfaces of the maxillary anterior teeth and did not include a bite plane, was probably responsible for the greater anchorage loss.

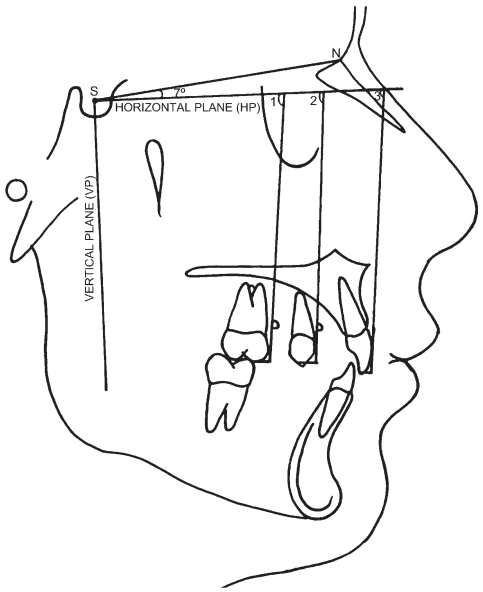

Figure 2 Reference planes and angular dental measurements. Horizontal plane (HP): a horizontal reference line which was constructed 7 degrees from the sella–nasion (SN) plane. Vertical plane (VP): a vertical line passing through point S perpendicular to the HP. 1, 2 and 3: the angles between HP and a line passing through the wire markers.

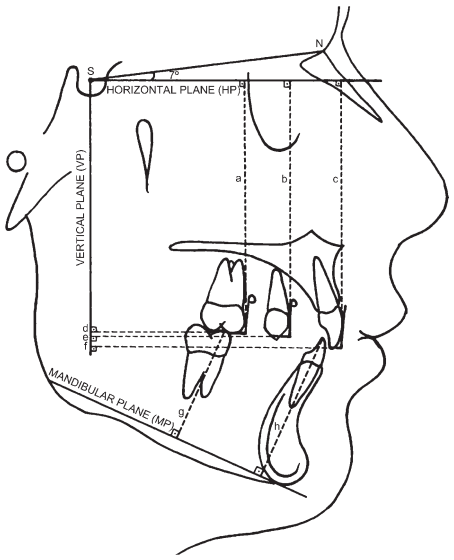

Figure 3 Reference planes and linear dental measurements. a, b and c: the perpendicular distance between the horizontal plane and occlusal edge of the wire markers. d, e and f: the perpendicular distance between the vertical plane and occlusal edge of the wire markers. g: the perpendicular distance between the mandibular plane (MP) and the tip of the mesial cusp of the mandibular first molar. h: the perpendicular distance between the MP and the incisal edge of the mandibular central incisor.

The appliance design in this study involved a force of approximately 150 g generated on the distalizing first molars. The optimum force suggested in the literature for molar distalizaiton ranges from 100 to 240 g (Blechman and Smiley, 1978; Cetlin and Ten Hoeve, 1983; Wilson and Wilson, 1987; Gianelly *et al.*, 1988, 1991; Bondemark and Kurol, 1992; Bondemark *et al.*, 1994; Bolla *et al.*, 2002).

In order to show the dental changes generated by the appliance, acrylic caps with wire markers were utilized. Since it is difficult to distinguish the right and left molars and premolars on cephalograms, a method for the detection of the position and angulation of each tooth must be used in order to determine accurately the changes.

In the present study the Class II molar relationship was corrected unilaterally by 2.85 mm ($P < 0.001$) bodily distal movement of the molars. The rate of distal movement was 0.48 mm per month. In the investigation by Keles (2001), 4.92 mm of molar distalization and 1.31 mm of premolar mesialization was noted. This difference in the amount of distalization and anchorage loss between the two studies may arise from the changes in the design of the appliance. The lack of an anterior bite plane in the present study may have caused the greater amount of anchorage loss with less distal molar movement.

With the Keles Slider in the present study the molars were distalized without any extrusion. The amount of distal tipping on the other hand was very unpredictable. The 2.56 ± 4.65 degrees of molar distal tipping was not statistically significant, which indicated that the results for this parameter could not be represented by an average. This variation resulted mainly from the position of the point of application, in other words the position of the molar tube. If the line of action can be directed to the level of the centre of resistance of the maxillary first molars, then the appliance is able to move the molars distally without any tipping, which is not easy to achieve routinely in every patient. When studies investigating the effects of the Distal Jet appliance, which is similar to the Keles Slider, were analysed, an average of 3 mm of molar crown distalization with 3–7 degrees of distal inclination was observed (Bolla *et al.*, 2002). These results are similar to the findings in the present study.

As stability of distally tipped molars is uncertain and their use as anchorage to retract anterior teeth is questionable, in order to upright the molars and stabilize anchorage, headgear may be necessary (Nanda, 1996). This however, introduces the unpredictability of relying on patient co-operation for success.

In their study with magnets, Bondemark and Kurol (1992) found that the molars moved 4.2 mm distally with 8 degrees of distal tipping. In a subsequent study (Bondemark *et al.*, 1994), comparing repelling magnets and super-elastic Ni–Ti coil springs, reported that with the modification of the appliance by extending a wire from the Nance through the palatal tube of the first molar bands, resulted in digitalization of the first and second molars with minimal tipping. This arrangement achieved molar distalization with sliding mechanics; nevertheless minimal distal tipping and distobuccal rotation of molars were observed.

In the present study the maxillary first premolars moved 2.0 ± 1.92 mm ($P < 0.01$) mesially, and were extruded

Table 1 Comparison of the skeletal and dental changes on the distalizing side using the Wilcoxon signed rank test.

	Pre-treatment				Post-treatment				Difference				*P* value	Probability
	Mean	SD	Median	Range	Mean	SD	Median	Range	Mean	SD	Median	Range		
Skeletal														
Go–Me/SN (°)	34.5	6.02	34.8	19.8	34.3	6.34	33.8	19.6	−0.21	1.5	0.1	6.2	0.795	NS
ANS–Me/N–me (%)	56	1.86	56.7	5.7	56.4	1.87	56.5	7.4	0.39	0.91	0.5	3.9	0.088	NS
Jarabak (%)	65	5.01	64	16.3	65.4	5.27	65.8	17.2	0.44	1.42	0.2	5.3	0.326	NS
∑ (°)	395	6.02	394.8	19.8	394	6.34	393.8	19.6	−0.21	1.5	0.1	6.2	0.868	NS
OCP–SN (°)	17.1	4.35	17.7	13.4	16.7	4.87	18.2	14.3	−0.41	1.33	−0.6	4.1	0.227	NS
SNA (°)	79.1	9.91	79.2	14.2	79.4	4.75	79.7	16	0.31	1.99	0.6	9.7	0.074	NS
SNB (°)	75.8	3.73	75.6	14.3	76.3	4.01	76.8	14.6	0.53	1	0.4	4.9	0.008	**
ANB (°)	3.26	2.33	2.5	7.4	3.04	2.32	2.1	8.7	−0.22	1.35	0.1	5.8	0.704	NS
Dental														
U6–HP (°)	61.8	14.3	62	62	59.3	14.39	61	59	−2.56	4.65	−4.5	15	0.055	NS
U4–HP (°)	69.5	11.2	69	41.5	67.3	13.72	66	50	−2.21	4.87	−2	18	0.093	NS
U1–HP (°)	79.8	13.3	80	50	81.6	12.5	79	46	1.79	2.35	2.5	9	0.009	**
U6–VP (mm)	36.9	7.94	36.5	25	34	8.38	35	25.5	−2.85	0.81	−3	3	0.001	***
U4–VP (mm)	54.8	6.67	54.5	27.5	56.8	6.7	55.5	24.5	2	1.92	3	6	0.002	**
U1–VP (mm)	71.1	6.77	72	27.5	72.4	6.74	73	28	1.32	1.37	1.5	5.5	0.002	**
U6–HP (mm)	67.9	5.05	67	17.5	67.8	5.16	67	17.5	−0.15	1.06	0	3.5	0.552	NS
U4–HP (mm)	71.1	4.41	71	15.5	73.1	4.09	72.5	15.5	2.03	1.49	2	5.5	0.001	***
U1–HP (mm)	74.2	3.93	74	13.5	75.3	3.95	75.5	14	1.12	0.98	1	8	0.001	***
IMPA	93.8	7.06	92.9	30.7	94.2	6.23	94.4	27.3	0.41	1.39	0.4	4.1	0.287	NS
Overjet	4.16	2.14	4.4	9.3	5.54	2.02	5.2	8.3	1.38	0.63	1.3	2.3	0.001	***
Overbite	3.08	1.94	3	7.2	2.61	2.36	3.2	8.6	−0.46	1.04	−0.2	3.6	0.131	NS
L6–MP (mm)	30.95	3.91	30	13.5	31.9	4.06	31.6	13.1	0.95	1.21	0.8	3.8	0.006	**
L1–MP (mm)	40.86	2.89	40.4	10.7	41.69	2.71	42.1	9.6	0.83	0.92	0.7	3.1	0.006	**

Positive values imply mesialization, extrusion, mesial and labial tipping.
$P < 0.01$;*$P < 0.001$; NS = not significant; SD = standard deviation.

Table 2 Comparison of the dental changes of the non-distalizing side using Wilcoxon signed rank test.

	Pre-treatment				Post-treatment				Difference				*P* value	Probability
	Mean	SD	Median	Range	Mean	SD	Median	Range	Mean	SD	Median	Range		
Dental														
U6–HP (°)	67.68	8.73	67	29	68.17	8.33	68	25	0.56	2.22	0	8.5	0.247	NS
U4–HP (°)	75.71	12.06	79	37	75.82	12.17	78	43	0.12	2.66	1	8	0.793	NS
U6–VP (mm)	37.18	7.18	37.5	25.5	36.91	7.54	38.5	26.5	−0.26	1.16	0	5	0.476	NS
U4–VP (mm)	53.26	6.73	53.5	24	52.94	7.05	52	27	−0.32	1.24	0	4	0.416	NS
U6–HP (mm)	68.15	3.71	67.5	13	69.23	3.35	69	12.5	1.08	1.24	1	4.5	0.051	NS
U4–HP (mm)	70.94	3.45	71	12	72.41	3.38	72.5	12	1.47	1.44	1.5	6.5	0.02	*

Positive values imply mesialization, extrusion, mesial and labial tipping.
*$P < 0.05$; NS = not significant; SD = standard deviation.

2.03 mm ($P < 0.001$). Distal tipping of the premolars was 2.21 ± 4.87 degrees which was not statistically significant. Forty-one per cent of the space was created by mesial movement of the first premolars in the buccal region. Bolla *et al.* (2002) reported premolar anchorage loss to be 1.3 mm, where half of the subjects had second molars erupted. Contrary to studies where the premolars were shown to tip mesially (Keles, 2001), the finding on distal tipping of the anchor premolars is very similar to the data of Bolla *et al.* (2002) of 2.8 degrees and Keles and Sayinsu (2000) of 2.73 degrees of distal tipping. The distal tipping of premolars in this study can be explained by the clockwise moment on the Nance button created by the force of coil spring. Ghosh and Nanda (1996), using the pendulum appliance, reported 2.55 mm of premolar mesial movement with 1.29 degrees of mesial tipping and 1.7 mm extrusion. For every millimetre of distal molar movement, the premolars moved mesially 0.75 mm. This anchorage loss was seen in conjunction with 8.36 degrees of molar distal tipping. The intraoral bodily molar distalizer moved molars distally without any tipping but with greater anchorage loss (Keles and Sayinsu, 2000). For every millimetre of molar distalization, 0.82 mm

anchorage loss was observed. It should be borne in mind that bodily molar distalization may cause an increase in anterior anchorage loss.

In the present study, there was the opportunity to evaluate the changes which occurred at the non-distalizing side with the aid of wire markers. The results showed that the only dental change was the extrusion of the premolars by 1.47 mm ($P < 0.05$; Table 2). This movement at the non-distalizing side can be explained by the moment created on the anterior part of the appliance.

The maxillary incisors were protruded 1.32 mm ($P < 0.01$) with 1.79 degrees ($P < 0.01$) of labial tipping and 1.12 mm ($P < 0.001$) extrusion. Similar results have been repeated in studies investigating the effects of intraoral distalization appliances. It should therefore be borne in mind that maxillary incisors tend to tip labially regardless of the type of distalization appliance (Bondemark and Kurol, 1992; Ghosh and Nanda, 1996; Keles and Işguden, 1999; Bussick and McNamara, 2000; Keles and Sayinsu, 2000; Keles, 2001; Bolla *et al.*, 2002).

During the stabilization period of 2 months with the Nance button spontaneous distal drift of the premolars and a reduction in the overjet was observed in all patients. The removal of the distalization appliance eliminated the mesially directed force on the premolars and incisors; consequently the anchorage unit relapsed distally.

The mandibular molars erupted 0.95 mm ($P < 0.01$) and the mandibular incisors 0.83 mm ($P < 0.01$) in order to compensate for the continued vertical and horizontal facial growth.

Conclusions

The modified unilateral Keles Slider distalized molars successfully to a Class I molar relationship with 0.48 mm of distal movement per month. Fifty-nine per cent of the space was created by the distal movement of the first molar in the buccal region. Although a unilateral force was applied, the anchorage loss was comparable with bilateral distalizing appliances. The only dental change at the non-distalizing side was the extrusion of the premolars by 1.47 mm, which could be explained by the moment created on the anterior part of the appliance. Patients with palatally inclined or upright maxillary incisors should be selected for treatment with distalization devices.

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