CHAPTER 2

SYSTEMATIC LITERATURE REVIEW: MAXILLARY MOLAR DISTALIZATION WITH OR WITHOUT TEMPORARY ANCHORAGE DEVICES

Introduction

Maxillary molar distalization is an important treatment option for the correction of Class II malocclusions.[14,40,41] Therefore, a large variety of distalization devices, intra- and extra-oral appliances, have been developed and used to move the maxillary molars distally.[40,42,43] However, undesirable movement of the anchorage units is unavoidable. The side effects are increased overjet, proclination of maxillary incisors and premolar mesialization. Therefore, the use of palatal miniscrew implants have become an important source of anchorage to stabilize distalizing appliances and to avoid undesirable anchorage unit movement.[40]

Conventional intraoral distalizing devices are composed of two main components: the active parts (such as open coil spring, magnets, TMA helix loops and expansion screws) which move the maxillary molars backward and an anchorage unit that mainly relies on a Nance button and premolars to serve as anchorage.[27,43] The anchorage unit resists the reacting force from the active part. However, an anchorage unit is unable to completely resist distalizing force; this is seen often as an increase in overjet and incisor protrusion.[27]

Since miniscrew implants provide absolute anchorage, they can be used to support distalizing devices, consequently reducing the unwanted incisor proclination and the mesial movement of premolars. Recently, several conventional distalizing devices have been adapted to allow their connection with miniscrew implants, thus providing anchorage reinforcement.[15,40] Such combination generates a new class of devices, so-called miniscrew supported devices.

Although several studies have been published describing the overall dental changes produced by intraoral distalizing devices, comparisons of the dental effects produced by both conventional distalizing devices and miniscrew supported devices have not been performed.

Therefore, the purpose of this systematic review was to compare the overall dental effects (amount of molar movement, the degree of molar distal tipping and the rate of molar movement) and distalizing force magnitude between conventional distalizing devices and miniscrew supported devices.

Materials and methods

PubMeb, Science Direct and Angle Orthodontist were searched up to the end of August of 2011 to identify articles on molar distalization. Articles were selected if the studies were on human subjects and their titles and abstracts were published in English. Because of cost constraints, the list of articles was limited to those for which the Chiang Mai University library covered access charges. The list was further reduced by including only studies that used non-compliance distalization devices and that had clear illustrations of the distalization technique, of the appliances and of the amount of maxillary molar movement. Case reports and summary articles were excluded.

Statistical analysis

A comprehensive Meta-Analysis program (Biostat Inc., Englewood, N.J., USA) was used for analysis with 95% Confidence Intervals (CI).

Heterogeneity assessment

I^2 statistic was calculated for heterogeneity assessment. Heterogeneity was defined as low (25%), moderate (50%), or high (75%).

Results

The search yielded 236 publications in Pubmed, 576 publications in Science Direct and 100 publications in Angle Orthodontist. There was overlap among the databases. Using the inclusion and exclusion criteria, 47 publications were selected for analysis. There were 34 articles on conventional distalizing devices and 13 articles on miniscrew supported devices (shown in Table 2.1 and 2.2, respectively). The articles on conventional distalizing devices were divided into eight device groups: eight articles on NiTi-coil springs, four on magnets, three on the Distal Jet, 20 on the Pendulum, two on the First Class Appliance, two on the Jones Jig, three on the Keles Slider, and two on fixed functional appliances. The articles on miniscrew supported devices were divided into six device groups: five articles on the Pendulum, two on NiTi-coil springs, five on group distalization, one on the Distal Jet, one on the Keles Slider, and one on elastics. In this systematic review, nine articles used miniscrew implants inserted in the palate, four used miniscrew implant inserted into buccal interradicular spaces and two used miniplates inserted in the zygoma.

Table 2.1 Details of conventional distalizing device studies included for data analysis

No.	Study	Type of study	Appliance	Buccal/ Palatal	Anchorage	Duration (month)	N	Age
1	Acar et al., 2010	Prospective	Pendulum with K-loop	Palatal	premolar and palate	3	15	15
2	Papadopoulos et al., 2010	Prospective	First class	Palatal	premolar and palate	4	15	9
3	Moro et al., 2009	Prospective	Cantilever Bite Jumper	Buccal	lower arch	21	26	10
4	Patel et al., 2009	Prospective	Jonejig	Buccal	premolar and palate	11	20	13
	Patel et al., 2009	Prospective	Pendulum	Palatal	premolar and palate	14	20	14
5	Polat-Ozsoy et al., 2008	Retrospective	Pendulum	Palatal	premolar and palate	5	17	14
6	Nazan et al., 2007	Prospective	Jasper jumper	Buccal	lower arch	6	25	12
7	Schütze et al., 2007	Retrospective	Pendulum	Palatal	Anterior teeth, premolar and palate	8	15	12
8	Karlsson and Bondemark, 2006	Prospective	NiTi coil	Palatal	premolar and palate	6	20	13
9	Mavropoulos et al., 2006	Prospective	Keles slider	Palatal	premolar and palate	4	12	13
10	Sayinsu et al., 2006	Prospective	Keles slider	Palatal	premolar and palate	6	17	14
11	Bondemark and Karlsson, 2005	Prospective	Ni-Ti coil	Palatal	premolar and palate	5	20	11
12	Bondemark and thorneus, 2005	Retrospective	Ni-Ti coil	Palatal	premolar and palate	6	20	15
	Bondemark and thorneus, 2005	Retrospective	Ni-Ti coil and bite plane	Palatal	premolar and palate	6	20	15
13	Chiu et al., 2005	Retrospective	Distal jet	Palatal	premolar and palate	10	32	12
	Chiu et al., 2005	Retrospective	Pendulum	Palatal	premolar and palate	7	32	13
14	Kinzinger et al., 2005	Retrospective	Pendulum	Palatal	premolar and palate	6	66	12

15	Mavropoulos et al., 2005	Prospective	Jone jig	Buccal	premolar and palate	4	10	13
16	Fortini et al., 2004	Retrospective	First class	Palatal	premolar and palate	2	17	13
17	Kinzinger et al., 2004	Prospective	Pendulum	Palatal	premolar and palate	5	36	12
18	Kinzinger et al., 2003	Prospective	Pendulum	Palatal	premolar and palate	5	10	10
	Kinzinger et al., 2003	Prospective	Pendulum	Palatal	premolar and palate	5	10	12
19	Taner et al., 2003	Prospective	Pend-X	Palatal	premolar and palate	7	13	11
20	Bolla et al.,2002	Retrospective	Distal jet	Palatal	premolar and palate	5	20	13
21	Keles, 2001	Prospective	Keles slider	Palatal	premolar and palate	6	15	13
22	Ngantung et al., 2001	Retrospective	Distal jet	Palatal	premolar and palate	7	33	13
23	Toroğlu et al., 2001	Retrospective	Pendulum	Palatal	premolar and palate	3	14	13
	Toroğlu et al., 2001	Retrospective	Pendulum	Palatal	premolar and palate	3	16	13
24	Bondemark Lars, 2000	Retrospective	Ni-Ti coil	Buccal and Palatal	anterior teeth and premolar	7	21	14
	Bondemark Lars, 2000	Retrospective	Magnetic	Buccal	anterior teeth and premolar	6	21	14
25	Bussick et al., 2000	Prospective	Pendulum	palatal	premolar and palate	7	101	12
26	Joseph and Butchart, 2000	Prospective	Pendulum	Palatal	premolar and palate	3	7	11
27	Keles and Sayinsu, 2000	Prospective	IBMB	Palatal	premolar and palate	8	15	14
28	Gulati et al., 1998	Prospective	NiTi coil	Buccal	premolar and palate	3	10	14
29	Byloff and Darendeliler, 1997	Prospective	Pendulum	Palatal	premolar and palate	4	13	11
30	Byloff et al., 1997	Prospective	Pendulum	Palatal	premolar and palate	7	20	13
31	Erverdi et al., 1997	Prospective	Magnet	Buccal	premolar and palate	3	15	12
	Erverdi et al., 1997	Prospective	NiTi coil	Buccal	premolar and palate	3	15	12
32	Ghosh et al., 1996	Prospective	Pendulum	Palatal	premolar and palate	6	41	12
33	Bondemark et al., 1994	Prospective	Magnet	Buccal	premolar and palate	6	18	15
	Bondemark et al., 1994	Prospective	NiTi coil	Buccal	premolar and palate	6	18	15

34	Bondemark and Kurol, 1992	Prospective	Magnet	Buccal	anterior teeth and premolar	4	10	13

Table 2.2 Details of miniscrew implant supported distalizing device studies included for data analysis

No.	Study	Type of study	Appliance	Buccal/ Palatal	Anchorage	Duration (month)	N	Age
1	Upadhyay et al., 2011	Prospective	NiTi-coil (group)	Buccal	MI (1.3x8)	14	14	17
2	Oh et al., 2011	Prospective	sliding on fixed appliance(group)	Buccal	MI (1.2x6)	20	23	22
3	Kinzinger et al., 2009	Prospective	distal jet	Palatal	2MIs (1.6x8,1.6x9)	7	10	12
4	Yamada et al., 2009	Prospective	sliding on fixed appliance(group)	Buccal	MI (1.3x8,1.5x9)	8	12	28
5	Polat-Ozsoy et al., 2008	Retrospective	BAPA	Palatal	2MIs (2x8)	7	22	14
6	Gelgor et al., 2007	Prospective	NiTi-coil	Buccal	MI (1.8x14)	5	20	13
	Gelgor et al., 2007	Prospective	Keles	Palatal	MI (1.8x14)	5	20	14
7	Escobar, 2007	Prospective	pendulum	Palatal	2MIs (2x11)	8	15	13
8	Önçag et al., 2007	Prospective	pendulum	Palatal (right)	MI (3.8x9)	7	15	14
	Önçag et al., 2007	Prospective	pendulum	Palatal (Left)	MI (3.8x9)	7	15	14
9	Cornelis and Clerck, 2007	Prospective	sliding on fixed appliance	Buccal	Miniplates	7	17	27
10	Kircelli et al., 2006	Prospective	pendulum	Palatal	MI (2x8)	7	10	14
11	Sugawara et al., 2006	Prospective	NiTi-coil (group)	Buccal	Miniplate	19	25	24
12	Park et al., 2005	Retrospective	sliding on fixed appliance(group)	Buccal	MI (1.2x6,1.2x8 ,1.2x10,2x15)	12	11	18
13	Gelgor et al., 2004	Prospective	NiTi-coil	Buccal	MI (1.8x8,1.8x14)	5	25	14

Data synthesis and heterogeneity assessment

The mean of amount of molar distalization presented high heterogeneity in conventional and miniscrew implant supported distalizing device, 97% and 96% respectively (shown in Table 2.3 and Table 2.4).

Table 2.3 Heterogeneity assessment of amount of molar distalization in conventional distalizing device.

	Heterogeneity				Publication bias	
Model	Q-value	Df(Q)	P-value	I-squared	Tau Squared	tau
Fixed effects	1368.714	41	0.000	97.004	1.062	1.031

Table 2.4 Heterogeneity assessment of amount of molar distalization in miniscrew implant supported distalizing device.

	Heterogeneity				Publication bias	
Model	Q-value	Df(Q)	P-value	I-squared	Tau Squared	tau
Fixed effects	367.888	14	0.000	96.194	2.441	1.562

Amount of molar distalization

The amount of molar distalization with conventional distalizing devices was 3.31 mm (95% CI = 3.00 to 3.60 mm) and that with miniscrew supported devices was 3.61 mm (95% CI = 3.00 to 4.40 mm) (See Figures 2.1 and 2.2, respectively). The Pendulum had the greatest amount of molar distalization with conventional distalizing devices, at 4.14 mm, followed by the First Class Appliance and the Keles Slider (4.00 mm and 3.53 mm, respectively). The amounts of molar distalization with the other devices were 2.92 mm with the Jones Jig, 2.71 mm with the Distal Jet and magnet 2.43 mm with NiTi-coil springs and 1.04 mm with fixed functional appliances. The Pendulum also had the greatest amount of distalization with miniscrew supported devices, at 4.98 mm, followed by NiTi-coil springs (3.92 mm), the Distal Jet (3.92 mm), the Keles Slider (3.88 mm) and elastics (3.27 mm). For group distalization, the mean amount of maxillary molar movement was 2.08 mm.

Model	Study name	Year	Statistics for each study						
			Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Bondemark and Kurol	1992	4.20	0.29	0.08	3.63	4.77	14.44	0.00
	Bondemark et al. (magnet)	1994	2.20	0.22	0.05	1.77	2.63	9.93	0.00
	Bondemark et al. (NiTi-coil)	1994	3.20	0.26	0.07	2.70	3.70	12.46	0.00
	Ghosh et al.	1996	3.37	0.33	0.11	2.73	4.01	10.28	0.00
	Byloff and Darendeliler	1997	3.39	0.35	0.12	2.71	4.07	9.78	0.00
	Byloff et al.	1997	4.14	0.36	0.13	3.43	4.85	11.50	0.00
	Erverdi et al. (magnet)	1997	3.80	0.28	0.08	3.24	4.36	13.38	0.00
	Erverdi et al. (NiTi-coil)	1997	2.10	0.03	0.00	2.05	2.15	81.33	0.00
	Gulati et al.	1998	2.75	0.27	0.07	2.22	3.28	10.23	0.00
	Bondemark Lars (magnet)	2000	2.60	0.11	0.01	2.38	2.82	23.36	0.00
	Bondemark Lars (NiTi-coil)	2000	2.50	0.15	0.02	2.20	2.80	16.60	0.00
	Bussick et al.	2000	5.70	0.19	0.04	5.33	6.07	30.15	0.00
	Joseph and Butchart	2000	5.10	0.45	0.21	4.21	5.99	11.24	0.00
	Keles and Sayinsu	2000	5.23	0.49	0.24	4.27	6.19	10.72	0.00
	Keles	2001	4.92	0.46	0.21	4.02	5.82	10.77	0.00
	Ngantung et al.	2001	2.10	0.31	0.10	1.49	2.71	6.70	0.00
	Toroglu et al. (high-angle)	2001	5.90	0.61	0.38	4.70	7.10	9.60	0.00
	Toroglu et al. (low-angle)	2001	4.10	0.20	0.04	3.71	4.49	20.50	0.00
	Bolla et al.	2002	3.20	0.31	0.10	2.59	3.81	10.22	0.00
	Kinzinger et al. (early mixed dentition)	2003	4.00	0.46	0.21	3.10	4.90	8.66	0.00
	Kinzinger et al. (permanent dentition)	2003	2.86	0.49	0.24	1.91	3.81	5.87	0.00
	Taner et al.	2003	3.81	0.62	0.39	2.59	5.03	6.11	0.00
	Fortini et al.	2004	4.00	0.36	0.13	3.29	4.71	10.99	0.00
	Kinzinger et al.	2004	3.14	0.15	0.02	2.84	3.44	20.48	0.00
	Kinzinger et al.	2005	3.46	0.13	0.02	3.20	3.72	26.03	0.00
	Bondemark and Karlsson	2005	2.20	0.17	0.03	1.86	2.54	12.61	0.00
	Bondemark and thorneus	2005	1.70	0.27	0.07	1.17	2.23	6.34	0.00
	Bondemark and thorneus (with bite plane)	2005	1.80	0.23	0.05	1.35	2.25	7.89	0.00
	Chiu et al. (distal jet)	2005	2.80	0.19	0.04	2.42	3.18	14.40	0.00
	Chiu et al. (pendulum)	2005	6.10	0.32	0.10	5.48	6.72	19.17	0.00
	Mavropoulos et al.	2005	2.80	0.27	0.07	2.28	3.32	10.54	0.00
	Mavropoulos et al.	2006	3.10	0.26	0.07	2.59	3.61	11.93	0.00
	Karlsson and Bondemark	2006	1.60	0.17	0.03	1.27	1.93	9.54	0.00
	Sayinsu et al.	2006	2.85	0.20	0.04	2.46	3.24	14.51	0.00
	Nazan et al.	2007	0.72	0.26	0.07	0.21	1.23	2.79	0.01
	Sch tze et al.	2007	3.83	0.28	0.08	3.28	4.38	13.61	0.00
	Polat-Ozsoy et al.	2008	2.70	0.41	0.17	1.89	3.51	6.55	0.00
	Moro et al.	2009	1.50	0.25	0.07	1.00	2.00	5.88	0.00
	Patel et al. (Jone jig)	2009	3.12	0.35	0.12	2.44	3.80	8.94	0.00
	Patel et al. (pendulum)	2009	3.51	0.39	0.15	2.75	4.27	9.07	0.00
	Acar et al.	2010	4.53	0.38	0.14	3.79	5.27	12.02	0.00
	Papadopoulos et al.	2010	4.00	0.13	0.02	3.75	4.25	31.62	0.00
Random			3.31	0.17	0.03	2.98	3.63	19.90	0.00

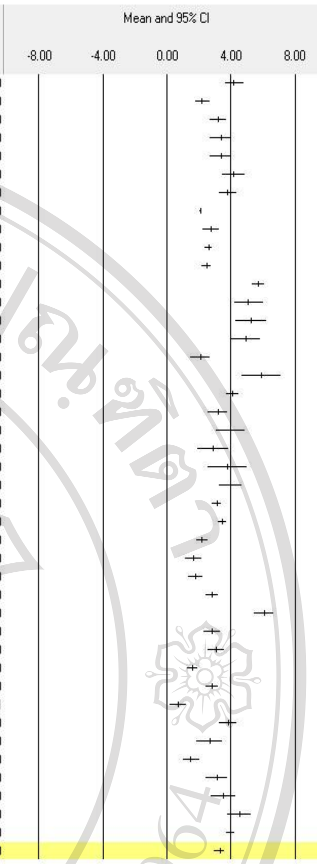

Figure 2.1 Forest plot for the mean amount of distalization for conventional distalizing devices.

Model	Study name	Year	Statistics for each study							Sample size
			Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Total
	Gelgor et al.	2004	3.90	0.32	0.10	3.27	4.53	12.11	0.00	25
	Park et al.	2005	1.64	0.37	0.14	0.92	2.36	4.46	0.00	11
	Kircelli et al.	2006	6.40	0.41	0.17	5.59	7.21	15.57	0.00	10
	Sugawara et al.	2006	3.78	0.27	0.07	3.26	4.30	14.21	0.00	25
	Cornelis and Clerck	2007	3.27	0.42	0.18	2.44	4.10	7.70	0.00	17
	Escobar	2007	6.00	0.59	0.34	4.85	7.15	10.24	0.00	15
	Gelgor et al. (distal jet)	2007	3.88	0.33	0.11	3.24	4.52	11.80	0.00	20
	Gelgor et al. (NiTi coil)	2007	3.95	0.38	0.14	3.21	4.69	10.51	0.00	20
	ńag et al. (left)	2007	4.50	0.31	0.10	3.89	5.11	14.52	0.00	15
	ńag et al. (right)	2007	3.40	0.30	0.09	2.80	4.00	11.16	0.00	15
	Polat-Ozsoy et al.	2008	4.80	0.38	0.15	4.05	5.55	12.51	0.00	22
	Kinzinger et al.	2009	3.92	0.17	0.03	3.59	4.25	23.39	0.00	10
	Yamada et al.	2009	2.80	0.46	0.21	1.89	3.71	6.06	0.00	12
	Oh et al.	2011	1.75	0.42	0.18	0.93	2.57	4.18	0.00	23
	Upadhyay et al.	2011	0.45	0.21	0.04	0.04	0.86	2.13	0.03	14
Random			3.61	0.41	0.17	2.81	4.42	8.81	0.00	

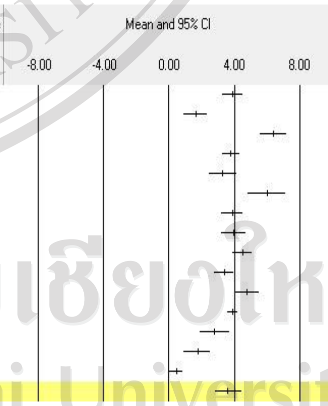

Figure 2.2 Forest plot for the mean amount of distalization for miniscrew implant supported distalizing devices.

Rate of molar distalization

The rates of maxillary molar distalization were 0.66 mm/month (95% CI, 0.54-0.77) and 0.52 mm/month (95% CI, 0.36-0.68) for conventional distalizing devices and miniscrew supported devices, respectively. Conventional distalizing devices showed rates of movement as follows: First Class Appliance = 1.33, Pendulum = 0.76, magnets = 0.67, Keles Slider = 0.66, NiTi-coil springs = 0.53, Jones Jig = 0.49, Distal Jet = 0.41 and fixed functional appliances = 0.09 mm/month (shown in Table 2.5). Miniscrew supported devices showed rates of movement as follows: Pendulum = 0.70, Keles Slider = 0.72, NiTi-coil springs = 0.85, Distal Jet = 0.58, elastics = 0.47 and group distalization = 0.15 mm/month (shown in Table 2.6).

Table 2.5 Rate of molar distalization in conventional distalizing devices.

Devices	Rate (mm/month)
First Class	1.33
Pendulum	0.76
Magnet	0.67
Keles Slider	0.66
NiTi-coil	0.53
Jones Jig	0.49
Distal Jet	0.41
Fixed functional	0.09

Table 2.6 Rate of molar distalization in miniscrew implant supported distalizing devices.

Devices	Rate (mm/month)
Pendulum	0.70
NiTi-coil spring	0.85
Distal Jet	0.58
Keles Slider	0.72
elastic	0.47
Group distalization	0.15

Amount of molar distal tipping

Distal tipping of maxillary molar distalization was 5.66 degrees (95% CI, 4.59-6.73) with conventional distalizing devices and 6.08 degrees (95% CI, 3.47-8.68) with miniscrew supported devices (See Figures 2.3 and 2.4).

Model	Study name	Year	Statistics for each study							Sample size
			Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Total
	Bondemark and Kurol	1992	8.00	1.12	1.25	5.81	10.19	7.17	0.00	10
	Bondemark et al. (magnet)	1994	1.00	0.33	0.11	0.36	1.64	3.07	0.00	18
	Bondemark et al. (NiTi-coil)	1994	1.00	0.33	0.11	0.36	1.64	3.05	0.00	18
	Ghosh et al.	1996	8.36	1.31	1.71	5.80	10.92	6.40	0.00	41
	Byloff and Darendeliler	1997	14.50	2.31	5.34	9.97	19.03	6.28	0.00	13
	Byloff et al.	1997	6.07	1.15	1.33	3.81	8.33	5.27	0.00	20
	Erverdi et al. (magnet)	1997	7.60	0.96	0.91	5.73	9.47	7.96	0.00	15
	Erverdi et al. (NiTi-coil)	1997	9.90	1.27	1.60	7.42	12.38	7.83	0.00	15
	Gulati et al.	1998	3.50	0.59	0.34	2.35	4.65	5.98	0.00	10
	Bondemark Lars (magnet)	2000	2.20	0.55	0.30	1.12	3.28	3.98	0.00	21
	Bondemark Lars (NiTi-coil)	2000	8.80	0.62	0.38	7.59	10.01	14.30	0.00	21
	Bussick et al.	2000	10.60	0.56	0.31	9.51	11.69	19.02	0.00	101
	Joseph and Butchart	2000	15.70	2.68	7.20	10.44	20.96	5.85	0.00	7
	Keles and Sayinsu	2000	1.15	1.67	2.78	-2.12	4.42	0.69	0.49	15
	Keles	2001	0.89	1.29	1.66	-1.64	3.42	0.69	0.49	15
	Ngantung et al.	2001	3.30	0.64	0.41	2.04	4.56	5.12	0.00	33
	Toroglu et al. (high-angle)	2001	14.90	1.42	2.01	12.12	17.68	10.52	0.00	14
	Toroglu et al. (low-angle)	2001	0.20	0.45	0.20	-0.68	1.08	0.44	0.66	16
	Bolla et al.	2002	3.10	0.63	0.39	1.87	4.33	4.95	0.00	20
	Kinzinger et al. (early mixed dentition)	2003	6.10	0.69	0.48	4.75	7.45	8.85	0.00	10
	Kinzinger et al. (permanent dentition)	2003	4.25	1.20	1.43	1.91	6.59	3.56	0.00	10
	Taner et al.	2003	11.77	3.09	9.55	5.71	17.83	3.81	0.00	13
	Fortini et al.	2004	4.60	0.63	0.40	3.36	5.84	7.29	0.00	17
	Kinzinger et al.	2004	3.29	0.72	0.52	1.88	4.70	4.58	0.00	36
	Kinzinger et al.	2005	4.24	0.57	0.33	3.11	5.37	7.38	0.00	66
	Bondemark and Karlsson	2005	2.90	0.43	0.18	2.06	3.74	6.75	0.00	20
	Bondemark and thorneus	2005	4.00	1.21	1.45	1.64	6.36	3.32	0.00	20
	Bondemark and thorneus (with bite plane)	2005	1.90	1.11	1.24	-0.28	4.08	1.71	0.09	20
	Chiu et al. (distal jet)	2005	5.00	0.64	0.41	3.75	6.25	7.86	0.00	32
	Chiu et al. (pendulum)	2005	10.70	0.97	0.95	8.79	12.61	11.01	0.00	32
	Mavropoulos et al.	2005	6.80	1.52	2.30	3.82	9.78	4.48	0.00	10
	Mavropoulos et al.	2006	4.00	0.98	0.96	2.08	5.92	4.08	0.00	12
	Karlsson and Bondemark	2006	3.00	0.95	0.91	1.13	4.87	3.14	0.00	20
	Sayinsu et al.	2006	2.56	1.13	1.27	0.35	4.77	2.27	0.02	17
	Sch tze et al.	2007	6.45	1.70	2.89	3.12	9.78	3.80	0.00	15
	Polat-Ozsoy et al.	2008	5.30	0.92	0.85	3.49	7.11	5.75	0.00	17
	Moro et al.	2009	1.47	0.32	0.10	0.84	2.10	4.57	0.00	26
	Patel et al. (Jone jig)	2009	9.54	0.94	0.89	7.69	11.39	10.13	0.00	20
	Patel et al. (pendulum)	2009	10.00	0.90	0.82	8.23	11.77	11.07	0.00	20
	Acar et al.	2010	5.13	1.27	1.60	2.65	7.61	4.05	0.00	15
	Papadopoulos et al.	2010	8.56	0.38	0.15	7.81	9.31	22.40	0.00	15
Random			5.66	0.55	0.30	4.59	6.73	10.34	0.00	

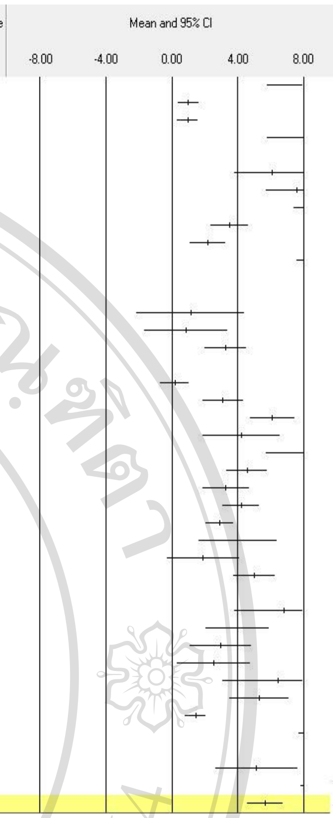

Figure 2.3 Forest plot of the mean amount of molar distal tipping in conventional distalizing devices.

Model	Study name	Sub grou	Statistics for each study							Sample size
			Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Total
	Gelgor et al.	2004	8.70	0.96	0.92	6.82	10.58	9.06	0.00	25
	Park et al.	2005	0.31	1.25	1.55	-2.13	2.75	0.25	0.80	11
	Kircelli et al.	2006	10.90	0.89	0.78	9.16	12.64	12.31	0.00	10
	Escobar	2007	11.30	1.60	2.56	8.16	14.44	7.06	0.00	15
	Gelgor et al. (NiTi-coil)	2007	9.05	1.04	1.09	7.00	11.10	8.67	0.00	20
	Gelgor et al. (Keles Slider)	2007	0.75	0.16	0.03	0.43	1.07	4.66	0.00	20
	Oncag et al. (Left)	2007	5.13	0.73	0.54	3.69	6.57	7.00	0.00	15
	Oncag et al. (right)	2007	7.06	1.51	2.29	4.09	10.03	4.67	0.00	15
	Polat-Ozsoy et al.	2008	9.10	0.98	0.96	7.18	11.02	9.28	0.00	22
	Kinzinger et al.	2009	2.79	0.79	0.63	1.23	4.35	3.52	0.00	10
	Yamada et al.	2009	4.80	1.30	1.69	2.25	7.35	3.70	0.00	12
	Oh et al.	2011	3.47	1.23	1.52	1.05	5.89	2.81	0.00	23
Random			6.08	1.33	1.76	3.47	8.68	4.58	0.00	

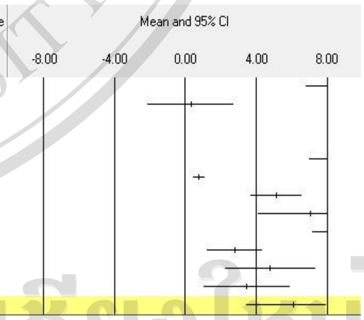

Figure 2.4 Forest plot of the mean amount of molar distal tipping in miniscrew implant supported distalizing devices.

Force magnitude

Means of force magnitude of molar distalization were 211.92 g and 245.00 g with conventional distalizing devices and miniscrew supported devices, respectively. Conventional distalizing devices showed force magnitude of distalization as follows: First Class Appliance = 200, Pendulum = 231.67, magnets = 195, Keles Slider = 166.67, NiTi-coil springs = 204.67, Jones Jig = 90 and Distal Jet = 240 g (shown in Table 2.7). Miniscrew supported devices showed force magnitude of molar distalization as follows: Pendulum = 280, Keles Slider = 250, NiTi-coil springs = 250, Distal Jet = 200, elastics = 150 and group distalization = 250 g (shown in Table 2.8).

Table 2.7 Force magnitudes in conventional distalizing devices.

Device	Force
Distal Jet	240.00
Pendulum	231.67
NiTi-coil	204.17
First Class	200.00
Magnet	195.00
Keles Slider	166.67
Jones Jig	90.00

Table 2.8 Force magnitudes in miniscrew implant supported distalizing devices.

Device	Force
Pendulum	280.00
Distal Jet	200.00
Keles Slider	250.00
NiTi-coil	250.00
Elastic	150.00
Group distalization	250.00

Discussion

Non-compliance maxillary molar distalization is popular as a treatment option to correct class II malocclusion or decrease protrusion of anterior teeth.[27,40] Nitinol coil springs are used as an instrument in fixed orthodontics to move the teeth by using other teeth as anchorage. Therefore, unwanted movement of anchorage teeth cannot be avoided. Magnets generate push or pull forces depending on the polarity of the pole. The disadvantages of magnet devices are a rapid decrease in force with increasing pole distance, and the bulky size of the device.[43] The Jones Jig appliance is a nitinol open coil spring; it exerts 70 to 75 g of force over a compression range of 1 to 5 mm to the maxillary molars. A modified Nance appliance is attached to the first premolars, second premolars, or deciduous second molars for anchorage.[42] The Distal Jet is composed of a large acrylic plate on the palate and auxiliary wire arms which are bonded to the premolars for anchorage.[44] There are bilateral 0.036-inch internal diameter tubes with a screw clamp on each side to slide on the arms. Nitinol open coil springs are activated by the tubes to distalize maxillary first molars.[45] The

First Class Appliance is composed of a large acrylic plate on the palate and open coil spring for molar distalization on palatal side with a guided tube (Formative screw) on buccal side between a premolar and a molar.[26] The Pendulum is a popular distalization device because it can control the movement of the molars with almost pure bodily movement.[24,46,47] However, the main side effect of distalization without a miniscrew implant supported appliance design is anchorage loss in the anterior unit. Temporary anchorage devices have been used to correct this side effect.[15] Several miniscrew implant supported distalizing devices have been designed in the last century.[15,40]

The present results showed similar distalization characteristics between conventional distalizing devices and miniscrew supported devices because the force magnitudes and mechanics of both device classes were similar.[23,48] There was no difference in the amount of molar distalization between both device classes because the space gained depended on the aim of each treatment plan. In general, correcting the interarch molar relationship in most of the patients needs similar amounts of distalization.[27]

There was similar rate of distalization between conventional distalizing devices and miniscrew supported devices because there was no difference in the force magnitudes used between both device classes. However, the rate of movement in group distalization was very low, at 0.15 mm/month. This low rate of movement may be the result of a low magnitude of force because of the distribution of the distalizing force among all of the posterior teeth to be moved together.[40]

The variance in the distal tipping of individual molars depended on several factors, such as mechanic design, force magnitude, and the eruption stage of the second maxillary molars.[27,49] However, in this review, the degree of distal tipping resulting from maxillary molar distalization of conventional distalizing devices and miniscrew supported devices are similar. This result can be explained by the fact that the differences between both device classes are at an anchorage part device locations which do not effect molar movement.

Controlling anchorage in distalization was a clear advantage in miniscrew supported devices. However, Kinzinger et al. found mobility of miniscrew implants after molar distalization.[23]

In this review, palatal miniscrew insertion positions were more common than buccal insertion positions for miniscrew supported devices. The reason that palatal sites were preferred may be explained by the low risk of anatomic injury and the availability of attached gingival mucosa.[14,34] Moreover, the success rate of miniscrew implants in the palatal area was found to be higher than that in the buccal area.[27,48] In the future, the study about palatal miniscrew implant placement will be interested since there are many topics to be discussed.

Conclusions

There was similar molar distalization characteristics between conventional and miniscrew implant supported distalizing devices because the similar force magnitude was applied, in terms of the similar amount of movement, the similar movement rate and the similar degree of distal tipping.