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The Uprighting Spring to Support an Anchorage During Canine Retraction in Class II Division 1 Malocclusion

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Abstract

Anchorage control in orthodontic treatment is of an important factor to achieve perfect occlusion, especially in Class II division 1 malocclusion patients who need all extraction spaces for overjet retraction. **Objective**: To study the effectiveness of the uprighting spring to enhance anchorage of posterior teeth during canine retraction. **Materials and methods:** 18 subjects (8 males and 10 females, mean age 21 years 7 months) with the upper first premolar extraction for canine distalization were participated. The anchorage control of upper posterior teeth was done by ligating the posterior teeth together. The uprighting spring will be placed at the second premolar of one side randomly (URS) whereas the other side had no uprighting spring (NURS). Canines were distalized with the force of 150 g for 4 months. Molar movement and rotation and canine movement were measured directly on study models. The change of molar angulation was evaluated from the cephalograph. **Results**: Mean anchorage loss recorded from molar movement in URS and NURS was 0.31±0.18 mm and 0.78±0.35 mm, respectively. Anchorage loss of URS was significantly lesser than NURS ($P<0.05$), whereas the amount of canine movement in URS was greater than NURS significantly. There were molar rotation in both groups but no significant different. Molar forward tipping was found greater in NURS than in URS significantly. **Conclusion:** The uprighting spring can enhance anchorage of posterior teeth effectively during canine retraction.

Keywords: Uprighting spring, Orthodontic anchorage, Anchorage preparation, Canine retraction

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Introduction

In Class II division 1 malocclusion patients who need all extraction spaces for overjet retraction, maximum anchorage conditions are indicated. In the maxilla, the extraoral appliances such as head gear can be applied to support the upper molars; however, patients' compliances are limited[1]. Intra-maxillary appliances as Nance appliances can be applied using the palatal shelf to support the molars but the effectiveness is questionable, particularly when the palatal shelf is relatively flat[2]. Transpalatal arch is another option; however, the prevention can be only for rotation but not for tipping of the molars[3]. However, both Nance appliance and transpalatal arch need more chair time and more visits for appliance fabrication and delivering.

Tooth anchorage may be defined as resistance to movement by using teeth as anchorage. The first way to enhance tooth anchorage is adding more teeth which increase more root surface area to resist the reactive tooth movement[4]. The more teeth are added into an anchorage unit, the lesser amount of force received per unit area along the periodontal membrane. In extraction cases, many prefer to include the second molars for additional anchorage and control proposes during canine retraction.

Another way to enhance anchorage of posterior segments is tipping the anchorage teeth back by off-center wire bending to change tooth inclination against reaction forces during canine retraction. Because of the off-center bend results in mesial root torque, mesial displacement of the molar would require bodily movement of that tooth, resulting in increased anchorage. This concept is called "the differential moment (torque concept)" from Begg technique[5]. The further studies had been proposed that, by using this concept, maximum anchorage can be achieved without adjunctive appliances[6-7].

Gianelly modified the uprighting spring from Begg technique to support the anchorage in the lower anterior teeth during molar protraction in the bidimensional technique. This technique use preadjusted edgewise brackets which have vertical slots[8]. The principle of the uprighting spring is to create the moment to tip the tooth forward in wire/slot space. That is the anchorage preparation against the reaction force during molar protraction like the differential moment concept. This same approach is possible to apply to the posterior teeth to enhance the posterior anchorage during canine retraction. Moreover, the uprighting spring can be made easily and immediately apply in the same visit. It would be of interest to evaluate the effectiveness of using of uprighting springs in supporting anchorage for canine retraction.

Objectives

To investigate the effectiveness of using the uprighting spring on the second premolar (URS) to support anchorage of posterior teeth during canine retraction compared to the other side without the uprighting spring (NURS).

Materials and methods

Sample selection

This prospective study was performed under the approval of the Ethics Committee for Human Research, Faculty of Dentistry, Prince of Songkla University (EC number: MOE 0521.1.03/749) approved by August 7th, 2008. The patients provided consent and participated in the study. The study was investigated on 18 subjects (8 males, 10 females) presenting for orthodontic therapy to the orthodontic clinic, Dental hospital, Faculty of Dentistry, Prince of Songkla university. The mean pretreatment age of samples was 21 years 7 months. These samples were selected by random sampling from the patient pool who met the following inclusion criteria.

1. The occlusion was Class II division 1 malocclusion.

2. Upper first premolars would be extracted during the treatment.

3. The spaces obtained from extraction would be closed as a moderate anchorage condition.

4. Patients had no medical history, no congenital missing (except the third molars), and no periodontal problem at the beginning of the treatment.

5. No to mild symmetrical arch length discrepancy.

Roth's prescription preadjusted edgewise appliances 0.022" slot with were placed from canine to second molar, whereas 0.018" slot for the incisors. All the brackets had vertical slots.

The patients' teeth were aligned and leveled without the first premolar extraction. Arch wires were changed until the size of arch wire was 0.016"x0.022" stainless steel wire (SS) and then, the patients were referred for extraction of the upper first premolars before the canines were retracted.

For each patient, split mouth technique was used. Upper second premolars, first molars and second molars were included to be an anchorage on both sides. The leg of the uprighting spring was placed in vertical slot of the second premolar bracket on only one side per arch randomly.

The uprighting spring

The uprighting springs (URS) (Fig. 1) in this study were made of a 0.016" SS placing into the vertical slot of the second premolar bracket. Before activation, the arm of the spring was extended passively to the sulcus, forming a 60 to 70 angle to the base of the arch wire[8]. To activate the uprighting spring, the leg of the spring was inserted through the vertical slot from the gingival side and hooked the activated arm onto the main arch wire mesial to the second premolar during canine retraction (Fig. 2). The springs were adjusted every month by the investigator to maintain the original configuration.

(A) (B)

Fig. 1 The uprighting springs.
A. Clockwise rotation
B. Counterclockwise rotation

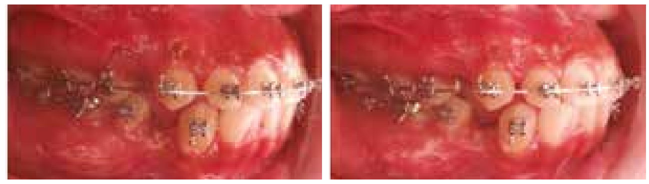

Fig. 2 The uprighting spring in the vertical slot of the second premolar before and after hooking to the arch wire.

The springs in this study were made of 0.016" stainless steel wire. The length from the circle to the hook (arm) was 5 mm. The diameter of the circle was 2 mm. The height of the hook was 2.5 mm.

Force application

Canines were distalized with Nickel Titanium (NiTi) closed coil spring on 0.016"x0.022" SS from canines to first molars. The main arch wires were passive through 4 months of the study period during canine retraction. The force for canine retraction was 150 gram[9]. NiTi closed coil springs were reactivated every month to maintain continuous force through the study period.

Data measurements

Anchorage loss was evaluated on the upper first molars in 3 aspects

1. Canine and molar movement: The upper impressions for study model were taken from the patient immediately before canine retraction [T0] and 4 months after retraction [T1]. These upper study models from each subject were used to measure the changes in the position of the upper canines and first molars (Fig. 3). The measurement was followed the method used by Lotzof et al[10].

2. Molar rotation: Rotational changes of the upper first molars were measured from the study models (Fig. 4) after the method used by Ziegler and Ingervall[11].

3. Molar angulation: The lateral cephalometric radiographs were obtained to determine the inclination of the maxillary first molars. Lateral cephalometric radiograph was taken at the same times as the study models. Tooth positional locating devices (wire jigs) (Fig. 5) were fabricated from sections of 0.021"x0.025"

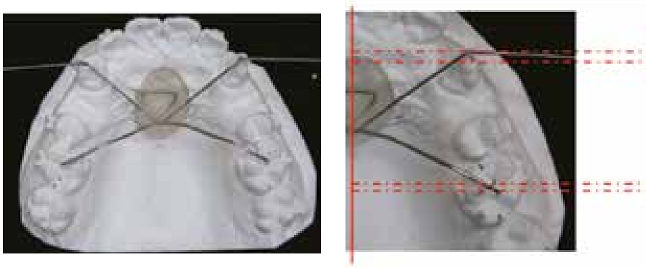

Fig. 3 Canine and molar movement.
A. Acrylic jig placing on the palate with 4 extending arms to the cusp tips of the canines and central pits of the first molars at T0.
B. At T1, the movement of both canine cusp tip and molar central pit were compared referred to the median line.

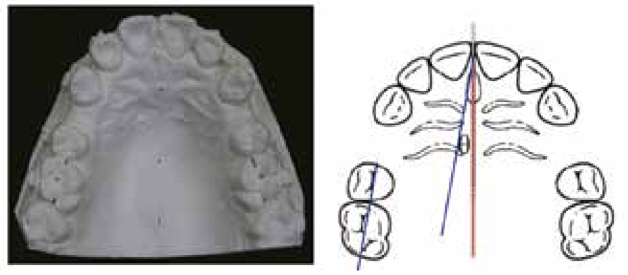

Fig. 4 Molar rotation measurement. The line between mesial and distal contact points of the molar was drawn to measure the angle with the median line at T0. The same measurement was performed at T1 to calculate for the molar rotation compared to T0.

stainless steel wires. The horizontal portion was inserted into the slots of maxillary first molars before film exposure at the start [T0] and the end of the experimental periods [T1]. The vertical portion of wire jigs which were bended perpendicularly to the horizontal portion would be a representative of the molar angulation. These devices aided in the precise measurements of angulations of the first molar and in separating the right and left molars[12].

Measurement error

Measurement error was tested in determining distance of tooth movement, and degree of rotation and tipping. To reduce method error associated with the measurement of the study models and lateral cephalometric radiographs, the examiner was blind to the study group (URS) and the control group (NURS) in each model. The study models were measured randomly.

Ten study models and ten lateral cephalometric radiographs were remeasured again 2 months later and these measurements were compared to the mean of the initial measurements using Dahlberg formula.

$$S_i = \sqrt{\frac{\sum d^2}{2n}}$$

Statistical analysis

The data was statistically analyzed by using SPSS software (version 13.0, SPSS, Chicago, Ill). The

Fig. 5 Tooth positional locating devices (wire jigs)

means and standard deviations of the changes in all of the measurements were determined. The Normality test was used to examine distribution of the results. We found that the results of this study did not have normal distribution and a Wilcoxon signed-ranks test would be used to analyze the differences between groups at [T0] and within group and between groups at [T1]. Statistical significance was tested at the alpha significant level of 0.05.

Results

A total of 36 extraction sites from 18 patients were compared in this study. There were 8 males and 10 females, ranging in age from 18 to 38 years with the mean pretreatment age of 21.58 years (SD = ±5.68 years).

To evaluate error from measurement, 2 months after the first measurement, 10 study models and lateral cephalometric radiographs were selected randomly. Measurement errors of linear and angular measurements were calculated from the difference between the 2 measurements followed Dahlberg formula. The results had shown 0.05 mm and 0.03 degree of linear and angular measurement errors respectively.

Due to the data of this study did not have normal distribution, non-parametric test was used for statistically testing using SPSS software. The differences between the 2 dependent measurements would be evaluated with a Wilcoxon signed-ranks test at an alpha significant level of 0.05. Table summarized all measurement findings on casts and cephalograms for 4 months of canine retraction period. All data were shown as mean + standard deviations, maximum and minimum values.

During canine retraction, the differences of molar rotation, molar angulation, and canine angulation at [T0] between groups could affect the results of this study. However, the results showed that there was no significant difference (P < 0.05) between groups of molar rotation, molar angulation, and canine angulation before canine retraction (Table 1).

Table 1. Measurement finding of NURS and URS at [T0]

Measurements	Groups	Mean	Standard deviation	Maximum	Minimum	Significance
Molar rotation	NURS	12.5	3.7	22.5	7	NS
	URS	11.5	2.8	20	6.5	
Molar angulation	NURS	80.5	3.5	84	71	NS
	URS	81.5	2.1	83	70	
Canine angulation	NURS	95.5	4.5	98	87	NS
	URS	96.0	3.2	100	90	

NS No significant difference

P < 0.05

Table 2. Measurements of the differences between [T1] and [T0]

Measurements	Mean	Standard deviation	Maximum	Minimum	Significance (B/W groups)
Anchorage loss (mm.)					
NURS	0.78 +	0.35	1.54	0.50	*
URS	0.31 +	0.18	0.63	0.00	
Molar rotation (degree)					
NURS	2.25 +	1.34	4.50	0.00	NS
URS	2.05 +	1.09	3.00	0.00	
Molar tipping (degree)					
NURS	1.50 +	0.94	3.00	0.00	*
URS	0.00	0.56	0.50	-1.00	
Canine retraction (mm.)					
NURS	2.93+	0.40	3.59	2.27	*
URS	3.20 +	0.32	4.00	2.90	

+ Significant difference compared to [T0]

* Significant difference between groups at [T1]

NS No significant difference P < 0.05

Anchorage loss

The amount of anchorage loss of both groups; for URS, the maximum anchorage loss was 0.63 mm and the minimum was no anchorage loss. The mean of this group was 0.31±0.18 mm. For NURS side, the maximum anchorage loss was 1.54 mm and the minimum anchorage loss was 0.50 mm. The mean of this group was 0.78±0.35 mm (Table 2).

The results were tested with a Wilcoxon signed-ranks test to compare the differences within group [T1-T0] and between groups (URS-NURS). The differences in the amount of forward movement of the upper first molars between URS and NURS groups were statistically significant ($P < 0.05$) (Table 2).

The differences of the amount of anchorage loss within group, however, were shown the statistically significant difference of mesial movement of the molars compared to the initial tooth position on both sides (Table 2).

Molar rotation

Table 2 described the amount of molar rotation of both sides after canine retraction for 4 months. We found that the upper first molars rotated mesiolingually during canine retraction. The amount of molar rotation of both groups; for URS side, the maximum molar rotation was 3 degree and the minimum molar rotation was 0 degree. The mean molar rotation of this group was 2.05±1.09 degree. For NURS side, the maximum molar rotation was 4.50 degree and the minimum molar rotation was 0.00 degree The mean molar rotation of this group was 2.25±1.34 degree (Table 2).

A Wilcoxon signed-rank test shown that, for within group [T1-T0], the differences of the upper fist molar rotation were statistically significant of both sides when compared to the initial tooth rotation ($P < 0.05$). For between groups, however, the result of the test shown that there were no statistically difference of the upper first molar rotation between the URS and NURS sides after 4 months of canine retraction.

Molar tipping

Degree of the upper molar tipping was measured from lateral cephalometric radiograph. The amount of molar tipping for both groups was shown in Table 2. The positive value represented mesial tipping of the upper first molars, whereas the negative value meant distal tipping of the upper first molars. For URS side, the maximum molar tipping was 0.5 degree and the minimum molar tipping was -1 degree. The mean molar tipping of this side was 0.00±0.56 degree. For NURS side, the maximum molar tipping was 3 degree and the minimum molar tipping was 0 degree. The mean molar tipping of this side was 1.50±0.94 degree.

A Wilcoxon signed-rank test showed that the change of molar angulation between [T0] and [T1] were no statistically difference in the URS side. For NURS side, angulation of the upper first molars at T1 was significantly difference when compared to the initial molar angulation [T0]. The differences of molar angulation between groups after 4 months of canine retraction were also significantly difference ($P < 0.05$).

Canine retraction

After the upper canines were distalized for 4 months, the amounts of canine retraction for both groups were shown in Table 3. For URS side, the maximum canine retraction was 4.00 mm and the minimum canine retraction was 2.90 mm. The mean canine retraction of this side was 3.2±0.32 mm. For NURS side, the maximum canine retraction was 3.59 mm and the minimum canine retraction was 2.27 mm. The mean canine retraction of this side was 2.93± 0.40 mm. The results were analyzed with a Wilcoxon signed-rank tests. We found that the distance of canine retraction in URS side was greater than in NURS side significantly ($P < 0.05$) (Table 2).

Table 3 described the rates of canine retraction and molar movement per month on both sides (URS and NURS) at [T1]. For URS side, the rate of canine retraction was 0.8 mm/month and the rate of anchorage loss was 0.08 mm/month. For NURS side, the rate of canine retraction was 0.73 mm/month and the rate of anchorage loss was 0.20 mm/month.

Table 4 showed the ratio of 1 mm of canine movement to the amounts of anchorage loss in both groups. In NURS side, we found that there was anchorage loss 0.26 mm when canine was distalized 1 mm In URS side, there was anchorage loss 0.09 mm when canine was distalized 1 mm.

Table 3. Rate of tooth movements per month

Sides	Rate of tooth movements (mm/month)	
	Canine retraction	Anchorage loss
NURS	0.73	0.20
URS	0.80	0.08

Table 4. The ratio of canine movements to the amounts of anchorage loss

Groups	Ratio of canine movement to anchorage loss	
	Canine retraction	Anchorage loss
NURS	1	0.26
URS	1	0.09

Discussion

The objective of this study was to investigate the effectiveness of the uprighting spring to support the posterior teeth during canine retraction in Class II division 1 malocclusion patients. The uprighting spring in the vertical slot of the second premolar would tip the crown distally against the reacting mesial force during canine retraction (Fig. 6). To obtain the appropriate force and moment of the uprighting spring against the reaction force (150 gram), the laboratory study was designed to investigate the force created from the different length of the uprighting spring's arm. The reaction force acted on the posterior segment composed of 3 teeth at the bracket level. When force applied away from the center of mass, the object will rotate due to moment.

Moment (M) = Force (F) X Distance from center of mass (D)

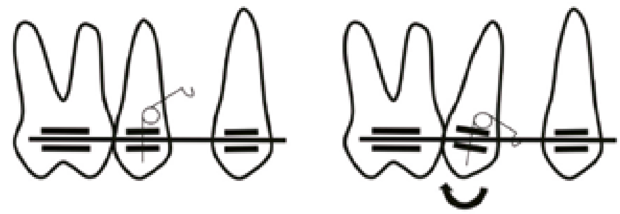

Fig. 6 A. The uprighting spring was inserted in the vertical slot of the premolar
B. After placing the spring to the arch wire, the premolar was tipped distally.

Similarly, the reaction force did not pass through the center of resistance of the 3 posterior teeth which ligated together. The center of resistance of the posterior segment should be at furcation of the first molar which was about 6 mm from the bracket level. Therefore, there should be a moment created with size 900 gm-mm (150 gm x 6 mm). To enhance the maximum anchorage, the additional moment with the size 900 gm-mm should be applied in the opposite direction to the reaction force.

The moment created by the uprighting spring was affected from the length of arm of the uprighting spring. The longer of the arm, the larger moment would be created. But the long arm could obstruct the movement of the canine and irritate soft tissue of the patient. We found from our laboratory experiment that the proper length of the arm was 5 mm which created moment 1,300 gm-mm after activation. We had to create the larger moment than 900 gm-mm due to the deformation of the spring after the activation which decreased the amount of created moment.

The patients were referred for extraction after the size of main arch wire reached 0.016"x0.022" stainless steel. The canines were retracted after extraction of the first premolars within 2 weeks to reduce the bone resistance. Diedrich and Wehbein[13] recommended that the orthodontic retraction into extraction sites should be initiated at an early stage due to lesser bone maturity, broader alveolar process, and reduced gingival invagination.

The split mouth technique was used in this study and there were no significantly differences of molar rotation, molar angulation, and canine angulation between NURS and URS groups at T0. The effectiveness of the uprighting spring to support anchorage evaluated based on how the spring can prevent the first molar to move, to rotate, and to tip. From our results, the mean amount of anchorage loss (molar movement) after canine retraction for 4 months in NURS and URS were 0.78±0.35 mm and 0.31±0.18 mm, respectively. The mean difference between groups (NURS - URS) was 0.47 mm clinically and there was a statistically significant difference ($P < 0.05$).

The results of molar tipping in NURS and URS were 1.50±0.94 degree and 0.00±0.56 degree, respectively. There was a significantly difference between groups at $P < 0.05$. In URS group, moreover, there was no significantly difference when compared tipping at [T1] to [T0] in URS group. The mean amounts of molar rotation were 2.25±1.34 degree and 2.05±1.09 degree in NURS and URS, respectively. There was no significantly difference of molar rotation within group and between groups. The amounts of canine retraction were 2.93±0.40 mm and 3.20±0.32 mm in NURS and URS, respectively.

From these results, we can conclude that the uprighting spring can enhance anchorage of posterior teeth during canine retraction. Moreover, the results had shown the effectiveness of the uprighting in the vertical slot of the second premolar bracket to prevent mesial tipping of the upper first molar which was the point of force application during canine retraction. Even molar rotation in URS group did not significantly difference from NURS group, the mean and standard deviation of URS group was less than NURS group.

The results of this study had shown the effectiveness of the uprighting spring to enhance anchorage of posterior teeth during canine retraction. It might be explained based on several reasons. First, the uprighting spring created the additional moment against the moment from reaction force. Second, likewise to the differential moment concept, the uprighting spring tipped the second premolar distally within the wire/slot space and increased the resistance to mesial tipping of the upper first molar from the reaction force. When the upper first molar could not be tipped during canine retraction, anchorage loss would be decreased. Third, from Thurow's theorizes[14], when bracket of the second premolar tipped against the main arch wire from moment of the uprighting spring, the frictional resistance would be occurred. This frictional resistance might be the additional force to prevent the posterior segment from mesial movement.

There was no study directly investigated the effective of the uprighting spring before, so we compared the effectiveness of the uprighting spring to other anchorage preparation methods[7, 10-11, 15] which measured anchorage loss during canine retraction with the comparable force. Due to the different of study

Table 5. Comparison of anchorage loss between different anchorage preparation methods

Author (Year)	Anchorage Preparation	Duration	Anchorage Loss	Anchorage Loss (mm/month)
Zeigler and Ingervall[11] (1989)	Headgear	3.5 months	0.4 mm	0.11
Lotzof et al.[10] (1996)	No anchorage Preparation	4 intervals	2.33 mm	0.58
Rajcich and Sadowsky[7] (1997)	Differential Moment	7 months	0.5 mm	0.07
Shpack et al.[15] (2008)	Nance appliance (without 7)	5 months	1.4 mm	0.28
Recent study - NURS - URS	 Bond 7 only Bond 7 + URS	 4 months 4 months	 0.78 mm 0.31 mm	 0.20 0.08

duration, we would compare in the rate of tooth movement per month (Table 5). The comparison showed the least anchorage loss per month in URS which is comparable to the use of differential moments for anchorage preparation[7].

In NURS, anchorage preparation was acquired from bonding the second molar to increase the root surfaces. The amount of anchorage loss per month was nearby the result of anchorage preparation by Nance appliance[15].

The amount of anchorage loss per month in NURS side from this study was less than the results of the studies which retracted canines without anchorage preparation[10] because of no second molars included as anchorage as our study.

The results of this study had shown that the amount of molar rotation in URS was 2.05±1.09 degree. When compared the amount of molar rotation to the study of Rajcich and Sadowsky[7] which uses the differential moment to enhance anchorage, they had shown molar rotation 8.4 degree. We would notice that molar rotation was the problem of this study. It might be due to using the round small wire like a 0.016" stainless steel during canine retraction. When force was applied to teeth, the main arch wire was not rigid enough to control rotation and angulation of moving teeth and teeth could bend the main arch wire. Moreover, the auxiliary wire which used to apply additional moment to the upper first molars to counteract the moment of reaction force was also the small round 0.016" stainless steel wire. When the auxiliary wire was bended and inserted into the auxiliary tubes, this small round wire could flip in the tubes and action of the differential moment would not be maximized.

The amount of canine retraction on URS and NURS were 3.20 mm and 2.93 mm respectively. The mean difference between groups of canine retraction was significantly difference. Canine on URS side could move distally more than NURS side. It might explain that when anchorage loss occurred, the retraction force was decreased due to the distance between canine and molar was decreased. So the retraction force on NURS side would be less than URS side and the amount of canine retraction would be less than URS side too.

Table 6. Rate of canine movement per month

Studies	Rate of canine movement (mm/month)
This study - NURS - URS	 0.73 0.80
Lotzof et al.[10] (1996)	1.63
Rajcich and Sadowsky[7] (1997)	0.81
Dixon et al.[16] (2002)	0.81

The rate of canine retraction per month of this study was 0.80 and 0.73 mm/month in URS and NURS side respectively. These rates were nearby to the results of the previous studies[7, 10, 16] (Table 6).

When we focused on the ratio of canine retraction to anchorage loss, we found that, from this study, when canine was moved distally 1 mm, the upper first molar was moved mesially 0.09 mm in URS group. This result was coincided with the result from the study of Rajcich and Sadowsky[7] who found that, with using the differential moment for anchorage preparation, when canine was moved distally 1 mm, the upper first molar was also moved mesially 0.09 mm. In NURS, when canine moved 1 mm, the the upper first molar would move 0.26 mm. This ratio was better than the study of Lotzof et al[10] which found that, without anchorage preparation, anchorage loss was 0.41 mm when canine was distalized only 1 mm.

The uprighting spring was introduced in Begg technique for root uprighting. It could be made easily, no time consuming, inexpensive, and no need of patient cooperation. This study evaluated the effectiveness of the uprighting spring which had high potential to support anchorage during canine retraction. From the results, we found that the rate of anchorage loss in URS was 0.08 mm per month which coincided to the rate of anchorage loss in the differential moment technique. The amount of molar rotation in URS group was 2.05±1.09 degree which was better than 8.4±5.67 degree of molar rotation in the differential moment technique. Moreover, the uprighting spring could prevent molar tipping during canine retraction significantly.

URS group also had anchorage loss after 4 months of canine retraction. The rate of 0.08 mm per month of URS and 0.20 mm per month of NURS, there are no clinically significant difference, however, in severe protrusion when all space is need for retraction, less anchorage loss must be considered. In clinical application, bonding the second molars and included into the posterior anchorage unit combined with using the uprighting spring could enhance the maximum anchorage during canine retraction. However, if the absolute maximum anchorage was desired, we would recommend to applying additional anchorage preparation methods such as tip back and toe in the main arch wire to maximized anchorage preparation during canine retraction.

To apply the uprighting spring clinically from the results of this study, the need of calculation of the reaction moment is recommended. To counteract the reaction moment which depended on the canine retraction force and the distance from bracket to center of resistance of the posterior teeth in the axial dimension, we needed the additional moment which had a magnitude of moment at least equaled to the moment of retraction force.

From this study, we found that the force used to activate the uprighting spring was about 360 g. With this amount of force, the main arch wire might be bended if canine retraction was done in the small main arch wire. When the wire was bended, there was the effect of wire bending likewise the differential moment technique. The posterior teeth might be extruded during canine retraction. If molar extrusion was not indicated, we recommended the main arch wire of larger or equal size to 0.016"x0.022" stainless steel wire.

A limitation of this study was that the effectiveness of the uprighting spring had never been evaluated; therefore, maximum anchorage supported from this spring could not be relied. Moderate anchorage situation was selected as our criteria instead. The situation consequently limited the observation time to be 4 months. However, from the results, we found that the uprighting spring could provide the maximum anchorage during canine retraction effectively. Moreover, the study was not investigated the vertical and transversal changes of the experimented teeth so that further investigation is recommended.

Conclusion

The uprighting spring can enhance anchorage of posterior teeth effectively during canine retraction.

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References

1. Egolf RJ, BcGole EA, Upshaw HS. Factors associated with orthodontic patient compliance with intraoral elastic and headgear wear. Am J Orthod Dentofac Orthop 1990;97: 336-48.
2. Chang HN, Hsiao H, Tsai C, Robert WE. Bone-screw anchorage for Pendulum appliances and other fixed mechanic application. Semin Orthod 2006;12:284-93.
3. Bobak V, Christiansen RL, Hollister SJ, Kohn DH. Stress-related molar responses to the transpalatal arch: A finite element analysis. Am J Orthod Dentofac Orthop 1997;112: 512-8.
4. Angle EH. Treatment of malocclusion of teeth, 7th ed. Philadelphia: White dental manufacturing Co; 1907.
5. Begg RP. Light arch wire technique. Am J Orthod 1961;47: 30-48.
6. Hart A, Taft L, Greenberg SN. The effectiveness of differential moments in establishing and maintaining anchorage. Am J Orthod Dentofal Orthod 1992;102:434-42.
7. Rajcich MM, Sadowsky C. Efficacy of intra-arch mechanics using differential moments for achieving anchorage control in extracton cases. Am J Orthod Dentofac Orthop 1997; 112:441-8.

8. Gianelly AA, Smith JB, Bednar JR, Dietz VS. Asymmetrical space closure. Am J Orthod Dentofac Orthop 1986;90: 335-41.
9. Smith R, Storey E. Force in orthodontics and its relation to tooth movement. Austr J Dent 1952;56:11-8.
10. Lotzof L, Fine H, Cisneros G. Canine retraction. A comparison of two preadjusted bracket systems. Am J Orthod Dentofac Orthop 1996;110:191-6.
11. Ziegler P, Ingervall B. A clinical study of maxillary canine retraction with a retraction spring and with sliding mechanics. Am J Orthod Dentofac Orthop 1989;95:99-106.
12. Erverdi N, Koyuturk O, Kuculleles N. Nickel-titanium coil springs and repelling magnets: a comparison of two different intra-oral molar distalization techniques. Bri J Orthod 1997;24:47-53.
13. Diedrich P, Wehrbein H. Orthodontic retraction into recent and healed extraction sites. J Orofacial Orthop, 1997;58: 90-9.
14. Thurow RC. Edgewise orthodontics. 2nd ed. St. Louis: The C. V. Mosby company; 1966.
15. Shpack N, Davidovitch M, Sarne O, Panayi N, Vardimon AD. Duration and anchorage management of canine retraction with bodily versus tipping mechanics. Angle Orthod 2008; 78:95-100.
16. Dixon V, Read MJ, O'Brien KD, Worthington HV, Mandall NA. A randomized clinical trial to compare three methods of orthodontic space closure. J Orthod 2002;29:31-6.