การเปรียบเทียบการสลายของปลายรากฟันซึ่งเป็นผลจากการจัดฟันแบบติดแน่นในผู้ป่วยที่มีภาวะสบลึกกับการสบเหลื่อมแนวดิ่งปกติ

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อเปรียบเทียบและประเมินการสลายของปลายรากฟันตัดหน้าบนและล่าง ระหว่างผู้ป่วยที่มีภาวะสบลึกกับการสบเหลื่อมแนวดิ่งปกติ ตัวอย่างประกอบด้วยผู้ป่วยจำนวน 86 คนที่ได้รับการรักษาทางทันตกรรมจัดฟันด้วยเครื่องมือจัดฟันแบบติดแน่น ณ ภาควิชาทันตกรรมจัดฟันและทันตกรรมสำหรับเด็ก มหาวิทยาลัยเชียงใหม่ จังหวัดเชียงใหม่ ประเทศไทย โดยได้มีการตรวจพิเคราะห์ภาพถ่ายรังสีรอบปลายรากของฟันตัดหน้าบนและล่างทั้งก่อนและหลังการรักษา ภาพฟันที่มองไม่เห็นตัวฟันหรือปลายรากฟัน มีรอยต่อเคลือบฟันกับเคลือบรากฟันที่พร่ามัว มีการเปลี่ยนแปลงมิติของตัวฟันระหว่างการรักษาเนื่องจากการแตกหักหรือการสึก และภาพรังสีที่ไม่มีคุณภาพ จะถูกคัดออกจากการศึกษาครั้งนี้ ตัวอย่างประกอบด้วยสองกลุ่ม ได้แก่ กลุ่มที่มีการสบเหลื่อมแนวดิ่งปกติจำนวน 44 คน (ชาย 20 คนและหญิง 24 คน) มีอายุเฉลี่ย 16.02 ± 4.76 ปี และกลุ่มที่มีภาวะสบลึกจำนวน 42 คน (ชาย 17 คนและหญิง 25 คน) มีอายุเฉลี่ย 15.62 ± 3.19 ปี ความยาวตัวฟันและรากฟันของฟันตัดหน้าบนและล่างที่เห็นบนภาพรังสีรอบปลายรากทั้งก่อนและหลังการรักษา ถูกวัดโดยใช้เครื่องวัดดิจิตอล หลังจากที่ได้มีการปรับกำลังขยายที่แตกต่างกันระหว่างภาพรังสีรอบปลายรากก่อนและหลังการรักษาแล้ว จึงทำการคำนวณปริมาณการสลายของปลายรากฟันในหน่วยมิลลิเมตรและร้อยละของรากฟันที่สั้นลง การทดสอบแมนวิทนียูถูกใช้เพื่อตรวจสอบความแตกต่างของการสลายของปลายรากฟันระหว่างสองกลุ่ม ผลการวิเคราะห์ทางสถิติพบว่าไม่มีความแตกต่างอย่างมีนัยสำคัญของปริมาณการสลายของปลายรากฟันตัดหน้าล่างระหว่างกลุ่มที่มีภาวะสบลึกและกลุ่มที่มีการสบเหลื่อมแนวดิ่งปกติ ในขณะที่ฟันตัดหน้าบนในกลุ่มที่มีภาวะสบลึกพบว่ามีการสลายของปลายรากฟันมากกว่าอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ร้อยละของฟันที่มีการสลายของปลายรากฟัน มีจำนวนที่ใกล้เคียงกันเมื่อเปรียบเทียบในฟันตัดระหว่างสองกลุ่ม สรุปได้ว่า ภาวะสบลึกอาจเป็นหนึ่งในปัจจัยเสี่ยงของการเกิดการสลายของปลายรากฟันตัดหน้าบน

คำสำคัญ : *การสลายของปลายรากฟันภายนอก การรักษาทางทันตกรรมจัดฟัน ภาวะสบลึกทางด้านหน้า*

A comparison of apical root resorption effects of fixed appliance treatment of deep and normal incisor overbite malocclusion.

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Abstract

The purposes of this study were to compare and evaluate apical root resorption of both maxillary and mandibular incisors between patients who had deep overbite and normal overbite. The sample consisted of 86 patients who completed orthodontic treatment with fixed labial appliance at the Department of Orthodontics and Pediatric Dentistry, Chiang Mai University, Chiang Mai, Thailand. Periapical radiographs of maxillary and mandibular incisors, before and after treatment, were examined. The images of teeth with crown or apex not fully visible, blurred cemento-enamel junction (CEJ) and altered crown dimension during the treatment period due to fracture, abrasion

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or attrition and poor radiographs were excluded from the study. The sample comprised of two groups. The normal overbite group included 44 individuals (20 males and 24 females) with a mean age of 16.02 ± 4.76 years. The deep overbite group included 42 individuals (17 males and 25 females) with a mean age of 15.62 ± 3.19 years. Crown and root lengths of maxillary and mandibular incisors shown on both pretreatment and posttreatment periapical radiographs were measured using a digital vernier caliper. After adjusting for magnification variation between pre- and posttreatment radiograph, the amount of apical root resorption in millimeters and percentage of root shortening were calculated. The Mann-Whitney U test was used to detect any difference of apical root resorption between the two groups. Statistical analysis revealed no significant difference in amount of apical root resorption for the mandibular incisors between the deep and normal overbite groups, whereas the maxillary incisors in the deep overbite group were found to have significantly greater apical root resorption. ($p<0.05$) Percentages of teeth affected by root resorption were similar comparing all sets of incisors of both groups. It can be concluded that a deep overbite can be one of the risk factors for external apical root resorption of maxillary incisors.

Key words: *External apical root resorption, orthodontic treatment, anterior deep overbite*

Introduction

External apical root resorption has long been recognized as an unfavorable side-effect of orthodontic treatment.[1,2] The great variation in susceptibility between individuals subjected to the same type and duration of treatment showed that root resorption has been reported in between 7 and 16% of treated cases.[3-5] The maxillary incisors appear to be the teeth which are most often affected while the maxillary and mandibular second permanent molars are the least susceptible to root resorption.[6,7]

Several factors, such as treatment variables and pretreatment patient characteristics have been related to orthodontic apical root resorption.[4,7-8] Examples of suggested treatment variables were duration of active treatment, orthodontic mechanics, intrusion arches, Class II elastics, maxillary expansion, rectangular archwires and uprighting springs.[2,9-10] Examples of pretreatment characteristics which may contribute to permanent destruction of the root include root morphology, dental anomalies, history of trauma, genetics, age, sex, race, lip/tongue dysfunction, ectopic eruption of canines, autotransplanted teeth, overjet and overbite, all of which have been implicated as predisposing factors for root resorption.[11-18]

Several attempts have been made to observe the association between overjet and/or overbite and apical root resorption during orthodontic treatment.[4,12,19] Some studies found that an overjet was significantly related to orthodontic root resorption due to the fact that increased overjet leads to other risk factors for root resorption such as trauma to the upper incisors, correction with fixed appliances, active torque with rectangular arch wires and the use of Class II elastics,[4] whereas root resorption was not significant in cases of overbite.[4] However, a relationship between overbite and orthodontic root resorption has been observed in some other studies.[12,19,20] Chiqueto *et al*. found that patients with deep overbite had significantly greater amounts of root resorption than did those with normal bite.[20] A deep overbite is frequently corrected by intrusion, which may overload the tooth apex and can cause apical root resorption.[9,20-21] According to Han *et al*.[22], intrusion of teeth causes about four times more root resorption than does extrusion. Malmgren *et al*.[9] observed shortening of 18% of the initial root length after the intrusion of upper incisors. However, the same study found no relationship between the amount of root resorption and the duration or the distance of the intrusive movement.[9]

At present, the role of deep overbite as a factor for orthodontic apical root resorption is still controversial. Therefore, it might be beneficial to conduct more studies to investigate the association between deep overbite and root shortening during orthodontic treatment. The purpose of this study was to compare the amount of apical root resorption of both maxillary and mandibular incisors in orthodontic patients who had normal overbite and deep overbite.

Subjects and methods

The case records of 86 Thai patients were selected from those of patients who had been treated by 18 postgraduate students during the period 1993-2005, at the Department of Orthodontics and Pediatric Dentistry, Chiang Mai University, Chiang Mai, Thailand. All patients were treated using fixed appliances with standard edgewise (33 patients) or straight wire (53 patients) techniques. 61 patients were treated by extraction and 25 patients were treated without extraction. The variables collected from records of each patient are presented in Table 1.

Table 1 Variables recorded for each patient and units of measurement/classification.

Variables	Units/Classification
Gender	Male/Female
Age at start of treatment with fixed appliances	Year
Overjet	mm.
Angle's classification	Class I, II, III
Treatment duration	Month

Table 2 The number and percentage of patients classified by Angle's classification in deep overbite and normal overbite groups.

Angle's classification	Type		Total
	Deep overbite (Group 1)	Normal overbite (Group 2)	
I	25 (59.52 %)	38 (86.36 %)	63 (73.26 %)
II	15 (35.71 %)	3 (6.82 %)	18 (20.93 %)
III	2 (4.76 %)	3 (6.82 %)	5 (5.81 %)
Total	**42 (100 %)**	**44 (100 %)**	**86 (100%)**

The sample comprised two groups, deep overbite and normal overbite groups. The deep overbite group (Group 1) was defined as the patients who had deep overbite before treatment (overbite ≥ 4 mm.). This group comprised 42 individuals (17 males and 25 females). The age at the beginning of treatment was 15.62 ± 3.19 years old. The normal overbite group (Group 2) included the patients who had normal overbite before treatment (0 mm. < overbite < 4 mm.). This group comprised 44 individuals (20 males and 24 females) and the age at the beginning of treatment was 16.02 ± 4.76 years old.

The number of patients classified by Angle's classification for deep overbite and normal overbite groups are shown in Table 2. The orthodontic records, including periapical radiographs of maxillary and mandibular incisors, before and after treatment were available. The radiographs were made by either bisecting or paralleling technique using any of four good-quality x-ray machines, two Gendex 765 DC machines (Gendex, Italy) and two Heliodent 70 machines with Dentotime (Siemens, Germany), which had been calibrated to produce good-quality radiographs and adjusted to provide a suitable image density for each tooth. The images of teeth with crown or apex not fully visible, blurred cemento-enamel junction (CEJ) and altered crown dimension during the treatment period due to fracture, abrasion or attrition and poor radiographs were excluded from the study.

Crown and root lengths of maxillary and mandibular incisors at pretreatment and posttreatment radiographs were measured using a digital vernier caliper (KEIBA®, Japan) with fine tips measuring to 0.01 mm. Crown length was measured from the tip of the incisal edge to the median CEJ point (the midpoint between the mesial and distal CEJs). The root length was measured from the median CEJ point to the apex of the root (Figure 1). All measurements were made along the long axis of the tooth.

Crown length was used to correct enlargement differences between pretreatment and posttreatment radiographs. This method has previously been used by Linge and Linge(2) and Mavragani *et al.*(23). A crown correction factor (C_1/C_2) was calculated using the ratio between crown length on pretreatment and posttreatment radiographs.

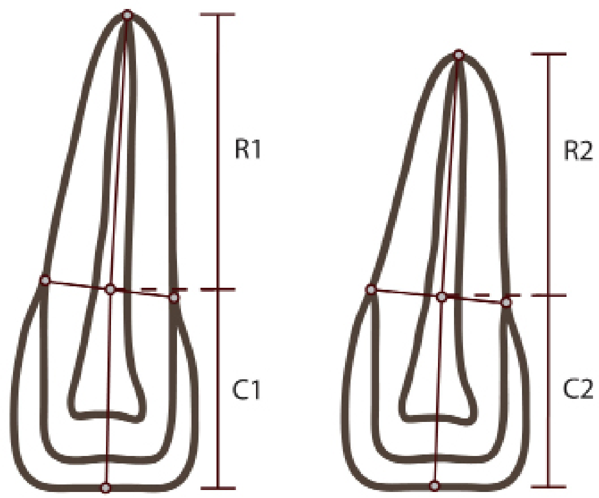

Fig. 1 *Diagram illustrating crown and root length measurement*
C1 = Crown length on pretreatment radiograph
R1 = Root length on pretreatment radiograph
C2 = Crown length on posttreatment radiograph
R2 = Root length on posttreatment radiograph

Correction Factor (CF) = C_1/C_2

C_1 = Crown length on pretreatment radiograph

C_2 = Crown length on posttreatment radiograph

The crown correction factor (CF) was used to adjust the root length on posttreatment radiograph (R_2) where there were notable differences between before and after measurements so that valid root length comparison could be made. The amount of apical root resorption in millimeters was subsequently calculated by subtract the adjusted root length on the posttreatment radiograph (R_2) from root length on the pretreatment radiograph (R_1). The amount of root resorption for each affected tooth was then calculated as a percentage of the pretreatment root length.

Apical root resorption (ARR) = R_1-(R_2 x CF)

R_1 = Root length on pretreatment radiograph

R_2 = Root length on posttreatment radiograph

Percentage of apical root resorption per tooth = ARR x 100/R_1

The measurements for maxillary and mandibular central and lateral incisors were evaluated separately.

Error of measurement

All measurements were performed by two examiners who had undergone calibration. One examiner was assigned to measure and evaluate the apical root resorption of maxillary incisors, while the other examiner measured the mandibular incisors. The reproducibility of the measurements was assessed by statistically analyzing the difference between double measurements by the same examiner. For the second measurement, which was done two weeks after the first, 25 radiographs from 10 patients were randomly selected. The systematic error for crown and root was evaluated by the paired t-test between double measurements. No significant systematic errors were found and the measurement variations were within acceptable limits.

Statistical analysis

Descriptive statistics were applied to determine means and standard deviations of the continuous data variables, while numbers and percentages were used for nominal data. In order to test the difference of the recorded variables between two groups, the two-sample t-test was used for quantitative variables, which were age at start of treatment, overjet and treatment duration.

Descriptive statistics were used to evaluate the amount of root resorption in millimeters and percentages for both groups. The Mann-Whitney U test was used to detect if there is any significant difference in apical root resorption in millimeters and percentage between the groups.

Results

After exclusion of 192 teeth due to unsatisfactory images, 496 teeth were examined. The numbers of the examined teeth for each type of incisor overbite are shown in Table 3.

The means and SDs for overbite in Group 1 (deep overbite group) and Group 2 (normal overbite group) were 5.10 ± 1.05 mm. and 1.97 ± 0.87 mm., respectively.

The two groups were not statistically different for all variables recorded, except for overjet and treatment time (Tables 4). Class II malocclusion was more common in the deep overbite group, whereas Class I malocclusion was more common in the normal overbite group. The deep overbite group had significantly greater overjet *($p<0.05$)* and treatment time *($p<0.05$)* than did the normal overbite group (Table 4). The means and SDs for overjet in Group 1 (deep overbite group) and Group 2 (normal overbite group) were 5.26 ± 2.87 mm. and 2.95 ± 2.29 mm., respectively. The average treatment time in Group 1 (deep overbite group) and Group 2 (normal overbite group) were 31.67 ± 7.91 months and 25.43 ± 9.91 months, respectively. Because Angle's classification showed some differences between the

Table 3 The numbers of the examined teeth classified by each type of incisors.

Type of incisors	**Numbers of examined teeth**		
	Deep overbite (Group 1)	**Normal overbite (Group 2)**	**Total**
Maxillary central incisor	71	82	153
Maxillary lateral incisor	63	68	131
Mandibular central incisor	67	78	145
Mandibular lateral incisor	30	37	67
Total	**231**	**265**	**496**

Table 4 The statistical comparisons of the quantitative variables of Group 1 (deep overbite group) and Group 2 (normal overbite group) and the result of t-test.

Variable	**Deep overbite (Group 1) (n = 42)**		**Normal overbite (Group 2) (n = 44)**		***p-value***
	Mean	**SD**	**Mean**	**SD**	
Age (year)	15.62	3.19	16.02	4.76	0.64
Overjet (mm.)	5.26	2.87	2.95	2.29	0.00*
Treatment time (month)	31.67	7.91	25.43	9.91	0.002*

* $p < 0.05$

Table 5 The average treatment time of each Angle's classification in deep overbite and normal overbite groups.

Angle classification	**Treatment time (month)**			
	N	**Deep overbite (Group 1)**	**N**	**Normal overbite (Group 2)**
Class I	25	32.28 ± 7.48	38	24.82 ± 8.70
Class II	15	29.87 ± 8.10	3	32.00 ± 21.63
Class III	2	37.50 ± 13.44	3	26.67 ± 13.05
Total	42	31.67 ± 7.91	44	25.43 ± 9.91

deep overbite and the normal overbite, attempt was made to find out if the average treatment times might be implicated in the difference. The average treatment times for each Angle's classification in deep overbite and normal overbite groups are shown in Table 5.

The numbers and percentages of teeth affected by root resorption for both groups are shown in Table 6 and Table 7. The amounts of apical root resorption of central and lateral incisors in deep overbite and normal overbite groups are shown in Table 8. It was found that there was no significant difference in the amount of root resorption for the mandibular incisors, between Group 1 and Group 2, whereas the maxillary central and lateral incisors in the deep overbite group were found to have significantly more root resorption than the normal bite group. *($p<0.05$)* However, the data from Table 7 suggests that there is no real difference in resorption experience comparing all set of incisor teeth of Group 1 and Group 2, even though there were significant differences in the amounts of resorption among the affected maxillary central and lateral incisors (Table 8).

Table 6 The amount of teeth affected by root resorption for both groups.

Type of incisors	Total numbers of examined teeth	Teeth with root resorption	Teeth without root resorption
Maxillary central incisor	153 (100 %)	143 (93.46 %)	10 (6.54 %)
Maxillary lateral incisor	131 (100 %)	127 (96.95 %)	4 (3.05 %)
Mandibular central incisor	145 (100 %)	107 (73.79 %)	38 (26.21%)
Mandibular lateral incisor	67 (100 %)	46 (68.66 %)	21 (31.34 %)
Total	**496 (100 %)**	**423 (85.28%)**	**73 (14.72%)**

Table 7 The numbers and percentages of teeth affected by root resorption between the deep overbite and normal overbite groups.

Type of incisors	Deep overbite (Group 1)			Normal overbite (Group 2)		
	Numbers of affected teeth	Total number examined	Percentage of affected teeth	Numbers of affected teeth	Total number examined	Percentage of affected teeth
Maxillary central incisor	67	71	94.4	76	82	92.7
Maxillary lateral incisor	62	63	98.4	65	68	95.6
Mandibular central incisor	51	67	76.1	56	78	71.8
Mandibular lateral incisor	21	30	70.0	25	37	67.6
Total	**201**	**231**	**87.0**	**222**	**265**	**83.8**

Table 8 Mean apical root resorption in millimeters (mm.) and in percentage (%) for central and lateral incisors in the deep overbite and normal overbite groups and the result of Mann-Whitney U test.

	Deep overbite (Group 1)			Normal overbite (Group 2)			***p*-value**
	n	Mean	SD	n	Mean	SD	
Maxillary central incisors	67			76			
Amount of root resorption (mm.)		1.72	1.72		1.13	1.17	0.006 *
Percentage of root resorption (%)		10.37	9.96		6.74	6.21	0.009 *
Maxillary lateral incisors	62			65			
Amount of root resorption (mm.)		2.01	1.51		1.32	1.03	0.008 *
Percentage of root resorption (%)		12.29	9.28		8.35	6.45	0.013 *
Mandibular central incisors	51			56			
Amount of root resorption (mm.)		2.21	1.91		1.87	1.29	0.708
Percentage of root resorption (%)		13.99	11.23		12.25	7.47	0.842
Mandibular lateral incisors	21			25			
Amount of root resorption (mm.)		2.23	1.47		2.52	1.63	0.544
Percentage of root resorption (%)		14.54	7.77		15.36	8.73	0.620

* $p<0.05$

Discussion

In this study, the maxillary central and lateral incisors in the deep overbite group had a significantly greater amount of root resorption than the normal overbite group. This finding supported the results of several previous studies.[20,22,24,25] The reason might be due to the fact that deep overbite is frequently corrected by reversing the curve of Spee, which intrudes and flares mandibular incisors, and simultaneously overloads the tooth apices, which can cause apical root resorption.[9,20-21] Another explanation for the apical root resorption is that the intrusive force which is applied labial to the center of resistance, created a moment that tips the teeth and moves root apex posteriorly (Figure 2).[20] Parker and Harris[24] found that maxillary incisor intrusion with an increase in lingual root torque were the strongest predictors of external apical root resorption. Faltin *et al.*[25] found that intrusion of human teeth with continuous forces induces root resorption, depending on the magnitude of force applied. Han *et al.*[22] found that intrusion of teeth causes about four times more root resorption than does extrusion. Recently, Martins *et al.*[19] investigated the influence of intrusion mechanics combined with anterior retraction on root resorption of the maxillary incisors in patients who have an increased overjet and deep overbite. They found significant positive correlations of the initial overbite severity and the amount of correction with apical root resorption.

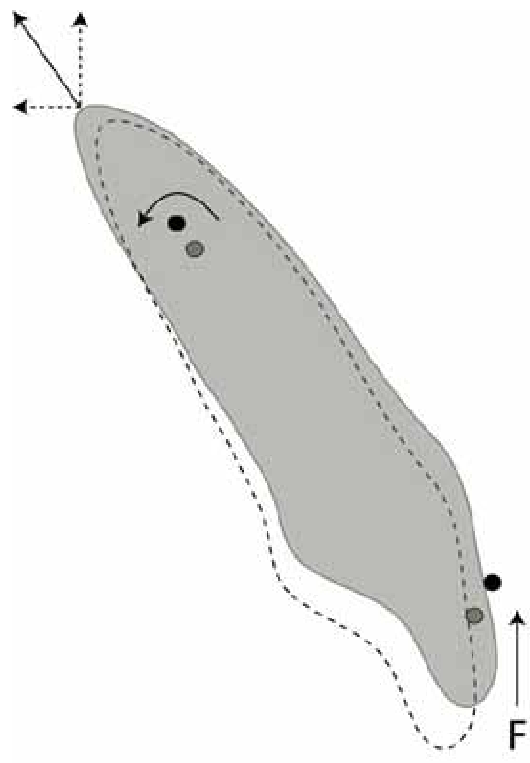

Fig. 2 *Diagram illustrating the intrusive force applied labial to the center of resistance, creating a moment that tips the tooth and moves root apex apically and posteriorly.*

No significant difference in root resorption was found in the mandibular incisors between deep overbite and normal overbite group. This lack of difference may be explained by two possible factors. The first is the susceptibility of maxillary incisors to root resorption. Our result supported the finding by McFadden *et al.*[6] who reported that the degree of root shortening was markedly higher in the maxilla (1.84 mm.) than the mandible (0.61 mm.) after the intrusion with the utility arch type of technique. The second factor might be related to anatomical limitations of the movement of maxillary incisors. The nasal floor is occasionally a limiting factor for intrusion of maxillary incisors and this may cause root resorption.[9]

In our study, the deep overbite was more often exhibited than normal overbite in patients with Class II malocclusion, which also related to increased overjet and prolonged treatment time. These variables have been considered as risk factors for orthodontic root resorption. Brin *et al.*[26] revealed a significant association between external apical root resorption and the magnitude of overjet reduction and the duration of fixed appliance treatment in patients who had Class II malocclusion. In addition, Lopatiene and Dumbravaite[27] revealed that root resorption was significantly correlated with treatment duration. McFadden *et al.*[6] reported that the treatment time was the most significant factor for occurrence of root shortening. Taner *et al.*[28] evaluated the apical root resorption of maxillary central incisors on lateral cephalometric radiographs after extraction therapy in patients with Class I and Class II malocclusion and found that the apical root shortening in Class II Division 1 patients was more severe than in Class I patients. The duration of active orthodontic treatment was longer in Class II patients. However, there were no significant correlations between the treatment duration and amount of apical root resorption. Therefore, deep overbite is not the only factor that can cause orthodontic root resorption. It should be noted that the Class II malocclusions were not distinguished as Division 1 or Division 2, each requiring different orthodontic mechanics for correction, particularly in the case of use of extractions (presumably only for Division 1 cases) as part of the correction procedures. The small number of Class III case included probably had little bearing on the study outcomes.

The major limitation of the present study is that Thai patients have extensive crowding especially of mandibular incisors. Many mandibular lateral incisors were found to have much overlapping with mandibular canines or central incisors resulting in being unable to make crown height measurements on periapical radiographs necessary for determining the magnification factor to be used in comparing pre- and post- treatment root lengths. This meant exclusion of more mandibular than maxillary incisors from the study sample.

This retrospective study, however, had some other limitations. It was not possible to fully standardize the radiographic imaging, or techniques for orthodontic treatment. Therefore, the use of correction factors was necessary to control magnification differences between pre- and post- treatment radiographs. This method has been used in many previous studies.[2, 4, 23]

The deficiencies of radiographic technique used for these subjects were part contribution to the exclusion of more than 25 per cent (192) of the possible total of 688 incisor teeth of the 86 subjects. It cannot be discounted that the total of exclusions, particularly of mandibular incisors, was a further limitation that may also have affected some findings of the study.

Mavragani *et al*.[23] found that standard edgewise technique produced less apical root resorption than the straight wire edgewise technique. However, Levander and Malmgren[29] and Beck and Harris[30] found that the light wire and edgewise techniques carried the same risk and degree of apical root resorption.

Clinical implications: In this study, we demonstrated greater amount of orthodontic apical root resorption of maxillary incisors after the correction of deep overbite than normal overbite. Angle Class II malocclusion, increased overjet and prolonged treatment time might be the factors which could promote greater apical root resorption in the deep overbite group. Therefore, the treatment mechanics should be carefully applied, especially in the maxillary incisors of patients with the characteristics mentioned above, in order to prevent or reduce the risk of orthodontic apical root resorption.

Conclusions

1. The maxillary incisors in the deep overbite group had a significantly greater amount of apical root resorption than the normal overbite group.

2. There was no significant difference in the amount of apical root resorption of mandibular incisors between deep overbite and normal overbite groups.

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