Hacettepe Diş Hekimliği Fakültesi Dergisi
Cilt: 33, Sayı: 1, Sayfa: 69-77, 2009

Apical Root Resorption During Intrusion And Extrusion of Upper Incisors

Üst Keserlerin İntrüzyonu ve Ekstrüzyonu Sırasında Oluşan Apikal Kök Rezorbsiyonu

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ABSTRACT

Aim: To determine the incidence and degree of apical root resorption of the upper central incisors during intrusion and extrusion and to compare the amount of root shortening with a control group having minimal upper central incisor movement after orthodontic treatment.

Subject and Methods: Thirty-eight patients were selected on the basis of intrusion or extrusion needs of the upper incisors. Twenty patients who had no vertical upper incisor change were included as control group. The median ages of the subjects were 17.3, 15 and 12.7 years for the intrusion, extrusion and control groups respectively. SNA, SNB, ANB, FMA, IMPA angles, overjet, overbite, inclination of the upper central incisor to the palatal plane, the perpendicular distances from the incisor tip and apex to the PTV plane and from the centre of resistance of the upper central incisor to palatal plane were measured on the cephalograms.

Results: The amount of apical root resorption was determined for each patient by subtracting the initial tooth length from the final tooth length. Root shortening following orthodontic treatment was found in all groups. The median apical root resorption was 0.9, 1.2 and 0.6 mm in the intrusion, extrusion and control patients respectively.

ÖZET

Amaç: İntrüzyon ve ekstrüzyon sırasındaki üst santral keserlerdeki apikal kök rezorpsiyonunun insidans ve derecesinin belirlenmesi ve ortodontik tedavi sonrasındaki minimal üst santral keser hareketine sahip kontrol grubu ile kök kısalma miktarının karşılaştırılmasıdır.

Bireyler ve Yöntemler: Araştırmaya, üst keserlerde intrüzyon ya da ekstrüzyon ihtiyacı olan 38 hasta seçilmiştir. Vertikal yönde üst keser değişikliği olmayan 20 hasta, kontrol grubu olarak dahil edilmiştir. Yaş ortancaları, intrüzyon, ekstrüzyon ve kontrol grupları için sırasıyla 17,3, 15 ve 12,7 yıldır. SNA, SNB, ANB, FMA, IMPA açıları, overjet, overbite, üst santral keserin palatal düzleme göre inklinasyonu, keser ucu ve apeksinden PTV düzlemine olan ve üst santral keserin rezistans merkezinden palatal düzleme olan dik mesafeler ölçüldü. Her hasta için apikal kök rezorpsiyonunun miktarı, başlangıç kök boyu, final kök boyundan çıkartılarak belirlendi.

Bulgular: Tüm gruplarda tedavi sonrasında kök kısalması bulundu. Ortanca kök rezorpsiyon miktarı; intrüzyon, ekstrüzyon ve kontrol grupları için sırasıyla; 0,9, 1,2 ve 0,6 mm idi.

Conclusion: The extent of root resorption was not related to the amount of vertical apical movement of the upper central incisors.

Sonuç: Kök rezorpsiyon miktarı, üst santral keserlerin vertikal apikal hareket miktarıyla ilişkili değildi.

KEYWORDS
Root resorption, intrusion, extrusion, orthodontic movement

ANAHTAR KELİMELER
Kök rezorpsiyonu, intrüzyon, ekstrüzyon, ortodontik hareket

INTRODUCTION

Root resorption is a common consequence of orthodontic treatment and several factors have been implicated in the initiation and progression of external root shortening. These can be divided into patient and local factors related to mechanotherapy[1]. Whenever the magnitude and duration of force exceeds the reparative capacity of the cementum, root resorption will occur [2-4]. There is a general agreement that resorption mostly occurs in the upper anterior region[5-8].

Several tooth movements have been associated with root resorption. These are prolonged tipping [3,9], bodily tooth movement[9], upper incisor retraction[10,11], and intrusion[12-14]. Intrusion has been suggested to have the most deleterious effect because the axial forces are concentrated near the root apex due to the cone shaped structure of the roots[15]. On the other hand, some studies have shown that external apical root resorption is not associated with either intrusion or extrusion[11,16].

There have been suggestions that the amount of root movement is also associated with root resorption[3-17]. However, only few investigations have evaluated the extent of root resorption based on orthodontically induced tooth movements[14,17,18].

The purposes of this study were to determine the incidence and degree of apical root resorption of the upper central incisor during intrusion and extrusion and to compare the amount of root shortening with a control group, with minimal upper central incisor movement, after treatment with fixed orthodontic appliances.

SUBJECTS AND METHODS

The radiographs of 700 subjects were evaluated from the files of the Orthodontic Department of Hacettepe University, Faculty of Dentistry. The cases were selected on the basis of the following criteria:

1. Subjects having non-extraction treatment with significant upper incisor intrusion.
2. Subjects having non-extraction treatment with significant upper incisor extrusion.
3. Initial and final standardized lateral cephalometric films after intrusion and extrusion treatment with visible upper incisor root apex and incisal tip available.
4. No evidence or history of trauma to the anterior teeth.
5. No alterations of the incisal edges during orthodontic treatment.
6. Root formation of the permanent maxillary central incisors completed before treatment.

A total of 38 subjects (19 deep bite, 19 open bite) met these criteria. The measurements were made on the initial and final lateral cephalometric head films and the upper central incisors were evaluated for the study. The clinically suggested force ranges were 40-60 gr for each upper central incisor and 30-45 gr for each upper lateral incisor for intrusion and extrusion movements. The forces of intrusion and extrusion had been applied on upper incisors until normal overbite relationship was achieved.

The initial and final lateral cephalometric head films of 20 subjects who had undergone

minimal upper central incisor movement after non-extraction fixed appliance therapy were also included in the study. The selection criteria 4-6 were valid for this control group. All the lateral cephalometric radiographs were taken with the same magnification on the same cephalostat. Table I shows the average initial age and duration of treatment in all groups.

Figure I shows the measurements used to determine the initial dentofacial characteristics. Seven skeletodental variables were measured at the start of treatment (Angles SNA, SNB, ANB, FMA and, IMPA, overjet (mm) and overbite (mm)).

Upper incisor positional changes

Figure 2 illustrates the measurements used to calculate the positional changes of the upper central incisors during orthodontic treatment. Sagittal tooth movements were calculated with one angular and two linear measurements: The inclination of the upper central incisors to the palatal plane (U1-PP, degrees), the perpendicular distance from the incisal tip of the upper central incisor to the pterygoid vertical plane (U1INC-PTV) (mm), the perpendicular distance from the apex of the upper central incisor to the pterygoid vertical plane (U1APEX-PTV) (mm). Vertical tooth movements were measured as the perpendicular distance from the center of resistance (CR) of the upper central incisor to the palatal plane (CR-PP) (mm).

CR was positioned on the long axis of the tooth, two-thirds of its length from the incisal edge. This localization was comparable to the 3/10 of the cervical level-apex distance of a parabolic shaped single rooted tooth[19]. This point was marked on the initial cephalometric radiograph and then relocated on the final cephalometric radiograph by means of a template[20].

Measuring root resorption

Each cephalogram was assessed to define the degree and severity of root resorption from the most procumbent upper central incisor. Tooth length was measured directly on the cephalograms and root shortening was defined as any reduction in tooth length of an upper central incisor measured from the tip of the incisal edge to the apex of the root[8,21]. The initial and final tooth lengths were recorded for each patient. The amount of apical root resorption was determined by subtracting the initial tooth length from the final tooth length.

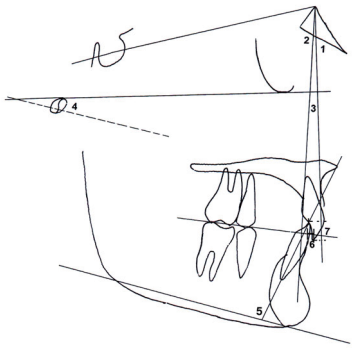

FIGURE 1

Initial dentofacial characteristics. (1) SNA: Inward angle toward the cranium between the NA line and the sella-nasion (SN) plane (2) SNB: Inward angle toward the cranium between the NB line and the SN plane (3) ANB: Angle between the NA and NB lines, obtained by subtracting SNB from SNA (4) FMA: Angle between mandibular plane and Frankfort horizontal plane (5) IMPA: Angle between mandibular central incisor long axis and mandibular plane (6) Over jet: The horizontal distance between the upper and lower incisor tips (mm) (7) Over bite: The vertical distance between the upper and lower incisor tips (mm).

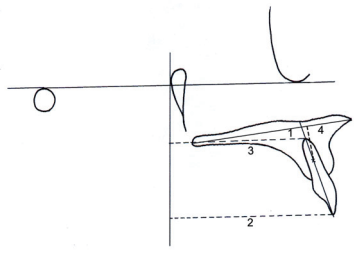

FIGURE 2

Upper central incisor positional changes. (1) U1-PP (°): Upper central incisor- palatal plane angle (2) U1INC-PTV (mm): The perpendicular distance from the upper central incisor tip to PTV plane (3) U1APEX-PTV (mm): The perpendicular distance from the upper central incisor apex to PTV plane (4) CR-PP (mm): The perpendicular distance from the center of resistance of the upper central incisor to PP plane.

Statistical analysis

Differences between the three groups were tested using the Kruskall-Wallis analysis of variance test. Test significance level was set at $\alpha = 0.05$. When the groups were statistically significant, pairwise comparisons were carried out by using Mann-Whitney U test with Bonferroni correction. Wilcoxon test was used to compare the initial and final maxillary incisor positional changes and tooth length.

All tooth length measurements were made by one author and upper incisor changes by a second author in order to eliminate inter-examiner variability. Intra-examiner variability in tooth length measurements was tested after two weeks by remeasuring 25 percent of the radiographs chosen at random using Dahlberg's formula[22]. The precision for tooth length measurements was 0.11 mm.

RESULTS

There was no difference between the age of patients who had intrusion or extrusion treatments but the pre-treatment age in the control group was significantly different than that of two groups. The duration of treatment between the intrusion and control groups was also different (Table I).

Initial facial characteristics of the three groups did not differ except for angles SNA, ANB, FMA and the amount of overbite. SNA angle was significantly different between the intrusion and control groups, while ANB angle was significantly different in the three groups. The median FMA values were 21.0, 31.5 and 27 degrees in intrusion, extrusion and control groups, respectively. The amount of median overbite in the intrusion group was 6.0 mm, the median open bite was -2 mm in the extrusion group and the control group had a median initial overbite of 2.3 mm (Table II).

The upper central incisors were significantly intruded in the intrusion group (mean: 1.3±0.1, $p < 0.001$) and significantly extruded in the extrusion group (mean: 2.7±0.2, $p < 0.001$). The upper incisor-palatal plane inclination (U1-PP degrees) increased significantly in the intrusion ($p<0.05$) and control groups ($p < 0.001$). The upper incisor- PTV distance (U1INC-PTV mm) increased significantly in the extrusion ($p<0.05$) and control groups ($p < 0.01$). The upper incisor-apex distance (U1APEX-PTV mm) significantly decreased in the intrusion ($p<0.05$) and increased in the extrusion groups ($p < 0.01$). Root length decreased significantly in all groups, with a mean difference of 1.43±0.17 for the intrusion ($p<0.01$), 1.53±0.94 for the extrusion ($p<0.001$) and 0.77±0.04 for the control group ($p < 0.001$) (Table III).

TABLE I

Age and duration of treatment in the intrusion, extrusion and control groups.

		N	Median	Minimum	Maximum	p
Age (years)	Intrusion	19	17.3[a]	12	30.3	0.001
	Extrusion	19	15[a]	12.5	23	
	Control	20	12.7[b]	11	26	
Duration of treatment (months)	Intrusion	19	26[a]	12	45	0.012
	Extrusion	19	22	11	51	
	Control	20	18[b]	9	32	

Groups with different letter are significantly different.

TABLE II

Comparison of the initial skeletodental variables of the intrusion. extrusion and control groups.

Variables	Groups	N	Median	Minumum	Maximum	p
SNA (°)	Intrusion	19	80.0[a]	72	90	
	Extrusion	19	80	73.5	84	0.014
	Control	20	78.0[b]	74	82	
SNB (°)	Intrusion	19	76	69	84	
	Extrusion	19	79	70.5	83	0.017
	Control	20	76	72	78	
ANB (°)	Intrusion	19	4.0[a]	-1	10	
	Extrusion	19	2[b]	0	3.5	0.000
	Control	20	2.5[c]	-2	6	
FMA (°)	Intrusion	19	21.0[a]	10	28.5	
	Extrusion	19	31.5[b]	17	36	0.001
	Control	20	27	16.5	36.5	
IMPA (°)	Intrusion	19	95	79	108.5	
	Extrusion	19	91	77	102	0.224
	Control	20	93.5	84	102	
OVERJET (mm)	Intrusion	19	3.5	2	14	
	Extrusion	19	3	-0.5	7.5	0.300
	Control	20	3	1.5	6	
OVERBITE (mm)	Intrusion	19	6.0[a]	2	7	
	Extrusion	19	-2.0[b]	-6.5	0	0.000
	Control	20	2.3[c]	0	6	

Groups with different letter are significantly different.

Table IV shows the comparison of changes in upper incisor movement and root length in all groups. The median amount of CR-PP distance was different among all groups (-1.0 mm for the deep bite, 2.5 mm for the open bite and 0.3 mm for the control group). However, the median amount of root length did not show any significant difference among the groups.

DISCUSSION

All types of tooth movement can cause apical root resorption although intrusion is assumed to have the most detrimental effect[15]. There is no agreement, however, on which type of tooth movement actually has the greatest impact on root resorption. In some studies no significant associations have been found between root resorption and intrusion or extrusion although significant associations were determined with retraction of the incisors[10,11] and the amount of overjet[23]. This may be because not all subjects with a deep overbite or open bite require significant intrusion or extrusion. The extent of tooth movement is also suggested to be a determining factor for root resorption[14,17,18]. Larger tooth

TABLE III

Changes in tooth movement and root length of the upper incisor during treatment.

			Initial			Final			
Variables	Groups	N	Median	Min-Max	X ± SD	Median	Min-Max	X ± SD	p
U1-PP (°)	Intrusion	19	100	83.5-135	104.4 ± 12.5	115	101-127	113.6 ± 7.9	0.011
	Extrusion	19	113	103-127	114.0 ± 7.6	115	98-129	112.6 ± 7.8	0.477
	Control	20	109.5	98-116	108.9 ± 4.4	114.5	102-121	113.7 ± 5.0	0.000
U1INC-PTV (mm)	Intrusion	19	57	48-68	57.0 ± 5.3	60.5	49-66	58.5 ± 4.5	0.144
	Extrusion	19	57	50-64	57.6 ± 4.4	59	51-65.5	59.5 ± 4.1	0.021
	Control	20	55.6	49-65	55.7 ± 3.2	58	49-66	57.9 ± 3.9	0.002
U1APEX-PTV (mm)	Intrusion	19	52	44-66	51.3 ± 4.4	50	43.5-55.5	49.8 ± 3.4	0.049
	Extrusion	19	47	41-54	47.1 ± 3.3	49.5	43.5-52.5	49.4 ± 2.8	0.001
	Control	20	47	18-56.5	46.0 ± 7.4	48	17-58	46.8 ± 7.9	0.093
CR-PP (mm)	Intrusion	19	12.5	10.5-17.5	12.8 ± 1.8	11	9-16.5	11.5 ± 1.7	0.000
	Extrusion	19	15.5	9.0-18	14.8 ± 2.3	18	11.5-21.5	17.5 ± 2.5	0.000
	Control	20	13.6	9.5-18.5	13.7 ± 2.4	14.3	10.5-18.5	14.0 ± 2.3	0.008
Root length (mm)	Intrusion	19	25.6	22.4-29	25.97 ± 2.07	24.4	19.6-28.8	24.54 ± 2.90	0.001
	Extrusion	19	25.3	21.5-27.7	25.14 ± 1.59	24.3	18-26.8	23.61 ± 2.53	0.000
	Control	20	24.9	21.4-29	25.00 ± 2.46	24.1	20.5-28.7	24.23 ± 2.42	0.000

TABLE IV

Comparison of the changes (final-initial) in upper incisor movement and root length in the intrusion, extrusion and control groups.

Variable change	Groups	N	Median	Minumum	Maximum	p
U1-PP (°)	Intrusion	19	9.0[a]	-25.0	29.5	0.001
	Extrusion	19	-1.0[b]	-12.0	13.0	
	Control	20	3.0[c]	-2.0	23.0	
U1INC-PTV (mm)	Intrusion	19	1.0	-4.0	9.0	0.646
	Extrusion	19	3.0	-3.0	7.50	
	Control	20	1.8	-2.0	10.0	
U1APEX-PTV (mm)	Intrusion	19	-2.0[a]	-5.0	3.5	0.001
	Extrusion	19	2.5	-1.5	6.0	
	Control	20	1.0[b]	-34.0	32.0	
CR-PP (mm)	Intrusion	19	-1.0[a]	-4.0	-0.5	0.000
	Extrusion	19	2.5[b]	0.5	5.0	
	Control	20	0.3[c]	-0.5	1.0	
Root length (mm)	Intrusion	19	-0.9	-7.1	0.0	0.320
	Extrusion	19	-1.2	-4.7	0.0	
	Control	20	-0.6	-2.3	0.0	

Groups with different letter are significantly different.

movements to correct malocclusions may result in a greater resorption potential. Thus; it is important to evaluate root resorption in patients in whom significant tooth movement is accomplished.

Achieving pure intrusion movement seems to be a difficult orthodontic movement. Although many patients were treated due to their deep-bite malocclusion, deep bite correction was mostly achieved by proclination of upper anterior teeth which might simulate an intrusion movement. As a consequence, although a large number of cases were assessed, a limited number of subjects could be included in the study due to the technique used to measure the actual amount of intrusion.

This study was designed to determine the incidence and degree of root resorption during significant vertical movement of the upper incisors to correct bite problems. A group of patients who did not show any vertical positional change in the upper central incisors after fixed appliance therapy was also included in the study as control group. The initial facial characteristics were similar in all groups except for angles SNA, ANB and FMA and amount of overbite. The initial age of the control group was younger than that of the intrusion and extrusion groups which may affect the amount of root resorption, yet no age dependent risk has been reported for apical root resorption in previous studies[15, 23-27].

The duration of orthodontic treatment is accepted to be a risk factor for apical root resorption[13,17,28]. However, no association between apical root resorption and duration of treatment could be found in other investigations[12,15,16,21,24]. In accordance with the studies mentioned above, there was no significant difference among the groups in the present investigation regarding root resorption although the duration of orthodontic treatment was different for each group.

Some labial inclination of the upper incisors during the intrusion, and some retrusion of the upper incisors during the extrusion were obtained simultaneously. In contrast, both intrusion and some retrusion were obtained in a similar study[12]. This difference in incisor inclination during intrusion may be due to the treatment needs of the subjects. In this study, the CR of the upper central incisor was determined on the pre-treatment radiograph and transferred to the post-treatment radiograph to measure actual vertical tooth movement[19,20]. Dermaut and DeMunck [12]and Melsen et al[29] also used similar methods to determine the actual amount of intrusion during intrusion.

Root shortening was obvious during orthodontic movement of the upper incisors but was not found to be statistically different among the three groups. This is in agreement with the results of previous investigators who reported that routine orthodontic treatment increases the risk of root resorption[5,13,17,30-32]. The mean amount of apical root resorption measured in this study (0.77-1.53 mm) is in agreement with the previous findings[5,13,21,23,31,33].

From a clinical point of view, the maximum single root resorption was measured as 7.1 mm, 4.7 mm and 2.3 mm in intrusion, extrusion and control groups respectively. However, the mean and median amounts of apical root resorption was not found to be associated with the extent of vertical displacement of the upper incisors. Other factors such as the differences in force magnitude or individual susceptibility can explain the maximum single root resorption seen in these patients[34]. Owman-Moll et al[35] stated that great individual variations may be even more important than force magnitude and type or duration of force application. In a recent study, it has been shown that due to either intrusion or extrusion, root resorption can occur in the same patient, confirming that there is susceptibility for root resorption[36].

CONCLUSION

The incidence and amount of apical root resorption during orthodontic tooth movement including intrusion and extrusion, was determined in this study. Similar amounts of apical root resorption occurred at the end of treatment. However, upper incisor retraction was required in some subjects, following intrusion. Studies showed more apical root resorption in patients when upper incisors were retracted than when no upper incisor retraction was performed[10,11]. Thus, it should be kept in mind that additional root resorption may occur when upper incisor intrusion and retraction are needed for orthodontic correction.

REFERENCES

1. Blake M, Woodside DG, Pharoah M J. A radiographic comparison of apical root resorption after orthodontic treatment with the edgewise and Speed appliances. Am J Orthod Dentofac Orthop 1995; 108: 76-84.
2. Stenvik A, Mjor IA. Pulp and dentine reactions to experimental tooth intrusion. A histologic study of the initial changes. Am J Orthod 1970; 57:370-385.
3. Reitan K. Initial tissue behavior during apical root resorption. Angle Orthod 1974; 44:68- 82.
4. Rygh P. Orthodontic root resorption studied by electron microscopy. Angle Orthod 1977; 47:1-16.
5. Sjölien T, Zachrisson BU. Periodontal bone support and tooth length in orthodontically treated and untreated persons. Am J Orthod 1973; 64: 28-37.
6. Newman WG. Possible etiologic factors in external root resorption. Am J Orthod 1975 ; 67: 522-539.
7. Hollender L, Rönnerman A, Thilander B. Root resorption, marginal bone support and clinical crown length in orthodontically treated patients. Eur J Orthod 1980; 2: 197-205.

8. Copeland S, Green LJ. Root resorption in maxillary central incisors following active orthodontic treatment. Am J Orthod 1986; 89: 51-55.
9. Follin ME, Ericsson I, Thilander B. Occurrence and distribution of root resorption on orthodontically moved premolars in dogs. Angle Orthod 1986; 56:164-175.
10. Baumrind S, Korn EL, Boyd RL. Apical root resorption in orthodontically treated adults. Am J Orthod Dentofac Orthop 1996; 110: 311-320.
11. Ahn JH, Baumrind S, Boyd RL. Factors associated with apical root resorption in orthodontically treated patient studied by a case control method. Am J Orthod Dentofac Orthop 2000; 117: A1.
12. Dermaut LR, DeMunck A. Apical root resorption of upper incisors caused by intrusive tooth movement: a radiographic study. Am J Orthod Dentofac Orthop1986; 90: 321-326.
13. McFadden W M, Engstrom C, Engstrom H, Anholm JM. A study of the relationship between incisor intrusion and root shortening. Am J Orthod Dentofac Orthop 1989; 96: 390-396.
14. Parker RJ, Harris EF. Directions of orthodontic tooth movements associated with external apical root resorption of the maxillary central incisor. Am J Orthod Dentofac Orthop 1998; 114: 677-683.
15. Beck B W, Harris EF. Apical root resorption in orthodontically treated subjects: analysis of edgewise and light-wire mechanics. Am J Orthod Dentofac Orthop1994; 105: 350-361.
16. Sameshima G T, Sinclair PM. Characteristics of patients with severe root resorption.Orthod Craniofac Res 2004; 7:108-114.
17. DeShields RW. A study of root resorption in treated Class II division 1 malocclusions. Angle Orthod 1969; 39: 231-245.
18. Mirabella AD, Årtun J. Risk factors for apical root resorption of maxillary anterior teeth in adult orthodontic patients. Am J Orthod Dentofac Orthop 1995; 108: 48-55.
19. Burstone CJ, Pryputniewicz RJ. Holographic determination of centers of rotation produced by orthodontic forces. Am J Orthod 1980; 77: 396-409.
20. Greig DM. Bioprogressive therapy: overbite reduction with the lower utility arch Br J Orthod. 1983; 10: 214-216.
21. Taner TU, Ciğer S, Şençift Y. Evaluation of apical root resorption following extraction therapy in subjects with Class I and Class II malocclusions. Eur J Orthod 1999; 21: 491- 496.
22. Dahlberg G. Statistical methods for medical and biological students. London: George Allen and Unwin Ltd. 1940: 122-32.
23. Linge L, Linge BO. Patient characteristics and treatment variables associated with apical root resorption during orthodontic treatment. Am J Orthod Dentofac Orthop 1991; 99: 35-43.
24. VonderAhe G. Postretention status of maxillary incisors with root-end resorption. Angle Orthod 1973; 43: 247-255.
25. Levander E, Malmgren O. Evaluation of the risk of root resorption during orthodontic treatment: a study of upper incisors. Eur J Orthod 1998; 10: 30-38.
26. Harris EF, Baker WC. Loss of root length and crestal bone height before and during treatment in adolescent and adult orthodontic patients. Am J Orthod Dentofac Orthop 1990; 98: 463-469.
27. Taithongchai R, Sookkorn K, Killiany DM. Facial and dentoalveolar structure and the prediction of apical root shortening. Am J Orthod Dentofac Orthop 1996; 110: 296-302.
28. Sameshima GT, Sinclair PM. Predicting and preventing root resorption: Part II. Treatment factors. Am J Orthod Dentofac Orthop 2001; 119: 511-515.
29. Melsen B, Agerbaek N, Markenstam G. Intrusion of incisors in adult patients with marginal bone loss. Am J Orthod Dentofac Orthop 1989; 96: 232-241.
30. Massler H, Malone A J. Root resorption in human permanet teeth. A roentgenographic study. Am J Orthod 1954; 40: 619-633.
31 Goldson L, Henrikson CO. Root resorption during Begg treatment: a longitudinalroentgenologic study. Am J Orthod 1975; 68: 55-66.
32. Sharpe W, Reed B, Subtelny JD, Polson A. Orthodontic relapse, apical root resorption and crestal alveolar bone levels. Am J Orthod Dentofac Orthop. 1987; 91: 252-258.
33. Mirabella A D, Årtun J. Prevalence and severity of apical root resorption of maxillary anterior teeth in adult orthodontic patients. Eur J Orthod 1995; 17: 93-99.
34. Brezniak N, Wasserstein A. Root resorption after orthodontic treatment: Part 2. Literature review. Am J Orthod Dentofacial Orthop 1993; 103:138-46.
35. Owman-Moll P, Kurol J, Lundgren D. 1996 Effects of a doubled orthodontic force magnitude on tooth movement and root resorptions. An interindividual study. Eur J Orthod 1996; 18: 141-150.
36. Han G, Huang S, Von den Hoff J W, Zeng X, Kuijpers-Jagtman AM. Root resorption after orthodontic intrusion and extrusion: an intraindividual study. Angle Orthod 2005; 75:912-918.

Geliş Tarihi : 13.10.2008
Kabul Tarihi : 18.05.2009

Received Date : 13 October 2008
Accepted Date : 18 May 2009

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