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AN ANALYSIS OF VARIOUS FACTORS ASSOCIATED WITH APICAL ROOT RESORPTION IN EXTRACTION AND NON EXTRACTION ORTHODONTIC TREATMENT: A RETROSPECTIVE RADIOGRAPHIC STUDY.

Dental Science

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ABSTRACT

Apical root resorption is a well-recognized iatrogenic phenomenon associated with orthodontic treatment.. The study consist of 100 samples of good quality radiographs. The radiographs were divided into two groups on the basis of extraction and non-extraction treatment. Group I treated with first premolar extraction and Group II given non-extraction treatment. The mean root resorption of **15.70% and 13.03%** was observed in Group I and Group II, respectively. Considering an average root length of 13 mm, a mean resorption of **2.12 mm and 1.76 mm** was observed in group 1 and group 2 respectively.. The study revealed slightly greater amount of apical root resorption in extraction subjects as compared to non-extraction subjects. However, no statistically significant difference was found between the two treatment modalities. In extraction subjects, the apical root resorption was directly proportional to the pre-treatment length of maxillary central incisor and inversely proportional to the root width. (Root resorption, extraction vs non-extraction)

KEYWORDS:

INTRODUCTION

External apical root resorption (EARR) is a well-recognized and widely accepted iatrogenic phenomenon associated with orthodontic treatment. Brezniak and Wasserstein[1-3] notified that all examined teeth after orthodontic treatment showed evidence of root resorption.

The maxillary incisors are the teeth most affected by root resorption, followed by the mandibular incisors and first molars.[4-6] In recent study by Marques et al., the incidence of severe EARR of the incisors after orthodontic treatment was found to be 14.5%.[7]

The factors associated with apical root resorption can be categorized as local and systemic factor:

Systemic factors include hormonal deficiency such as hypothyroidism, hypopituitarism, drug –nabumetone, genetic predisposition and chronic alcoholism.

Local factors are tooth root morphology , tooth length , root width , root with developmental abnormality, root proximity to cortical plate, alveolar bone density, previous trauma, endodontic treatment, tooth movement, orthodontic force, severity of malocclusion and habits (nail biting ,tongue thrust).

AIM & OBJECTIVES

The aim & objectives of present study are:

- To investigate the amount of apical root resorption in extraction and non-extraction cases through panaromic radiograph.
- To investigate the effect of cortical plate proximity of maxillary central incisor root on apical root resorption through lateral cephalogram.
- To investigate the correlation between the apical root resorption and various relevant parameters such as root width, tooth length, maxillary alveolar bone width and amount of tooth movement through lateral cephalogram.

MATERIAL AND METHOD

The study was conducted in the Department Of Orthodontics and Dentofacial Orthopedics, Kothiwal Dental College & Research Centre, Moradabad, on 100 samples of good quality radiographs (lateral cephalographs and panaromic radiographs).The samples were randomly selected from the existing pre and post treatment records present in the department.

Inclusion criteria:

1. Subjects were in the age group of 12-24years when the treatment was commenced. Treatment time range was 18-24 months.
2. All subjects had permanent dentition.
3. All permanent maxillary central incisors were intact, caries-free, and without previous endodontic treatment.
4. All subjects finished the treatment with Angle's Class-I molar relationship and functionally and esthetically acceptable occlusions.
5. Non extraction subjects were treated by dentoalveolar expansion or molar distalization or a combination of both.
6. All radiographs were taken in natural head position.

Exclusion criteria:

1. Subjects with congenital anomaly or craniofacial defect were excluded.
2. History of trauma to the maxillary central incisors as ascertained by patient history from case records.

The radiographs were divided into two groups on the basis of extraction and non-extraction treatment. Group I [n= 50] treated with first premolar extraction and Group II [n= 50] given non-extraction treatment.

Methodology:

The pre- and post-treatment cephalographs and panaromic radiographs were digitized along with the scale using Epson scanner (Epson perfection V700) (fig 1). The scale was used for the standardization of radiograph. The scanned image was stored as jpeg storage format after the scanning. (fig 1)



Figure 1 – Epson scanner (right) and storage format (left)

The jpeg image of the radiographs is then transferred to the digimizer software (digimizer version 4) (fig 2). The landmarks were marked

and linear and angular measurements were carried out using various tools given in software.

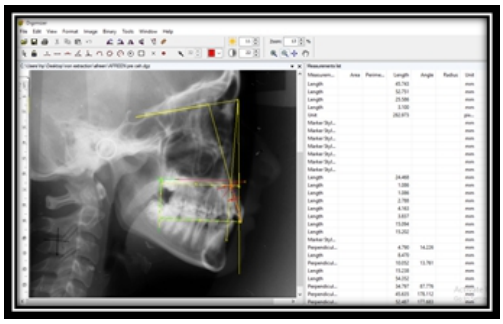

Figure2 – Digimizer Software

Panaromic radiographs[75] were used to assess the apical root resorption of maxillary central incisor using the formula mentioned below.

$$\frac{R(T2) \times R(T1) \times 100}{R(T1) \times R(T2)} = x\%$$

Where, R = Root length
C= Crown length
T1= pre-treatment
T2= post-treatment

Landmarks used in the study-

1) PANAROMIC RADIOGRAPHIC LANDMARKS[8] (fig 3)

Following landmarks were used in the study:

a. **R = Root length** – distance between the cementoenamel junction and root apex.
b. **C= Crown length** - distance between the cementoenamel junction and incisor edge.
c. T1= pre-treatment
d. T2= post-treatment

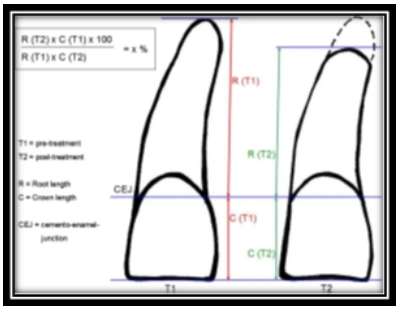

Figure3- OPG landmarks - R = Root length, C= Crown length, T1= pre-treatment, T2= post-treatment.

2) CEPHALOMETRIC LANDMARKS: following cephalometric landmarks were used in the study.

1) Skeletal landmarks:[9] (fig 4)

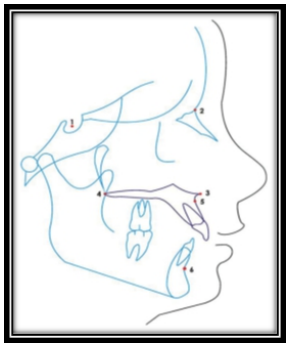

Figure 4- Skeletal landmarks: (1) sella (S), (2) nasion (N), (3) anterior nasal spine (ANS), (4) posterior nasal spine (PNS), (5) point A (subspinale), and (6) point B (supramentale)

2) Dental Landmarks: (fig 5)

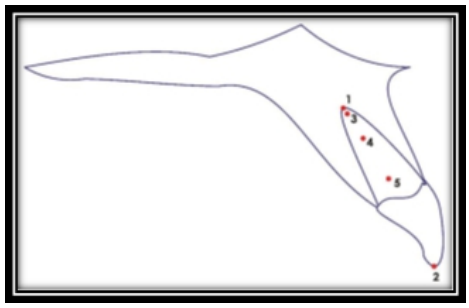

Figure 5- dental landmarks (1) Root apex (Ra), (2) Incisor superious (Is), (3) Ra-1 (4) Ra-4 and (5) Is-15

3) Cephalometric planes and lines:10(fig 6)

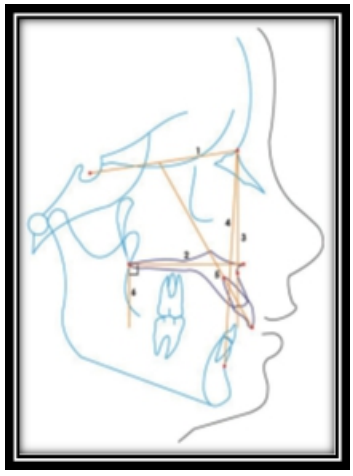

Figure 6 – planes and lines: (1) sella–nasion plane, (2) palatal plane, (3) NA line, (4) NB line, (5) incisor axis (IA), (6) PNS perpendicular

4) Parameters:

1) Angular parameters:[11] (fig 7)

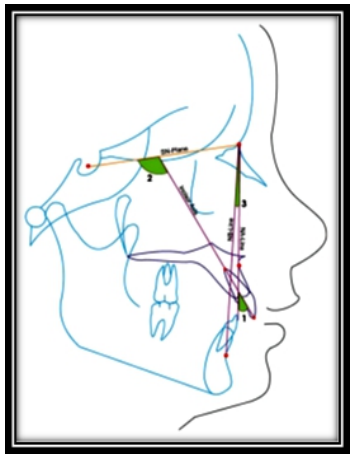

Figure 7- angular parameters[11] : (1) IA to NA angle, (2) SN–IA angleand (3) ANB angle .

2) Linear parameters in antero-posterior plane: (fig 8)

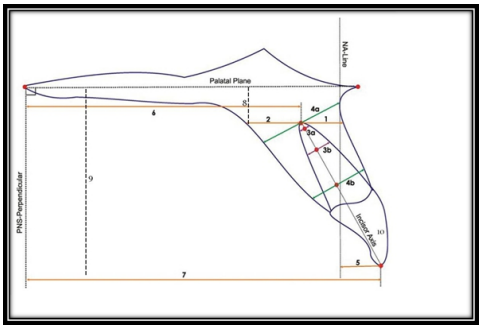

Figure 8 - Linear parameters in anteroposterior plane: (1) Ra–LP (labial plate) distance[12], (2) Ra- PP (palatal plate) distance[12], (3a) root width at point Ra-1[13], (3b) root width at point Ra-4[14], (4a) alveolar width at point Ra[14], (4b) alveolar width at point Is-15[13], (5) Is to NA distance, that is, distance of incisal edge from the NA line measured parallel to the horizontal floor[16], (6) horizontal apical distance (Ra-HRZ)[16], and (7) horizontal incisal distance (Is-HRZ)[16] . Linear parameters in vertical plane[16]: (8) Ra-VRT,(9) Is-VRT, and (10) Is–Ra distance.

Apical root resorption was assessed as a change in the tooth length during the orthodontic treatment and was calculated by subtracting the post-treatment Is–Ra distance from the pre-treatment Is-Ra distance.

Apical root resorption = pretreatment tooth length (Is-Ra distance) – post treatment tooth length (Is-Ra distance).

Statistical Analysis

The pre-treatment, post-treatment mean, standard deviation, mean changes, and level of significance for the various parameters of Group I and Group II subjects were obtained, and compared by paired "*t*"-test using SPSS software. The level of significance was set at 5% Pearson's correlation coefficient were done to test the correlation between the apical root resorption and the various parameters.

Results

Results were drawn as follows:

Table 1: Comparison of OPG reading means, SD, mean changes and level of significance of extraction and non-extraction group.

	OPG READING					
Groups	Number	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Extraction	50	84.30%	5.05%	2.67%	1.529	0.09
Non-extraction	50	86.97%	4.37%			
Unpaired t-test **# Non-significant difference**						

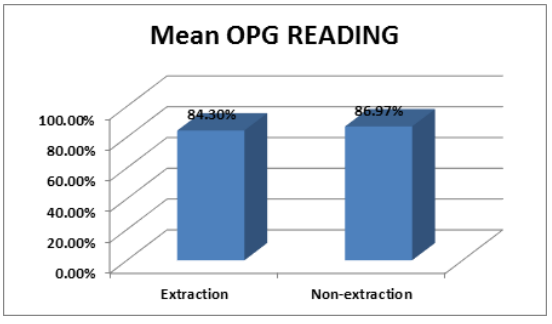

Figure 9: Comparison of OPG reading means of extraction and non-extraction group.

The mean OPG reading was compared between Extraction and Non-extraction groups using the **unpaired t-test**. There was no significant difference in mean OPG READING between Extraction and Non-extraction groups.

Table 2: Comparison of root resorption means, SD, mean changes, and level of significance of extraction and non-extraction group.

	Root resorption					
Groups	Number	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Extraction	50	15.70%	5.05%	2.63%	1.529	0.72#
Non-extraction	50	13.03%	4.37%			
Unpaired t-test **# Non-Significant difference**						

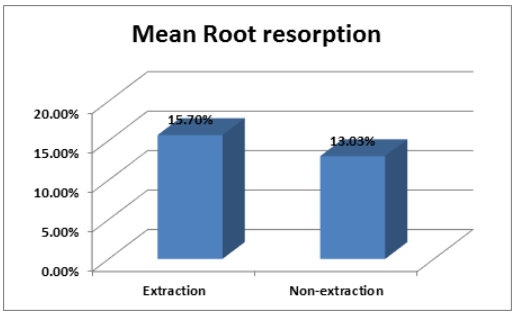

Figure 10 - Comparison of root resorption means of extraction and non-extraction group.

The mean Root resorption was compared between Extraction and Non-extraction groups using the **unpaired t-test**. The mean Root resorption was non-significant among Extraction and Non-extraction group.

Table 3: Pre and Post treatment means of parameters of extraction and non-extraction group.

	Extraction			Non Extraction		
Parameters	Mean	Std. Deviation	p-value	Mean	Std. Deviation	p-value
Is-Ra – PRE	27.10	1.70	< 0.001*	26.41	1.99	< 0.001*
Is-Ra – POST	24.86	2.16		24.51	1.54	
Ra1 – PRE	2.60	1.11	0.001*	2.50	0.47	0.001*
Ra1 – POST	3.58	2.03		2.95	0.62	
Ra4 – PRE	3.70	1.43	0.001*	3.48	0.63	0.01*
Ra4 – POST	4.36	1.39		3.94	0.66	
Is15 – PRE	8.85	1.76	0.327	8.72	1.39	0.815
Is15 – POST	8.64	1.82		8.65	1.88	
Ra – PRE	11.07	2.72	0.001*	11.96	3.21	0.288
Ra – POST	11.98	3.03		11.32	2.90	
Ra-LP – PRE	5.85	1.94	0.001*	4.97	1.79	0.01*
Ra-LP – POST	4.75	2.32		3.31	1.75	
Ra-PP – PRE	7.48	1.70	0.001*	8.51	3.83	0.001*
Ra-PP – POST	8.67	1.84		9.80	2.50	
PNS-Ra – PRE	46.97	5.46	0.646	46.50	6.74	0.01*
PNS-Ra – POST	46.66	4.61		48.85	4.33	
PNS-Is – PRE	58.10	6.81	0.001*	58.57	6.63	0.049
PNS-Is – POST	51.26	5.46		56.71	4.84	
NA-Is – PRE	8.50	3.57	< 0.001*	7.68	4.11	0.001*
NA-Is – POST	4.15	4.16		5.22	3.84	
PP-Ra – PRE	7.70	4.64	0.001*	6.64	7.84	0.03*
PP-Ra – POST	6.12	3.01		7.52	8.97	
PP-Is – PRE	30.03	3.57	0.674	28.93	4.24	0.303
PP-Is – POST	30.25	3.82		28.06	4.06	

ANB angle – PRE	4.75	2.44	0.144	4.00	3.31	0.619
ANB angle – POST	4.63	2.41		3.71	3.19	
Ia-NA angle – PRE	29.46	7.68	< 0.001*	27.55	8.07	0.001*
Ia-NA angle – POST	20.38	8.19		19.84	8.50	
Ia-SN angle – PRE	114.26	8.03	< 0.001*	108.82	8.26	0.001*
Ia-SN angle – POST	103.38	8.53		100.67	8.55	
Paired t-test *** Significant difference**						

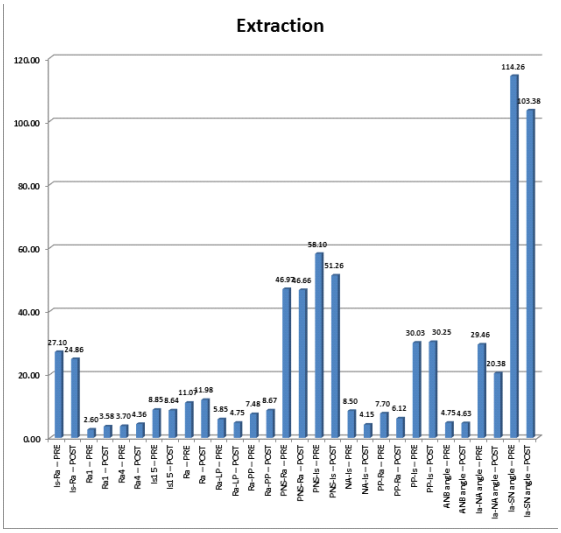

Figure 11 - Pre and Post treatment means of parameters of extraction group.

The mean Is Ra, Ra1, Ra4, Is15, Ra, Ra-LP, Ra-PP, PNS-Ra, PNS-Is, NA-Is, PP-Ra, PP-Is, ANB angle, Ia-NA angle and Ia-SN angle was compared pre and post treatment using the **paired t-test**. There was a significant decrease in mean Is Ra, Ra1, Ra4, Ra, Ra-LP, PNS-Is, NA-Is, PP-Ra, Ia-NA angle and Ia-SN angle from pretreatment to post treatment.

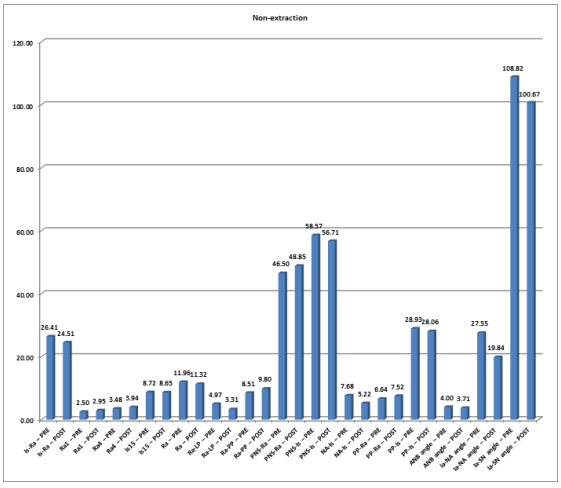

Figure 12 - Pre and Post treatment means of parameters of non-extraction group.

The mean Is Ra, Ra1, Ra4, Is15, Ra, Ra-LP, Ra-PP, PNS-Ra, PNS-Is, NA-Is, PP-Ra, PP-Is, ANB angle, Ia-NA angle and Ia-SN angle was compared pre and post treatment using the **paired t-test**. There was a significant decrease in mean Is Ra, Ra1, Ra4, Ra-LP, Ra-PP, PNS-Ra, NA-Is, PP-Ra, Ia-NA angle and Ia-SN angle from pre-treatment to post treatment.

DISCUSSION

In the present study, the mean root resorption of **15.70% and 13.03%** was observed in Group I and Group II, respectively. Considering an average root length of 13 mm (according to Wheeler RC: Dental anatomy, physiology and occlusion. Philadelphia, 1974, W. B. Saunders Co.), a mean resorption of **2.12 mm and 1.76 mm** was observed in group 1 and group 2 respectively. There was no significant difference observed between the extraction and non-extraction groups. This finding is in agreement with the reports of previous studies by Baumrind[13] and Mcfadden[16].

Baumrind[13] reported an average of 0.99 ± 0.34 mm root resorption in maxillary incisors during fixed orthodontic therapy when the Ra displacement approximated zero, and stated "jiggling" as the possible reason for this. He further reported that there is no differences in propensity for resorption was noted between patients who had been treated without extraction and those treated with extraction i.e 1.35 mm in extraction and 1.36 mm in non-extraction group. This finding is consistent with previous observations by McFadden et al[16] and VonderAhe.[17]

Tooth length - The results show proportionate increase in apical root resorption with increased Is–Ra in Group I i.e with increase in tooth length the root resorption increases. This finding was observed by Goldin,[18] Levander and Malmgren,[19] and Mirabella and Artun.[13] The latter stated that the amount of root movement and presence of long, narrow, and deviated roots increase the risk for apical root resorption and maxillary central incisors with longer root need higher force to be moved and torqued lingually. Weltman et al[21] indicated that movements that rotate the apex lingually are strongly correlated with root resorption.

Root width – root width is assessed from two points Ra1 (root width at 1 mm from root apex) and Ra4 (root width at 4 mm from root apex). There is an increase in root width at both Ra-1 and Ra-4 due to the shift of Ra in cervical direction or into a wider area of the root because of the apical root resorption. The mean change in root width at Ra1 and Ra4 is 0.98 and 0.66 respectively in extraction group and in non-extraction group the mean change in root width at Ra1 and Ra4 is 0.45 and 0.48 respectively.

The calculation of mean change in the root width at Ra-1 reveals lesser value in Group II than in Group I. This is due to simultaneous intrusion and retraction during extraction treatment so there is greater amount of apical root resorption in group I hence there is greater shift of Ra in cervical direction or into a wider area of root. This finding is supported by previous studies of Reiten[20], Mcfadden[16], Parker et al[15].

Alveolar width – In this study alveolar width is measured at two points Ra (alveolar width at root apex) and Is15 (alveolar width at a point 15 mm from incisal edge).

An increase of 0.91 mm and 0.65 mm in the alveolar width at point Ra in Group I and Group II subjects, respectively, was observed. As all the subjects in the study were non-growing, the alveolar width should not increase during treatment. The increase in the alveolar width in the present study is because of intrusion of incisors so that the root apex lies in the wider area of alveolus[9].

In the study by Horiuchi et al[22], it was found that narrowing of the maxillary alveolar bone width during orthodontic treatment contributes about 12% to the amount of root resorption; this suggests that patients with narrow maxillary alveolar bone width are more susceptible to root resorption.

Cortical plate proximity - In the present study, cortical plate proximity of the maxillary central incisor root was assessed using the parameters Ra–LP distance and Ra–PP distance. A significant decrease in Ra–LP distance was observed in Group I (1.10 mm) and in Group II (1.65 mm). However, no significant difference was observed in these two treatment modalities. This finding is in agreement with study of Goldin[18] and Kaley and Phillips[23].

Kaley and Phillips[23] concluded that the risk of clinically significant apical root resorption increased 20 times when the maxillary incisors were in close proximity to the lingual or labial cortical plate. Accordingly, the root resorption may be due to the amount of tooth movement rather than pressure from the cortical plate.

Tooth movement in different direction – In the present study, tooth movement in antero-posterior direction is assessed using the parameters Ra–PNS distance and Is–PNS distance and tooth movement in the vertical direction is assessed using parameters Ra-PP distance and Is- PP distance.

Is-PNS distance is reduced by 6.84 mm and 1.86 mm in group I and group II respectively. The reduction in the extraction group is greater as compare to non-extraction group, shows greater amount of retraction in extraction group.

PP-Ra distance is reduced by 1.58 mm and .88 mm in group I and group II respectively, indicates greater amount of intrusion in the extraction group as compare to non-extraction group.

Hence in this study, slightly greater apical root resorption value was observed due to the greater amount of intrusion and retraction of maxillary central incisor in extraction group. This finding is in agreement with the report of Kaley and Pillips[23], Parker et al[15].

Torquing movement - In the present study, torquing movement is assessed using the parameters Ia-NA angle and Ia-SN angle.

Ia-NA angle is reduced by 9.08 degree and 7.71 degree in group I and group II respectively and Ia-SN angle is reduced by 10.88 degree and 8.15 degree in group I and group II respectively.

This reduction in both Ia-NA angle and Ia-SN angle is because of labial root torquing of maxillary central incisors, leading to proximation of the roots with the labial cortical plate and apical root resorption. This finding is supported by Goldin[18] who observed a mean root resorption of 0.9 mm/year when labial root torque was incorporated and also by kaley and Phillips[23].

CONCLUSION

The following conclusions were drawn from the present study:

1. The choice of treatment modality for fixed orthodontic therapy, that is extraction versus non-extraction, does not have relevance with the amount of apical root resorption in maxillary central incisor. The amount of apical root resorption was slightly greater in extraction subjects than in non-extraction subjects. However, no statistically significant difference was reached between the two treatment modalities.
2. In both extraction and non-extraction subjects, labial cortical plate proximity has been found relevant with apical root resorption. In both subjects statistically significant relationship was present between labial cortical plate proximity and apical root resorption.
3. In extraction subjects, the apical root resorption was directly proportional to the length of maxillary central incisor and inversely proportional to the root width in apical one-third region, though there was a weak correlation.
4. In non-extraction subjects, the pre-treatment anteroposterior position of the Ra of maxillary central incisor in the alveolar bone, in combination with its root width in the apical one-third region formed the predictive factors for the variance in the amount of the apical root resorption, though there was a weak correlation.
5. The net changes in the alveolar widths at Ra and Is-15 were found as predictive factors for the amount of apical root resorption during extraction and non-extraction treatments respectively.

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