The effect of central incisor's root proximity to the cortical plate and apical root resorption in extraction and non-extraction treatment

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ABSTRACT

Aims: The present study was conducted to investigate the relevance of cortical plate proximity of maxillary central incisor root, maxillary alveolar bone width, and the apical root resorption in extraction and non-extraction orthodontically treated cases. Further, the correlation between the apical root resorption and the various parameters was investigated.

Materials and Methods: A total of 80 lateral head cephalographs, 40 pre-treatment and 40 post-treatment, of orthodontic subjects with a mean age of 15 years treated with fixed standard edgewise appliance were obtained. All subjects were divided into two groups as extraction and non-extraction cases. Twelve linear and three angular parameters were measured and evaluated. The paired "*t*"-test, Pearson's correlation coefficient, and the stepwise regression analysis were done to test the relationship between the apical root resorption and the various parameters.

Results and Conclusions: 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 in apical one-third region, though there was a weak correlation. In non-extraction subjects, the pre-treatment anteroposterior position of the root apex 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. Furthermore, the changes in the alveolar widths at the root apex and mid-root region were considered as predictive factors for the amount of apical root resorption during extraction and non-extraction treatment, respectively.

Key words: Apical root resorption, cortical plate proximity, maxillary alveolar bone width, maxillary central incisor

INTRODUCTION

External apical root resorption (EARR) is a well-recognized and widely accepted iatrogenic phenomenon associated with orthodontic treatment. Various other etiological factors include individual biologic characteristics, genetic predisposition, pathological, iatrogenic, and idiopathic causes.[1-3] Brezniak and Wasserstein[2-5] notified that all examined teeth after orthodontic treatment showed evidence of root resorption. Orthodontic treatment-related risk factors include the treatment duration, magnitude of applied force, direction of tooth movement, amount of apical displacement, and method of force application.[1] The maxillary incisors are the teeth most affected by root resorption, followed by the mandibular incisors and first molars.[1,6-8] EARR occurs in different degrees. Severe EARR is defined as a shortening that is more than 4 mm or one-third of the root length, and is observed in 1-5% of teeth.[1] In a recent

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Access this article online	
Quick Response Code:	Website: www.jorthodsci.org
	DOI: 10.4103/2278-0203.132917

study by Marques *et al.*, the incidence of severe EARR of the incisors after orthodontic treatment was found to be 14.5%.[9]

According to Handelman,[10] the anatomic limits set by the cortical plates of the alveolus at the level of the incisor apices may be treated as "orthodontic walls." It is imperative to consider these orthodontic walls as a danger zone for heightened probability of iatrogenic root loss. According to Ten Hoeve and Mulie,[11] if the objectives of treatment are beyond these anatomic limitations, then surgical intervention may be required.

It has been reported that contact or approximation of maxillary incisor roots with the lingual cortical plate may predispose to apical root resorption.[11,12] Horiuchi *et al.*[13] also concluded that maxillary central incisor apical root resorption is influenced by root proximation to the palatal cortical plate during orthodontic treatment.

No previous studies have been performed to find the relevance between the mode of fixed orthodontic therapy, that is, extraction versus non-extraction treatment, and the amount of apical root resorption in maxillary central incisors.

Hence, the aims of the present study were to evaluate the relevance of cortical plate proximity in maxillary incisor root resorption and to assess the effect of maxillary alveolar bone width on apical root resorption during extraction and non-extraction orthodontic treatment. Further, we aimed to investigate the correlation between the apical root resorption and various relevant parameters.

MATERIALS AND METHODS

Materials

The study was conducted on 40 pre-treatment and post-treatment lateral head cephalographs of subjects treated with fixed standard edgewise appliance (0.022 slot). The radiographs were obtained from the existing records at Department of Orthodontics, FODS, King George's Medical University, Lucknow, India. The radiographs (*N* = 40) were divided into Group I (*n* = 20) treated with first premolar extraction and Group II (*n* = 20) given non-extraction treatment.

Selection Criteria

1. Subjects were in the age (range) group of 12-18 years (with a mean age of 15 years) when the treatment was commenced. Treatment time range was 18-24 months (average mean 21 months).
2. All subjects had permanent dentition except the third molars.
3. There was no history of trauma to the maxillary central incisors as ascertained by patient history from case records.
4. All permanent maxillary central incisors were intact, caries-free, and without previous endodontic treatment.
5. None of the selected cases had any crowding or rotations in the anterior segment in upper/lower arch.
6. None of the subjects had undergone any kind of removable, semi-fixed, or functional therapy prior to or along with the fixed standard edgewise treatment. In standard edgewise treatment biomechanics, the torque was incorporated simultaneously during the anterior retraction.
7. The pre-treatment subjects were Angle's Class-I type 2 and Angle's Class-II Div-1 malocclusion.
8. All subjects finished the treatment with Angle's Class-I molar relationship and functionally and esthetically acceptable occlusions.
9. The average amount of anterior retraction in Group I (extraction) cases was 6-7 mm approximately.
10. Group II subjects were treated by dentoalveolar expansion or molar distalization or a combination of both. This involves the need for labial root torque also. The average amount of root apex (Ra) movement in Group II (non-extraction) cases was 2-4 mm approximately.
11. Subjects with congenital anomaly or craniofacial defect were excluded.

The division of the subjects on the basis of sex was not undertaken because of the contradictory results for sexual dimorphism reported in various studies.[6,14-16]

Methods

The pre- and post-treatment cephalographs were traced on acetate tracing sheets of 0.005 mm in thickness using a 0.3-mm-tip lead pencil (Staedtler, Marsmicro, Germany) on a view box using transilluminated light in a dark room.

In the pre-treatment radiograph, the most prominent permanent maxillary central incisor was used for the study purpose. The exact distance between two pin pricks marked at the Ra and incisal edge of the maxillary central incisor was measured by a digital sliding caliper (Baker, Type RD-10) calibrated to 0.01 mm, as done earlier by Copeland.[17]

The following parameters were used in the present study:
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) [Figure 1].

Dental landmarks: (1) Ra,[18] (2) incisor superious (Is), (3) Ra-1,[19] (4) Ra-4,[20] and (5) Is-15[19] [Figure 2].

Cephalometric planes and lines: (1) sella–nasion plane, (2) palatal plane, (3) NA line, (4) NB line, (5) incisor axis (IA),[13] and (6) PNS perpendicular[18] [Figure 3].

Linear parameters in anteroposterior plane: (1) Ra–LP (labial plate) distance,[10] (2) Ra- PP (palatal plate) distance,[10] (3a) root width at point Ra-1,[19] (3b) root width at point Ra-4,[20] (4a) alveolar width at point Ra,[13] (4b) alveolar width at point Is-15,[19] (5) Is to NA distance, that is, distance of incisal edge from the NA line measured parallel to the horizontal floor, (6) horizontal apical distance (Ra-HRZ),[18] and (7) horizontal incisal distance (Is-HRZ)[18] [Figure 4].

Linear parameters in vertical plane: (1) vertical apical distance (Ra-VRT),[18] (2) vertical incisal distance (Is-VRT),[18] and (3) Is–Ra distance[17,18,20] [Figure 5].

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.[13,20]

Angular parameters: (1) IA to NA angle,[21] (2) SN–IA angle,[14] and (3) ANB angle[21] [Figure 6] (SN: sella nasion plane, ANB: Angle formed between nasion-point-A line and nasion-point-B line).

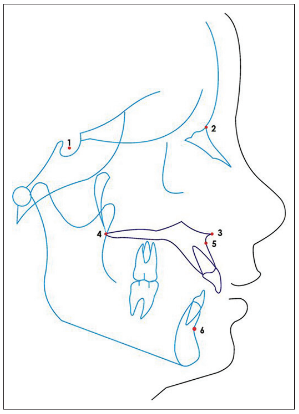

Figure 1: Skeletal landmarks: (1) Sella, (2) nasion, (3) Anterior nasal spine (ANS), (4) Posterior Nasal spine, (5) Point A, and (6) Point B

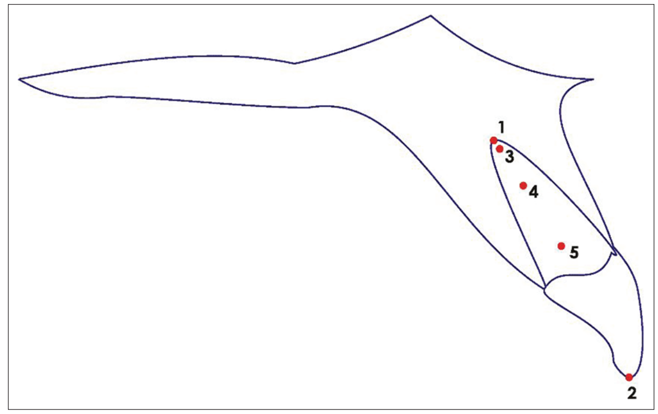

Figure 2: Dental landmarks: (1) Root apex, (2) Incisor edge, (3) Ra-1, (4) Ra-4, and (5) Is-15

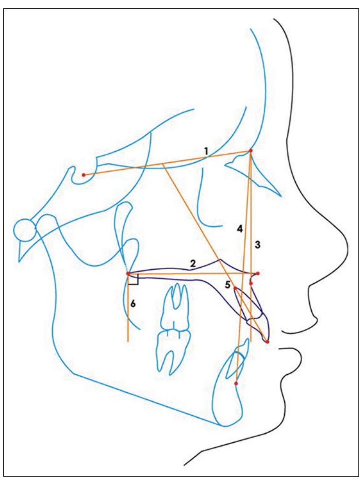

Figure 3: Cephalometric planes and lines: (1) Sella–nasion plane, (2) Palatal plane, (3) N–A line, (4) N–B line, (5) Incisor axis, (6) PNS perpendicular

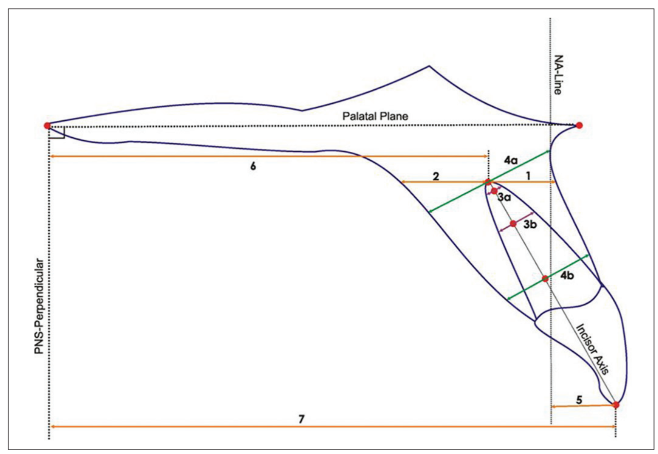

Figure 4: Linear parameters in anteroposterior plane: (1) Ra–LP distance, (2) Ra–PP distance, (3a) Root width at Ra-1, (3b) Root width at Ra-4, (4a) Alveolar width at Ra, (4b) Alveolar width at point 15 mm from Is, (5) Is–NA distance, (6) Ra-HRZ, and (7) Is-HRZ

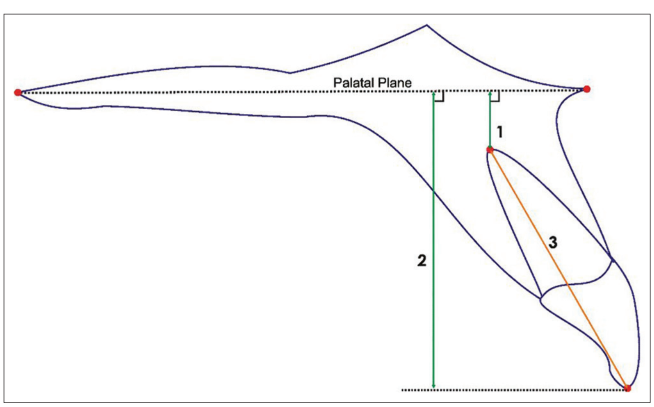

Figure 5: Linear parameters in vertical plane: (1) Ra-VRT, (2) Is-VRT, and (3) Is–Ra distance

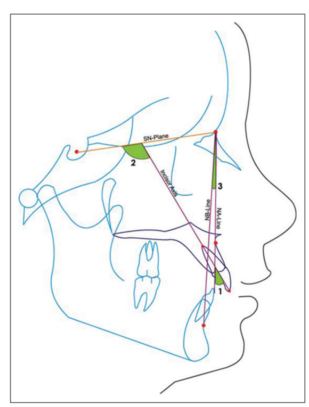

Figure 6: Angular parameters: (1) IA–NA angle, (2) SN-IA angle, and (3) ANB angle

Statistical Analysis

The pre-treatment, post-treatment means, standard deviation, mean changes, and levels of significance for the various parameters of Group I and Group II subjects were obtained, and compared by paired "*t*"-test [Tables 1-3]. The level of significance was set at 5%.

Pearson's correlation coefficient and stepwise regression analysis were done to test the correlation between the apical root resorption and the various parameters [Tables 4-6].

Measurement of Reliability

For testing the reliability of measurement, double determinations of 15 cephalograms randomly selected at 15 days interval from the collected sample were done by the same operator. The comparison was drawn between first and second determinations by Student's "*t*"-test. No

Table 1: Pre- and Post-treatment means, SD, mean changes, and level of significance of parameters of Group I

Parameters	Pre-treatment mean±SD	Post-treatment mean±SD	Mean change±SD	*t*	*P* value
Linear measurements (in mm)					
Ra–LP distance	5.9440±1.2072	4.6150±1.1510	−1.3290±1.5533	3.83	0.01**
Ra–PP distance	10.0435±3.5452	11.7250±4.9208	1.6815±4.1034	1.833	0.08
Root width					
At point Ra-1	1.9785±0.4028	2.7340±0.3455	0.7555±0.3931	8.60	0.001***
At point Ra-4	3.7970±0.4754	4.330±0.4373	0.5330±0.4474	5.52	0.001***
Alveolar width					
At point Ra	15.0345±3.2972	15.3610±4.4948	0.3265±4.7687	0.31	0.75
At point Is-15	9.0500±0.8052	8.7675±1.2340	−0.2825±1.5338	0.82	0.42
Is to NA distance	8.9740±2.8385	2.2970±2.6202	−6.6770±3.2022	9.33	0.001***
Ra-HRZ	40.0915±2.8502	41.1110±3.7126	1.0195±2.9277	1.56	0.14
Is-HRZ	53.9905±3.8509	46.2480±3.4818	−7.7425±4.2315	8.18	0.001***
Ra-VRT	4.0935±2.2294	4.1450±2.5413	0.0515±2.0293	0.11	0.91
Is-VRT	27.1670±2.5582	27.8285±2.5153	0.6615±1.7583	1.68	0.11
Is–Ra distance	27.0905±1.7852	24.5480±1.6832	−2.5425±1.1282	10.10	0.001***
Angular measurements (in degrees)					
IA to NA	32.5250±7.1589	15.9750±8.8815	−16.5500±11.0011	6.73	0.001***
SN to IA	114.975±6.71189	96.1750±7.6507	−18.80±10.30	8.16	0.001***
ANB	4.5000±2.2595	4.2250±2.4033	−0.2750±2.1973	0.56	0.58

P value: NS – Non-significant; *<0.05 significant; **<0.01 moderately significant; ***<0.001 highly significant; SD – Standard deviation

Table 2: Pre- and post-treatment means, SD, mean changes, and level of significance of various parameters of Group II

Parameters	Pre-treatment mean±SD	Post-treatment mean±SD	Mean change±SD	*t*	*P* value
Linear measurements (in mm)					
Ra–LP distance	6.4565±1.9335	4.9220±1.5562	−1.5345±1.7707	3.88	0.001***
Ra–PP distance	12.325±3.9824	14.3790±9.3466	2.0525±9.9052	0.93	0.40
Root width					
At point Ra-1	2.1420±0.5007	2.5615±0.2984	0.4195±0.5036	3.73	0.01**
At point Ra-4	3.8385±0.5986	4.3335±0.4997	0.4950±0.3965	5.58	0.001***
Alveolar width					
At point Ra	15.0885±2.7013	15.1940±2.3488	0.1055±3.2186	0.15	0.90
At point Is-15	9.1265±0.9233	8.5480±0.6959	−0.5785±0.7559	3.42	0.01**
Is to NA distance	7.2260±4.0563	3.8700±3.0123	−3.3560±4.2989	3.49	0.01**
Ra-HRZ	41.5365±3.9019	44.1180±2.1773	2.5815±3.3173	3.48	0.01**
Is-HRZ	53.9375±3.1685	52.5335±4.2745	−1.4040±4.1302	1.52	0.14
Ra-VRT	2.9355±3.0275	4.2880±2.5903	1.3525±1.5110	4.03	0.001***
Is-VRT	24.1805±5.8452	26.5100±3.2218	2.3295±6.1637	1.69	0.12
Is-Ra distance	26.0810±2.2243	23.9690±2.1145	−2.1120±0.8024	11.77	0.001***
Angular measurements (in degrees)					
IA to NA	29.8700±13.2075	19.7250±10.3992	−10.1450±13.6146	3.33	0.01**
SN to IA	111.5250±12.395	102.9750±9.8975	−8.5500±14.8350	2.58	0.05*
ANB	4.0500±2.0125	3.9000±1.848	−0.15±2.1343	0.33	0.88

P value: NS – Non-significant; *<0.05 significant; **<0.01 moderately significant; ***<0.001 highly significant;SD – Standard deviation significant differences were found between the two sets of data (*P* > 0.05) [Table 7].

Table 3: Comparison of mean change values, standard deviation, and level of significance of Group I and Group II

Parameters	Mean change±SD		*t*	*P* value
	Group I	Group II		
Linear measurements (in mm)				
Ra–LP distance	−1.3290±1.5533	−1.5345±1.7707	0.39	0.70
Ra–PP distance	1.6815±4.1034	2.0525±9.9052	0.15	0.88
Root width				
At point Ra-1	0.7555±0.3931	0.4195±0.5036	2.35	0.05*
At point Ra-4	0.5330±0.4474	0.4950±0.3965	0.28	0.78
Alveolar width				
At point Ra	0.3265±4.7687	0.1055±3.2186	0.17	0.86
At point Is-15	−0.2825±1.5338	−0.5785±0.7559	0.77	0.45
Is to NA distance	−6.6770±3.2022	−3.3560±4.2989	2.76	0.01**
Ra-HRZ	1.0195±2.9277	2.5815±3.3173	1.58	0.12
Is-HRZ	−7.7425±4.2315	−1.4040±4.1302	4.79	0.001***
Ra-VRT	0.0515±2.0293	1.3525±1.5110	2.30	0.05*
Is-VRT	0.6615±1.7583	2.3295±6.1637	1.16	0.25
Is–Ra distance	−2.5425±1.1282	−2.1120±0.8024	1.39	0.17
Angular measurements (in degrees)				
IA to NA	−16.5500±11.0011	−10.1450±13.6146	1.64	0.11
SN to IA	−18.8000±10.3000	−8.5500±14.8350	2.54	0.05*
ANB	−0.2750±2.1973	−0.1500±2.1343	0.18	0.86

P value: NS – Non-significant; *<0.05 significant; **<0.01 moderately significant; ***<0.001 highly significant; SD – Standard deviation

RESULTS

In the present study, mean root resorption of 2.54 ± 1.13 mm and 2.11 ± 0.80 mm was observed in Group I and Group II, respectively. There was no significant difference observed. The amount of apical root resorption was slightly greater in Group I than in Group II, with no statistically significant difference.

The mean value of root resorption per year was 2.03 mm in Group I and 1.69 mm in Group II.

DISCUSSION

The occurrence of root resorption during orthodontic treatment has been widely reported.[6,14,16] Various risk factors have been reported, such as the magnitude of force,[22] intrusion,[15,22,23] duration of active treatment,[14,15] cortical plate proximation,[12,13] the use of rectangular archwires and class II elastics,[16] apical root form,[18,20] overjet correction,[16] genetic predisposition,[6] etc., This study is an attempt to find the relevance between the mode of fixed orthodontic therapy, that is, extraction versus non-extraction treatment, and the amount of apical root resorption in maxillary central incisors.

In the present study, the mean root resorption of 2.54 ± 1.13 mm and 2.11 ± 0.80 mm was observed in Group I and Group II, 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.[14,15]

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 Group I when compared to

Table 4: The correlation of apical root resorption with the linear and angular parameters of Group I and Group II

	Apical root resorption					
	Group I pre-treatment values	Group I post-treatment values	Group I mean change values	Group II pre-treatment values	Group II post-treatment values	Group II mean change values
Apical root resorption	1.00	1.00	1.00	1.00	1.00	1.00
Ra–LP distance	0.061	−0.29	0.27	0.26	−0.19	0.41
Ra–PP distance	−0.302	−0.45*	0.33	0.05	0.10	−0.07
Root width: (a) At point Ra-1	−0.27	−0.02	−0.31	−0.37	0.25	−0.56**
(b) At point Ra-4	−0.44*	0.18	−0.67***	−0.31	0.1	−0.61**
Alveolar width (a) At point Ra	0.001	−0.51*	0.48*	−0.28	−0.17	−0.041
(b) At point Is-15	−0.12	−0.44*	0.28	−0.15	−0.24	−0.58**
Is to NA distance	0.39	0.33	0.08	0.22	0.08	0.24
Ra-HRZ	−0.002	−0.07	0.09	−0.34	−0.14	−0.24
Is-HRZ	0.14	0.06	0.07	−0.11	−0.31	0.19
Ra-VRT	−0.14	0.24	−0.46*	−0.19	−0.17	0.02
Is-VRT	−0.05	0.03	−0.10	−0.12	−0.10	0.11
Is-Ra distance	0.44*	−0.24	-	0.31	−0.05	-
IA to NA	0.38	0.13	0.17	0.13	0.22	0.25
SN to IA	0.33	0.30	−0.01	0.11	−0.31	0.25
ANB	−0.36	−0.11	−0.32	−0.18	0.08	0.01

*r>0.44, P<0.05 significant; **r>0.55, P<0.01 moderately significant; ***r>0.67, P<0.001 highly significant; Apical root resorption has been used with a positive sign for the purpose of correlation

Table 5: Stepwise regression analysis in Group I with the amount of apical root resorption as the dependent variable and other parameters as independent variables

Regression equation	F	*P*	R^2
Pre-treatment value			
Step 1			
Apical root resorption=(1.0542) root width at Ra-4 – 6.5454	4.42	0.04*	0.20
Step 2			
Apical root resorption=(1.1312) root width at Ra-4	6.287	0.02*	0.39
+(−0.2775) Is–Ra distance	5.334	0.03*	
Post-treatment value			
Step 1			
Apical root resorption=(0.1269) alveolar width at Ra + (−4.4914)	6.176	0.02*	0.26
Net change			
Step 1			
Apical root resorption=(−1.6453) root width at Ra-4+(1.6656)	13.34	0.0018**	0.43
Step 2			
Apical root resorption=(−1.5122) root width at Ra-4	14.10	0.0017**	0.58
+(0.0944) Alveolar width at Ra	6.33	0.022*	
Step 3			
Apical root resorption=(−1.3451) root width at Ra-4	14.10	0.0017**	0.69
+(0.1167) alveolar width at Ra	11.58	0.0036**	

P value: NS – Non-significant; *<0.05 significant; **<0.01 moderately significant; ***<0.001 highly significant

Group II [Table 3]. This finding is in agreement with the report of Mohandesan *et al.*[24]

Taithongchai and Sookkorn[19] and Dermaut and De Munck[23] observed mean root resorption of 2.04 mm and 2.5 mm, respectively, on maxillary central incisor. Taithongchai and Sookkorn[19] randomly selected the cases treated by fixed appliance, that is, standard edgewise/Tweed edgewise/Begg/straight wire. Dermaut and De Munck[23] mainly evaluated the effect of intrusion. They found that the relation between root lengths before and after treatment indicates a mean root resorption of 18%. 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 2.5 mm was found in their study.

Baumrind[14] 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. Further, Horiuchi *et al.*[13] mentioned in their study that the overall frequency of maxillary central incisor root resorption of less than 1.0 mm was approximately 9%, and for more than 3 mm, it was 22%.

The findings in Group I were consistent with the results of the studies carried out by Dermaut[23] and McFadden and Engström[15] that have shown intrusion could be the most

Table 6: Stepwise regression analysis in Group II with the amount of apical root resorption as the dependent variable and other parameters as independent variables

Regression equation	*F*	*P* value	R^2
Pre-treatment value			
Step 1			
Apical root resorption=(0.1068) Ra-HRZ+(−6.7370)	4.73	0.04*	0.21
Step 2			
Apical root resorption=(0.8774) root width at Ra-4	9.049	0.0079**	0.48
+(0.1261) Ra-HRZ	9.307	0.0072**	
Post-treatment value			
Step 1			
Apical root resorption=(0.1578) Ra-HRZ+(−9.0768)	11.147	0.00036***	0.38
Net change			
Step 1			
Apical root resorption=(−1.4274) root width at Ra-4+(−1.3474)	10.38	0.0047**	0.37
Step 2			
Apical root resorption=(−1.2432) root width at Ra-4	11.570	0.0034**	
+(−0.5242) Alveolar width at Is-15	10.140	0.0052**	0.60
Step 3			
Apical root resorption=(−1.4241) root width at Ra-4	15.63	0.0014**	
+(−0.4296) Alveolar width at Is-15	6.82	0.019*	0.67
+(0.0189) Is to NA distance	3.07	0.09	
Step 4			
Apical root resorption=(−1.4147) root width at Ra-4	21.942	0.0002***	
+(−0.4471) Alveolar width at Is-15	10.484	0.0055**	0.78
+(0.0356) Is to NA distance	7.77	0.014*	
+(0.2302) Is-VRT	10.75	0.0051**	

P value: NS – Non-significant; *<0.05 significant; **<0.01 moderately significant; ***<0.001 highly significant

detrimental movement for the roots involved. Intrusive forces together with lingual root torque and jiggling movement remain the most influential forces in causing EARR.[1,18,25,26]

The correction of space discrepancy in Group II was achieved by dentoalveolar expansion, molar distalization, or a combination of both. The correction of the inclination of the maxillary central incisor was done by labial root torque leading to proximation of the roots with the labial cortical plate. This finding is supported by Goldin[16] who observed a mean root resorption of 0.9 mm/year when labial root torque was incorporated.

The results show proportionate increase in apical root resorption with increased Is–Ra in Group I. This finding was observed by Goldin,[16] Levander and Malmgren,[25] and Mirabella and Artun.[20] The latter stated that the maxillary central incisors with longer root need higher force to be moved and torqued lingually. Further, Reitan[22] mentioned that these torqueing forces concentrated at the apex and may cause root resorption. Weltman *et al.*[1] indicated that movements

Table 7: Comparison of cephalometric variables at two different time intervals

Parameters	Pre-treatment mean±SD at time T1	Pre-treatment mean±SD at time T2	*t*	*P*	Significance
Linear measurements (in mm)					
Ra–LP distance	5.84±1.15	5.82±1.11	0.03	0.98	NS
Ra–PP distance	10.14±2.82	10.16±2.80	0.02	0.98	NS
Root width					
At point Ra-1	1.87±0.40	1.83±0.32	0.25	0.80	NS
At point Ra-4	3.80±0.30	3.82±0.25	0.65	0.52	NS
Alveolar width					
At point Ra	15.03±3.20	15.10±3.40	0.05	0.96	NS
At point Is-15	9.05±0.80	9.10±0.82	0.14	0.90	NS
Is to NA distance	8.90±2.83	8.95±2.80	0.03	0.98	NS
Ra-HRZ	40.11±2.85	40.15±2.86	0.03	0.98	NS
Is-HRZ	53.99±3.85	53.90±3.82	0.05	0.96	NS
Ra-VRT	4.10±1.12	4.12±1.15	0.04	0.97	NS
Is-VRT	27.16±2.62	27.20±2.60	0.03	0.98	NS
Is–Ra distance	27.10±1.18	27.20±1.20	0.19	0.85	NS
Angular measurements (in degrees)					
IA to NA	32.52±6.12	32.50±0.14	0.07	0.95	NS
SN to IA	114.80±5.12	114.70±5.13	0.04	0.97	NS
ANB	4.54±2.12	4.52±2.40	0.01	0.99	NS

'*P*' value : (NS = Non-significant; *<0.05 Significant; **<0.01 Moderately significant; ***<0.001 Highly significant

that rotate the apex lingually are strongly correlated with root resorption.

The post-treatment results of the present study show an obvious 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.

In the present study, the average root resorption was 2.11 mm. Hence, the post-treatment Ra-1 would lie apical to pre-treatment Ra-4 and post-treatment 'Ra-4' would lie incisal to pre-treatment 'Ra-4', on superimposition of the crown of central incisor. The apical portion from the Ra up to pre-treatment Ra-4 was considered as "apical one-third" of the root.

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, retraction, and lingual root torque during extraction treatment. This finding is supported by previous studies[15,18,22,23] [Table 3].

The average crown length and root length for the maxillary central incisor is 10.5 mm and 13 mm, respectively, and the point Is-15 lies at a distance of 15 mm from the incisal edge of the maxillary central incisor; so, this indicates that the point Is-15 lies approximately in mid-portion of the root.

An increase of 0.33 ± 4.77 mm and 0.11 ± 3.22 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 did not increase during treatment. The larger increase in Group I as compared to Group II subjects justifies the higher intrusive movement in maxillary central incisor.

On the contrary, a decrease of 0.28 ± 1.53 mm and 0.57 ± 0.76 mm in alveolar width at Is-15 in Group I and Group II subjects, respectively, was observed because of the remodeling changes in the alveolar bone in the mid-root region of maxillary central incisor. This finding is in agreement with Edwards'[27] result.

Ten Hoeve and Mulie[11] and Goldson[7] reported that contact of maxillary incisors with the lingual cortical plate may predispose to root resorption. 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 (−1.33 ± 1.55 mm) and in Group II (−1.53 ± 1.77 mm). However, no significant difference was observed in these two treatment modalities.

Correlation (Extraction Subjects)

The pre-treatment Is–Ra distance was observed to be positively correlated ($r > 0.44$) with the apical root resorption. This shows that the tendency for apical root resorption increases with increasing length of the maxillary central incisor, though there is a weak correlation.

The pre-treatment root width at Ra-4 was found to be negatively correlated ($r > -0.44$) with the apical root resorption. Thus, the tendency of apical root resorption decreases with the increasing width of the root at Ra-4, though there is a weak correlation. The above findings were in line with Mirabella and Artun's[20] results.

A positive correlation ($r > 0.48$) was observed between increase in the net change value of alveolar width at point Ra and the apical root resorption. This is because of more intrusion, so that Ra lies in the wider area of the alveolar bone nearer to the palatal plane and the effect of growth is better perceived. This same observation was reported by Iseri and Solow.[28] They reported in their study that the point A or subspinale, on average, shows about 4.5 mm downward and about 0.5 mm forward appositional relocation from 8 to 25 years of age.

Correlation (Non-Extraction Subjects)

None of the pre-treatment and post-treatment values were found to be correlated to the apical root resorption.

In the net change values, the root widths at Ra-1 ($r > -0.56$) and Ra-4 ($r > -0.61$) were observed to be negatively correlated with the apical root resorption. This shows that the tendency of apical root resorption decreases with the increasing width of the root at Ra-1 and Ra-4. This finding coincides with Mirabella and Artun's[20] study.

A negative correlation ($r > -0.58$) between the mean change value of alveolar width at Is-15 and the apical root resorption showed a greater tendency for resorption when there was less decrease in the alveolar width at Is-15 during non-extraction treatment. This finding is in agreement with the results obtained by Dermaut[23] and Mc Fadden and Engstrom.[15]

The findings of the present study are justified by various reports. However, due to the multifactorial etiology of apical root resorption and the complexity of root movement during orthodontic treatment, further studies are needed with more refined scientific study aids to investigate the prospects of apical root resorption that are still unknown.

CONCLUSIONS

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 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.
3. 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.
4. 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.
5. In non-extraction treatment, none of the post-treatment values were found to be correlated to the apical root resorption.

ACKNOWLEDGMENT

The author gratefully thanks his parents for their blessings and selfless support.

REFERENCES

1. Weltman B, Vig KW, Fields HW, Shanker S, Kaizer EE. Root resorption associated with orthodontic tooth movement: A systematic review. Am J Orthod Dentofacial Orthop 2010;137:462-76.
2. Brezniak N, Wasserstein A. Orthodontically induced inflammatory root resorption. Part I: Basic science aspect. Angle Orthod 2002;72:175-9.
3. Al-Qawasmi RA, Hartsfield JK, Evrett ET, Flury L, Liu L, Foroud TM, *et al*. Genetic predisposition to external apical root resorption. Am J Orthod Dentofacial Orthop 2003;123:242-52.
4. Brezniak N, Wasserstein A. Root resorption after orthodontic treatment: Part 1. Literature review. Am J Orthod Dentofacial Orthop 1993;103:62-6.
5. Brezniak N, Wasserstein A. Root resorption after orthodontic treatment: Part 2. Literature review. Am J Orthod Dentofacial Orthop 1993;103:138-46.
6. Newman WG. Possible etiologic factors in external root resorption. Am J Orthod 1975;67:522-39.
7. Goldson L, Henrikson CO. Root resorption during Begg treatment. A longitudinal roentgenologic study. Am J Orthod 1975;68:55-66.
8. Singh SP, Utreja A. Apical root resorption in permanent incisor teeth following orthodontic treatment- A radiographic study. J Indian Orthod Soc 2005;38:198-205.
9. Marques LS, Ramos-Jorge ML, Rey AC, Armond MC, Oliveira Ruellas AC. Severe root resorption in orthodontic patients treated with the edgewise method: Prevalence and predictive factors. Am J Orthod Dentofacial Orthop 2010;137:384-8.
10. Handelman CS. The anterior alveolus: Its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. Angle Orthod 1996;66:95-110.
11. Ten Hoeve A, Mulie MR. The effect of anteroposterior incisor repositioning on the palatal cortex as studied with laminography. J Clin Orthod 1976;10:804-22.
12. Kaley J, Phillips C. Factors related to root resorption in edgewise practice. Angle Orthod 1991;61:125-32.
13. Horiuchi A, Hotokezaka H, Kobayashi K. Correlation between cortical plate proximity and apical root resorption. Am J Orthod Dentofacial Orthop 1998;114:311-8.
14. Baumrind S, Korn EL, Boyd RL. Apical root resorption in orthodontically treated adults. Am J Orthod Dentofac Orthop 1996;110:311-20.
15. McFadden WM, Engström C, Engström H, Anholm JM. A study of the relationship between incisor intrusion and root shortening. Am J Orthod Dentofacial Orthop 1989;96:390-6.
16. Goldin B. Labial root torque: Effect on the maxilla and incisor root apex. Am J Orthod Dentofacial Orthop 1989;95:209-19.
17. Copeland S, Green LJ. Root resorption in maxillary central incisors, following active orthodontic treatment. Am J Orthod Dentofacial Orthop 1986;89:51-5.
18. Parker RJ, Harris EF. Directions of orthodontic tooth movements associated with apical root resorption of the maxillary central incisor. Am J Orthod Dentofacial Orthop 1998;114:677-83.
19. Taithongchai R, Sookorn K, Killany DM. Facial and dentoalveolar structures and the prediction of apical root shortening. Am J Orthod Dentofacial Orthop 1996;110:296-302.
20. Mirabella AD, Artun J. Risk factors for apical root resorption of maxillary anterior teeth in adult orthodontic patients. Am J Orthod Dentofacial Orthop 1995;108:48-55.
21. Steiner CC. Cephalometrics for U and me. Am J Orthod Dentofacial Orthop 1953;39:729-55.
22. Reitan K. Initial tissue behavior during apical root resorption. Angle Orthod 1974;44:68-82.
23. Dermaut LR, De Munck A. Apical root resorption of upper incisors caused by intrusive tooth movement: A radiographic study. Am J Orthod Dentofacial Orthop 1986;90:321-6.
24. Mohandesan H, Ravanmehr H, Valaei N. A radiographic analysis of external apical root resorption of maxillary incisors during active orthodontic treatment. Eur J Orthod 2007;29:134-9.
25. Han G, Huang S, Von den Hoff JW, Zeng X, Kuijpers- Jagtman AM.

Root resorption after orthodontic intrusion and extrusion: An intraindividual study. Angle Orthod 2005;75:912-8.
26. Costopoulos G, Nanda R. An evaluation of root resorption incident to orthodontic intrusion. Am J Orthod Dentofacial Orthop 1996; 109:543-8.
27. Edwards JG. A study of the anterior portion of the palate as it relates to orthodontic therapy. Am J Orthod Dentofacial Orthop 1976;69: 249-73.
28. Iseri H, Solow B. Average surface remodeling of the maxillary base and the orbital floor in female subjects from 8 to 25 years. An implant study. Am J Orthod Dentofacial Orthop 1995;107:48-57.

How to cite this article: Agarwal A, Sharma VP, Singh GK, Tikku T, Agarwal N, Mengi A. The effect of central incisor's root proximity to the cortical plate and apical root resorption in extraction and non-extraction treatment. J Orthodont Sci 2014;3:46-54.

Source of Support: Nil, **Conflict of Interest:** None declared.