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Radiographic Evaluation of External Apical Root Resorption After Orthodontic Treatment: A Study of Contributing Factors

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ABSTRACT

Background: The most common risk factors of orthodontic treatment is apical root resorption. It is hence the purpose of this study to examine the risk factors contributing to orthodontically induced external apical root resorption (OIEARR) by evaluating and comparing different conventional radiographic images.

Materials and methods: The sample consisted of fifty-four retrospective pre- and post- orthodontic treatment radiographs, including panoramic, lateral cephalometric, and periapical radiographs (PA). The age range of the subjects was between 13-30 years old with a mean age of 19 ± 4 years. The sample was distributed demographically into 36 females and 18 males with 14 extraction and 40 non-extraction cases. In addition, the sample was divided into three different groups based on their anteroposterior skeletal configurations (19 patients of Class I, 19 patients of Class II, and 16 patients of Class III). Root length and anteroposterior skeletal configurations were assessed by using digital software. Data were analysed by using Kurskal-Wallis, and Mann-Whitney tests.

Results: Age and gender were not of significance concerning OIEARR. On the other hand, skeletal classification (p=0.02), treatment duration (p=0.00), and the presence of extractions (p=0.02) were of statistical significance. Maxillary central incisors were the most type of teeth effected by OIEARR when measured in the three different radiographs. In addition, a PA radiographs showed that the teeth in extraction cases are at increased risk of root resorption during orthodontic treatment than non-extraction cases with a mean value of 1.13 mm of root resorption.

Conclusion: Risk factors contributing to OIEARR were found to be limited to the skeletal configuration, duration of treatment, and the presence of extractions. Moreover, it is essential to note that some types of teeth are more prone to OIEARR, which are usually the maxillary central incisors. The diagnosis of root resorption can be highlighted from the Panoramic and cephalometric radiographs, the characteristics of which must be observed with a PA radiographs.

Key words: Apical root resorption, Contributing factors, Orthodontic treatment, Radiographic evaluation

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INTRODUCTION

Orthodontic treatment is a double-edged sword. On the upside, it provides the patient with enhanced esthetic and function. On the downside, excessive force, and improper handling, as well as lack of adequate knowledge by an unexperienced physician, might constitute detrimental and unintended effects to the patient. One of the most common iatrogenic consequences of orthodontic treatment is external apical root resorption (EARR) caused by orthodontic excessive forces, which is irreversible and harmful to the patient if forces exceeded the cementum reparative capacity and reaches the dentin.

A review of the literature on orthodontically induced external apical root resorption (OIEARR) shows a continuing debate among researchers regarding the prevalence and range of root resorption occurrence during orthodontic treatment; with some arguing for as low a range as 4% and others as high as 98% occurrence [1,2]. This difference in root resorption prevalence and occurrence varies according to the different evaluation methods and techniques used, whether in relation to number of patients or to the number of teeth [2,3]. Moreover, 1-5% of severe EARR in the anterior teeth can reach 4 mm or exceeds one-third of the root length with higher percentage reaching 14.5% [4]. The majority of previous studies discussed that maxillary central incisors were most effected by root resorption following orthodontic treatment due to its morphological root shape, which is either tapered or blunted, as well as orthodontic mechanics with specific directions of tooth movements; such as lingual root torque and intrusion [5,6]. The relationship between orthodontic treatment and EARR is studied by many researchers who found that the age and gender have no significant relation [3,5,6]. In addition, other studies found that root-canal-treated teeth were not at an increased risk of root resorption during orthodontic treatment [7]. On the other hand, duration of treatment, type of fixed appliances used, the amount of force applied, treatment with extractions, expansion, and amount of apical root movement have shown a significant association with OIEARR and considered as risk factors. Additional etiological factors that can contribute to EARR are individual variations, genetics, and root anatomical shape [1,5-11].

Evaluation of root resorption can be performed through 3D images such as cone-beam computed tomography (CBCT), or 2D images such as periapical (PA), panoramic and lateral cephalometric radiographs. Many researchers favored and used 2D images since PA, panoramic and cephalometric radiographs are routinely used for orthodontic records and hence their availability for retrospective analysis. Also, the use of 2D images has the advantages of no additional cost or radiation exposure. It has been found that PA radiographs are better in reassessing root resorption than panoramics and cephalometrics; for the latter have more image distortion and overlapping structures. Therefore, the panoramic and cephalometric radiographs could overestimate the amount of root resorption following orthodontic movement. Even though CBCT has a higher radiation dose and more expensive than the conventional radiographs, it has been proved to be superior for diagnosing and measuring EARR due to its higher accuracy and better visualization of specific tissue [2,4-6,8,10-13].

The association between orthodontic treatment and EARR had been studied immensely, but to this time, the contributing factors of EARR are not clearly understood. The purpose of this study is to retrospectively examine the risk factors contributing to OIEARR by evaluating and comparing panoramic, cephalometric, and periapical radiographs in different anteroposterior skeletal discrepancies with extraction and non-extraction cases on a sample of Saudi patients. Furthermore, the study will evaluate the validity of each radiographic technique in assessing the root length changes.

MATERIAL AND METHODS

This cross-sectional observational study was approved by the Institutional Review Board (IRB), King Saud University [E-17-2626], and the College of Dentistry Research Center (CDRC), King Saud University, Riyadh, Saudi Arabia [IR 0242]. The sample of the present study consisted of 98 retrospective and randomly selected pre- and post- orthodontic treatment radiographs including panoramic, lateral cephalometric, and PA radiographs. Out of which, only 54 panoramic and lateral cephalometric radiographs were selected and only 10 cases with a complete set of PA radiographs were found and included based on the following inclusion criteria:

The pre- and post-treatment radiographs should be of high quality.

There should be no systematic illness or craniofacial abnormalities.

There should be no evidence or history of trauma and with complete apical root formation.

There should have been no pathological lesions, or resorption before orthodontic treatment.

There should be no root canal treated teeth, prosthetic crown or cosmetically reshaped teeth with increased incisal edges or cusps.

All radiographs utilized in the present study were digitized and derived from a single source with a fixed distance between the subject and the source of the x- ray of 6 feet, and the same exposure being made by one machine.

The present study was conducted in Riyadh city at the orthodontic dental clinics of King Saud University. The selected radiographs are for patients who were previously treated by fixed orthodontic appliances (0.022-inch standard brackets, straight wire technique). The average treatment time was ranging from 6 to 24 months. The age range of the subjects were between 13-30 years old with a mean age of 19 ± 4 years. The sample was categorized demographically into 36 females and 18 males with 14 extraction and 40 non-extraction cases. In addition, the sample was divided into three different groups based on their anteroposterior skeletal configurations using cephalometric radiographs (19 patients of Class I, 19 patients of Class II, and 16 patients of Class III). Cephalometric analysis was done digitally through dolphin Imaging 11.7 software (Chatsworth, CA, USA), registered by the College of Dentistry, King Saud University, to determine the anteroposterior jaw relationship by two cephalometric parameters; ANB angle and Wits Appraisal analysis (Figure 1) [14,15].

Furthermore, a standardized root length measuring technique for all maxillary and mandibular anterior teeth as well as premolars was performed by using a modified Levander and Malmgren [16] EARR scoring system, with index scores from 0-4, to compare the length of roots in pre and post-orthodontic treatment radiographs through Romexis digital imaging radiograph viewer (PM 2002CC, Planmeca, Helsinki, Finland) for panoramic, cephalometric, and PA radiographs. A mathematical formulation [17] was used to measure the EARR and to overcome magnification error as follow:

Correction Factor (CF)=C1/C2, Where C1=Crown length pre-treatment, C2=Crown length post-treatment.

The apical root resorption per tooth in millimetres was calculated using the following formula:

Apical root resorption (ARR)=R1 – (R2-CF), where R1=Root length pre-treatment, R2=Root length post-treatment.

Age, gender, treatment duration, presence or absence of extraction, and the anteroposterior skeletal classification were considered as dependent variables in the present study.

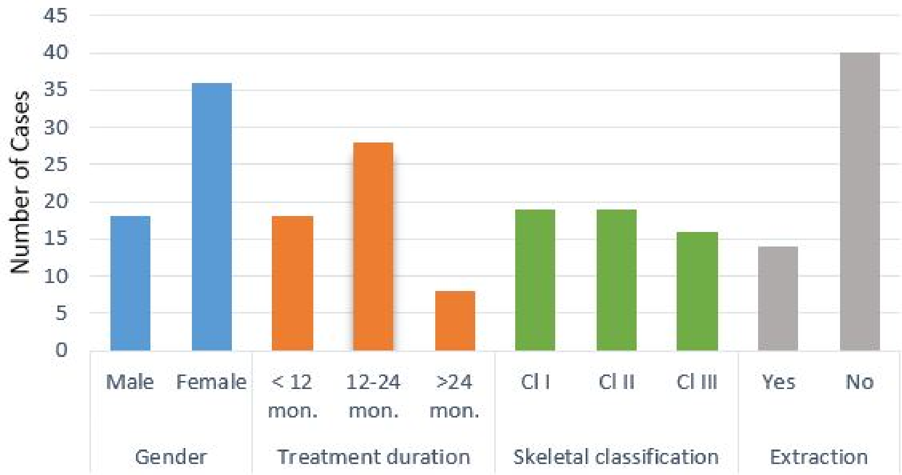

Figure 1: Sample distribution of the demographic data.

Statistical analysis

All data were analyzed using the Statistical Package for Social Sciences version 22 (SPSS Inc., Chicago, IL, USA). Dahlberg ' s double determination method error, correlation coefficient, and the student's t-test were used to determine the intra-examiner reliability of readings when they were performed by the same examiner 3 weeks later on 20 randomly selected radiographs, and also to determine the inter-examiner reliability, when the ranking levels of the EARR of the same 20 radiographs were re-assessed by the other investigator within the same week. The inter-examiner and intra-examiner correlations showed significant reliability and minimum method errors of all readings as demonstrated by high coefficient values ranging from 0.97 to 0.99 ($p<0.001$).

Descriptive statistics were performed among various studied groups. Nonparametric Kurskal Wallis, and Mann Whitney tests were used to correlate the EARR with different studied variables. In addition, the validity of each radiographic technique in assessing the root length changes was established. In all statistical assessments performed, the level of significance was recognized at 95% level of confidence ($p<0.05$) to indicate the statistical significance between the studied variables.

RESULTS

As stated above, the sample of the present study consisted of 98 retrospectives pre- and post- orthodontic treatment radiographs including panoramic, lateral cephalometric, and PA radiographs. Out of this sample, only 54 panoramic and lateral cephalometric radiographs were selected, and only 10 cases with PA radiographs were found and hence selected. A total of 44 radiographs were excluded from the study because they did not meet the inclusion criteria. The degree and percentage of resorption observed in PA radiographs were presented in Figure 2.

It is clear from the results that out of one hundred twenty teeth that were assessed using PA radiographs, only 47 teeth (39.2%) showed shortening of root length at different grades, with the highest frequency of resorption affecting the maxillary central incisors 11(55%) with a mean value of resorption 2.07 ± 2.83 mm (Table 1).

Root length measured in OPG showed resorption in 39% of the sample (211 teeth), where 80 teeth (38%) showed grade 1 resorption, 75 teeth (35.5%) showed grade 2 resorption, and the reminder 56 teeth (26.5%) showed grade 3 resorption. The teeth that have shown the highest amount of resorption were the maxillary central incisors with a mean of 2.02 ± 1.25 mm as shown in Table 1. Evaluation of root length using the cephalometric radiographs showed the highest mean of resorption in the maxillary incisors of skeletal Class II patients with a mean value of resorption 1.13 ± 1.4 mm (Table 2).

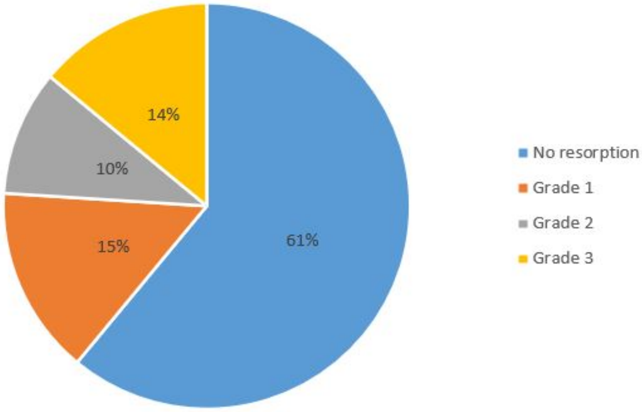

Figure 2: Degree and frequency of resorption observed in PA radiographs by using a modified Levander and Malmgren ERR scale and compare the length of roots in pre- and post-orthodontic treatment radiographs.

Table 1: Degree and mean values of external root resorption per a tooth as observed in panoramic and PA radiographs.

		**Resorption grade No. (%)				***Mean±	Total
*Tooth	Radiographs	Grade 0	Grade 1	Grade 2	Grade 3	SD	
Upper central incisor	Panoramic	30 (55.6%)	4 (7.4%)	9 (16.7%)	11(20.4%)	2.02 ±1.25	Panoramic 54, PA 20
	PA	9 (45%)	1 (5%)	4 (20%)	6 (30%)	2.07±2.83	
Upper lateral incisor	Panoramic	26 (48.1%)	13(24.1%)	12(22.2%)	3 (5.6%)	1.85±0.96	
	PA	14 (70%)	3 (15%)	1 (5%)	2 (10%)	0.43±0.96	
Upper canine	Panoramic	30 (55.6%)	9 (16.7%)	8 (14.3%)	7 (13%)	1.85±1.11	
	PA	13 (65%)	4 (20%)	1 (5%)	2 (10%)	0.39±0.78	
Lower central incisor	Panoramic	26 (48.1%)	8 (14.3%)	15(27.8%)	5 (9.3%)	1.98±1.07	
	PA	11 (55%)	2 (10%)	3 (15%)	4 (20%)	0.99±1.55	
Lower lateral incisor	Panoramic	39 (72.2%)	7 (13%)	4 (7.4%)	4 (7.4%)	1.50±0.93	
	PA	13 (65%)	5 (25%)	0	2 (10%)	0.88±2.27	
Lower canine	Panoramic	36 (66.7%)	5 (9.3%)	8 (14.3%)	5 (9.3%)	1.67±1.05	
	PA	13 (65%)	3 (15%)	3 (15%)	1 (5%)	0.47±0.77	
Upper 1st premolar	Panoramic	32 (59.3%)	7 (13%)	4 (7.4%)	11(20.4%)	1.89±1.22	
Upper 2nd premolar	Panoramic	39 (72.2%)	9(16.7%)	5 (9.3%)	1 (1.9%)	1.40±0.74	
Lower 1st premolar	Panoramic	39 (72.2%)	8 (14.3%)	3 (5.6%)	4 (7.4%)	1.48±0.91	
Lower 2nd premolar	Panoramic	32 (59.3%)	10(18.5%)	7 (13%)	5 (9.3%)	1.72±1.02	
Total	Panoramic	329(61%)	80 (38%)	75 (35.5%)	56 (26.5%)		
	PA	73 (61%)	18 (15%)	12 (10%)	17 (14%)		
Overall total	Panoramic				540		
	PA	120					

*Tooth: Tooth type in the panoramic radiographs, based on average of right and left side.

**No: Number of teeth based on EARR scale; Grade1: 0.1-0.9 mm; Grade 2: 1-2mm; Grade 3: > 2mm.

***Mean amount of EARR in millimeters.

Table 2: Mean and standard deviation values of the resorption as observed in cephalometric radiographs for each skeletal configuration.

	Skeletal Classification		
Teeth	Class I	Class II	Class III

	No.	* Mean ± SD	No.	* Mean ± SD	No.	* Mean ± SD
Upper anterior	19	0.91 ± 1.18	19	1.13 ± 1.4	16	0.81 ± 1.04
Lower anterior	19	0.8 ± 0.93	19	0.51 ± 0.63	16	0.96 ± 0.84
*Mean amount of EARR in millimeters.						

Mann–Whitney non-parametric test compared the three radiographic methods in relation to gender and the presence of teeth extraction as contributing factors to OIEARR. The results demonstrate that no significant relations with the EARR among three radiographic modalities. Only statistically significant relation was found between the degree of EARR observed in PA radiographs and the presence of extractions (P=0.02, P ≤ 0.05) (Table 3). In terms of studying the relation of the amount of root resorption to the skeletal classification, Kruskal-Wallis non-parametric test for OPG radiographs at the 0.05 level demonstrated a statistical significant correlation between Class II patients and the degree of EARR of the maxillary central incisors with a mean of 1.10 ± 1.23 mm (P=0.02, P ≤ 0.05). Furthermore, the results showed significant correlation between Class I patients and the degree of EARR of the mandibular central incisors with a mean of 1.05 ± 0.77 mm (P=0.04, P ≤ 0.05) (Table 4). The results of the Kruskal-Wallis test studying the relation of amount of EARR to the orthodontic treatment duration in cephalometric radiographs showed that there was a significant correlation between the treatment duration and the EARR affecting the maxillary central incisors (p=0.027, P ≤ 0.05). The treated cases that lasted less than a year and more than two years were more likely to have a highest means of resorption (1.021 and 2.34 2.1, respectively) (Table 5). Moreover, PA radiographs demonstrated a high degree of EARR among the maxillary central incisors (p 0.05, P ≤ 0.05) with a mean value of resorption 1.90 mm for the treated cases that lasted more than two years (Table 5).

Table 3: Mann–Whitney non-parametric test and level of significance results for PA radiographs in relation of the degree of EARR to the presence or absence of extraction.

Extraction v/s non-extraction	*No.	**Mean ± SD	Mean Rank	***Sig. (p-value)
Non-extraction case	72	0.70±1.78	53.43	
Extraction case	48	1.13±1.78	71.1	0.02
* No: the number for PA radiographs which based on a total of 10 patients (120 teeth).				
** Mean= mean amount of EARR in millimeters.				
*** Sig = approximate significance, where P-value at 0.05 level.				

Table 4: Kruskal-Wallis non-parametric test for Panoramic radiographs in relation of the degree of EARR to skeletal classification.

Tooth	Skeletal Classification	*Mean ± SD	Range	Mean Rank	**Sig. (p-value)
	Class I	0.31±0.57	1.78	22.42	
	Class II	1.10±1.23	4.04	34.55	
Upper central incisor	Class III	0.50±0.84	2.16	25.16	0.026
	Class I	0.74±0.99	3.16	30.08	
	Class II	0.49±0.68	2.24	26.16	
Upper lateral incisor	Class III	0.511±0.69	1.98	26.03	0.642
	Class I	1.27±1.50	4.52	31.32	
	Class II	0.69±1.02	2.79	26.08	
Upper canine	Class III	0.68±1.14	2.84	24.66	0.338
	Class I	0.98±1.23	3.07	30.5	
	Class II	0.73±2.34	10.19	21.97	
Upper 1st premolar	Class III	1.71±3.19	11.81	30.5	0.102
	Class I	0.19±0.37	1.22	26.68	
Upper 2nd premolar	Class II	0.88±1.91	8.12	32.11	0.091

	Class III	0.08±0.25	0.98	23	
Lower 2nd premolar	Class I	0.55±1.07	4.18	28.97	0.806
	Class II	0.93±2.60	11	26.03	
	Class III	0.48±0.77	1.99	27.5	
Lower 1st premolar	Class I	0.43±0.68	2.53	31	0.297
	Class II	0.81±2.37	9.89	26.21	
	Class III	0.24±0.75	2.94	24.88	
Lower canine	Class I	0.44±0.75	1.9	28.05	0.727
	Class II	1.22±2.57	10.3	28.74	
	Class III	0.37±0.78	2.68	25.38	
Lower lateral incisor	Class I	0.28±0.72	2.87	25.84	0.444
	Class II	0.92±2.05	7.54	30.42	
	Class III	0.16±0.52	2.07	26	
Lower central incisor	Class I	1.05±0.77	2.3	34.08	0.046
	Class II	0.74±1.25	4.25	25.34	
	Class III	0.40±0.66	2.07	22.25	

*Mean=Mean amount of EARR in millimeters.

** Sig =Approximate significance, where P-value at 0.05 level.

Table 5: Kruskal-Wallis non-parametric test for Cephalometric & PA radiographs in relation of the degree of EARR to treatment duration.

Radiographs	Tooth	*Treatment Duration	**No.	***Mean ± SD	Mean Rank	****Sig. (p-value)
Cephalometric	Upper central incisor	<12 mon	18	1.02±1.01	29.92	0.027
		12-24 mon	28	0.53±0.59	22.71	
		>24 mon	8	2.34±2.10	38.81	
	Lower central incisor	<12 mon	18	0.56±0.80	23.14	0.24
		12-24 mon	28	0.84±0.88	28.48	
		>24 mon	8	0.84±0.62	33.88	
PA	Upper canine	<12 mon	6	0.44±0.74	11.67	0.18
		12-24 mon	6	0.84±1.16	12.67	
		>24 mon	8	0.03±0.08	8	
	Upper lateral Incisor	<12 mon	6	0.94±1.52	11.5	0.33
		12-24 mon	6	0.48±0.80	12.08	
		>24 mon	8	0.02±0.06	8.56	
	Upper central incisor	<12 mon	6	0.32±0.50	10	0.05
		12-24 mon	6	0.12±1.08	14.5	
		>24 mon	8	1.90±0.28	7.88	
	Lower canine	<12 mon	6	0.42±3.68	9.67	0.17
		12-24 mon	6	0.23±2.60	15	
		>24 mon	8	0.95±0.80	7.75	
	Lower lateral incisor	<12 mon	6	1.57±3.06	13.67	0.1
		12-24 mon	6	1.35±2.88	10.83	

	>24 mon	8	0.02±0.05	7.88	
Lower central incisor	<12 mon	6	0.75±1.14	10.5	
	12-24 mon	6	1.99±2.32	12.5	
	>24 mon	8	0.42±0.71	9	0.49

*Treatment duration: Divided in to three categories; < 12months, 12- 24months, and >24 months.

** No.: The number for PA radiographs which based on a total of 10 patients (120 teeth), and for cephalometric based on average of right and left side.

*** Mean=Mean amount of EARR in millimeters.

**** Sig =Approximate significance, where P-value at 0.05 level.

Furthermore, Kruskal-Wallis non-parametric test was conducted to evaluate the validity and compare three radiographic methods (panoramic, PA, and Cephalometric radiographs) in assessing the amount of EARR among maxillary and mandibular incisors and in examining the risk factors contributing to OIEARR. The results showed that there were no statistically significant differences among the three methods. However, it is essential to note that the mean of the apical resorption rate in PA and panoramic radiographs were almost the same for the maxillary incisors. On the other hand, PA and Cephalometric radiographs yielded approximately the same mean value for the mandibular incisors, (Table 6).

Table 6: Kruskal-Wallis non-parametric test comparing the effectiveness of different radiographic methods (panoramic, cepahometric, and PA) in the assessment of the EARR.

Tooth	Radiographs	*Mean ± SD	Mean Rank	**Sig. (P-value)
Maxillary incisors	PA	0.40 ± 1.07	9.29	
	panoramic	0.45 ± 0.85	10.5	
	Ceph	0.90 ± 1.45	13.21	0.35
Mandibular incisors	PA	0.62 ± 1.08	10.86	
	panoramic	0.12 ± 0.20	8.14	
	Ceph	0.67 ± 0.52	14	0.16

* Mean=Mean amount of EARR in millimeters.

** Sig=Approximate significance, where P-value at 0.05 level.

DISCUSSION

Apical root resorption is a common iatrogenic effect resulting from orthodontic treatment [18]. This cross-sectional observational study was carried out to assess the validity of different radiographic methods to determine the risk factors contributing to OIEARR. In this study, the anteroposterior jaw relationship was determined by the two commonly used cephalometric parameters; ANB angle and Wits Appraisal analysis to avoid errors associated with discrepancies of the position of the cranial base within the skull. The assessment of the degree of root resorption for all maxillary and mandibular anterior teeth, as well as premolars in this study, was performed by using the modified Levander and Malmgren EARR scale [16]. This scale is relatively simple and widely applicable to evaluate and compare the root length before and after treatment from different radiographs and eliminating any subjectivity concerns that could arise when assessing the radiographs visually [16,19]. In the present study, it was found that 76% of all teeth showed no resorption or mild EARR. A similar finding has been reported by other researches [6,20]. On the other hand, 10% and 14% of severe resorption was observed in PA and panoramic radiographs, respectively. This finding agrees with the results of Marques et al. [4], who found high percentages of severe resorption (14.5%). In contrast, several studies reported low number of teeth with severe EARR that range between 1-5% [6,20,21]. Such inconsistency can be attributed to multiple factors including differences in sample size, ethnic background, and/or subjectivity of the utilized methods and techniques. Consistent with the results of other researches [6,18,22,23], the present study found that age and gender did not relate to the presence of OIEARR. However, in other studies, age has been shown to have significant impact on the occurrence of EARR, and adult male patients are more likely to have EARR than female patients [16,24,25]. Orthodontic treatment with extraction has been reported in this study as significant for EARR, which is in consistent with the systematic review conducted by Vlasa et al. [1], as well as other studies [5-9,25,26]. This finding could be attributed to the fact that orthodontic treatment involving teeth extraction requires increased movement, retraction of the incisor's apex to close extraction spaces, and hence increased treatment duration. Another factor, such as treatment duration, was significantly correlated with the presence of EARR in this study. This was consistent with previous findings in the literatures [1,5-9,26], and in contrast to other studies that concluded there was no correlation between treatment duration and the amount of EARR [17,19,20]. In this study, treatment duration was of significance when assessing EARR affecting the maxillary central incisors in cephalometric radiographs in the cases where the treatment periods lasted less than a year and longer than two years. In addition, PA radiographs demonstrated a high degree of EARR among only the maxillary central incisors (p 0.05, $P \leq 0.05$) with a mean value of resorption 1.90 mm for the treated cases lasted more than two years. These findings could be attributed to the treatment force as it is more likely for a clinician to increase the force to reduce the treatment time. Moreover, unnecessary prolongation of the treatment period could contribute to increased cumulative forces that would eventually lead to EARR. Thus, a balance between force and duration would provide the safest route of treatment.

Most studies have found an association between skeletal classification and the presence of EARR [1,5-9,25]. It was found in this study that teeth with Class II tendency are more likely to develop EARR, which is consistent with the finding in the study conducted by Taner et al. [17]. In the present study, the maxillary central incisors in Class II cases were mostly affected with EARR; this could be due to the retraction forces of the maxillary incisors to reduce overjet and close the extraction spaces during fixed appliance treatment. In addition, Class I patients were also found to have a significant relation with EARR in the mandibular central incisors. Several studies supported this finding and showed significant relation between orthodontic treatment and the amount of resorption of mandibular central incisors [9,10]. Another study by Lopatiene and dumbravaite [27] reported similar association and correlate a high risk of EARR with narrow and short, rooted teeth as the mandibular central incisors. Maxillary incisors have been found as the most vulnerable teeth to EARR. This finding was consistent with the conclusion of several studies [3-6,9,26], and it could be explained and supported by the fact that these teeth are more subjected to many orthodontic movements than others such as intrusion, retraction, as well as lingual root torque to reduce overjet and to close extraction spaces

The present study examined the validity of different radiographic methods to assess the changes of root length resulting from orthodontic treatment. This study found that there were no significant differences between these three radiographic methods in the assessment of the EARR. However, it is essential to note that the mean of the apical resorption rate in PA and panoramic radiographs were almost the same for the maxillary incisors. On the other hand, PA and Cephalometric radiographs yielded approximately the same mean value for the mandibular incisors. This finding could be explained by the superimposition of the intervertebral spaces and artifacts due to the pronounced depression of the mental region found in panoramics [28]. The results of this study suggest that the diagnosis of apical root resorption can be highlighted using the Panoramic and cephalometric radiographs, the characteristics of which must be observed with the PA radiographs. By enabling the clinician to evaluate the amount of OIEARR directly from routinely obtained lateral cephalograms, panoramics, and PA, the patient will be guarded against additional needless cost and radiation associated with CBCT, even though, the CBCT has been found superior for diagnosing and measuring EARR [29].

Limitations of the study include small sample size, especially for PA radiographs that were not completed for some of the retrospectively selected cases. In addition, not all the risk factors contributing to OIEARR were covered in this study. Therefore, further studies are required to increase the sample size with a complete radiographic record including PA, cephalometric and panoramic radiographs pre- and post-orthodontic treatment. Other factors that increase the risk of OIEARR need to be investigated such as genetics, Root shape and proximity to the cortical bone, dental trauma prior to orthodontic treatment, as well as orthodontic mechanics and magnitude of force for stronger evidence-based approach and better understanding of OIEARR. Moreover, future studies that use CBCT data can diagnose, analyze and measure EARR.

CONCLUSION

In conclusion, risk factors contributing to OIEARR in this study were found to be limited to the skeletal configuration, prolonged treatment duration, and orthodontic treatment with extraction. Moreover, it is essential to note that some types of teeth are more prone to OIEARR, which are usually the maxillary central incisors. The diagnosis of root resorption can be highlighted from the Panoramic and cephalometric radiographs, the characteristics of which must be observed with a PA radiographs. This finding could assist orthodontists in making clinical decisions regarding the choice of radiographs needed for diagnosing EARR as it could aid the clinician to provide the best functional and esthetic outcome with the lowest risks possible.

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