

Prevalence of external apical root resorption among orthodontic patients: a Cross-sectional study

Michael Francis

University of Nevada, Las Vegas

Tanya Al Talib

University of Nevada, Las Vegas

Neamat Hassan Abubakr

neamat.hassan@unlv.edu

University of Nevada, Las Vegas

Research Article

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Abstract

Objectives

With the increased demand for orthodontic treatments in adults, external apical root resorption (EARR) has always been a complication during orthodontic treatment. The present study aimed to investigate the presence of external apical root resorption (EARR) among orthodontics patients attending dental clinics at the School of Dental Medicine, University of Nevada, Las Vegas.

Methods

A retrospective keywords search of the clinical notes of UNLV School of Dental Medicine (SDM) patient charts in axiUm™ was performed using the search terms “orthodontics”, “root resorption”, and “external apical root resorption” to identify the number of orthodontic cases that clinically presented with EARR using the Levander & Malmgren ranking of the EARR levels. The inclusion criteria encompassed patients with previous orthodontic treatment, non-extraction cases, no congenital abnormalities, and no preexisting documented root resorption or endodontic treatment prior to the study. The patient population's inclusion criteria encompassed records of individuals who were ≥ 12 years.

Results

148 patients presented with EARR, the Hispanic population had the most significant incidence of EARR (50%). Among all EARR cases, 59% were under the age of 18 yrs, followed by the age group 18–24 years (22%). Females comprised 60.8%, with males accounting for 39.2% of total cases. Most cases had a grade 2 EARR (64.2%) ranking as moderate resorption, while only 6.1% had a grade 4 EARR (Extreme resorption).

Conclusion

Within the limitations of the present investigation, the presence of EARR was dominant among young adult Hispanic females. Upper and lower anterior teeth exhibited more EARR with level 2, indicating moderate resorption.

Introduction

The demand for orthodontic treatment has increased markedly, largely owing to heightened patient motivation and greater dental health awareness, particularly among adults. As more patients are treated with fixed orthodontic appliances, the associated risks—such as caries, periodontal complications, and root resorption—become increasingly relevant. One such complication is external apical root resorption (EARR), a condition arising from the pathological or physiological activity of resorptive cells, which leads to loss of the root apex and consequent shortening or deformation of the root (Alqerban et al. 2009).

EARR is a multifactorial and complex phenomenon, exhibiting variable severity among different patients and even among different teeth within the same individual. It is considered an undesirable outcome of orthodontic tooth movement. Several studies have found that much of the root resorption occurs during the first 6–9 months of treatment (Levander and Malmgren 1988). In fixed-appliance orthodontics, EARR is often viewed as an iatrogenic consequence. Numerous risk factors have been implicated, including malocclusion type, patient age, root morphology, dental anomalies, duration of treatment, and prior trauma (Weltman et al. 2010; Segal et al. 2004; Shahrure and Acar 2022; Nanekrungsan et al. 2012; Picanco et al. 2013).

A positive association has been noted between higher orthodontic force levels and increased root resorption (Roscoe et al. 2015; Dawood et al. 2023). Orthodontic tooth movement itself has been estimated to account for one-tenth to one-third of the total variance in EARR (Roscoe et al. 2015). Significant reduction in root length can adversely affect the dentition, particularly when accompanied by alveolar bone loss (Roscoe et al. 2015).

Genetic predisposition also plays a critical role in EARR susceptibility. Twin and association studies suggest that genetic factors account for a portion of the observed variation in post-orthodontic root resorption (Sharab et al. 2015; Pinheiro et al. 2021; Baghaei et al. 2023; Nieto-Nieto et al. 2017). A growing body of literature addresses the incidence, etiology, and management of EARR across diverse populations. The present study aims to evaluate the prevalence and characteristics of EARR among orthodontic patients treated at the UNLV School of Dental Medicine.

Materials and Methods

In the present cross-sectional study, clinical notes from patients at the University of Nevada, Las Vegas (UNLV) dental clinics were analyzed using AxiUm™ software. A search was conducted using the following keywords “orthodontics”, “root resorption”, and “external apical root resorption” to identify the number of orthodontic documented patients at SDM, UNLV. The inclusion criteria encompassed patients who had previous orthodontic treatment, non-extracted cases, no congenital abnormalities, no preexisting documented root resorption or endodontic treatment prior to the study. Figure 1, shows the demographics of the collected data. The MiPACS (Medical Imaging Picture Archiving and Communication System) is a comprehensive digital imaging system fully integrated with the axiUm™ dental software, and it was used for all examined radiographic.

Figure 1: Descriptive data collection flowchart

MiPACS is the primary imaging module for capturing, viewing, and managing dental radiographs such as intraoral radiographs, cephalometric, and panoramic images. MiPACS enhances clinical diagnostics with advanced image enhancement tools, including zoom, contrast adjustment, annotations, and measurement tools. The amount of EARR was evaluated using the Levander & Malmgren ranking of the EARR levels [figure 2] (Levander and Malmgren 1988). The ranking was as follows:

Grade 0:Absence of root resorption;

Grade 1:Mild resorption, root with its normal length, and only an irregular contour;

Grade 2:Moderate resorption, small area of root loss with the apex exhibiting an almost straight contour;

Grade 3: Accentuated resorption, loss of almost one third of root length; and

Grade 4: Extreme resorption, loss of more than one third of the root length

Figure 2: Levander & Malmgren EARR ranking levels [2]

The Chi-square tests and One-Way ANOVA were used to analyses the results. The association between EAR grades and ethnicity cross tabulation was assessed using Pearson chi- squared test (SPSS version 28).

Results

148 patients of Orthodontic patients of the SDM UNLV presented with EARR. Among all EARR cases, females comprised 60.8%, with males accounting for 39.2% of total cases. Results showed that Hispanics had the most significant incidence of EARR (50%) followed by mixed ethnicity (27%) while both Asian and African American had the least EARR (Figure 3).

Figure 3: EARR distribution according to ethnicity

Among all EARR cases, 59% occurred in individuals under the age of 18, followed by 22% in the 18–24 age group, 14% in the 25–34 age group, and 3% in the 35–44 age group. Patients aged 45 years and older accounted for less than 3% of EARR cases. The majority of cases were classified as Grade 2 EARR, while only 6.1% were categorized as Grade 4 EARR (Table 1). Sample cases of different grades of EARR are show in figure 4.

Analysis using one-way ANOVA demonstrated a significant difference in the mean age among cases with different EARR grades. Cases with Grade 1 EARR exhibited the highest mean age, followed by Grades 2, 4, and 3, respectively (Table 1).

Grade	N (%)	Mean Age (Years)	± SD	P value
Grade 1	20 (13.5%)	25.50	13.983	0.019*
Grade 2	95 (64.2%)	19.35	8.896	
Grade 3	24 (16.2%)	17.54	4.709	
Grade 4	9 (6.1%)	17.56	4.096	

**p < 0.05; Significant*

Table 1: EARR ranking level distributions

Figure 4: Cases with different EARR grades.

The Chi-Square test was employed to assess the distribution of various EARR grades across ethnicity, gender, and dental arch. The analysis revealed that the distribution of EARR grades differed significantly among ethnic groups. In contrast, no statistically significant differences were observed in the distribution of EARR grades concerning gender or dental arch (Table 2).

		Grade 1	Grade 2	Grade 3	Grade 4	P value
		N (%)	N (%)	N (%)	N (%)	
Ethnicity	African American	2 (66.7%)	1 (33.3%)	-	-	0.037*
	Asian	-	2 (66.7%)	-	1 (33.3%)	
	Caucasian	6 (22.2%)	16 (59.3%)	4 (14.8%)	1 (3.7%)	
	Hispanic	3 (4.1%)	52 (70.3%)	14 (18.9%)	5 (6.8%)	
	Mixed	9 (22.0%)	24 (58.5%)	6 (14.6%)	2 (4.9%)	
Gender	Female	13 (14.4%)	55 (61.1%)	17 (18.9%)	5 (5.6%)	0.659; NS
	Male	7 (12.1%)	40 (69.0%)	7 (12.1%)	4 (6.9%)	
Arch	L	8 (19.5%)	23 (56.1%)	6 (14.6%)	4 (9.8%)	0.055; NS
	U	5 (23.8%)	16 (76.2%)	-	-	
	U/L	7 (8.1%)	56 (65.1%)	18 (20.9%)	5 (5.8%)	

Chi-Square Test: NS: $p > 0.05$; Not significant; $*p < 0.05$; Significant

Table 2: Distribution of different EARR grades among ethnicity, gender and arch

Pairwise comparisons of EARR grades among ethnic groups using the Chi-Square test indicated that statistically significant differences were present specifically between African American and Hispanic, Caucasian and Hispanic, and Hispanic and Mixed ethnicities (Table 3).

Ethnicity	Grade 1 N (%)	Grade 2 N (%)	Grade 3 N (%)	Grade 4 N (%)	P value
African American Vs	2 (66.7%)	1 (33.3%)	-	-	0.189; NS
Asian	-	2 (66.7%)	-	1 (33.3%)	
African American Vs	2 (66.7%)	1 (33.3%)	-	-	0.411; NS
Caucasian	6 (22.2%)	16 (59.3%)	4 (14.8%)	1 (3.7%)	
African American Vs	2 (66.7%)	1 (33.3%)	-	-	<0.001**
Hispanic	3 (4.1%)	52 (70.3%)	14 (18.9%)	5 (6.8%)	
African American Vs	2 (66.7%)	1 (33.3%)	-	-	0.371; NS
Mixed	9 (22.0%)	24 (58.5%)	6 (14.6%)	2 (4.9%)	
Asian Vs	-	2 (66.7%)	-	1 (33.3%)	0.196; NS
Caucasian	6 (22.2%)	16 (59.3%)	4 (14.8%)	1 (3.7%)	
Asian Vs	-	2 (66.7%)	-	1(33.3%)	0.347; NS
Hispanic	3	52 (70.3%)	14 (18.9%)	5 (6.8%)	
Asian Vs	-	2 (66.7%)	-	1(33.3%)	0.217; NS
Mixed	9 (22.0%)	24 (58.5%)	6 (14.6%)	2 (4.9%)	
Caucasian Vs	6 (22.2%)	16 (59.3%)	4 (14.8%)	1 (3.7%)	0.042*
Hispanic	3	52 (70.3%)	14 (18.9%)	5 (6.8%)	
Caucasian Vs	6 (22.2%)	16 (59.3%)	4 (14.8%)	1 (3.7%)	0.997; NS
Mixed	9	24 (58.5%)	6 (14.6%)	2 (4.9%)	
Hispanic Vs	3	52 (70.3%)	14 (18.9%)	5 (6.8%)	0.028*
Mixed	9 (22.0%)	24 (58.5%)	6 (14.6%)		

*Chi-Square Test: NS: $p > 0.05$; Not significant; * $p < 0.05$; Significant; ** $p < 0.001$; Highly significant*

Table 3: Pair wise comparison of EARR grade among different ethnicities

Discussion

EARR remains a complex and clinically relevant complication of orthodontic treatment. Because root resorption may result in root shortening and compromise tooth stability, it is crucial that clinicians understand both its prevalence and contributing risk factors. In the current cross-sectional study, we assessed the prevalence and distribution of EARR in orthodontic patients at the UNLV School of Dental

Medicine (SDM). Our findings provide insight into demographic, ethnic, and age-related patterns of EARR in this patient population.

In our sample, EARR prevalence was higher in females (60.8%) than in males (39.2%). This aligns with suggestions that hormonal influences and sex-related differences in bone metabolism may affect EARR risk. However, literature findings are mixed. Some studies reported no significant correlation between sex and EARR (Harris et al. 1997; Sameshima and Sinclair 2001), whereas others found greater root resorption among females (Levander et al. 1998; Kjaer 1995; Guo et al. 2016; Jiang et al. 2003). Conversely, some reports indicated males might be at higher risk (Guo et al. 2016). Our findings support studies reporting higher incidence in females (Levander and Malmgren 1988; Heboyan et al. 2018; Bayir and Gumus 2021).

Genetic factors also heavily influence bone mass, with certain chromosomal loci strongly associated with bone mineral density (BMD) (Hou et al. 2020). Because alveolar bone integrity is pivotal during orthodontic loading, differences in BMD may modulate susceptibility to EARR. Ethnic variation in BMD, partly driven by genetic and metabolic differences such as vitamin D metabolism, has been documented in Hispanic populations and may partly explain our observation of increased EARR prevalence among Hispanic patients (Hou et al. 2020; Wu and Dai 2023; Durdin et al. 2022). In our study, Hispanic patients exhibited the highest rate of EARR (50%), followed by individuals of mixed ethnicity (27%), with Asian and African American patients showing the lowest rates. Statistically significant differences in EARR grades were found between African American and Hispanic, Caucasian and Hispanic, and Hispanic and Mixed groups. These results suggest that genetic predisposition, cultural oral health behaviors, and disparities in orthodontic care access may influence EARR susceptibility across ethnic groups.

Recent narrative reviews have identified several candidate gene polymorphisms associated with EARR, highlighting the potential for future pre-treatment risk profiling (Kalra et al. 2020). Previous investigations also found greater susceptibility to resorption among Hispanic groups compared to Asians (Sameshima and Sinclair 2001), consistent with our findings of a significant association between EARR and Hispanic ethnicity. Most EARR cases in our sample were classified as Grade 2, representing moderate resorption, whereas only 6.1% were Grade 4 (severe). One-way ANOVA revealed significant differences in mean patient age across EARR grades. Patients with Grade 1 EARR had the highest mean age, which might reflect shorter treatment duration, less forceful treatments, or a reduced biological response. Conversely, Grades 3 and 4 were associated with younger patients, potentially reflecting greater biological susceptibility to resorption under orthodontic forces.

The significant ethnic disparities and age-related trends observed underscore the importance of personalized orthodontic planning that accounts for risk factors such as ethnicity, age, and sex. Early diagnosis and close monitoring of root resorption are particularly critical in younger patients and those from higher-risk ethnic backgrounds, such as Hispanics. Genetic polymorphisms may, in the future, serve as predictive biomarkers to identify individuals at elevated risk of severe EARR (Liu et al. 2024).

A limitation of our study was the use of periapical and panoramic radiographs. Panoramic imaging may underestimate root resorption compared to three-dimensional modalities such as cone-beam computed tomography (CBCT) (Ren et al. 2013). However, some researchers suggest that well-taken panoramic films can be as diagnostic as periapical series while providing a better cost-benefit ratio (Bayir and Gumus 2021; Apajalahti and Peltola 2007; Pandis et al. 2008). Future longitudinal studies with larger and more diverse populations are needed to explore the underlying biological and genetic mechanisms driving these disparities. Such research will aid clinicians in developing strategies to minimize the risk of EARR during orthodontic care.

Conclusion

Within the limitations of the present investigation, the presence of EARR was dominant among young adult female Hispanics. The grade of the EARR was level 2 which indicate the presence of moderate resorption, small area of root loss with the apex exhibiting an almost straight contour.

Declarations

Ethics Approval and Consent to Participate:

As no additional radiographs or examinations were performed specifically for this study, and all collected data were analyzed and presented anonymously, the study was granted exempt status by the Institutional Review Board (IRB) of the University of Nevada, Las Vegas (#UNLV-1464468-3).

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Author Contribution

MF, TA, NHA conceived the study and edited the manuscript; NHA wrote the manuscript; MF collected all the data; MF, TA, NHA contributed to interpreting results; TA, NHA contributed to methodology, validation, , project administration and revision of manuscripts. All Authors reviewed the manuscript.

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Figures

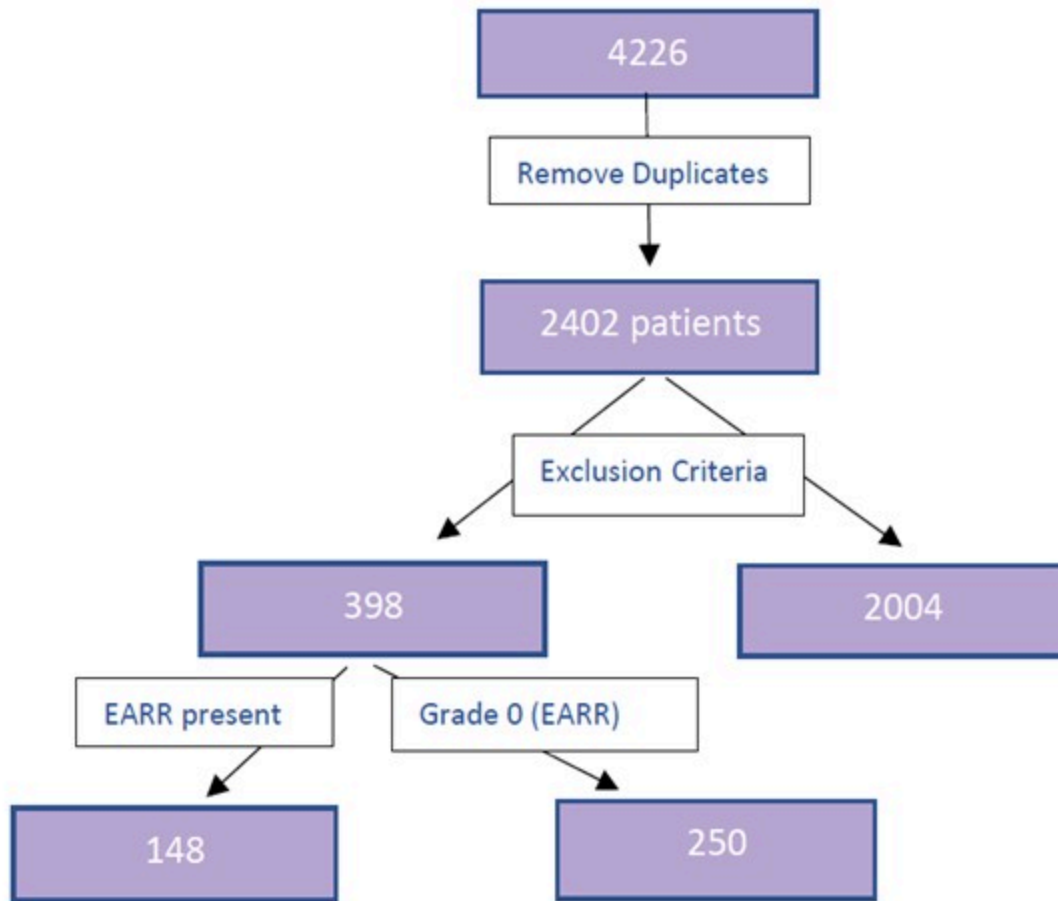


Figure 1

Descriptive data collection flowchart

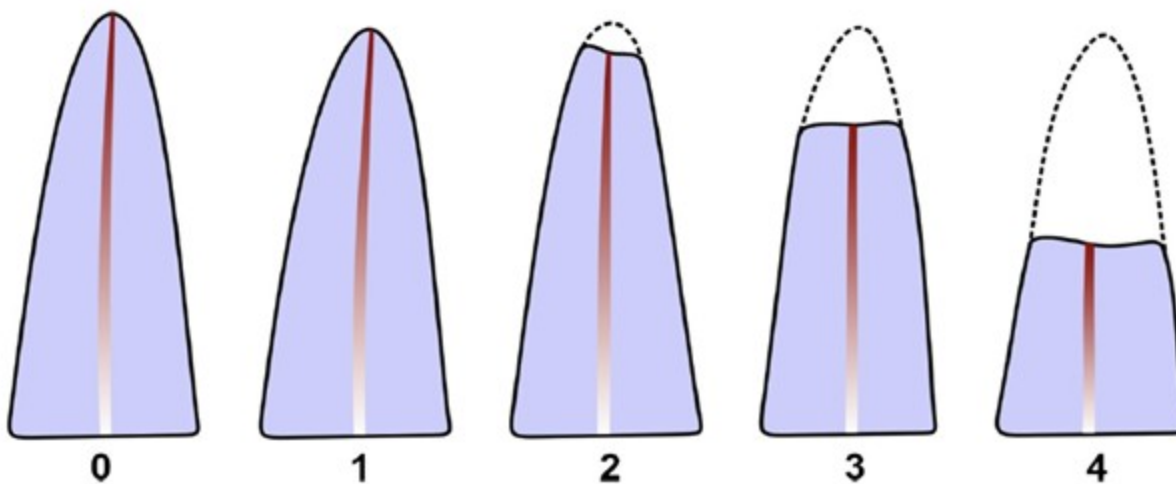


Figure 2

Levander & Malmgren EARR ranking levels [2]

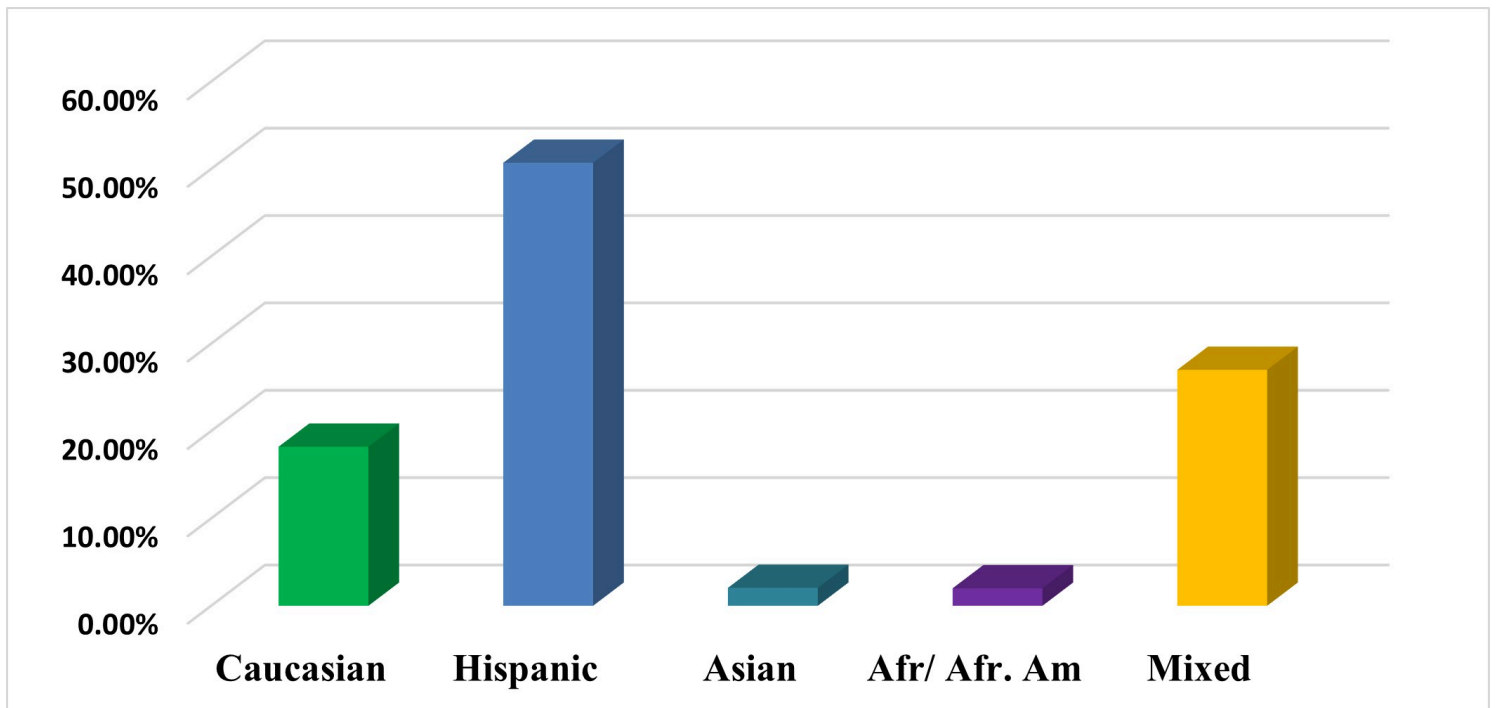


Figure 3

EARR distribution according to ethnicity

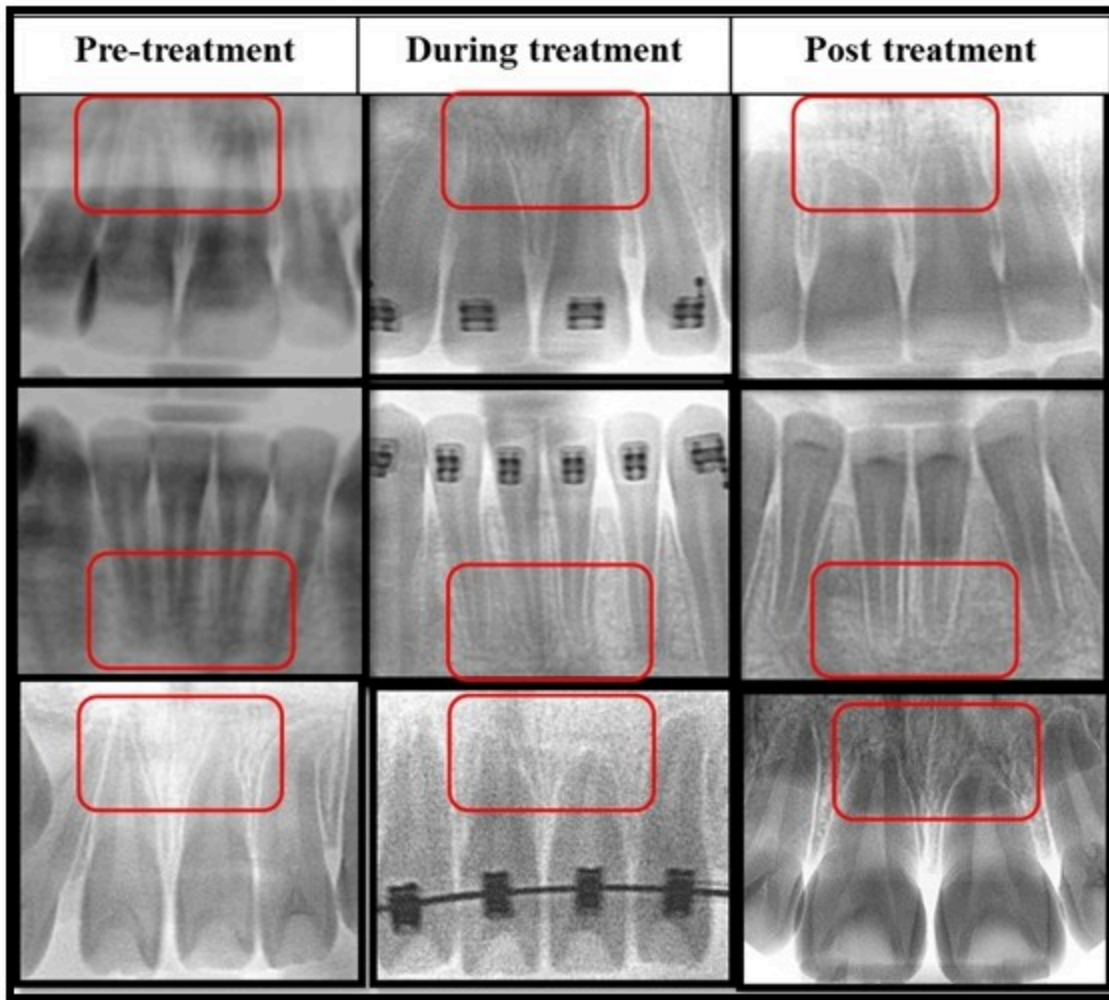


Figure 4

Cases with different EARR grades.