

A study of External Apical Root Resorption and vitality in patients treated with fixed orthodontic therapy

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Abstract

Introduction: The impact of orthodontic forces on the dental pulp tissue has become a matter of interest due to increased incidence of root resorptions. External apical root resorption (EARR) and associated changes in tooth vitality are most common iatrogenic consequences observed in orthodontic tooth movement.

Aim: To evaluate the external apical root resorption and loss of tooth vitality in patients who underwent fixed orthodontic treatment.

Materials and Methods: A total of 53 patients were evaluated in the study for presence of external apical root resorption and associated loss of vitality. Pre and post treatment OPGs of patients who underwent fixed orthodontic therapy were evaluated. Root apices were observed on OPGs and resorption if present was graded as per 5 graded ordinal scale. Vitality of individual tooth subsequent to the orthodontic tooth movement was

evaluated using electric pulp testing method. The number of teeth was recorded as vital and non-vital based on response to electric pulp testing. The results were compiled and subjected to statistical analysis.

Results: A statistically significant ($p < 0.001$) difference was found in terms of external apical root resorption being present in cases treated with fixed orthodontic therapy. However, no significant difference was seen in the vitality check of the teeth receiving the orthodontic tooth movement.

Conclusion: It could be concluded that the physiological changes in the pulp affect the nerve fibres in the early stages of the orthodontic force application often leading to periapical changes like external apical root resorption and may affect the vitality of tooth. However, longitudinal studies with a larger sample size are required to validate the results of this study.

Keywords: Tooth, EARR, OPG.

Introduction

Application of orthodontic forces to the teeth at times has undesirable side effects on the dentition. One of the common side effects is root resorption. External apical root resorption (EARR) is an inflammatory process that leads to ischemic necrosis localized in the periodontal ligament when orthodontic force is applied resulting in permanent loss of tooth structure from the apex.¹ Multiple factors are involved in the mechanism including genetics, systemic factors, gender differences, type of tooth movements, magnitude, duration and type of force.²⁻³ Apical external root resorption is finally repaired by cellular cementum but nevertheless may result in permanent loss of the root length. Vital and endodontically treated teeth are equally affected, regardless of age.

Lateral cephalogram and orthopantomogram (OPG) are routinely performed radiographs during various stages of orthodontic treatment and are often used to diagnose early conditions like EARR, so as to plan a suitable modification in the mechanotherapy. The advantages of OPG are less radiation exposure, both maxillary and mandibular skeletal and dental structures can be visualized in a single radiograph, low cost and usually there is no need for additional full mouth intraoral periapical (IOPA) radiographs for evaluating EARR.⁴ OPG being a two-dimensional representation of three-dimensional structures has certain limitations also like magnification errors, need of proper head positioning during radiography and inability to be readily repeated and reproduced. OPG often overestimates EARR by 20% when compared with periapical radiographs.

Several studies have evaluated the influence of orthodontic forces on the dental pulp. However, the reported results in the literature are inconsistent and inconclusive, mostly due to the methodological

limitations.⁵⁻⁶ Histological examination, is neither practical nor feasible in clinical situation. Therefore, application of pulp testing methods is considered to provide additional diagnostic information. Electrical pulp testing (EPT), a simple non-invasive test that provides the clinician with the electrical responsiveness of the pulp. This method provokes a group of fast-acting low-threshold A delta fibers, present within the pulp. EPT can be used as a sensitivity test. Although the results of this test might be accompanied with errors, prior knowledge about the situations in which the results might get aberrant, can reduce the potential errors.⁷ EPT only provides information on the status of nerves in the pulp, and does not directly determine the vitality (vascularity) of pulp. However, a positive response to EPT is generally interpreted as the pulp vitality.⁸ Based on the duration of the response and the history of the patient, the clinician can judge whether the pulp is healthy or inflamed. Changes in the physiology of the pulp might have some effects on pulpal nerves, especially A beta and A delta fibers, which can cause alterations to the EPT results.⁹⁻¹⁰

The aim of this study was to evaluate EARR and post treatment vitality of teeth in patients who have undergone fixed orthodontic therapy.

Material and methods

Study sample: The study sample was selected on the basis of convenience sampling, i.e., all the cases who had undergone treatment with fixed orthodontic therapy previously and met the inclusion and exclusion criteria of the study were selected for the study. The orthodontic records (soft and hard copy of pre- and post-treatment OPG) of 53 patients were finally selected based on the criteria mentioned below

Inclusion criteria

- Age between 15 and 30 years.
- Patients treated previously with fixed orthodontic appliance therapy in both the arches.
- The sample teeth, which have completed root formation, will only be evaluated.
- No radiographic evidence of pre-treatment EARR.

Exclusion criteria

- Radiographic evidence of pre-treatment Root Resorption.
- Invaginations or severe dilacerations of the roots.
- Teeth with peri apical radiolucency
- Teeth with deep carious lesions
- OPGs of patients with systemic diseases affecting bone and bone metabolism, such as osteoporosis, hyperthyroidism, hyper-parathyroidism, etc., were not included.
- Tooth apices that could not be clearly seen while viewing the OPG on an X-ray viewing box at a standardized source of light.

All the patients (total 53) selected for this study previously undergone fixed orthodontic therapy with pre-existing pre-treatment and post treatment OPGs and institutional clearance has been obtained for performing the study at ADC(R&R).

Measurement of EARR

The root apices of centrals, laterals, canines, premolars, first molar were evaluated for the presence of EARR by a single operator on an radiograph viewing box at a standardized source of light. EARR is measured using a five graded ordinal scale proposed by Levander and Malmgren, which is widely accepted in the orthodontic literature [1988]. According to this index, severity of root resorption increases from grade 1, defined as presence of irregular root contour, to grade 4, where root

resorption is greater than 1/3 of the original root length (Table 1)

Grade	Definition
0	No evidence for resorption
1	Irregular root contour
2	Apical root resorption less than 2 mm
3	Apical root resorption > 2mm and < 1/3 of original root length
4	Root resorption exceeding 1/3 of original root length

Table 1: Levander-Malmgren classification for root resorption (1988).

The measurements of EARR according to scale are graded (Fig 1,2,3,4) were repeated selected OPGs after 1 week by the same operator to calculate intra-examiner reliability and also by another operator to calculate inter-examiner reliability. The data were compiled and were subjected to statistical analysis.



Fig 1: No evidence of root resorption – grade 0



Fig 2: Irregular root contour – grade 1



Fig 3: Initial treatment OPG showing no resorption in relation to 36.



Fig 4: Same OPG revealing root resorption in relation to distal root of 36 – grade 2

Measurement of vitality

Among these patients assuming all teeth are vital pre-treatment, post treatment vitality of individual tooth were evaluated using electric pulp testing method.

Electrical stimulation was provided by the EPT device (Digitest II Tooth Vitality Tester Parkell) with toothpaste used as the conduction medium. Examination procedures were performed by the same operator and using same EPT unit. The electrical stimulus was applied to the centrals, laterals, canines, premolars, first molar. Testing was repeated after a 3-min interval to reduce the subjective fatigue and to minimize the

Table 2: Number of teeth showing EARR and their distribution according to grades. (Values are n% of cases).

Teeth	No of teeth showing EARR	Grade 1	Grade 2	Grade 3
Maxillary Centrals	42	35	7	0
Maxillary Laterals	36	29	6	0
Maxillary Canines	21	15	6	0
Maxillary Premolars	16	14	2	0
Maxillary First Molar	39	32	7	0
Mandibular Centrals	31	23	8	0
Mandibular Laterals	26	20	6	0
Mandibular Canines	16	12	4	0

possibility of nerve accommodation. Examination procedures were performed by the same operator. The numerical values on the EPT display were recorded. Teeth that failed to respond to electric testing were recorded as non-vital at a reading of 25 EPT units.

The statistical analysis was performed using statistical package for social studies SPSS, version 24.0. The level of statistical significance was set at $p < 0.05$.

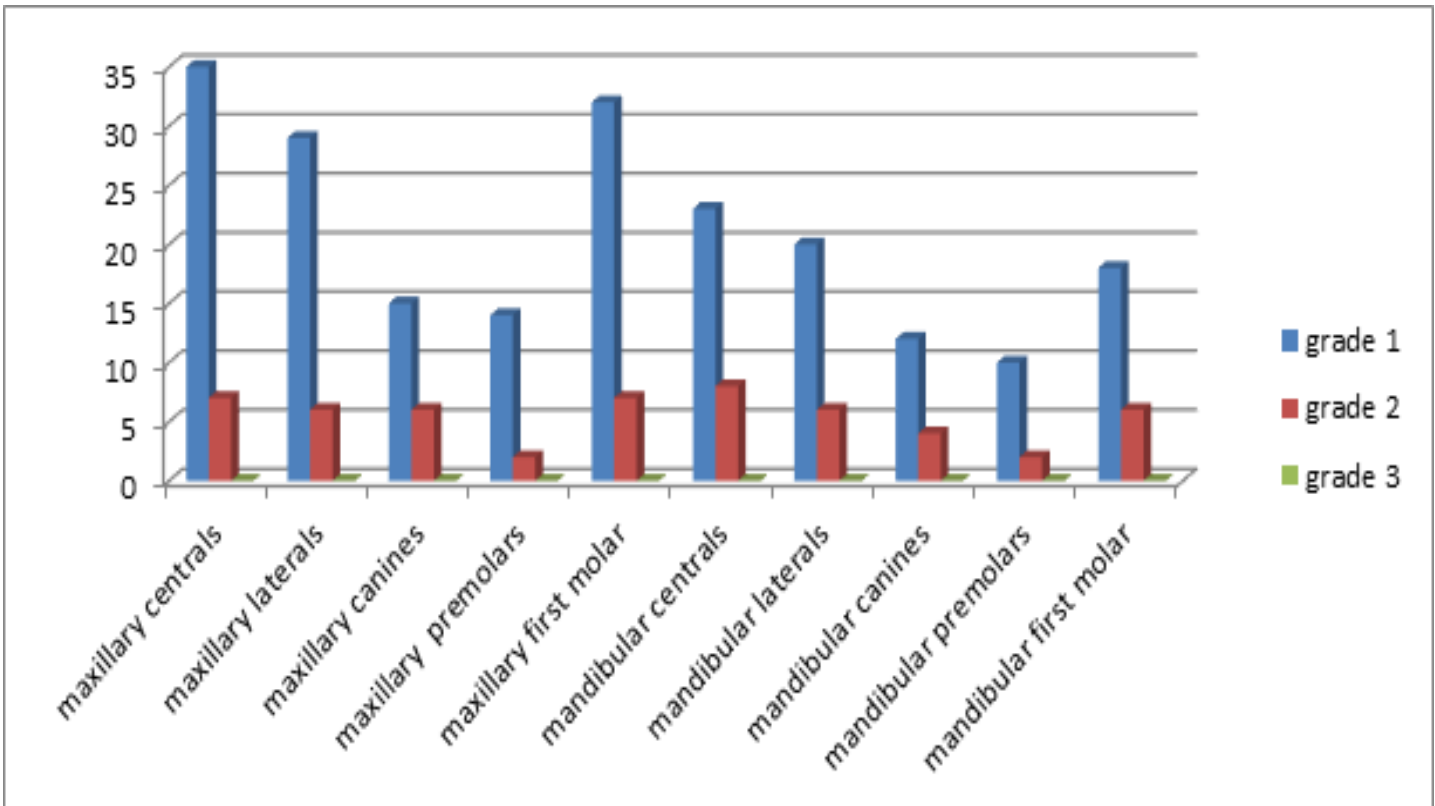
Results

There was a statistically significant intra-operator (Kappa score – 0.758) and inter-operator agreement (Kappa score – 0.728) in the evaluation and grading of EARR. A total of 1272 tooth apices (6 in each quadrant) were evaluated for EARR. 20.6% of teeth (263) showed evidence of EARR (Grade 1 – 209 teeth, Grade 2 – 54 teeth). No Grade 3 EARR was observed (Fig 5). No radiographic evidence of EARR (i.e., Grade 0) was observed in 73.2% of teeth. Maximum EARR was observed in anteriors (65.3%). Minimum EARR was observed in maxillary and mandibular premolars (10.6%) (Table 2).

The number of teeth did not respond to electric pulp testing post orthodontic treatment are not statistically significant. Only 13 teeth are non-vital which required endodontic intervention.

Mandibular Premolars	12	10	2	0
Mandibular First Molar	24	18	6	0

Fig 5: Distribution of different grades of EARR



Discussion

Radiographically, there are two methods to assess root resorption, i.e. direct measurement of root length from the radiograph or the use of ordinal scales to grade the degree and severity of root resorption⁴. The present study used an ordinal scale rather than direct measurements of tooth length to avoid the errors associated with magnification of teeth in OPGs and measurement error associated with landmark identification similar to various other studies.

The prevalence of EARR as per existing literature ranges from 65.6% to 98.1%, depending on whether it is calculated per patient (65.6–98.1%) or per tooth (72.9–94.2%)¹¹⁻¹³. Overall root resorption reported in the present study (20.6%) was very less than this range.

Histological evaluation shows microscopic areas of resorption lacunae on affected root surfaces often leading to permanent loss of tooth structure and shortening of root apex.²⁻³ Its prevalence is up to 100% in histologically examined teeth and much lower in teeth examined by routine two dimensional radiographs.³

More anterior teeth are shown affected with EARR in present study because of more amounts of intrusive forces applied on anterior teeth especially on incisors.

EARR following orthodontic treatment can be caused by patient-related factors like age, sex, systemic conditions, type of malocclusion and treatment-related factors like appliance type, treatment duration, magnitude of orthodontic force and type of orthodontic tooth movement.⁴ The magnitude of orthodontic force is believed to be an important factor in the aetiology of

EARR and it is believed that too strong forces will cause an increased damage to the affected tissues leading to root resorption. A few studies consider duration of force to be a more critical factor than the magnitude of the force, especially in connection with long treatment periods¹⁴. The orthodontic force produces a local inflammatory response with characteristic signs of inflammation. This inflammation, which is essential for tooth movement, is actually the fundamental component behind the root resorption process.¹⁵⁻¹⁶

It has been shown that the greater the tooth movement, more the apical root resorption. Intrusive movements and forces are also thought to cause apical root resorption. The severity of apical root resorption can be directly correlated to duration of treatment, but there is disagreement on this hypothesis.¹⁷⁻¹⁸

Orthopantomogram radiographs can only detect apical root resorption after a certain amount of root shortening. Furthermore, radiographs show only the phenomenon but not the causes of apical root resorption.¹⁹ The underlying factors predisposing a patient to apical root resorption from orthodontic tooth movement are biologic rather than radiographic.²⁰ The factor of time could be a summation of all factors predisposing a patient to apical root resorption during orthodontic tooth movement.

The results of tooth vitality were not significant as only 7 cases (13 teeth) have shown no response to EPT which require endodontic intervention. Of these 9 teeth are anteriors and 4 are premolars.

Some previous studies have reported pulp necrosis of non-traumatized teeth during orthodontic treatment. Possible explanations include anatomic variations of the apical foramen or the supplying vessels. Further research should investigate whether pulpal sensitivity is associated with the common apical root resorption or perceived pain during orthodontic treatment. If there is

any relationship between these, EPT can serve as a diagnostic tool during the orthodontic tooth movement.⁷

Conclusion

It could be concluded that the physiological changes in the pulp affect the nerve fibers in the early stages of the orthodontic force application often leading to periapical changes like external apical root resorption and may affect the vitality of tooth. However, longitudinal studies with a larger sample size are required to validate the results of this study.

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