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Research Article

ROOT RESORPTION DURING LEVELING AND ALIGNING PHASE OF ORTHODONTIC TREATMENT – A RADIOGRAPHIC STUDY

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ABSTRACT

Aim: This study aims to evaluate the root resorption (RR) during the leveling and aligning phase in patients undergoing fixed orthodontic treatment.

Objective: This study helps in evaluating RR of anterior teeth during leveling and aligning phase of orthodontic treatment.

Methods: This study involves 12 patients undergoing fixed appliance mechanotherapy. The roots of the anterior teeth root were evaluated for RR in each of these patients at 2 time intervals (a) at the start of fixed orthodontic treatment and (b) at the end of leveling and alignment with the help of either two-dimensional digital radiograph or three-dimensional cone-beam computed tomography.

Results: Computerized evaluation of apical RR showed that the mean averaged RR was 0.53 mm (standard deviation [SD] 0.47) for all four incisors; the average for the central incisors was 0.48 mm (SD 0.53).

Conclusions: RR can be detected even in the early leveling stages of orthodontic treatment. About 25% of patients have an average resorption of up to 2 mm of the four maxillary incisors, in the leveling and alignment phase of fixed appliance therapy. Although teeth with long, narrow, and deviated roots are at increased risk of resorption during this early stage, the explained variance of these risk factors is <25%.

Keywords: Root resorption, Leveling and alignment, Malmgren scoring, Fixed mechanotherapy, radiograph.

INTRODUCTION

External apical root resorption (EARR) is an undesirable treatment-induced sequel of dental braces [1]. Root shortening can result in irreversible consequences to the support of orthodontically treated teeth and so is of great interest to orthodontists [2].

RR is a common idiopathic problem associated with orthodontic treatment and has recently received considerable attention due to medicolegal exposure. As the movers of the teeth, it is incumbent for us to know as much as possible about the causes, effects, and prevention of this phenomenon. Many general dentists and other dental specialists believe that RR is avoidable and hold the orthodontist responsible when it occurs during orthodontic treatment. It is, therefore, important to identify which orthodontic treatment factors contribute to RR so that the detrimental effects can be minimized and RR reduced. Regardless of genetic or treatment-related factors, the maxillary incisors consistently average more apical RR than any other teeth followed by the mandibular incisors and first molars.

The EARR etiology, although widely discussed in literature, remains somewhat obscure and controversial. Several factors contributing to EARR have been analyzed and are classified into orthodontic-related risk factors and patient-related risk factors. Orthodontic treatment-related risk factors include treatment duration, magnitude of applied force, direction of tooth movement, amount of apical displacement, and method of force application (continuous vs. intermittent, type of appliance, and treatment technique). Individual susceptibility is considered a major factor in determining RR potential with or without orthodontic treatment. Patient-related risk factors include previous history of RR; tooth-root morphology, length, and roots with developmental abnormalities; genetic influences; systemic factors including drugs (nabumetone), hormone deficiency, hypothyroidism, and hypopituitarism; asthma; root proximity to cortical bone; alveolar bone density; chronic alcoholism; previous trauma; endodontic treatment; severity and type of malocclusion; patient age; and sex. This study concerns few of the above-said factors, leading to RR [1-4].

METHODS

A total of 12 patients undergoing orthodontic treatment in our department were enrolled in a study on parameters associated with apical RR. All patients were treated with multibonded, pre-adjusted appliances, with 0.022-in bracket slots. Leveling and alignment, typically with round and rectangular superelastic wires, was achieved. Periapical radiographs were obtained according to a standardized technique at predetermined stages of treatment. Radiographic projections were made at two stages, one before treatment (T1) and approximately 4–6 months after placement of maxillary incisor brackets, i.e., end of leveling and alignment (T2) were evaluated. Only the maxillary central and lateral incisors were evaluated because those teeth are the most prone to dental injury and RR [5-7].

Patients with a history of previous orthodontic treatment were excluded from the study. Traumatic injuries, through clinical and radiographic examination and patient interviews at T1, were recorded as present or absent. If present, differentiations were made between no apparent dental injury, tooth luxation, tooth exfoliation, crown fracture, and root fracture.

Extraction pattern was recorded as non-extraction, extraction of four teeth (various premolar and molar combinations), and extraction of only maxillary teeth. In addition, a number of months from T1 to T2, use of round and square wire, were recorded.

Digital radiography is used to capture the root status at T1 and T2. Corresponding radiographs were evaluated simultaneously on the screen (Fig. 1). Three anatomic landmarks were identified on each incisor at T2 (Fig. 1b) – mesial end of cementoenamel junction (CEJ) and distal end of CEJ and root apex. The same three landmarks were then identified on the T1 image (Fig. 1a). By superimposing on these three landmarks, we used the software to reconstruct the T1 image according to the projection of the T2 image. The quality of their construction was checked by subtracting the reconstructed T1 image from the T2 reference image (Fig. 1c). If only minimal root and crown structures could be discerned on the subtracted image, the reconstruction was considered successful (Fig. 1b-d). Before identifying measurement points, each pair of reconstructed T1 and original T2 images was evaluated jointly.

If the incisal edge was not readily identified on both radiographs, a decision was made whether to use two points on the projection of the CEJ (Fig. 2) or the bracket (Fig. 3) as the common incisal measurement point. The latter was the preferred option if the T1 radiograph was made immediately after bracket placement. Then, the radiographs were coded and measured in random order with the aid of the Facad software, recording the number of pixels between landmark pairs [8]. If the incisal edge could be identified, tooth length (TL) was measured as the distance from the tip of the apex to the midpoint of the incisal edge. In addition, if indicated in the code, modified TL was measured to a point on the CEJ or the bracket (Fig. 4a). Root width was measured from the mesial to the distal outline of the root 4 mm from the apex (Fig. 4b). Assuming that the enlargement factor was negligible, absolute distances were calculated according to the formula, 1 pixel_ 0.085 mm, because all images were scanned at are solution of 300 dpi.

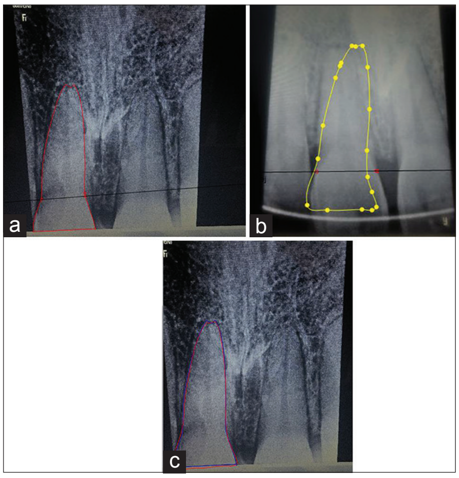


Fig. 1: (a) T1 pre-treatment; (b) T2 image reconstructed according to T1; (c) superimposition of reconstructed T2 on T1

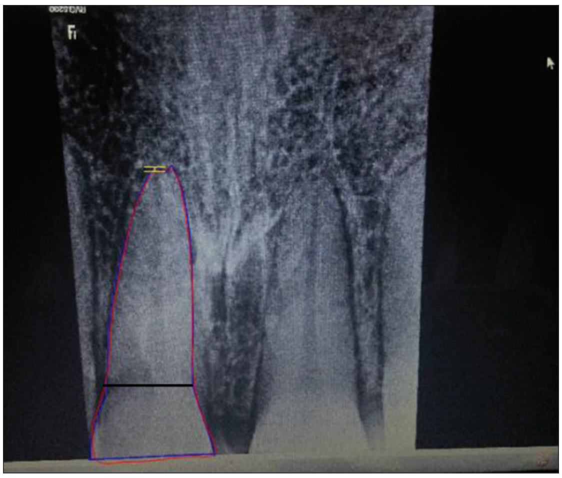


Fig. 2: The superimposition points mesial of cementoenamel junction (CEJ), distal of CEJ, and the root apex

The original T1 radiographic images were evaluated in random order, and root form was scored subjectively as normal, blunt, eroded, pointed, bent, or bottle shaped (Fig. 5). Then, each pair of original T1 and T2 radiographic projections was evaluated simultaneously [8].

Signs of RR were scored on a scale from 0 to 5 (Fig. 6) [21]. Reproducibility of the measurements was assessed by statistically analyzing the difference between double measurements taken at least 1 week apart on radiographs at T1 and T2 of 12 randomly selected patients. For the computerized measurements, the reconstruction and landmark identification procedures were repeated.

RESULTS

Computerized evaluation of apical RR showed that the mean averaged RR was 0.53 mm (standard deviation [SD] 0.47) for all four incisors; the average for the central incisors was 0.48 mm (SD 0.53).

DISCUSSION

A study by Brin on EARR was designed to supplement information relating to optimal timing for treating preadolescent patients with Class II malocclusion. A previous progress report on these patients suggested that there is little difference in the effectiveness of early versus delayed treatment to correct this malocclusion. The total time in treatment is generally longer for two phases than for one phase. The importance of this data about EARR lies in the assumption that the randomization procedure used to form the initial treatment groups is likely to have created groups that were similar across both known and unknown prognostic factors (i.e., predisposition to EARR). Randomization ensures that, except for the vagaries of chance, the critical variables (whatever they are and however they interact to affect the treatment outcome)

Fig. 3: T1 radiographic images taken after bracket placement allowing bracket to be taken as the reference point for superimposition between T1 and reconstructed T2

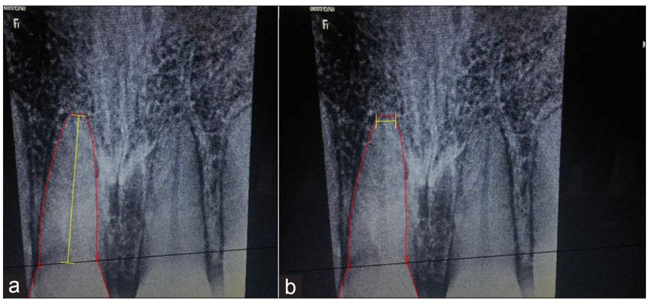


Fig. 4: (a) Modified tooth length measurement (b) The root width 4 mm from the apex

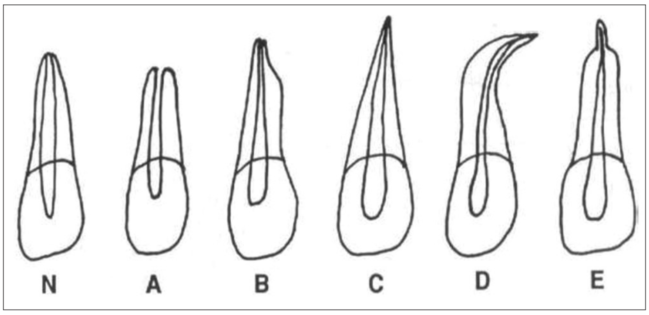


Fig. 5: Criteria for subjective scoring of root form. N: Normal; A: Blunt; B: Eroded; C: Pointed; D: Deviated; E: Bottle shaped

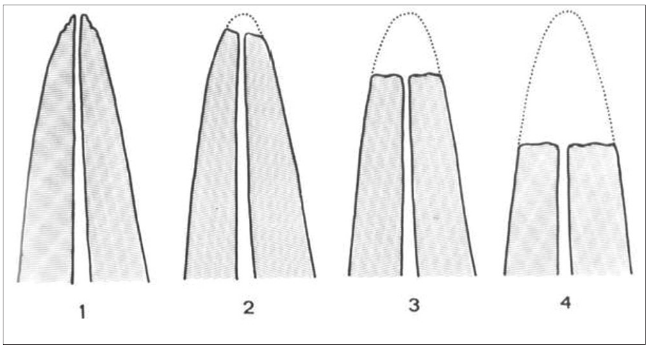
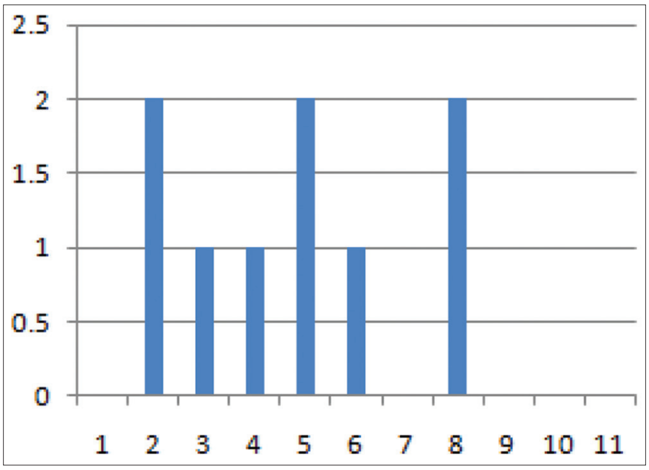


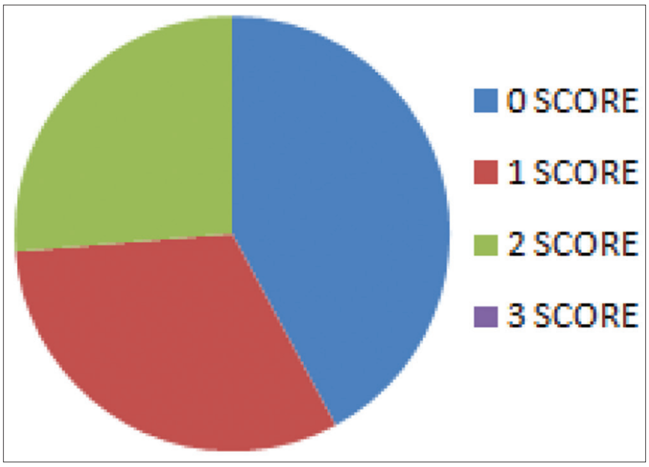
Fig. 6: Criteria for subjective scoring of root resorption. 0: No resorption; 1: Irregular root contour; 2: Apical root resorption <2 mm of original root length; 3: Apical root resorption from 2 mm to 1/3 of original root length; 4: Apical root resorption exceeding 1/3 of original root length [8]

will not systematically affect one treatment over another. By making the treatment groups as similar as chance will allow, it becomes safer to attribute the differences in observed outcomes to differences in treatment rather than to difference in the people studied. In more traditional observational or case series studies, the groups assembled are likely to be different, often in unrecognized ways, making interpretation of treatment effect difficult. This study used both intraoral and extraoral films to evaluate EARR because these films were available. In general, the use of extraoral films can be criticized. In a comparison of periapical and panoramic films to assess RR and root shape, it was suggested that when using panoramic films to estimate pre-treatment and post-treatment EARR, the amount of root loss might be overestimated by 20% or more [9]. However, the greatest differences between the periapical and panoramic films are in the mandibular incisors (which we did not include), whereas the least differences are in the maxillary incisors. Thus, the possible overestimation of EARR in this study should be considered, but it might be minimal, because RR was determined for the maxillary incisors only from evaluating both intraoral and extraoral films. A recent methodologic study concluded that linear measurements on panoramic radiographs taken at different times are sufficiently accurate for measuring changes in root length, if the occlusal plane is kept in a similar position on both occasions and not tilted more than 10° [4,8].

In keeping with Levander and Malmgren [8], we confirmed that most orthodontic patients develop visible signs of apical RR of the maxillary incisors during the initial stages of fixed appliance therapy. However, the resorption is typically expressed only as a slight change in apical contour without actual root shortening. Although we judged 24.0% of the teeth to express root shortening, only 3.6% had shortening of more than 2 mm. Comparable figures by Levander and Malmgren [8] were 34.4% and 1.3%, respectively. However, the wide range in severity of resorption among teeth with subjective score 3, which is from 2 mm to one-third of initial TL [9], makes direct comparisons of severity



Graph 1: The Malmgren scoring for the 12 individual patients taken for the study



Graph 2: Pie chart showing the percentage of patients with different Malmgren scores

between the two studies difficult. The low kappa for our duplicate subjective scoring of root resorption could be interpreted as support of a previous finding of low agreement when scoring intact versus irregular root contour [10].

Objective evaluation of RR requires radiographs made according to a standardized paralleling technique to minimize errors due to differences in projection and magnification. However, interpretation of the whole range of RR estimates on such radiographs shows that some teeth are judged to have tooth elongation even though continued root growth can be ruled out [6,11], suggesting that projection and magnification errors might still occur. Attempts have been made to reduce such biases by adjusting for differences in crown length measurements [6,8]. When we compared the two techniques, we found that greater tooth length was calculated more frequently [7] and estimated resorption was less and more varied [5,7], probably due to errors associated with locating the CEJ. Projection errors are likely to be random and evenly distributed with standardized radiographs, so they might not affect mean values. However, individual cases might be inaccurately recorded. The minor amount of resorption likely to occur early in treatment could be particularly difficult to record. Attempting to minimize this problem, we used a recently introduced digital reconstruction technique [10], which could be liable method of adjusting projection errors when comparing pre-treatment and post-treatment radiographic projections. The fact that maximum enlargement in our study was 0.9 mm as opposed to 2 mm or more without reconstruction [6,7] confirms the usefulness of the technique. About 41% of the subjects in our sample had an average resorption of more than 1.5 mm, with a maximum value of 2.2 mm. Even though such amounts of resorption are usually of minor clinical significance at the end of treatment, it might be of concern at this early stage if it is progressive. Although Levander and Malmgren [8] concluded that even teeth with an irregular root contour 6–9 months into active treatment are at risk of severe resorption by the end of treatment, the predictive value of that finding is rather limited because 71% of the teeth fell into that category. Our aim was to explore the predictive value of early signs of resorption in detail once all treatments are completed. Of particular, significance might be the final amount of resorption among 13.4% of the patients in our study who had at least one tooth with apical root loss of 2.0 mm or more at this stage. We confirmed previous findings of an association between greater TL and amount of RR [11,12]. We could also confirm an association between narrow, pointed, and deviated roots and resorption. Since such root forms are more common in maxillary lateral incisors than in centrals, the common finding that maxillary lateral incisors are resorbed more than other teeth during orthodontic treatment [5-7] should not be unexpected. In keeping with the previous studies [11,12], we found no indication that teeth with short, blunt roots are at increased risk of resorption. We used three different estimates of tooth irregularity as surrogate variables for tooth movement in our study but detected no associations between measurement and amount of RR. This might be because typical tooth movements during initial leveling are in the form of crown tipping rather than root movement. Our material might, therefore, not have been suitable for confirming previous findings of an association between apical RR and amount of root movement [14,15]. However, we did find an association between initial treatment time and resorption. Our results suggest that 1 month of extra treatment time causes 0.1 and 0.2 mm of additional RR of the most severely resorbed central and lateral incisor, respectively. The findings in the previous studies are inconclusive regarding any association between treatment length and amount of resorption at appliance removal [16]. One explanation could be that treatment time might include periods when the appliances are passive and that variables that might be correlated with treatment time, such as amount of root movement, are not always accounted for in analyses. We did not consider the use of anterior or posterior elastics due to insufficient use at this early stage of treatment. Neither did we include malocclusion parameters such as overjet and overbite because any active corrections were unlikely to have started at this early stage.

However, we did confirm the previous findings that the explained variance of the identified risk factors was low [18-20], only 14% for the central and 24% for the lateral incisors. This strongly supports the notion that the major risk factors for apical RR during orthodontic treatment are related to individual predisposition.

CONCLUSIONS

RR can be detected even in the early leveling stages of orthodontic treatment. About 25% of patients have an average resorption of up to 2 mm of the four maxillary incisors, in the leveling and alignment phase of fixed appliance therapy. Although teeth with long, narrow, and deviated roots are at increased risk of resorption during this early stage, the explained variance of these risk factors is <25%.

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