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A Comparative Analysis of Orthodontically Induced Root Resorption Using Panaromic Radiography and Cone Beam Computed Tomography

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ABSTRACT

Background: Orthodontically induced apical root resorption is a common and untoward iatrogenic side effect of orthodontic treatment. In the current study, an attempt was made to correlate the amount of root resorption following orthodontic treatment by maxillary distalization on OPG and CBCT.

Material and method: The sample consisted of 268 maxillary teeth in 20 patients who underwent distalization of maxillary dentition and were around the completion of their fixed orthodontic treatment. Two calibrated examiners assessed blindly the presence or absence and the severity of apical root resorption on the OPG images and the corresponding reconstructed CBCT images after treatment. Resorption was evaluated as no, mild, moderate, severe, and extreme.

Results: On OPG, 8 incisors and 4 molars could not be assessed. These and their CBCT counterparts were excluded from the study. Statistically significant difference was found between the two methods of assessment of root resorption ($P<0.001$) although a significantly strong correlation (Spearman's Coefficient 0.718) was found between the two. 70.9% teeth showed no resorption on OPG while 49.6% teeth showed no resorption on CBCT. 25.3% teeth showed mild resorption on OPG while it was 39.5% on CBCT, 2.9% on OPG showed moderate resorption while it was 9.3% on CBCT. Severe and extreme resorption was found in only 2 teeth by CBCT.

Conclusions: OPG tends to underestimate apical root resorption after orthodontic tooth movement. CBCT might be a useful complementary diagnostic method to conventional radiography for fine tuning and necessary modification in treatment modality to curtail further loss of root.

Keywords: CBCT, OPG, Orthodontics, Root resorption.

INTRODUCTION

Orthodontically induced root resorption is a relatively common and extensively reported side effect of orthodontic treatment[1]. The biologic responses which control tooth movement[2,3] and those which often lead to orthodontically induced root resorption have been studied over the years. The osteoclastic activity at the root apex leads to shortening of the root length, and in routine dental practices it is mostly identified using radiographic methods. Panoramic radiograph is the most commonly used diagnostic aid in orthodontics and is used for diagnosis, prediction of tooth eruption,

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root alignment and assessment of treatment outcome. Inherent limitations like projection and distortion errors, blurred images, artifacts, superimposition owing to two dimensional imaging[4,5,6,7,8] and inability to differentiate palatal and buccal root abnormalities have deterred the faith of radiographic analysis based on 2 dimensional imaging.[9,10,11]

The presence or absence and the extent of root resorption determines the strategy of treatment while extremes of root resorption may render the treatment impossible[12]. Early detection is crucial, thus ensuring correct treatment strategy, reduced treatment time, and minimizing complications.

A substantial amount of mineral loss occurs before it is readily identified on regular orthpantomograph. Studies have shown that OPG overestimates root loss by about 20% as compared with periapical radiographs[13]. Digitalized periapical radiographs tend to underestimate the amount of root shortening in contrast to micro-computed tomography scanner[14]. Root resorption less than 0.6mm in diameter and 0.3 mm in depth cannot be readily identified on 2 dimensional radiographs[15, 16]. The conventional radiographs have been found to be inefficient in grading resorption lesions and in detecting resorption dimensions.[17, 18, 19]

With the advent of cone beam computed tomography, the lights have shifted towards a more accurate assessment of root resorption. The great advantage of this technology is that it offers 3-dimensional (3D) imaging of dental structures and provides clear images of highly contrasted structures, such as bone. Minimization of the radiation dose, image accuracy, rapid scan time, fewer image artifacts, chair-side image display, and real-time analysis are some of the advantages that outweigh the routine conventional computed tomography scan.[20,21] Linear measurements have been found to be highly accurate when studied on CBCT[22] thus allowing it to be useful for assessment of root resorption following orthodontic treatment.

With the growing trend towards non extraction treatment, the concept of distalization has increased in the recent times. Molecular studies have shown that with increasing force for orthodontic tooth movement, the chances of apical root resorption increases. Study on lateral cephalograms has shown statistically significant root resorption following distalization movement in incisor region on applying a force range of 300gms on each side (Yamada et al 2009).[23] However, the study conducted was a two dimensional assessment and no attempt was made to study the resorption of roots of second molars.

Only a few studies have been conducted comparing orthodontically induced root resorption using panaromic radiography and cone beam computed tomography.[24,25] In the current study, a comparative evaluation of root resorption following distalization movement of maxillary dentition was done on OPG and CBCT to ascertain the amount and pattern of resorption in mechanics that involves higher orthodontic forces.

MATERIAL AND METHOD

The aim of this study was to compare and correlate the root resorption on OPG and CBCT in patients undergoing distalization movement.

The study was carried out in the department of Orthodontics and Dentofacial Orthopaedics, PGIDS, Rohtak. 20 patients (8 males, 12 females) with a mean age of 20.60 ± 1.9 years (age range 17-24 years) who underwent en-masse distalization of the maxillary dentition using zygomatic miniplates were included in this study. They were near the end of orthodontic treatment with fixed appliances. Only the maxillary teeth (maxillary incisors, canines, premolars, 1st and 2nd molars) were evaluated. Thus, a total of 280 teeth were evaluated for the purpose of this study.

OPG images were obtained using Carestream CS 8100 (ROCHESTER, NY, USA). The CBCT scans were performed using CS 9300 (Carestream CS 9300; ROCHESTER, NY, USA) at 85 kV, 4mA current, exposure time of 6.30 seconds, 17 x 6 cm FOV and a voxel size of 200 micrometer. All the scans were performed by the same researcher.

Two calibrated examiners (C.S. and S.T.) assessed separately and blindly the presence or absence and the degree of apical root resorption in the OPG and CBCT images using the scoring system of Levander and Malmgren[26] that classifies root resorption into 5 grades:

0, no root resorption;

1, mild resorption, with root of normal length and only an irregular contour;
2, moderate resorption, with small areas of root loss and apex having an almost straight contour;
3, severe resorption, with loss of almost one third of root length; and
4, extreme resorption, with loss of more than one third of the root length.

Fig 1: Index for evaluation of root resorption on the OPG: A, 0, no resorption; B, 1, mild resorption; C, 2, moderate resorption; D, 3, severe resorption; E, evaluation impossible.

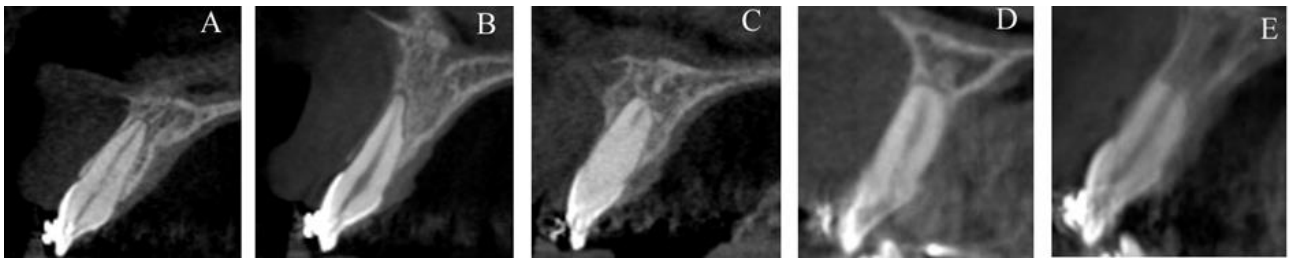

Fig 2: Index for evaluation of root resorption on the CBCT: A, 0, no resorption; B, 1, mild resorption; C, 2, moderate resorption; D, 3, severe resorption; E, 4, Extreme resorption.

In case of disagreement between the 2 examiners, a new evaluation was made, and this consensus was used for the final evaluation. The grades of apical root resorption as observed in our study are presented in Figure 1(OPG images) and Figure 2(CBCT images). Only the grades found in our sample are shown.

All radiographic assessments were performed blindly by the both the observers in a darkened room. The radiographic images were coded with a numerical ID so as to prevent bias, and the investigator, therefore, was not aware of the identity, age or sex of the patient. The CBCT images were arranged in a presentation (Microsoft Office PowerPoint 2010) with a black background and codes that were displayed sequentially on a high-definition computer monitor. No change in contrast or brightness of these images was undertaken.

The kappa statistic showed substantial agreement between the 2 observers with the CBCT method (value, 0.91) and poor agreement with the panoramic method (value, 0.66). The Pearson chi-square test was used to test the null hypothesis that there is no difference in evaluating apical root resorption on OPG and CBCT images. The statistical analysis was processed with SPSS software for Windows (release 25.0.0, standard version, SPSS, Chicago, USA).

RESULTS

A total of 280 teeth were evaluated by OPG and CBCT for apical root resorption (80 incisors, 40 canines, 80 premolars and 80 molars). Evaluation was impossible in 8 incisors and 4 molars with the OPG method. Hence these teeth and their CBCT counterpart were not included for the purpose of this study. The remaining 268 teeth (teeth evaluated by both methods) were used for statistical purpose.

The numbers and percentages of teeth with the different grades of apical root resorption as evaluated by OPG and CBCT are shown in Table I. Significant differences were observed between the 2 methods and for all grades of resorption ($P<0.001$). The total numbers of teeth on OPG showing no resorption were 190, mild resorption were 68, moderate resorption were 8, severe resorption were 2 and extreme resorption were 0. The total

numbers of teeth on CBCT showing no resorption were 133, mild resorption were 106, moderate resorption were 25, severe resorption were 2 and extreme resorption were 2.

Since the maxillary incisors showed the most pronounced differences, their percentages were calculated separately, as depicted in Table II. Incisors with no resorption on OPG were 30, with mild resorption were 32, moderate resorption were 8, severe resorption were 2 and extreme resorption were not present. On CBCT, incisors with no resorption were 12, mild resorption were 36, moderate were 20, severe resorption were 2 and extreme resorption were 2. Overall, the difference between the two methods for evaluating root resorption was found to be statistically significant with a significant correlation of 0.718. Root resorption scores of incisors showed strong correlation (Spearman Coefficient 0.77) between OPG and CBCT.

Table 1: Evaluation of apical root resorption in all teeth by OPG and CBCT.

	OPG				Total
	0	1	2	3	
CBCT					
0	(133)100.0%	(0)0.0%	(0)0.0%	(0)0.0%	(133)100.0%
1	(57)53.8%	(49)46.2%	(0)0.0%	(0)0.0%	(106)100.0%
2	(0)0.0%	(19)76.0%	(6)24.0%	(0)0.0%	(25)100.0%
3	(0)0.0%	(0)0.0%	(0)0.0%	(2)100.0%	(2)100.0%
4	(0)0.0%	(0)0.0%	(2)100.0%	(0)0.0%	(2)100.0%
Total	(190)70.9%	(68)25.4%	(8)3.0%	(2)0.7%	(268)100.0%

Table 2: Evaluation of apical root resorption in maxillary incisors by OPG and CBCT.

	OPG Total				Total
	0	1	2	3	
CBCT					
0	12(100.0%	(0)0.0%	(0)0.0%	(0)0.0%	(12)100.0%
1	(18)50.0%	(18)50.0%	(0)0.0%	(0)0.0%	(36)100.0%
2	(0)0.0%	(14)70.0%	(6)30.0%	(0)0.0%	(20)100.0%
3	(0)0.0%	(0)0.0%	(0)0.0%	(2)100.0%	(2)100.0%
4	(0)0.0%	(0)0.0%	(2)100.0%	(0)0.0%	(2)100.0%
Total	(30)41.66%	(32)44.44%	(8)11.1%	(2)2.8%	(72)100.0%

DISCUSSION

Orthodontically induced apical root resorption is considered one of the most common and most detrimental iatrogenic effects of orthodontic treatment. Thus there has been an increasing interest in orthodontically induced root shortening which in its most severe cases may render the treatment incomplete. However, a gold standard for the detection of root resorption has not been established. While OPG is one of the most commonly used diagnostic aid in orthodontics, its use for detection of root resorption is questionable owing to blurring and two dimensional projections. The aim of our study was to determine the accuracy of OPG in evaluating orthodontically induced root

resorption in comparison with it evaluation on CBCT in patients treated orthodontically by distalization of maxillary dentition using zygomatic miniplates.

Distalization is one of the most effective, popular and non-compliant method for treatment of maxillary crowding and correction of Class II malocclusion. However, for complete arch distalization the force level required is on the higher side[27]. Thus careful monitoring of force level and detection of root resorption radiographically is of utmost importance to minimize the clinical side effects.

The quantification of root resorption must be done with precision as it is a three dimensional phenomenon. The most precise results may be yielded by extraction of the tooth after orthodontic movement and then histological evaluation under scanning microscope. These studies[28,29] conducted in the past however, required sacrificing the tooth for the same purpose. The proclined incisors which lie outside the focal trough during evaluation by OPG, often project them shorter[30] thus leading to misinterpretation of facts.

Silveira et al[31] showed high sensitivity and excellent specificity in detecting simulated external apical root resorption in cavities prepared at cervical, middle and apical root thirds when detected using CBCT. The effective dose of CBCT was found to be five to six times higher than OPG and seven to eight times lesser than multi slice CT by Silva et al[32]. Frequency of incisors showing orthodontic root resorption increased from 15% to 73 % after orthodontic treatment while 1 to 25 % of teeth have been found to undergo moderate to severe resorption[33,34].

In our study, we compared the results of root resorption found in patients who underwent distalization of maxillary dentition using zygomatic miniplates. Significant differences were observed between the 2 methods and for all grades of resorption ($P<0.001$). We compared the OPG findings with those obtained with CBCT: whereas 50% of the teeth were diagnosed as having apical root resorption by CBCT, only 29% showed apical root resorption with OPG. Furthermore, 12 teeth could not be evaluated by OPT. Overall, these results suggest that apical root resorption might be underestimated by OPG.

The difference in grades of resorption was most marked in moderate and severe cases. Thus it can be said that OPG tends to under estimate the amount of root resorption especially in moderate and severe resorption as slanting resorption may go undetected by the two dimensionally obtained images. This is in concordance with previous studies by Dudic et al[25] who found that panaromic radiographs tend to underestimate the apical root resorption. Similar studies by Alquerban[35] have showed that with panoramic imaging, 21% of the lateral incisor root resorption cavities were correctly classified compared with 40% for Accuitomo CBCT and 41% for ScanoraCBCT .

Thus it is evident that although CBCT cannot replace OPG as a diagnostic aid, it is recommended that on signs of moderate root resorption CBCT imaging be done to ascertain the amount and severity of resorption and subsequently a decision be taken clinically to modify the force levels and/ or the treatment modality for successful completion of treatment.

CONCLUSION

OPG tends to underestimate the amount of orthodontically induced apical root resorption. CBCT is a more accurate supplementary method to assess root resorption. However, owing to the inherent radiation effects of CBCT, a more judicious use is warranted. In cases of moderate to severe root resorption, CBCT may prove to be a better indicator of prognosis and hence any modification

required in the treatment strategy be made based on it.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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