Original Article

Assessment of Root Resorption and Root Shape: Periapical vs Panoramic Films

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Abstract: A radiographic examination is an essential part of the diagnostic process in orthodontics. However, what radiographs are needed to properly evaluate root shape and position? Most clinicians order panoramic or periapical radiographs in addition to the cephalometric radiograph. The purpose of this study was to find out whether one type of film is more accurate than the other in the pretreatment evaluation of root shape and the posttreatment computation of apical root resorption. Pretreatment and posttreatment panoramic films and full-mouth periapical films from 42 patients who completed fixed orthodontic treatment were assessed for tooth length and root shape. Panoramic films showed significantly greater average apical root resorption than periapical films for the 743 teeth surveyed. The greatest differences were found in the lower incisors, the least in the maxillary incisors. Classification of root shape was significantly different between the 2 types of radiographs. Root dilacerations and other abnormal shapes, clearly visible on periapical films, often appeared normal on panoramic films. The findings strongly suggest that root shape is much harder to assess on panoramic films. We conclude that, in cases where the apices are obscured or other factors are present that might suggest higher risk for root resorption or vertical bone loss, periapical films should be ordered. The use of panoramic films to measure pre- and posttreatment root resorption may overestimate the amount of root loss by 20% or more. (*Angle Orthod* 2001;71:185–189.)

Key Words: Radiographic examination; Diagnosis and treatment planning; Risk factors; Root resorption

INTRODUCTION

Evaluation of radiographs is a crucial step in the initial diagnostic process in orthodontics. The visualization of key structures, detection of pathology, and assessment of developing teeth are but a few of the conditions that can be obtained only from radiographs. A cephalometric film and a panoramic film are routinely ordered as the primary pretreatment radiographs. Most educational programs also recommend cephalometric and panoramic films.[1] However, an increasing number of practitioners now also order a full-mouth series on adult patients, while others obtain both a panoramic film and periapical films. One survey found that the majority of general dentists order periapical films on adult patients only.[2]

The advantages of the panoramic film are less radiation exposure, less patient chair time, less operator time, and better patient cooperation.[3] The single panoramic film visualization of the entire lower half of the face, including the joints, extending from the lower orbits to the most inferior portion of the mandible is also a diagnostic plus in simplicity and patient education.

There are known limitations, however, with panoramic radiography. The quality of the image is dependent on correct patient positioning and the closeness of the desired anatomical structures to the focal trough.[3] By positioning the chin too high, the hard palate becomes superimposed on the roots of the maxillary teeth. If the chin is tilted down, the teeth will appear overlapped. The correct position is to align the head so that the Frankfort plane is parallel to the floor.[3,4] The amount of magnification varies within the skull, but generally averages 20–35% enlargement. The magnification factor is relatively constant in the vertical dimension, but horizontal measurements were found to be less reliable.[5,6] In one study, 40% of panoramic films lacked the clarity needed to visualize the premaxilla.[7] They suggested that supplemental films were needed in many cases.

Periapical films also have a magnification factor, but it is usually less than 5%.[8] In one article, implant length was measured on periapical and panoramic films.[9] Periapical films were accurate to within 0.3 mm, but panoramic films overestimated the length by 0.4 mm to 1.7 mm.

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Periapical films have been found to be superior to panoramic images for fine detail and less distortion. Greater detail of periapical pathology was found on periapical films, although the panoramic films were sufficient to make a diagnosis.[10] Caries is most clearly detected from bitewings, periapical films, and panoramic films, in that order.[11] Several studies have examined the effectiveness of panoramic films in finding bone loss.[12–14] Panoramic films tended to underestimate the amount of osseous destruction that was visible on periapical films. The difficulty in identifying the cementoenamel junction was given as the main reason for the inability to measure on panoramic films.

Most studies of apical root resorption occurring as a direct result of orthodontic tooth movement have shown that root shape and length are associated with increased resorption.[15,16] Teeth with abnormally shaped apices have been found to have a greater risk of root resorption than teeth with normally shaped apices.[17–22] Maxillary lateral incisors, the most commonly resorbed tooth in the dentition, also have the highest incidence of dilaceration. Maxillary central incisors, the second most commonly resorbed teeth, have the highest incidence of pointed teeth. It is important, therefore, that diagnostic records permit adequate assessment of maxillary incisor roots.

The primary objective of this study was to determine if the root shape could be evaluated as accurately on panoramic films as they can on periapical films. We also investigated whether root resorption could be measured as accurately on panoramic films as it can on periapical films.

MATERIALS AND METHODS

From a previous multioffice study, 1 office was chosen from 3 that routinely take pre- and posttreatment panoramic films and periapical films. From a block of 100 consecutive starts within the last 3 years, the first 42 complete records were procured. (An additional 20 records were drawn from the same block when it became apparent that there were insufficient numbers of bicuspids to measure.) A total of 743 teeth were measured. All of the patients had undergone complete orthodontic treatment with fixed appliances in a single-phase treatment. The age range of patients was from 10 years to 42 years, and the majority of the patients were female. Both initial and final radiographs were taken at the same laboratory. The practitioner was ABO (American Board of Orthodontics) certified with more than 20 years experience in the private, exclusive practice of orthodontics.

A 10×-magnification loop with parallax correction and a built-in 20-mm grid was used to measure the crown, root, and total tooth length of all teeth from first molar to first molar (excluding first bicuspids) directly on the films against a uniformly lit light box. Root resorption was computed as the difference between the pretreatment total tooth length minus the posttreatment total tooth length.[17] For molars, the mesiobuccal root was measured. Total tooth length was used instead of difference ratios because previous work has shown the latter increase error variance.

TABLE 1. Amount of Apical Root Resorption as Measured on Periapical and Panoramic Teeth (Millimeters)

Location	n	Periapical Mean	Periapical SD	Panoramic Mean	Panoramic SD	Significance[a]
Bicuspids	163	0.27	2.33	0.44	2.38	NS
Canines	107	0.76	2.11	1.33	3.12	NS
Lower incisors	157	0.55	1.49	1.14	2.31	**
Molars	154	−0.18	2.12	0.30	2.08	NS
Upper incisors	162	1.21	1.92	1.34	2.44	NS
Total	743	0.51	2.03	0.87	2.43	**

[a] NS, not significant; **, highly significant ($P < .01$).

Shape assessment was performed for each tooth on the pretreatment films. A 5-parameter ordinal scale (normal [N], blunted [B], pointed [P], dilacerated [D], and bottle shaped [O]) was used.[17] Teeth with open apices and teeth that could not be measured were also identified. The same investigator assessed both shape and length.

Statistical analysis

Descriptive statistics were generated for all variables. The results were analyzed using repeated measures analysis of variance (ANOVA) with amount of root resorption in millimeters as the dependent variable and type of radiograph as a fixed factor (no within-subjects variance). Post hoc tests were done with the Student-Newman-Keuls test. The root shape variable was independently assessed using Cohen's Kappa test for categorical variables. Total tooth and crown lengths were tested with multiple paired *t*-tests.

In order to examine method error, 10 cases were randomly selected and remeasured 2 weeks after the original measurements were taken. Paired *t*-tests were used on replicate pairs for pre- and posttreatment tooth length for panoramic and periapical groups separately. No significant differences were found. Replicates for shape assessment were tested using the Kappa statistic as the measure for agreement. The obtained value of .791 showed acceptable agreement between replicates.

Other sources of error that could not be controlled but are known to us were film/patient position, development times, developer and fixer consistency, and accuracy of the x-ray unit. These errors were assumed to be an insignificant part of the total variance.

RESULTS

The mean root resorption was calculated for all teeth individually. For analysis, teeth were grouped into bicuspids, canines, molars, lower incisors, and upper incisors. Root resorption measured on panoramic films was significantly higher ($P < .01$) for all teeth (Table 1). Between groups,

TABLE 2. Comparison of Total Tooth Length and Crown Length on Panoramic vs Periapical Films (in Millimeters)

	Total Tooth Length			Crown Length		
	Panoramic	Periapical	Significance[a]	Panoramic	Periapical	Significance[a]
Bicuspids	24.5 ± 2.9	20.4 ± 3.2	***	7.11 ± 1.79	5.78 ± 1.57	***
Canines	27.9 ± 3.5	25.7 ± 3.2	***	8.97 ± 1.48	8.73 ± 1.24	NS
Molars	23.5 ± 2.9	18.9 ± 3.3	***	7.41 ± 0.98	6.25 ± 0.96	***
Mx Incisors	27.3 ± 2.7	24.7 ± 2.3	***	9.22 ± 1.11	8.89 ± 1.10	***
Md Incisors	21.6 ± 2.5	20.3 ± 2.0	***	6.89 ± 0.86	7.67 ± 0.83	***
Total	24.7 ± 3.7	22.3 ± 3.7	***	7.86 ± 1.58	7.38 ± 1.72	***

[a] Significance: ***, $P < .001$; ns, none.

TABLE 3. Frequency of Root Shapes Detected by Panoramic and Periapical Radiographs

	Panoramic Films		Periapical Films	
Shape	n	Percent	n	Percent
Blunt	24	3	28	4
Dilacerated	76	10	112	15
Normal	632	85	578	78
Bottle shape	10	1	17	2
Pointed	1	<1	8	1

TABLE 4. Cross-tabulation of Root Shape: Periapical vs Panoramic Radiographs[a]

		Shape Assessment From Periapical Films					
		B	D	N	O	P	Total
Panoramic shape assessment	B	1	2	20	0	1	24
	D	1	53	19	2	1	76
	N	24	56	538	8	6	632
	O	2	1	0	7	0	10
	P	0	0	1	0	0	1
	Total	28	112	578	17	8	743

[a] B, blunted; D, dilacerated; N, normal; O, bottle shaped; P, pointed.

the difference was significant only for mandibular incisors (panoramic 1.14 mm vs periapical 0.55 mm). The least observed difference was in the maxillary incisors (panoramic 1.34 mm vs periapical 1.21 mm).

On periapical films, the upper incisors were the most resorbed teeth (1.21 ± 1.92 mm) followed by canines, lower incisors, bicuspids, and molars. The mean overall resorption for all teeth on periapical films was 0.48 mm. On panoramic films, the order by location was the same. The mean overall resorption for all teeth on panoramic films was 0.92 mm.

Total tooth length was significantly different for all 5 groups between x-ray film types (Table 2). In all 5 groups, the total tooth length was higher in panoramic films by approximately 5–20%. Panoramic films also enlarged the crown lengths for all groups except the canines.

The frequency of abnormal shapes was also significantly different between the 2 groups (Table 3). The most frequent abnormal shape on periapical films was dilaceration (15%), followed by blunting, bottle shape, and pointed. The most frequent abnormal shape seen on the panoramic films was dilaceration (10%). Consistently more abnormal root shapes were found with periapical films.

There was a highly significant lack of agreement ($P >$ .001) between the 2 groups for shape (Table 4). For example, teeth with dilacerations visible on periapical films were classified as normal 56 times, blunted twice, and bottle shaped once. Agreement was found in less than 50% of these cases. Teeth classified as dilacerated on the panoramic films were classified as normal 19 times, pointed once, bottle shaped once, and blunted once.

Measurability was examined on all pre- and posttreatment radiographs. Identifying the incisal edges or cusp tips was not significantly different between the 2 types. However, for crown length, over half the incisors and canines were difficult to measure on panoramic films compared with 4% of periapical films. In particular, the CEJ (cemento enamel junction) on maxillary canines on panoramic films was difficult to visualize.

DISCUSSION

Recent literature supports the finding that abnormal root shape is significantly associated with apical root resorption. Our results show that the 2 groups are significantly different in the assessment of root shape. Roots found to have an abnormal shape on periapical films were rated normal on panoramic films in a large number of cases. Because the literature overwhelmingly supports the superiority of periapical films over panoramic films in delivering detail, it is probable that the periapical film is correct. Therefore, our results show that it is much more difficult to correctly assess root shape on panoramic films.

The observed amount of apical root resorption, as computed from panoramic films, was found to be much greater overall than when computed with periapical films. The differences we noted can be explained largely by the inherent differences in magnification in the 2 types of films. Yet even when adjusted for an enlargement factor of 20%, the overall resorption as measured on panoramic films was greater. By location, however, only in the lower incisors were the differences statistically significant. In the critical maxillary anterior region, the differences between the 2 radiographs were less than 0.2 mm. The lower incisors are thus the most likely to be distorted to the extent that post-treatment evaluation of root resorption in this segment may be compromised. The severity of root resorption may be greatly exaggerated. A possible explanation for this finding may be in patient positioning. Usually the focal trough is aligned with the maxillary dentition and the patient is instructed to bite forward into the bite block. This would tend to exaggerate lower incisor malposition relative to the occlusal plane. It would be interesting to see if overjet and/or incisor inclination are correlated with increased tooth magnification or distortion.

One limitation of this study is the use of only a single panoramic machine, raising the question of external validity beyond this particular unit. Variability among machines has been reported;[4,23,24] however, these studies have also shown that patient positioning was a greater cause of error than intermachine variance. One-third of panoramic films were found to have projectional and processing errors when submitted with biopsy specimens.[25] In a similar study, over 1800 panoramic radiographs were judged for diagnostic acceptability and over 33% were found unacceptable due to positioning errors, low density, and low contrast.[26] Newer machines with smaller focal spots and variable centers of rotation may be more accurate, although a recent study could not confirm this.[27] A future investigation to control more fully the many external and internal sources of variance might involve the use of teeth of various lengths and conformations placed in a mannequin, exposed on several different panoramic units and compared with a reference-standard periapical film of the same teeth.

Newer forms of imaging adopted into practice may make the present debate a moot one. For optimum visualization of the root, cross-sectional tomography[28] may be the method of choice, although the cost and radiation exposure make it unpractical for routine use in orthodontics. Digital imaging will soon supplant ''wet'' radiography.[29] The reduced exposure and enhanced images from this rapidly evolving technology should encourage more clinicians to take periapical films in this manner.

Periapical films provide a more detailed view of the alveolar bone and root. A well-taken panoramic film can be as diagnostic as a set of periapical films, but there is much variability among laboratories and machines. If the panoramic films are consistently distorted or hard to read in the same region, the clinician should discuss and resolve the problem with the technician. We agree with other investigators who caution against ordering the same set of pretreatment radiographs routinely on every patient.[30,31]

CONCLUSIONS

Root shape is more difficult to properly assess on panoramic films. The CEJ is more difficult to see, making crown or root length determinations from this junction inaccurate. If initial and final panoramic films are used, the amount of root resorption will be exaggerated by 20% or more. Mandibular incisors are especially vulnerable to this distortion.

Panoramic films suit a wide variety of purposes as initial diagnostic radiographs in orthodontics. However, clinicians should check the films carefully and order periapical films if the roots cannot be visualized accurately. We also recommend periapical films for patients at higher risk for root resorption or bone loss.

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