DECEPTIVENESS AND LIMITATIONS OF ROENTGENOGRAMS IN ENDODONTICS; A COMPARATIVE STUDY WITH RADIOVISIOGRAPHY AND COMPUTERIZED TOMOGRAPHY

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Abstract

This research was designed to compare the limitations and deceptiveness of conventional radiographs with radiovisiography (RVG) and computerized tomography (CT) in determination of procedural errors during routine root canal therapy (RCT). In 50 single and multirooted extracted teeth were used randomly and, custom made procedural errors were created as their anatomical structures allowed to simulate potential errors during RCT. Then they were photographed and the X-rays of all teeth were taken at a standart angle with parallel technique, the second step was taking the X-rays and pictures from proximal aspects to prove the errors. Additionally, RVG and CT images were taken. The RVG images and the X-rays were evaluated comparatively by the same combined group of dentists, endodontists and students to find out the hidden procedural errors on. In RVG group to determine the procedural errors, the failure rate was 79% (The statistical result was significant, p=0,00001). In the X-ray group the failure rate was 71,8% (The statistical result was significant, p=0,0042). We could not obtain the expected outcome from CT. CT could only differ the unfilled canals from others; could not visualize the difference of densities of any filling materials or instruments existing in the canals. We concluded that during the root canal therapy, RVG was the better to finding out the procedural errors in comparison to routine x-rays, but both of them were not precise sufficiently.

Keywords: Computerized tomography, procedural error, radiographic limitations, radiovisiography, unfilled canal.

Introduction

Radiography may be the most accurate and least subjective diagnostic aid available to the endodontist. Further constraints arise from the assessment of equivocal three-dimensional disease processes that vary over time from two-dimensional radiographic images (1). Although radiographs are inseparable parts of endodontic therapy; e.g. they have some disadvantages; magnification, distortion, superpositioning (overlapping of roots) and they also causes some troubles on diagnosis of bucco-lingual lesions, crack lines. Therefore, sometimes roentgen films lead us to misdiagnosis of cases or they are deceptive for evaluation, examination of root canal fillings and procedural errors. Although conventional periapical radiographs produce acceptable details in the mesiodistal direction, the observation of details in buccolingual dimension is inadequate (2).

Other disadvantages of film-based techniques include the time required to process the film interrupting the dental treatment, and variability of image quality associated with chemical film processing. In addition, film processing
and storage require much space, and manipulation of film-based images is impossible after processing (3).

Everyday, specialists, general practitioners and students perform many root canal treatments and these fillings are evaluated by instructors in dental schools or in private practices by the doctors. But sometimes very successfully looking root canal fillings on X-ray may be a really substandard one because of deceptiveness of radiographs.

In recent years, new imaging techniques have been developed with the aim of improving the clarity of the image whilst reducing the radiation dose (4).

The first radiovisiography (RVG) system was introduced to the international market in 1987.

RVG offers following advantages, e.g. the images are produced nearly instantaneously which there is a reported reduction in the radiation dose to the patient, chemical processing is eliminated, images can be stored electronically or on thermal prints, digital images can be transmitted over telephone lines for consultations or referrals, and RVG images can be manipulated by computerized functions (5). These computerized functions include the manipulation of digital images allowing for variation in image presentation; e.g. contrast and brightness manipulation, digital filtering, zoom function, millimeter gridding, reverse imaging, color intensity mapping, gray-level enhancement, upside-down flip, pseudo-coloring, image recalling and printing. The gray-scale image type relies on image presentation through 256 shades of gray. Reverse imaging converts the digital image to a negative, and color intensity mapping substitutes different colors for gray-scale values (6).

The operating principle of these machines is first to obtain a suitable TV image of a specimen, after which each line of the TV frame is then divided into a number of picture points. Each point is assigned a ‘gray-level’ value (usually from 0 to 64) depending upon the brightness or darkness of that region of the specimen. Areas with similar gray-level values may be detected by adjusting ‘thresholds’ to a range which excludes all parts of the image with brighter or darker gray-level values (7).

The most common advantage of radiovisiography system for the patients is the creation of cooperation between the patient and the dentist by examining whole of his treatment on the monitor. By this way the patient gets knowledge about his treatment and trusts the dentist more.

In dentistry computerized tomography has been widely used in oral implantation to determine the structure of mandible. CT can image the transversal informations missing from X-rays. It also gives three-dimensional images, and can clearly image the relation-ship between the anatomically neighbouring structures and bone. Although CT has advantages over conventional tomography, it also has some disadvantages such as motion and metal artifacts, increased radiation exposure, limited availability, and higher cost (2).
CT produces its images by dividing the region of the body which is going to be determined into millimeters (8). Unlike the two-dimensional systems, the information derived from any object within the slice is unaffected by variations in the material on either side of the slice (9).

CT can provide the necessary information prior to surgery which brings problems that occur during standard implant procedures such as malpositioned implants, damage to neurovascular structures, or intraoperative bleedings threatening the patient’s life (10).

The purpose of this study was to determine the limitations and deceptiveness of conventional systems versus radiovisiography (RVG) and computerized tomography (CT) comparatively in certain cases with procedural errors like perforations, broken instruments, inadequate root canal fillings, stripping, superpositioned roots in vivo and in diagnosis statistically.

**Materials and methods**

Randomly selected 50 teeth were used for this study (14 anteriors, 12 premolars, 24 molars). These teeth were numbered from 1 to 50. The preoperative X-rays of each were taken at the beginning of the study. We have decided what kinds of custom made procedural errors we were going to create as their anatomical structures allow. The procedural errors were broken instruments, over and underfillings, perforations, zipping, stripping, fractures, false canal, inadequate root canal fillings. These iatrogenic errors were created while filling the canals in some strategic points which are examining difficult with X-rays. The idea when creating these errors were to think clinical procedural errors and select the teeth to reflect such errors. Procedural errors were also selected on the basis that at the normal angle the error would not be seen, but when the mesial and distal aspects were taken, the error was going to be seen from one direction.

![Fig 1](image.jpg)

**Fig 1:** The photograph of the sample. The overfilled gutta-percha can be viewed at the perforated apical portion.
Following step, all these teeth were filled with AH26 and gutta-percha and during cleaning, shaping and filling, the hidden errors were created purposely. Then all the teeth were photographed in order to prove the error if the error was seen from outside of the root (Fig. 1). All specimens were mounted in custom-built Plexiglass devices with the attachment of the Rinn positioning ring (Rinn Corp. Elgin, IL) that provided a uniform orientation, constant source-to-object distance of 4.5 cm, and object-to-film distance of 2.5 cm. The film was held parallel to the long axis of the jaws, and both were perpendicular to the X-ray beam. Kodak Ultraspeed (Eastman Kodak Co., Rochester, NY), size 2 film, was used and exposed for 0.64 s at 70 kVp, 15 mA (Siemens Heliodent). Each specimen was positioned with a standard orientation that allowed the use of paralleling techniques throughout (Fig. 2). Later, these teeth were radiographed from different aspects such as 30 degrees mesial or distal to the teeth where we also tried to keep standardization procedures and tried to prove the iatrogenic errors on different aspects (Fig. 3). After conventional radiographs, the samples were imaged with dental digital radiographic (DDR) techniques and computerized tomography.
Same mounts were used to ensure consistency of angulation and source-to-object distance for the RVG images. Trophy (model 32000) use a radiation source (fixed at 70 kVp and 8 mA) that is integrated with the imaging system. The settings used were that of a lower molar (Trophy designation 48). These exposure parameters for Trophy were measured at 0.25 or 0.29 s (15 and 17 impulses) by using a Mini-X-digital kVp/exposure time monitor (Frank Barker Associates, Pequannock, NJ). Trophy images were taken from the same aspects where we could not see the procedural errors in conventional techniques (Fig. 4). Our aim was to determine the results of the two techniques in the same directions and to examine if RVG was adequate where X-ray images were limited. Trophy images were printed using a UP 850 video thermal printer (Sony). Then enhanced images of each were examined, and printed. The images were manipulated if the observation of details would get better without any other exposures and changing the direction, as the computer functions allowed. The enhancements were such as gray-scale, color intensity mapping, reverse image, contrast and brightness manipulation and zoom. Again the thermal prints were obtained.

![Fig 4: RVG image of the first sample taken with the same parallel technique that the procedural errors cannot be detected on X-ray.](image)

The CT images were obtained at 120 kV and 150 mA by using a spiral CT scan (Siemens Volume Zoom) with a speed of 1mm per rotation and 1mm slice thickness. The images were reconstructed from the raw data to obtain oblique cuts, which were 1mm apart (Fig. 5).

We have prepared a questionnaire form that includes the X-ray and the RVG images from the same directions that we took first where examining the errors was so difficult, for the randomly selected examiners from the Department of
Endodontics in Hacettepe. They analyzed all the images in a darkroom and noted what they could see as a procedural error. Then they were scored according to the number of their right and wrong answers. After 20 days interexaminer agreement test was also applied to the evaluators. Hypothesis test of two proportions for independent samples was used for the statistical analysis in finding out the success rate of X-ray and RVG alone, and their success according to each other. We ourselves also examined the images of CT and compared with X-rays and RVG for the procedural errors.

![Fig5: CT of the second sample with 1mm slice thickness. Second canal is not filled.](image)

**Results**

According to the statistical results in X-rays, the success rate was 21% indicating highly significant differences (p=0.00001). In RVG, the success rate was 28.2%, with significant differences (p=0.0042). And when we compared the failings in determining the procedural errors of both X-rays and RVG to each other, the difference between the rates 79% and 71.8% was found significant statistically (p=0.0051).

As a result, RVG was more successful on imaging the procedural errors from the same angle over conventional radiography. When the second image from a different angle was taken, we could examine the procedural errors standing behind the structures in front. The procedural errors in CT images could not be seen clearly, on the contrary we were expecting getting well on 1mm slices and three-dimensional images at the beginning of the study. Superpositions were never seen because of three-dimensional imaging. As there were no superpositions, we could be able to examine the exact number of unfilled canals or roots, but we could not be able
to differ any kinds of materials that have different density in a canal such as gutta-percha, broken instruments, any of the filling materials.

**Discussion**

To obtain maximum information it is necessary to expose at least two radiographs of the area under investigation, one taken at the normal, standard (direct) angle and the other with an altered angulation (11). In endodontics, altering the angulation can be useful to determine the number, location, shape, size and direction of curvature of roots and canals; identify superimposed roots and canals; establish the position of root curvatures; locate the position of root apices in relation to anatomical landmarks; distinguish between anatomical landmarks and radiolucent apical pathology; establish the position of iatrogenic errors (perforations, fractured instruments etc.); distinguish between internal and external root resorption; locate foreign bodies following trauma; establish the position of root fractures or resorptive processes (11).

Roots that are superimposed on a standard radiograph can be visualized when a mesial or distal view is taken (11).

In general, because of excessive time loss and cost we happen to take just one radiograph at a standard angle. If the endodontist does not feel any need for further care in cases of canal variations or procedural errors that cannot be detected at a normal angle, then the patient is at risk for a less effective treatment (12). Even if the radiographs that endodontists evaluate look to be perfect, the iatrogenic errors may not be visible on the radiographs at the first angulation.

Zakariasen et al. (1984) reported that when radiographs from three different angles were taken of each periapical area, intraobserver agreement rose from 70% to 87%. The data from this study indicate that unreliability of endodontic radiographic interpretation is a serious problem and that incorrect/failure diagnoses are occurring (13).

One of the problem noted with the RVG images was the inability to see a file in the canal when the image was enhanced to make the apex clearly visible. Too much enhancement resulted in a loss of fine detail, such as the tip of the file disappearing from the image (14). Conversely, in our study we found that the RVG images were superior to the X-rays because of magnification and enhancement, and especially the procedural errors that were created in small areas were more clearly visualized by that magnification. According to the results of Melius et al. (15), the 0.1mm difference between the digital and conventional radiographs had no clinical significance. Because of this, a dental film read without magnification has about the same amount of observable information as a filmless dental radiograph (16).

The data in our study indicated that digital radiographs have so many advantages over X-rays. These are; less radiation dosage, real-time images, image enhancement during interpretation, image storage without loss of any
knowledge, no need for darkroom, better diagnosis (17). In our study RVG images could not directly visualize the errors different from the X-rays, but because of the enhancement of the images, and the density changes we could make, RVG images could prove the errors where we estimated. It is suggested that the other advantage of digital radiography is environmental protection, because the use of developer and fixing solutions will become history (17).

One of the problems we have met with RVG was the difficulty on placing the hard sensor especially to the palate, because of this, many times we could not be able to see the apices of roots and we had to increase the number of RVG images with extra radiation dosages.

Prints of images of RVG can be achieved. The prints do not have quality of the monitor-displayed images and the advantage of operating with the image in the dynamic electronic form is lost (17). This point is in agreement with our study too; an ideal image on monitor cannot be the same as the print of the real image. In spite of all these advantages, filmless dental radiology has not really become popular in the world. Probably the single most important reason for this is cost (16). These systems cost three to five times that of a conventional radiographic system. As with all new technology, it is expected that the cost will drop as the system improves.

In contrast to conventional radiography and radiovisiography, all the anatomical structures and canal variations lying behind a root canal treatment can always be detected in computerized tomography. The most significant advantage of CT that makes it superior to other systems is the imaging ability of transversal details and buccolingual aspects that are missing in other techniques. Buccal and lingual root canals cannot be differentiated on the radiographs because they are superimposed (2). CT has disadvantages over other systems such as motion and metal artifacts, increased radiation exposure, limited availability, and higher cost (2). But the radiation dosage and exposure time used for CT scans are decreasing because of improvement in technology in recent years (2). Reconstructing is time-consuming (9). In addition, the equipment needs too large space and educated personnel for reconstruction is necessary.

If the endodontist in a clinic wants to take a series of radiographs from one patient at once, the radiation dosage is going to be reported as approximately 2 rad, and it is equal to the dosage in CT.

In this study, differing the density of any radiopaque material in a canal such as filling materials, broken instruments, was impossible. We think that the first reason was the existence of silver inside AH26, and the second reason was the pixel spacing of 1-2mm that was too thick for the structure of a canal. The little spread that the silver created in the canal resulted in ignorance of whole image. While passing to a radiolucent area from a dense radiopaque area (the canal with root canal treatment), some kinds of radiolucent artifacts were seen like shadow. These radioluencies were just artifacts, but they could make the endodontist think that voids were present in the root canal treatment.
In a study of Youssefzadeh et al. (18), the metallic artifacts of the post overlaid the buccal root and deteriorated the image quality, and the fracture line could not be detected. In our study, CT resolution was insufficient to render the exact shape of the canals, but we could demonstrate the width of the canals comparatively. In the radiographs we daily take in clinics, extra roots and canals are missing (12). It is suggested that computerized tomography might be used within the field of endodontics when a differential diagnosis or more information was needed for the clinical management of periapical bone lesions. In that regard it was important to know that dose reduction methods had been established so that the technique might be used with low radiation risk (19). Tidmarsh has pointed out (20) that psychological factors played a particularly important role in the process of visual interpretation. It seems that at times an observer sees only what he or she wants to see. It is also suggested that such factors as tiredness, whether the observer was upset, and closeness of involvement with the case might all influence the results. We also think that if the examiners had more experience about the evaluation of RVG images, then the results would have changed so much.

**Conclusion**

The present study indicates that most of the procedural errors during the endodontic therapy, we could not see on conventional radiographs and could not also be seen on RVG. Either routine radiography or RVG are generally deceptive to determine if any procedural error is exist. On the other hand, a very satisfying looking root canal filling may not be a real good one indeed unless we can not be seen from different aspect or could be evaluated by different techniques. However the advantageous difference of RVG comes from the advantage of magnification and manipulation of the images even if it is too little. We suggest that because of the advantages that RVG has brought, it should be routinely used in the field of endodontics. Additionally, whenever the two-dimensional system (conventional technique) is used, we suggest that the second angulation should be used (paralactic film technique). We suggest that CT should just be used at times of need such as implantology or apical surgery; it should be used as a last applied technique.

Overall to evaluate the quality of the RCT performed, the hidden and unvisible (unexamined) procedural errors must be keeped in mind and their potential dangers to failure of the case shouldn’t be figured out. Using the recent and contemporary technology in the field of endodontics and dental diagnostics is very critical factor to improve the success rate, patient satisfaction and clinical practice.

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References