# Reduction of radiations exposure in endodontics: comparative analysis of direct (GX S-700, Gendex) and semidirect (VistaScan Mini View, Dürr) digital systems

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**The importance of intraoral periapical radiography is crucial as it represents a fundamental mean of evaluation and diagnosis for supporting bone and teeth hard tissues diseases and pathologies. Even though conventional film technology is still widespread, presently there are many digital radiography alternatives. Direct digital systems are devices with an intraoral sensor wired or paired wireless with a computer. These devices do generate an image immediately during exposure and acquisition. The semi direct digital systems instead are based on phosphor image plates. Digital radiography offers many chances to improve our patient's healthcare standards reducing exposition to X-rays and the related stochastic radiation risk. Aim of this study is to compare the quality of images for endodontic purposes comparing three systems: conventional films, direct digital radiography and semidirect digital radiography.**

The importance of intraoral periapical radiography is crucial as it represents a fundamental mean of evaluation and diagnosis for supporting bone and teeth hard tissues diseases (1) and pathologies. In endodontics, a periapical preoperative radiograph is always needed to address periapical pathologies, evaluate the endodontic anatomy and more generally make a correct diagnosis (2-9). Even though conventional film technology is still widespread, presently there are many digital radiography alternatives. Direct digital systems are devices with an intraoral sensor wired or paired wireless with a computer. These devices do generate an image immediately during exposure and acquisition. The semi direct digital systems (10) instead are based on phosphor image plates; the exposed image plate needs to be read from a digital scanner to obtain the desired radiographic image (11-15).

An advantage for semidirect systems is that the image plates are very thin (same thickness of conventional films) and are available in several different dimensions to meet different clinical situations. The conventional dimension allows for use of conventional intraoral radiography holders (16-25).

Direct systems, being based on a physical intraoral sensor, are available in few dimensions, varying from brand to brand, and are always rigid and thick. These sensors do need specific holders and can be more difficult to be used in not optimal situations such as lack of space or small mouths. Despite these drawbacks they can generate the images immediately without the need for processing in a separate dedicated scanner (26-32).

The great advantage of digital over traditional radiology is reduced radiation dose needed to generate image, speed of image generation, easy recording and handling of the image, easy image sharing, and finally possibility of image editing in dedicated software to increase contrast, lightness sharpness (33-36). Overall, digital radiography offers many chances to improve our patient's healthcare standards reducing exposition to x-rays and the related stochastic radiation risk.

Some authors found that direct digital systems

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have same accuracy of traditional film technology in diagnosing periapical lesions; comparing different digital radiology devices, some authors did not find any significative difference in the generated images (37-41).

On the other hand, comparing traditional radiology with digital radiology, many other authors claim that the old traditional film still is slightly superior to any digital technology. In the comparison between direct and semidirect digital systems there is no agreement in literature to assess if one system is superior to the other (42, 43). Presently, there is no definitive word on what the best radiographic technique is to evaluate periapical lesions. In the last years, the diffusion of digital radiography systems increased due to reduction of radiation exposure and ease of record managing (44-53) but there is still a lack of knowledge in what system is better than the other. Aim of this study is to compare the quality of images for endodontic purposes comparing three systems: conventional films, direct digital radiography and semidirect digital radiography.

## MATERIALS AND METHODS

*Inclusion and exclusion criteria and sample size*

All included patients for the study were in good health and between 20 and 60 years of age. The patients were enrolled in the UOSD-Emergency Dental Department and Unit of Conservative, Restorative and Endodontic Dentistry of the Tor Vergata Policlinic, Rome, Italy. All patients with cognitive deficit or in treatment with mind-altering drugs, pregnant women, patients professionally exposed to X-rays or recently undergone to high radiation doses for diagnostic or treatment reasons, were excluded from the study.

The study was approved from Tor Vergata Ethical Committee and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. The sample size was calculated using the necessary parameters (mean, effect size, standard deviation) and resulted in 150 patients (Power 80% and Significance 0.05%).

*Radiographic images*

All radiographic images were taken with the same X-ray generator unit: X70PP (Castellini, Imola-Italy). This unit is fully compatible with all imaging technologies used in the study varying the exposure time according to producers' indications.

1. Conventional films used: Carestream Ultra-speed DF-58 (Carestream Dental, Italy).
2. Semidirect digital system used: Image Plates Plus size 2 3x4 and digital scanner VistaScan Mini View (Durr Dental, Germany).
3. Direct digital system used: GX S-700 Intraoral Digital Sensor (Kavo Gendex, Germany).

To reduce variability all radiographic films were processed with a Durr automatic developer using dedicated developer and fixer solutions. All processed films were stored and evaluated on the same white light X-ray film viewer with 4.5x optical magnification (10) in a controlled light ambient.

All digital radiographs were stored and evaluated with the same laptop PC with an integrated high-definition monitor and in a controlled light ambient. All radiographs were taken with appropriate intraoral holders following indications of the producers.

*Anamnestic data, informed consent and operative procedure*

During first visit appointment a complete anamnestic interview and an informed consent was obtained from each enrolled patient. According to inclusion and exclusion criteria, 150 patients were enrolled for the study, 68 males (45.3%) with age 44.56 ± 16.39 years and 82 females (54.7%) with age 48.65 ± 17.45 years.

Each patient received only one kind of radiography out of: radiographic film, direct digital and semidirect digital, from one expert endodontist (more than 10 years of practice). The sample was randomly divided into three groups:

- Group 1 (n=50): radiographic film
- Group 2 (n=50): semidirect digital imaging with Image Plates Plus size 2, 3x4cm
- Group 3 (n=50): direct digital imaging with intraoral sensor

*Images, analysis and evaluation*

Images were analyzed by six examiners: three expert endodontists (with more than 10 years of experience) and three limited experience operators (young dentists with less than one year of practice). All six examiners

participated to a preliminary calibration session to the evaluation of the different radiographic images and the scoring procedure. Each examiner individually evaluated the 150 radiographic images giving a score to these parameters (Table I):

1) ease of visualization of the periodontal ligament at the cervical and middle third of the root (score 0-1-2) (LPCM);
2) ease of visualization of the periodontal ligament at the apical third of the root (score 0-1-2) (LPA);
3) ease of visualization of endodontic canal/s at the cervical and middle third of the root (score 0-1-2) (RCCM);
4) ease of visualization of endodontic canal/s at the apical third of the root (score 0-1-2) (RCA).

Score: 0- not visible; 1- partially visible; 2- perfectly visible.

*Statistical Analysis*

All data were initially entered into an EXCEL database (Microsoft, Redmond, Washington – United States) and the analysis was performed using the Statistical Package for the Social Sciences Windows, version 15.0 (SPSS, Chicago, Illinois, USA). Descriptive statistics consisted of the mean ± standard deviation for parameter with normal distributions (after confirmation with histograms and the Kolgomorov-Smirnov test), median and range (min/Max.) for variables with non-normal distributions and for frequencies percent. Comparison among groups was performed *Chi*-Square test or Fisher's exact test (if cells<5) for categorical variables. A p value of $<0.05$ was considered statistically significant.

## RESULTS

The three expert examiners gave similar scores. Results of the two groups of examiners and experts *vs* novices, gave slightly different scores. Comparing the three expert examiners with each other for each single parameter, no statistically significant differences emerged in the assessments given, while for novices this applies to the LPCM and RCCM parameters, while the assessments of LPA and RCA are less uniform. By assuming the values expressed by the group of experts as a reference parameter, it is possible to construct an assessment of agreement by parameter with respect to the method.

For the LPCM parameter, the test performed is significant. Method 3 determines more concordances *vs* method 2 *vs* method 1. Method 1 therefore determines a greater discrepancy. For the LPA parameter the test is not significant. Methods 2 and 3 appear to have similar agreement, method 1 less. For the RCCM parameter the test is not significant, and the 3 methods are quite concordant. Finally, for the RCA parameter the test is significant. Method 2 determines more concordances *vs* method 1 and 3. Conversely, method 1 determines a greater discrepancy.

## DISCUSSION

Digital radiography has substantial advantages such as reduction in X-ray dosage and digital image acquisition without the use of a dark room and liquids for development and fixing. The two types of intraoral digital radiographs mainly used are semi-direct and direct (phosphors). Some authors (54-58) report that the direct system (phosphors) is better than the semi-direct system, but the limit of this *ex vivo* study is that of having radiographs performed in the absence of saliva and without the presence of

**Table I.** *Legend of parameters.*

| Parameter | Legend |
|---|---|
| LPCM | Periodontal ligament of the cervical and middle third |
| LPA | Periodontal ligament of the apical third |
| RCCM | Root canal of the cervical and middle third |
| RCA | Root canal of the apical third |

soft tissues. Furthermore, according to the authors, the semi-direct system is more difficult to handle and to place in the oral cavity than the direct one.

In our study we conducted an analysis of the results obtained for the group of experts and for the group of novices. In the group of experts, for the LPCM parameter, it seems that there is no disproportion in the values obtained and therefore there is no statistically significant difference. As regards the intergroup analysis between methodologies, this is highly significant for the group of expert operators for the LPCM parameter. In fact, there is a difference in the results, as the response to the two digital technologies is discordant with respect to the conventional methodology (59-62).

As regards the LPA parameter, the results obtained are not statistically significant. It should be emphasized that, however, a more consistent trend was seen in the judgment of operators 2 and 3 compared to operator 1 among the expert. The results between the 3 methodologies reported that in methodologies 2 and 3 no operator had doubts on the detection of LPA (no 0-value reported), and therefore it is more amplified for LPA than LPCM. This makes us assume that the expertise of expert is certainly more similar to the conventional methodology as it is still easily interpretable for operators. On the contrary, digital methodologies are more difficult to interpret by expert operators, probably due to less experience with the digital system.

Analyzing the RCCM parameter, the operators are in agreement with the results and there is no statistically significant difference. In the analysis between the methods there are no concordant results and therefore there appears to be a highly significant difference, even if there is uniformity. If we consider the conventional method as a reference, parameter 0 is the most represented. There is no statistically significant difference between the examiners for the RCA parameter. For the methodologies there are no values of 0 (possible maximum errors), probably associated with the fact that the direct system is the one most subject to distortion.

The analysis of the group of novices showed less uniformity in the results compared to the expert group.

Examining the LPCM parameter, it emerged that operator 2 provided more 0 results than the others, although this is not statistically significant. Also, for the methodologies examined, there are no statistically significant results. This consistency of results with respect to 0 shows that these operators have more doubts than the group of experts analyzed previously. This indicates that non-expert traders are less in agreement on the evaluation of the analog system than experienced traders.

As for the LPA parameter, in the analysis between operators there are limit values and therefore there is a statistically significant difference. The value 0 is what determines the most relevant values. The analysis, on the other hand, between methodologies, there are percentage inversions between methodology 1 and 2 (less among the experts) and therefore there is a statistically significant difference.

The RCCM parameter is even more relevant since in the analysis between operators there is no statistically significant difference even if operators 1 and 3 report clearly different values for the values of 0; while for the methodologies there is a highly significant difference, even if the methodologies 2 and 3 report almost overlapping values. Finally, for the RCA parameter, discordant results emerged among the operators, while for the methodologies the values are uniform, but this does not express statistical significance.

The comparison of the three studied types of radiographic images does not give the supremacy of one technique on another. All three radiographic imaging techniques demonstrated the same accuracy in visualizing correctly small structures such as the periodontal ligament and the endodontic canal. The results confirm that all three techniques are valid diagnostic media for endodontic diagnosis and treatment planning. The direct and semidirect digital techniques offer the advantage of a highly reduced radiation dose for the patient maintaining a very high quality of the image (63-69). Between direct and semidirect systems, the semidirect is often less invasive in the oral cavity due to the much lower thickness similar to conventional films. Digital systems offer the great advantage of an immediate image, no chemicals for processing that need to

be disposed of ease of image enhancing if needed and measuring software tools. A digital image is also very useful for patient data storage and referral purposes. Overall, the most important factor to digital radiography is the reduction of X-ray exposure which means less risks for the patient (70-72). As for almost every other application in radiology, the advance of technology made the conventional films a thing of the past. The present and the future of radiology is digital imaging.

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