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Research Report

Biological changes after dental panoramic exposure: conventional versus digital

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ABSTRACT

Background: *Dental digital radiography is more practical and requires fewer doses of radiation than conventional radiography. Because ionizing radiation has a biological effect on exposed tissue, concerns regarding its stochastic effect merit greater attention. In a previous study, it was found that biological changes and increases in the micronucleus occurred after conventional panoramic exposure to gingival crevicular fluid (GCF).* ***Purpose:*** *The purpose of this study is to investigate the difference in biological effects after digital panoramic exposure compared with conventional exposure.* ***Methods:*** *Twenty subjects were classified into two groups according to the radiographic technique employed. The techniques consisted of ten subjects undergoing digital panoramic radiograph exposure and ten others being subjected to conventional exposure. GCF calculated in mm^3 was collected by applying paper strips to the anterior maxillary labial gingival sulcus for one minute prior to and ten minutes after exposure. A micronucleus was obtained from a gingival smear on the same quadrant ten days after panoramic exposure.* ***Results:*** *There was a significant difference in the number of micronucleus between conventional and digital panoramic radiographs both before and after exposure (p=0.000). In contrast, increased GCF volume was not statistically significant (p=0.506) before or after digital panoramic exposure, while the significant difference of conventional panoramic exposure was p=0.017.* ***Conclusion:*** *Digital panoramic radiograph exposure induced a biological change only in terms of an increase in the number of micronucleus but not in the volume of GCF.*

Keywords: *digital panoramic; gingival crevicular fluid; micronucleus*

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INTRODUCTION

Dental digital radiography is gaining rapidly in popularity. The advantages of using dental digital radiography include: optimization of image contrast and sharpness, ease of processing, less prolonged storage and the enhanced practicality of carrying out diagnostic procedures.[1] Digital radiographs can reduce the effective dose by up to 50% compared with conventional radiography.[2] This attempt represents one radiation protection procedure because, although dental radiography administers extremely limited doses, it is not completely without risk.[3]

Theoretically, the biological effects of dental panoramic exposure can damage cells through oxidative reaction, including the formation of micronucleus.[4,5] A micronucleus is often employed as a biomarker of chromosomal damage that, in its early stages, contributes to carcinogenesis.[6] Research has confirmed the increase in micronucleus after conventional panoramic radiograph exposure which has a correlation with 8-oxo-dG expression as a marker of DNA adduct.[7]

In addition to the micronucleus, the volume of gingival crevicular fluid (GCF) also increases after conventional panoramic radiograph exposure. A previous study confirmed a significant increase in the volume of a patient's GCF due to conventional panoramic radiograph exposure.[8] The increase in GCF volume is related to the enhanced permeability of the blood vessels after exposure to radiography. The findings of these studies indicate the incidence of both cytogenetic and genetic damage due to

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panoramic radiograph exposure. The sulcular epithelial of the oral mucosa produces GCF which contains plasma protein and has antimicrobial properties. Conditions that increase the production of GCF include: rough food mastication, brushing of the teeth, gingival massage, smoking, periodontal disease and contraceptive use. The amount of GCF also increases in correlation with the severity of inflammation.[9]

Endothelial vascular cells are radiosensitive to X-rays whose effect on vascular permeability constitutes an early symptom of ionizing radiation toxicity.[10] Vascular permeability increases in normal tissue immediately after radiation before gradually decreasing after two to three days.[11] Increased GCF volume may occur due to enhanced vascular permeability in the inflammatory state. Plasma fluids leaving the blood vessels are released into the gingival crevicular region through the junctional epithelium.[12]

Because of the numerous risks of conventional panoramic radiograph exposure, it is also necessary to conduct research on its effects, especially in the form of an increase in the number of micronucleus in the gingival mucosa and GCF using digital panoramic radiography. The purpose of this study is to investigate the different biological effects after digital panoramic exposure compared with conventional treatment.

MATERIAL AND METHODS

Sampling was conducted randomly and included an experimental and control group. The research was conducted at the Dentomaxillofacial Radiology Laboratory, Faculty of Dentistry, Universitas Gadjah Mada after Ethical Clearance from the Faculty of Dentistry Universitas Gadjah Mada (No.001099/KKEP/FKG-UGM/EC/2017) had been obtained. The subjects were patients who, on the basis of his/her dentist's recommendation, underwent dental panoramic digital or conventional radiography.

Informed consent was obtained from willing participants whose suitability for this study was based on the inclusion criteria. Preferred subjects were those free from systemic disease, who were able to return for a gingival mucosa smear on day 10, had not been exposed to X-rays during the 14 days prior to the start of the study, were gingivitis-free at the research site, did not smoke and were not alcoholics.

Two groups participated in this study, one undergoing digital panoramic radiography and the other conventional radiography, each consisting of ten subjects selected by purposive sampling technique (referred to in the previous study).[8] The volume of GCF on the labial anterior maxillary around teeth 12 to 22 was measured both prior to and ten minutes after exposure. Paper strips were inserted into the labial gingival sulcus for one minute, before a drop of 2% ninhydrin solution was added. After the paper had turned purple, measurements were taken to quantify the volume of GCF in mm^3.[8]

Analysis of the increase in the number of micronucleus was conducted by swabbing the anterior gingival mucosa using a cervical brush and subsequently smearing the material obtained onto a microscope slide. The swabbed cells subjected to micronucleus analysis had been obtained from the same region as the GCF whose volume was measured. The swabbed cells were stained with Schiff's reagent for 90 minutes following the Feulgen-Rossenbeck method and a counter stain was performed with 1% fastgreen for one minute. The micronucleus were examined under a light microscope at 400X magnification. A micronucleus was defined as a cell having an additional nucleus around the main nucleus, while possessing the same colour and a diameter approximately 1/3 that of the main nucleus.

Based on the results of a Saphiro Wilk Test, the normally distributed data was further analyzed by means of an Independent T-Test to examine the difference in the number of micronucleus on the exposed gingival mucosa between conventional and digital panoramic techniques. Paired T-tests were conducted to analyze the data relating to GCF volume both before and after digital and conventional panoramic exposure.

RESULTS

The results of this study confirmed the mean number of micronucleus before conventional panoramic radiography exposure as 0.40 ±0.15, increasing post-exposure to 12.4±3.08. On the other hand, the mean number of micronucleus pre-digital exposure was 0.60±0.23 and post-exposure 7±1.78 (Figure 1). These numbers confirmed the mean of the increase in micronucleus to be higher in conventional panoramic radiography exposure than digital exposure. The micronucleus presented in Figure 2 possess a smaller extranucleus around the main nucleus and similar staining to the main nucleus. The appearance of micronucleus as the result of digital and conventional panoramic radiography has a similar character.

The volume of GCF was measured pre- and post-exposure by means of both digital panoramic radiography

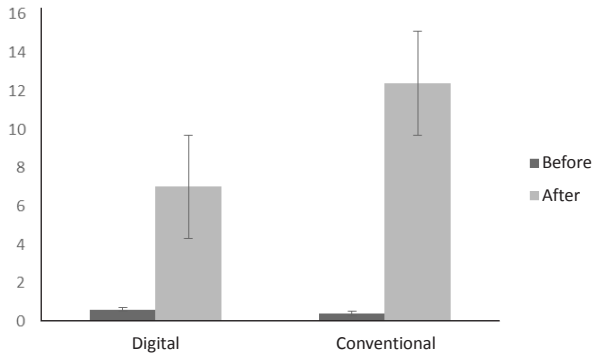

Figure 1. The differences mean of micronucleus increasing between digital and conventional panoramic radiography at day 10 after exposure.

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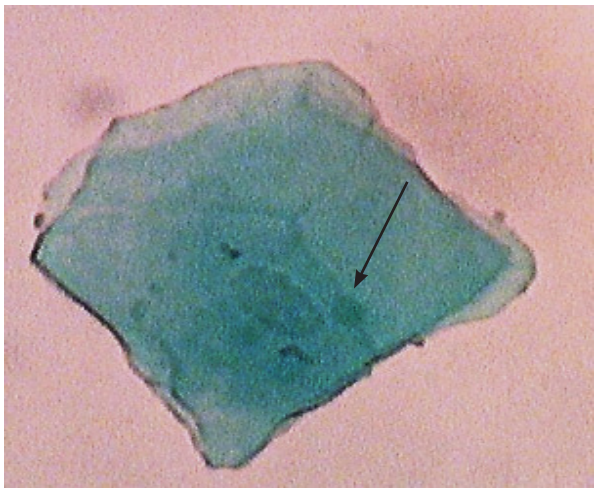

Figure 2. A representative cell with micronucleus after panoramic radiography exposure (arrow).

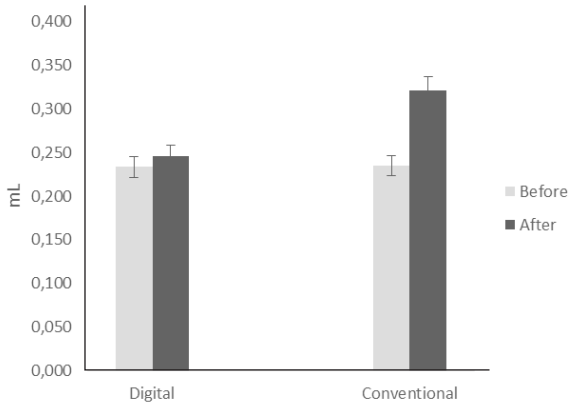

Figure 3. The means of GCF volume between before and after digital and conventional panoramic radiography exposure.

Table 1. Paired T-Test analysis before and after penoramic exposure in digital panoramic.

Parameters Micronucleus number	Conventional		Digital	
	Std Error Mean	Sig.	Std Error Mean	Sig.
Before	0.163	0.000*	0.221	0.000
After	1.002		0.526	

*Significant difference <0.05

exposure and conventional technique. There was a higher increase in the volume of GCF post-digital panoramic exposure with a mean of 0.246±0.050 compared with pre-exposure (0.233±0.052). Similar to this result, a conventional panoramic technique showed a higher increase post-exposure (0.321±0.067), compared to pre-exposure (0.235±0.047) (Figure 3).

A statistical analysis of the number of micronucleus by means of paired T-test pre- and post-conventional and digital panoramic exposure revealed significant differences (Table 1). Moreover, an independent T-test of the differences in the micronucleus increasing between digital and conventional panoramic radiography is shown in Table 2 indicates a significant difference (p=0.000) between digital and conventional panoramic radiographic exposures.

A statistical analysis of GCF volume pre- and post-exposure by using Paired T-test was conducted. Table 3 shows that there were significant differences in GCF volumes before and after conventional panoramic exposure (p<0.05). In contrast, the GCF volumes before and after digital panoramic exposure were not significantly different (p>0.05). Table 4 shows that there was a significant difference in GCF volume (p<0.05) between the number of digital and conventional panoramic exposures.

DISCUSSION

In this study, the pre-exposure number of micronucleus was considerably lower than the post-exposure number in both digital and conventional panoramic radiography. The post-exposure increase in micronucleus was lower in patients undergoing digital panoramic exposure than those of conventional ones (Figure 1). The micronucleus detected pre-exposure represented the positive control because they had been swabbed without exposure. The micronucleus

Table 2. The result of Independent T-test of micronucleus increasing between digital and conventional panoramic radiography.

Micronucleus number	n	Std.Error Mean	F	Sig.
Digital	10	1.0022	0.545	0.000*
Conventional	10	0.6110		

* Significant difference <0.05

Table 3. Paired T-Test analysis before and after penoramic exposure in digital panoramic.

Parameters GCF Volume	Conventional		Digital	
	Std Error Mean	Sig.	Std Error Mean	Sig.
Before	0.1836	0.017*	0.1488	0.506
After	0.1632		0.2114	

* Significant difference <0.05

Table 4. Independent T-test analysis between GCF volume of digital and panoramic exposure.

CSG Volume	n	Std.Error Mean	F	Sig.
Digital	10	0.5162	1.572	0.012*
Conventional	10	0.6686		

* Significant difference <0.05

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in the digital and conventional panoramic radiography appeared with smaller extranuclei, approximately 1/3 the size of the main nucleus with which they appeared same colour (Figure 2).

It is believed that digital radiography can reduce the effective dose by up to 50% compared with conventional radiography. Therefore, it is assumed that the effect of digital radiography will decrease.[6] This result was in line with the statistical analysis results (Table 1 and 2) that showed the significant differences ($p<0.05$) between both groups and might be related to the theory that digital radiography techniques constitute an effort to reduce dose exposure, compared with conventional techniques.[2] Since image receptors in digital techniques are more sensitive to X-rays, this allows a reduction in the dose administered to patients.[2]

The volume of GCF increased when both techniques were used, although more so with conventional radiography exposure than digital exposure (Figure 3). A paired T-test only produced a significant difference ($p<0,05$) between pre- and post-panoramic radiography exposure with a conventional technique (Table 3.). The samples of the pre-exposure group represented the control because they had not yet been exposed to X-ray. The results indicated that the effects of digital panoramic radiography exposure still cause cytotoxic and genotoxic damage, although they do not increase blood vessel permeability. While digital radiography is believed to produce lower doses of radiation protection, there is still a significant increase in micronucleus between the pre- and post-digital panoramic exposure.

In this study, the increasing number of micronucleus along with a greater volume of GCF due to digital panoramic exposure was confirmed. The result of an independent T-test indicated that the GCF volume between conventional and digital panoramic exposure differed significantly ($p<0.05$) (Table 4). Digital radiography exposure is estimated to reduce the effective dose by up to 50% compared to conventional radiography, thereby avoiding dilatation of the capillary blood vessels in the gingival mucosa.[2] The volume of CGF in cancer patients was found to be statistically higher after they had undergone head and neck radiotherapy.[13] Similiarly, a recent study conducted by Zuelkevin indicated a significant increase in GCF volume after conventional panoramic radiography exposure.[8] Blood vessels consist of X-ray radiosensitive cells so that panoramic exposure will increase vascular capillary permeability.[10] Vascular plexus that secretes GCF is very sensitive to various types of stimulants.[14]

These results confirm that the effects of digital and conventional panoramic radiography exposure are stochastic and there is no dose-limiting value.[3] Thus, the use of radiography exposure should be noted and guided by the principle that radiological protection should be as low as reasonably achievable (ALARA). An extremely limited dose does not mean a complete absence of effect in exposed patients.[3] Dental digital radiography could reduce dose exposure, but still trigger cytotoxicity due to DNA damage. This was proved by the formation of markers related to the early mechanism of carcinogenesis in the form of an increase in the micronucleus.

Based on this study, it was found that the increase in the number of micronucleus and the volume of GCF identified through conventional panoramic radiography was significantly different to that established through digital panoramic radiography. The conclusion of this study is that digital panoramic radiography exposure induced biological change only in terms of an increase in the micronucleus, but not in the volume of GCF.

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