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Radiology

DOSE REDUCTION IN DIGITAL DENTAL PANORAMIC RADIOGRAPHY: MAKING IMAGING MUCH SAFER

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ABSTRACT The present study investigated how much radiation dose can be reduced *without* adversely affecting the subjective image quality and diagnostic performance.

Hundred patients having pathological findings and requiring panoramic radiographs were randomly divided into 4 groups based on reduction in tube current(30%,40%,50% and 60% reduction) with 25 patients per group. Two radiographs were obtained for each patient; first at constant exposure setting, second at reduced tube current. Three observers rated both images. Best image quality was seen at 6mA(40% reduction); but even at 5mA(50% reduction) and 4mA (60% reduction) the results were good and readily acceptable. No diagnostic details were lost even at last reduction. It was concluded that orthopantomographs captured at reduced tube current had slightly inferior image quality, without any difference in the diagnostic performance. Thus, a reduction in tube current up to 60%(4mA) is recommended for routine digital panoramic radiography.

KEYWORDS : Digital Orthopantomography, exposure parameters, image quality.

INTRODUCTION

The term ***Dose*** is used to describe the amount of energy absorbed per unit mass at a site of interest. ***Exposure*** is a measure of radiation based on its ability to produce ionization in air under standard conditions of temperature and pressure (STP) [1].

Digital orthopantomography is one of the most readily available and economical imaging modality for lower socio-economic group of patients even today. The use of digital technology results in a reduction in patient exposure. Literature shows that further reduction of the dose can be done without compromising the quality of image [2]. Dula et al emphasized dose reduction should be achieved by a reduction of the mA setting rather than the kV setting due to an increase in the absorption of radiation by the tissues with lower kV settings [3]. Reduction of the dose in digital orthopantomography is required to further minimize the *harmful effects* of radiation; in an effort to make it more safely useful in surveying, diagnosing, and in evaluating the treatment outcome.

Thus the present study was done to investigate how much the radiation dose can be reduced from a digital panoramic radiographic system *without* adversely affecting the subjective image quality and diagnostic performance.

MATERIALS AND METHODS

The study was conducted in Kothiwal dental college and hospital, Moradabad. Ethical clearance was obtained from the institutional ethical committee. Informed consent was taken from the patients prior to the study.

A double blind randomized controlled clinical trial was designed. Patients attending Kothiwal dental college and hospital who were of age 18 years and above, had pathological finding(s) and required panoramic radiography for diagnostic purposes were eligible for the study. Patients having pregnancy, occupational X-ray exposure and patients with previous extensive radiographic examinations were excluded from the study.

Out of those eligible, patients who gave informed consent were selected for the study (n=100). Four groups were formed (Group A to Group D) depending on the reduction in tube current (30% reduction, 40% reduction, 50% reduction and 60% reduction respectively). Patients were randomly assigned to these groups with 25 patients in each group.

Armamentarium used

1. Digital panoramic radiography unit the Villa Sistemi Medicali Strato 2000 D (Italy).
2. Kodak Dry View 8900 Laser Imager.
3. Computer.
4. Medix-View L.C.D X- Ray Viewer.
5. Kodak Dryview Laser imaging Films, size 14× 17 inches

Digital panoramic radiography unit

The *Villa Sistemi Medicali Strato 2000 D (Italy)* is a digital charged-coupled device (CCD) sensor based Digital Panoramic System. The CCD sensor is with Cesium Iodide Scintillator Screen. Sensor is 6×146 mm in size. The physical pixel size is 48 µm. Pixels are stored as 96µm to reduce the size of the image file. The theoretical spatial resolution is 10.4 line pairs per millimeter, 5.2 line pairs per millimeter with CTF (Contrast Transfer Function); and 60% real in binning modality.

Kodak Dry View 8900 Laser Imager.

Has a 39-micron laser spot, 14 bit digital signal and generates continuously toned images at 16,384 gray levels. Up to 200 sheets of films per hour the resolution for every image is 650 dpi. It can be connected to all DICOM network modalities and can serve upto 12 systems simultaneously.

Image acquisition

Two Digital panoramic radiographs were obtained for each patient (total of 200 radiographs).

The first image was obtained at 68 kv, 10 mA and 15 seconds for all the patients. The second image was obtained at a reduced tube current setting.

Group A (n = 25) 68 kv, 7 mA, 15 seconds (30% dose reduction)
Group B (n = 25) 68 kv, 6 mA, 15 seconds (40% dose reduction)
Group C (n = 25) 68 kv, 5 mA, 15 seconds (50% dose reduction)
Group D (n = 25) 68 kv, 4 mA, 15 seconds (60% dose reduction)

As 4 mA is the lowest tube current setting in the *Villa Sistemi Medicali Strato 2000 D*, the four lowermost tube current settings were used. The Tube voltage was reduced in one step; to small built adult patient setting provided by the manufacturer i.e. 68 kv (as per default automatic settings in machine). Tube voltage (68 kv) and exposure time (15seconds) were kept constant throughout the study.

All images were obtained by one radiographer. Reproducible positioning of the patients was achieved by lines drawn on the face to coincide with the horizontal and vertical light beams on the machine. In addition a line was drawn on the floor for the feet (Fig. 1).

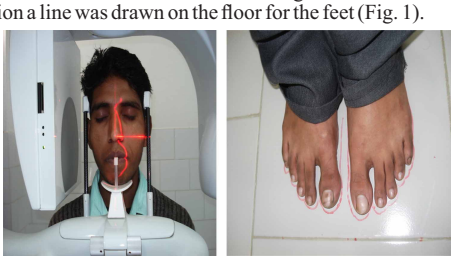

FIG. 1 Lines drawn on face to coincide with laser beam and lines drawn on the floor for patient repositioning

Observers and observation criteria

All images were printed on Kodak Dry View 8900 Laser Imager. Brightness and contrast were fixed for all radiographs. The radiographs were scored for image quality and diagnostic performance.

Image quality was assessed by the visibility of 21 anatomical landmarks chosen from the list of landmarks, which are commonly found on panoramic radiographs [4]. The *diagnostic performance* was assessed by scoring 30 pathological findings selected from the 100 image pairs.

Three observers (Oral & maxillofacial Physicians and Radiologists) with academic experience ranging from 6 to 13 years scored the radiographs on a five point rating Scale [4].

1. Excellent
2. More than adequately represented
3. Adequately represented
4. Barely adequately represented
5. Inadequate for diagnosis

The pathological findings were also scored on the five-point rating scale as above.

The images (n=200) were presented to each observer separately but in the same sequence. The observers used Magnifying Lens wherever required. The observers were blinded to exposure parameters and against each other. Before evaluating the images, the observers received verbal and written explanation of the nature of the study.

Statistical analysis was done using SPSS (Statistical Package for Social Sciences) version 15.0 statistical analysis software. Various statistical tests applied were chi-square test, Wilkoxon Rank Sum Test and Mann-Whitney U test. Inter-observer agreement was analyzed using kappa statistic. Level of significance was taken as 'p' < 0.05.

RESULTS

The first image for all the patients was obtained at 68 kv, 10 mA and 15 seconds. All these images (25 images per group) were perceived to be excellent by the three observers. The second image for all the patients was taken at reduced tube current setting (Group A at 7 mA; Group B at 6 mA; Group C at 5 mA; Group D at 4 mA) (Table 1).

Table1: Images obtained at reduced tube current setting

S. No.	Scoring	Group A			Group B			Group C			Group D		
		Observer No.			Observer No.			Observer No.			Observer No.		
		1	2	3	1	2	3	1	2	3	1	2	3
1.	Excellent	15	13	16	21	21	21	20	17	20	18	15	16
2.	More than adequately represented	10	12	09	04	04	04	05	08	05	07	10	09
3.	Adequately represented	–	–	–	–	–	–	–	–	–	–	–	–
4.	Barely adequately represented	–	–	–	–	–	–	–	–	–	–	–	–
5.	Inadequate for diagnosis	–	–	–	–	–	–	–	–	–	–	–	–

The kappa statistic showed a statistically significant level of agreement among the different observers, who perceived the images to be excellent to more than adequately represented.

Comparison of Radiographic Image quality

Within the group

For each group, there were a total of 75 observations before reduction (25 observations by each observer) and 75 observations after reduction. Statistically significant difference was seen between the standard images and the images obtained after reduction (table 2). Thus, after reduction there was a significant change in the *quality of radiographic image* in all the 4 groups.

Table2: Comparison of Radiographic Image quality within group before and after reduction in tube current (75 observations per group)

S. No.	Scoring	Group A		Group B		Group C		Group D	
		Before reduction	After reduction	Before reduction	After reduction	Before reduction	After reduction	Before reduction	After reduction
1.	Excellent	75	44	75	63	75	57	75	49
2.	More than adequately represented	-	31	-	12	-	18	-	26
3.	Adequately represented	-	-	-	-	-	-	-	-
4.	Barely adequately represented	-	-	-	-	-	-	-	-
5.	Inadequate for diagnosis	-	-	-	-	-	-	-	-
(Wilcoxon Rank-Sum Test)		Z=5.568; p<0.001		Z=3.464; p=0.001		Z=4.243; p<0.001		Z=5.099; p<0.001	

In between groups

Statistically significant difference was seen among different groups with Group B showing maximum number of excellent images and Group A showing the least (p=0.003) (Table 3).

Group A had significantly lower image quality as compared to Group B (p=0.001) and Group C (p=0.024) but not with Group D (p=0.402). Statistically no significant difference was seen between Group B and C (p=0.402); and Group C and D (p=0.153). Statistically significant differences were seen between Group B and D (p=0.009).

Table 3: Comparison of Radiographic Image quality in between groups after reduction (75 observations per group)

S. No.	Scoring	Group A	Group B	Group C	Group D
1.	Excellent	44	63	57	49
2.	More than adequately represented	31	12	18	26
3.	Adequately represented	0	0	0	0
4.	Barely adequately represented	0	0	0	0
5.	Inadequate for diagnosis	0	0	0	0

x^2=13.777 (df=6); p=0.003

Comparison of Diagnostic Performance

Diagnostic performance was assessed by the presence of pathological findings on the radiographs

Within the group

There was no difference in the diagnostic performance before and after the reduction as all the images were perceived excellent by the three observers.

In between groups

There was no difference between the groups after the reduction in tube current and even the images of last group for reduction ie., Group D were also found to be excellent by all the three observers denoting that no diagnostic details were lost even at last reduction.

DISCUSSION

In the study there was moderate to high interobserver agreement in all the four groups. In terms of ***Image quality***; best image quality was achieved at 68 kV, 6 mA and 15 seconds (Group B); However even at 5mA (Group C) and 4mA (Group D) the image quality was considered to be good by all the observers and no anatomic detail was lost.

In terms of ***Diagnostic performance*** there was no difference between the groups denoting that no diagnostic details were lost even at last reduction.

G Kaeppler et al [5] found no significant difference in the diagnostic accuracy between panoramic radiographs at low tube potential settings (70 kV) and those taken at high tube potential settings (85 kV). K Dietz et al [6] also found no significant difference between the diagnostic accuracy at 60 kV or 90 kV. S Reinert [7] found no statistically significant difference between panoramic radiographs at high tube potential settings and those at low tube potential settings. At the same time they also suggested that Digital panoramic radiographs *should be taken* at low tube potential levels, with an exposure equivalent at least to a regular intensifying screen.

Therefore, in the present study, the tube potential was kept at the lowest standard setting (68 kV) provided by the manufacturer and remained unchanged for the entire study. This reduction is also equivalent to dose reduction achieved by the use of regular intensifying screens at low tube potential levels in conventional film based systems.

G Kaeppler et al[5] also suggested a lower tube potential value at *unchanged tube current level* led to higher absorbed dose. Dose reduction with the same beam quality could only be obtained by reducing the milliampere value. An increase in tube potential and a reduction of milliamperes could reduce the radiation dose but could also result in poorer image contrast and image quality, so the choice of constant tube potential level with reduction of milliampere would be more practical[8]. In our study we kept the tube potential constant and reduced the tube current stepwise.

Dula et al[3] emphasized dose reduction should be achieved by a reduction of the mA setting rather than the kV setting due to an increase in the absorption of radiation by the tissues with lower kV settings. In the present study the tube current levels were reduced upto 60% of the tube current settings provided by the manufacturer, and the results at higher milliampere settings were compared with the results at reduced milliampere settings while keeping the kV unchanged and no significant depreciation in the diagnostic performance was observed.

Gijbels et al[4] found that reduction in exposure did not seem to influence the diagnostic image quality, except for some anatomical landmarks. In our study also the image quality and diagnostic performance were reasonably acceptable even at the 60% dose reduction.

B Dannewitz et al[2] achieved a dose reduction up to 50% while maintaining satisfactory image quality and diagnostic performance. They also observed that despite the generally inferior image quality of the dose-reduced panoramic images, it seemed that the diagnostic accuracy for pathological findings was not impaired significantly. In our study the dose reduction of 60% was achieved while satisfactorily maintaining the image quality and diagnostic performance of the panoramic images.

Alkurt MT et al[9] achieved a 25% dose reduction with digital panoramic radiography without any loss of image quality of either anatomical structures or pathological findings. In the present study a dose reduction of 60% of the maximum was achieved without any loss in diagnostic details.

Discussing the limitations and future prospects of the study, further extensive in vivo studies altering the exposure time as well as the role of post capture enhancement tools in machines are the areas of detailed research works to be done.

CONCLUSION

As per the highly significant results from the study it is recommended to capture radiographs at low tube current settings for obtaining good image quality at lower radiation levels.

These can further be improved by radiologists using various post capture enhancement tools provided in machines.

By considering the dose reduction factor one can significantly limit the harmful effects of the x-rays which is one of the most important objective of the radiography.

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