An assessment of the relative safety of dental x-ray equipment

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SUMMARY

Concern among patients, often prompted by medical practitioners, regarding the harmful effects of radiation caused by dental x-ray procedures, has caused several patients of the dental school of the University of Pretoria to refuse dental radiographic procedures.

Buch and Fensham in a previous article demonstrated that radiation doses to the eyes and thyroid resulting from a single pantomogram constituted less than 10 % of that which would be imparted by a transatlantic flight in terms of added natural background radiation.

The authors in this study investigated doses to the same organs resulting from a full-mouth periapical series first using films and then digital imaging. Doses to the uterus resulting from these same examinations as well as from a pantomogram were also determined both with and without the use of a lead apron.

Doses to the eye from a full-mouth examination using film compared favourably with those for a panoramic examination, but were much reduced when digital imaging techniques were employed.

Doses to the uterus were small (equivalent to half a day of background radiation) for both a full-mouth examination using digital imaging, as well as for a pantomogram. However, from the results it would appear that there is little difference in the dose of scatter radiation to the uterus from a full-mouth examination whether or not a lead apron is used.

The use of a lead apron for a pantomogram significantly reduces the dose to the uterus.

INTRODUCTION

Public concern regarding the harmful effects of ionising radiation has been in vogue for a number of decades. Such concern has been encountered in several patients seen at the dental school of the University of Pretoria who, often prompted by their medical practitioners, refuse to allow the taking of any dental radiographs.

Despite the fact that professional staff at dental schools are generally sufficiently knowledgeable to avoid undertaking x-ray examinations carelessly or unnecessarily and will apply vigorous precautionary protective measures, lack of knowledge still exists among many members of the public as well as many of the medical profession with regard to radiation dose. It is therefore not surprising that patients sometime lose perspective and may refuse to submit to necessary dental x-ray procedures.

The work of Buch and Fensham[1] using thermoluminescence dosimetry, showed that a standard pantomogram taken on an Orthophos® machine imparted a mean dose of 20µSv to the eyes and 90µSv to the thyroid, both of which are in the immediate vicinity of the x-ray beam. Van der Merwe, Frost and Nortje[2] , two decades earlier, demonstrated slightly higher doses to the same organs using an older model of panoramic machine and lithium fluoride powder in place of the Harshaw® discs used by Buch and Fensham. In both cases, however, the doses proved to be small, causing no potential ill-effects.

Translated into everyday practical terms using the principle of Background Equivalent Radiation Time (BERT)[3], doses to these vital organs imparted by a single pantomogram would constitute less than 10 % of that which would be imparted by a transatlantic flight or eight hours of daily television viewing over a period of a year. Background radiation to which every individual on earth is exposed is about 3000µSv per year. Therefore any dose of added radiation received can easily be calculated as an equivalent number of days of background radiation without necessarily citing everyday examples as already given.

Having determined doses to the eyes and thyroid resulting from a panoramic x-ray examination, the authors embarked on a study to determine the absorbed doses to the same vital organs resulting from a full-mouth periapical series, using films in the first place and thereafter comparing this with digital imaging. On rare occasions a dentist may deem it necessary to x-ray a pregnant woman during the third trimester when the fetus is less sensitive to radiation. It was therefore decided to determine the absorbed dose to the region of the uterus for the abovementioned procedures as well as for a panoramic examination. Doses to the uterus were determined both with and without the use of a lead apron.

MATERIALS AND METHODS

The method employed was that of thermoluminescence[4-8] using lithium fluoride discs. Since lithium fluoride discs are known to vary from one to another in their responses to the same dose of radiation, a vigorous method of selection and calibration of discs was necessary.

Table 1: TLD readings after irradiation by calibrated RT 100 x-ray source
455286
455296
409757
478040
455281
478046
500814
409993
409757
443758
456553
477663
426774
409777
478003
454438
444327
409935
455293
454442
444331
409328
456739
455111
Mean = 44938.5

Table 2: Dose readings – intraoral machine (µSv)

Left eye (films)	**Right Eye (films)**	**Thyroid (films)**	**Uterus (No lead apron) (films)**	**Uterus (lead apron) (films)**
46.98	43.79	44.33	2.19	2.01
48.44	42.66	44.98	2.77	2.08
48.01	42.98	45.68	3.01	2.99
Mean = 47.81	Mean = 43.14	Mean = 44.99	Mean = 2.66	Mean 2.36
(digital)	**(digital)**	**(digital)**	**(digital)**	**(digital)**
0	2.01	8.01	2.01	2.68
0.87	1.99	8.06	2.73	2.01
0	2.66	7.93	2.48	2.02
Mean = 0.29	Mean = 2.22	Mean = 8.00	Mean = 2.40	Mean = 2.23

Table 3: Dose readings – Panoramic machine (µSv)

Uterus (No lead apron)	**Uterus (lead apron)**	**Handles**
7.98	2.33	5.33
7.91	1.98	5.75
8.01	2.41	5.14
Mean = 7.97	Mean = 2.24	Mean = 5.41

Twenty-four Harshaw® lithium fluoride dosimeters (TLDs) were irradiated using a calibrated RT100 x-ray source. These were read in a Toledo 654 TLD reader. All TLDs fell within 10 % on either side of the mean reading for the dosimeters.

Twelve which did not vary more than 5 % from the mean were finally selected. These selected dosimeters were utilized in the next phase of the study.

These were placed in a Rando® female phantom, three corresponding to the lens of the left eye, three to the right eye, three in the region of the thyroid and three in the region corresponding to the uterus.

A full mouth series of 16 films was exposed using a Siemens Heliodent® intra oral x-ray machine operating at 70 kVp and 7 mA. An exposure time of 0,2 seconds was used for anterior teeth and 0,16 for posterior teeth. (The increased exposure time for anterior teeth was due to the fact that faster films were not available for the latter).

The TLDs were read in the Toledo reader. The procedure was then repeated but on this occasion a lead apron was draped over the region of the uterus. It should be noted that the same set of TLDs were annealed after each set of readings and re-used.

Both procedures were then repeated, but on this occasion instead of films, digital imaging was employed using a Gendex® intra oral x-ray machine operating at 65 kVp and 7 mA. An exposure time of 0,16 seconds was used for anterior teeth and 0,25 seconds for posterior teeth.

A separate set of measurements for the uterus, both with and without a lead apron, was then carried out during the taking of a standard pantomogram using an Instrumentarium® panoramic machine. Since this type of machine is fitted with a pair of handles which the patient holds during an exposure in order to ensure lack of patient movement, the dose to the hands was determined by placing TLDs on each handle during the exposure cycle.

RESULTS

The dose readings are presented in Tables 2 and 3

DISCUSSION

It is apparent from the above results that the direct dose to the eye resulting from a full-mouth periapical examination using films was found to be relatively high (five days of background radiation) as compared with the findings of the same authors when using a panoramic machine[1,7].

The dose imparted to the thyroid, however, was found to be half that of the panoramic examination[1]. A similar examination using digital imaging, however, imparted a negligible dose to the eyes and a very low dose to the thyroid (one day of background radiation). These findings are in accordance with the work of Eun-Sang Cho *et al*[9] who demonstrated a 50 – 95% reduction in patient exposure with digital technology owing to the greater sensitivity of digital receptors. These authors in addition showed that skin entrance doses with digital radiography at the same exposure parameters were significantly lower than with films. The exposure times used for digital radiography gave the best possible images and could not be significantly reduced in accordance with the work of Farman and Farman[10] who found that lower exposure times increased the "noise" of the image.

Regarding doses to the uterus resulting from a full-mouth periapical examination, there appears to be no significant difference between digital radiography and films, the distance between the mouth and the uterus allowing for a minimal dose of scatter radiation to reach the uterus, equivalent to a mere half day of background radiation.

It may surprise readers that the dose to the uterus from a full mouth examination is unchanged when a lead apron is used. However two standard textbooks of radiation physics explain that lead, contrary to popular belief, does not block out a full range of x-ray photons[11, 12]. The shielding action of any material is due

Figure 1. TLD dosimeters being placed in Rando® phantom.

to the photoelectric effect which, in the case of lead, will effectively block out photons of high energy at and above its K edge but will let through photons of low energy below its K edge. The dose to the uterus for a full-mouth x-ray examination using digital technology and a lead apron was found to amount to half a day of background radiation. This dose, however, appears to be unchanged if a lead apron is dispensed with[8].

The opposite is true, however, with a panoramic examination which owing to a far greater exposure time cycle, imparts more higher energy photons to the region of the uterus. These are effectively blocked out by a lead apron. Taking such a precaution will impart a dose equivalent to one third of a day of background radiation.

CONCLUSION

One often sees lower figures quoted in the literature and elsewhere for absorbed doses of radiation emitted by specific X-ray machines for certain types of examinations.

It should be noted that such figures usually refer to average full-body doses. It is of more significance, however, to heed figures for absorbed doses to specific vital organs.

The study described appears to indicate that the dose imparted to certain of these organs by a single examination(either a full-mouth series of periapicals or a panoramic) more particularly with the use of digital technology, poses no serious threat to the patient.

It behoves a dentist, nevertheless, to act in a responsible manner, weighing up the value of the x-ray examination against the potential risk, most particularly in the case of a pregnant woman. The dentist must also be aware of the deleterious effects of cumulative low dose radiation and must never neglect to implement those protective measures recommended for the operator[9].

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