DOSIMETRY AND THE USE OF A LEAD APRON IN DENTAL RADIOGRAPHIC MODALITIES

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Abstract

The use of a lead apron is a well discussed issue in dentistry while using panoramic radiograph (PR) or cone beam computed tomography (CBCT). The aim of this study was the in vitro evaluation of energy doses in different sites of a human full body phantom. Therefore thermoluminescence dosimeters (TLD) were placed in 55 different sites in a full body RANDO® Man phantom. Eight different protocols were performed using three different machines from three different manufactures in CBCT and/or PR mode. The energy doses were calculated after a readout process of the dosimeters and statistically evaluated. The results showed that there was no significant difference between the protocols using a lead apron and those that do not. Although TLD measurements are discussed controversially, the results of the present study showed a similar distribution of the energy doses along the phantom in the related protocols.

1. INTRODUCTION

In Germany every year 60 million radiographic images are taken only by dentists. From the total number of 135 million X ray examinations those are 37%. By far this is the major part of all examination modalities [1]. The use of a lead apron is a well discussed issue in dentistry while using panoramic radiograph (PR) or cone beam computed tomography (CBCT). Many studies were performed calculating the effective dose (µSv) but not considering the influence of an apron and therefore only a human head phantom was used. To make different examination protocols comparable, the effective dose is calculated. The aim of this study was the in vitro evaluation of energy doses (µGy) in different sites of a human full body phantom.

2. MATERIAL AND METHODS

In this study a RANDO® Man phantom (The Phantom Laboratory, Salem, NY, USA) with the following specifications was used:

- Full human skeleton (bone);
- Surrounding soft tissue equivalent material (68% C, 20% O, 9% H, 3% N, other);
- Physical density: 0.997 g/cm³;
- Drilled holes for dosimeters.

The radiation dosimetry was performed with solid TLD GR 200 (Thermo Fisher Scientific, Waltham, USA). These TLD were accurate in the range from 0.1µGy – 10 Gy. The total number of used TLD in this study was 60. To preserve the TLD chips from any contamination, they were placed in a PMMA container. For transposition of the TLD a vacuum forceps (Aspirette®, Hirschmann Laborgeräte, Eberstadt Germany) was used. All TLD were calibrated through a defined exposure (D_{def}) by 215.3 mGy. After the readout process, an averaged calibration factor (K) with 3.471E-03 for each TLD was calculated. To reset and anneal all TLD at the same time and in a reproducible manner, a microprocessor-controlled TLD oven (PTW, Freiburg, Germany) was used. After the calibration process 55 TLD were placed at different sites in the phantom representing those tissues listed in the weighting factor table in the 2007 ICRP Publication 103 [2].

Before exposure, all TLD were heated to 220 °C and cooled down to room temperature. This annealing procedure took about two hours. The readout process was performed in a Fimel LTMWin (Fimel, Fontenay-aux-Roses, France) with a standard planchet that enables measurements of TLD with

a diameter of 5 mm or less. Each TLD was placed separately in the reader and the readout process under nitrogen atmosphere was initialized. The results of the process (digits) were displayed and exported to a .txt-file.

In this study two different CBCT machines with integrated PR mode and an additional CBCT device were used in each CBCT and/or PR mode:

1. ProMax 3D Mid, Planmeca Oy, Helsinki, Finland;
2. SCANORA 3D, SOREDEX Oy, Tuusula, Finland;
3. Kodak 9500, Carestream Health, Stuttgart, Germany.

The assembled phantom was placed in the device according to the manufacturer's instructions. 15 repeated exposures were performed in CBCT mode. 50 repeated exposures were performed while using PR mode. Each protocol was performed twice and averaged afterwards. The protocols were the following:

- Protocol 1.1: device 1, PR mode;
- Protocol 1.2: device 1, PR mode, lead apron;
- Protocol 2.1: device 1, CBCT mode;
- Protocol 2.2: device 1, CBCT mode, lead apron;
- Protocol 3.1: device 2, PR mode;
- Protocol 3.2: device 2, PR mode, lead apron;
- Protocol 4.1: device 3, CBCT mode;
- Protocol 4.2: device 3, CBCT mode, lead apron.

To calculate the energy doses in each TLD position the values from the readout process were multiplied with the calibration factor (K) and the detected background radiation (D_{back}) was subtracted. The calculated values then were divided by the number of performed exposures.

3. RESULTS

There was no statistical difference between protocols with and without using a lead apron.

TABLE I. STATISTICAL EVALUATION OF DIFFERENT PROTOCOLS

	Mean (µGy)	Median (µGy)	Max (µGy)	Min (µGy)	Range (µGy)
Protocol 1.1	107.8	75.6	439.8	4.6	435.2
Protocol 1.2	106.5	71.2	450.5	3.8	446.6
Protocol 2.1	951.1	137.1	5474.3	9.0	5465.2
Protocol 2.2	957.8	133.4	5534.1	10.8	5523.3
Protocol 3.1	87.6	47.1	472.2	2.3	469.9
Protocol 3.2	87.7	54.8	449.3	5.1	444.2
Protocol 4.1	627.6	154.0	2520.3	25.8	2494.5
Protocol 4.2	634.3	163.8	2560.2	35.4	2524.8

4. DISCUSSION

Many influencing factors have to be considered when performing TLD based dose measurements, such as temperature, air pressure, light and transportation time. A lot of these factors could be excluded in this study, because the readout process of the TLD was performed directly next to the devices. Even if the factors decrease the accuracy of any dose measurement, in this study it was possible to create a standardized workflow for all modalities.

Nevertheless, new ways for dose calculation in dental radiographic modalities such as Monte-Carlo simulation have to be investigated to develop more precise predictions in dose relevant issues.

5. CONCLUSION

The results of the study showed that there was no significant difference in dose distribution along a full human body phantom no matter if a lead apron was used or not. Of course different methods for dose evaluation have to be considered and further investigated.

REFERENCES

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