Evaluation of surface radiation dose to the thyroid gland and the gonads during routine full-mouth intraoral periapical and maxillary occlusal radiography

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Abstract

Aim: The quantitative aspects of radiation doses to critical organs can help the dental professionals to take the necessary radiation protective measures as deemed necessary and can help the general public to allay radiation exposure fear in dental radiography, if any. Our study determines the surface radiation dose to thyroid and gonads in full-mouth intraoral periapical (IOPA) and maxillary occlusal radiography.

Materials and Methods: A total number of 120 subjects participated in the study. The surface radiation dose was estimated to the thyroid gland and the gonads in full-mouth IOPA radiography using 10 IOPA (E speed films) and in maxillary occlusal radiography. The measurements were calculated using a digital pocket dosimeter (PD-4507).

Results: The average dose at the thyroid gland level during full-mouth intraoral and maxillary occlusal radiography was estimated to be 10.93 mRads (1.093 × 10^{-2} mGy) and 0.4 mRads (4.0 × 10^{-2} mGy), respectively. The average surface radiation dose at the gonadal region during a full mouth intraoral and maxillary occlusal radiography was estimated to be 1.5 mRads (1.5 × 10^{-2} mGy) and 0.15 mRads (1.5 × 10^{-3} mGy), respectively.

Conclusion: Our results suggest that although the radiation exposure doses to critical organs namely thyroid and gonads is within the safe limits still precautionary measures for these organs are advocated.

Keywords: Gonads, intraoral radiography, radiation dose, thyroid

Introduction

Every dose of radiation produces some potential biologic damage. The doses to “critical organs” of known sensitivity to the stochastic effects of radiation must be measured. The damage to these tissues would be detrimental to the health of that person.[1]

The highest risk in dental radiography are for leukemia and cancer of the thyroid, even in doses as low as 500 mSv.[2] The gonadal dose from full mouth survey is approximately 0.002 mSv.[2]

The aim of this study was to calculate the average surface radiation dose to the thyroid gland and gonads during full-mouth intraoral periapical (IOPA) and maxillary occlusal radiography.

Materials and Methods

A performa was prepared for this study as given in Table 1.

The various materials used were routine diagnostic instruments, namely rubber bands, pocket dosimeter, X ray machine “EXPLOR” MODEL, Ektaspeed plus IOPA films, Ectaspeed plus occlusal film, and thyroid collar [Figures 1 and 2].

In this study, a Pocket Dosimeter model no. PD4507 [Table 2, Figures 3 and 4] with a digital display manufactured by Bhabha Atomic Research Centre, Mumbai, Maharashtra, India was used to measure the surface radiation dose. The minimal unit displayed in this dosimeter was 1 mR (10^{-2} mGy). It also had the facility of depicting cumulative doses which made calculations of doses less than 1mR (10^{-2} GY) possible. This Pocket Dosimeter had the capacity to measure the maximum level of radiation upto 999mR (9.99 mGy). Other technical specifications are shown in Table 1.

Besides, this pocket dosimeter had an added advantage over other conventional dosimeters in that the measured radiation dose was expressed in digits, which ruled out chances of error in reading, unlike the pen dosimeter, where the reading was to be read against a meter which gave room for error in visual reading. However, like the pen dosimeter, the pocket dosimeter also made use of a Geiger-Muller counter.

The subjects for the study were average adult patients of age group ranging from 16 years to 65 years. The subjects were randomly chosen with informed consent.

The X ray machine used was “EXPLOR” model from Confident Dental Equipments, with standardized 65 Kvp and 10 mA.
Figure 1: Armamentarium

Figure 2: Lead lined thyroid collar

Figure 3: Pocket dosimeter PD - 4507

Figure 4: Pocket dosimeter with a charger

### Table 1: Proforma

| Radiation detected       | Gamma and X rays                                                                 |
|--------------------------|----------------------------------------------------------------------------------|
| Dose range               | 0 to 9.99 X 10^-3 Gy                                                            |
| Detector                 | GM Counter ZP 1310                                                               |
| Accuracy                 | ± 15% at Cs137 energy for dose rates upto 0.01 Gy/hr. Within ± 40% upto 0.01 Gy/ |
| Energy dependence        | ± 20% from 60 KeV to 1.35 MeV (with filter)                                      |
| Indications: Visual      | 3-Digit LCD indication for integrated upto 9.99 X 10^-3 Gy in steps of 10^-5 Gy  |
| Aural                    | Beep tone per mR. Alarm when dose exceeded the present level which could be fixed at any value between 10 mR to 999 mR in steps of 10 mR, through PCB mounted DIP switch |
| Power                    | Two miniature Ni-Cd batteries of 3.6 V each to be recharged after continued use of 8 hours. "LOBAT indication was on display. |
| Dimensions               | 160 X 65 X 25 mm                                                                |
| Weight                   | 190 g                                                                            |
| Charger                  | Dosimeters are stored in a charger rack when not in use. A green LED near the charging slot indicated the correct insertion |
| Charging time            | 14 h from full discharge to full charge                                          |
| Capacity                 | Two dosimeters                                                                  |
| Power for a charger      | 230 V Av, 50 Hz                                                                  |
The films used were KODAK Ektaspeed plus IOPA films of size 31 × 41 mm (1¹/₄ × 1⁵/₈ inches) and KODAK Ektaspeed plus occlusal films of size 57 × 76 mm (2¹/₄ × 3 inches).

The patient was made comfortable and asked to sit on the dental chair.

To measure the surface radiation dose at the thyroid level during full-mouth IOPA radiography, the patient was positioned such that the mid sagittal plane was perpendicular to the floor.

For the maxillary five film series, the head of the patient was adjusted such that the maxillary occlusal plane was parallel to the floor. The X ray cone angulation was set at +40, +45, +30, +20 degrees for maxillary IOPA films for anterior teeth, canines, premolars, and molars, respectively.

For the mandibular five- film series, the head of the patient was adjusted such that the mandibular occlusal plane was parallel to the floor, upon opening the mouth. The X ray cone angulation was set at -15, -20, -10, -5 degrees for mandibular IOPA films for anterior teeth, canines, premolars, and molars, respectively.

The timing was set for 1 s per IOPA.

The dosimeter was placed at three levels, namely the isthmus, right lobe, and the left lobe [Figures 5-7] and the average dose was calculated. The total number of subjects taken amounted to 60, 20 each, for the three levels, namely the right lobe, the left lobe, and the isthmus.

To measure the surface radiation dose at the thyroid level during maxillary occlusal radiography [Figure 8], the head of the patient was adjusted such that the mid sagittal plane was perpendicular to the floor. The head of the patient was positioned such that the maxillary occlusal plane was parallel to the floor.

The X ray cone was angulated at +65 degrees and positioned such that the central rays passed between the eyes through the base of the nose. The timing was set for 1.5 s per maxillary occlusal film. The dosimeter was fixed in place as mentioned.

| Table 2: Specifications for a pocket dosimeter |
|-----------------------------------------------|
| **Organ** | **Full-mouth IOPA** | **Maxillary occlusal** | **Total** |
| Right lobe | Isthmus | Left lobe |  |
| **Thyroid** | 20 | 20 | 20 | 80 |
| **Gonads** | 20 | 20 | 40 |  |
| **Grand total** | 120 | | |

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previously and doses were recorded at the thyroid level on the same patient. This procedure was done on a total of 20 subjects.

To measure the surface radiation dose at the gonadal region [Figure 9], during a 10 film full-mouth IOPA radiography, the patient was adjusted into position as mentioned earlier. The timing was set for 1 s per IOPA film. The dosimeter was placed in the center between the thighs, as close to the gonads as possible. The cumulative dose was recorded, and reset for the next subject. A total number of 20 patients were included.

To measure the surface radiation dose at the gonadal region during maxillary occlusal radiography [Figure 10], the patient was positioned as mentioned before and the dosimeter was placed on the center of thighs, as close to the gonads as possible. The timing was set for 1.5 s per maxillary occlusal film. The cumulative doses were recorded. A total number of 20 patients were included.

After each reading, the dosimeter was reset and used for another subject.

The digital readings were recorded, tabulated, and the average dose for single patient was calculated.

The total number of subjects involved in the study was 120.

**Results**

The surface radiation doses observed at the isthmus level, at the level of the right and left lobe of the thyroid gland during a 10 film full-mouth IOPA radiography, were 6.3 mRads, 13.9 mRads, and 12.6 mRads, respectively, and cumulative dosage was 10.93 mRads. The surface radiation dose at the thyroid level during maxillary occlusal radiography was 0.4 mRads. [Tables 3-5]

The surface radiation dose at the gonadal region during 10 film full-mouth IOPA radiography and maxillary occlusal radiography was 0.4 mRads and 0.15 mRads, respectively.

**Table 3: Total number of subjects**

| Area                  | No. of subjects | Dose     |
|-----------------------|-----------------|----------|
| Thyroid - Isthmus     | 20              | 6.3 mRads|
| Right lobe            | 20              | 13.9 mRads|
| Left lobe             | 20              | 12.6 mRads|
| Average thyroid       | -               | 10.93 mRads|
| radiation dose        |                 |          |
| Gonads                | 20              | 0.4 mRads|

**Table 4: Average surface radiation dose in full-mouth IOPA radiographs (10 films)**

| Area        | No. of subjects | Dose     |
|-------------|-----------------|----------|
| Thyroid     | 20              | 10.93 mRads|
| Gonads      | 20              | 0.4 mRads|

**Table 5: Average surface radiation dose in maxillary occlusal radiography**

| Area                  | No. of subjects | Dose     |
|-----------------------|-----------------|----------|
| Thyroid               | 20              | 1.5 mRads|
| Gonads                | 20              | 0.15 mRads|

Figure 8: Dosimeter at the thyroid gland level in maxillary occlusal radiography

Figure 9: Dosimeter at the gonadal region in full-mouth IOPA radiography

Figure 10: Dosimeter at the gonadal region in maxillary occlusal radiography
Discussion

Dental radiographs and chest radiographs are the most common radiographs taken for routine investigations. Radiation exposure to patients in dental radiographic examination has been investigated time and again.

Many of the previous studies were based on methods or conditions that do not provide good bases for comparison. Most of the dose determinations have been done with phantoms, mannequins or, with cadavers. No real effort has been made to determine the actual tissue - equivalence of dental phantoms as compared to living subjects.

In 2004, Mortazavi et al estimated the entrance surface doses (ESD) to skin at mandibular or maxillary arcs using TLD badges to be $1.173 \pm 0.606 \text{ mGy}$.\textsuperscript{[4]}

The use of pocket dosimeter in our study makes possible precise measurements of surface radiation dose in living subjects and rules out the chances of error in visual reading.

Until 1982, the exposure dose to the thyroid gland in full-mouth examination using IOPA radiography still remained as high as 49 mRads (Julian Gibbs). Similarly in 1980, Danforth and Gibbs reported the radiation dose to the thyroid using 20 IOPA films to be 400 $\mu$Gy to 920 $\mu$Gy, and to the parotid gland to be 130$\mu$Gy to 480$\mu$Gy.\textsuperscript{[1]}

In our study, during full-mouth IOPA radiographic survey using 10 films, radiation exposure dose to the thyroid gland was calculated as 10.93 mRads and the average radiation dose at the thyroid level during maxillary occlusal radiography was calculated as 1.5 mRads.

In 1982, Julian Gibbs et al calculated the gonadal dose from a full-mouth IOPA survey to be 2 mRads.\textsuperscript{[3]} Similarly in 1993, Tankij Saini et al found the radiation dose to the male gonadal region to be 0.8 mRads using 20 IOPA films.\textsuperscript{[6]}

In our study the surface radiation dose at the gonadal region during a 10 film intraoral full mouth radiographic survey and in maxillary occlusal radiography was found to be 0.4 mRads and 0.15 mRads, respectively.

Conclusion

To conclude, the surface radiation dose to the thyroid gland and the gonads was evaluated during a 10 film full-mouth IOPA and maxillary occlusal radiography using a digital pocket dosimeter PD4507. This study may be beneficial for the dental professionals worldwide to undertake proper precautionary measures to limit the radiation dose and allay the fear among the patients regarding the dental radiography, if any.

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