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# Evaluation Effective Dose for Patients Undergoing Dental X-Ray Examination

**Edrees M. Tahir Nury**[(1)]**; Bayan Saber Ibrahim**[(2)]

***Background and objectives:*** The dental radiographic examinations rank among the most frequent radiographic procedures. Since the radiation risks for different organs vary with age, exposure and sex. The specific objectives of this study include investigation of ESD using Thermo Luminescent Dosimeter (TLD-100) for patients undergoing dental x-ray examination.
***Patients and methods:*** ESD was measured using LiF Thermo Luminescent Dosimeters (TLD-100) on the skin (either mandibular or maxillary arcs) for all patients. Monte Carlo simulation was performed to estimate an effective dose (ED) by using PCXMC Dose Calculation software. Analysis of data was carried out using the available statistical package of SPSS-22 (Statistical Packages for Social Sciences- version 22).
***Results:*** The mean of the effective dose for 1-15 years old patients undergoing maxillary molar dental x-ray examination were 3.734 µSv, 3.505µSv for females and males, respectively. For 16-30 years old, the mean of the effective dose were 6.212 µSv, 3.530 µSv for females and males, respectively. And for 31-60 years old were 3.220 µSv and 3.209 µSv for females and males, respectively. Also for patients undergoing the mandibular molar dental x-ray examinations, the mean effective dose for 1-15 years old were 4.998 µSv, 3.969 µSv for females and males, respectively. For 16-30 years old were 3.270 µSv, 1.170 µSv for females and males, respectively. And for 31-60 years old were 2.020 µSv, 1.131 µSv for females and males, respectively.
***Conclusion:*** The use of the entrance surface dose(ESD) or effective dose(ED) is not an accurate indicator for physicians to judge the radiation risk of an x-ray examination in accordance with the result of the present study. The overall risk from radiation in children was more than in adults and in female patients was more than in male patients. It is recommended that the average risk caused by exposure be considered as a guide to assess the risk and benefit for each age group.

***Keywords:*** Intraoral radiograph, Effective dose, Maxillary molar, Mandibular molar, Male, Female, Pediatric, Adult.

(1) B.D.S., M. Sc., Ph.D., Assistant Professor at the College of Education - Salahaddin University.
(2) B.D.S., M. Sc., Assistant Lecturer at the College of Dentistry- Hawler Medical University.

## Introduction

Dental examinations rank among the most frequent radiographic procedures. Their individual levels of exposure are low relative to other diagnostic procedures, but their high frequency justify seeking an ever finer tuning of the radioprotection of the population from them.[1] Moreover, a large part of dental radiography is carried out on children and young adults, for whom the risk from exposure to x-rays is up to 3 times higher. In addition to that, many patients in general dental practice may be subjected to unnecessarily high radiation doses due to unsatisfactory equipment and outdated techniques.[2] The interest in dental radiology is therefore very high because of the

large amount of equipment and the large number of persons exposed. In recent years, concern has risen over the hazards of exposure to small doses of ionizing radiation.[2,3] So effective dose estimate for medical exposure is necessary, which is used for assessing radiation risk to patients.[4] Although radiation doses in dental radiography are low. The International Commission on Radiological Protection (ICRP) has reiterated (2016), in its latest recommendations, that it is appropriate to use sex and even age-specific data for the purposes of retrospective individual evaluation of radiation related risks following internal or external exposure to ionizing radiation. Effective Dose(ED), which has the same units as equivalent dose, is obtained by summing individual organ equivalent doses ($H_T$) multiplied by the corresponding tissue weighting factors.

$$ED = \sum_T W_T H_T \qquad \sum_T W_T = 1$$

Where $W_T$ are dimensionless tissue weighting factors characterizing the relative sensitivity of various tissues with respect to the endpoints, such as cancer induction and mortality.[5] The most appropriate method for ED calculations is the Monte Carlo simulation of the radiography accompanied by measurements of entrance surface dose (ESD) or dose area product (DAP). The effective dose delivered to patients per radiograph is low but the collective dose is significant because of the large number of radiographs made.[6]

## Patients and methods

This study was carried out in the College of Dentistry – Hawler Mwdical University clinical hospitals in Erbil city, for three months. 120 patients were divided into six groups, three groups of ages (1-15), (16-30) and (31-60) years old are for males and three other groups for females. Weight, height, thickness and technical parameters (tube voltage kVp, current-time product mAs and focal to film distance FFD) were recorded. The Entrance Surface Dose (ESD) for each patient involved in periapical intraoral dental x-ray examination was measured by putting the Thermo Luminescent Dosimeter (TLD) at the surface of the face. In this study, the Monte Carlo simulation was performed to estimate the effective dose (ED) by using PCXMC Dose Calculation software copyright STUK 2004, pp 16.

**Statistical analysis.** Analysis of data was carried out using the Statistical Package for Social Sciences (SPSS) version 22. Data were presented in simple measures of mean, standard error of the mean, and range (minimum-maximum values).

The significance of difference of means (quantitative data) was tested using Students t-test for difference between two independent means or ANOVA test for difference among more than two independent means. Statistical significance was considered whenever the $p \leq 0.05$.

## Results

The exposure factors kVp, mA and time/sec with FFD focal to film distance were included in this study for maxillary and mandibular intraoral radiographs as shown in Table 1. Range and mean of entrance surface dose ESD/mGy for male and female patients in maxillary molar and mandibular molar dental x-rays examinations are presented in Table 2 and 3. In Table 2 for all age groups, we see that there are no significant differences $P$=0.613 between the groups of sex for maxillary radiographs, and in Table 3 for all age groups, in mandiblular radiographs we see that there are no significant differences $P$=0.147 between groups of sex.

On the other hand, the effective dose was estimated based on the obtained entrance surface dose (ESD) values received by patients in three groups. The average effective dose had been estimated by using Monte Carlo simulation (using PCXMC software version

1.5). The range and mean of effective dose ED/μSv for male and female patients in maxillary molar and mandibular molar dental x-ray examinations of three age groups (1-15, 16-30 and 31-60) years old are presented in Table 4 and 5, respectively. The mean effective dose was 3.734 μSv and 3.505μSv for females and males, respectively, for (1-15) years old age group of patients undergoing maxillary molar dental x-ray examination.

**Table 1: The exposure factors kVp, mA and time/sec with FFD/cm focal to film distance, for maxillary and mandibular intraoral radiographies for male and female.**

| Age group (year) | Dental radiology | KVp | mA | Time/sec | FFD/cm |
|---|---|---|---|---|---|
| **1-15** | Maxillary | 65 | 20 | 0.5 | 23 |
| | Mandible | 65 | 20 | 0.5 | 23 |
| **16-30** | Maxillary | 65 | 20 | 0.6 | 23 |
| | Mandible | 65 | 20 | 0.6 | 23 |
| **31-60** | Maxillary | 65 | 20 | 0.6 | 23 |
| | Mandible | 65 | 20 | 0.6 | 23 |

**Table 2: The range and mean of entrance surface dose ESD/mGy for male and female patients in maxillary molar dental x-ray examination of three age groups (1-15, 16-30 and 31- 60) years old.**

| Clinical variables value | Range of ESD/mGy | | | | Mean of ESD/mGy | | *P* |
|---|---|---|---|---|---|---|---|
| | Female | | Male | | Female | Male | |
| Age group (year) | Max | Min | Max | Min | | | |
| **1-15** | 2.68 | 2.37 | 2.22 | 1.63 | 2.52 | 1.91 | 0.721 |
| **16-30** | 10.18 | 3.61 | 4.94 | 3.04 | 7.87 | 3.72 | 0.780 |
| **31-60** | 3.10 | 1.65 | 4.99 | 3.24 | 2.28 | 4.09 | 0.679 |
| **1-60** | | | | | 4.22 | 3.24 | 0.147 |

For (16-30) years old group, the mean of effective dose is 6.212 μSv and 3.530 μSv for females and males, respectively, and for (31-60) years are 3.220 μSv and 3.209 μSv for female and male, respectively. For females in all age groups the mean of effective dose was 4.38 μSv, and for males in all age groups was 3.417 μSv. We see that there are significant differences between males and females *P*-value = 0.027, 0.014 and 0.031, for the three age groups (1-15), (16-30) and (31-60) years old respectively. And there are significant differences between all ages groups for males and females *P*-value = 0.022.

**Table 3: The range and mean of entrance surface dose ESD/mGy for male and female patients, in mandibular molar dental x-ray examination of three age groups (1-15, 16-30 and 31-60) years old.**

| Clinical variables value | Range of ESD/mGy | | | | Mean of ESD/mGy | | *P* |
|---|---|---|---|---|---|---|---|
| | Female | | Male | | Female | Male | |
| Age (year) | Max | Min | Max | Min | | | |
| **1-15** | 8.82 | 2.93 | 3.13 | 2.65 | 5.88 | 2.89 | 0.047 |
| **16-30** | 2.80 | 1.31 | 8.69 | 2.87 | 2.06 | 1.06 | 0.673 |
| **31-60** | 1.98 | 0.87 | 3.27 | 1.77 | 1.42 | 1.98 | 0.861 |
| **1-60** | | | | | 3.12 | 1.97 | 0.613 |

For patients undergoing mandibular molar dental x-ray examinations, the mean effective doses for (1-15) years old were 4.998 µSv and 3.969 µSv for females and males, respectively, and for (16-30) years old were 3.270 µSv and 1.170 µSv for females and males, respectively. And for (31-60) years old the mean effective doses were 2.020 µSv and 1.131 µSv for females and males, respectively. For females in all age groups the mean effective dose was 3.429 µSv, and for males in all age groups it was 2.09 µSv. Also, we see that there are significant differences between males and females *P*-value=0.013, 0.002 and 0.047, for the three age groups (1-15), (16-30) and (31-60) years old respectively. And there are significant differences between all ages groups for males and females *P*-value =0.0285.

**Tale 4: The range and mean of effective dose ED/µSv for male and female patients in maxillary molar dental x-ray examination of three age groups (1-15, 16-30 and 31-60) years.**

| Clinical variables value | Range of ESD/µSv | | | | Mean of ESD/ µSv | | *P* |
|---|---|---|---|---|---|---|---|
| | Female | | Male | | Female | Male | |
| Age (year) | Max | Min | Max | Min | | | |
| **1-15** | 4.878 | 1.681 | 4.781 | 3.226 | 3.734 | 3.505 | 0.027 |
| **16-30** | 8.540 | 2.626 | 3.739 | 3.226 | 6 212 | 3.530 | 0.014 |
| **31-60** | 3.850 | 2.568 | 4.140 | 2.478 | 3.220 | 3.209 | 0.031 |
| **1-60** | | | | | **4,38** | **3,414** | **0.022** |

**Table 5: The range and mean of effective dose ED/µSv for male and female patients in mandibular molar dental x-ray examination of three age groups (1-15, 16-30 and 31-60) years.**

| Clinical variables value | Range of ESD/µSv | | | | Mean of ESD/ µSv | | *P* |
|---|---|---|---|---|---|---|---|
| | Female | | Male | | Female | Male | |
| Age (year) | Max | Min | Max | Min | | | |
| **1-15** | 8.695 | 2.428 | 6.693 | 1.243 | 4.998 | 3.969 | 0.013 |
| **16-30** | 4.880 | 1.668 | 2.969 | 0.906 | 3.270 | 1.170 | 0.002 |
| **31-60** | 3.393 | 1.058 | 4.236 | 2.03 | 2.020 | 1.131 | 0.047 |
| **1-60** | | | | | 3.429 | 2.09 | 0.028 |

**Table 6: Mean ESD (mGy) and stander deviation for maxillary molar and mandibular molar x-ray examination for three age groups.**

| Age (year) | Maxillary molar | | Mandibular molar | |
|---|---|---|---|---|
| | Female | Male | Female | Male |
| | Mean±SD | Mean±SD | Mean±SD | Mean±SD |
| **1-15** | 2.52 ±1.96 | 1.910 ±1.10 | 5.88 ± 2.87 | 2.89 ±1.25 |
| **16-30** | 7.87±3.83 | 3.720±1.17 | 2.02 ±1.35 | 1.06 ±0.90 |
| **31-60** | 2.28±2.05 | 4.09±0.642 | 1.42 ±1.60 | 1.98 ±0.32 |

**Table 7: Mean ED (mSv) and stander deviation for maxillary molar and mandibular molar x-ray examination for three age groups.**

| Age (year) | Maxillary molar | | Mandibular molar | |
|---|---|---|---|---|
| | Female | Male | Female | Male |
| | Mean±SD | Mean±SD | Mean±SD | Mean±SD |
| **1-15** | 3.734±1.57 | 3.505 ±0.41 | 4.998 ±2.62 | 3.969 ±1.16 |
| **16-30** | 6.212±2.45 | 3.530±0.48 | 3.270 ±1.45 | 1.170 ±1.85 |
| **31-60** | 3.220±1.72 | 3.209 ±0.69 | 2.020 ±1.87 | 1.131 ± 1.86 |

## Discussion

In this study, ESD and effective dose value in dental periapical radiographs for molars in lower and upper jaws were obtained for three age groups in both genders.

The values of effective dose obtained in this study do not differ from those estimated in other countries, for example in the United Kingdom is 3µSv. France 5µSv.[11] In European Commission Issue 136 the effective dose ranged from 1µSv to 8.3µSv.[1] The reason is that in the current study and the other study they used the same tissue weighting factor (ICRP60).[12] The mean effective dose in our study for adults are 3.2 for the maxillary molar and 2.02 for the mandibular molar, while the effective dose in the studies by Hart *et al*.[10] Tung *et al*.[14] and the Department of Health Services[15] were 5.7 µSv, while in the Chaparian and Dehghanzade for adults they were 9 µSv in maxillary molar and 6.6 µSv in mandibular molar. The differences between the results are due to the use of the new weighting factor (ICRP103).[13]

Too short an exposure time may lead to the necessity to repeat the test and, as a consequence, to re-expose the patient to ionizing radiation. A diagnostic reference level value of 7 mGy for ESD is proposed for intraoral radiographs by the International Atomic Energy Agency (IAEA).[8] In the Portugal, the median of ESD for mandibular molars is 6.3 mGy.[9] Also the values of effective dose obtained in this study do not differ from those estimated in other countries, for example in the United Kingdom is 3µSv and France 5µSv.[11] And in European Commission Issue 136 the effective dose ranged from 1µSv to 8.3µSv[1] due to the use of the same tissue weighting factor (ICRP60).[12] However the averaged dose for intra-oral radiography can be assessed from data which ranged from less than 1 to around 20 µSv.[7,10] Finally, in Figure 1 and 2, we show the ESD/mGy and ED/µSv comparisons between the males and females in the three age groups for maxillary molar and mandibular molar dental examinations, respectively.

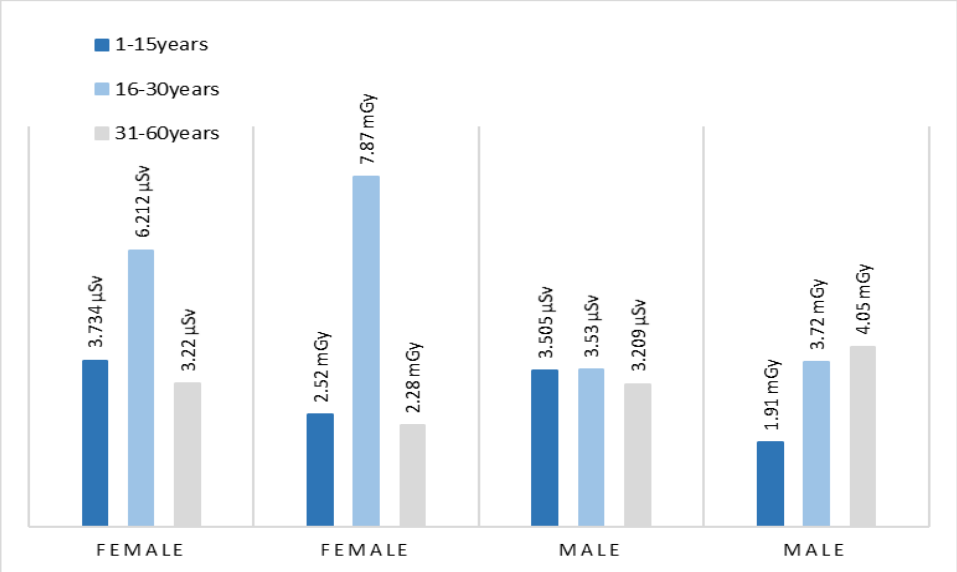


**Figure 1: Comparision of ED/µSv and ESD/mGy between Male and female patients in maxillary molar dental X-ray examination for three age groups.**

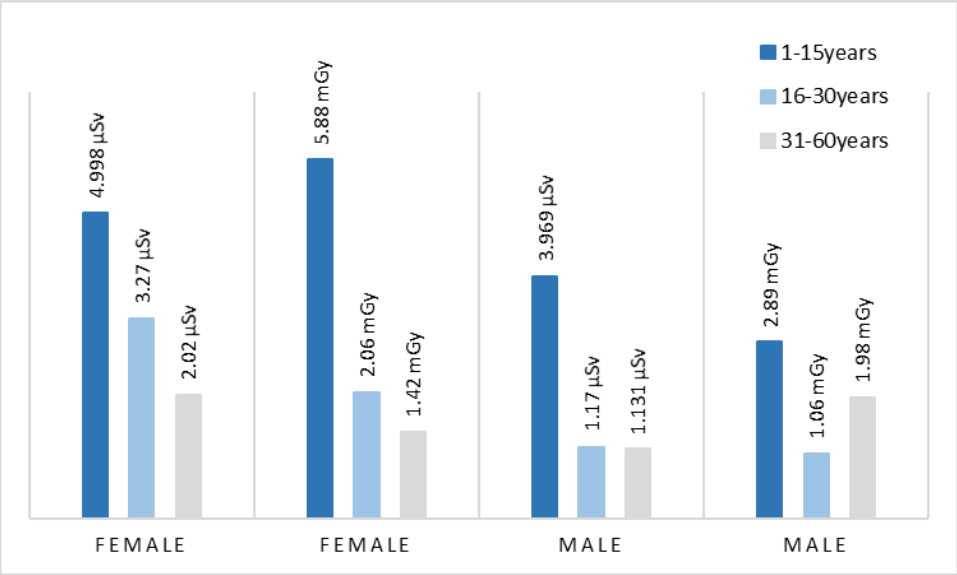


**Figure 2: Comparesion of ED/µSv and ESD/mGy between Male and female patients in mandibuler molar dental x-ray examination for three age groups**

In general, the exposure radiation in this study is considered to be low, but the exposure to a child is something larger than the adult. The effective dose decreased with increasing age groups (Table 6 and 7), and the exposure radiation is relatively higher for female than male groups because females are more sensitive to ionizing radiation than males. This happens because the radiation field includes more radiosensitive organs for smaller patients/pediatrics and for female patients.

The higher dose exposure to children in this study is due to using the same kVp, mA and exposure time that is also used for adults.

## Conclusion

The results of this study showed that the the entrance surface dose (ESD) or effective dose (ED) cannot be accurate indicators for the physician to judge the radiation risk of an x-ray examination. The overall risk from radiation in children was more than in adults and in female patients it was more than in male patients in dental x-ray examination. It is recommended that the average risk caused by exposure be considered as a guide to assess the risks and benefits for each age group.

## Conflicts of interest

The authors reported no conflicts of interest.

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