COMPARISON BETWEEN ABSORBED DOSES IN TARGET ORGANS IN PANORAMIC RADIOGRAPHY, USING SINGLE EMULSION AND DOUBLE EMULSION FILMS

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Abstract- The use of panoramic radiography, due to its numerous advantages, is increasing. Radiographic films used in this technique are of double emulsion (DE) type which are used with intensifying screens. Single emulsion (SE) films can also be used. The purpose of this study was to determine the exposure parameters to achieve an appropriate optical density in these two types of films, and to estimate under such parameters, radiation doses to mandibular bone marrow (MBM), thyroid gland and parotid gland. This study was performed through a tissue equivalent phantom. First, with various tube voltage and tube current, 128 radiographs were taken of phantom with these two types of films. After examining the optical densities, the exposure parameters under which both films have the same density, were determined. Then, phantom again was exposed and MBM, thyroid gland and parotid gland absorbed doses were measured, using TLDs. It was demonstrated that: 1) SE films, in order to provide appropriate optical density, require two times radiation in comparison with double emulsion film; 2) using SE films increases MBM dose, up to 2-2.5 times, thyroid gland dose up to 1.7-2 times and parotid gland dose up to 1.3 times, in comparison with DE films; 3) in DE films, under lower exposure parameters and desirable processing, MBM dose up to 3.5 times, thyroid gland dose up to 1.5 times and parotid gland dose up to 2.5 times will increase. Considering that the risk of radiation induced cancers increases with repeated radiation doses, using SE films is not recommended.
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Key words: Double emulsion films, Densitometry, Dosimetry, Single emulsion films

INTRODUCTION

Nowadays, radiography seems a necessary procedure in diagnosis and treatment of patients with dental problems. Panoramic radiography, which is able to show a general view of teeth and jaws, enjoys a special importance in the field of diagnostic images. This kind of radiography is used for subjects that for different reasons can not tolerate intraoral films. Moreover, the time needed for a panoramic radiography is very short (1). Investigation have shown that the amount of X-ray exposure in panoramic radiography is 10 times less than a complete series of intraoral radiography with fast films, and is equal to 4 Bite–wing radiographies with fast films (2).

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Because of the broad application of panoramic radiography, clinics attempt to present radiographs with the highest optical quality. To achieve this goal, advanced radiography machines, valid and standardized films, ideal processing and experienced technicians, are used. Also, some clinics use video films or special films that are commonly used in computed tomography (CT) scan and magnetic resonance imaging (MRI).

Video films are single emulsion that only one side of them is mixed with X-ray sensitive emulsion to increase the ability of exposed tissues separation. It should be noted that the image sharpness in CT scan and MRI is significant, so the use of such films is essential (3). On the other hand, through using such techniques, films are not exposed directly, so the amount of exposure dose does not have any influence on the image. Such films, because of having an emulsion layer on one side, have lower speed. As a result, to make an image with similar density, in comparison with double emulsion films, they require more exposure rate.

Films commonly used in panoramic radiography are double emulsion, which their both sides are mixed with radiation sensitive emulsion (3). In order to obtain two radiographs of these two films with similar densities, single emulsion film needs more exposure (2). On the other hand, the image sharpness, needed in CT scan and MRI, is not necessary in panoramic radiography for general examination of teeth and jaws.

In the head and neck area, there are critical organs such as active bone marrow and salivary glands that are sensitive to delayed effects of X –ray radiation. Injuries to these tissues endanger one's health (4). Too much radiation, in the head and neck area, put these organs under radiobiologic risk. Radiation to bone marrow, due to its capability for leukemia, is very important. Thyroid gland is subject to a high percentage of irradiation induced cancers, so is considered very significant (1).

The purpose of this study was the investigation of the absorbed doses in organs and sensitive areas in head and neck during panoramic radiography and comparison of such doses between two common films called single emulsion and double emulsion.

MATERIALS AND METHODS

In this study, a phantom of human's head, called RANDO phantom (Radiation Analog Dosimetry) was used. Rando phantom is a living tissue equivalent that is made of isocyanate plastic that surrounds the skull and the areas such as nasopharynx, oropharynx and cavities like sinuses are filled with air. Phantom has been divided into parallel segments with the thickness of 2.5 cm and the segment number zero (0) is placed on the top of it. There are cylinder cavities, containing dosimeters, with dimensions of 5×25 mm in different parts of this phantom (4).

The main goal of this study, was estimating the radiographic density of single emulsion and double emulsion films according to different parameters (KVp, mA). For this purpose, a panoramic radiograph is first taken of this phantom. In this radiograph, that is completely similar to that of an adult man, the inferior border of mandible, the cancellous bone around the mandibular first molar and maxillary sinuses are marked. Then, on the face of phantom in the mentioned areas, metal circles with the diameter of 1 cm are attached and radiography is again repeated until point A in the middle of maxillary sinus, point B in the cancellous bone of periapical area of first mandibular molar and point C on the inferior border of mandible, are placed.

The radiographic machine, used in this investigation, is called planmeca 2002cc proline. After checking the proper position of phantom, the intended radiographs were provided as follows. First, common or double emulsion films were used. Phantom was exposed for 18 seconds under the parameters of 60 KVp and 4 mA. Then, the film was transmitted to a darkroom, assigned a number and placed in protective boxes far from the light. Finally, under mentioned parameters, phantom was exposed for 7 times. Totally, radiographies were taken under parameters of 60, 70 and 180 KVp and 4, 8, 12 mA, each KVp with each mA. After taking 63 radiographs, the film was changed and this time a single emulsion film was used.

After providing 126 radiographs of both types of films, they were transferred to radiography center of

Imam-Khomeini Hospital. For processing, an automatic processor was used, while the developing temperature was 32°C and time for each panoramic film was 2 minutes. After this phase, films were transferred to "Iran Atomic Energy Organization, the protection center against radiation". In this centre, by a digital densitometer machine, films densitometry was done. Optical density, under each of the KVp and mA parameters, is the average density of 7 radiographs. After it was observed that some of them have similar densities. These taken radiographs, totally were put on a negatoscope (view box).

From among them, by 3 orofacial radiologists, and 1 oral medicine specialist, 2 radiographs of single emulsion films and 2 radiographs of double emulsion films, were chosen as the best ones according to their optical density, contrast, definition and image sharpness. The characteristic of radiographs and their densities are presented in table 1. During the next phase, under each exposure parameters, doses of sensitive organs such as thyroid gland, parotid gland and mandibular bone marrow are measured by special dosimetries.

Dosimetries used in this investigation, are lithium flouride thermoluminescent crystals (TLD 100) in the form of cubic segments with the dimensions of 1× 3×3 mm that can be used repeatedly. Such dosimeters are too much exact and efficient for small and repeating doses. The number of TLD used in this investigation was 40 and also 2 more, for estimating back ground radiation, were used.

In this investigation, TLD was used as follows: First, in segment number 6 of phantom as right parotid gland, then in segment number 7 in the apex area of the first and third molars and right premolar of mandible, and also in segment number 9 of phantom on the left, right, middle and surface of thyroid gland, 3 TLDs were placed for each of them. Then, Phantom was placed in radiology machine and was exposed under the parameters of: (60KVp, 4mA) (70KVp, 4mA) (60KVp- 8mA)(70KVp-8mA). During each exposure, dosimeters were taken out and their numbers were noted down.

In order to read the received dose of TLD by analyzer machine, phantom is exposed 10 times, under these parameters.

Table 1. Exposure parameters and optical density in single and double emulsion films

Film	Tube Current mA	Tube Voltage	Optical Density	Number of samples
S	8	60	69	9
D	4	60	63	68
S	8	70	181	34
D	4	70	176	88

Abbreviations: S, single emulsion films; D, double emulsion films

RESULTS

After reading dosimeters and estimating doses in micro gray, according to a prepared table, the obtained numbers are as follows (Table 2):

After investigating and comparing the findings of dosimetry, based on location and exposure parameters, the following results are suggested: 1) In a constant kilovoltage (KVp = 60), if the mA is doubled, bone marrow dose will become approximately 2.5 times (234/96 = 2.53) and thyroid gland dose will become 2 times (13.4/7.5 = 1.78). Parotid gland received dose will also increase (322.234 = 1.3) to 1.3 times.

In a constant kilovoltage (KVp = 70), if the mA is doubled, the bone marrow dose (725.358 = 2.02) and also the thyroid gland dose (23.11 = 2.09) will become 2 times. The received dose of parotid gland will also increase up to 1.3 times (800/620).

Under the conditions of constant mA, that equals 4, by adding 10 kilovoltage, bone marrow dose will approximately become 3.5 times (358.96 = 3.7), parotid gland dose will become 2.5 times (20.234 = 2.6), and thyroid gland dose will increase up to 1.5 times (11.75 = 1.4).

Table 2. Average absorbed dose in critical organs due to exposure parameters (μGy)

Organ	4 mA 60KVp	8 mA 60KVp	4 mA 70KVp	8 mA 70KVp
Bone marrow*	96	243	358	725
Parotid Gland	234	322	620	800
Thyroid Gland	7.5	13.4	11	23

* Mandible

DISCUSSION

Panoramic radiography, because of its advantages, is of high importance for medical doctors and dentists, and always has been used as a main tool in diagnosis and treatment of patients. It has also been observed that, narrow beam radiography made by some panoramic machines, is an alternative to periapical radiography (5). A research showed that a new generation panoramic machine delivers approximately 5% to 12% of the E of a complete mouth intraoral radiographic examination (6).

One of the steps taken for the development of optical quality of panoramic radiographs, is using single emulsion or video films instead of double emulsion films. In this study, done by the panoramic radiography machine called “Planmeca 2002 cc”, was shown that a panoramic radiograph taken by a conventional film, under the exposure parameters of KVp = 60 and mA= 4, is able to produce optical density equal to an radiograph taken by a Video film under the exposure parameters of KVp=60 and mA= 8. More over, under the parameters of KVp=70 and mA= 4, Optical density in usual films is equal to single emulsion films under KVp=70 and mA= 8.

Different exposure parameters cause different absorbed doses of X-ray radiation in critical head and neck organs. Finding show that, single emulsion films due to having one layer of the material sensitive to X-ray radiation, need more exposure to produce appropriate optical density and in order to achieve this goal, we have to double the mA rate of radiographic machine, the received dose in organs such as bone marrow, parotid gland and thyroid gland will highly increase. In bone marrow and thyroid gland, it will approximately become 2-2.5 times.

It has also been observed that, while using conventional films, lower exposure parameters and idealized processing, cause radiographs of high quality, increasing kilovoltage, makes an increase in tissue dose up to 1.5-3.5 times.

Estimating doses of sensitive head and neck organs has been investigated in a lot of studies, through different panoramic machines and different radiographic techniques. The reason for such investigations, is the existence of sensitive organs such as: bone marrow, thyroid gland, salivary gland and brain and eye lenses under radiobiologic risk (4).

In a study, by Rose and White, in order to estimate tissue dose in head and neck area, they concluded that the main risk resulting from dental radiography, is the probability of inducing leukemia (7). In another study in the United States, it was observed that the risk of inducing leukemia in dental examinations is not too much but, it is combined with other environmental risks (8). According to a research, as a result of ionizing radiation, the risk of thyroid cancer increases, and 10% of people with thyroid cancer will die for this reason (9). A significant reduction (15%-30%) of absorbed dose to the thyroid gland was obtained using smaller field size in panoramic radiography (10). Moreover, the prevalence of salivary gland cancers, among people undergone various dental radiographies, has increased (9). Studies performed to estimate tissue doses, due to different location of dosimeters, different kinds of panoramic machines and dosimetry systems, have yielded different results.

In a research by Weissman *et al.* by a panoramic machine, thyroid gland dose, parotid gland dose and bone marrow dose in the first mandibular molar were estimated: 2.6-13.9, 248-485, 4.9-21.8 millirad, respectively (11). Also in 1994, by Freeman *et al.* through panoral machine, doses of mandibular bone marrow, parotid gland and thyroid gland were estimated 50, 1314, 40 micro gray, respectively (12). Lecomber *et al.* by orthophos machine, which has special programs for exposure certain areas of jaws, estimated parotid gland dose as 610 and thyroid gland dose as 51 micro gray (13).

The most similar research to the present one, is an investigation performed by Hayakowa *et al.* at Tokyo dental faculty. In this study, with a panoramic machine called “Planmeca 2002 cc”, thyroid gland dose and parotid gland dose were estimated 17-22 and 400-700 micro gray, respectively (14).

A research by Lecomber *et al.* to compare E from conventional radiography (panoramic-cephalometry-cross-sectional tomography) with CT scan in dental implant planning, showed the greatest individual organ doses for any examination were in salivary tissue (15). E for panoramic radiography varied between 0.004 msv to 0.02 msv (14). These figures are completely similar to those gained from the present study. All the above mentioned studies, especially the recent one, confirm the precision of the present study in estimating doses of the intended organs.

As it was mentioned, estimating the risk of cancers induced by ionizing radiation is a difficult job. First, due to the fact that there are a few people affected with such cancers and the amount of exposure to them has been very high, so estimating the effects of low doses is not possible.

Second, cancer is a prevalent disease and measuring the prevalence of radiation induced cancers is difficult. The only estimation existed is the amount of X-ray radiation in panoramic radiography in comparison with background radiation, that, in average, is equal to 12-24 hours of background radiation (7). Anyway, since cancer is the probable or stochastic cause of ionizing radiation, its induction is dose dependant and ad a result, its probability increases while tissue doses increases.

Now, except the present study, there is no more investigation, comparing two types of radiographic films, regarding X-ray radiation to critical organs, by panoramic machine. In conclusion, in this investigation, it was proved that since single emulsion films, which are recently used in radiology clinics, have a structure different from conventional films used in panoramic radiography, should be exposed two times in comparison with conventional films, to produce an appropriate radiographic image.

Radiographs, provided with such films, only because of their transparency, attract Doctors and patients. This characteristic, does not yield any additional diagnostic information, but, this amount of radiation, increases tissue doses in Patients, considering the fact that panoramic radiography is increasing. Although investigations have shown that the probability of leukemia (bone marrow cancer), salivary glands cancers and thyroid gland concerns, does not have any direct relationship with X-ray radiation during dental radiographies, its risk increases among patients who are under dental radiographic examinations periodically. In addition, environmental cancerous elements, that nowadays are increasing, give rise to this probability. Therefore, since the purpose of radiography is diagnosis and treatment, and this can be achieved by usual radiographic films and under lower exposure parameters, single emulsion films are not recommended for panoramic radiographs.

Conflict of interests

The authors declare that they have no competing interests.

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