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Study the Effect pf Using Intensifying Screen on Magnitude of Changing Calibration Curve For Dental X-Ray Film in Manual Development Method

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ABSTRACT

Aim: To study the effect of using intensifying screen (Rare Earth),with a film which dose not exist with it. **Materials and Methods**: The patient received the radiation dose during dental fustigation by x-ray radiation. The optical density of the x-ray film was measured using densitometer. **Result**: A decrease in radiation dose was approximately 20% for the same condition . ^{241}Am was used, because its energy (59.5keV) is close to the energy of x-ray in dental radiography. **Conclusions:** It is essential to use intensifying screen I.S in the diagnoses field of dentistry for the purpose of reducing the amount of radiation dose. It could be concluded that small calibration operation must be determined during the regular interval periods for the optical density measurements of the optical density by densitometer to show its efficiency

Keyword: intensifying screen , dental x-ray film , densitometer , radiation exposure.

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INTRODUCTION

The intensifying screens are characterized by their ability to reduce the amount of radiation exposure that needed for the purpose of producing image by diagnostic x-ray .The use of these screens protect the patient from radiation exposure accompanied by radiography and also reduce the movement chance on the x-ray image. There are three properties to specify the efficiency of the intensifying screen material which are:

1. The screens that magnify the intensity must have a high x-ray absorption .
2. The screens that magnify the intensity must have high x-ray conversion to the light with a suitable energy of certain frequency.
3. The following radiance must be small or not exist when radiation stop. (The following radiance is the phosphor tense to continue giving the light after x-ray exposure).

The first intensifying screens (phosphorous) produced in 1896 by Tomas Edison [(1)].It was made from Calcium Tungsten which is used for emitting the light close to regions of ultraviolet-ray spectrum that is important because of high sensitivity to silver halide within diaphragm emulsion of this spectrum of light.

Tungsten's Calcium ($CaWO_4$) has relatively high absorption ability and it has efficiency to change to the light. There is another type of intensifying screens called Rare Earth or called, lanthanides chain. It consists of Lanthanum and its elements begin by atomic number Lanthanum ^{57}La and end by Lutetium element ^{71}Lu discovered in 1972.It is beaming phosphoric crystals attached with each other and mounted on carbonic plastic base and then placed inside cassette coated by emulsion material on its two sides for radiography purpose. When the x-ray hits the phosphorous crystals will radiance and sequence emit visible light .The time of x-ray photons absorption and re-irradiation as visible light is bigger in condition of using intensifying screens of calcium tungsten ($CaWO_4$) type. But, Rare Earth screens efficiency in x-ray absorption is less [(2)] reducing absorption radiation dose that have been achieved in the bone radiography of human face[(3)] when using thermoluminescent dosimeter (TLD) as x-ray detector by ratio 18% when using intensifying screens at eye surface during face radiography.

The received dose [(4)] for x-ray in dentistry is about (0.25 mGy) for x-ray in dentistry which is accepted in (28.8 mR), and according to the measurements of this research, the reducing amount is about 20% x-ray film and had been used in many researches as detector for x-ray. The film used as detector of two dimensions for x-ray (XRD) (x-ray Diffraction) with intensifying screens[(5)].

X-ray have been used in medical inspection for all body parts in radiography with using intensifying screens to reduce the radiation dose, especially during the exposure to the sensitive members of the body to the high dose It had been used during exposure parts of the chest with the x-ray radiography film, which worked at voltage of (70 kV) [(6)] **,** as well as reducing from radiation dose amount by chemical method and by using recent technique [(7)].However , the radiation film has been used to estimate the amount of radiation dose used in dentistry to treat face and jaw [(8)].

The x-ray film used according Queensland Government [(9)] as detector for ultraviolet ray at high energies (UVC) and low x- ray energies, so ,in some general cases the film can be used to diagnosis the body parts .The intensifying screens are used to increase optical density on the film so that the exposure amount of radiation dose would be possibly low [(6)].

Finally, at 2006 Mahrok and Al-Dulamey [(10)] used x-ray film to find calibration curve for densitometer device by optical density gauge.

The reason of using intensifying screens for ray film used in dentistry in this research is to reduce the radiation dose received by the patient with increasing the optical density and for same conditions.

METHODS

Intensifying screens (i .s.).

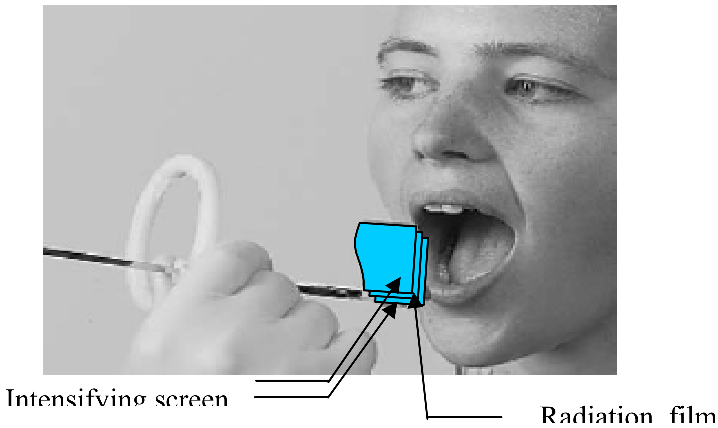
The fluorine materials used in Intensifying screens, other fluorine screens characterized with the absorption of energy for x-ray. They re –irradiation the absorbed energy as a visible light .These materials known as fluorine materials when the time different between the absorption of photon from radiation and re-irradiation as a very short visible light about 10^{-9} second .

The emitted light color from radiated fluorine crystals does not depend upon fluorine materials itself and types of alloys contained it.

The following conditions must be available on the fluorine materials to be used for medical diagnostic field:

1- They must have high ability to absorbe for x-ray. i.e. it should have high absorption coefficient and for this reason, the used material for this purpose is of high atomic number.
2- They must give suitable amount of radiation of visible light and of suitable color.
3- The interval period between ray absorption and visible light sending must be very short .

The fluorine property is used for medical diagnostic field. The I.S. naturally compose of strong base may be thick paper which its surface is coated with very white material like magnesium oxide or titanium dioxide and over these white surface fluorine crystals is placed to make a thin paint, because of crystals small size. It is of great use of I.S. in radiography operation, these screens are placed close to the photographic films and the irradiant film of the dual coating is enclosed from its the sides by through screens for the purpose of increasing the optical density on the film without the need to increase amount of radiation exposure to protect the patient being tested radiantly as in Figure (1).



(Figure-1) Intensifying screens with the film

Dental x-ray film properties

The detector used in this research is radioactive film which is manufactured by Kodak Company (Kodak dental x-ray film).This detector classified to E class speed type which is placed inside the mouth. The dimensions of film are (3.1 cm x 4.1 cm), and each film contains of two emulsion layers (double side emulsion film).

The screen or photographic film used for radioactive picturing purpose by x-ray consisted of this laminar of transparent material either from cellulose national or from polyester material and a pigment of blue color was added. Silver bromide crystals must be distributed equally inside the two emulsion layers for the purpose to get equal sensitivity for all parts of the film. At exposure of the film to radioactive beam, the silver bromide crystals affected by the radiation with change transform chemically making (latent image) which can not be appeared before proceeding form of chemical operation on the film.

The stages of developing radiography (image) on the film, summarized in two stages.

1- First stage is developing, and in this latent image is appeared which is composed in places of radiation exposure.
2- The second stage; is fixing stage the silver bromide crystals that is not affected by radiation would be eliminated and separated from emulsion layer where left empty and transparent place referred that no radiation exposure in the regions.

The radioactive image that appeared on the film is accounted negative, because the parts exposed to the radiation appeared black, but the parts that are un exposed to the radiation appeared transparent. The whole time to show the image on the irradiative film had been decreased in a large degree by using automatic processor. To measure the optical density on radiation film, the optical density measurement (densitometer) had been used.

The used instrument is of type DT 1105, and it is used to distinguish the optical density of radiation film from spot to another or from film to another. This instrument contains two units:

1- Base unit type 305.
2- Optical measurement unit type 205: Optical intensity passing through the radiation film will be measured by optical dual (photodiode).

The main function of photodiode is to transform the light to electric pulse (signal) .This done amplify the electric pulses by amplifier and transmitting them in to digital panel meter

$D = \log_{10} I_0/I_t$ …….. (1) [2]

Where I_0, the incident visible light optical intensity on small area of the film and I_t, the optical intensity which passes through that small area, and optical density for rays film at point on the film represent the measure to the blackness degree on that point. In this research radioactive source had been used of kind ^{241}Am which gamma-ray radiation emitted at 59.5 keV. Optical density had been measured for ordinary back radiation of the radiation film. Several radiation films had been fixed at constant distances from (3 cm), the radioactive source and by different times. After that, chemical treatment proceeded manually for purpose to show the blackness degree which represents optical density to the radiation film which was measured through densitometer instrument as shown in(Figure -2).

Figure(2): Densitometer Instrument

After proceeding the chemical treatment manually of the conditions by existence of intensifying screens and then without its existence for radiates film for the same conditions. The proceeding the measurement for blackness degree by optical density measurement. After that it would return to the relationship between optical density and radiation exposure amount in (m Gy) unit according to manufacturing company to Kodak radiates films which is illustrated in (Figure-3) and then calculating what is match from radiation dose [11].

CALCULATIONS

The error attached to estimation of the radioactive dose exposure value by (m Gy) unit which the calculated at (3cm) position attributes to the error in the optical density measurement to the one of used films, for example. The error in the optical density reading the back radiation film and according for the back radiation film and according to the (Squires Properties) [12] which contains diagram for the relationships between errors .The error in measurements of any optical density by Densitometer equal ± 0.01 , so the error in the final optical density becomes as follow :

$(\Delta D_f)^2 = (\Delta D_1)^2 + (\Delta D_2)^2$ ………… (2)

Where ΔD_f, final optical density error to a certain film.

ΔD_1,error in the optical density for the same film.

ΔD_2,error in the optical density for the back radiation film.

And by substituting instead of ΔD_1 and ΔD_2 by the value ±0.01 in the equation (4) results:

$(\Delta D_f)^2 = (0.01)^2 + (0.01)^2$

$\Delta D_f = \pm 0.014$

Whereas (± 0.014) represents the error in final optical density, and then we will calculate the relative error in the optical density (O.D.) according to the following relationship:

$\Delta O.D_f/O.D.\times 100\%$………………….(3)

For example the optical density relative error (0.26) as in Table (1), could be calculated according to equation (3) as follow:

$\pm 0.014 / 0.26 \times 100\% = \pm 5.3\%$

This error in the final optical density results in error in evaluating the exposure (m Gy) by using properties curve in (Figure-3) by amount twice the error in the optical density and equal (± 0.028 mR) and then relative error accounting achieved relates with every value from radiation exposure value as shown in (table-1) by using the following relationships : $\Delta mGy/mG \times 100\%$ ------------- (4)

For example the relative error for dose (0.61 mGy) according to equation (4) as in Table (1) is:

± 0.028 m Gy / 0.61 m Gy × 100 % = ± 4.5 %

The Reeducation ratio for radiation exposure dose by (Rare Earth) calculated (equation-5) [2] And put the Reducation ratio in the first column from right view of (Table 1).

$$\text{Reduction ratio} = \frac{\text{Exposure without screen}}{\text{Exposure with screen}} \times 100 \ldots 5$$

The conversion of radiation exposure dose from (mR) to (mGy) could be done by equation (6) .

100 mR = 1 mGy……………………….(6)

Table-(1): Optical Density Measurements with Radiation Exposure Amount in (m Gy)

Film No.	Exposure Time /h	With out I.S		With I.S		Reeducation in Dose %(mGy)
		O.D manual $\pm\frac{\Delta O.D}{O.D}\times 100\% = \pm\%$	Exposure in m Gy*10^{-2} anual $\pm\frac{\Delta mGy}{mGy}\times 100\% = \pm\%$	O.D manual $\pm\frac{\Delta O.D}{O.D}\times 100\% = \pm\%$	Exposure in m Gy*10^{-2} manual $\pm\frac{\Delta mGy}{mGy}\times 100\% = \pm\%$	
1	**1**	0.26±5.3	0.62±4.5	1.196±1.1	31.24±0.081	1.9
2	**2**	0.28± 5	1.2±2.3	1.288±1.0	34.25±0.081	3.5
3	**5**	0.34±4.1	2.97±0.9	1.564±0.8	43.27±0.064	6
4	**7**	0.38±3.6	4.16±0.6	1.748±0.81	49.28±0.05	8
5	**9**	0.42±3.3	5.34±0.5	1.957±0.71	56.11±0.049	9.5
6	**23**	0.69±2.0	13.5±0.2	3.243±0.42	98.14±0.02	13.7
7	**40**	1.00±1.4	22.5±0. 12	4.70±0.29	145.75±0.019	15.5

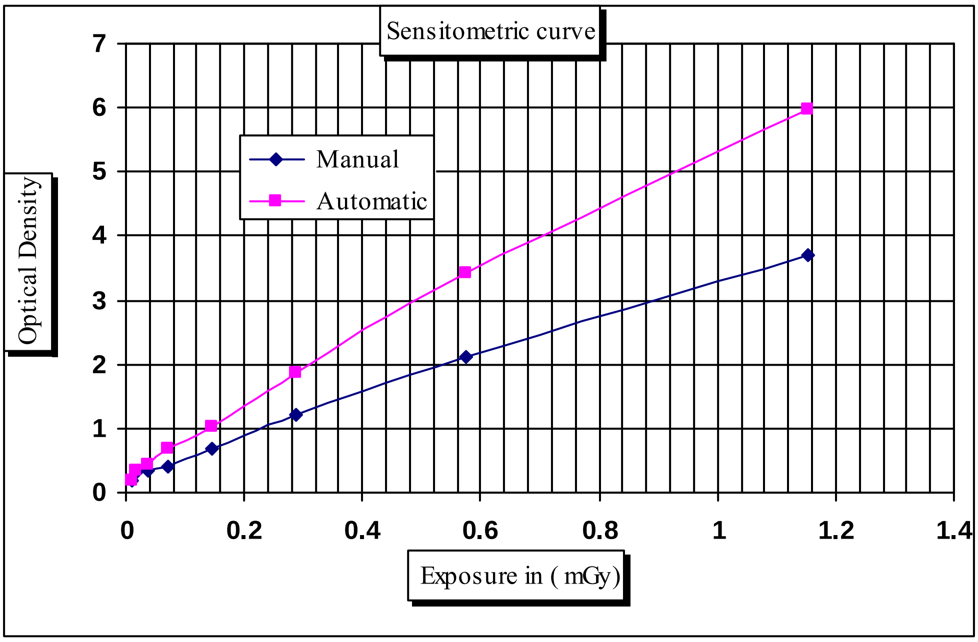
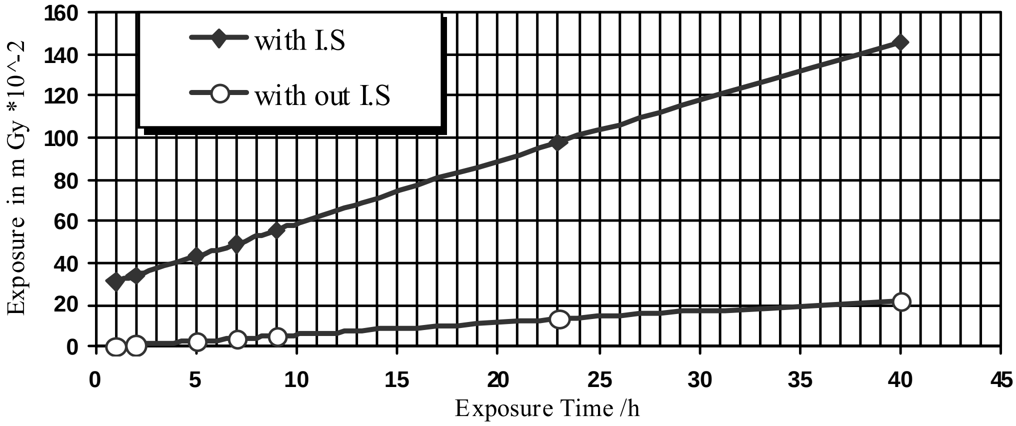


Figure (3).Relationship between optical density of gamma -ray radiation films and radiation exposure amount in mGy

RESULTS

The relationship between exposure amounts in (m Gy) unit with exposure time depending on (Table-1) and (Figure-4).

It is observed that the intensifying screens have a big role in increasing the exposure amount of radiography dose in (m Gy) unit . The proportion properly with the optical density depended on radiography film property according to the (Figure-4). So, this will help us to reduce the high dosage which patient needed during the diagnosis in the dentistry by reducing the exposure time or radiation intensity emitted from the x-ray tube; i.e. reducing exposure according to : E= I t,I represent intensity, and t, represented exposure time and reducing anyone of them results in reducing exposure.This result refer to reduce the radiation dose upon the patient and at the same time getting obtaining upon the same degree from the blackness and contrast upon the radiation film where the benefit of the intensifying screens become clear.



(Figure-4).Relationship of radiation dose exposure amount in mGy unit with exposure time (with I.S. and without I.S.)

From (Table 1), the ratio reeducation was about (4.6 – 4.7) times[2] and is match with what concluded by Fugate [2], which found that intensifying screen enlarge from the amount of the radiation exposure dose from (4-6) times according to the properties of used intensifying matter.

It had used in this study intensifying screens containing ($CaWO_4$) matter which was fluoride and characterized by its ability to absorption the x-ray and return a part of what was absorbed in shape of visible light.

For the application of inverse square law is better in case of long distances equation (1) So, it is always preferrd to find calibration lines after each time period and for every special chemical processing. It was possible to determine reading for the two conditions radiation doses with and without screens.The importance of using Radiation source ^{241}Am in this study depends upon being its energy near from x-ray photon energy that was generated from evacuation tubes used in teeth medical instruments which work at voltage amount 50-70 kV [13] readings of radiation dose manual development condition without and with intensifying screens is near from each other, especially at a low dose exposure and the error ratio increases for the received dose according to the radiation film properties placing of radiation film at distance of the aim 3cm was to get the bigger radiation dose ,because the lower radiation dose that the film sensitivity is 6700 nSv/h [10] .

The received radiation dose from x-ray tube is about 0.25 mGy [4] **,**as well as its existence x-ray film at same distance avoid us by covering the source with thin paper to prevent from α- particles radiation exposure which results in error in measurements and x-ray coating most of film parts perfectly for less possible distance.

In this research used Rare Earth as intensifying screen which have high ability to absorbe for x-ray. i.e. it should have high absorption coefficient , but less than $CaWO_4$ in reference to Al-Badrani *etal* **[14]** (Table -2). The time of x-ray absorption for photons and they re –irradiation the absorbed energy as a visible light refer to Rare Earth best than $CaWO_4$

Table(2): Comparison present work with previous search

Research	intensifying screen	Reduction dose ratio %	Optical density measurement	Detector
(Julin,1984)[3]	$CaWO_4$	18	………..	TLD
(Al-Badran *etal* 2008) [14]	$CaWO_4$	24	Densitometer	Dental x-ray film (Altra-speed film)
(Present work,2008)	Rare earth	20	Densitometer	Dental x-ray film (high-speed film)

CONCLUSIONS

1 -It is essential to use intensifying screen I.S in the diagnoses field of dentistry for the purpose of reducing the amount of radiation dose by increasing the optical density for the same conditions according to ALARA principle as low as Reasonably Achievable

2- From the obtained results, it could be included that small calibration operation must be determined during the regular interval periods for the optical density measurements of the optical density by densitometer to show its efficiency and to get the less error ratio .

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