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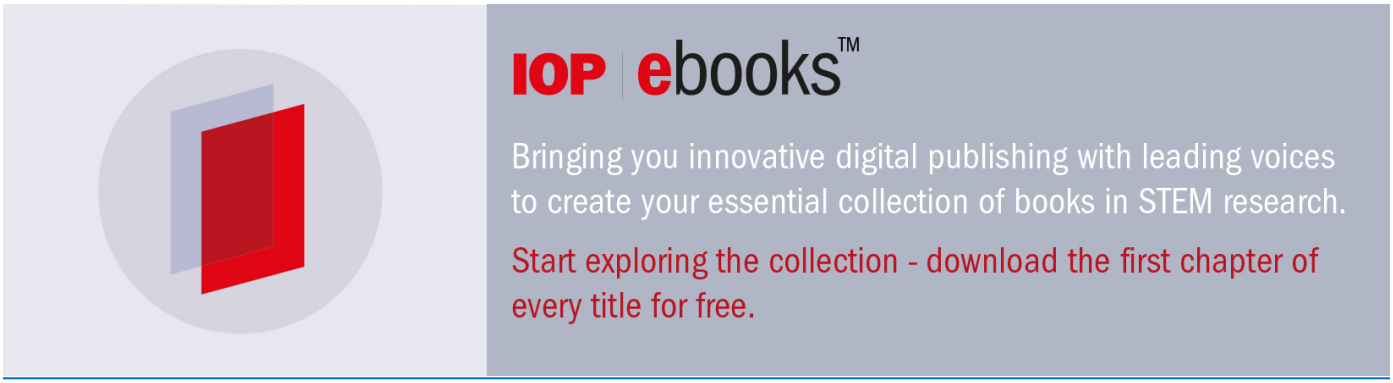

Cancer risks from head radiography procedures

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Abstract. The goal of this study is to evaluate the risk of cancer induction in head radiography procedures with a view to promote dose optimization and enhance patient safety. Thermoluminescent dosimeter (TLD 100) was used to determine the entrance surface dose (ESD) of 20 patients presented for head radiography in two tertiary healthcare institutions in Southwest Nigeria. The corresponding effective dose and doses to the brain, oral mucosa and salivary gland were evaluated using PCXMC software. Incidence cancer risks were evaluated using BEIR VII model. The total entrance surface dose (ESDT) for mandible, paranasal sinuses and skull radiography ranged between 3.01-19.12 mGy with a mean of 7.52 mGy. The resulting effective dose, brain dose, oral mucosa dose and salivary gland dose has a mean of 0.25 mGy, 2.84 mGy, 3.06 mGy, and 4.97 mGy respectively. The least incidence of cancer risk obtained in this study is 1: 7000. Failure in the adoption of complete optimization technique was responsible for the increased risk. Periodic dose audit and enforcement of radiation protection policy will help to checkmate the lapses and alleviate patient risk.

Keywords: Head radiography, Entrance surface dose, Incidence cancer risk

1. Introduction

Head radiography is used to visualize the cranium, facial bones and jaw bones for fractures. Included under head radiography are skull examinations, mandible examinations and postnasal or paranasal sinuses examinations. The examination is performed to investigate cases such as head injury, head pain, sinus infection, hypertrophy of the adenoids, inflammatory diseases of the sinus cavities, tumors, facial fractures among others [1-3].

In the developed society, higher imaging technique such as computed tomography is employed in the diagnosis of head injuries and diseases. However, in the study environment, plain radiography is the most easily accessible radiodiagnostic tool for head conditions due to its availability and cost effectiveness. The use of plain radiography for diagnosis in place of higher imaging techniques is a common phenomenon in developing countries as reported in literature [1-2, 4-5].

During head radiography procedures 2-3 views are projected thus, making the radiation dose delivered to patients to increase. Imaging of the head exposes several organs located in the head region to the risks of ionizing radiation. Cancer induction in low dose radiation cannot be overruled. Even, microwave radiation is known to induce DNA damage, produce chromosomal aberration, histological changes, genotoxic effects and others in tissues of exposed rats [6-9]. It is based on this fact that this

study was embarked upon in order to estimate the risks of cancer induction in head radiography with a view to promote dose optimization and enhance patient safety.

2. Materials and Methods

This study was conducted in the radiology departments of two tertiary healthcare institutions in Southwest Nigeria, designated as centre E and centre F. A total of 10 adult human subjects who visited the x-ray unit for head radiography were selected in each centre. The study was conducted for a period of one month. Consent was obtained from each patient before the commencement of the examination. Institutional consent was also obtained from each of the hospital used and also from the Nigerian Institute of Medical Research (NIMR). Thermoluminiscent dosimeter (TLD-100: LiF: Mg, Ti) chips were used to obtain the entrance surface dose (ESD) during the procedure. The TLD chips were obtained from RadPro International GmbH, Poland. The chips were oven-annealed according to specification using Carbolite oven made in England. Irradiation was conducted at the Secondary Standard Dosimetry Laboratory (SSDL) of the National Institute of Radiation Protection and Research (NIRPR), Ibadan. Calibration of TLD chips and reader were conducted and TLD signal was read using Harshaw Reader (Model 3500) at the Department of Physics, Obafemi Awolowo University Ile-Ife. Each of the TLD was enclosed in labelled black polythene pack. A total of three coded chips were used to measure the entrance surface dose (ESD) of each projection view during each head procedure in order to obtain the mean and enhance precision. The chips were attached to an elastic tape and placed in the primary beam of x-rays where the beam intercepted with the irradiated part of the patient.

The quality control of the x-ray machines were conducted using MagicMax quality control kits (IBA Dosimetry, Germany). Patient's clinical information and exposure parameters were noted and recorded using self-structured form. The effective dose, brain dose, oral mucosa dose and salivary gland dose was evaluated from the measured entrance surface dose (ESD) using PCXMC software (version 20Rotation). Thereafter, BEIR VII model was used to estimate the incidence cancer risk. Statistical analysis was done using SPSS (Version 23).

3. Results and Discussion

Twenty (20) adult human subjects underwent head radiography under three (3) different examinations; mandible (6), paranasal sinuses (6) and skull (8). The total entrance surface dose (ESDT) delivered to each patient; the corresponding effective doses; brain dose; oral mucosa dose; salivary gland dose; incidence cancer risks and the patients' indices are presented in Table 1. Descriptive analysis of parameters in Table 1 is presented in Table 2. Analysis of variance for entrance surface dose for each projection is presented in Table 3. Table 4 displayed the coefficients of predictors and Table 5 revealed the Pearson correlation. Figures 1, 2, and 3 compares the exposure parameters and entrance surface dose between the two hospitals for mandible, paranasal sinuses and skull examinations respectively. Figure 5 compares the entrance surface dose from this study with international standards. Sample of radiographs of three views is depicted in Figure 4.

Patient dose assessment is encouraged worldwide due to increased knowledge of the health effects of ionizing radiation. High dose implies high risks. The total entrance surface dose (ESDT) for this study ranges from 3.01-19.12 mGy with a mean of 7.52 mGy. The resulting effective dose varies from 0.09-0.70 mSv with a mean of 0.25 mSv. Total dose to the brain; oral mucosa; and salivary gland ranges from 1.01-7.77 mGy; 1.02-9.03 mGy; and 1.82-13.46 mGy respectively in ascending order of dose. The order of organ dose increase is similar to that reported for Head LAT by [10]. The least incidence cancer risk is about 14 per 100,000 (1:7000); this is considered a low risk and the highest incidence cancer risk is about 156 per 100,000; this is categorized as moderate risk [10]. Large variation in radiation dose values as recorded in this study is well documented in literature [11-14].

Table 1: Distribution of radiation doses and the associated incidence cancer risk from head radiography

Centre	Examination	No of views	Age (y)	Sex	BMI	ESD_T (mGy)	ED (mSv)	BD (mGy)	OMD (mGy)	SGD (mGy)	ICR
E1	Mandible	3	20	F	24.22	9.48	0.35	3.88	4.24	6.60	156.04
E2	Mandible	3	33	F	25.39	10.25	0.36	4.11	4.44	6.94	99.24
E3	Mandible	3	41	F	28.13	10.30	0.35	3.88	3.98	6.61	89.03
E4	PNS	3	54	M	24.38	18.7	0.65	7.28	7.78	12.52	102.33
E5	PNS	3	60	M	26.18	19.12	0.64	7.03	6.96	11.80	93.50
E6	PNS	3	47	M	21.51	18.84	0.70	7.77	9.03	13.46	118.45
E7	Skull	2	65	M	27.97	3.69	0.11	1.25	1.25	2.23	13.63
E8	Skull	2	49	M	25.46	3.08	0.10	1.11	1.12	1.95	18.57
E9	Skull	2	55	F	29.69	3.22	0.10	1.12	1.16	1.97	21.66
E10	Skull	2	19	F	21.48	3.34	0.12	1.38	1.68	2.70	57.87
F1	Mandible	3	24	M	22.59	4.81	0.16	1.80	2.04	3.18	39.16
F2	Mandible	3	56	F	28.91	4.99	0.15	1.70	1.76	3.01	31.33
F3	Mandible	3	36	M	20.08	3.86	0.14	1.55	1.78	3.14	27.79
F4	PNS	3	65	M	25.10	8.01	0.25	2.74	2.76	5.02	29.59
F5	PNS	3	50	M	23.67	7.88	0.26	2.93	3.42	4.97	46.57
F6	PNS	2	52	F	29.69	8.03	0.24	2.59	2.68	4.69	57.14
F7	Skull	2	38	F	27.34	3.08	0.09	1.05	1.06	1.93	28.73
F8	Skull	2	41	M	27.97	3.06	0.09	1.01	1.02	1.82	19.35
F9	Skull	2	21	F	20.70	3.01	0.10	1.16	1.40	2.35	47.19
F10	Skull	2	43	M	23.83	3.73	0.13	1.44	1.66	2.54	22.48

BMI = body mass index; ESDT = Total entrance surface dose; ED = effective dose; BD = brain dose; OMD = oral mucosa dose; SGD = Salivary gland dose; ICR = incidence cancer risk

Radiation risk models are a function of patient dose and age at exposure. Also, exposure parameters are key factors that determine the patient dose. It is therefore important that these factors are considered during irradiation of patients. The impact of exposure parameters to entrance (ESD) in this study is significant as shown in Table 3 and 4. Literature has shown that the use of appropriate exposure parameters is a means of dose reduction strategy [11, 15]. It is evidenced in this study that the choice of appropriate exposure parameters was responsible for the low ESD recorded in centre F. This implies that the implementation of appropriate dose reduction methods are more pronounced in centre F compared to centre E as shown in Figures 1, 2 and 3. This gap might be attributable to the fact that centre F has more trained professionals compared to centre E. Ultimately, there will be a higher incidence cancer risks accrue to patients who underwent head radiography in centre E. Training on optimization of dose and procedures is essential in centre E. This will help to improve the dose outcome and minimize risk to patient.

Though low ESD enhances minimal risks, the influence of age factor to incidence cancer risks should not be compromised. According to the risk models, age at exposure is proportional to risks [10, 16]. But age grouping by the world standards in radiology considers age 16 and above as adults [12, 17]. This implies using the same exposure parameters for all adults; the outcome will be higher risk to young adults compared to older adults. It is important that the adult age bracket should be revisited such that exposure parameters will be age dependent within the adult age bracket just as we have for paediatrics. This will enhance low risk to young adults. At centre F, though the ESD is low but the age at exposure increased the incidence cancer risk for younger patients. Same was also observed in centre E for patients with low ESD and young in age.

Table 2: Statistical analysis of radiation doses and incidence cancer risks

		Age	ESD_T	ED	BD	OMD	SGD	ICR
N	Valid	20	20	20	20	20	20	20
	Missing	0	0	0	0	0	0	0
Mean		43.45	7.52	.25	2.84	3.06	4.97	55.98
Median		45.00	4.90	.16	1.75	1.91	3.16	42.87
Std. Deviation		14.51	5.52	.20	2.19	2.38	3.69	40.12
Variance		210.58	30.48	.04	4.81	5.66	13.59	1608.64
Skewness		-.336	1.302	1.350	1.352	1.435	1.376	1.067
Std. Error of Skewness		.512	.512	.512	.512	.512	.512	.512
Kurtosis		-.863	.593	.711	.707	1.196	.841	.327
Std. Error of Kurtosis		.992	.992	.992	.992	.992	.992	.992
Range		46.00	16.11	.61	6.76	8.01	11.64	142.41
Minimum		19.00	3.01	.09	1.01	1.02	1.82	13.63
Maximum		65.00	19.12	.70	7.77	9.03	13.46	156.04
Percentiles	25	33.75	3.25	.10	1.18	1.29	2.26	23.81
	50	45.00	4.90	.16	1.75	1.91	3.16	42.87
	75	54.75	10.06	.35	3.88	4.18	6.61	92.38

ESDT = Total entrance surface dose; ED = effective dose; BD = brain dose; OMD = oral mucosa dose; SGD = Salivary gland dose; ICR = incidence cancer risk

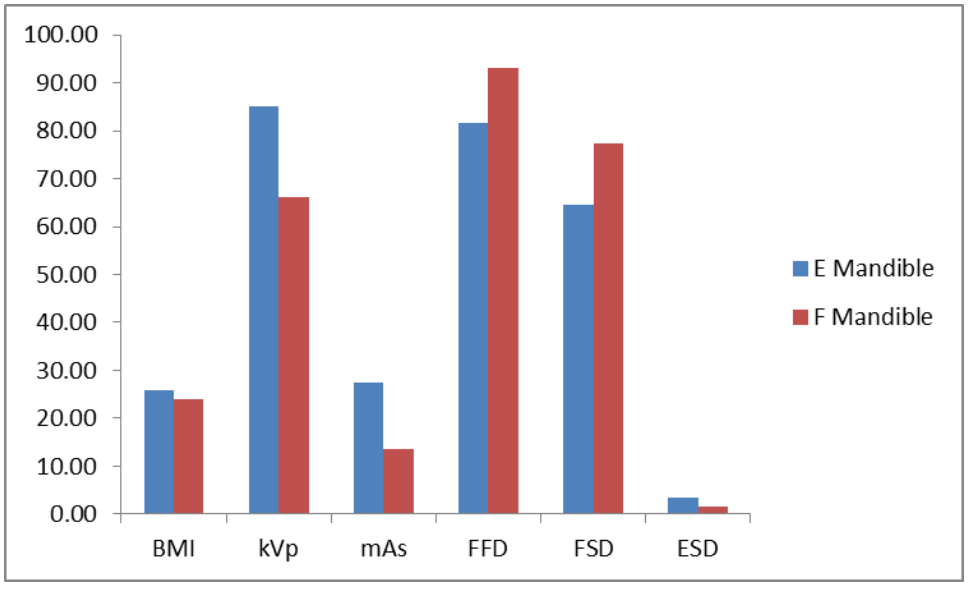


Figure 1: Comparison of exposure parameters for mandible examination in the two centres

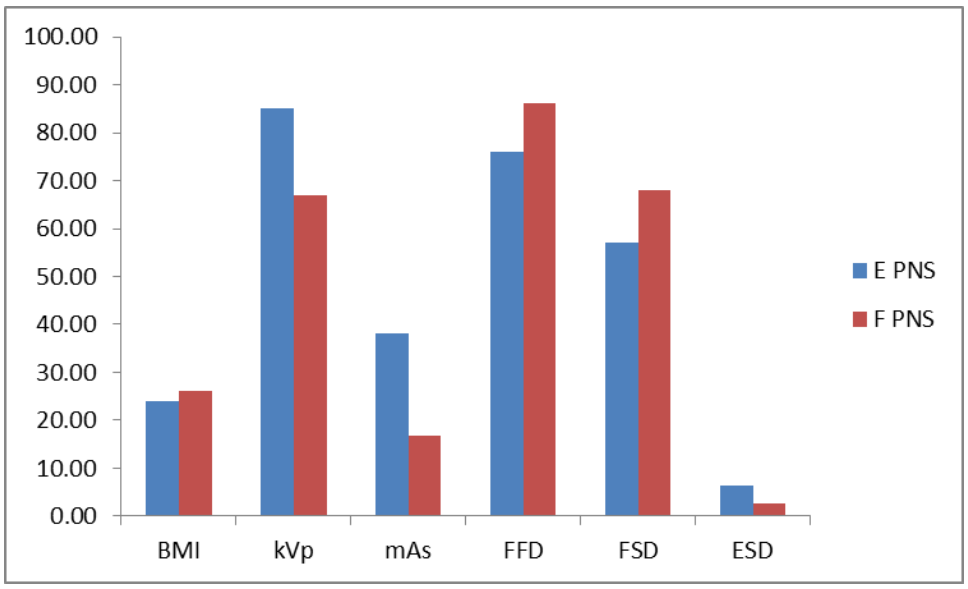


Figure 2: Comparison of exposure parameters for PNS examination in the two centres

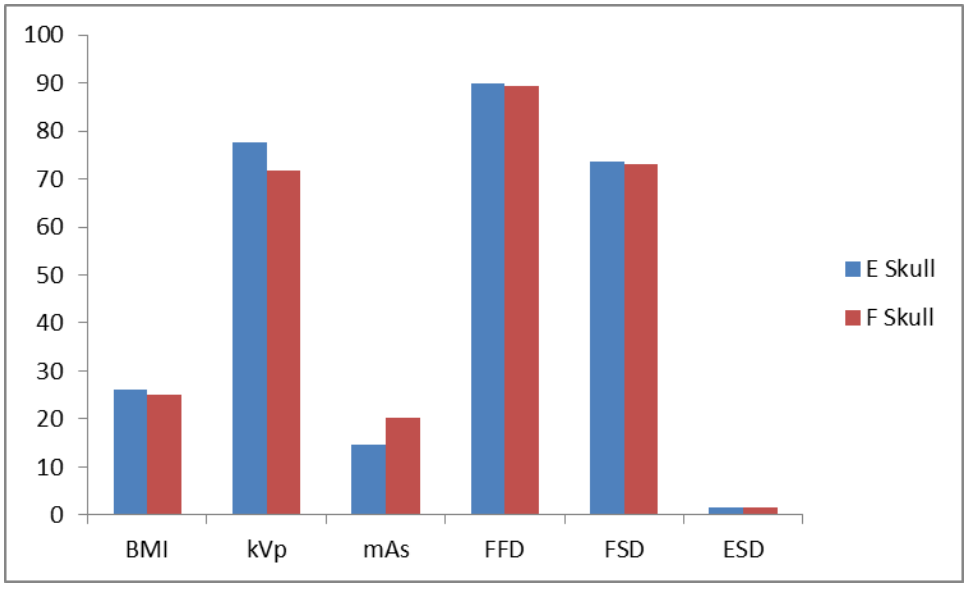
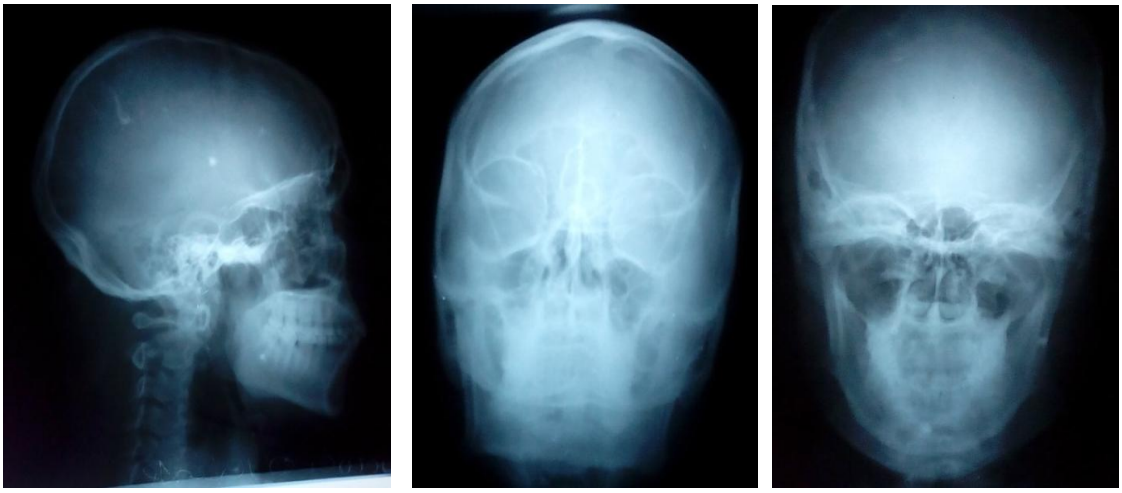


Figure 3: Comparison of exposure parameters for Skull examination in the two centres



(a) (b) (c)

Figure 4: Radiographs of head examination: (a) lateral (LAT) view (b) occipitomental view (OMV) (c) posterior-anterior (PA) view

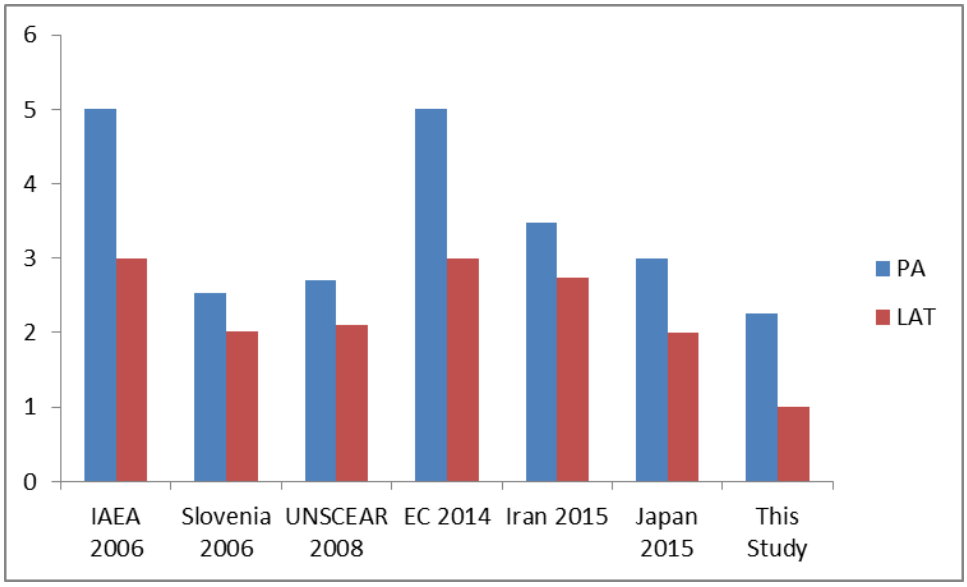


Figure 5: Comparison of entrance surface dose for skull with other studies

Table 3: Analysis of variance for entrance surface dose

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	169.203	5	33.841	41.639	.000[b]
	Residual	37.385	46	.813		
	Total	206.588	51			

Table 4: Model summary showing coefficients of predictors

Model		B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.257	2.322		3.125	.003
	BMI	-.051	.045	-.074	-1.138	.261
	kVp	-.023	.021	-.111	-1.072	.289
	mAs	.114	.020	.641	5.678	.000
	FFD	.125	.049	.446	2.575	.013
	FSD	-.212	.049	-.823	-4.368	.000

Table 5: Pearson Correlation showing correlation between variables

		ESD	BMI	kVp	mAs	FFD	FSD
Pearson Correlation	ESD	1.000	-.063	.613	.828	-.575	-.739
	BMI	-.063	1.000	.120	.053	.163	.100
	kVp	.613	.120	1.000	.790	-.365	-.472
	mAs	.828	.053	.790	1.000	-.450	-.582
	FFD	-.575	.163	-.365	-.450	1.000	.924
	FSD	-.739	.100	-.472	-.582	.924	1.000

ESD = entrance surface dose; BMI = body mass index; kVp = kilo-voltage peak; current time product; FFD = focus film distance; FSD = focus skin distance

Though skull radiography is considered out dated [5], comparison with other studies as depicted in Figure 5 showed that it is still relevant in similar society such as ours. The entrance surface (ESD) for skull examination for this study was lower compared to others because the mean ESD was used while other studies used the third quartile. Also, large variation in ESD is bound to occur due to different methods employed in its evaluation. The importance of head radiography in diagnosis of injuries and diseases cannot be over emphasized especially in an environment where higher imaging equipment for such examination is scarce. The relevance of head radiography in a developing society cannot be neglected in view of its availability and accessibility for skull imaging, it is important that the procedure is evaluated in order to minimize risk to patient.

4. Conclusion

Incidence cancer risk was evaluated in head radiography procedures. Entrance surface dose (ESD), age at exposure, professional expertise and choice of exposure parameters were factors that influenced the incidence cancer risks. Failure in the adoption of complete optimization technique was responsible for the increased risk. It is important that age of adults and dose reduction strategies are considered during irradiation of patients. This will enhance optimization of dose and minimize radiation risk to patients.

5. Acknowledgment

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