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The Use of Extended Focus-to-Film-Distance (FFD) for Dose Reduction in Radio-Diagnostic Examination of the Skull

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Abstract

The method of increasing the focal to film distance technique was used in this work to determine the input dose and the absorbed dose of the radiograph using the Perspex phantom of an adult skull. The film quality was also analyzed by a radiologist and the best film quality was obtained in the X-ray department, at the University of Jos Teaching Hospital (JUTH). The input doses obtained in this work are all below the diagnostic reference level of 5mGy recommended by the IAEA and the European Commission for the skull (AP, PA) x-ray examination. In all the irradiations, FFD of 90cm appears to give a higher (4.14mGy) dose to the patients while a lower dose (1.67mGy) was obtained at FFD of 130cm. The absorbed doses obtained in this work also appeared to be reducing greatly from 3.78mGy at FFD 90cm to 1.44mGy at FFD 130cm. The five radiographs of the skull were analyzed by two radiologists and the best radiograph for the skull anterior-posterior is at FFD 110cm with a minimal absorbed dose of 2. 17mGy.The value of the absorbed dose for the best radiograph was compared with the reference value 3mGy for the skull (AP, PA) X-ray radiography by ICRP and found to be below the reference value. The results obtained from this work show that the best radiograph for skull AP will be obtained at a Focal-film Distance of 110cm when a constant tube voltage is set at 90kVp and 50mAs with a minimal absorbed dose of 2.17mGy and radiation protection is optimized.

Keywords: Focal-Film-Distance (FFD), Focus to Surface Distance (FSD), Anterior-Posterior (AP), Posterior Anterior (PA), Absorbed Dose.

1. Introduction

Numerous National and regional surveys have revealed large dose variations for patients undergoing the same type of diagnostic X-ray examination (Shrimpton, 1986). The findings

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have indicated a need for improvement that should lead to patient dose reduction without compromising diagnostic information. The concept of investigation level for diagnostic medical exposure was first proposed by the International Commission on Radiological Protection (ICRP) in its 1990 recommendation (ICRP 1990) and further developed into diagnostic reference level (DRL) in 1996 ICRP publication 73 (ICRP,1996). In accordance with the concept of maintaining dosages As Low As Reasonably Achievable (ALARA), the European Union member state controlled the optimization of medical exposure via the adoption and implementation of the Medical Exposure Directive (MED). Dosage levels are anticipated to remain within limits when standard procedures and optimal practices for diagnostic and technical performance are used.

In recent years, there has been growing concern among patients and radiological professionals over the excessive radiation exposure associated with routine X-ray procedures. Once an examination is warranted, the next imaging procedure must be improved by ensuring that the radiation dosage administered is As Low As Reasonably Achievable (ALARA) while maintaining good diagnostic picture quality. In accordance with the ALARA concept, the European Union member state controlled the optimization of medical exposure via the adoption and implementation of the Medical Exposure Directive (MED). Dosage levels are anticipated to remain within limits when standard procedures and optimal practices for diagnostic and technical performance are used. This ensures that the clinical objective of the examination is met with the lowest possible risk to the patient, (Brennan, 2003). The dangers of ionizing radiation have been appreciated for many years and the levels and the risks from high doses (nuclear explosions and therapeutic uses) are well established. (Geijer, H, 2001) It has been more difficult to estimate the danger from the much lower levels encountered in diagnostic radiology. However, it is a fact that there are no safe levels of exposure below which adverse effects cease to occur, hence the need to reduce the dose as much as possible using all manner of techniques applicable without compromising the quality of the radiographs.

Numerous dose-reduction strategies have been proposed in recent years. These include the use of rare-earth filters, fast film-screen combinations and low-attenuation materials as cassettes. (ICRP 1991), Although research has demonstrated the effectiveness of these and other methods for minimizing dose, there are often cost implications to imaging departments, and in the current climate of finite resources, the resultant application appears limited. It is, therefore, important to consider dose-reducing measures with little resource implication, (Brennan 2000). One way is to increase the focus-to-film distance (FFD) between the patient and the X-ray tube focus. According to the inverse square rule, it is clear that the dosage at the patient's entry surface exceeds that at the image receptor.

2. Experimental details

2.1 Determination of the effect of FFD on the absorbed dose

This survey was carried out using a skull phantom to represent the skull of an adult. A ray-safe multipurpose Dosimeter was placed at the centre point on the entrance and exit surface of the phantom to capture the input and output dose. A cassette was placed behind the phantom. A constant tube output current and voltage were set at 50mAs and 95kVp respectively. The focal-to-film distance (FFD) varied from 90cm to 130cm. Two exposures were made with the dosemeter placed at the front and the back of the phantom. Another was made with a film in the cassette behind the phantom. Five radiographs were processed manually and analyzed independently by two radiologists. The absorbed dosage was determined by calculating the difference between the observed input and output doses.

Assessment of the dosages absorbed by the cranium. The absorbed dosage was derived directly from its definition as established by [D. D. Marciniak, 1999].

Absorbed dose = Input dose – Output dose (i.e., differences between the input and output dose)

$A_d = I_d - O_d$

Where: A_d = Absorbed dose

I_d = Input dose

O_d = Output dose

3.Results and Discussion

Table 1: Typical parameters and doses measured from skull (AP) phantom examination at constant 95 kVp and 50mAs

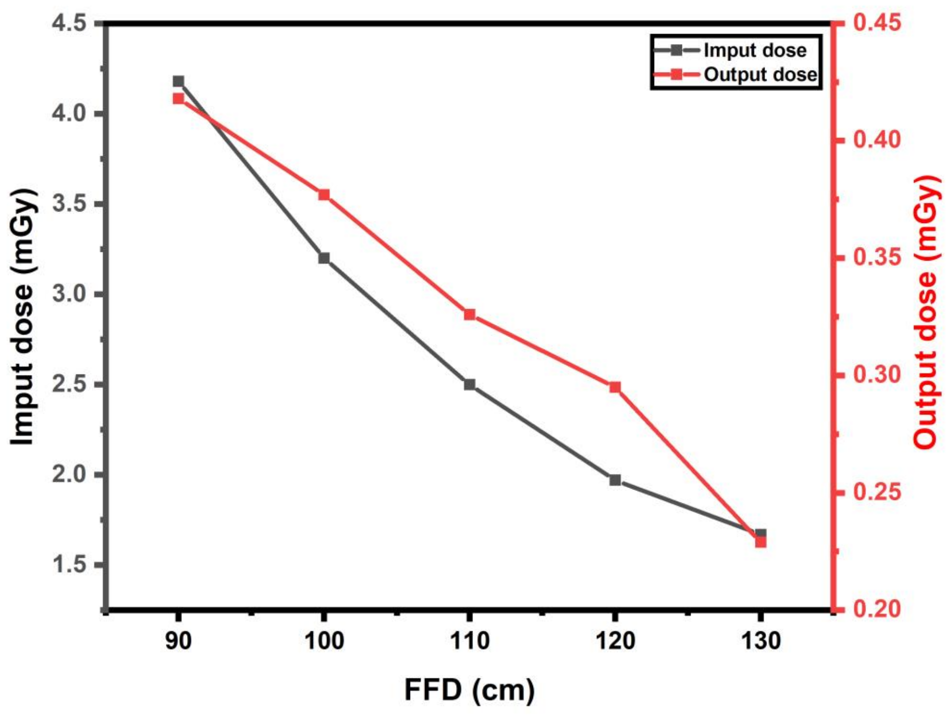
FFD (cm)	FSD (cm)	Input Dose (mGy)	Output Dose (mGy)
90	67	4.18	0.418
100	77	3.20	0.377
110	87	2.50	0.326
120	97	1.97	0.295
130	107	1.67	0.229

Table 2: Showing reduction in absorbed dose due to increase in FFD examination

FFD (cm)	FSD (cm)	Input Dose (mGy)	Output dose (mGy)	Absorbed Dose (mGy)
90	67	4.18	0.418	3.76
100	77	3.20	0.377	2.82
110	87	2.50	0.326	2.17
120	97	1.97	0.295	1.68
130	107	1.67	0.229	1.44

Table 3: Radiologists' assessment of the radiography of skull AP at varied FFDs

FFD (cm)	Inadequate (%)	Adequate (%)	Perfect (%)	Remark
90	70	30	0	Poor quality
100	55	45	0	Poor quality
110	00	35	65	Perfect quality
120	20	65	15	Good quality
130	70	20	10	Poor quality



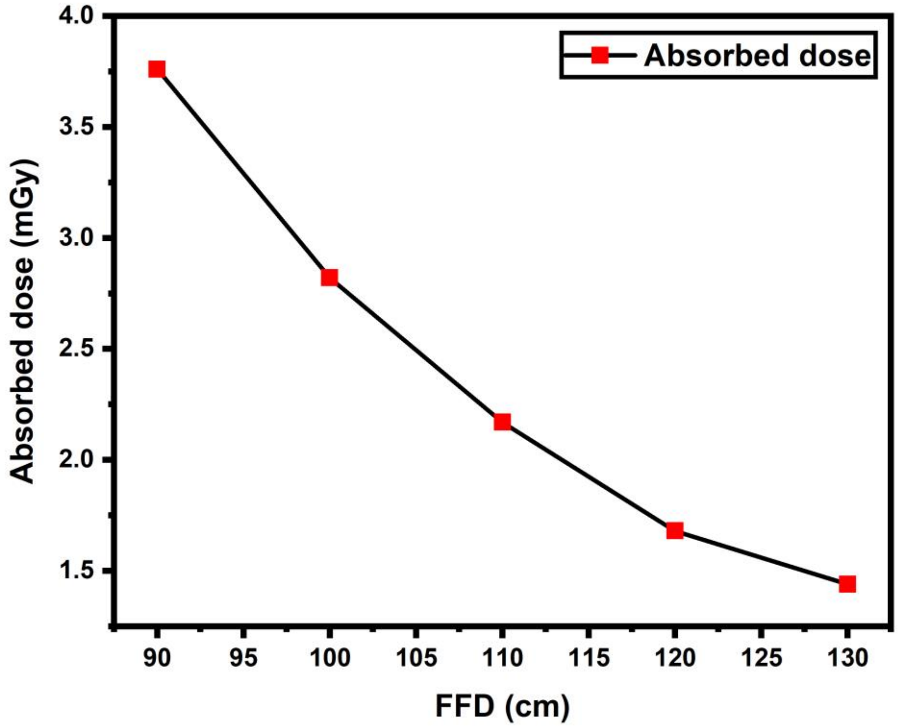


Fig.2 Graph showing the reduction in absorbed dose with an increase in Film-Focus-Distance (FFD)

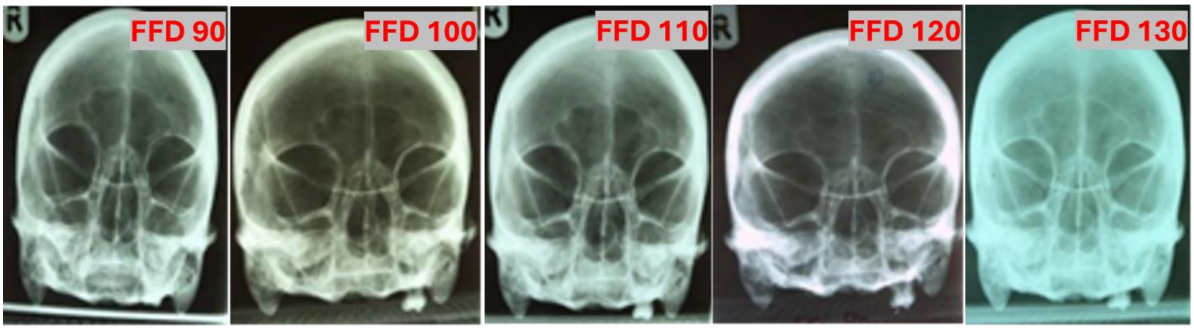


Fig.3 The radiographs of the skull at FFDs 90-130cm

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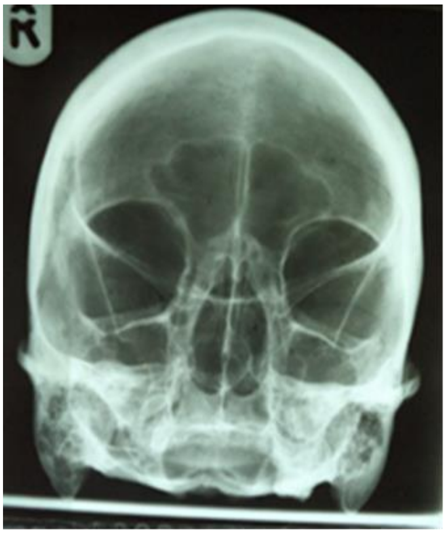

Fig 4. Picture of the best radiograph of Skull at obtained at FFD 110 cm

Table 1 shows that the input doses obtained in this work are all below the diagnostic reference level 5mGy recommended by the IAEA and the European Commission for skull (AP, PA) x-ray examination, (Damijan, 2006). This shows that the study department has good and normal practice (optimization) regarding diagnostic skull exposure. In all the irradiations, an FFD of 90cm appears to give a higher (4.14mGy) dose to the patients while a lower dose (1.67mGy) was obtained at FFD, 130cm.

Table 2 shows that the absorbed dose obtained in this work is highest at FFD 90cm about 3.78mGy and lowest at FFD 130cm about 1.44 mGy. This implies that more doses are absorbed by tissues at FFD 90cm and less dose at FFD 130cm. This justifies the contribution of distance in overall patient absorbed dose for skull AP x-ray examination.

Table 3 shows the assessment of these four experts as inadequate, adequate and perfect. The radiographs of the skull at FFDs 90cm and 130cm are 70% inadequate. This indicates a very poor quality. That is, bones of interest are not visible. The best image quality of the radiograph of the skull was recorded at FFD 110cm which is 70% perfect and 30% adequate. This shows that all the major bones in the skull radiograph are visible. Fig. 1 below shows the radiographs of the skull arranged in order of increasing FFD (90-130CM)

Fig.1 Additionally, it demonstrates the decrease in output dosage resulting from the augmentation of Film-Focus Distance (FFD). The highest output dosage is 0.418 mGy at a minimum FFD of 90 cm, while the lowest output dose is 0.229 mGy at a maximum FFD of 130 cm, indicating that distance significantly influences the dose given to patients during x-ray examinations.

Fig. 2 illustrates the decrease in absorbed dose resulting from an increase in Film-Focus Distance (FFD). As the FFD was augmented, the absorbed doses correspondingly diminished, with a maximum absorbed dose of 3.76 mGy observed at the minimum FFD of 90 cm, indicating that distance significantly influences the radiation dose administered to patients during x-ray examinations.

Fig.3 shows the picture of the radiograph's of the skull taken at different FFD. The radiologist assessments indicated that the radiographs at FFD 90cm, 100cm appeared darker, and it was because of very high exposures which translated too much penetration of the images of the skull.

Fig.4 shows the radiograph at FFD 120 cm and 120cm which according to the report of the two radiologists, is the radiograph that gave the optimum image quality. That showed that the image quality of the skull was perfect indicating that all the bones of anatomical interest were seen and present.

4. Conclusion

With the steady increase in public and professional concern regarding the biological effect of ionizing radiation, there is an urgent need for radiography professionals to improve imaging techniques using the focal film distance technique. The data provided in this study demonstrated that increasing the FFD is an effective dose-reducing tool with no deleterious effect on the total image quality for AP skull radiography.

The results are consistent with the principle of inverse square law and demonstrate the beam hardening on patient's doses in radiology. That is; while increasing radiation exposures for FFDs, the additional air gap will reduce patient radiation doses delivered to the patients from the measure examinations are generally lower compared with the guidance reference dose level for skull AP examinations. There is optimization in the department for both patients and equipment.

The research indicates that elevating the focal film distance to 110 cm, with appropriate exposure parameters (95 kVp, 50 mAs), may significantly decrease patient radiation doses while preserving optimal picture quality without incurring extra costs. This study's results will be presented to medical imaging professionals to develop and assure the successful application of laws that define acceptable requirements for good radiographic practice in skull radiography.

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