RESEARCH ARTICLE

A Comparison of Patients Absorption Doses with Bone Deformity Due to the EOS Imaging and Digital Radiology

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Abstract

Background: This study has aimed to measure the patient dose in entire spine radiography by EOS system in comparison with the digital radiography.

Methods: EOS stereo-radiography was used for frontal and lateral view spine imaging in 41 patients in a prospective analytical study. A calibrated dose area product (DAP) meter was used for calibration of the DAP in EOS system. The accuracy and precision of the system was confirmed according to the acceptance testing. The same procedure was used for 18 patients referred for lumbar spine digital radiology (overall 36 images).

Results: Although radiation fields in the EOS were almost twice of that in digital radiology, and the average peak tube voltage (kV_p), current supply to the tube (mA), and the average size and age of the patients referred for EOS imaging were greater than digital radiology, however, the average DAP in EOS was 1/5 of that in digital radiology system. Also, the average dose in the EOS was about 1/20 of that in digital radiology.

Conclusion: The patient dose in EOS imaging system was lower in comparison with digital radiology (1/20).

Keywords: Digital radiography, Dose area product, Dosimetry, EOS, Stereo radiography

Introduction

Accurate assessment of bone rotations is an important issue as they can lead to pathological states necessitating orthopedic intervention (1). Computerized tomography (CT) imaging with high spatial resolution is commonly used for the measurement of skeletal bone parameters. Impossibility of whole body image acquisition in standing or sitting postures as well ashigh-dose radiation exposure are the most important disadvantages of this method; therefore, alternative methods such as two-dimensional radiography with lower radiation dose compared to CT scans are recommended (2).

A two-dimensional radiographic system using low patient dose due to proportional micro-grid detectors has been designed in recent decades (3). Hence, instead of CT scans, electro-optical system (EOS) method is recommended for femoral and tibial torsion measurements in adult patients (3-5). Anatomical studies have shown up to 20 times lower patient dose in EOS method compared to the conventional radiography, and much lower in comparison with CT scan (5, 6). Reducing the absorbed patient dose in children with radiation sensitive tissues is even more important, emphasizing the use of EOS system for these patients (6). The aim of this study was to evaluate the patient dose in EOS two-dimensional imaging in comparison with digital radiography.

Materials and Methods

The spine front and side view images of 41 patients that were prepared by EOS system were evaluated in this prospective analytical study in Shahid Sadoughi hospital, Yazd, Iran. Radiation conditions of each image including the peak tube voltage (kV_p), current supply to the tube (mA), exposure time, dose area product (DAP), and the length and width of the radiation field as well as the name, age and body weight of patients were recorded. This

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information was also recorded for 18 patients referred for lateral and frontal lumbar imaging performed by a digital X-ray machine (Toshiba, Japan). Only two digital radiography images from each patient were studied for the comparison between the two imaging systems. The quality of images provided by either EOS systems or digital radiography was assessed by two radiologists. The average dose was calculated by dividing the DAP on the radiation field area. A DAP meter (PTW Co., Germany) was used to calibrate the DAP meter of EOS system. For this purpose, after placing the DAP meter detector in front of the radiography tube in lateral and frontal positions, the radiation field was adjusted to the detector dimensions. A 20 cm air gap was left behind the DAP detector to prevent backscatter rays reaching the detector. The calibration of the digital radiology machine monitor was also performed in the same way. The calibration coefficients were applied to the measured results. Both directed digital radiology (DDR) and EOS systems had passed the acceptance tests at the time of study. Patients were categorized into underweight (group 1), normal (group 2), and overweight (group 3) according to their size. A measuring ruler was used on both systems to measure the length and width of the radiation field on digital images.

Results

The patients' age ranges for EOS and digital imagings were 14-86 and 6-63 years, respectively. The patients' average sizes were greater in EOS system compared to digital radiology. The DAP of the lumbar spine in digital radiography (4.26 Gy.cm^2) was almost 5 times higher than that of the entire spine (neck to pelvis) imaging in EOS system (0.89 Gy.cm^2). Also, the average radiation field of patients in EOS system (2781.9 cm^2) was almost twice of that in digital radiology (1394.4 cm^2). Thus, despite the large radiation fields, DAP of patients exanimated by EOS system was lower than digital radiology. Also, the mean dose or entrance skin dose of patients in EOS was much lower than that of digital radiology [Table 1]. The mean dose of patients in digital radiology method (6.6 mGy) was 18.5 times greater than that in the EOS system (0.355mGy). The mean duration of irradiation in the EOS and digital radiology system was 10.7 and 0.12 seconds, respectively. Also, the tube electrical current intensity in EOS and digital radiology systemswere250 mA and 450 mA, respectively. The exposure duration was also 9 times greater in EOS, but the electrical current in EOS was almost half the digital radiography system. On the other hand, the current supply to the tube in the EOS was about 55 times greater than that in the digital radiology [Table 1].

Table 1. Characteristics of the patients, radiation conditions and dosimetry parameters in the digital radiology (DDR) and EOS imaging system

Variables	Technique		P
	DDR (n=18)	EOS (n=41)	
Age (Mean±SD)	33.8±13	42.7±19	0.056
Patient's size	1.67±0.63	2.17±0.72	0.071
kV_p	75.8±6.91	91.5±6.05	0.042
mAs	52.3±31.23	2659.5±508.41	0.001
Radiation field (cm^2)	1394.4±275.4	2781.9±438.70	0.041
DAP (Gy.cm^2)	4.26 ± 1.44	0.89.3± 0.31	0.051
Dose (mGy)	6.6±2.92	0.335±0.12	0.001

Discussion

Both the current supply to the tube and the peak voltage, as effective factors in the absorbed dose of patients, are greater in EOS compared todigital radiology. This can be partly attributed to the micro-grid proportional detector with high efficiency used in the EOS system, while selenium-based flat-panel detectors are used in digital radiology. On the other hand, the fan-shaped x-ray beam (thickness 0.5 mm) in EOS system produces a two-dimensional image by scanning the patient's body and converts the two-dimensional images of the frontal and lateral views to three-dimensional images of skeletal bones using a special software. It has been shown that despite a greater radiation time in the EOS compared todigital radiography, the absorbed dose has been reduced in EOS. This is due to the fan beam shape during exposure time (10.7 sec). In digital radiography, a cone beam is exposed to the body and a greater dose as well as more scattering beam is produced as a result. The grid used to prevent scattered rays reaching the detector in digital radiography requires further x-ray photons, and thereby increases the patient dose. Measurement of body organs dimensions is another advantage of EOS method. In a previous study on foot bones length measurements by fast and slow protocol EOS system compared to the conventional radiography and CT scans, more accurate and less absorbed dose was reported with EOS system. The mean absorbed dose in the EOS fast protocol (6.8 µGy) was about 40 times lower than that of the conventional radiography (290 µGy) and almost half of the EOS slow protocol (7). Although, the patient dose in foot bone measurements was in the µGy range while nd in the mGy range in our study, the dose ratios were similar.

In vitro dosimetry using a pencil-type ionization chamber and a CT abdomen phantom for CT dose index (CTDI) measurement by both EOS and CT imaging as well as in vivo dosimetry using thermos luminescent dosimetry (TLD) to obtain the skin dose ($H_{d(0.07)}$) have shown 69 mGy.cm, 3.1 mGy.cm, and 0.5 mGy.cm. for in vitro CT, EOS and CT pilot expose; and13.4 mGy and 0.59 mGy for in vivo CT and EOS, respectively. In other words, in both in vivo and in vitro methods, the CT dose was about 22 times greater than that of the EOS, which makes the imaging condition specific for children (8). This report is consistent with the results of our study wherein the average dose of digital radiology system was estimated 18.5 times greater than EOS method. Other studies have also shown that the patient dose is reduced in EOS imaging. It has also been shown that despite the higher expense in EOS Imaging, the low dose used in this method is an important advantage especially in children and pregnant women (9). It has also been found that EOS method has a higher image quality and a lower patient dose compared to radiography. For example, the patient dose in frontal and lateral lumbar spine imaging was respectively 5 and 6 times higher in analog radiography compared to the EOS method. Also, the absorbed dose for frontal and lateral spine images in computerize radiology (CR) was found to be respectively 6 and 8 times more than the EOS system (10, 11).

In this study, the absorbed dose of CT and digital radiology was approximately 20 times greater than that in EOS. Comparison of the image quality and the absorbed dose of patients in chest imaging by EOS, conventional, and digital radiography methods have shown that EOS image quality was competitive to radiography and digital radiology, while the absorbed dose in EOS (0.22mGy) is more than conventional (0.05mGy) and lower than digital radiography andstandard (0.3mGy) (12).

The repetitions in EOS examinations due to operator error have been reported as13%, which was lower than that of analog and digital radiography. In our study, 18 patients needed overall 36 frontal and lateral images, while 48 radiography images had been prepared by digital radiology. In other words, repeated confirmatory tests for digital radiography were about 24%, while there was no repetitions for EOS imaging. This would cause a significant increase in patient dose in digital radiology due to unused film and film processing as well as failure in quality assurance programs in the radiology department.

In addition to lower absorbed dose of EOS in comparison with digital radiology (1/20), the use of two and three-dimensional EOS system allows imagings in either standing or sitting position. This advantage has led to an increased image quality, which allows viewing three-dimensional anatomical images, and may also attract the attention of physicians, especially orthopedists to EOS imaging system.

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