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Research Article

FACTORS AFFECTING THE CONTRAST OF RADIOGRAPHIC IMAGING IN ANALOG AND DIGITAL RADIOLOGY: THE IMPACT OF KV CHANGES

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ABSTRACT

In radiography images , Contrast and density are the most important characteristics . Contrast is the difference between darkness and brightness. To investigate the effect of kilo voltage changes on the contrast of radiographic images in both analog and digital radiology systems. Due to the applied nature of the current study, radiographic study of the distal region of bone of the right arm with approximately the same gender, physical and age conditions of 18 patients, using two types of analog and digital radiographic systems with 10 kilo voltage type with a 1 kV difference and fixed FFD and mAs was performed. the intensity of brightness of images were analyzed by MATLAB software. The density and difference of visual contrast of diaphysis, metaphysis and epiphysis areas were divided by three lateral, central and medial zones. The results of Pearson correlation test showed that there was no significant relationship between kV and diaphysis contrast (r = 0.50, p = 0.17), metaphysis contrast and kV (p = 0.27 and r = 0.41), kV and epiphysis contrast in analogue radiology (r = 0.50, p = 0.17). Pearson correlation results showed that there was no significant relationship between kV and diaphysis contrast (p = 0.14 and r = 0.53), kV and metaphysis contrast (r = -0.18, p = 0.65), kV and epiphysis contrast in digital radiology (r =-0.64 and p = 0/066). Independent t-test results showed that diaphysis contrast in digital radiology was significantly higher than that of analogue radiology (p = 0.001, but metaphysis contrast and epiphysis contrast were not significantly different in digital radiology and analogue radiology (p = 0.676), (p = 0.992). According to the results of the radiographic image obtained for elongated bones of epiphysis area, the digital system was preferable whereas for examination of metaphysis and epiphysis regions, the results of the analog system were approximately equal to those of the digital system. In this study, the average kilovoltage used in the analog system was lower than that of the digital system but in general, we have to reduce the kilovoltage to have higher contrast, which increases the absorbed dose of the patient, while the higher kilovoltage in the digital system reduces the event of the photoelectric phenomenon and the absorbed dose of the patient.It was concluded that in the pathological or traumatic cases of the elongated bones of the diaphysis area, the digital system should be used more to have higher contrast, and although the analogue system is also suitable for metaphysis and epiphysis areas, it is better to use digital system to reduce the dose received by the patient.

Keywords: Contrast, analog radiography, digital radiography, kilo voltage changes

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INTRODUCTION

In radiology, by passing the X-rays through the tissue and their exposure to a radiographic film, an image of the area of interest appears on the film and after processing, a stereotype is given to the physician that by using it and his/her own interpretation, he /she can find out the presence of the probable damage and its prognosis. In this applied study, the effects of kV on the contrast of radiographic images in analog and digital systems were investigated.

Contrast is the characteristic of radiology images, and the difference in densities in a radiographic image is called contrast, which is the difference between darkness and brightness (Hadizadeh et al., 2008).

The main factors of radiation or physical factors of radiation are: mA (current intensity), seconds (time), kV (penetration power) and film distance to X-ray lamp target (Kerry et al., 2014).

Generally, to create density on film, X-ray photons must have enough energy to penetrate the body to reach the film. The energy of X-photons is controlled by the voltage applied to the X-ray lamp. The higher the voltage, the higher the energy and power of the X-ray penetration is, and vice versa. The optimal kV is the minimum kV that produces the x-rays that are sufficiently penetrable in a given organ (Kerry et al., 2014). The desired kV for different devices, different phases, and different patients is the same, and the amount of it depends only on the physical characteristics of the organs such as the thickness and type of the tissues forming it. In radiography, X-rays are used to create image. Whether the image is digital or analog does not make any difference to the structure of the device generating the image. In other words, each image starts with an analog form that needs to be converted to numerical matrices. This difference is in the output receivers, otherwise the physical form and imaging technology are the same. The components of an analog image are intertwined tiny dots connected to each other. Digital images are consisted of small square units which the smallest component of it is called pixel. In the digital cameras, there is a receiver that converts the light photons into processable electric charges which its final output is a digital image. Another achievement is the conversion of images printed on film or paper into digital images that have all the capabilities of a computer file such as ability of storing, processing, and transferring associated with processing (Shakibafard, 2014).

Today, ADC in radiography is performed in two general ways: Computed Radiography (CR) and Direct Digital Radiography (DDR).

In CR, the procedure is similar to conventional radiography, ie the cassette is used for image conversion. But the cassette has a phosphorus guarantee (PSP) instead of the film, which holds the image stored until it is read by the laser and then converts it into visible light which is directed to the out of the conduction chamber by PMT and is converted to electrical charges,and appears as an image on the monitor (Shakibafard, 2014).

DDR uses a variety of technologies, the most common is the Flat Panel Detector (FPD).

Direct detectors have both direct and indirect technologies. In the direct form, usually of silicon, the ray photons are directly converted to electricity. In the indirect form, the photons are first converted to light and then by the photodiodes to the electric current. Regardless of the

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characteristics of each form of FPD, the indirect type is more applicable (Fatemi, 2014).

Background

In recent years, significant research amount has been done on radiation conditions such as kv and current intensity on contrast, density, and image quality or their impact on dose received by patient in digital and analogue radiography systems. In addition, the researchers have studied the images of various body organs or phantoms. Bashizadeh Fakhar and Emadian Razavi (2014) studied the design of an algorithm and examined its accuracy to determine the radiographic film density by changing the irradiation, so an aluminum wedge was made. 50 EOSPEED kodak films were exposed. Radiation times varied from 0.05 s to 0.5 s with 0.05 s intervals. The films were prepared by an automatic aperture and recording device and digitized by the EPSON 1240U PHOTO scanner.

Images were cut at a size of 10 mm from selected image stairs by Microsoft office picture manager software. The average pixel value of the image was calculated by applying the algorithm designed in MATLAB. By increasing the thickness of object and irradiation time, the accuracy of the algorithm in detecting density changes was increased. This software could detect radiographic changes in aluminum wedge images at a minimum thickness of 4 mm in 0.3 seconds and 5 mm in 0.5 seconds (Bashizadeh Fakhar and Emadian Razavi, 2014). Lorusso et al. (2015) in their study showed the importance of the optimization of the increased voltage tube (kVp) and the product of decreased irradiation time strategy (ie, high kvp and low mAs). The specialists evaluated this strategy by examining the appearance and quality of the diagnosis of direct digital radiographs obtained with this strategy. Ninety nine specialists (Radiologists - Radiology Residents - Radiographers and Radiology Students) from eight clinical centers in Ontario examined three types of radiographs (standard image - Kvp20 + image and Kvp30) of the pelvis - breast - skull and hand phantoms and scored each image (on a 5-point scale) for its appearance, diagnostic quality, and visualization of anatomical structures. Initial findings showed that pelvic, skull, and hand images except breast images which obtained with standard technical factors had higher scores in terms of diagnosis and aesthetic quality than those obtained with high kvp low mAs strategies. Kei Ma et al. (2014) studied the effect of kilo volts and milli amper seconds and focal point size on image quality. So, using 70 CR images of the phantom of the hand in inclined position and PA with different kvs and mAs values were obtained with the small and large focal point sizes. The images were displayed on low-light quality-controlled monitors. The reference table was used for hand radiography and image display. Five diagnostic radiographs rated image quality as compared to the reference image using the LIKERT 15-point scale. Finally, no significant differences in image quality between small and large focal point sizes with kv value of (P = 0.46) and mAs of (P = 0.56) was observed. As milliseconds increased, the image quality gradually increased from 0.4 MAS to 4 MAS, and then the image quality got worse. When the kV was increased to about 40-55 Kv, the image quality increased and after 55 Kv, the image quality remained the same. This study showed that both large and small focal point sizes produced similar quality images, and a wide range of kV and mAs can be used to create images with acceptable quality. The importance of these findings is in the ability to extend the durability of radiographic equipment and to reduce the dose received by patients during adjunctive trials. As a result, large focal point size can be used in hand PA imaging without affecting the apparent quality of the image, and the apparent image quality remains acceptable and constant in a wide range of kV and mAs (Hashemi and Marami, 2009).

Aim

The aim of this study was to evaluate the effect of kV changes on the contrast of radiographic images in both analog and digital radiology systems. To achieve this, the following sub-aims were implemented:

1- Providing distal images of the arm bone with kilovolts defined in two analog and digital radiography systems.

2- Determining the relationship between the kilo voltage changes and the contrast of the radiographic images.

4. Introducing the subject of the study

The present study was an applied study to investigate the effect of kilo voltage changes on the contrast of radiographic images in analog and digital radiology.

In this study, 18 patients with the request of radiographic examination of the distal region of the right arm bone or the right elbow joint with approximately the same gender, physical and age conditions, and male, aged 30 to 45 years (at this age and gender, the probability of osteoporosis and diseases affecting the osteoporosis is low) who were referred to the radiology department for radiography from the distal part of the right arm and the right elbow joint were selected.

Digital radiographs were obtained at the Imam Khomeini Hospital in Bonab city and analog radiographs of this research were obtained at Shohada Educational and Medical Center in Tabriz.

MATERIAL AND METHODS

It should be noted that before the test, informed consent was obtained from all volunteers. This research was approved by the Ethics Committee of Islamic Azad University, Tabriz, Iran.

Digital Radiography

All images of digital radiographs of this study were obtained by DDR device (DIRECT DIGITAL RADIOGRAPHY) TOSHIBA and ROTANDO2015 model. The digital radiograph of right arm and right elbow joint of 9 patients were obtained by ROTANDO. In normal cases after the initial stages before positioning, despite the selection of these patients based on similarity of age (30 to 45 years) and physical conditions, the right arm circumference was measured in centimeters (20 to 21 cm). Radiographs of the right elbow joint of the patients in the complete AP position and distal bone of the right arm while the arm bone was completely parallel to the FPD were obtained. Field of view (FOV) was adjusted for all patients as 12*20 by collimator.

In this study, since the kV was the variable, the other main factors of radiation including FFD and current intensity (mA) and irradiation time were considered constant. Focus Film Distance (FFD) was set to 100 cm in all cases. In all radiographic systems including analog and digital, the standard exposure conditions for radiographs of different areas of the body can be seen in the control panel of the device. These conditions were used to produce the first digital radiographic image.

The first digital radiographic image was taken with defined system exposure conditions including Kv = 52, 6.3 mAs, FFD = 100CM, and subsequent radiographic images of the next 4 patients were taken at the same mAs as the first case (6.3 mAs) and decreased kV. In each case, Kv1 was considered to be lower than previous radiographs including (51-50-49-48 kV).

In the next stage, a radiographic image of 4 patients was obtained in the same mAs conditions as previous cases (6.3 mAs) but with a 1 kV increased kV. (Including 53-54-55-56 kvs).

Images were recorded and stored immediately after processing by digital radiography software without any modification.

Analog Radiography

All analog radiographic images of this study were obtained by the General Electric CGR S, ULTRANET SM. The cassettes by SIEMENSE were used and the films used were of AGFA type. The processor device used in this study was PROTEC, a fully automatic radiographic film processing device.

Analogue radiographic image of distal right arm bone and right elbow joint of nine patients in this study were obtained by GE radiography device (film-screen).

As with digital radiographs, all cases had the same arm circumference of approximately 20 to 21 cm due to physical similarity of the selected patients. As with digital radiographs, in AP position, the right elbow joint, the right arm distal and radiant field size were set as 1 * 1 in all cases by collimator. The cassette containing the raw film was selected in 18 * 24 dimensions. FFD was set to 100cm.

The first X-ray radiography film was made on standard conditions defined in GE control panel without using Grid system (exposure conditions: 47 Kv - 2/3 mAs).

Like the digital system, the kV variable increased and decreased precisely, and the conditions provided for all patients was as similar as possible in terms of the exposure and emergence and fixation conditions. After exposure of the first radiographic image and before processing, the Protec appearance and fixation device was completely controlled. The appearance and fixation substances were usually replaced every five days, with radiographic images taken on the second day after the replacement.

Subsequent radiographic images were obtained for the other 4 patients in the same exposure and position (same 3.2 mAs as the first case and FFD = 100 CM) and same field (FOV) and decreasing kV voltages. As in each kV exposure, it was reduced one unite (applied voltages were including 46 - 45 - 44 - 43 kv).

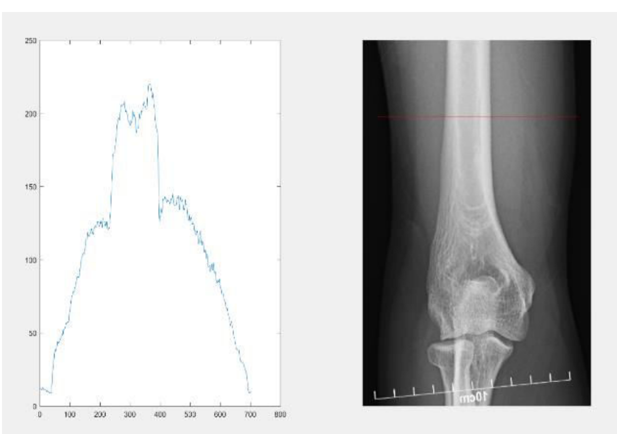
In the next step, for each patient the applied kV amounts were increased one unite and were 48 - 49 - 50 - 51 kv. The resulting imagesappeared in similar processing conditions and by Canon camera using Mamia 45 mm lens on the standard negatoscope as JPEG format without any retouching or changing the darkness and brightness.

All the images were transferred to the computer's memory in separate files for pre-analysis and analysis.

Pre-analysis and analysis stage

In the pre-analysis stage, all radiographic images were reviewed and corrected using PAINT - 3D software for humerus bone to have a full 90 degree angle with the horizontal axis of the film. The images were then opened in PAINT software and using RULERS and Grid lines, the points related to the diaphysis and metaphysis and epiphysis regions in the humerus bone distal to plot lines of diaphysis and metaphysis and epiphysis of the bone perfectly and precisely at the bone and tissue boundaries.

Using MATLAB software and opening the image and performing the designed algorithm, the average pixel value of each specified part appeared in the output list of the algorithm, and then the densitometer line and brightness curve were plotted on the marked areas. The diaphysis, metaphysis and epiphysis lines were plotted with curves of brightness intensity (Fig. 1).



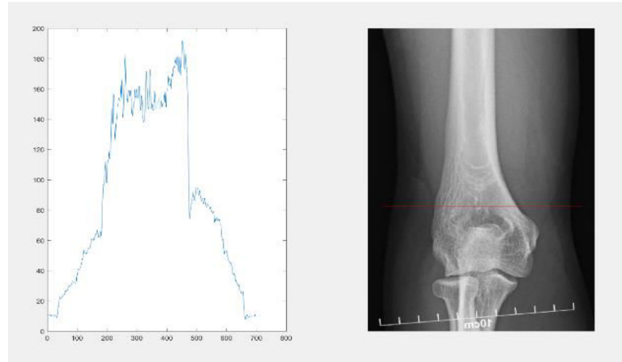


Fig. 1 Diaphysis and metaphysis area brightness intensity curve.

For all 9 analogue radiographic images and 9 digital radiographic images, 3 densitometer lines and 3 brightness curves were obtained. At the end, 27 brightness curves for analogue X-rays and 27 brightness curves for digital images were obtained. Then the brightness intensity curve numbers for the diaphysis-metaphysis and epiphysis lines were extracted and analyzed separately.

In a more detailed analysis of the brightness intensity curve, the analysis was performed in general and partial. An overall analysis was performed on the order of the brightness curve numbers for one line, and extracting the minimum and maximum pixel values on the curve to obtain the total mean brightness intensity. The partial analysis was performed by dividing the brightness intensity of each line to lateral, medial, central zones and obtaining the mean of each zone. The numbers extracted from the whole curve were entered in EXCEL software, and the corresponding curve and then the mean of the total brightness intensity of each line were obtained (Fig. 2). Then numbers of lateral, central and medial zones were entered in EXCEL software, and the average of each line was calculated and recorded.

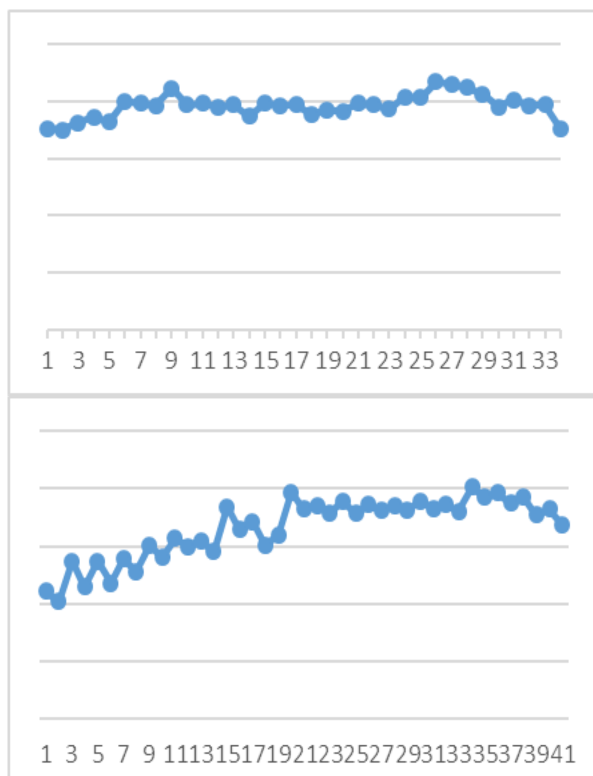


Fig. 2 Brightness intensity curve.

RESULTS

The numbers obtained from the 27 brightness curve for the lateral, central and medial segmentation of the diaphysis and metaphysis zones in the radiographic images obtained from the analog system and optical density of the lateral, central and medial zones, respectively, were separately recorded and the average brightness intensity of each region was calculated in Excel software and recorded in Table 1.

Table 1. Optical density of the lateral, central and medial zones and averages in the analog radiography

Analog												
kv		diaphysis				metaphysis					epiphysis	
kv	lateral	central	medial	average	lateral	central	medial	average	lateral	central	medial	average
43	223	224	224	224	213	223	222	218	207	224	212	212
44	222	223	223	223	217	224	223	220	208	224	214	212
45	217	215	216	216	193	212	203	201	173	203	191	186
46	213	211	210	211	175	200	183	186	96	188	163	141
47	219	220	220	219	210	214	216	209	188	216	193	196
48	204	204	205	204	125	192	187	165	136	205	128	152
49	206	201	200	202	143	179	173	165	103	189	109	128
50	209	213	210	211	187	209	203	198	202	211	176	183
51	208	206	206	206	186	208	200	197	165	209	148	169

The results of the 27 brightness curves for diaphysis, metaphysis and epiphysis regions in the radiographic images obtained from the digital system were recorded in Table 2.

Table 2. Optical density of the lateral, central and medial zones and averages in the digital radiography

Digital												
kv		diaphysis				metaphysis					epiphysis	
kv	latral	central	medial	average	lateral	central	medial	average	lateral	central	medial	average
48	209	205	215	210	153	171	171	166	153	196	125	156
49	211	205	212	209	148	170	176	162	145	175	137	148
50	216	206	210	211	153	170	174	165	142	172	124	147
51	210	191	214	205	107	146	146	144	87	152	98	109
52	191	194	204	196	138	177	186	166	122	164	112	130
53	202	195	207	201	143	155	171	156	143	174	143	153
54	184	172	181	179	120	149	148	138	110	155	114	129
55	172	167	190	175	130	141	149	139	120	157	123	134
56	176	172	188	179	134	141	146	140	123	163	117	125

To compare the results statistically and to calculate the contrast, we compared the difference of lateral, central, and medial densities with each other and summed up the absolute values.

Shapiro-Wilk test was used to check the normality of the distribution of variables. The null hypothesis in this test was that the distribution was normal. If the significance level of the test was greater than 0.05, the null hypothesis was confirmed, and we would conclude that the distribution of the variable in question was normal.

According to the significant levels obtained, it was concluded that all variables had normal distribution (significance level greater than 0.05).

Investigation of the Relationship between the Contrast of Diaphysis, Metaphysis and Epiphysis with KV in analog radiology

Pearson correlation test was used to investigate the relationship between diaphysis, metaphysis and epiphysis contrast with kV. The null hypothesis in this test was that the correlation coefficient was zero (no correlation). If the significance level of the test was lower than 0.05, the null hypothesis would be rejected.

Pearson correlation results in the table showed that there was no significant relationship between kv and diaphysis contrast in analog radiology ($r = 0.50$, $p = 0.17$).

There was no significant relationship between kv and metaphysis contrast in analog radiology ($r = 0.41$, $p = 0.27$).

There was no significant relationship between kv and epiphysis contrast in analog radiology ($r = 0.50$, $p = 0.17$).

Investigating the Relationship between Diaphysis ,Metaphysis, and Epiphysis Contrast with KV in Digital Radiology

Pearson correlation test was used to investigate the relationship between diaphysis, metaphysis and epiphysis contrast with kV. The null hypothesis in this test was that the correlation coefficient was zero (no correlation). If the significance level of the test was less than 0.05, the null hypothesis would be rejected.

Pearson correlation results showed that there was no significant relationship between kv and diaphysis contrast in digital radiology ($p = 0.14$ and $r = 0.53$).

There was no significant relationship between kv and metaphysis contrast in digital radiology ($r = -0.18$, $p = 0.65$).

There was no significant relationship between kv and epiphysis contrast in digital radiology ($r = -0.64$, $p = 0.06$).

Comparison of Contrast Rate in Analog and Digital Radiology

Independent t-test was used to compare the contrast in analogue and digital radiology. The null hypothesis was the equality of the means of

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contrast in analog and digital radiology. If the significance level of the test was less than 0.05 the null hypothesis would be rejected.

Independent t-test results showed that diaphysis contrast in digital radiology (m = 27.56) was significantly higher than analog radiology (m = 4.67) (p = 0.001) (Fig. 3).

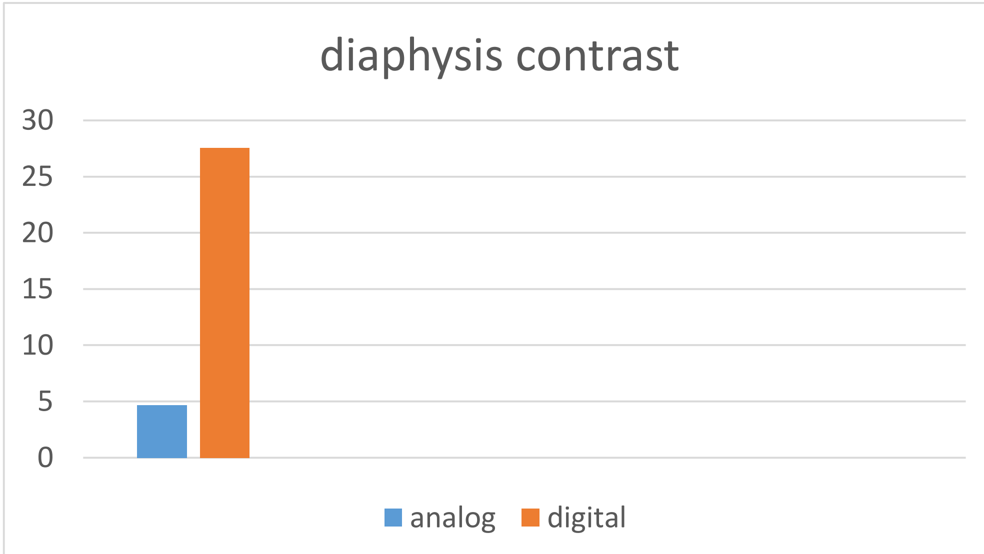

Fig. 3 diaphysis contrast in digital and analog radiology.

Metaphysis contrast was not significantly different in digital (m = 53.56) and analog radiology (m = 47.33) (p = 0.676) (Fig. 4).

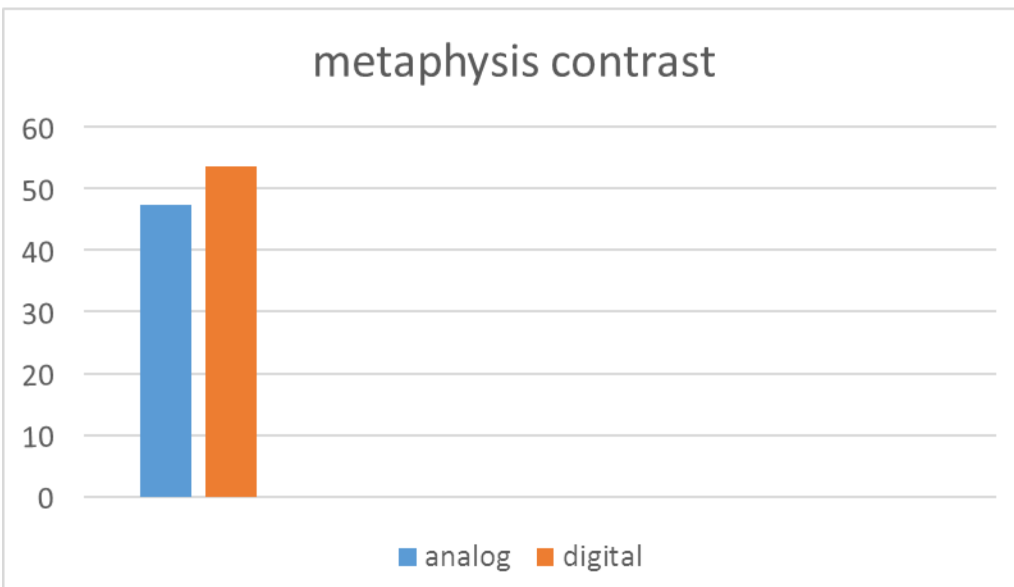

Fig. 4 Metaphysis contrast in digital and analog radiology.

There was no significant difference in the amount of epiphysis contrast between digital radiology (m = 98.00) and analog radiology (m = 98.22) (p = 0.992) (Fig. 5).

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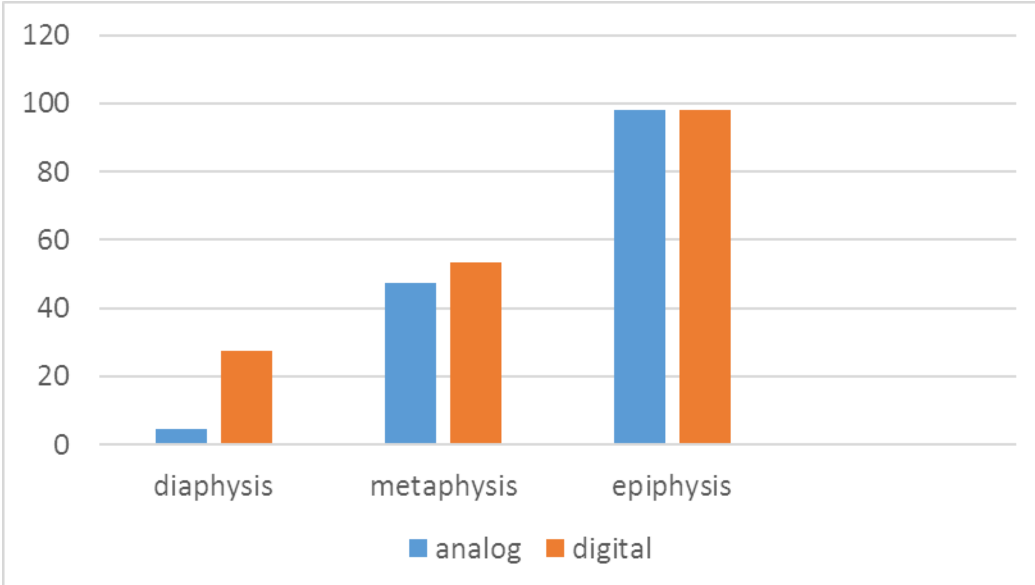

Fig. 5 Diaphysis and metaphysis and epiphysis contrast in digital and analog radiology.

By observing and comparing the numbers in Tables 1 and 2, it seemed that the overall density decreased with increasing kv in both analog and digital images.

DISCUSSION

Analog System Images

The density decreased regularly with increasing kV to the reference kV (Hadizadeh et al., 2008), but after the reference kV the density decreased dramatically with increasing kV (in all three diaphysis, metaphysis and epiphysis regions).

No significant density differences were observed in lateral, central and medial diaphysis zones, and at all three zones, the densities were similar. According to the statistical results, Pearson's correlation coefficients showed that diaphysis contrast was not significantly correlated with analogue radiology ($r = 0.50$, $p = 0.17$).

In the study of recorded densities of the metaphysis area the density difference between the lateral zone and the central zone of the metaphysis area was significant and it increased by increasing kV from 45 and there was no significant relationship between the kV and metaphysical contrast in analog radiology ($p = 0.27$) and ($r = 0.41$).

In the study of recorded densities of epiphysis area, there was a significant difference between lateral and central - central and medial - lateral and medial epiphysis zones and there was no significant relationship between kV and epiphysis contrast in analog radiology ($P = 0.17$ and $r = 0.50$).

Digital System Images

It was observed that the decreasing density trend from 48 kV to 53 kV was regular, but there was a sharp drop after 53 kV (reference kV) as the kV increased as the density decreased and when we went down from the reference kV, the density increased in all three lateral, central and medial zones.

In the study of recorded densities of diaphysis area, the density difference between lateral and central - central and medial diaphysis zones was significant. Also, the difference between lateral and medial diaphysis zones at 55 kV and 56 kV was significant. Pearson correlation showed that there was no significant relationship between kV and diaphysis contrast in digital radiology ($r = 0.53$, $p = 0.14$).

In the study of the recorded densities of the metaphysis region, the density difference between the lateral and central-lateral and medial zones from 48 to 51 kV and the density difference between all three zones from 52 to 56 kV was significant, and there was no significant relationship between kV and metaphysis contrast based on the statistical results obtained from digital radiology ($p = 0.65$, $r = -0.18$).

In the study of recorded densities in the epiphysis area, the difference in density was significant between all three zones from 48 to 52 kV, and higher than 53 kV the density difference between lateral, central, medial and central zones was significant. There was no significant relationship between epiphysis contrast and kV in digital radiology ($p = 0.06$ and $r = -0.64$).

In analogue and digital images, the mean total optical density decreased from diaphysis to epiphysis at all kilovolts that was due to the decrease in bone tissue density from diaphysis to epiphysis.

Overall mean density in all three diaphysis, metaphysis and epiphysis areas was higher in digital images than the analogue images. As a result, the mean optical density in analogue images was higher than in digital images, but at higher kilovolts, the mean density in diaphysis, metaphysis and epiphysis regions was similar to the mean density of the corresponding regions in digital images but of course this increase in kV reduced the contrast.

In digital images at all kiloVolts, the optical density of the central zone of the metaphysis zone was lower than that of the diaphysis and epiphysis zones, but in analog images this was only significant at the kiloVolts higher than the reference voltage, ie. 47 to 51 kV. This could be due to density difference in the central zones of the diaphysis and epiphysis area because the bone tissue is denser in the central region of the diaphysis and increases the optical density of this region than in the central zone of the metaphysis and in the central region of the epiphysis due to the presence of ulna bone head and overlapping the image of the lower arm bone and ulna bone head, the optical density of the central epiphysis zone was greater than that of the central metaphysis zone.

Independent t-test results showed that diaphysis contrast in digital radiology ($m = 27.56$) was significantly higher than analogue radiology ($m = 4.67$) ($p = 0.001$). So the diaphysis contrast in digital images was far better than the analog images (Fig. 4).

But the metaphysis contrast was not significantly different in digital radiology ($m = 53.56$), and analogue radiology ($m = 47.33$) with these kilovoltage changes ($p = 0.676$) (Fig. 2).

There was also no significant difference in the of epiphysis contrast in digital ($m = 98.00$) and analogue radiology ($m = 98.22$) ($p = 0.992$) (Fig. 3).

So, it can be concluded that the contrast of the metaphysis region and the epiphysis were similar in analogue and digital images, but in the diaphysis region, the contrast of the digital images was preferable.

Finally, it was concluded that there was no significant difference between the analog and digital imaging systems in pathologic or traumatic cases of metaphysis and epiphysis areas of the elongated bones, but digital imaging systems because of having more contrast are stronger for the diagnosis of pathologic or traumatic cases of elongated bones of diaphysis area.

It was needed to use lower kilovoltage for achieving greater contrast in analog images to difference in the tissue absorption caused by the photoelectric effect increased the contrast, which would increase the unwanted absorbed dose of the patient, preferably using the digital system instead of the absorbed dose. It can increase both the diagnostic power of the image due to good contrast, and reduce the absorbed dose of the patient.

CONCLUSIONS

Finally, it can be concluded that increasing the voltage in both digital and analog systems reduces the mean optical density of bone tissue in elongated bones but almost independent of density and depending on the examined area, the image contrast had different result in the image. This difference was due to the difference in tissue absorption and overcoming the photoelectric absorption phenomenon, which led to the emergence of contrast differences in images. According to the results of the radiographic image obtained for elongated bones of epiphysis area, the digital system was preferable whereas for examination of metaphysis and epiphysis regions, the results of the analog system were approximately equal to those of the digital system. In this study, the average kilovoltage used in the analog system was lower than that of the digital system but in general, we have to reduce the kilovoltage to have higher contrast, which increases the absorbed dose of the patient, while the higher kilovoltage in the digital system reduces the event of the photoelectric phenomenon and the absorbed dose of the patient.

It was concluded that in the pathological or traumatic cases of the elongated bones of the diaphysis area, the digital system should be used more to have higher contrast, and although the analogue system is also suitable for metaphysis and epiphysis areas, it is better to use digital system to reduce the dose received by the patient.

Declaration of interest:
The authors declare that they have no conflict of interest.

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