

Greyscale Appearance of Film-screen Radiographic Artefacts in a University Teaching Hospital

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ABSTRACT

Objective: To link the greyscale appearance of radiographic artefacts with their origin, with a view to understanding and minimizing their occurrence. **Materials and Methods:** A formula was used to establish a minimum sample size of 400 radiographs out of a population of 5500 radiographs produced between January 2013 and June, 2013. On a daily basis within the study period, all radiographs approved for reporting by the quality control radiographer with over 10 years' experience were scrutinized prospectively by the researchers with the aid of a giant 100 cm × 50 cm viewing box with brightness adjustment, until 400 artefactual radiographs were eventually isolated. The nature, greyscale appearance and origin of artefacts were arrived at by consensus and documented. Divergence in opinion and ambiguous artefacts were resolved through observation of radiographers and darkroom assistants at work, as well as darkroom simulations. The data on subdivision of artefacts was done using simple statistics. **Result:** 400 radiographs out of a population of 5500 were sampled for the study. Twelve specific artefacts were isolated and categorized into three distinct appearances of black, white and grey. Preprocessing, processing and postprocessing were established as a broad classification for artefacts. Dispersed dots emanating from preprocessing (grey) and occurring in cassettes had the highest frequency of 140 (35%) while grid lines, $n = 3$ (0.8%) was the least noted. **Conclusion:** All black artefacts arise during the preprocessing stage while processing and postprocessing have the middle-course greyscale appearance of artefacts.

Key words: Artefacts; darkroom; processing; radiographer

Introduction

Radiographic artefacts occur on radiographs as features that mimic pathologic appearances.^[1] They mask true abnormalities and create pseudo-lesions.^[2] Their radiographic appearances range from opaque to grey and depending on their origin, may have a constant or different position on follow-up or repeat radiographs.^[1] They are distracting and compromise accurate diagnoses^[3] with extreme cases leading to gross misdiagnoses.^[4] Artefacts also lead to film repeat,^[5] which invariably leads to a repeat visit to the hospital as well as additional radiation dose to patients.^[6]

Although most artefacts that occur in conventional radiography have become familiar,^[3] others still present a true diagnostic challenge,^[2] especially in developing countries where film-screen radiography is still widely practiced. Although the likelihood of hospitals still involved in film-screen radiography changing to digital systems is high, even that is not a panacea to artefacts as gleaned from Waaler and Hofmann who stated that the introduction of digital radiography, which has supplanted film-screen systems, has only managed to reduce artefacts rather than eliminate them.^[7]

In order to avoid misinterpretation of radiographs, recognizing artefacts and understanding their physico-technical background are of great importance in imaging.^[8]

This work sets out to investigate the origin and appearance of artefacts encountered in the course of our work in the Radiology Department of a Teaching Hospital.

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Materials and Methods

A formula was used to establish a minimum sample size of 400 radiographs out of a population of 5500 radiographs produced between January 2013 and June, 2013. On a daily basis within the study period, all radiographs approved for reporting by the quality control radiographer with over 10 years' experience were scrutinized prospectively by the researchers with the aid of a giant 100 cm × 50 cm viewing box with brightness adjustment, until 400 artefactual radiographs were eventually isolated. The nature, greyscale appearance and origin of artefacts were arrived at by consensus and documented. Divergence in opinion and ambiguous artefacts were resolved through observation of radiographers and darkroom assistants at work, as well as darkroom simulations. The data on subdivision of artefacts was analyzed using simple statistics.

Results

The appearance of artefacts in radiographs was greyscale. Black artefacts were always seen during packaging, preprocessor handling, developer stasis and $\text{Ag}_2\text{S}_2\text{O}_3$ (silver thiosulfate) adhesion. Every other radiographic “bus stop” produced either a white or grey appearance [Table 1]. Twelve distinct artefacts were isolated as noted in Table 2.

Discussion

Our findings reveal that abrasion and pressure on films from dry objects prior to processing induced black artefacts with unpredictable shape in the film [Figure 1]. Radiation from visible light or X-Ray were also noted to induce black artefacts which in radiographic parlance is known as fog [Figure 2]. These high-density areas of the radiographs are caused by premature ionization of silver halide in the film emulsion leading to latent image formation through deposition of

silver atoms. A subsequent exposure by X-ray increases the deposition of more silver atoms atop the previous ones thereby increasing the density (blackness) of the sensitized area of the film [Figures 1 and 2].

Another important finding necessary for the formation of black artefacts is prolonged stay of film in the developer compartment of the automatic processor as a result of power failure. This ‘stasis’ increases the deposition of black silver atoms through prolonged developer interaction with ionized silver halide. The shape of the blackness is predictably straight lines because of roller grip [Figure 3]. The last kind of film blackening noted were multiple, dispersed black stains on radiographs. This arose from accumulated, blackened silver thiosulfate particles in the fixer solution, which had

Table 1: Origin and appearance of artefacts

Classification	Origin	Appearance
Preprocessing	Packaging	Black
	Procedure (accessories manipulation)	White and grey
	Patient	White and grey
	Preprocessor (darkroom handling)	Black
Processing	Feed tray (wet/dusty)	Grey
	Developer (stain/stasis)	Black
	Fixer (stain/stasis)	White
	$\text{Ag}_2\text{S}_2\text{O}_3$ (silver thiosulfate) particles from fixer	Black
	Rinse (dirt/contamination)	Grey
	Dryer (roller abrasion)	Grey
Postprocessing	Name inscription	Grey
	Grease stain	Grey
	Powder stain	Grey
	Carbon paper stain	Grey

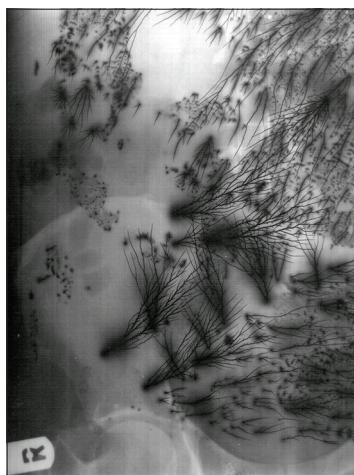


Figure 1: Electrostatic discharge artefacts. This was simulated by cleaning intensifying screens with dry cotton wool. A film processed immediately preceding the cleaning shows copious tree-like dark tatoos. The induced electrical charges on the screen are gradually lost

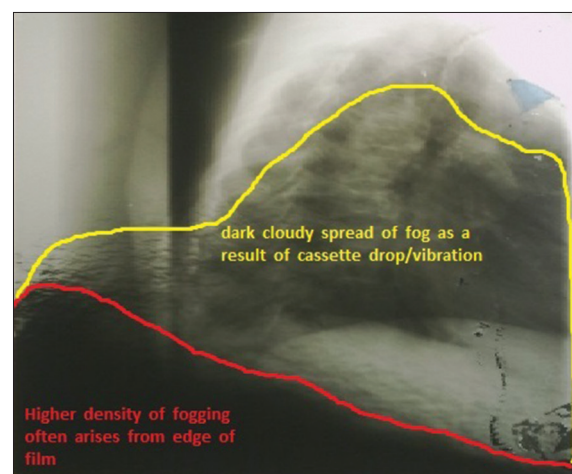


Figure 2: Light fog artefacts. An open edge of the cassette before and after X-ray sensitization exposes film to visible light resulting in film blackening (fog). The surface area of film exposed determines the extent of fogging. The darker areas in the image above represent higher intensity of light, and it is always at the edge. The dark cloudy fog shown superior to the uniformly dark band below is as a result of both light-leak and dropping/vibration of cassette on the floor during handling

Table 2: Characteristics of artefacts

Appearance	Origin	Nature of artefacts	Description	Specific cause (s)	Frequency (%)
Grey	Preprocessing	Dispersed dots	Tiny, irregular bright spots	Dirty intensifying screens	140 (35.0)
Black	Preprocessing	Often-solitary, high densities	Dark, finger edge-shaped marks	Film bending during loading into cassette	65 (16.0)
Grey	Postprocessing	Scratches	Thin irregular lines	Abrasion of radiograph with a hard surface	62 (15.5)
Black	Preprocessing	Fogging; uneven	Dark irregular borders	Light leak from cassette edge	55 (14.0)
Grey	Processing	Water marks	Minus density, irregular thick tattoos	Stuck films in processor	21 (5.3)
Grey	Processing	Roller marks	Uniform, thick band or thin strip running from edge-to-edge of radiographs	Roller friction with film or paused film transport	13 (3.2)
Grey	Postprocessing	Grease stains	Erasable finger prints	Poor handling during sorting	11 (2.7)
Grey	Preprocessing	Radiopacities	Bright or grey object-shaped densities	Dense foreign bodies on patients	10 (2.5)
Black	Processing	Silver-thiosulfate particles	Dark, fairly-erasable particles adhering to radiographs	Unclean rollers after prolonged idleness	9 (2.2)
Grey	Processing	Tattoos	Greyscale, uniform designs	Developer-stained feed tray	7 (1.8)
Black	Preprocessing	Static electric discharge	Dark tree-shaped tattoos	Intensifying screen abrasion with rough, dry material	4 (1.0)
Grey	Preprocessing	Grid lines	Faint, very thin, parallel, grey stripes	Immobile grid or wrong surface of stationary grid	3 (0.8)

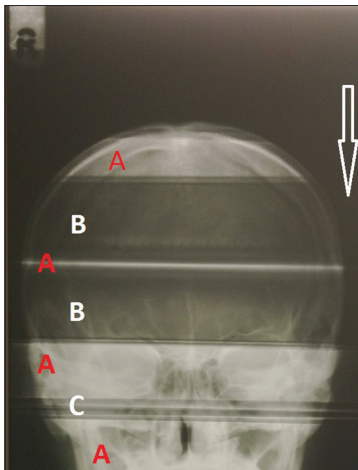


Figure 3: Roller marks artefacts In the event of power failure films may be trapped in the rollers of the automatic processor. (A) Is the evidence of completion of development. (B) Represents region of film in contact with developer-wet exit rollers in developer compartment. (C) Represents film in contact with developer-wet cross-over roller and roller compartment. White arrow shows film movement through the automatic processor

not received adequate agitation. These particles do not cling to the film as grits or an area of embossment but induced black stains in the film. This may have been possible due to continuity of development in the fixer section as a result of the cross-over silver thiosulfate. No dark artefacts however, were found after processing of radiographs.

Conversely, a consistently greyish-bright spot with smooth borders was produced by fixer on contact with film prior to processing.

The spot is evidence of film base devoid of silver halide emulsion [Figure 4] The major action of fixer is elimination

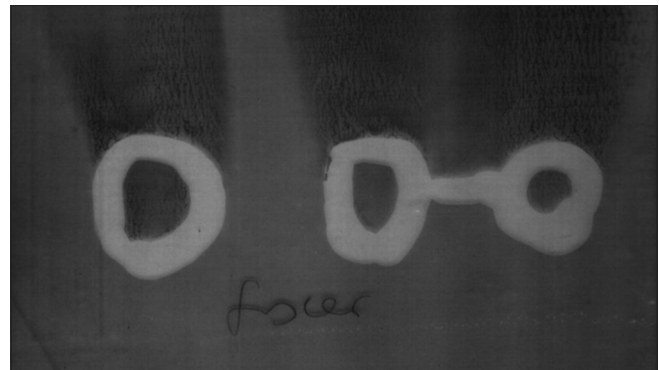


Figure 4: Fixer stain artefacts. Contact of fixer solution with (i) a radiation-sensitized but not-yet-processed film results irredeemably in a white smooth-edge mark on the radiograph as shown above; (ii) a processed film does not discolor the image; (iii) a non-radiation-sensitized film has the same effect as (ii) but such films should not be used anymore due to the risk of screen stains and developer neutralization during processing. The white patch, as shown above, is evidence of silver halide erosion

of silver halide which had not been sensitized to radiation to prevent further activation which may form new images and hence, compromise the resolution of the prior images.

Whether a film is therefore sensitized to radiation or not, on contact with fixer solution, a greyish-bright spot should be expected. The possibility of this happening in the automatic processor however, is remote. Our image was therefore simulated [Figure 4]. Aside fixer which stands alone in the eliminating of silver halide emulsion as its mechanism of artefact formation, other greyish artefacts resulted from partial or complete attenuation of radiation by dense objects. This attenuation arises in the radiographic process from foreign bodies on patients, improper use of radiographic accessories and automatic processor faults [Figure 5].

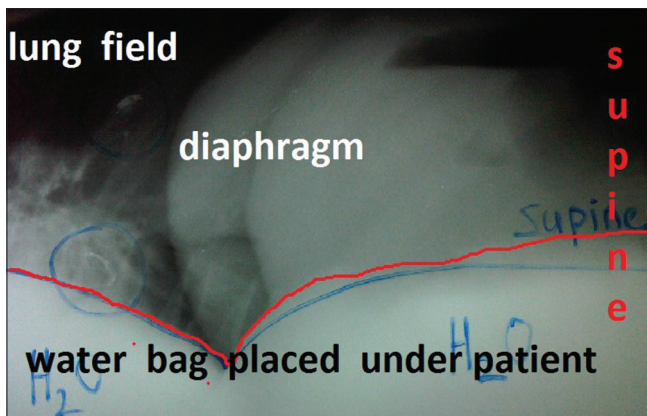


Figure 5: Water as an artefact. The image represents an attempt to perform a lateral chest X-ray on a quadriplegic on a waterbed to avoid bedsores. The inferiorly-located (below red line), greyish homogenous opacity represents the water bags. It is almost iso-dense with the diaphragm located superior to it. This water artefact could be a source of confusion to the reporting radiologist oblivious of its origin

Excessive attenuation results in less-vigorous ionization of silver halide by X-Rays resulting in reduced surface area for developer interaction. In principle, the more silver halide ionized the more silver atoms that would be deposited as black metallic silver to form the image. Attenuation of radiation by any radiopaque object results in fewer ionization of silver halide. This results in a greyish-white artefact. The brightness of the spot increases with increasing density. This latter type of artefacts however, have a brighter hue than fixer-induced artefacts [Figure 5]. This is because the film base of films used in our centre and which is exposed by the fixer, has a default bluish tinge.

The authors deduced three mnemonic origin of artefacts to aid memory recall [Table 1]. These origins are linked to processes involved in the radiographic image. This division is fairly in tandem with several previous works. Van Ongeval *et al.*, classified artefacts as patient-related, technologist-related, machine-related, processing-related and viewing-conditions related^[6] while Hogge *et al.*, preferred to use the processor, technologist, machine and patient-related artefacts.^[2] However, Jiménez *et al.*, working on digital radiographic artefacts, centered their classification on “exposure” rather than “processing” as we did in our work. They established preexposure, exposure and postexposure artefacts.^[9] Although different researchers may come-up with different closely-related classifications, our mnemonic classification gives some edge due to ease of recall.

The authors also found out that 94% (n = 376) of the artefacts were introduced in the darkroom [Table 2]. The major cause was dirty intensifying screens which were shabbily cleaned.

This resulted in stains on the screens which attenuated radiation resulting in tiny, bright spots on radiographs (n=140; 35%). These spots are easily identified by the constancy in their positions in subsequent radiographs produced with the offending screens. Aside grease stain with a frequency of 2.7% (n = 11) jointly shared by the darkroom assistants and the radiographers, the only artefacts traceable to the latter was grid lines (0.8%, n = 3). Kirberger and Roos are also of the opinion that most radiographic artefacts can be prevented by proper storage and handling of films and by optimal darkroom technique.^[1]

Conclusion

We recommend regular problem-solving triangular communication between radiologists, radiographers and darkroom assistants to minimize the occurrence of artefacts. If the 94% of artefacts introduced in the darkroom could be drastically reduced, distractions during film reporting by the radiologists will concomitantly reduce.

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