Validated simple tip to aid eliminating light scatter in viewing overexposed radiographs

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ABSTRACT

INTRODUCTION Overexposed radiographs can hinder the diagnostic performance of the examining physician. We describe a new, simple technique to aid eliminating light scatter in overexposed radiographs and examine its effect objectively.

MATERIALS AND METHODS The new technique is simply manufacturing a monocular device out of another rolled up XR sheet and examining the object radiograph through it to mask the light scatter. Controlled environments were created to examine five different radiographs and register the light scatter reduction using a digital high resolution camera.

RESULTS The light scatter reduction was noted to be statistically significant by using the new technique. ($P < 0.001$).

CONCLUSIONS This technique is simple, readily available and avoids the need to repeat radiographs with the associated increased cost, chronological delays and potential radiological harm.

KEYWORDS

X-ray – Light scatter – Glare

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Overexposed radiographs can be difficult to interpret. Repeating the X-ray will inevitably lead to wasting precious time and resources and cause potentially avoidable harmful radiation to the patients.

Light scatter from the X-ray viewing box illuminator, room lighting, sunlight, surface reflection and adjacent illuminators can cause a bright glare that can: (i) blind the observer's eyes; (ii) interfere with objective radiograph interpretation; and (iii) ultimately diminish the diagnostic performance of the examiner. It happens more often when the film being viewed is smaller than the area of the viewing screen of the illuminator. The light from around the radiograph will cause apparent blackening and reduces the film contrast.^{1,2}

Drivers will know how they can be totally blinded when faced by the full-beam headlights of an oncoming car.

The poor visual acuity experienced due to light scatter is a function of the retinal rods rather than the cones. The light scatter causes migration of the pigmented granules between the rods in the retina – scotopic vision as opposed to photopic vision when the cones are used at the fovea centralis.¹

The room luminance and ambient light can affect image quality, especially for soft tissue interpretation.^{1–4} Moreover,

Goo *et al.*⁴ showed that ambient light and room illumination can cause visual fatigue to the eyes of the radiograph's examiner.

Kim *et al.*⁵ and others^{6–8} used duplicated film techniques to remedy overexposed radiographs. In 1990, Kaplan *et al.*⁹ went further and used bleaching chemicals to rinse the overexposed radiographs to improve contrast.

Figure 1 The design set-up.

Table 1 Test values

Test No	Ambient light (ms)	No monocular (ms)	Monocular (ms)	Binocular (ms)	White paper (ms)
1	2000	12.5	77	67	50
2	2500	12.5	125	100	77
3	5000	40	333	167	90
4	5000	166	1300	770	250
5	5000	50	333	200	100
Mean	3900.00	56.20	433.60	260.80	113.40
SD	1516.58	63.59	498.32	289.48	78.63

In all tests, the distance between the object radiograph and the camera lens was 35 cm and the lens aperture was fixed at F4.5. The ambient light source was constant; however, the changes in data values reflect changes of the density of the actual radiograph as measured with the viewing box light source switched off (the higher the shutter speed in milliseconds, the darker is the object radiograph). The digital camera media sensitivity was fixed manually to ISO 200.

Patel *et al.*¹⁰ showed that using masking does help in improving the diagnostic performance in dentistry. This was mirrored by Maldjian *et al.*¹¹ in examining cervical spine radiographs.

We describe a simple, 'low-tech', and readily available method to eliminate the blinding light scatter by using nothing more than a rolled-up radiograph (monocular device) and we examine, objectively, the effect of that in reducing the light scatter from the viewing box illuminator.

Materials and Method

A tube-like monocular is devised using another radiograph that can be found in the same patient's X-ray pack. This is used to view the overexposed radiograph where spot-light illuminators are not available or not functioning.

Five different radiographs were used in this experiment to measure the light intensity with and without the monocular device using a standard X-ray viewing box illuminator. The ambient light, room illumination, and light brightness from the source viewing box were measured indirectly using a digital photographic camera (Fuji Finepix 6900, Fuji Photo Film Co., Ltd, Japan). The exposure needed to obtain a digital photograph, the aperture of the lens, and the sensitivity of the media (ISO) were fixed to a given value (Table 1). The distance between the viewing box and the objective lens of the camera was fixed at 35 cm. The camera was mounted on a tripod in a fixed horizontal position throughout.

The light intensity is expressed in relation to the time required (in milliseconds) for the camera to register the same exposure factor. The time (in milliseconds) needed to obtain a digital photograph was the only variable in this study. The time corresponds to the amount of light that is needed to obtain the same exposure. With the aperture on

the fixed lens set to F4.5, a bright image will require less time to register the same exposure than when the image is darker. As the image is fixed to a same radiograph (an overexposed one), the light scatter will be measured accurately from the room illumination, the ambient light and the viewing box. This can then be compared accurately with the effect of the monocular technique.

The light scatter reduction was calculated by obtaining the ratio of the shutter speed to the standard viewing modality, *i.e.* without the use of any light scatter masking technique.

The data collected were statistically analysed using Student's *t*-and SPSS v12.5 statistical analysis software (SPSS Inc., Chicago, IL, USA).

Results

The mean reduction in light scatter was 7.76 times (SD $\pm$ 1.53; range, 6.1–10) when comparing the monocular light scatter eliminating technique to the standard viewing plate. This was statistically significant ($P < 0.001$).

When comparing the binocular light scatter eliminating technique to the standard viewing (*i.e.* without the use of light scatter masking techniques), the mean reduction in light scatter was 5.24 times (SD $\pm$ 1.65; range, 4–8). This was statistically significant ($P < 0.003$).

Similarly, there was a statistically significant difference in the light scatter reduction merely by using A4 white paper. The mean reduction in light scatter was 3.16 times (SD $\pm$ 1.9; range, 1.5–6.1; $P < 0.004$).

Statistically significant differences were also found in correlating monocular to binocular, monocular to white paper sheet, and binocular to white paper sheet techniques, with *P*-values less than 0.007, 0.002, and 0.001, respectively.

Discussion

The full-beam headlight analogy used in the introduction of this article is a reminder of how the driver can act to solve

this problem. The driver improves his vision of the road ahead almost instantly by scowling his eyebrows and contracting the ocular facial muscles to act as a sun visor to mask the blinding light from the incoming cars, thus improving subconsciously the low contrast of the vision at night. Also, cars are fitted with sun visors to stop the sun's blinding light, especially at dawn and dusk.

A cylindrical tube will allow elimination of the light scatter (Fig. 2).

Although the monocular light scatter eliminating technique is superior to the binocular variation ($P < 0.007$), the stereovision here will be lost at the expense of visual acuity. Where stereovision is essential to a particular individual, the binocular technique is still superior to the standard viewing environment ($P < 0.002$).

Using another radiograph for the formation of the cylindrical tube helps in many ways by allowing a dark media (the inside of the cylindrical tube itself) to reflect away further light from the desired object focus point to the viewing eye of the observing examiner and eliminate any unwanted light from the viewing box source or the ambient light. This will improve the subjective assessment of contrast, definition and average density and reduce the apparent film blackening of overexposed radiographs. This accords with the simple principles used by classic photographic cameras and, indeed, by the human eye.

This technique is superior to even a bright spot-light; the object focus point remains uniformly lit in contrast to the bright spot-light that is largely bright at the centre of the spot and decreases towards the edges.¹ This technique is more versatile than the spot-light illuminator as the latter is dependent on the type and power source while the monocular cylinder can be adjusted according to individual preferences. Here, one does not have to move the radiograph to the spot-light.

Figure 2 (a) An elbow radiograph as seen without the monocular light scatter eliminator. Notice the loss of definition and contrast. (b) The image as seen through the monocular. Notice the improvement in the definition and the contrast of the radiograph. (c) As (b), but here the monocular cylinder is used as a binocular.

Figure 3 Reduction in light scatter as compared to a one time factor of standard radiographic viewing (i.e. without the monocular light scatter eliminator). The figures shown are the mean values of the ratio of the shutter speed in milliseconds of each technique to the standard viewing shutter speed.

This technique can be used not only in most obvious orthopaedic applications but in all medical and surgical specialties and subspecialties especially when overexposed radiographs are the only available X-ray and repeating them is impossible due to time constraints, *etc.*, as well as lack of a spot-light illuminator.

This technique cannot only be used in overexposed radiographs but also in normal exposure radiographs to eliminate light scatter from the viewing box and from the ambient light; however, we do not suggest that this is a substitute for a good quality radiograph.

Obviously, with this method, only one person can view the radiograph at a time, which can be a hindrance when more than one observer is examining a given radiograph.

Until digital radiography is widely available (when most of the above problems will be resolved using a mouse and sophisticated software) we recommend the use of this technique in all specialties.

Conclusions

The rolled-up radiograph light scatter eliminator technique is simple, readily available and avoids the need to repeat radiographs with the associated financial expenses, chronological restraints, and potential for radiological harm.

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