



Are physical measures good indicators of clinical image quality at low dose levels? A pilot study

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Background/rationale

- For dose reduction actions, the principle of “image quality as good as possible” to “image quality as good as needed” requires to know whether the physical measures and visual image quality relate
- Visual evaluation and objective physical measures of image quality can appear to be different
- If there is no noticeable effect on the visual image quality with a low dose but there is a objective physical measure impact, then the overall dose may be reduced without compromising the diagnostic image quality

Uffmann M, Schaefer-Prokop C. Digital radiography: The balance between image quality and required radiation dose. *Eur J Radiol.* 2009;72(2):202–8.

Background/rationale

- Low dose imaging can be used for certain types of observations, e.g.
 - thoracic scoliosis, control after metal implantation for osteosynthesis, reviewing pneumonia and tuberculosis

Uffmann M, Schaefer-Prokop C. Digital radiography: The balance between image quality and required radiation dose. *Eur J Radiol.* 2009;72(2):202–8.

Zhang M, Zhao B, Wang Y, Chen W, Hou L. Dose Optimization for Different Medical Imaging Tasks From Exposure Index, Exposure Control Factor, and mAs in Digital Radiography. *Health Phys.* 2012;103(3):235–40.

Aim

- To determine whether physical measures of noise predict visual (clinical) image quality at low dose levels

Method – study design

- An experimental pilot study was undertaken to determine whether physical measures such as SNR and CNR predict visual measures of image quality at low dose levels

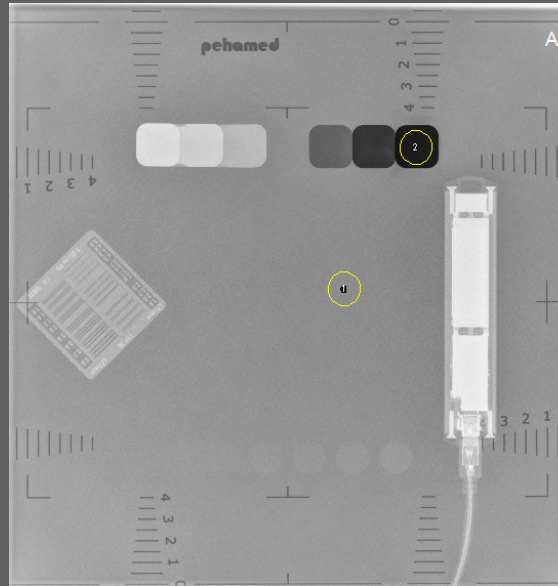
Method

- 24 images
- DR equipment (Phillips, Digital Diagnostic NZR 83)
- Pehamed DIGRAD phantom
- 60, 70 and 81 kVp across a range of mAs values (2.9-159.9)
- Exposure (mGy) was measured (UnforsTM Xi Prestige Platinum dosimeter)



Method – physical measures

- SNR and CNR
 - ROIs
 - Mean value
 - Standard deviation

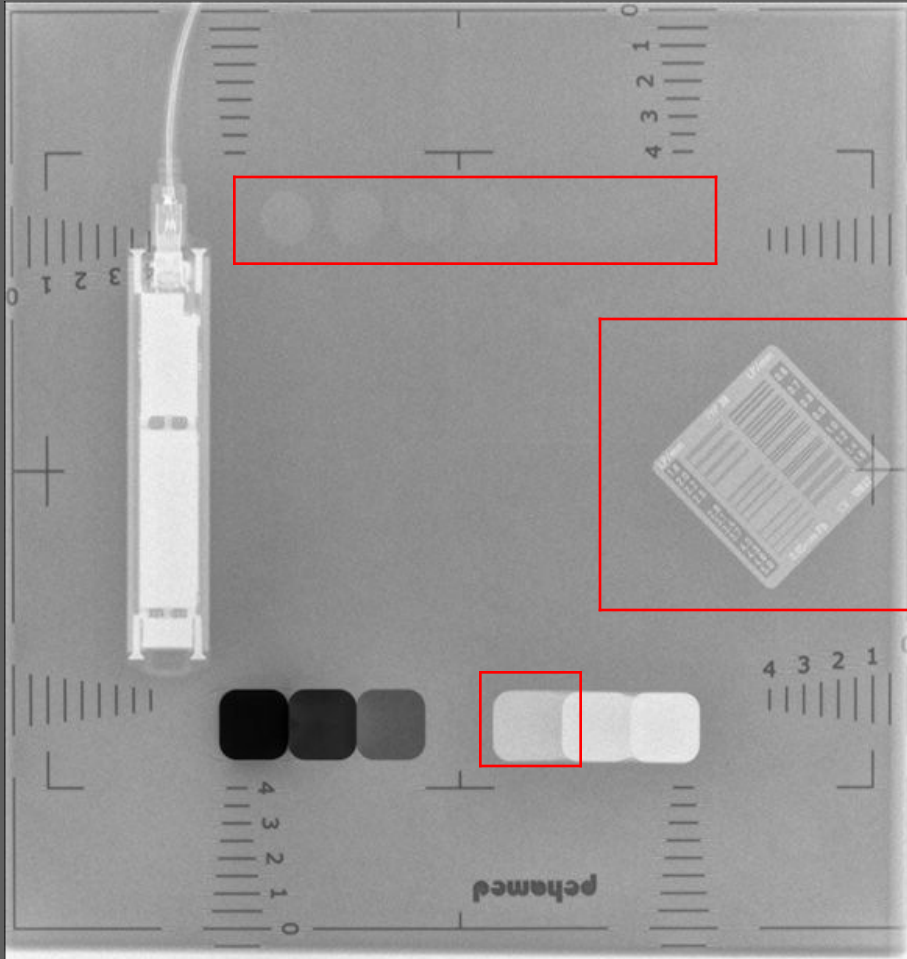


$$SNR = 0.66 \times \frac{S}{N} = \frac{\mu_a}{\sigma_b} \quad (\text{eq. 1a})$$

$$CNR = \frac{|\mu_a - \mu_b|}{\sigma_b} \quad (\text{eq. 1b})$$

Equation 1a) μ_a is the mean intensity of the area of interest, σ_b is the standard deviation of the air filled area of the phantom. One standard deviation for 'correction factor' has been added. *Equation 1b)* μ_a is the mean intensity of one low contrast circle, μ_b is the mean intensity of the homogenous background and σ_b is the standard deviation of the homogenous background.

Method - visual perception measures

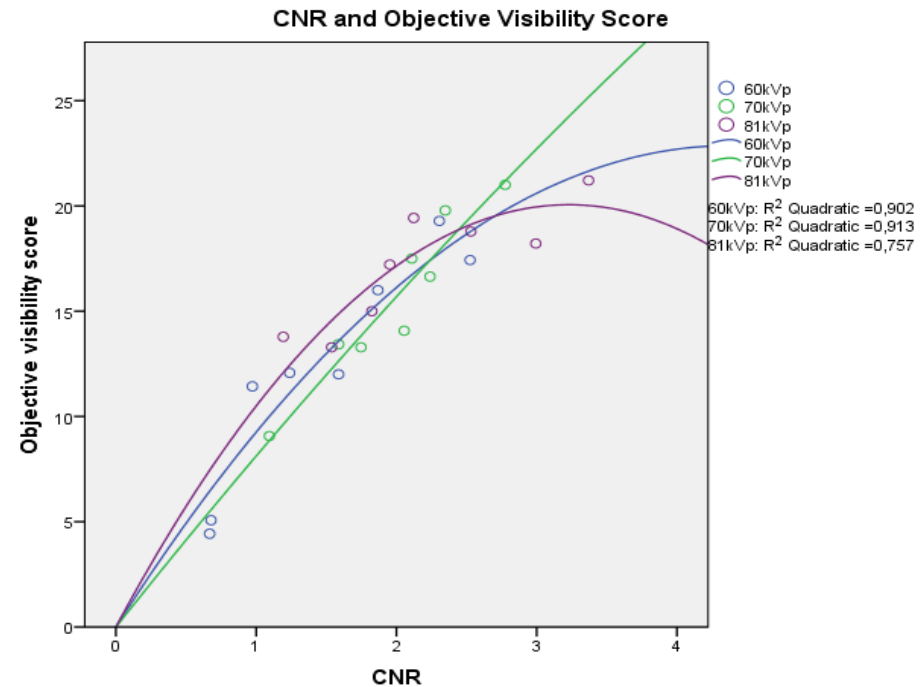
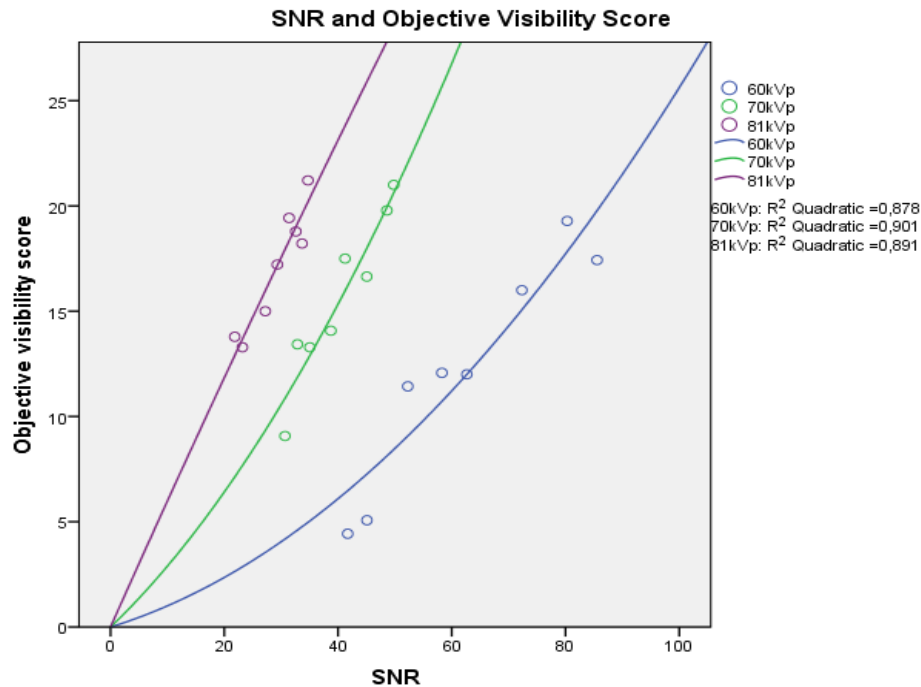


- 14 observers performed image scoring
- Absolute scale (1 Low – 6 High)
- Perceptual visual measures
 - Low contrast objects
 - Linepairs
 - Copper wedges
- EIZO Radiforce MX242W 2.3 Megapixel 24.1"LCD

Method

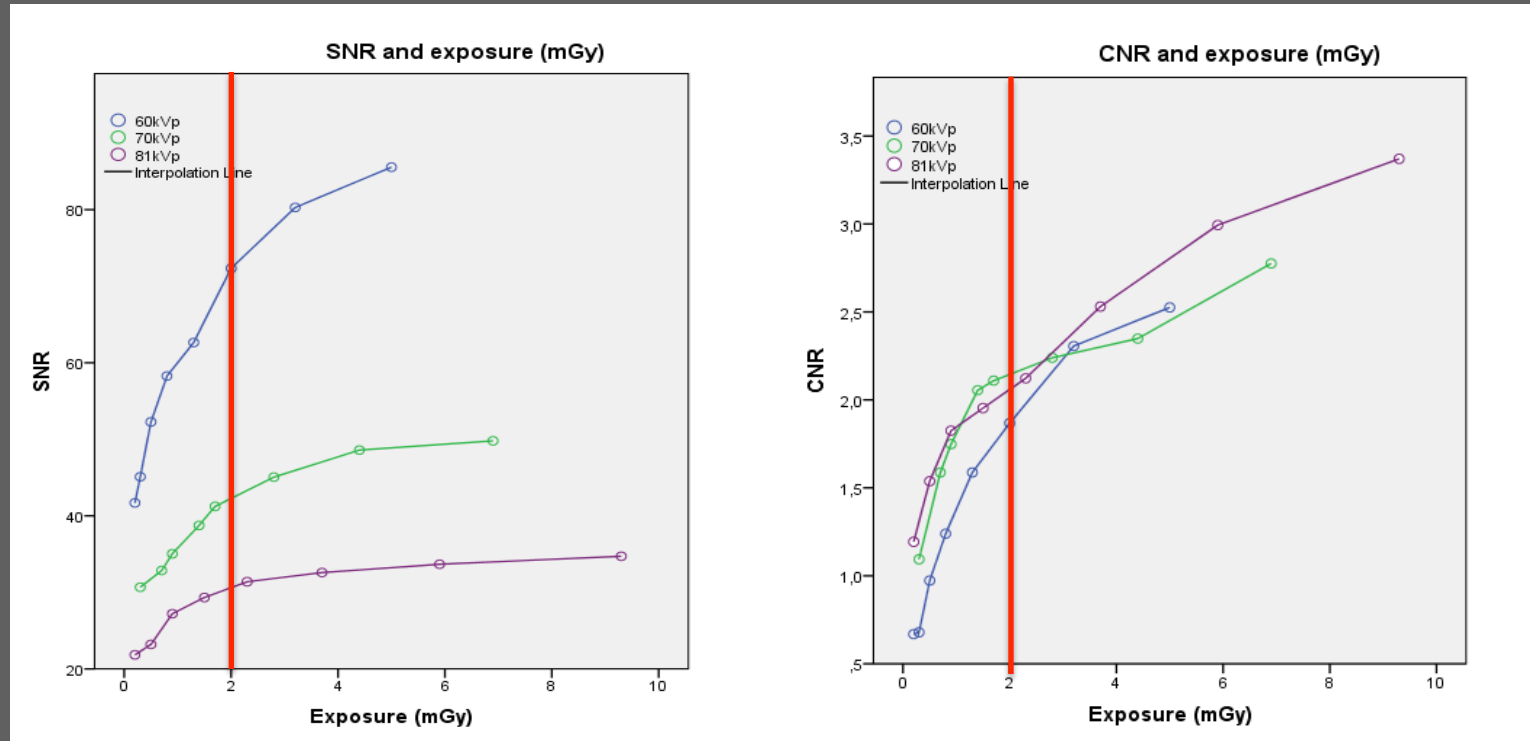
- Image quality Score (IQS) and Objective Visibility Score (OVS) calculated
- Correlation (Pearson r) analysis was done to explore the relationship between the physical and visual perception measures for exposure doses ≤ 2 mGy

Results



- A non-linear (quadratic) relationship between physical and visual measures was observed
- R^2 values between OVS vs SNR and CNR demonstrate a good curve fitting for all 3 kVp settings

Results



- The largest increase for SNR at low exposure values (up to 2 mGy) was observed at 60kVp
- CNR response to exposure is similar at the 3 kVp settings

Results

		60 kVp		70 kVp		81 kVp	
		SNR	CNR	SNR	CNR	SNR	CNR
IQS	Pearson r	.009	.069	.782	.718	.720	.503
	p -value	.987	.896	.118	.172	.280	.497

		60 kVp		70 kVp		81 kVp	
		SNR	CNR	SNR	CNR	SNR	CNR
OVS	Pearson r	.559	.538	.372	.179	-.046	.151
	p -value	.249	.271	.538	.774	.954	.849

- Pearson r was calculated to assess the correlation between IQS, OVS, SNR and CNR.
- None of the correlations reached statistical significance ($p > 0.05$)

Discussion

- At low SNR values a modest increase in SNR will not necessarily improve visual grading scores
- It is possible that at low SNR values, SNR may not accurately predict visual image quality

Bourne R. Fundamentals of Digital Imaging in Medicine. Springer; 2010. 200 p.

Discussion

- In this study, as the CNR value increases the object visibility also increases for all 3 kVp settings
- Object visibility does not differ between all 3 kVp's
- The non-linear relationship between object visibility and CNR reaches a point of saturation - this may indicate that beyond a certain point an increase in CNR does not improve further object visibility

Discussion

- As expected, increasing exposure increases both SNR and CNR in a broad range of exposures up to 10mGy
- Below 2 mGy SNR and CNR may not be reliable indicators of image quality and visual scoring should be considered
- For low dose exposures (≤ 2 mGy) SNR decreases from 60 kVp to 81 kVp, confirming the findings from other authors and giving a normal response from the detector to the absorbed dose

Conclusions & take-home messages

- Physical measures might not predict (clinical) image quality at low dose levels
- At low doses radiographic noise does not have a strong influence on object visibility

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