SINGHEALTH · DUKE-NUS
SCIENTIFIC CONGRESS
17 - 18 SEPTEMBER 2021

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Effects of Non-Physical Grid on Image Quality and Radiation Dose in Lumbar Spine X-ray

Eunice Shannon Teh Wan Ni, Chong Mei Choo, Eunice Shannon Teh Wan Ni, Oh

Background

Low back pain (LBP) is one of the leading causes of years lost due to disability, resulting in loss of functional status in the workforce. In Singapore, over 80% of the adult population will suffer from LBP. Lumbar spine X-ray involves high radiation doses and scattered radiation. Recent emergence of digital scatter correction software (DSCS) produces radiographs with image qualities comparable to those acquired with anti-scatter grids.

Numerous studies investigated radiation dose reduction and image quality optimisation on chest, cervical spine, lower extremities and pelvic regions using DSCS. However, no study investigated image quality using DSCS in lumbar spine X-ray.

The aim of this study is to investigate the feasibility of DSCS associated with delivered radiation dose and consequential image quality when applied to lumbar spine X-ray in DR systems. The objective is to quantifiably assess the effects of DSCS on radiographic image quality.

With decreased milliamperage seconds (mAs) values and DSCS, it is postulated that: patient radiation dose are reduced; there is no significant compromise in radiographic image quality; and all radiographs remain diagnostically acceptable.

Methodology

This was a quantitative-based, experimental anthropomorphic phantom study with ethical approval waived by the Institutional Review Board. Philips DigitalDiagnost X-ray unit, SkyPlate wireless portable X-ray detector, SkyPlate large anti-scatter grid and SkyFlow DSCS algorithm (Hamburg, Germany) were used in this study. Contrast-to-noise ratio (CNR) was calculated using mean pixel values obtained from regions of interest (ROIs) defined using ImageJ software.

Positioning of phantom was in accordance with guidelines from Clark's Radiographic Positioning (4th ed.) Total of 12 phantom radiographs were taken (Figure 1). The images are randomized and exported to Vue PACS system for image evaluation. Hardcopy image quality evaluation forms, paraphrased based on the scale items published in the European Guidelines on Quality Criteria for Diagnostic Radiographic Images, was used.

Two radiologists with experienced 5 years were blinded to evaluate the randomized radiographs.

Figure 1. Anteroposterior (AP) and lateral lumbar spine radiographs acquired using physical grid (R1 and L7) and SkyFlow (R4 and L10).

Results

Lumbar spine radiographs had statistically significant lower ($p<0.05$) DAP (29.9 ± 3.07 μGym^2) using SkyFlow compared to anti-scatter grid usage (47.8 ± 4.92 μGym^2), $t(4) = 5.348$, $p = 0.006$.

The AP radiographs using SkyFlow (2.68 ± 0.25) had statistically significant lower ($p<0.05$) CNR values as opposed to anti-scatter grid (3.27 ± 0.12), $t(4) = 3.639$, $p = 0.02$.Likewise, the lateral radiographs using SkyFlow (5.01 ± 0.16) had statistically significant lower ($p<0.05$) CNR values as opposed anti-scatter grid (7.84 ± 0.17), $t(4) = 21.182$, $p = 0.0003$.

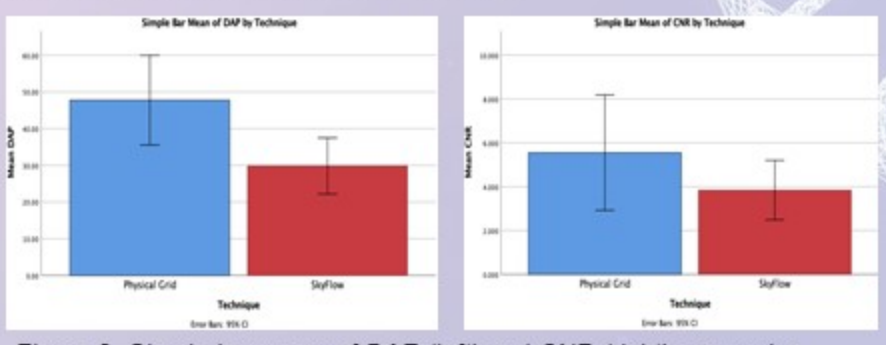

Figure 2. Simple bar mean of DAP (left) and CNR (right) comparing physical grid (blue) and Skyflow (red).

The results illustrate positive impacts of DCSC technique for AP and lateral lumbar spine X-ray, with a 37.5% and 50.7% dose reduction respectively. This aligns with previous studies using a phantom and similar optimisation strategies. However, CNR values were found to be lower in SkyFlow radiographs than those acquired with anti-scatter grid. DSCS mimics the properties of an anti-scatter grid by addressing scattered radiation effects.

The image quality generally is satisfied for anti-grid software. However, the agreement between two radiologists is low, κ = -0.176 (95% confidence interval, -0.474 to 0.122), $p = 0.258$.

SkyFlow works based on Monte-Carlo simulations targeted to deliver computed scatter correction tailored to each patient. As such, inaccuracies could arise from estimation. Hence, persistent poor image contrast and increased granularity could explain the lower CNR values from SkyFlow radiographs. The disagreement between our results and previous studies can be attributed to acquiescence in affirmation as scale items could be due to positively worded.

Conclusion

Results from this study aligns with current literature on radiation dose and image quality optimisation using DSCS technique. Despite disagreements between radiologists, with DSCS technique, AP and lateral lumbar spine X-ray were acquired with an average of 37.5% and 50.7% dose reduction, and were deemed to be of diagnostic quality, albeit with lower CNR values. This proposes the idea of replacing anti-scatter grids with DSCS technique, which also brings along added convenience. Future studies could be conducted on patients to encompass different body habitus, better demonstrating the effects of DSCS technique in the clinical setting. Beyond this study, DSCS technique could be explored in thick anatomical regions requiring anti-scatter grids, to ensure maximisation of diagnostic information at lower radiation doses.

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