Title: Two-dimensionally focused anti-scatter grids – performance and grid-line removal for CBCT

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Structured Abstract:

Introduction: Cone-beam computerized tomography (CBCT) differs from traditional single slice CT by using a three-dimensional approach for data acquisition. Unfortunately, Compton scatter is then able to affect multiple rows of the detector array exacerbating its detrimental effects in image contrast. The increased scatter fraction cannot be fully corrected during image post-processing; and therefore, scatter related artefacts, increased noise, and errors in quantitative imaging remain a challenge for CBCT systems. The objective of this study is to evaluate the anti-scatter characteristics of two novel two-dimensionally focused anti-scatter grids (2DF-ASGs), and to remove grid-line artefacts prior grid implementation in CBCT.
Methods: One square and one hexagonal 2DF-ASGs were fabricated using powder selective laser melting (AM400, Renishaw plc). The square grid was manufactured in chrome-cobalt whereas the hexagonal grid was manufactured in stainless steel. The square grid (ratio, 10:1; septal-thickness, 100.6 μm; transmission-efficiency, 83%) was coupled to a flat panel detector (DRX Plus 3543, Carestream Health) with 139 μm pixel-size. A combination of conventional offset-gain-defect correction and Fourier filtration was used to remove residual grid-line artefacts. The scatter rejection characteristics of the grid were measured using a 14 cm water phantom. The hexagonal grid (grid ratio, 10:1; septal-thickness, 102.4 μm; transmission-efficiency, 86.19%), was coupled to the 20 μm pitch detector of a preclinical micro-CT scanner (eXplore Locus SP, General Electric HealthCare). The 2DF-ASG was held in place using a cylindrical mount which allowed rotation of the grid one revolution per frame. Residual grid-line artefacts were removed using conventional offset-gain-defect correction.
Results: Both 2D-ASGs were successfully mounted with their respective detectors and x-ray projection images were acquired. In the case of the square profile, grid-lines partially affected one or two detector elements. Line-artefacts, for this scenario, were successfully removed using offset-gain correction, and Fourier filtration. The square 2DF-ASG was able to remove 68.2% of the scatter generated by the water phantom up to an incident angle of 5.7 degrees. For the hexagonal profile, the cylindrical mount proved to be mechanically stable and most of the grid-line artefacts were successfully blurred. Nevertheless, residual artefacts might require additional strategies before implementation in CBCT.
Discussion: Selective laser melting can produce highly efficient 2DF-ASGs, which are effective at scatter rejection in CBCT. The removal of grid-line artefacts proved to be dependant of the relationship between the detector elements pitch and the "shadow" generated by the grid. Finally, residual grid-line artefacts might require additional corrections due to non-linearities at the detector caused by light scattered within the detector's scintillator.