Use of Monte Carlo simulation to assist in the removal of scatter in quantitative computed radiographic imaging

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ABSTRACT

We are investigating a method of producing quantitative measures of bone mineralization in the monitoring of the healing of tibial shaft fractures using Computed Radiography images. Radiographic images are formed by the detection of primary radiation transmitted through the object and the detection of radiation scattered by the object. Information about the attenuation properties of the object is contained in the primary radiation. In order to perform quantitative analysis on radiographic images, it is essential to remove the scattered radiation contribution from the image. We have investigated a technique of using an analytical model of the scattered radiation distribution to generate a scatter point spread function which was then used to deconvolve the scatter degraded images. This was found to be helpful in the removal of the scatter component. However, this model is applicable to an infinite extent uniform thickness of homogeneous scattering material and therefore required refinement for application to real images of complex composition. Monte Carlo simulation was used to model the clinically used imaging technique, and provided a means of validating the analytical model. Further, it allowed modelling experiments to be conducted so that the input parameters, for the analytical model could be determined more reliably. A mathematical phantom of the lower leg was constructed to simulate the clinical imaging scenario. A physical test phantom consisting of calibrated mass thicknesses of hydroxyapatite place on scattering material was imaged using the Computed Radiography system. Test results using the refined analytical model for scatter deconvolution with both the mathematical and the physical phantoms were encouraging. Using the mathematical phantom with a 100mm air gap, 100mm of soft tissue and bone phantoms of varying mass thicknesses, bone mineral densities were retrieved to within 4% after scatter correction. Tests using the physical phantom with no air gap and 60mm of perspex resulted in a 10% error in bone mineral density after scatter correction. This technique continues to be further refined.