Editors' pick

Dual-energy CT imaging of orbits during episcleral brachytherapy with Ru-106 plaques: a phantom study of its potential for plaque position verification

Kostas Perisinakis, Efstathios T. Detorakis, Antonis Tzedakis, Dimitris Liakopoulos, Efrosini Papadaki, John Damilakis
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What was your motivation for initiating this study?

Radioactive plaque brachytherapy is nowadays the dominant vision-preserving treatment for intraocular tumours. Prefabricated solid-silver-coated ruthenium-106/rhodium-106 (Ru-106/Rh-106) plaques are widely used for treatment of ocular tumours of <6 mm thick. At the University Hospital of Heraklion, in Crete, Greece, the technique has been in use for the past five years and so far 38 patients have been treated (32 cases with uveal melanoma, four cases with vasoproliferative retinal lesions and two cases with conjunctival squamous cell carcinomas). Results have been successful with only two cases of local recurrence (6.25%) for uveal melanomas.

Since magnetic resonance imaging (MRI) provides images of high soft-tissue contrast, it has been reported to be superior to computed tomography (CT) and other imaging techniques available for depicting intraocular tumours and treatment planning. Imaging the eye after plaque placement is important for verification. However, silver-coated Ru-106 plaques are not MRI compatible. Post-operative conventional single-energy CT imaging has been reported to be of limited value regarding plaque positioning verification, since it suffers from severe streaking/shaping artifacts. Besides, dual energy CT (DECT) imaging technology has rapidly evolved during the last decade and advanced metal artifact reduction algorithms (MARs) have been reported to provide high potential for metal artifact reduction in CT imaging. The current study was motivated by the need to test the feasibility of DECT imaging for positioning verification of Ru-106 plaques after surgery. The potential of DECT imaging in combination with an advanced MAR algorithm to provide artifact-free imaging of Ru-106 plaques after surgical placement was investigated.

What were the main challenges during the work?

The main challenge of this work was to generate a physical anthropomorphic head that closely resembled the head of an adult individual after surgical placement of a Ru-106 plaque. A commercially available physical anthropomorphic head phantom was appropriately modified by attachment of eye-balls that were made of tissue-equivalent material and a silver dummy Ru-106 plaque to the posterior nasal sclera region of the right eye.

The phantom was subjected to all available DECT protocols for head imaging. Image quality was assessed and compared. The radiation burden to the eye-lens of both healthy and treated eyes from post-surgery DECT imaging was determined with advance Monte Carlo dosimetry methods to suggest the optimum procedure to acquire images in terms of the resulting image quality and radiation dose to eye lenses. The efficiency of eye-bismuth shielding to suppress eye-lens dose from DECT imaging was also assessed.

What is the most important finding of your study?

DECT imaging of orbits after Ru-106 plaque positioning was found to provide images with considerably suppressed plaque-related metal streaking/shaping artifacts. The radiation dose to lenses of the eyes from the recommended DECT imaging protocol was found to be similar to corresponding conventional single-energy CT imaging protocols. This dose may be considerably reduced with the use of bismuth shielding without induction of shielding-related artifacts that could obscure the delineation of plaque

borders. The optimum DECT image acquisition procedure in terms of image quality and radiation dose to eye lenses was identified.

What are the implications of this research?

DECT imaging may enable reliable post-surgery verification of plaque position in patients with intraocular tumours who are treated with silver-coated Ru-106 plaques.

Kostas Perisinakis
Associate Professor of Medical Physics
University of Crete Medical School
Department of Medical Physics
Heraklion, Crete, Greece
perisynk@uoc.gr