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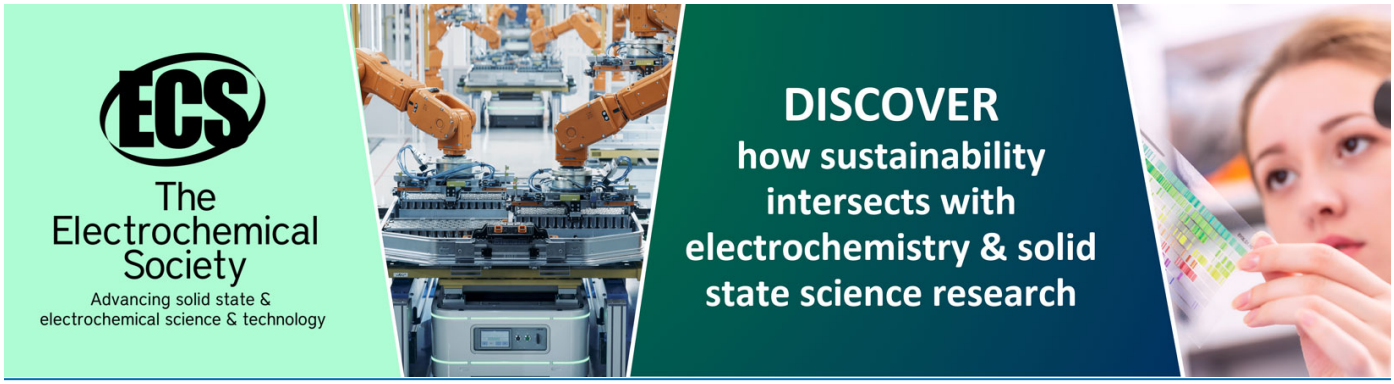

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Computer tomography dose index measurements on a multislice CT scanner using polymer gels

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1. Introduction

A previous study investigated the use of polymer gel dosimetry on a helical X-ray CT for the purposes of acceptance testing and quality assurance measurements [1]. This demonstrated the potential for polymer gel dosimeters in diagnostic dose measurements, where previously polymer gel dosimetry was primarily used in radiotherapy dose investigations [2,3]. The clear benefit of using polymer gel dosimeters over conventional ionization chambers, film or thermoluminescent dosimeters (TLD) is the increase in available data with a single measurement of a 3D dosimeter.

Currently, it is particularly important to understand the various parameters that can be selected on a clinical multislice diagnostic CT scanner and it is the role of the medical physicist to optimise these parameters for various clinical protocols [4]. In this study the PAGAT polymer gel dosimeter [5] was used for measurement and image analysis with MRI to investigate slice width dose profiles (SWDP), Computer Tomography Dose Index ($CTDI_{100}$) and z-efficiency on multislice x-ray CT scanners. The measurements obtained using the polymer gel dosimeters were compared to conventional integrating dosimeters; a dedicated CT ionisation chamber and TLD for phantoms of various diameters.

2. Materials and Method

A Toshiba multislice CT scanner (Toshiba Medical, Japan) was used for all CT measurements. Three phantoms were used of 6, 9 and 16 cm diameter. The CT dose was measured with a 100 mm ion chamber in each of these phantoms. This was used to indirectly calibrate dose response of the polymer gel dosimeter measured under the same conditions and the CT dose index (CTDI) was calculated for both.

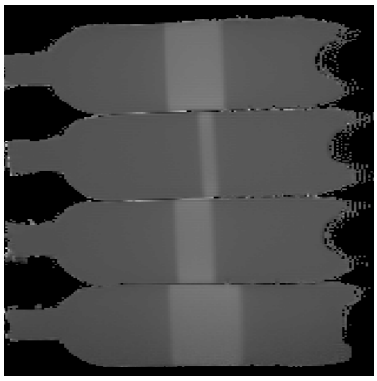

Figure 1. MRI of various slice widths.

The PAGAT polymer gel dosimeter was manufactured following a previously described method [5]. The phantoms were positioned centrally in the CT scanner. One slice of 16 mm slice thickness, 135 kV, 400 mAs were delivered to an axial plane on the central part of the first 6 cm diameter phantom ensuring it remained in the same position throughout. This was repeated for 2, 5, 10, 20, 40, 50 and 80 slices for individual 6 cm diameter phantoms. This was related to measurement following the same conditions with an ionisation chamber placed centrally into the phantom. An indirect calibration of the polymer gel could therefore be achieved in this manner.

SWDP was measured for all phantom diameters for 2, 4, 8, 12, 16, 24 and 32 mm nominal slice widths. Image slice width was determined using a Catphan 500© to determine z-efficiency of the multislice CT scanner.

All phantoms containing polymer gels were scanned in a Siemens Vision or Avanto 1.5T whole body scanner using a head coil. T_2 weighted base images were acquired using a 32 or 64 multiple slice multiple spin-echo pulse sequence (Figure 1) [6].

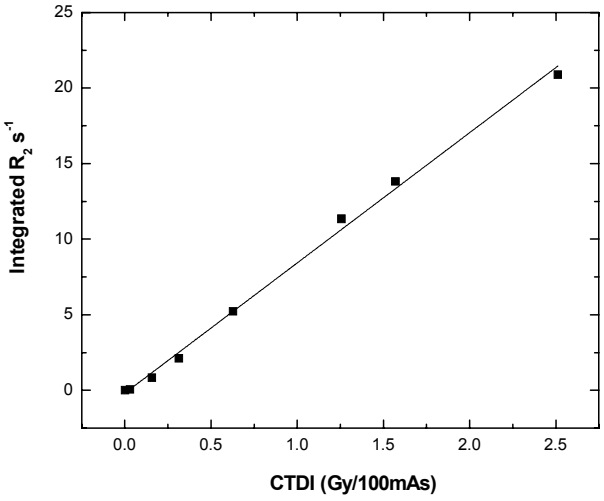

Figure 2. R_2 – CTDI response of PAGAT.

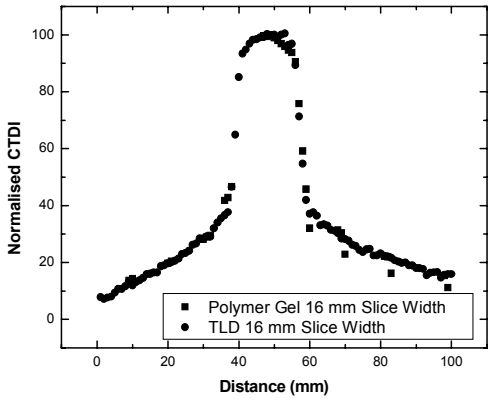

Figure 3. Slice width dose profiles.

3. Results

Figure 2 shows the R_2-CTDI response of PAGAT polymer gel dosimeter as a function of CTDI. Figure 3 shows the normalised CTDI response of PAGAT polymer gel dosimeter coronal profile as a function of distance compared to the TLD normalised CTDI response. This plot may be considered a SWDP for a 16 mm nominal slice width. Figure 4 shows the corresponding CTDI response of PAGAT polymer gel dosimeter, ionisation chamber and TLD for the 16 cm diameter phantom as a function of nominal slice width.

4. Discussion and Conclusions

Measurements were performed with the PAGAT polymer gel dosimeter to compare SWDP, CTDI and determine the z-efficiency of a multislice CT scanner. Figure 2 demonstrates that the dose response from CT on an un-irradiated gel can be significant when more than one slice is used to evaluate the polymer gel dosimeter. Furthermore, when the PAGAT polymer gel dose is related to an ionisation chamber dose response an indirect calibration of the polymer gel can be determined due to the linearity of dose response of both.

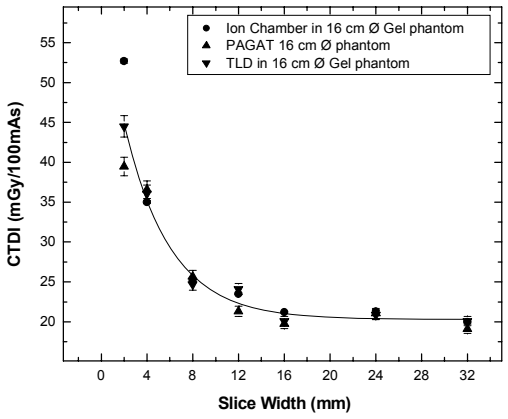

Figure 4. CTDI for various slice widths.

Figure 3 shows that the role of polymer gel dosimeters in the measurement of diagnostic CT dose was determined to be complimentary to conventional methods. It is important to understand and optimize dose parameters for multislice CT scanners. TLD measurements can achieve the same information, however require the use of many single point dosimeters requiring interpolation between each point. Polymer gel dosimeters offer an alternative to TLD in any size soft tissue equivalent phantom. In Figure 4 the polymer gel dosimeter compares well for CTDI for various slice widths. The 2 mm slice width variation from ionisation chamber measurement indicates the limit of resolution of both the polymer gel and the TLD for this region. The ability to use several phantoms of varying diameter show the potential of polymer gel to be manufactured and used in any combination of cylindrical phantom size or more importantly in an anthropomorphic phantom.

Generally polymer gel dosimeters can be used in acceptance testing of multislice diagnostic x-ray CT scanners to compliment existing methods. A further application is as a specialised tool for comparative dose investigations of several types of protocol.

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