An Efficient Automatic Dose-space Registration Technique for Clinical IMRT/VMAT QA with Radiochromic Film Dosimetry

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Introduction

Radiochromic film is one of the common tools to perform routine clinical IMRT/VMAT quality assurance. To develop a contrast based, marker-free, automatic dose-space registration technique for patient specific IMRT QA verification using radiochromic film. Dose-space registrations of the reference and evaluation dose distributions of clinical IMRT QA plans are typically done either through the recognition of made-ahead marks on films, CT fiducial marks or through the subjective method involving the tedious process of manual rotation. Made-ahead fiducial marks can be used to facilitate registration but requires extra work and the error is typically over millimeter

Methods

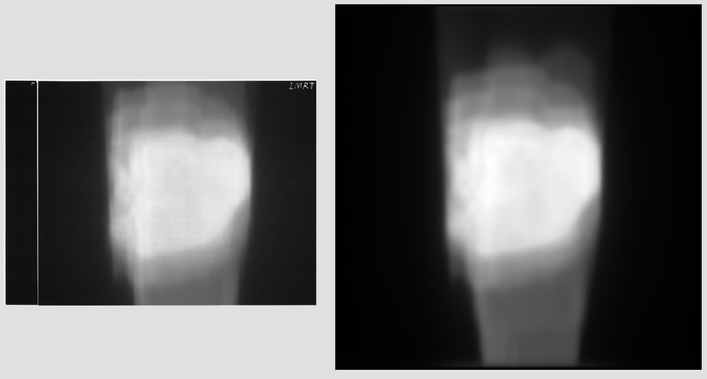

Fig 1. Dose map generated by the triple-channel dosimetry from the film measurement. (b) Dose plane where film sit was calculated by RayStation 6 treatment planning system. .

$$\Omega(D_F, D_{TPS}; \mathbf{r}) = \frac{1}{N} \sum_{(x,y)\in Z} (D_F(\mathbf{r}(x,y)) - D_{TPS}(x,y))^2$$

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Results

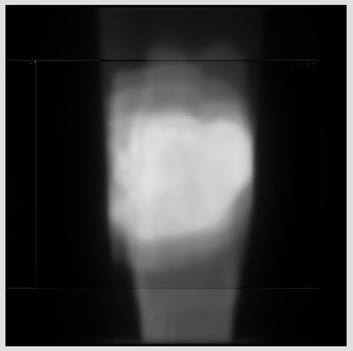

Fig 2. Registered dose map of film and TPS.

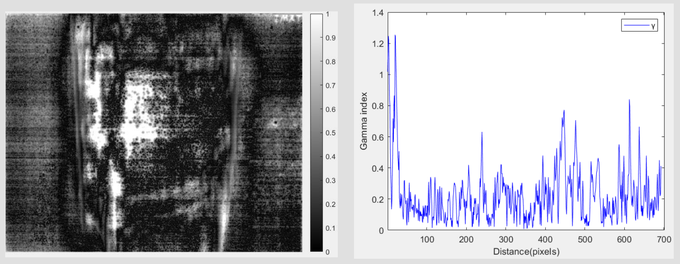

Fig 3.Left: global gamma index with the tolernece 2%2mm map for the registered IMRT plan. Right: a 1-D profile plot of the gamma map.

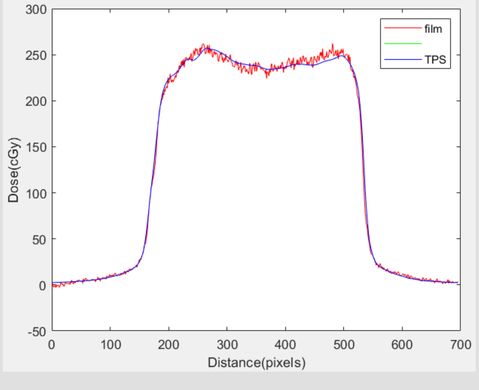

Fig 4. The 1-D dose profile plot of the IMRT plan against the film measurement.

Table I. Passing rates of gamma index analysis and mean gamma value for 3% 3 mm， 1% 1mm and 2% 2mm tolerance with the threshold (TH) 10% of the evaluation IMRT plan

Tolerence	1%/1 mm	2%/2mm	3%/3mm
γ<1	85%	96%	100%
Mean γ	0.53	0.32	0.20

Conclusions

The evaluation dose pixels were resampled to match the pixel spacing of film measurement through bicubic interpolation by automatically detecting the pixel spacing information from both the reference film measurement and the treatment planning calculation. The algorithm employs the dose pixels above 20% of the maximum dose from the evaluation dose map to perform the registration by minimizing the normalized dose value-based metric residuals. The algorithm was programmed in MATLAB code. As a test case, a clinical lung IMRT plan was measured by GafChromic™ EBT 3 film inside a solid-water phantom on an Elekta VersaHD™ linear accelerator. The triple-channel dosimetry method was deployed to generate generate the reference dose plane from film. An unexposed film piece was used to correct the scan-to-scan artifact of an Epson 10000XL photo scanner. The evaluation dose plane was generated by the RayStation 6 treatment planning system. Gamma index analysis was used for the 2-D spatial dose comparison after the automatic registration.

An efficient, automatic dose comparison registration technique for radiochromic film dosimetry has been developed and evaluated, showing robust performance. The method requires no made-ahead marks or other fiducial markers for either film or phantom use during the routine clinical IMRT/VMAT QA.