Magic Gel for Head and Neck IMRT

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Introduction

A redesigned version of the RPC's IMRT head and neck phantom was developed to incorporate a polymer gel dosimeter. The phantom design revision included converting the currently used imaging/dosimetry insert from a block-style design to a cylindrical design (Figure 1). This insert contains embedded structures that simulate a primary and secondary target volume as well as an organ at risk (OAR). An additional insert was then constructed to house the polymer gel dosimeter. This insert was specially designed using Barex® plastic. Both the imaging insert and the gel insert had an image registration system incorporated into their construction (figure 2).

Fig. 1 Images of the currently used IMRT head and neck phantom (above) and the redesigned version that facilitates polymer gel dosimetry (below).

Methods and Materials

A commercially available optical computed tomography (OCT) scanner (Figure 3) was commissioned for this project and future RPC work with polymer gel dosimetry. The OCT scanner was used to image polymer gels before and after being irradiated. The pre-irradiation images were subtracted from the post-irradiation images using a pixel by pixel subtraction method. The resultant images had "difference in pixel values" that were directly proportional to the dose received by each given pixel.

Fig. 2 Polymer gel insert (center) with the disassembled planning insert. The primary and secondary target volumes are the brown structures. The OAR is the small Lucite cylinder partially encompassed by the primary target volume. Note the acrylic external registration key on both the gel and planning inserts.

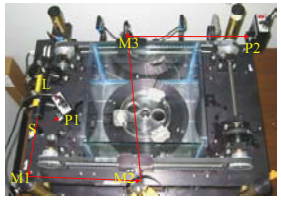

Fig. 3 OCT scanner with laser path diagramed. Note: Laser (L), laser splitter (S) mirrors (M1, M2 and M3), and photodetectors (P1 and P2).

Fig. 4 The RPC investigated and learned how to manufacture the MAGIC polymer gel used for this project (Fong *et al* 2001).

IMRT Evaluation

- Phantom imaged with planning insert installed
- PTV1, PTV2, OAR and TLD volumes contoured
- CORVUS treatment planning used
- 9-field IMRT treatment
- 6 MV energy
- TLD used to verify treatment plan
- 3 Gel inserts treated for reproducibility evaluation
- 4th gel used for dose calibration
- Subtracted 'raw data' images converted to dose images
- Measured dose images compared to TPS dose image using DoseLab (Childress et al)
- Profile comparisons and planar comparisons performed using two methods
  - Absolute comparison with 10% dose / 5 mm Distance to Agreement (DTA) criteria
  - Relative comparison with 5% dose / 3 mm DTA criteria

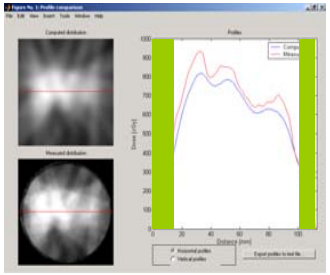

Fig. 5. Typical lateral profiles from an absolute comparison between gel measurements and the computed dose distribution. The 2-D dose distribution images are shown on the left. The red line on these images indicates where the profile was acquired. Note only the central 80mm diameter was evaluated (ie grayed out region excluded). This was considered the "effective measurement" constraint for the OCT scanner.

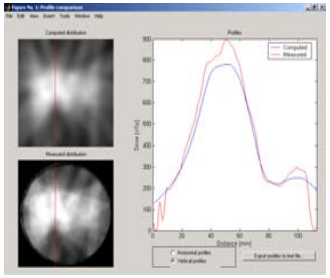

Fig. 6. Typical AP profiles from an absolute comparison between gel measurements and the computed dose distribution. Note the agreement in the high gradient regions.

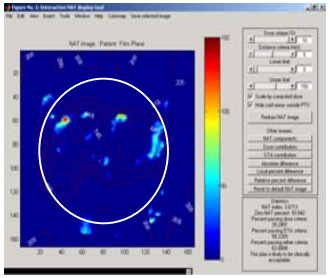

Fig 7 A typical DoseLab image for an absolute comparison between gel measurements and computed dose distributions. The dark blue region indicates pixels that pass the 10% dose/5 mm DTA criteria. Note that only localized regions and the canister wall artifact fail the criteria. The computed isodose contours appear in red. The white circle indicates the "effective measured" region evaluated.

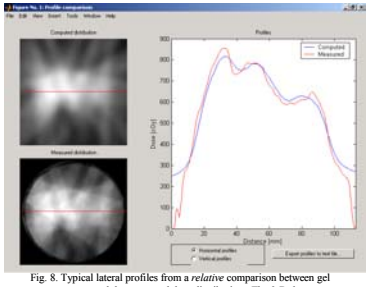

Fig. 8. Typical lateral profiles from a *relative* comparison between gel measurements and the computed dose distribution. The 2-D dose distribution images are shown on the left. The red line on these images indicates where the profile was acquired.

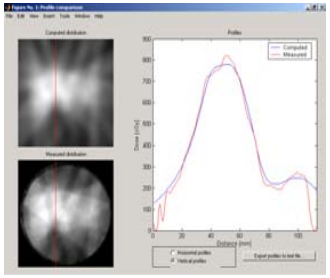

Fig. 9. Typical lateral profiles from a *relative* comparison between gel measurements and the computed dose distribution. Note the excellent agreement in the high gradient regions.

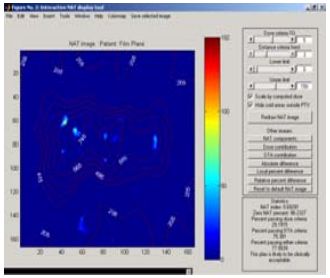

Fig. 10. A typical DoseLab image for the *relative* comparison between a gel measured dose distribution image and the calculated dose distribution image. The dark blue region indicates pixels that passed the 5% dose/3 mm DTA criteria.

Summary

- TLD verified calculated dose distribution
- Measured dose distributions agree with calculated dose distributions
  - Absolute w/in 10% / 5 mm DTA (over 88% of region)
  - Relative w/in 5% / 3 mm DTA (over 97% of region)
- Reproducibility between the 3 different gels ± 1.9%.
- Reproducibility between OCT scans ± 0.8%

Conclusions

- Infrastructure for "in house" polymer gel dosimetry has been established at the RPC
  - OCT scanner commissioning
  - IMRT head and neck phantom w/gel dosimetry
- MAGIC gel inserts are reproducible within 2%
- OCT scanned images are reproducible within 1%
- Absolute gel dosimetry?
  - 10% / 5 mm DTA - not optimal
  - Supports hypothesis? Further work necessary
- Relative gel dosimetry?
  - 5% / 3mm DTA
  - Supports hypothesis? Yes

References

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