Reproducibility of 3DCRT Isodose Curves Evaluation Obtained Using Spherical Fricke Xylenol Gel Phantom

Christianne C. Cavinato[1*], Benedito H. Souza[2], Henrique Carrete Jr.[2], Kellen A. C. Daros[2], Regina B. Medeiros[2], Adelmo J. Giordani[3], Orlando Rodrigues Jr.[1] and Letícia L. Campos[1]

[1]Instituto de Pesquisas Energéticas e Nucleares, Gerência de Metrologia das Radiações, Av. Prof. Lineu Prestes, 2242, 05508-000, São Paulo, Brazil
[2]Universidade Federal de São Paulo, Departamento de Diagnóstico por Imagens, Rua Napoleão de Barros, 800, 04024-002, São Paulo, Brazil
[3]Universidade Federal de São Paulo, Unidade de Radioterapia, Rua Napoleão de Barros, 715, 04024-002, São Paulo, Brazil
*E-mail: ccavinato@ipen.br

1. OBJECTIVE

In this study, in order to evaluate the reproducibility of 3DCRT photon beam isodose curves determination using Fricke xylenol gel (FXG) dosimetry, the isodose curves were obtained from images slices obtained employing magnetic resonance imaging (MRI) evaluation technique of different spherical FXG phantoms, prepared using 270 Bloom gelatine from porcine skin (made in Brazil).

2. Materials and Methods

❑ FRICKE GEL SOLUTION (FXG)

- 5% by weight 270 Bloom gelatine from porcine skin;
- Ultra-pure water;
- 50 mM H_2SO_4;
- 1 mM NaCl;
- 1 mM Morh's salt [$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$];
- 0.1 mM xylenol orange ($C_{31}H_{28}N_2Na_4O_{13}S$);
- Conditioning:
  * Polymethyl methacrylate (PMMA) cuvettes;
  * Spherical glass balloons (2000 mL).

❑ PMMA CUVETTES IRRADIATION

- ^{60}Co gamma source: GENERAL ELECTRIC COMPANY® Alcyon II (UNIFESP);
- Absorbed dose range: 2 – 30 Gy;
- Dose rate: 74.98 cGy.min^{-1};
- Field size: 40 x 40 cm²;
- Source-surface distance (SSD): 80 cm;
- PMMA phantom (30 x 30 cm² plates 1.5 cm thick).

❑ FXG PHANTOMS IRRADIATION

- Linear accelerator: VARIAN® Clinac 600C (UNIFESP);
- Photon energy: 6 MV;
- Absorbed dose: 20 Gy;
- Dose rate range: 300 cGy.min^{-1};
- Multiple static radiation fields;
- SSD: 91.9 cm.

❑ EVALUATION

- Magnetic resonance imaging (MRI) technique:
  * SIEMENS® MAGNETOM® Sonata Maestro Class 1.5 T MRI scanner (UNIFESP);
  * Image orientation/acquisition/processing: Coronal, sagittal, axial/ cranium protocol-T1/ softwares syngo fastView® version VX57F24, ImageJ® version 1.42q and MATLAB;
- Optical absorption (AO) spectrophotometry technique:
  * SHIMADZU® UV2101-PC spectrophotometer (IPEN);
  * Wavelength range: 190 – 900 nm.

3. Results

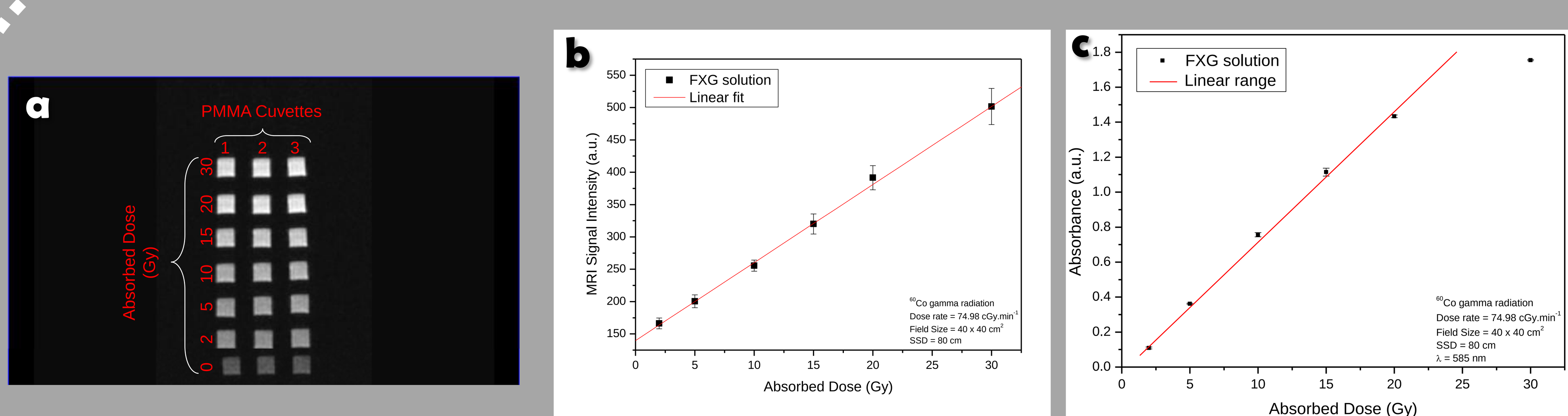

Fig. 1. Coronal MRI images of the FXG solution conditioned in PMMA cuvettes non-irradiated and irradiated with ^{60}Co gamma radiation (a). MRI signal intensity curve in function of absorbed dose (b) and optical dose-response curve (c) of the FXG solution irradiated with ^{60}Co gamma radiation.

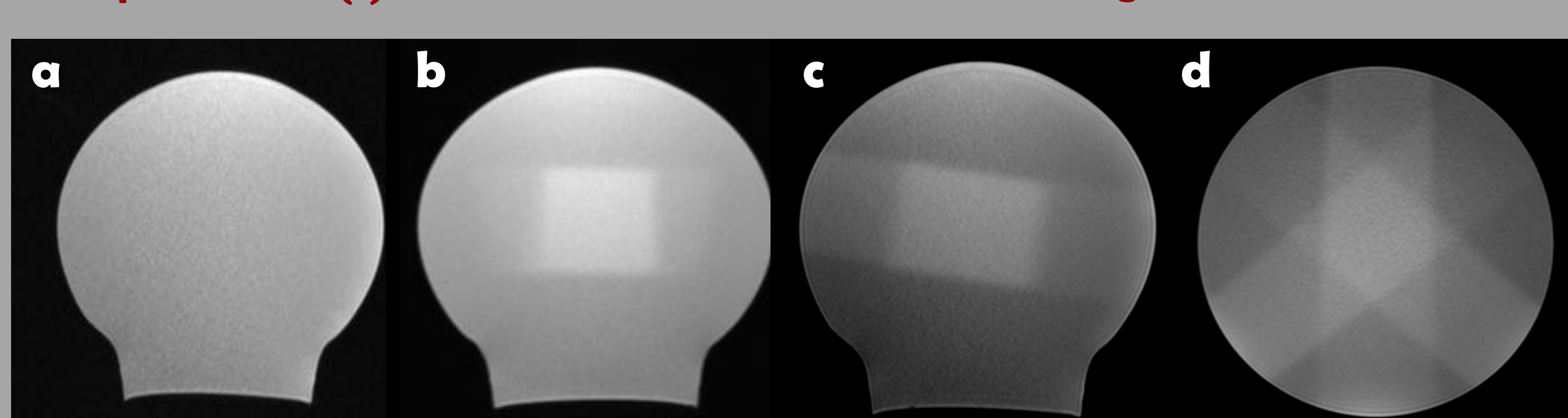

Fig. 2. Sagittal MRI image slice of non-irradiated spherical FXG phantom (a). Coronal (b), sagittal (c) and axial (d) MRI images slices of the FXG phantom irradiated with 6 MV photons.

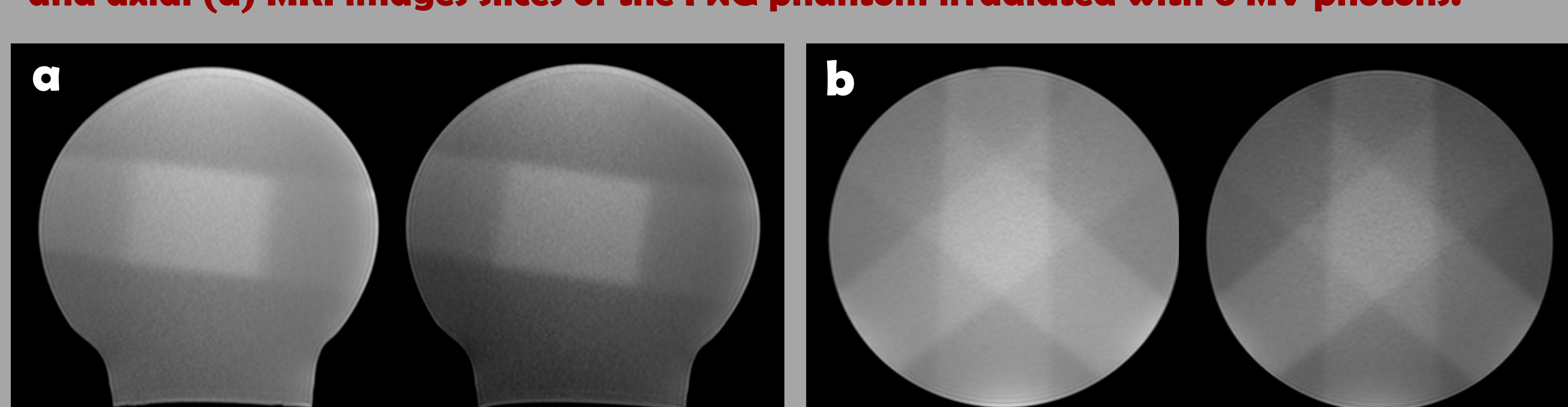

Fig. 3. Sagittal (a) and axial (b) MRI images slices of different spherical FXG phantoms irradiated with 6 MV photons.

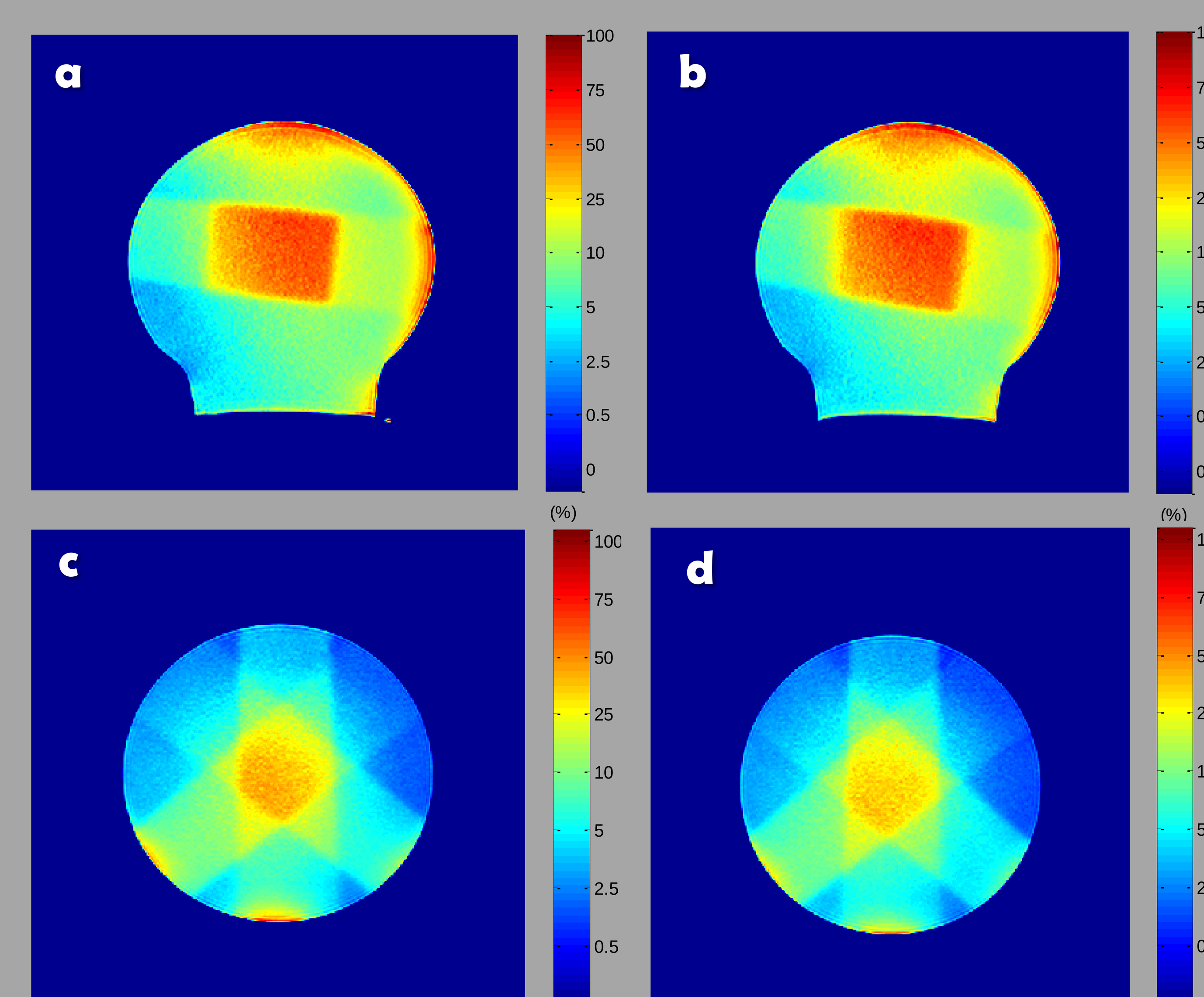

Fig. 4. Dose distribution evaluated for sagittal (a, b) and axial (c, d) MRI slices of two FXG phantoms irradiated with 6 MV photons.

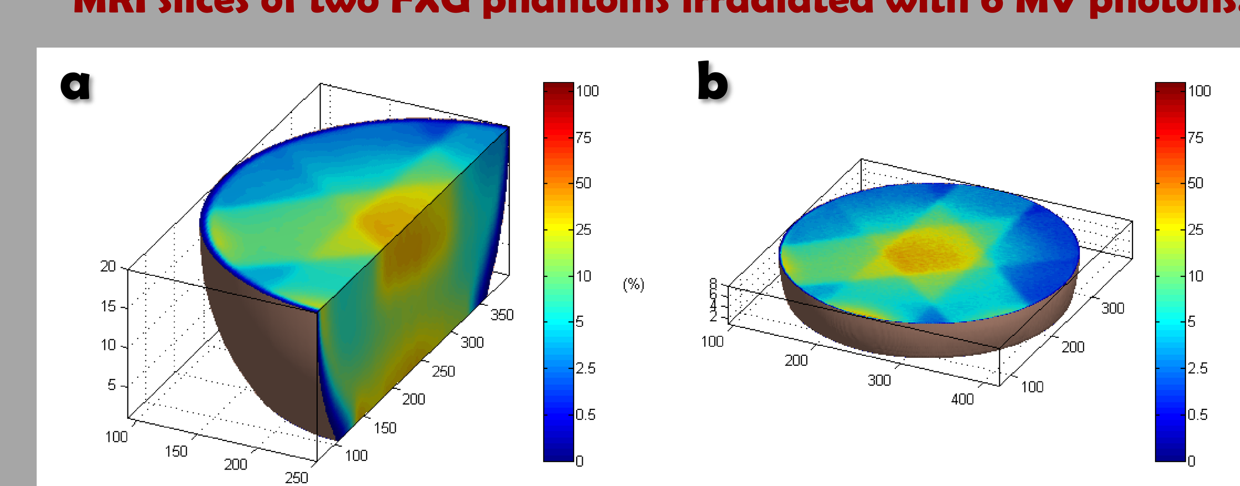

Fig. 5. Three-dimensional axial MRI slice reconstruction: 40 slices (cuts in xSlice = 250/ zSlice = 20) (a); 1 slice (cut in zSlice = 8) (b).

4. Discussion

❑ FIGURE 1: Linear behavior in the clinical interest dose range (2 to 20 Gy) for both evaluation techniques, tending to saturation to doses ≥ 20 Gy (AO technique). The optical dose-response curve was obtained only as reference system;

❑ FIGURE 2: It is clearly possible to observe the target volume irradiated in the MRI images slices in different orientations (coronal, sagittal and axial) and in the axial image slice, can also be seen the imput and the overlap of multiple radiation fields;

❑ FIGURE 3: Good qualitative reproducibility of the MRI images slices of two FXG phantoms in different orientations was obtained;

❑ FIGURES 4 and 5: The highest percentage of the dose in the target volume and the overlap of multiple static radiation fields and their projections can be seen.

5. CONCLUSIONS

Good qualitative reproducibility in obtaining MRI images of spherical FXG phantoms (prepared with 270 Bloom gelatine, made in Brazil) can be obtained aiming use these results to calculate the isodose curves and the percentage of the dose, to confirm the treatment planning.

Acknowledgements: