Comparative dosimetry of an extensive scalp lesion: HDR brachytherapy, electronic brachytherapy, VMAT, and Tomotherapy

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Purpose and Objectives

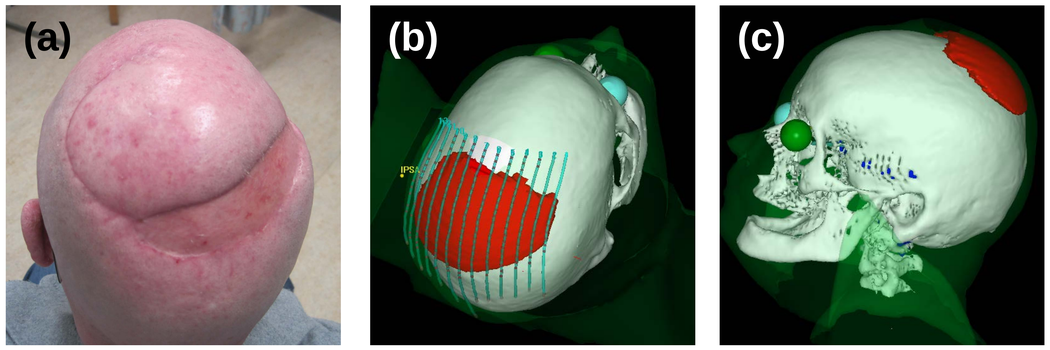


Fig. 1. Clinical picture (a) and 3D reconstruction (b, c) of extensive scalp lesion.

It is difficult to deliver conformal homogeneous radiation doses to superficial targets with complex geometry (see Fig. 1) [1-4]. We studied a patient with an extensive scalp lesion to compare the target and normal tissue dosimetry of high-dose-rate brachytherapy (HDR), electronic brachytherapy (eBx), volumetric modulated arc therapy (VMAT), and TomoTherapy (TOMO).

Materials and Methods

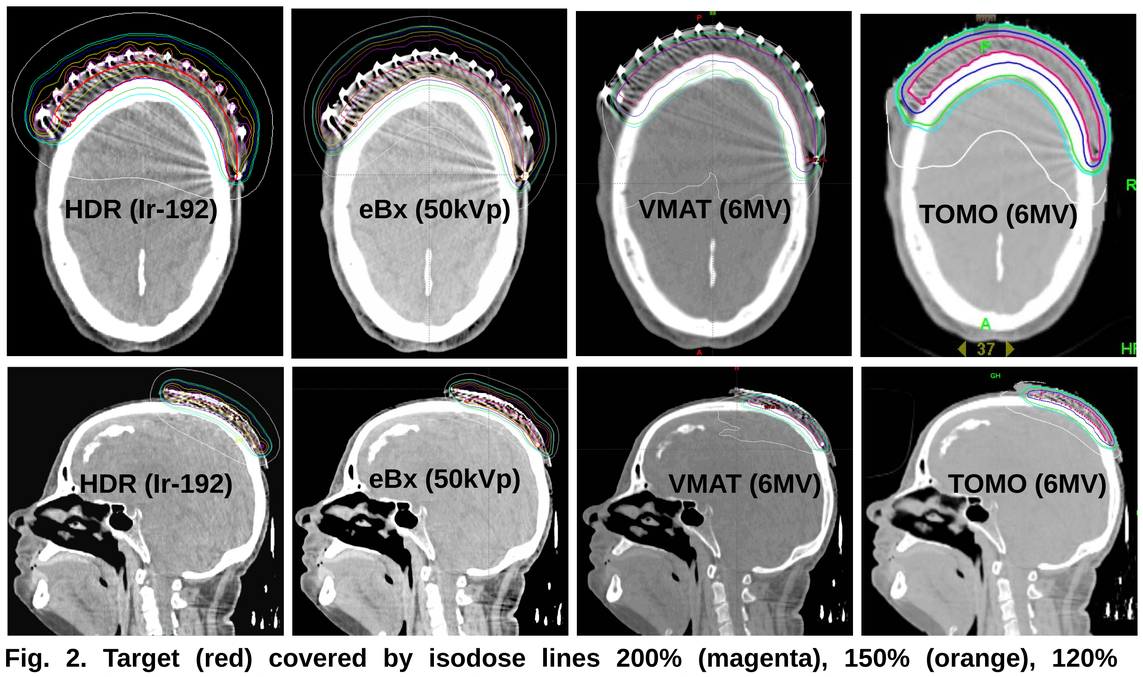
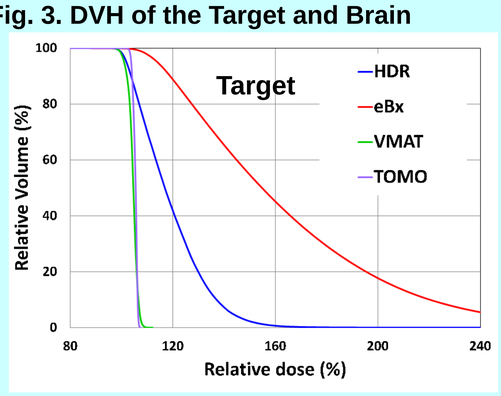


Fig. 2. Target (red) covered by isodose lines 200% (magenta), 150% (orange), 120% (yellow), 100% (blue), 90% (green), 85% (cyan) and 50% (white) from HDR, eBx, VMAT, and TOMO.

- The patient had a large atypical fibroxanthoma resected from the skin overlying the calvarium. A customized HDR skin applicator was constructed by attaching brachytherapy catheters at 1 cm intervals to a 5 mm thick bolus.
- Two treatment plans were generated for brachytherapy: one for Iridium-192 HDR and the other which assumed treatment with 50 kVp eBx using the same applicator.
- Two treatment plans were created for external beam therapy: one for a 2 full arc 6 MV photon VMAT (also with a 5 mm thick bolus) and the other for a 6 MV photon TomoHelical mode.
- The target and organs at risk (OAR) were contoured on a simulation CT scan. The prescription was 36 Gy in 8 fractions for a 9 cm × 12 cm × 1 cm target.
- The plans were optimized to a standard target coverage (V100% > 98%) and to minimize dose to the OAR using Oncentra MasterPlan for HDR (Nucletron), BrachyVision for eBx (Varian), Eclipse for VMAT (Varian), and TomoTherapy planning system for TOMO (Accuray).
- We compared target dose, dose heterogeneity, and doses to the OAR.

Results

Fig. 3. DVH of the Target and Brain



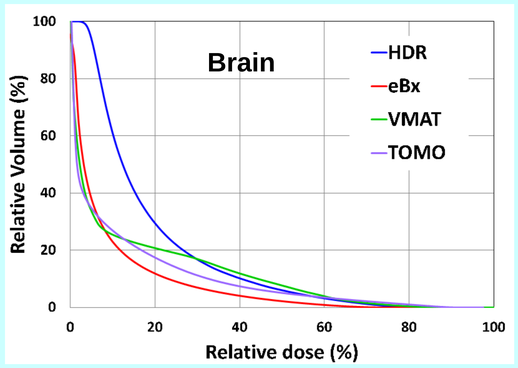


Table 1. Dosimetry to Treatment Target

Target	Dose to the target as % of prescription and V100%			
	Ir-192 HDR	50 kVp eBx	6MV VMAT	6MV TOMO
D_{mean} (D_{min}–D_{1cc})	119 (86–151)	164 (86–271)	104 (96–108)	105 (101–107)
D90%	104	119	102	104
V100%	98	100	98	100

Table 2. Dosimetry to Organs at Risk

OAR	Mean (min-max) dose to OAR as % of prescription			
	Ir-192 HDR	50 kVp eBx	6MV VMAT	6MV TOMO
Brain	18.3 (2.9–87.9)	8.6 (0.5–84.1)	11.7 (0.2–98.4)	10.1 (0.3–97.5)
Brainstem	7.4 (3.6–12.1)	1.4 (0.6–2.8)	0.6 (0.2–1.3)	0.6 (0.3–0.9)
RT Lens	2.7 (2.5–2.8)	0.4 (0.4–0.5)	0.5 (0.4–0.6)	0.7 (0.6–0.7)
LT Lens	2.5 (2.4–2.7)	0.4 (0.4–0.5)	0.5 (0.4–0.7)	0.7 (0.6–0.7)
RT Eye	2.9 (2.1–3.8)	0.4 (0.3–0.6)	0.5 (0.2–1.1)	0.7 (0.5–0.9)
LT Eye	2.7 (2.0–3.5)	0.4 (0.3–0.5)	0.5 (0.2–1.5)	0.7 (0.5–0.9)
RT Optic nerve	4.6 (3.5–5.7)	0.7 (0.5–1.0)	0.6 (0.5–0.8)	0.7 (0.7–0.8)
LT Optic nerve	4.3 (3.3–5.6)	0.7 (0.4–0.9)	0.6 (0.4–0.9)	0.8 (0.6–0.8)

Conclusions and Future Work

- eBx provided the least dose to closest OAR (brain) due to rapid dose fall-off of low-energy X-rays, but it resulted in higher mean target doses and more heterogeneity than HDR, VMAT, and TOMO.
- HDR, VMAT, and TOMO provided similar V100% and D90% target doses. As expected, TOMO provided most dose uniformity.
- All methods resulted in acceptable normal tissue doses, but they were lower for eBx, VMAT, and TOMO than HDR specifically for this lesion located on the top of the skull.
- Comparative dosimetry facilitates treatment modality selection for extensive superficial lesions with complex surfaces, irregular contours, and close proximity to OAR.

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