

Testing the limits of stereotactic radiosurgery for multiple brain metastases

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The Study

- Increasing trend to employ stereotactic radiosurgery in treatment of brain metastases
- 50-60% of patients presenting with brain metastases have multiple lesions
- Several guidelines recommend SRS for patients with up to 4 lesions
 - Bhatnagar et al. (2006) reported that number of mets was not a significant factor in survival period for patients with more than 4 mets treated with SRS
- V12 in brain is most significant factor in predicting radionecrosis
 - occurring in 2-14% of patients
 - Risk is high when V12 exceeds 5-10 cc, increasing by 8% for every 1 cc increase in V12
- This study examined the feasibility and deliverability of static conformal arc treatments for patients with up to 12 mets

The Phantom

- 5 multiple brain met presentations were generated on CT of CIRS head phantom
 - 4, 6, 8, 10, 12 mets; 0.5 to 2.0 cm diameter
 - Largest met located on film plane
- EBT3 film was calibrated for doses between 0 and 26 Gy
- Pre- and post- scanned using Epson V800
- netOD polynomial fit
- Maximum uncertainty = 2.6%



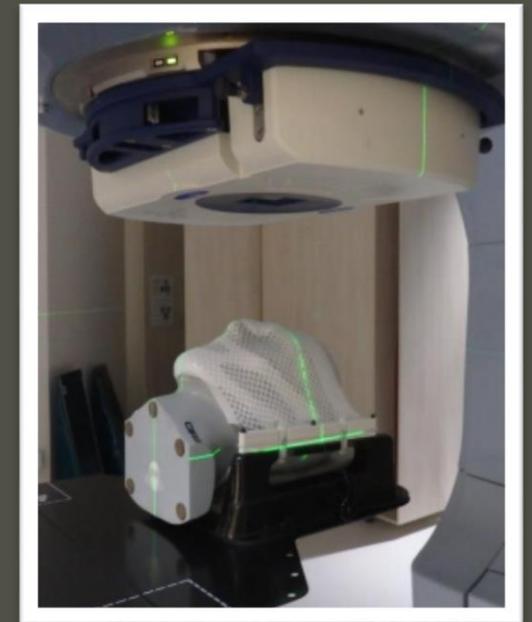
The Planning

- Static conformal arc treatments planned for BrainLab m3 micro-MLC system on a Varian 21iX (6 MV)
- Planned in BrainLab iPlan TPS
- Prescription of 24 Gy to 90% isodose
 - Wanted high dose for better out of field response
 - 24 Gy is value used in RTOG trial for 1-3 mets
- Forward planned by a radiation therapist, with angular separation between non-coplanar arcs maximised, with care taken to prevent mechanical collisions

# Mets	Total Vol. (cc)	# Arcs	Mean dose (Gy)	Total MU per plan
4	4.39	21	26.8	3031
6	4.95	34	26.7	4073
8	5.96	44	26.7	5520
10	6.99	58	26.6	6600
12	8.01	69	26.7	7947

The Delivery

- Phantom immobilised with thermoplastic mask and BrainLab cranial array
- Film from calibration batch cut to fit CIRS phantom
- Treatments delivered over 3 days
 - Each treatment took at least an hour
 - ExacTrac kV x-ray pair used to verify position before deliveries (so much imaging!)



The Evaluation

- Prescription poorly chosen, V12 exceeded 10 cc for all plans
- V12 increased with number of mets, as expected
- Gamma evaluation performed for film plane with 3%/1.5 mm criteria using SNC MapCheck software
 - Local action level is 90%
- Disagreement between film and TPS calculations more pronounced for 10 and 12 met plans
- Aside: film area receiving 12 Gy was not a good predictor for V12 calculated in TPS

# Mets	GAI
4	96.4%
6	96.9%
8	96.8%
10	91.4%
12	92.0%

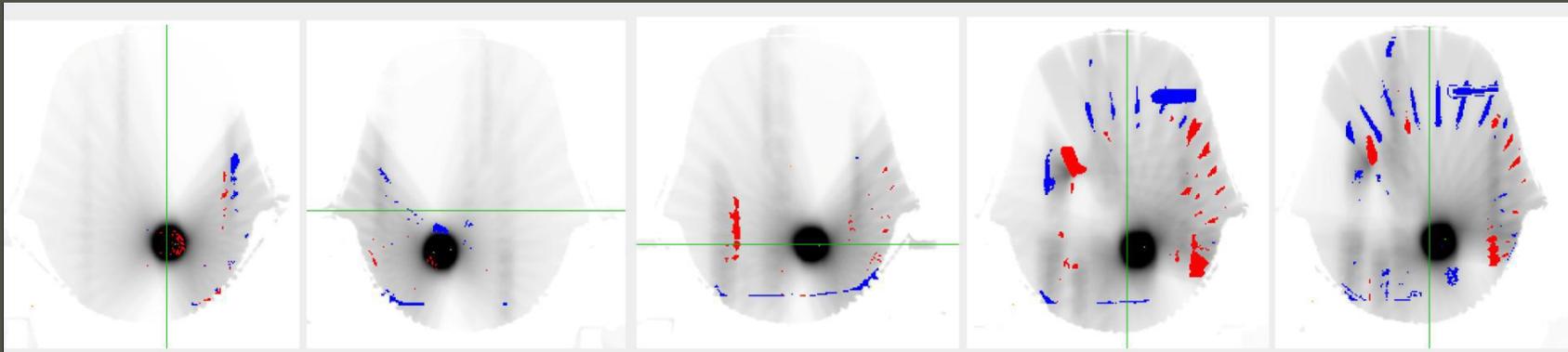
The Evaluation

- What if we used 16 Gy as prescription (reported as median dose for 205 patients with 4 or more mets by Bhatnagar et al.)?
 - Linear relationship between total metastatic volume and V12 in healthy brain ($R^2 = 0.999$)

# Mets	Total met volume (cc)	V12 (cc)
4	4.39	7.98
6	4.95	9.86
8	5.96	12.58
10	6.99	16.18
12	8.01	19.36

The Evaluation

- Film results and TPS calculations agree in high dose and beam penumbrae regions
- Dose differences up to 3% in periphery regions of films were evident.
- Possible causes?
 - Greater probability of treatment delivery error with increasing number of lesions?
 - Increased peripheral dose and inefficiency of TPS to estimate out-of-field accurately?
 - iPlan calculates dose using discrete 5 degree gantry control points – error compounds with more mets
 - In the film plane, these dose differences aren't contributing to V12 differences, even for this high prescription



Conclusion

- Treatment of more than 5 cc of metastatic volume comes with a risk of radionecrosis
- Peripheral dose calculation in iPlan is inaccurate
- Film is a wonderful tool!