



Abstract ID 352

Stereotactic radiosurgery for multiple brain metastases: A dose-volume study

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Aims & objectives

- A substantial number of cancer patients develop brain metastases, which often present as multiple lesions.
- Stereotactic radiosurgery (SRS) can be used to treat brain metastases, with some incidental dose to the healthy brain [1].
- This study evaluated the effect of the number and combined volume of metastatic lesions on the deliverability and dosimetric quality (in particular 12 Gy coverage of healthy brain) of a small sample of SRS test treatments.





Aims & objectives

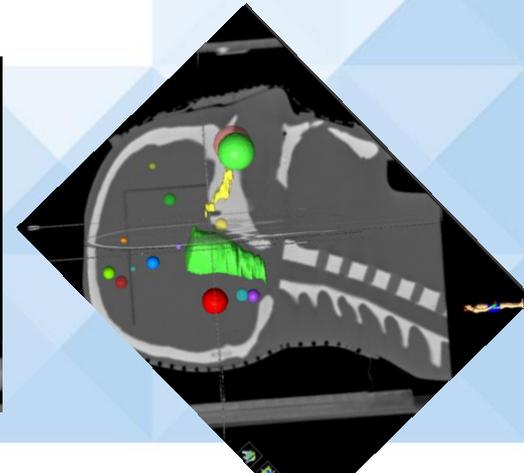
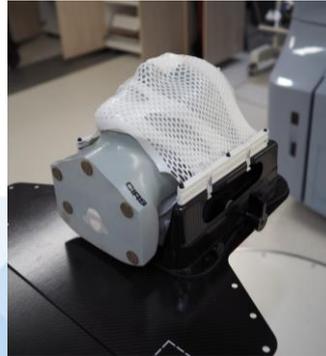
- The more metastases a patient has, the higher the dose delivered to the healthy brain by the radiosurgery treatment.
- The threshold at which linac-based SRS becomes clinically unacceptable remains debatable
 - Many centres limit the number of radiosurgically treated metastases to 3 or 4 [1, 4]
 - Treatments of 10 to 14 metastases within a course of radiosurgery have been reported [2, 3]
- The volume of healthy brain receiving a dose of 12 Gy is widely recognised as a useful predictor of radionecrosis and consequent neurocognitive decline [5, 6]
 - QUANTEC reported a significant risk of radiation injury from radiosurgery when the volume of brain tissue receiving 12 Gy exceeds 5-10 cm³ [7]
 - Blonigen et al recommend a specific limit of 7.9 cm³ [5]



Materials and methods

Five simulated test cases:

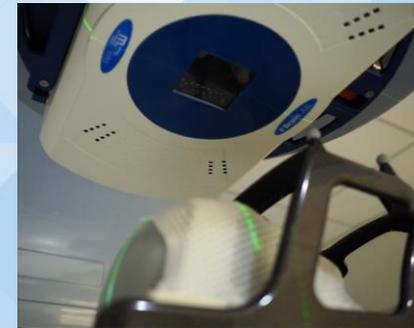
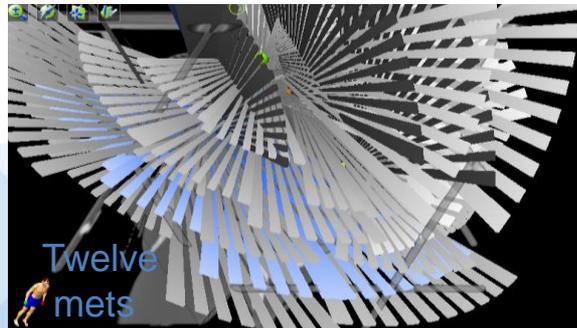
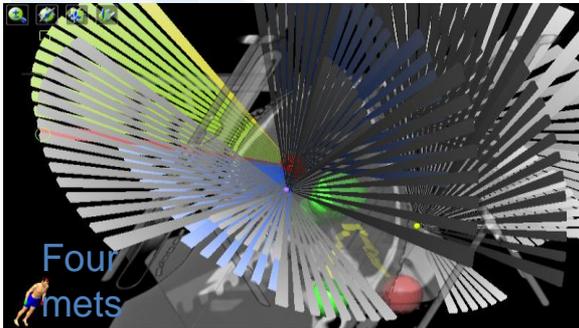
- 4 metastases, 6 metastases, 8 metastases, 10 metastases, 12 metastases
- PTVs contoured on CT scan of a CIRS 605 head phantom
- “Healthy brain” structure created by subtracting all PTVs (plus 1 mm dose fall-off margin) from brain contour





Materials and methods

- Two sets of prescriptions, two sets of plans:
 - PTV doses of 14-80 Gy prescribed to 90% covering isodose, according to local practise
 - PTV dose of 24 Gy prescribed to 90% covering isodose (prescription taken from RTOG 0320 1-3 met trial protocol [4])
- Linac-based, multi-isocentre, static conformal arc treatments, with Brainlab m3 microMLC, planned using Brainlab iPlan TPS, with reference to published small field beam data [8]

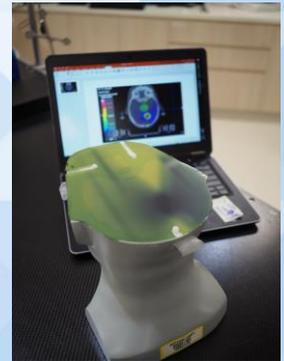
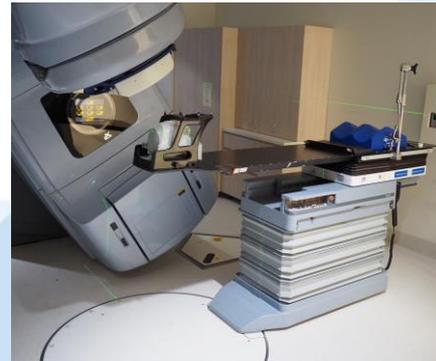
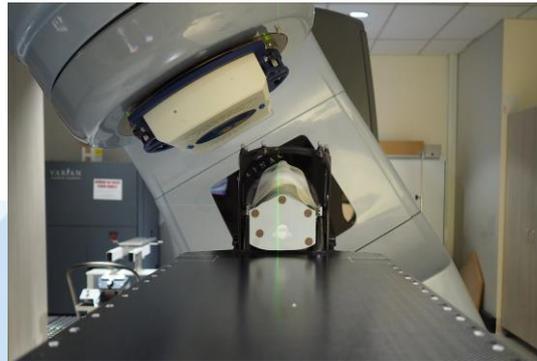




Materials and methods

Film measurements:

- Gafchromic EBT3 radiochromic film placed within head phantom, in the transverse plane
- Phantom immobilised, imaged and treated as though it was a cranial SRS patient
- Film analysis and comparisons with planned dose planes completed using established techniques [9, 10]



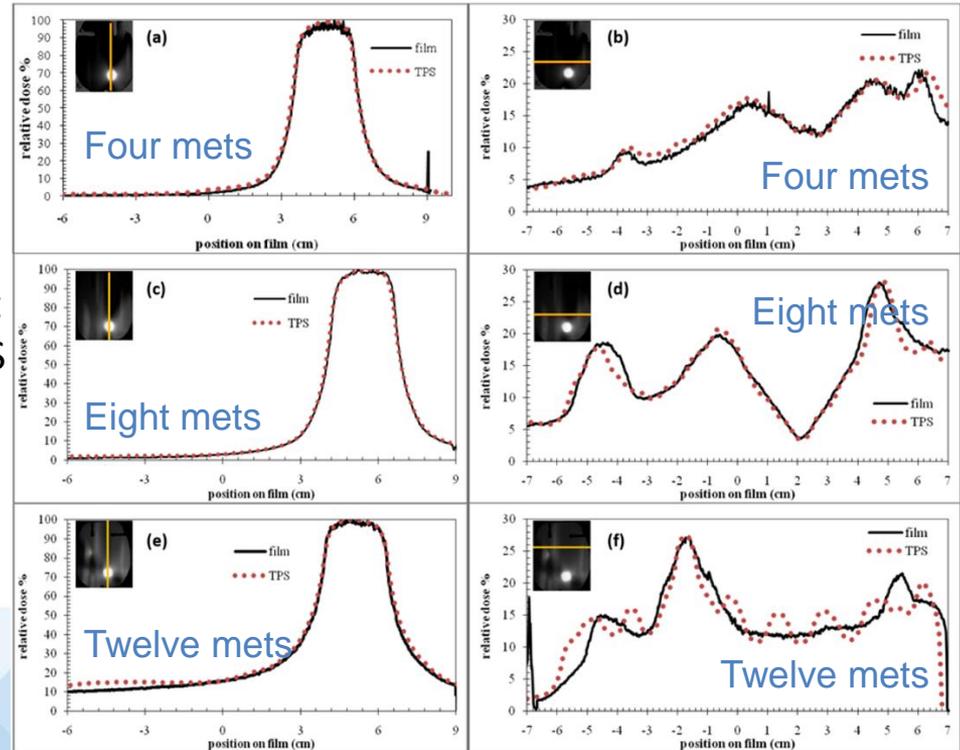


Results & discussion

Dose profile comparisons show:

- For four to eight metastases, the TPS accurately predicted the delivered dose.
- For ten or twelve metastases, disagreement between the film measurement and the TPS dose calculation increased, with the TPS generally over-estimating the out-of-field dose.

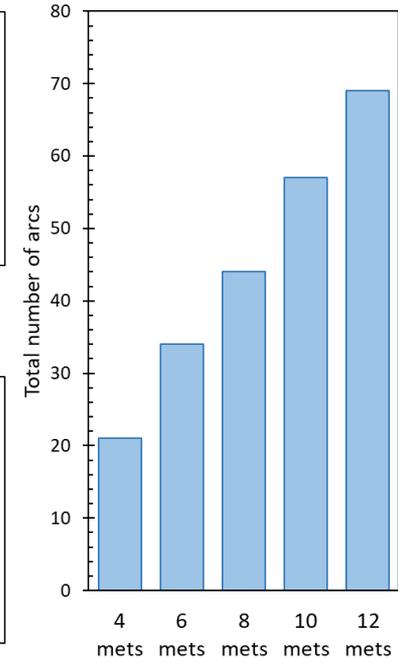
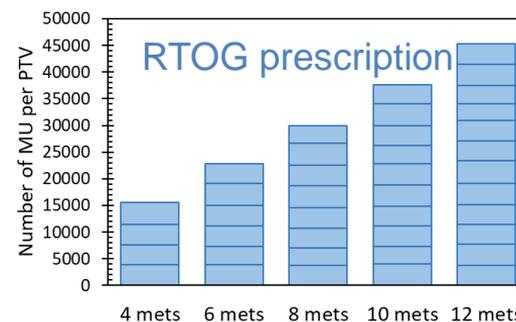
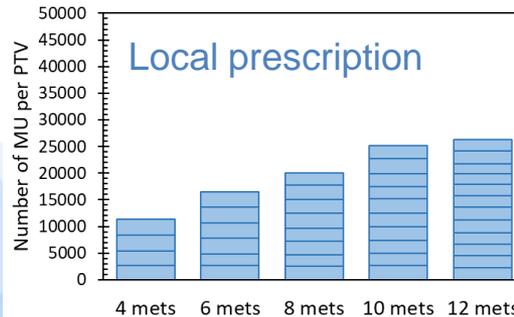
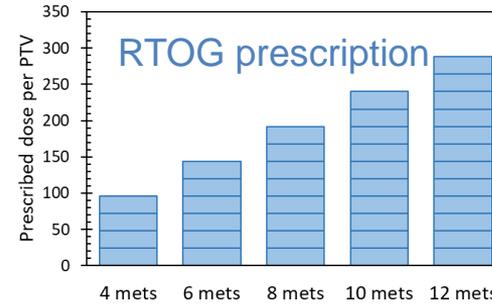
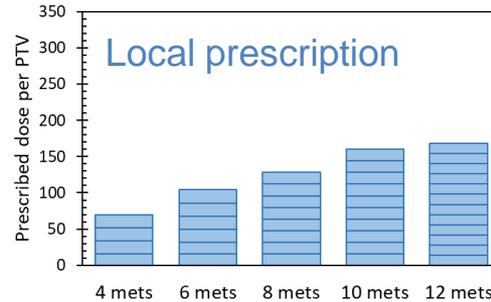
These results suggest that the TPS dose calculation can be used as a worst-case-scenario estimate of the healthy brain dose.





Results & discussion

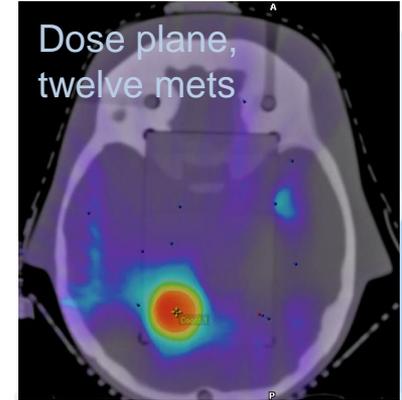
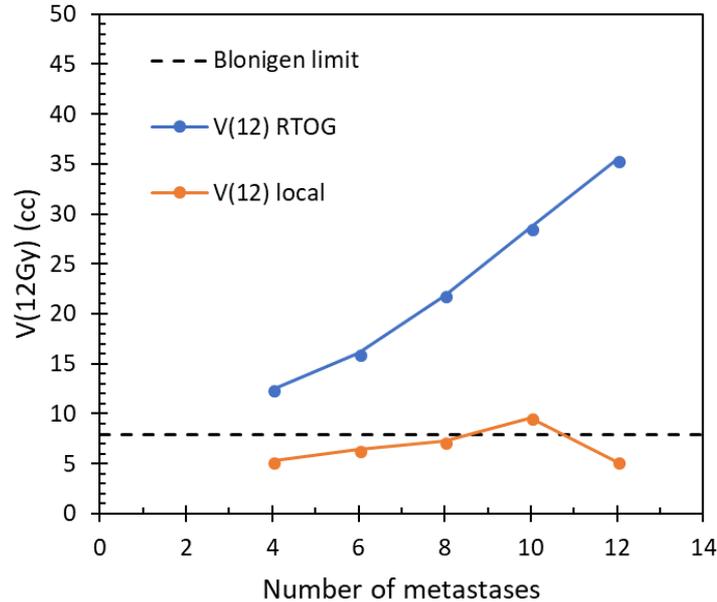
Increasing the number of targets requires increasing the number of beams, the number of MUs and the total radiation dose delivered by the SRS treatment, while also complicating the challenge of arranging the beams to spare the healthy brain.





Results & discussion

Several of the test plans resulted in clinically acceptable 12 Gy coverage of the healthy brain (less than 7.9 cm³ [5]), when local dose prescriptions (14 to 18 Gy) were used, but when the prescription dose to all metastases was increased 24 Gy (a prescription designed for treating no more than three metastases [4]), no plans resulted in a V12 less than 10 cm³.





Conclusion

Using a multi-isocentre static conformal arc method, it is possible to deliver treatments to relatively large numbers and total volumes of brain metastases without excessive radiation doses being delivered to the healthy brain, provided it is acceptable to compromise the prescription dose. If prescription doses above 18 Gy are required for such cases, the decision to use SRS and the particular SRS method selected for use may both need to be reconsidered.





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World Congress on Medical Physics & Biomedical Engineering

June 3–8, 2018, Prague, Czech Republic, www.iupesm2018.org



Conflict of interest

The authors declare that they have no conflict of interest.