
Rhod:- An Anthropomorphic phantom for end-to-end SRS audits

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What to Audit?

The two critical aspects of single fraction Stereotactic Radiosurgery (SRS) are positioning and dosimetric accuracy. The purpose of an SRS audit was to verify:

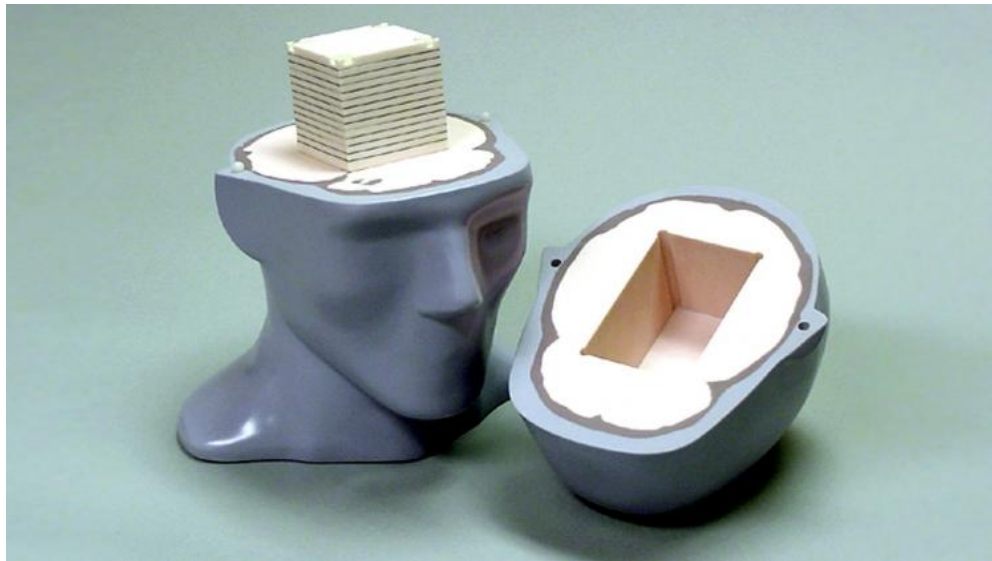
- Patient set-up – how well do our positioning systems work?
- Dose delivery – how accurate is our isocentre dose?

We needed a new phantom, capable of measuring both.



The Phantom

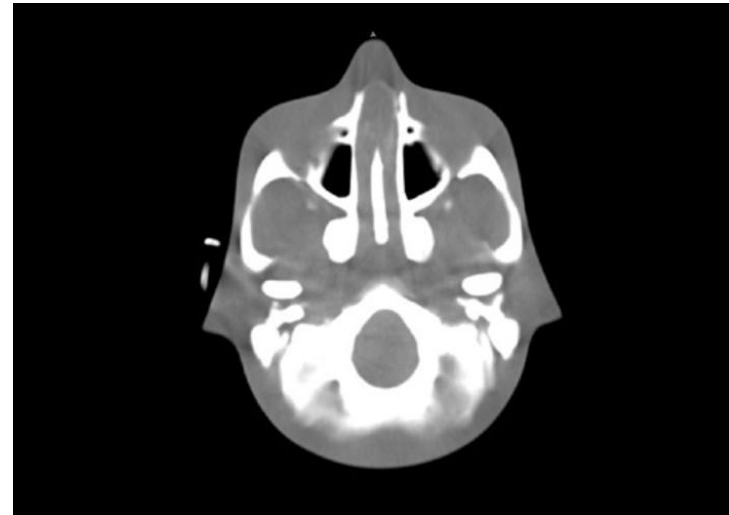
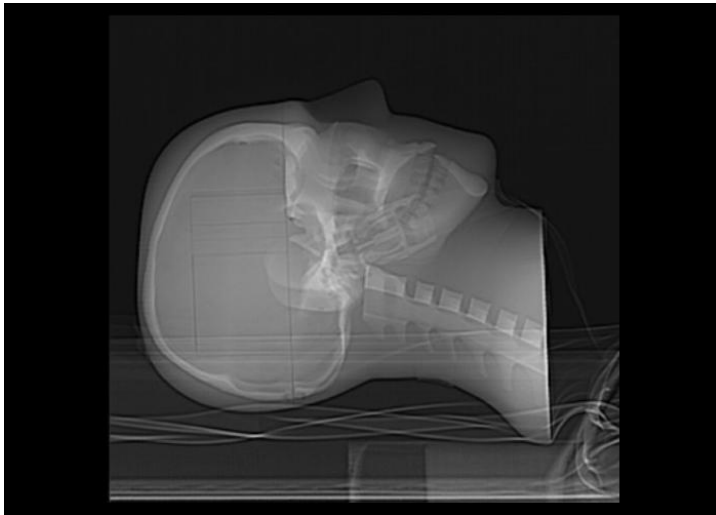
Bespoke anthropomorphic phantom – Dental phantom with modifications for SRS measurements, known locally as “Rhod”



Manufactured by CIRS

Phantom Anatomy

Realistic anatomy – brain, bone, spinal cord, vertebral disks and soft tissue

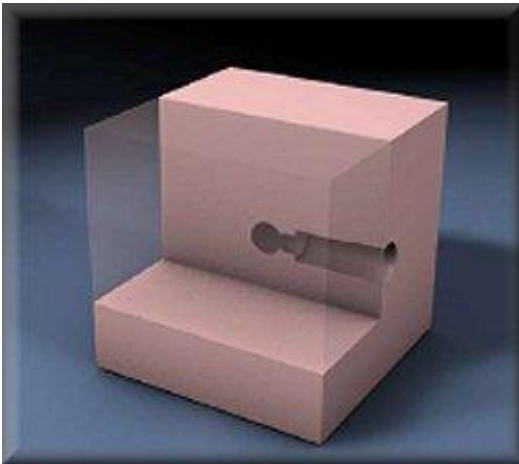


Made of proprietary epoxy materials – linear attenuations within 1% of actual (50 keV to 25 MeV)

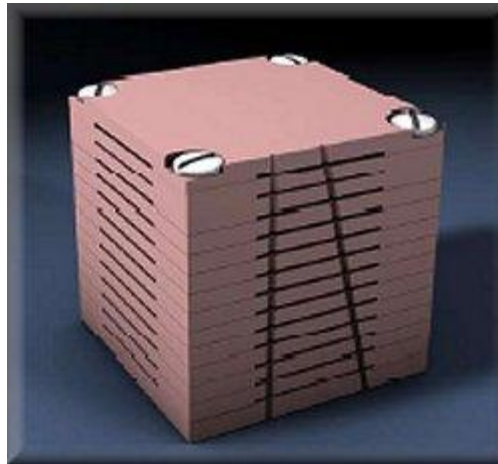


The Phantom

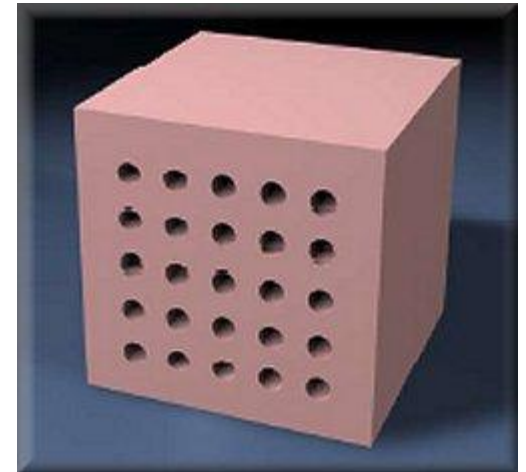
Inserts – holder for stack of film, insert to hold a Pin-point ionisation chamber and an insert to hold TLDs.



Pin-point insert



Film insert



TLD insert



Positional Audit

Phantom used to check positioning accuracy. Having a phantom with complete bony anatomy allows positioning using the same imaging system as the patient.

End-to-end audit

- Phantom in same immobilisation system as patient
- Scanned and planned using clinical protocol
- Positioned on set, imaged and repositioned according to clinical protocol



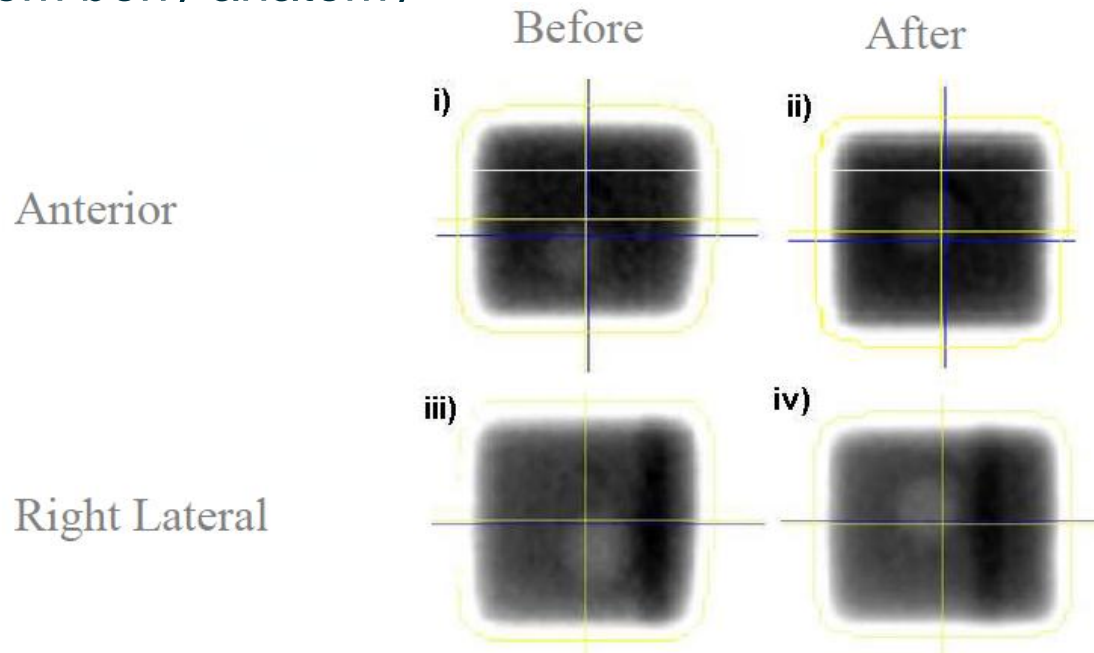
Positional Audit

- Rhod has a chamber shaped insert with a 3 mm ball bearing that be used as the treatment isocentre
- Visible on both planning CT and MV portal images
- Phantom positioned using SRS localisation system, any moves suggested by image guidance are applied
- MV images taken at 0 and 90 degrees. Distance from centre of ball-bearing to centre of field provides a measure of positional accuracy



Position Audit - Results

- IQWorks used to calculate differences between ball-bearing position and centre of field.
- Accuracy was improved when using image guidance and phantom bony anatomy



Dose Audit

Phantom was used for dose measurements at two centres (CCC and Royal Preston Hospital)

End-to-end audit

- Phantom in same immobilisation system as patient
- Scanned and planned using clinical protocol
- Positioned on set, imaged and repositioned according to clinical protocol
- Treatment plan delivered and compared to plan



Immobilisation and Simulation

Phantom was immobilised and CT scanned as if a patient at each centre



CCC – Brainlab
frameless system



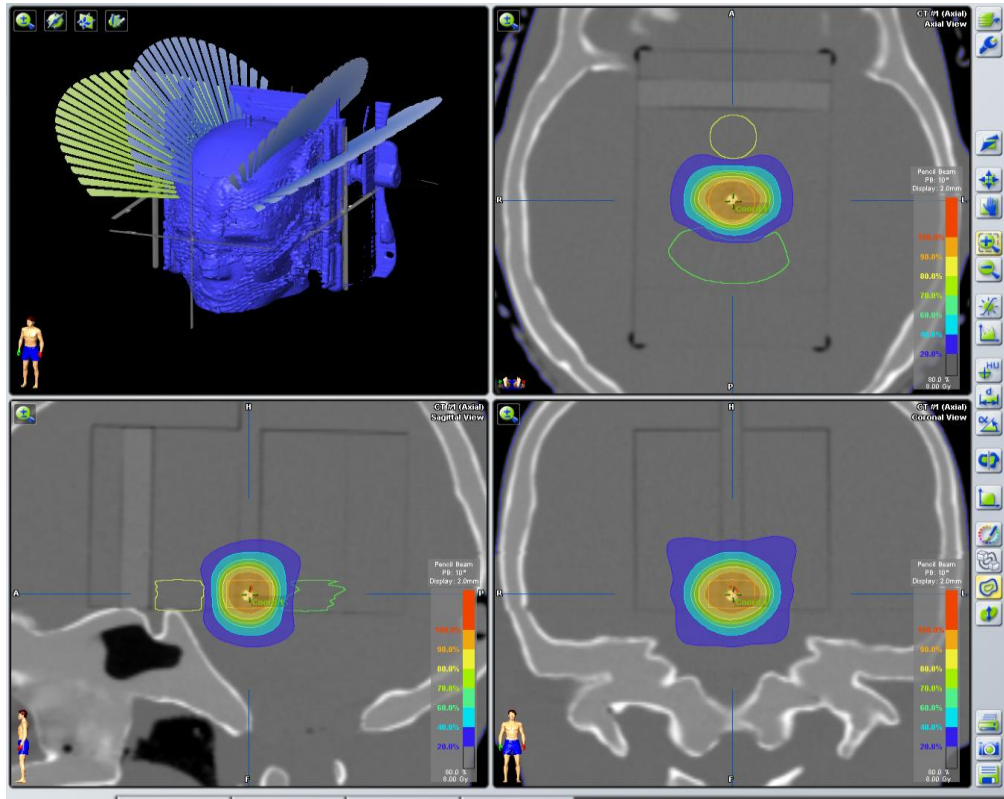
RPH – Fraxion
system



Planning

Planned – using dynamic conformal arcs (CCC)

- Field size range 1.5-2 cm equivalent square

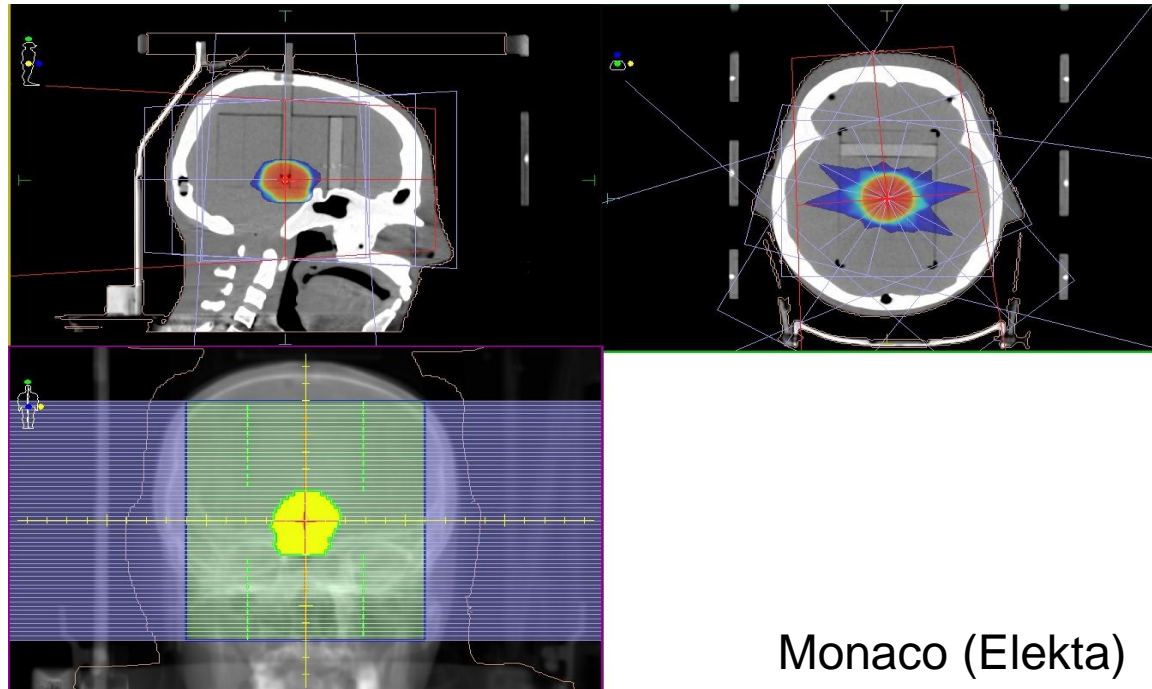


iPlan (Brainlab)

Planning

Patient treatment transferred onto phantom – multiple fixed fields (standard at RPH)

- Field size range 3-4 cm equivalent square



Monaco (Elekta)



Calibration

- Intercomparisons between Pin-point chamber and field instruments – allows dose comparison with plans
- Performed isocentrically – 95 cm SSD 5 cm deep
- Substitution method used in solid water (WT1)
- Field size of 5 x 5 cm used for calibration (10 x 10 cm factor also measured)



Results

All measurements within 2% of planning system predicted doses across both centres

RPH			
<u>Field</u>	<u>Measured dose (cGy)</u>	<u>Predicted dose (cGy)</u>	<u>Difference (%)</u>
1	246.63	247.2	0.23%
2	443.48	437.9	-1.26%
3	365.69	365.5	-0.05%
4	153.14	151.5	-1.07%
5	403.99	399.3	-1.16%
Total	1612.93	1601.4	-0.72%
CCC			
<u>Field</u>	<u>Measured dose (cGy)</u>	<u>Predicted dose (cGy)</u>	<u>Difference (%)</u>
Arc 1	247.19	245	-0.89%
Arc 2	253.98	258	1.58%
Arc 3	255.40	258	1.02%
Arc 4	241.80	238	-1.57%
Total	998.37	999	0.06%



Phantom/Method Improvements

- Uncertainty as to what is the best detector to use for small field measurements – Pin-point not suitable for smaller (<1 cm sq) fields
- Gafchromic film or stereotactic diode?
- Additional difficulty in ensuring EBT3 film remains perpendicular to the treatment couch – most treatment planning systems cannot calculate oblique dose planes
- NPL Alanine – Possible detector for the audit?
- Phantom can be immobilised in Brainlab Fixed Frame but must also be usable with other fixed frame systems



Logistical Improvements

- Combine positional and dosimetric audit in the same visit
- Clear protocol – guide to setup/preparation sent with phantom in advance of visit.
- Immobilisation, scanning and planning can then be done entirely by audited centre prior to visit



Conclusion

- Anatomy in the phantom worked well – set-up was straight forward according to clinical protocol
- Phantom density appears suitable - evidenced by good results for larger fields (in early testing) and small fields
- The phantom can be therefore be used for dosimetric and positional audit
- Still room for improvement of both the phantom and protocol



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