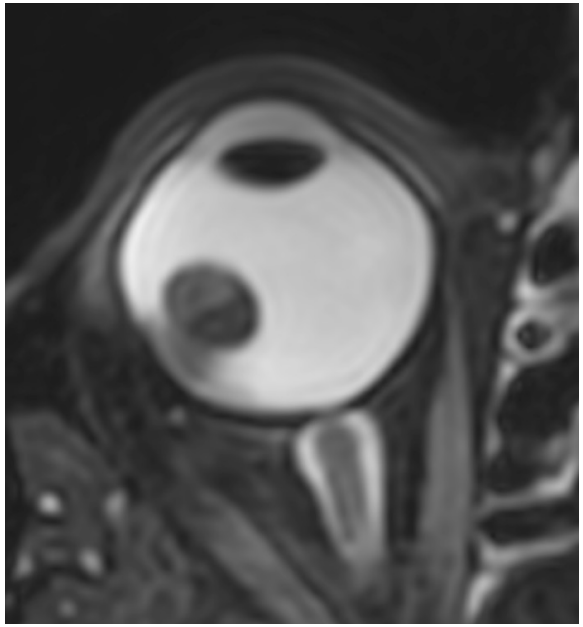
Leiden University Medical Center

MR imaging for ocular proton therapy



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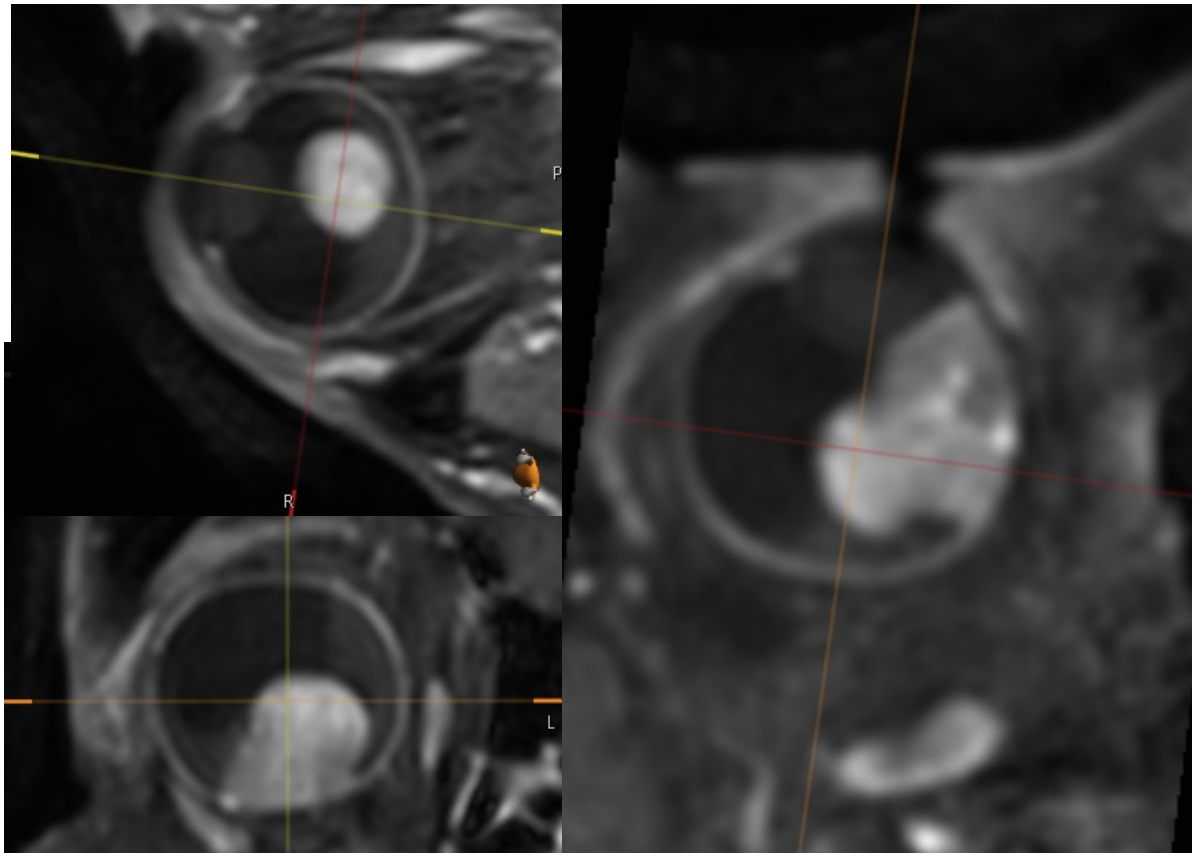
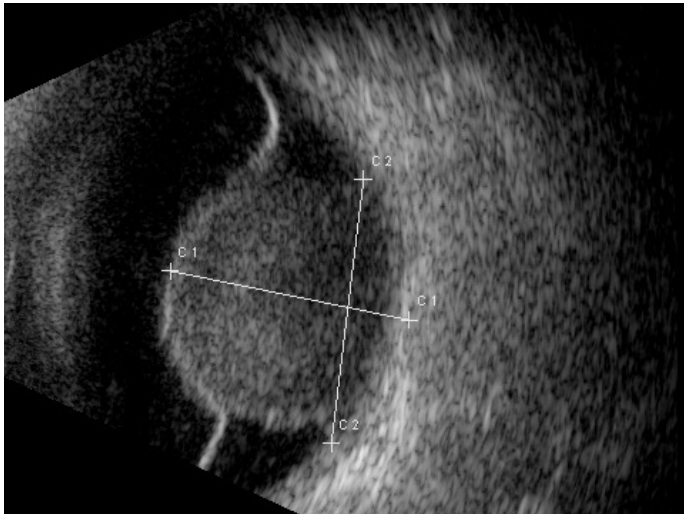
Why MRI?

- 3D visualization
  - More accurate (3D) description of tumour geometry





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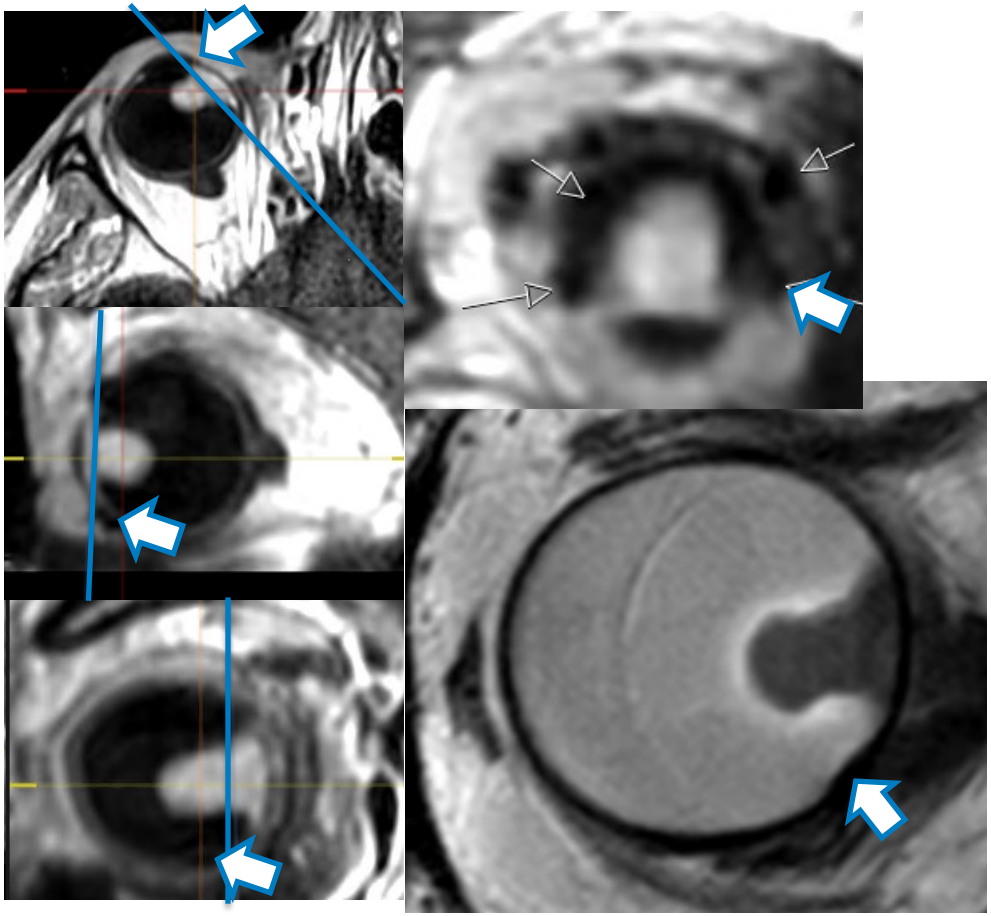
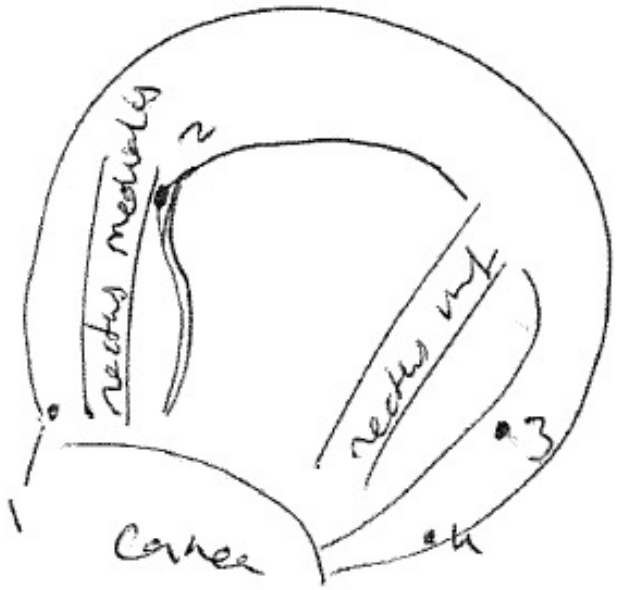
    - And relation to clips





Why MRI?

- 3D visualization
  - More accurate (3D) description of tumour geometry
    - And relation to clips
- Some ophthalmic measurements are less accurate in UM patients
  - E.g. tumor affects eye-length measurement in 68% of patients [1]
- (Functional scans)[2]

- Our patients receive 3 MRI's
  - Diagnostic MRI (Pre clip surgery)

    -> Tumour geometry & involvement of nearby structures (& diagnosis)
    - Change in optimal therapy (brachy/protons/enucleation)
  - MRI for clip-tumour relations (short protocol)
  - 3mnts post PBT: follow-up

1.Jaarsma, Comparison of MRI-based and conventional measurements for proton beam therapy of uveal melanoma, submitted
2. Kamrava, Quantitative multiparametric MRI in uveal melanoma, Neuroradiology 2015

How?

- Hardware, protocols, etc. available from major MR-manufacturers
- Hardware: 3Tesla & surface coil

Ferreira, MRI of Uveal Melanoma, Cancers (2019)

How?

- Hardware: 3Tesla & surface coil
- Protocol:
  - 3D isotropic (<0.7mm acquisition resolution)
    - allow for reformatting in all directions
    - measure dimensions, distances
  - 2D multi-slice (<0.5mm in plane resolution)
    - Detailed evaluation (optic nerve invasion, origin of lesion,…)
    - Clip-tumour relation
  - Functional imaging (DWI, DCE)
    - Diagnosis, follow-up
- Contrast agent is strongly advised to differentiate between UM and RD
- Enhanced gradient strength (and localized shimming) for clips

- Experienced radiologist

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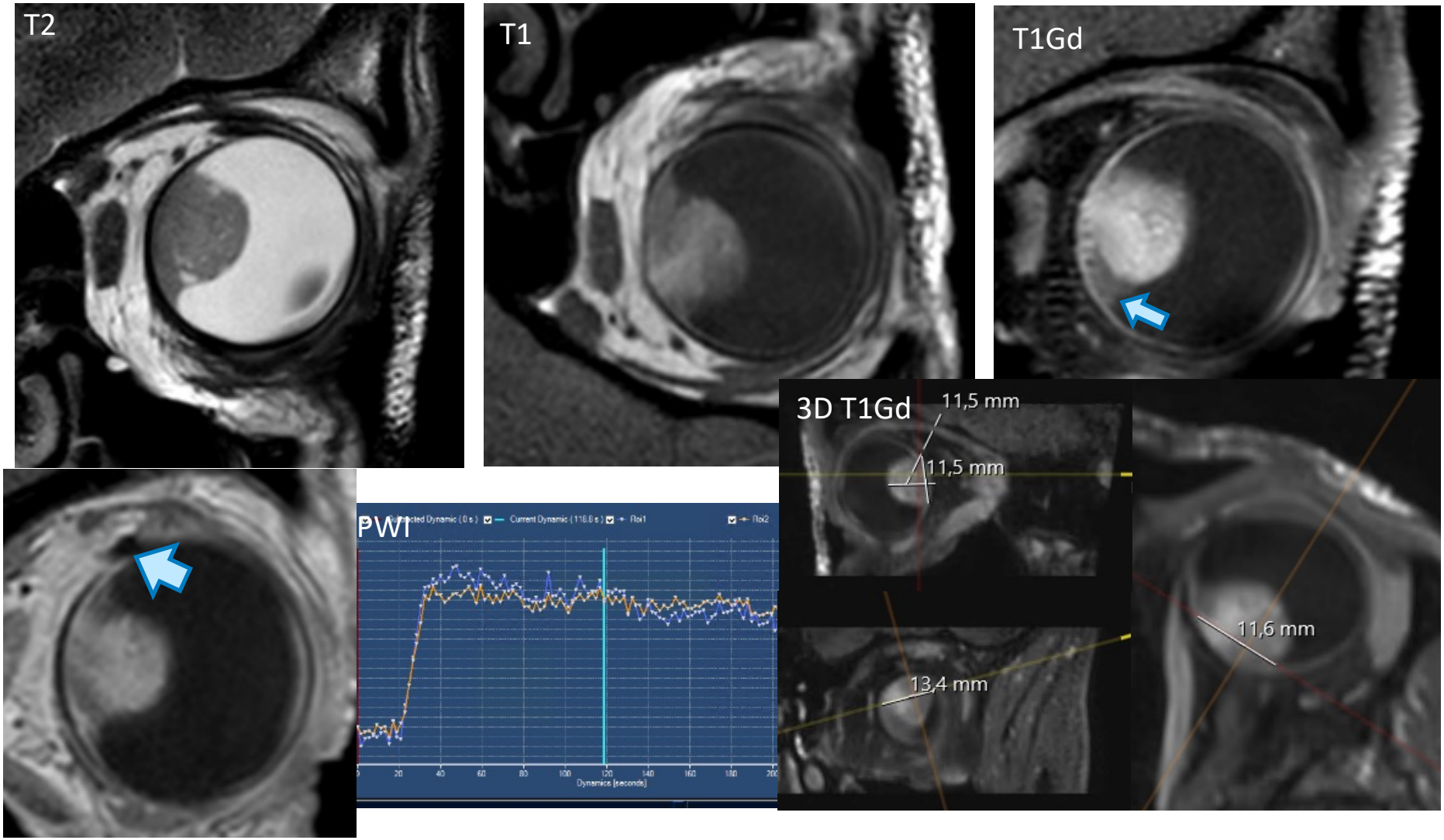
Example patient



Ferreira, MR imaging characteristics of uveal melanoma with histopathological validation, Neuroradiology (2022)

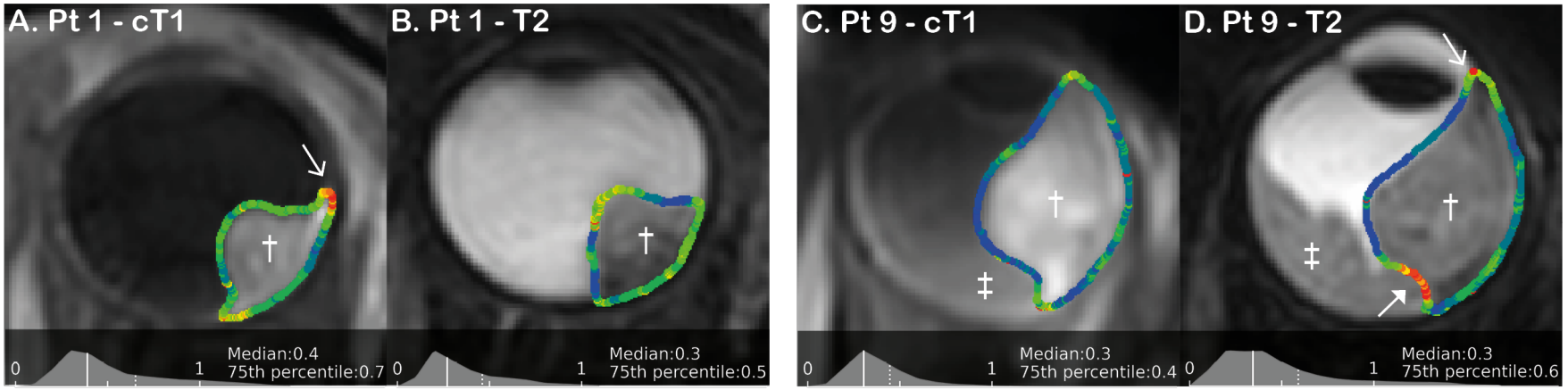
Interobserver variation

- 10 patients, 6 observers (Radiologists, Ophthalmologists, Radiation oncologists)

- Median localSD: 0.4mm
  - 1/2 acquisition voxel
- T2 smaller than T1gd
- Contrast enhanced T1 advised

Local SD	cT1	T2	
	Median; 75th perc	Median; 75th perc	p-value (n)
Vitreous	0.39 mm; 0.49 mm	0.24 mm; 0.34 mm	<0.001* (10)
Sclera	0.37 mm; 0.51 mm	0.39 mm; 0.51 mm	0.99 (10)
Edge	0.62 mm; 0.90 mm	0.52 mm; 0.71 mm	0.08 (10)
RD	0.54 mm; 0.85 mm	0.47 mm; 0.79 mm	0.35 (5)
GTV	0.41 mm; 0.60 mm	0.35 mm; 0.54 mm	0.12 (10)

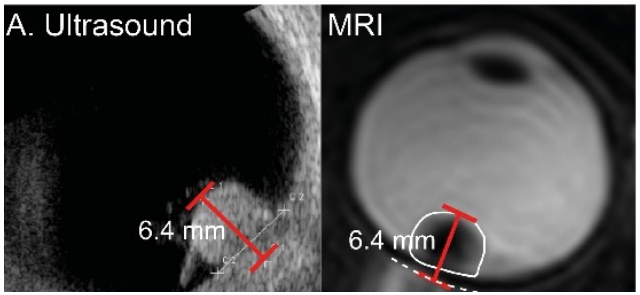
perc = percentage, * significant difference

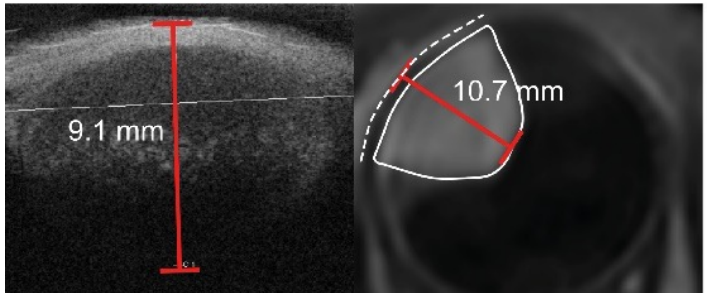


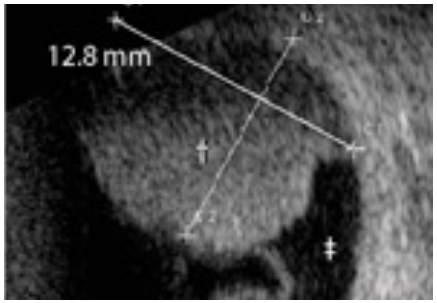
Jaarsma, Inter-Observer variability in MR-based target volume delineation of uveal melanoma, submitted

MR-based tumour dimensions

- Manual MRI (T1gd) & ultrasound measurements generally match[1,2]
  - IQR prominence -0.2 – 0.6mm; largest diameter -1.4 – 1.5mm (n=72) [3]
- Except for anterior tumors[2,3]:
  - Full tumour extend often not visible on ultrasound
  - Correct positioning of transducer not always possible



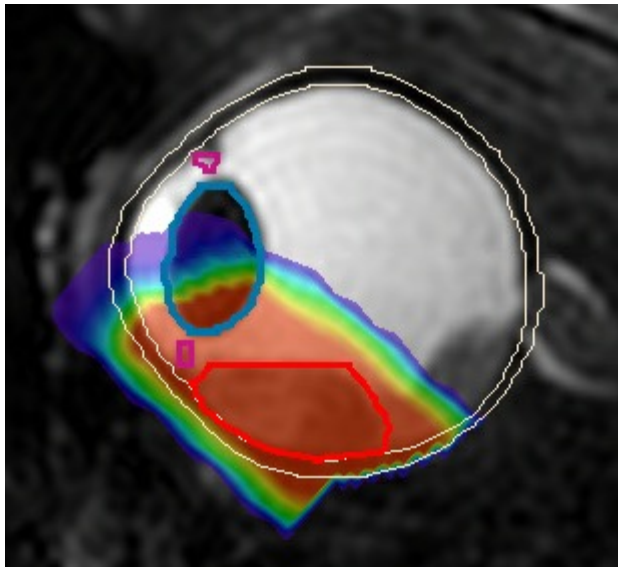




1.Ferreira, MR imaging characteristics of uveal melanoma with histopathological validation, Neuroradiology (2022)
2.Jaarsma, Comparison of MRI-based and conventional measurements for proton beam therapy of uveal melanoma, submitted
3. Jaarsma, Magnetic resonance imaging in the clinical care for uveal melanoma patients, in preparation

Main points

- High resolution ocular MRI is feasible in regular clinical practise
- Main benefits:
  - 3D visualisation of tumor, clips and eye
  - More accurate tumour dimensions for anterior tumors
  - More accurate eye length determination for posterior tumors
  - Detailed radiological evaluation (invasion, functional parameters, ...)
  - Follow-up
- 3D MR-based PT planning



Fleury et al, Medical Physics (2020)

Acknowledgements

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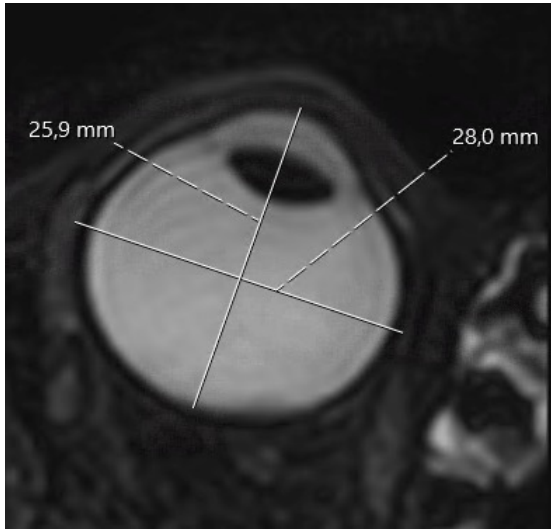
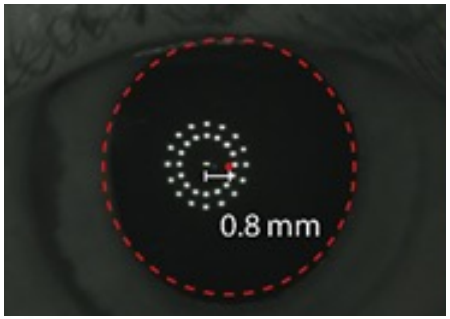
Eye dimensions

- MRI and biometry match in healthy population (SD <0.3mm)[1,2]
- 15/22 UM patients: signs of unreliable biometry :
  - -> average 0.8mm shorter eye
  - Multiple reflections in raw biometry signal
  - Large iris decentration
- MRI prefered over biometry of contralateral eye





1. Beenakker, Automated Retinal Topographic Maps Measured With Magnetic Resonance Imaging, IOVS 2015
2.Jaarsma, Comparison of MRI-based and conventional measurements for proton beam therapy of uveal melanoma, submitted