The Clatterbridge Cancer Centre
NHS Foundation Trust

Introduction to Session: Treatment planning in ocular proton therapy

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Scope

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1. Elements of an ocular treatment plan
2. Main goals of ocular treatment planning
3. Overview & comparison of (dedicated) ocular Treatment Planning Systems (TPS)
4. Planning workflow: traditional & modified (with 3D image data)
5. Choice of TPS: past and present survey results
6. What might the future hold for treatment planning in OPT?

Fundamental elements of an ocular treatment plan

Eye model: geometric, patient-specific scaling

Tumour volume: delineation guided by clinical data

Clips (markers): tumour delineation & precise set-up

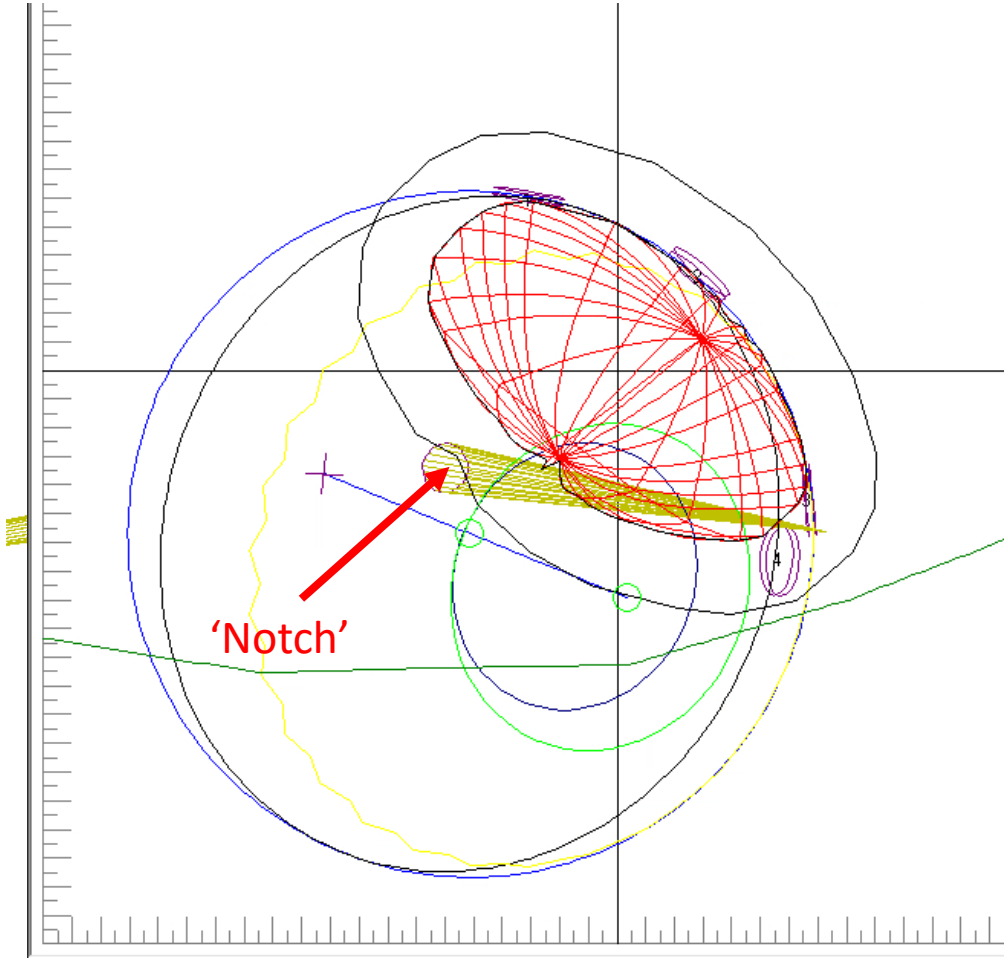
Immobilisation: mask, fixation light

Wedges: reduce modulation, entrance / ON dose

Torsion: model of eye twist (neutral gaze reference)

Lid tissue: account for if in the proton field

Margins: ~2.5mm universally adopted (range 2 - 3mm)



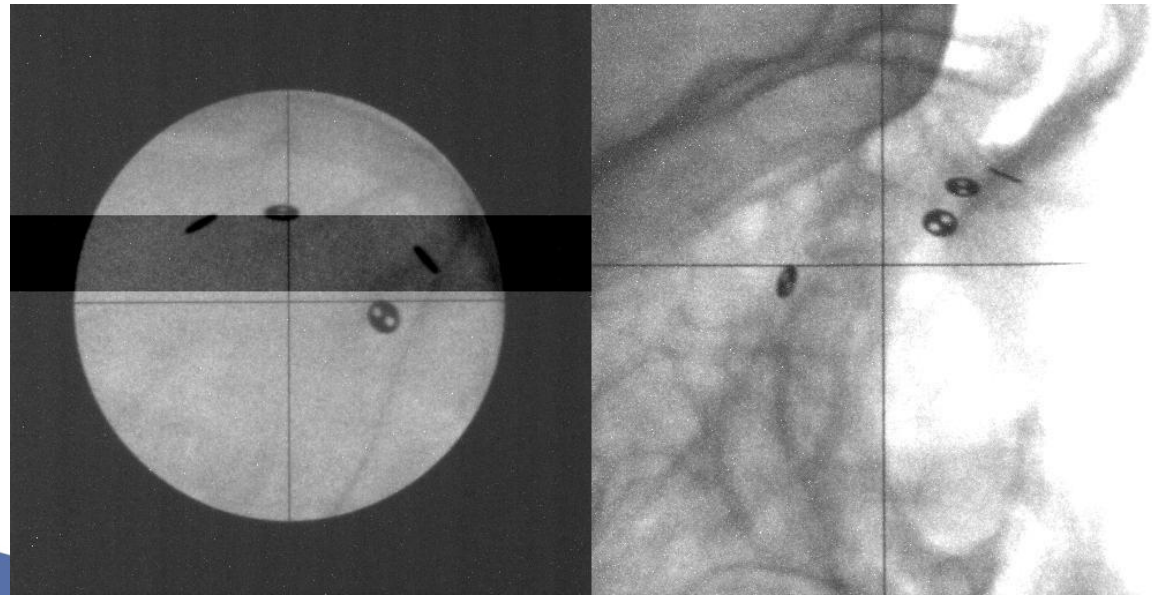
Main goals of ocular treatment planning

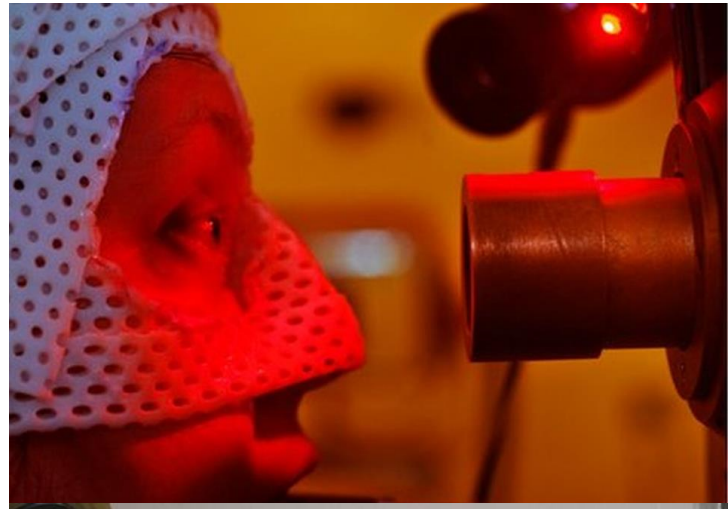
Select **best gaze angle** (optimise OAR doses)

Define **aperture shape** (BEV)

Determine proton (particle) **range** (energy) & range **modulation**

Generate **clip projections (**orthogonal views), relative to aperture & cross-wires





Overview of dedicated Ocular TPS

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EYEPLAN	• ~1975, first dedicated system at MGH[1], collaborative development (PSI then CCC)	Planning based on a geometric eye model
EOPP	• ~2003, Eclipse Ocular Proton Planning (Varian Medical Systems)	All support fundus image registration except EOPP
OCTOPUS	• ~2005, developed by German Cancer Research Centre; use restricted to HZB/Charité[2]	3D imaging (eye model refinement, clip positions, target definition)
RayOcular	• RayStation Ocular Module (first clinical use 2021 at WPE)[3]	Pencil Beam Algorithm: improved accuracy (wedges)

[1]Goitein M & Miller T, Med. Phys. 1983; 10(3): 275-283

[2]Dobler B & Bendl R, Phys. Med. Biol. 2002; 47: 593-613

[3]Wulff J, Koska B, Heufelder J et al. Med Phys. 2023;50: 365-379

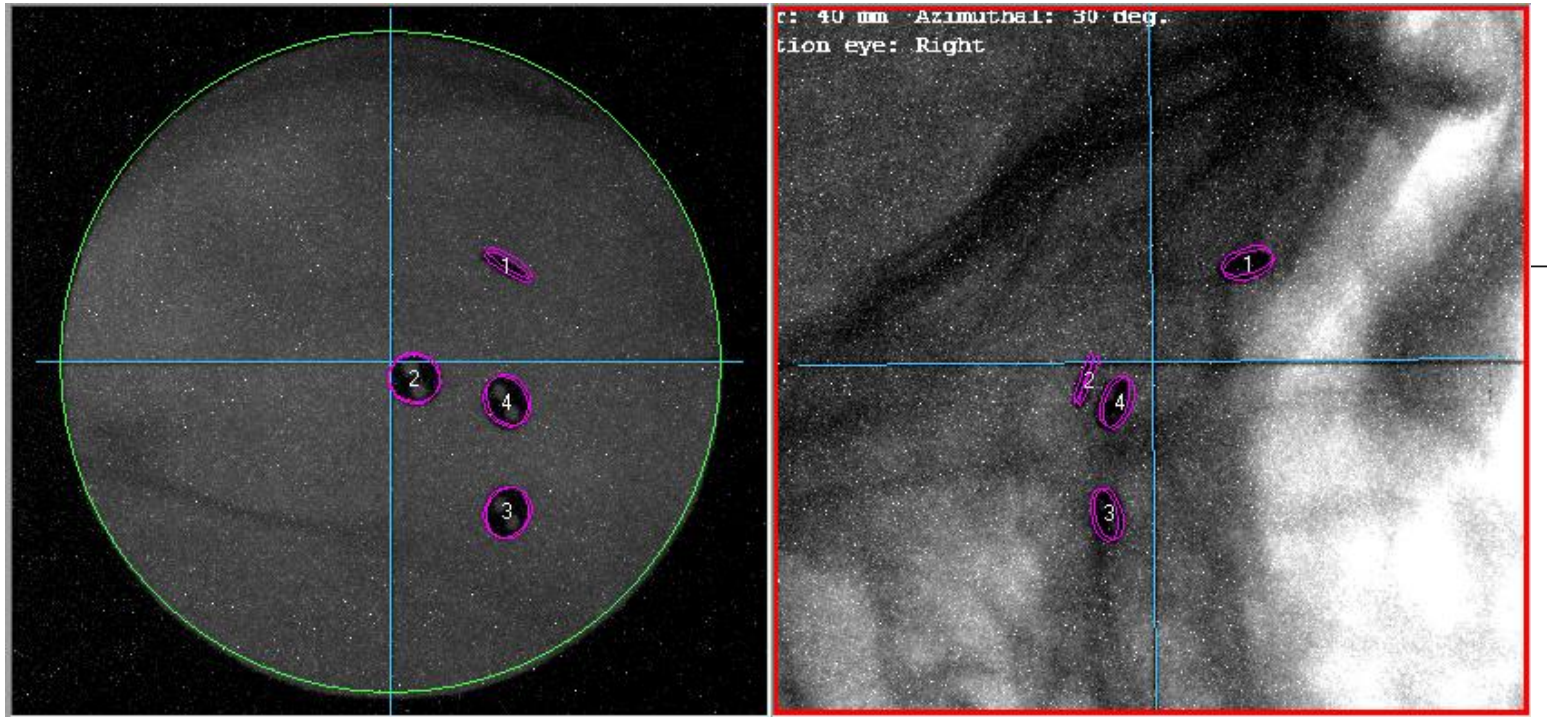
Comparison of dedicated ocular TPS

TPS	Register Fundus image?	Register CT/MR?	Dose calculation	Integrated x-ray image acquisition	Eyelid model or skin plane only?	Ongoing support?
EyePlan 3.07	Yes	No	Simplistic	Yes	Yes	No
EOPP	No*	No	Simplistic	No	Skin plane	No
Octopus	Yes	Yes	Simplistic	No	Yes	No
RayOcular	Yes	Yes	PBA	No	Skin plane	Yes

EOPP - Eclipse Ocular Proton Planning;
Simplistic Dose Calculation; utilise measured profiles, lateral & distal penumbrae
PBA – Pencil Beam Algorithm

* Adaptation can enable this

Traditional workflow, e.g. using EYEPLAN / EOPP

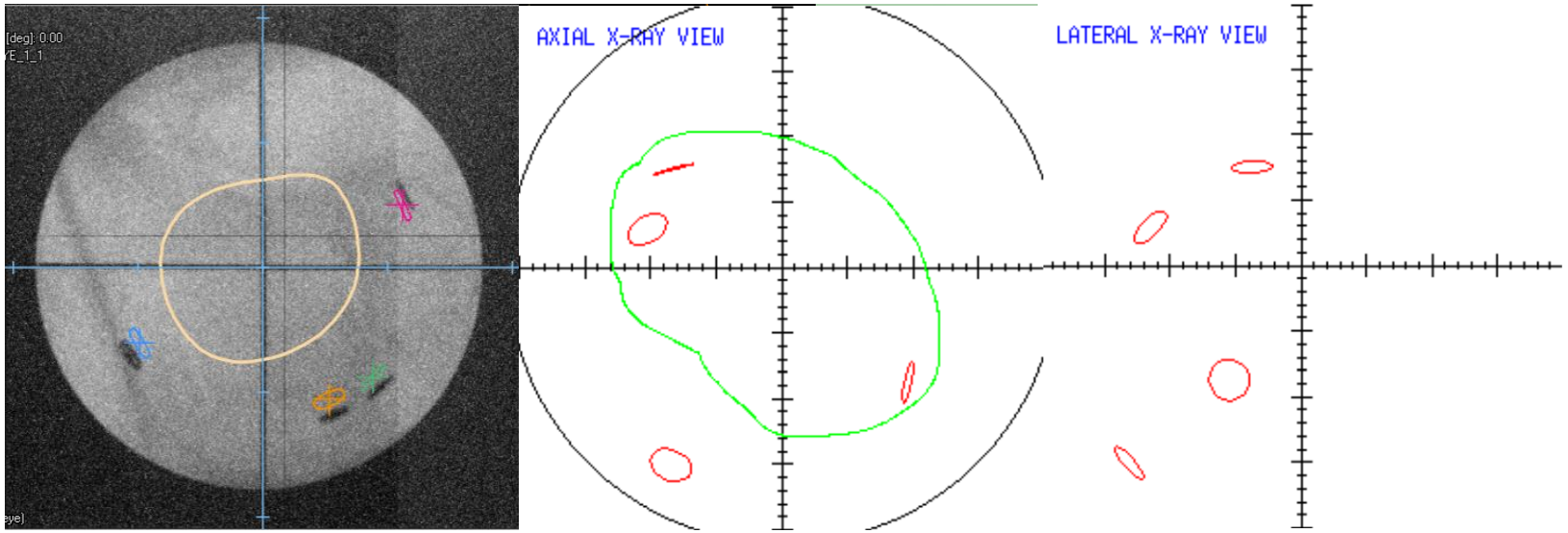


Eye model: geometric → **Patient simulation:** 2D images (3-6 gaze angles) → **Clips located:** → 3-6 models → **Assess gaze:** model selection → **Target:** created in fundus view → **Plan:** optimized gaze; 2D clip projections → Final Simulation:

Modified workflow using RayOcular / OCTOPUS

RayOcular: Axial DRR

OCTOPUS: 2D clip projections



OCTOPUS images: courtesy of Jens Heufelder

3D image acquisition (CT/MR)

Eye model: geometric; refined using 3D images

Clips added: using 3D images

Target: fundus view; slice-by-slice in 3D views

Plan: optimized gaze; DRRs & clip projections

Patient simulation: 2D images (treatment & neutral gaze)

Assess gaze & torsion: apparent vs nominal projections

Final simulation

Choice of TPS: past & present survey results

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Survey data **2015**[4]

TPS	Centres (%) Total 10
EyePlan	7 (70%)
EOPP	1 (10%)
EOPP & EyePlan	1 (10%)
Octopus	1 (10%)

[4]Hrbacek et al. Int J Radiat Oncol Biol Phys. 2016; 95(1): 336-343

Dedicated Ocular TPS

General Purpose TPS

Survey data **2022-24**

TPS	Centres (%) Total 19
EyePlan	7 (37%)
EOPP	4 (21%)
Octopus	1 (5%)
RayOcular	1 (5%)
Eclipse (GPM)	2
RayStation (GPM) & XIO	1
CMS Xio	1
Siemens Syngo	1
XiDose*	1
Total	6 (32%)

Planned treatments in 2023

TPS	%
EyePlan	~ 67
EOPP	~ 9
Octopus	~ 11
RayOcular	~ 6
General Purpose Systems	~ 7

GPM:
general-purpose PBS/DS/US module

*XiDose:
an in-house system supported by Elekta

What might the future hold?

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- Shift to RayOcular (dedicated lines)?
- Increased use of General Purpose TPS (general purpose lines)?
- Combined use of RayOcular (anatomy / fundus registration) & GP TPS (dose calculation)?
- Increased experience in 3D image –based planning
- Recommendations / guidance for ocular proton planning?

Thank you for your attention
Comments / other ideas welcome ☺

Talks to follow……..

- **Uncertainties** in ocular proton therapy workflow (*Martijn Hol*)
- Exploring the suitability of **lateral margins** in PT for ocular malignancies (*Daniel Bjorkman*)
- **RayOcular evaluation** at Antoine Lacassagne center: a preclinical cases study (*Juliette Kobus*)
- **Pencil beam scanning** proton therapy for uveal melanoma: Modulated **multi-beam treatment** in a regular gantry room (*Haibo Lin*)
- **Multi-modality image processing** for treatment of eyes with light ion beams (*Mr Zhuangming Shen*)
- Configuration and calibration of **Monte Carlo based dose calculations** for eye treatments with light ion beams (*Rongcheng Han*)