Introduction to Session:
Treatment planning in ocular proton therapy

Linda Mortimer, PhD
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linda.mortimer2@nhs.net
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Scope

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

**EYEPLAN**
- ~1975, first dedicated system at MGH\(^1\), collaborative development (PSI then CCC)

**EOPP**
- ~2003, Eclipse Ocular Proton Planning (Varian Medical Systems)

**OCTOPUS**
- ~2005, developed by German Cancer Research Centre; use restricted to HZB/Charité\(^2\)

**RayOcular**
- RayStation Ocular Module (first clinical use 2021 at WPE)\(^3\)

Planning based on a geometric eye model

All support fundus image registration except EOPP

3D imaging (eye model refinement, clip positions, target definition)

Pencil Beam Algorithm: improved accuracy (wedges)

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## Comparison of dedicated ocular TPS

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

EOPP - Eclipse Ocular Proton Planning;
Simplistic Dose Calculation; utilise measured profiles, lateral & distal penumbras
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

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

### Survey data 2015

<table>
<thead>
<tr>
<th>TPS</th>
<th>Centres (%)</th>
<th>Total 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>EyePlan</td>
<td>7 (70%)</td>
<td></td>
</tr>
<tr>
<td>EOPP</td>
<td>1 (10%)</td>
<td></td>
</tr>
<tr>
<td>EOPP &amp; EyePlan</td>
<td>1 (10%)</td>
<td></td>
</tr>
<tr>
<td>Octopus</td>
<td>1 (10%)</td>
<td></td>
</tr>
</tbody>
</table>

### Survey data 2022-24

<table>
<thead>
<tr>
<th>TPS</th>
<th>Centres (%)</th>
<th>Total 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>EyePlan</td>
<td>7 (37%)</td>
<td></td>
</tr>
<tr>
<td>EOPP</td>
<td>4 (21%)</td>
<td></td>
</tr>
<tr>
<td>Octopus</td>
<td>1 (5%)</td>
<td></td>
</tr>
<tr>
<td>RayOcular</td>
<td>1 (5%)</td>
<td></td>
</tr>
<tr>
<td>Eclipse (GPM)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>RayStation (GPM) &amp; XIO</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CMS Xio</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siemens Syngo</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>XiDose*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6 (32%)</td>
<td></td>
</tr>
</tbody>
</table>

### Planned treatments in 2023

<table>
<thead>
<tr>
<th>TPS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>EyePlan</td>
<td>~67</td>
</tr>
<tr>
<td>EOPP</td>
<td>~9</td>
</tr>
<tr>
<td>Octopus</td>
<td>~11</td>
</tr>
<tr>
<td>RayOcular</td>
<td>~6</td>
</tr>
<tr>
<td>General Purpose Systems</td>
<td>~7</td>
</tr>
</tbody>
</table>

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GPM: general-purpose PBS/DS/US module

*XiDose: an in-house system supported by Elekta
What might the future hold?

• 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*)