Ocular Proton Therapy in its 4th Decade
(introducing OPTIS2)

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The MGH approach (1975)

- Proton therapy with an “en face” approach
- The use of clips sutured to the eyeball for planning and (highly accurate) positioning purposes
- A geometry-based treatment planning system
- Active cooperation of the patient (eye fixation)
- Stereotactic imaging
- Continuous eye (tumour) position surveillance during treatment
Treatment planning: identifying the clips on X-ray Images
Treatment Planning using EyePlan

Fundus View

Lateral Projection

Axial Projection
Head fixation, gazing angle, position control

Position Control

Lateral X-ray
Axial X-ray

Video-camera
Collimator
Fixation Light
The longevity of the MGH Approach

In 1975 MGH introduced:

*Image guided stereotactic radiotherapy with protons*

In 2010 OPTIS2 still has the same MGH approach.
Why hasn’t 35 years of developments in medical physics made a bigger impact?

- The pioneering institutes are often physically separated from the referring hospital, or without substantial diagnostic imaging departments. Drive for change comes from the ophthalmologists.
- The pioneering ophthalmologists learned to work with (the limits of) EyePlan. Together with the large patient throughput adding anatomical imaging into the process not deemed to be practical/worthwhile.
- Non-invasive techniques? Much is learned by having a look at the tumor, allows for a more accurate definition of tumor base (i.e. flat extensions). Operation is well tolerated, tantalum clips can remain in eye.
- Clips allow for very precise positioning (0.2 mm) and consequently small safety margins.
- Non-invasive modern photon therapy techniques haven’t shown the same clinical outcome with sufficient follow up
Challenges operating an eye line in a modern facility

- Modern facilities have a 235/250 MeV cyclotron and multiple treatment rooms.
- The clinical success of the ‘first generation’ of ocular beam lines (often with a lower energy cyclotron) was obtained with beam characteristics and a dose rate that cannot be matched with ‘all purpose’ cyclotrons.
- The limited duration a patient can actively cooperate and, in modern facilities, the high loss of protons (99%) degrading the energy down to 70 MeV requires *compromises with respect to the first generation of beam lines.*
- Possible compromises:
  - Prolonged treatment duration
  - Larger distal dose fall off
  - More efficient (less robust) beam shaping system
  - Larger lateral fall off
  - Maximum available field size
OPTIS and OPTIS2

- OPTIS at PSI introduced proton therapy to Europe in 1984
- By the end of 2009 >5200 ocular lesions were treated in the OPTIS program
- Maintenance and reliability issues of the >35 year old cyclotron used for OPTIS, combined with the wish to continue to provide ocular proton therapy in Switzerland, resulted in OPTIS2, a new ocular treatment facility at PSI
OPTIS2 - Aim

• Build a technically modern eye treatment facility,
• meeting the clinical results of OPTIS (with same or similar beam line characteristics) using an ‘all purpose’ 250 MeV cyclotron,
• while minimising beam time requirements to allow for high patient throughput in a multiple treatment room environment.
OPTIS2 - Challenges

- Build a new treatment room to be integrated with an already running facility
- Meet the OPTIS beam characteristics with 25 times fewer beam intensity than provided for OPTIS
- Be prepared for patient treatment without range, modulation and dose verifications before each treatment
OPTIS2 - Solutions

- Commissioning and development took place during evening hours and weekends
- Beam shaping is done using a second multi-ring scatter foil (compromises: dose rate, robustness of beam shaping; only marginally increased distal/lateral fall offs)
- Multiple ionisation chambers, absolute encoders, barcode scanners etc. provide the signals for the independent Therapy Delivery System and the Therapy Verification System. The ‘Patient Steering File’ is verified once prior to the start of the treatment week.
OPTIS2 Nozzle and chair
In conclusion

- Ocular proton therapy hasn’t fundamentally changed since 1975
- Treatment facilities with all purpose cyclotrons will have to compromise with the respect to the first generation of treatment facilities (impact on clinical success still unknown)
- OPTIS2 is a new eye treatment facility using a 250 MeV cyclotron and prepared to swap quickly between treatment rooms with compromises on dose rate (max. 60 s) and robustness (relies on stable beam position and intensity)
Outlook

- Ocular proton therapy (using the MGH approach) will continue to treat more patients year by year (new eye lines being built, growing awareness and acceptance)
- Ongoing technical developments will allow for the routine treatment of clip delimited retinoblastoma
- Other indications may become more broadly accepted (choroidal haemangioma) or get a second look (AMD)
- Anatomical based treatment planning will become more widespread, especially when sparing of the critical eye structures (macula, optic disc/nerve) is involved
Thank you for your attention