Session 3: Dedicated Ocular Beamline & Universal Beamlines Adapted for Ocular Therapy

Abstract: **Introduction to Session 3: Delivery of optimal ocular proton beams in the next decade?**

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Ocular proton therapy was developed to provide an alternative to enucleation or resection of medium and large choroidal melanomas. Although the first proton therapy treatment took place at Berkeley in 1954, it was not until 1975 that the first ocular treatments were performed at the HCL 160 MeV synchrocyclotron beam at the HCL, following a collaboration between clinicians and physicists. The HCL horizontal beam line with patient mask and bite restraint, precision movement chair and patient specific brass aperture became the standard treatment configuration for proton eye therapy facilities. Four decades of treatment experience from all centres, have demonstrated exceptionally high local tumour control (>95%)[1] indicating excellent treatment accuracy, optimal dose regimes and treatment planning. Improvements have therefore focussed on short- and long-term side-effects, by dose reduction to OAR and normal tissue, sharper treatment margins and compensator techniques, as well as advances in post-treatment adjuvant therapies.

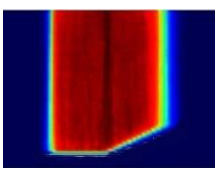

Figure 1 Wedged 60 MeV full SOBP

The sharp proton isodoses (e.g. fig 1) are degraded by a combination of design and physics factors. The latter includes range straggling (RS) and multiple Coulomb scattering (MCS). Reducing high energy beams, to the 60 to 75 MeV range useful for ocular PBT, requires significant investment in design to mitigate the effects of energy degradation. Low-energy cyclotrons with minimal energy degradation, have been converted to ocular therapy, e.g. Clatterbridge, Nice, UCSF and HMZ. These have optimal isodose characteristics [2,3] as well as simpler beamline configurations.

Synchrotrons, despite their large footprint, can produce pristine variable-energy beams with little degradation, e.g. LLUMC, CNAO. The number of high energy beams, at multi-room facilities, which are degraded to the useful ocular treatment range, is increasing. No clinical machine vendor is likely to provide a clinical accelerator in this energy range. Developments of low-cost, compact low-energy proton accelerators (e.g. S/C cyclotrons, proton linacs) are unlikely to come to fruition in the next decade.

In 2022, there are twenty ocular PBT facilities worldwide including five dedicated only to ocular therapy, but the move towards ocular treatments, at high-energy proton treatment centres, particularly on adapted high energy gantries or fixed lines, has been driven by advantages in costs and space and requiring little specialist ancillary equipment. Whether the beam quality in terms of penumbrae, distal fall-off, dose-rate and beam uniformity [2,3] would be acceptable to ophthalmologists and oncologists will be key to future beamline development.

References:

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2) Ocular Proton Therapy Centers (Kacperek A, 2012 Springer); pp.149-177; Chapter 10 in Ion Beam Therapy (ed. Linz U). DOI: 10.1007/978-3-642-21414-1
3) Fleury E et al. (2021) Characterization of the HollandPTC proton therapy beamline dedicated to uveal melanoma treatment and an interinstitutional comparison. Medical Physics 48(1) DOI: 10.1002/mp.15024