From EYEPLAN to OCTOPUS: from model based to 3D planning

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Since 1983 EYEPLAN [Goitein1983] is used for treatment planning in ocular proton therapy at many institutions [Hrbacek2016]. The model based approach does only allow an indirect use modern imaging modalities like fundus, CT, MRI, US used in ocular oncology [Heufelder2004, Daftari2005, Daftari2010]. To overcome these limitations the treatment planning system OCTOPUS was developed by the Deutsches Krebsforschungszentrum (DKFZ) in close cooperation with the proton therapy unit at the Helmholtz-Zentrum Berlin (HZB) and the Charité – Universitätsmedizin Berlin.

OCTOPUS (OCular TumOr Planning UtilitieS) allows the use of different imaging modalities, like, fundus, CT and MRI [Dobler2002]. It can be used like EYEPLAN: Creating an eye model from ophthalmological data and X-rays, defining a tumor and create a plan. Alternatively, one uses CT and/or MRI data to modify the eye model with its sub-structures like macula, optic disc, nerve, lens, cornea, etc to match them to the used imaging data. The tumor can be delineated either slice by slice using CT or MRIs or by drawing the tumor base on the registered fundus image like in EYEPLAN [Dobler2002]. A combination of both methods is possible, too. For dose calculation, a fast ray-tracing algorithm quite similar to EYEPLAN is used [Pfeiffer2001]. In principle a pencil beam algorithm for dose calculation was tested [Rethfeldt2006], but due to version issues not implemented clinically.

After a test and evaluation period in 2005 [Cordini2017] OCTOPUS is used as standard treatment planning system for ocular proton therapy at the HZB/Charité clinically since 2006. More than 3400 patients were planed: >2300 using CT and fundus, >950 using CT, MRI and fundus and > 150 only model based (predominantly Iris melanoma). The use of OCTOPUS lead to some changes in the treatment planning workflow and strategy: Clip positions can be extracted direct from the CT. Thus, treatment planning can start, when all imaging data (fundus, CT, MRI) were done and imported into the planning system. An initial simulation of the patient prior to treatment is not necessary anymore. A treatment plan can be generated within one to three hours depending on the complexity of the individual case. The use of CT and MRI lead to more realistic tumors and thus smaller CTVs and collimators, especially for larger tumors [Marnitz2006]. Additionally, it is possible to plan patients with silicon oil in the eye [Weber2012]. The automatic collimator correction for wedge scatter resulted to a more frequent use of wedges and double wedges. 60° wedges are used in about 57% of the cases.

Still there are some limitations in OCTOPUS: The beam data and geometry are hardcoded and cannot be adapted to other centers. Actual no further development is possible. A clinical usable pencil beam algorithm would produce more reliable dose distributions for wedges, silicone oil and tantalum clips.

The introduction of OCTOPUS had no significant negative effect on the tumor control: 95.5%@3years [Höcht2004] vs. 96.4%@5years [Seibel2015]. Despite the above-described weaknesses treatment planning can be performed in a safe and efficient way with OCTOPUS.

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