Robust proton CSI planning in Proteus®ONE

INTRODUCTION AND OBJECTIVES

This work studies the craniospinal irradiation (CSI) with pencil beam scanning proton therapy in an IBA Proteus®ONE gantry. Robust optimization can be used to create gradient-shaped field-junctions if robustness against setup uncertainties is considered in all dimensions. However, the number of scenarios to compute increases exponentially with the number of beams. In an IBA Proteus®ONE facility, where the maximum field size available is 20x24 cm², at least four beams are typically needed to cover the whole craniospinal axis + beams for brain irradiation.

Robust scenarios = (setup scenarios)²(number of fields)×(range)

For a plan composed of 5 beams, 50421 robust scenarios to be computed!!!

2 possible solutions are investigated:

- Robustness against setup uncertainties only in the craniocaudal direction
- The ancillary beam technique proposed by Farace et al.[1].

MATERIALS AND METHODS

- RayStation 6
- CT images of two patients in supine position
- 3 posterior beams to cover the spine + 2 lateral beams for brain irradiation
- 4 cm range shifter

Ancillary Beam Technique:
- PTV: 3-mm isotropic expansion of the CTV
- Implementation of the ABT

RESULTS

- Both approaches yielded an optimal nominal plan. On the other hand, the ancillary beam method, together with the PTV, offered a homogeneous and robust dose distribution throughout the whole craniospinal axis.

Robust optimization:
A dose gradient was obtained through the junction, but the dose distribution for each individual beam was highly inhomogeneous in the anterior-posterior and left-right directions. Therefore, the plan was not robust to setup uncertainties in those directions.

Ancillary Beam Technique:
A dose gradient was obtained through the junction and a homogeneous and robust dose distribution was obtained throughout the whole craniospinal axis.

Step 1
Step 2
Step 3
Final dose distribution

In step 1 the ancillary beams are placed and then used to inversely plan the brain and central spinal beams in step 2. In step 3 the ancillary beams are removed. The brain and central spinal beams are switched on during the optimization of the upper and lower spinal beams to obtain the final dose distribution [2].

CONCLUSION

- The ancillary beam technique offered a superior plan quality and it is therefore the recommended solution to plan CSI irradiations in a Proteus®ONE proton therapy gantry.

References: