New combined proton-photon strategy for dose escalation in clivus chordoma irradiation.

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INTRODUCTION

Clivus chordoma is a recognized indicator for proton therapy treatment [1]. Dose escalation is very challenging in this localization due to chiasmatic, optic nerves and brainstem proximity and their low dose tolerance. The idea of this work is to dosimetrically test different treatment techniques available at Centre Antoine Lacassagne (Nice, France) to reach the therapeutic dose (72-74 Gy RBE), including proton therapy single-field uniform dose (SFUD) and intensity modulated proton therapy (IMPT) both for sequential and integrated boosts (SIB) and stereotactic body radiotherapy (SBRT) (Cyberknife®) for sequential boost.

For the boost, the hypothesis was that SBRT could achieve better coverage and conformity than IMPT.

MATERIAL AND METHODS

10 patients with a clivus chordoma were included in this study.

Protontherapy SFUD and IMPT plans were computed with RayStation 6.0 (RaySearch Laboratories, Sweden) and realized with a CTV-based robust optimization with parameters as follow: 3% of the range for range uncertainties and 3 mm for metric uncertainties (patient positioning, contouring, robot couch accuracy...).

SBRT treatments were planned with Multiplan (Cyberknife®, Accuray, USA).

Plans were calculated for sequential boost with proton SFUD, IMPT and SBRT with 50.4 GyE (1.8 GyE/fraction) delivered to the low risk CTV (LRCTV) and 23.4 GyE (1.8 GyE/fraction) for PT plans or 22 GyE (2 GyE/fraction) for SBRT plans delivered to the high risk CTV (HRCTV). SIB plans were computed to deliver 73.5 GyE (2.1 GyE/fraction) to the HRCTV, the LRCTV receiving 56 GyE (1.6 GyE/fraction). SBRT was not used for the planning of the low dose CTV because of its large size.

OAR dose constraints were evaluated following the ICRU91 and ICRU78 recommendations for SBRT and protons plans respectively. All plans are clinically deliverable and respect the OAR constraints – differences between the plans are about tumor coverage, conformity and homogeneity.

RESULTS

An example of DVH obtained for 3 different techniques is shown for one patient in Figure 1 and the corresponding isodoses are shown in Figure 2.

In general, plans comparison showed that IMPT SIB achieved better tumor coverage for the boost than SFUD SIB (50.8% vs 70.9% for the example patient shown in Fig.1 and Fig.2); this was also better than sequential SFUD (60.4% vs 70.9%); the best tumor coverage was however reached with SFUD + SBRT technique (80.2% tumor coverage for the example patient).

For the 10 patients included in the study, Figure 3 shows clearly that in average, IMPT-SIB achieved the best tumor coverage for Low Risk CTV and High Risk CTV for protons-only plans. However, the best tumor coverage for both volumes was reached for the combined proton-photon technique including SBRT.

This tendency was observed for 7 patients over 10. The 3 other patients presented a large High Risk CTV not suitable with SBRT irradiation conditions, and the SIB strategy was adopted.

CONCLUSIONS

7 over 10 patients were treated with the SBRT technique to reach the therapeutic dose of 73.8 Gy RBE for dose escalation in the High Risk CTV in addition to the proton SFUD irradiation for the low risk volume, due to the better coverage of the high dose CTV, while respecting the constraints of the critical OAR (brainstem, chiasma, optic nerves). In the future months, proton IMPT plans will be used for the low risk CTV irradiation and Monte-Carlo calculation will be used for both SBRT and proton plans computation.