

GRADIENTNA TEHNIKA PRI OBSEVANJU KRANIOSPINALNEGA PODROČJA Z UPORABO VOLUMETRIČNE LOČNE TERAPIJE

SEGMENT GRADIENT BASED TECHNIQUE FOR CRANIOSPINAL IRRADIATION WITH VMAT

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IZVLEČEK

Uvod in namen: Namen prispevka je predstaviti prednosti volumetrično modulirane ločne terapije (VMAT, angl. volumetric modulated arc therapy) in uporabo gradientne tehnike (tj. tehnika, pri kateri ustvarimo postopno padajoč dozni profil žarkovnega snopa) pri obsevanju kraniospinalnega področja (CSI, angl. craniospinal irradiation). V nadaljevanju prispevka je predstavljeno tudi preverjanje kakovosti obsevalnega načrta pred obsevanjem (QA, angl. quality assurance).

Metode: Za namen raziskave sem izdelal osnoven obsevalni načrt VMAT s tremi izocentri. Vsakemu izmed izocentrov sem pripisal dva para prekrivajočih se ločnih žarkovnih snopov. Žarkovni snopi so zajeli področje glave in dve spinalni področji. Z namenom pridobitve postopno padajočega profila doze, sem v področju prekrivanja žarkovnih snopov ustvaril deset dodatnih segmentov oz. kontur znotraj planirno tarčnega volumna (angl. planning target volume). Vsa področja z ustreznimi žarkovnimi snopi sem ločeno dozno optimiziral. Najprej sem optimiziral področje glave in spodnji spinalni predel, naknadno pa še zgornje spinalno področje in pri tem upošteval dozno porazdelitev že optimiziranih predelov. Za ovrednotenje občutljivosti oz. robustnosti (angl. plan robustness) obsevalne tehnike na premike pri nastavitvi pacienta (angl. set up errors) sem simuliral $\pm 3,5$ in 10 mm

premike v longitudinalni smeri. Normalizirane dozne profile (% PDD) obsevalnih načrtov s simulacijo premika sem primerjal z osnovnim obsevalnim načrtom.

Ustreznost prvotnega obsevalnega načrta sem preveril s primerjavo načrtovane in izmerjene doze. Za analizo sem uporabil gamma kriterij (γ), (ang. Gamma index), z nastavitvami 3 % v dozi (DD, angl. dose difference) in 3 mm v oddaljenosti (DTA, angl. distance to agreement) med točkama primerjave.

Rezultati: Simulacija premikov pri nastavitvi pacienta ± 3 , 5 in 10 mm v longitudinalni smeri rezultira v $\approx 6,7$ in 16 % razliko v % PPD glede na osnoven obsevalni načrt. Pri analizi načrtovane in izmerjene doze je 98,8 % merjenih točk manjših od γ vrednosti 1.

Zaključek: Uporaba tehnike VMAT z gradientnim pristopom pri obsevanju kraniospinalnega področja omili dozimetričen učinek, ki nastane kot posledica napake pri nastavitvi pacienta. Analiza dozne porazdelitve kaže na ustrezno ujemanje izračunane in izmerjene doze.

Ključne besede: obsevanje kraniospinalnega področja, volumetrično modulirana ločna terapija, tehnika gradientnega pristopa, napake pri nastavitvi pacienta, robustnost

ABSTRACT

Introduction and purpose: To present advantages of volumetric modulated arc therapy technique (VMAT) with "segment gradient based approach" for craniospinal irradiation (CSI) and associated pre-treatment quality assurance procedure.

Methods: A three isocenter VMAT plan was designed. Each isocenter contained two pairs of overlapping partial arc fields that covered the cranial and two spinal parts. In the overlapping regions, an additional 10 segments were contoured in order to obtain a gradually decreasing dose profile. All parts (cranial and two spinal) with associated partial arc fields were optimized separately. Cranial and lower spinal parts were optimized first. Subsequently, upper spinal part was optimized by taking into account the dose contribution from previously optimized parts. To investigate plan insensitivity against the set up errors $\pm 3, 5,$ and 10 mm, longitudinal shifts were simulated. Normalized dose difference profiles (%PDD) with original plan were evaluated.

For plan verification phantom dose was calculated and compared with the measured dose. Analysis was performed using gamma index (γ) criteria with settings 3% of dose difference (DD) and 3mm of distance to agreement (DTA).

Results: Simulating set up errors $\pm 3, 5$ and 10 mm in longitudinal direction % PPD versus the original plan, were $\approx 6,7$ and 16% , respectively. Plan verification dose analysis revealed that 98.8% of measured points were within γ index < 1 .

Conclusion: The VMAT with "segment gradient based approach" for CSI has turned out to be a favorable technique in terms of its robustness to set up errors. Dose distribution analysis showed an appropriate calculated and measured dose matching.

Keywords: craniospinal irradiation, gradient based approach, set up errors, robustness

LITERATURA / REFERENCES

- Bartlett F, Kortmann R, Saran F. Medulloblastoma. *Clinic. Oncol.* 2013; 25: 36-45.
- Cao F, Ramaseshan R, Corns R, et.al. A Three-Isocenter Jagged-Junction IMRT Approach for Craniospinal Irradiation Without Beam Edge Matching for Field Junctions. *Radiation Oncology.* 2012 (82); 648-654.
- Depuyt T, Van Esch A, Huyskens P. A quantitative evaluation of IMRT dose distributions: refinement and clinical assessment of the gamma evaluation. *Radiotherapy and Oncology.* 2002 (62); 309-319.
- Fogliata A, Bergstrom S, Cafaro I, et.al. Cranio-spinal irradiation with volumetric arc therapy: A multi-institutional treatment experience. *Radiotherapy and Oncology.* 2011 (99); 79-85.
- Hadley A, Ding G. A single-gradient junction technique to replace multiple-junction shifts for craniospinal irradiation treatment. *Medical Dosimetry.* 2014 (39); 314-319.
- Leman J, Late effects of craniospinal irradiation for standard risk medulloblastoma in paediatric patients: A comparison of treatment techniques. *Radiography.* 2016: 1-5.
- Low D, Harms W, Mutic S et. al. A technique for quantitative evaluation of dose distributions. *Medical Physics.* 1998 (25); 656-661.
- Mayers P, Stathakis S, Mavroidis P, et al. Evaluation of localization errors for craniospinal axis irradiation delivery using volume modulated arc therapy and proposal of technique to minimize such errors. *Radiotherapy and Oncology.* 2013 (108); 107-113.
- Parker W, Freeman C. A simple technique for craniospinal radiotherapy in the supine position. *Radiotherapy and Oncology.* 2006 (78); 217-222.
- Seppala J, Kulmala J, Lindholm P, et. al. A method to improve target dose homogeneity of craniospinal irradiation using dynamic split field IMRT. *Radiotherapy and Oncology* 2010. (96); 1193-8.
- Strojnik A, Mendez I, Peterlin P. Reducing the dosimetric impact of positional errors in field junctions for craniospinal irradiation using VMAT. *Oncology and Radiotherapy.* 2016 (21); 232-239.
- Wang K, Huipeng M, Chen J, et.al. Plan quality and robustness in field junction region for craniospinal irradiation with VMAT. *Physica Medica.* 2018 (48); 21-26.