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The pilot study of on-site end-to-end IMRT audit in radiotherapy in the Czech Republic with the head anthropomorphic phantom

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Introduction

In the Czech Republic, intensity modulated radiation therapy (IMRT) became a standard type of treatment. Each centre has established the quality controls for IMRT plans but these controls can miss some aspects because they are not “end-to-end” tests. National Radiation Protection Institute in Prague (NRPI) has developed a tool for comprehensive verification of IMRT head plans.

Material and Methods

Anthropomorphic head phantom including bones, soft tissues, and cavities was adjusted for the purposes of the audit.

Apertures for chambers were drilled and volumes were marked out in the phantom to distinguish PTV and OARs unambiguously. Structures are always the same to all centres.

Two treatment sites can be verified separately (nasopharynx and glioblastoma).

Verification of point doses with ionization chambers (Semiflex 0.125cc) and planar doses with films (EBT3) in PTV and organ at risk can be performed as well as planning process control.

Material and Methods

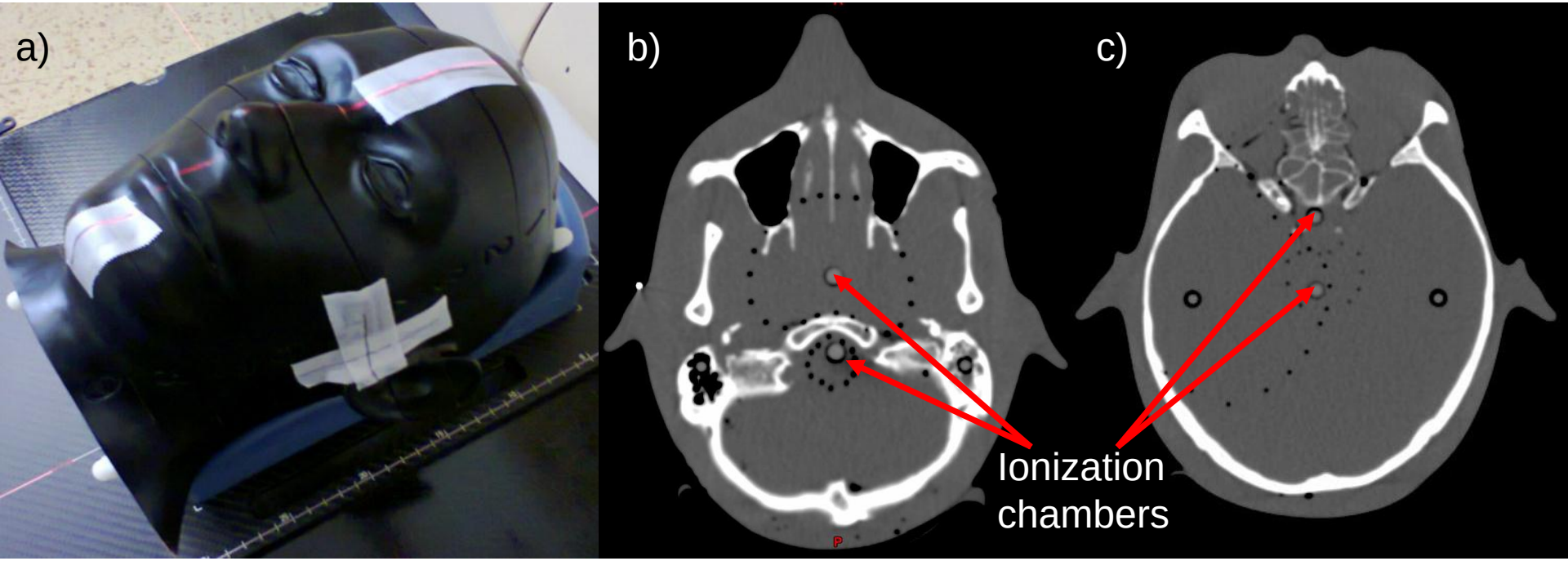

Fig. 1: a) Head phantom customized for the purposes of NRPI end-to-end test; b) Transversal plane with holes indicating PTV nasopharynx and brain stem, two larger apertures with PMMA fillings indicate position of ionization chambers; c) Transversal plane with holes indicating PTV glioblastoma overlapping with brainstem, two larger apertures with PMMA fillings indicate position of ionization chambers (in PTV overlapping region and chiasma opticum).

PTV Nasopharynx

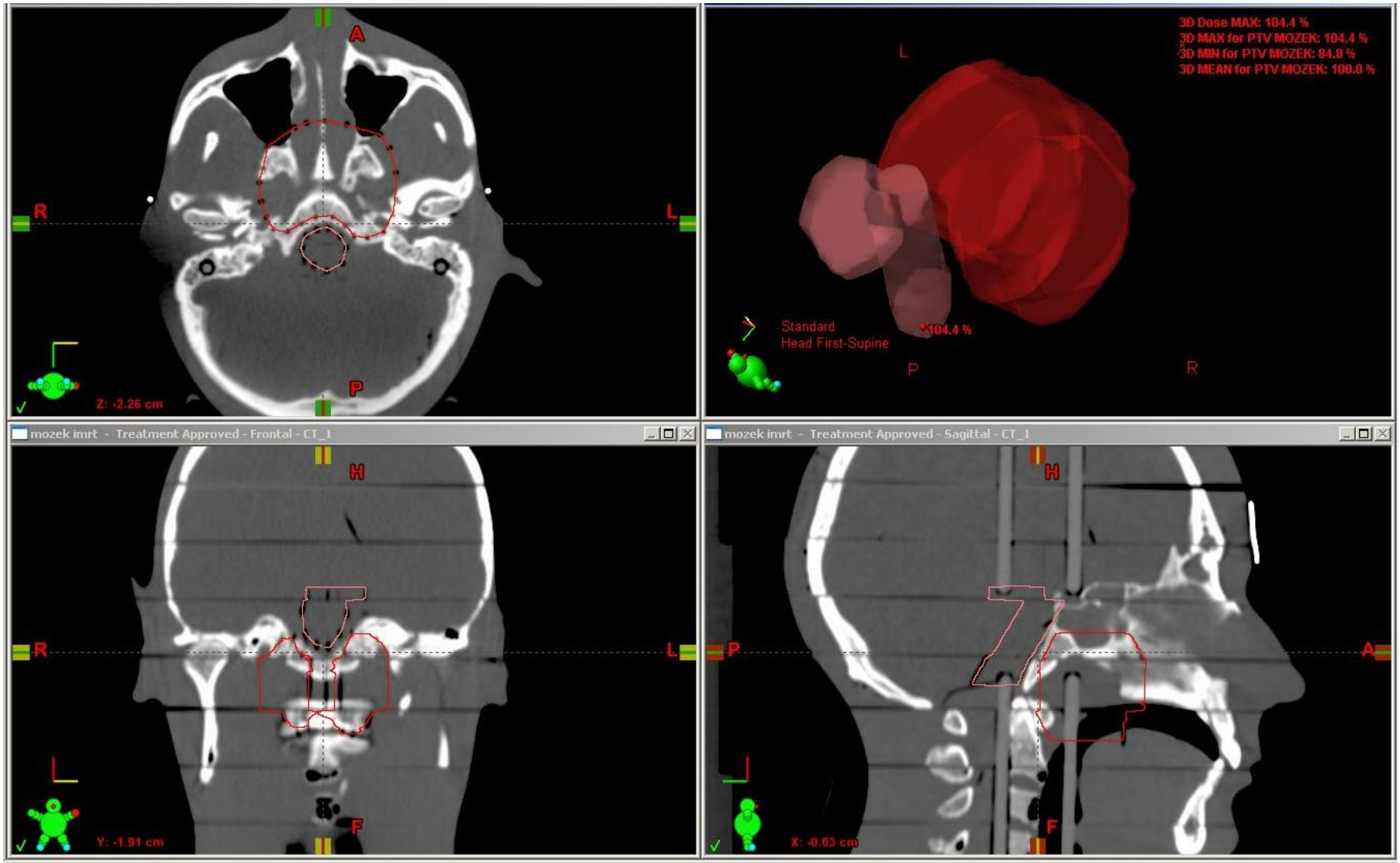

Fig. 2: Contours and 3D Model View for PTV nasopharynx and Organ at Risk Brain Stem. Air cavities are included in the PTV.

PTV Nasopharynx

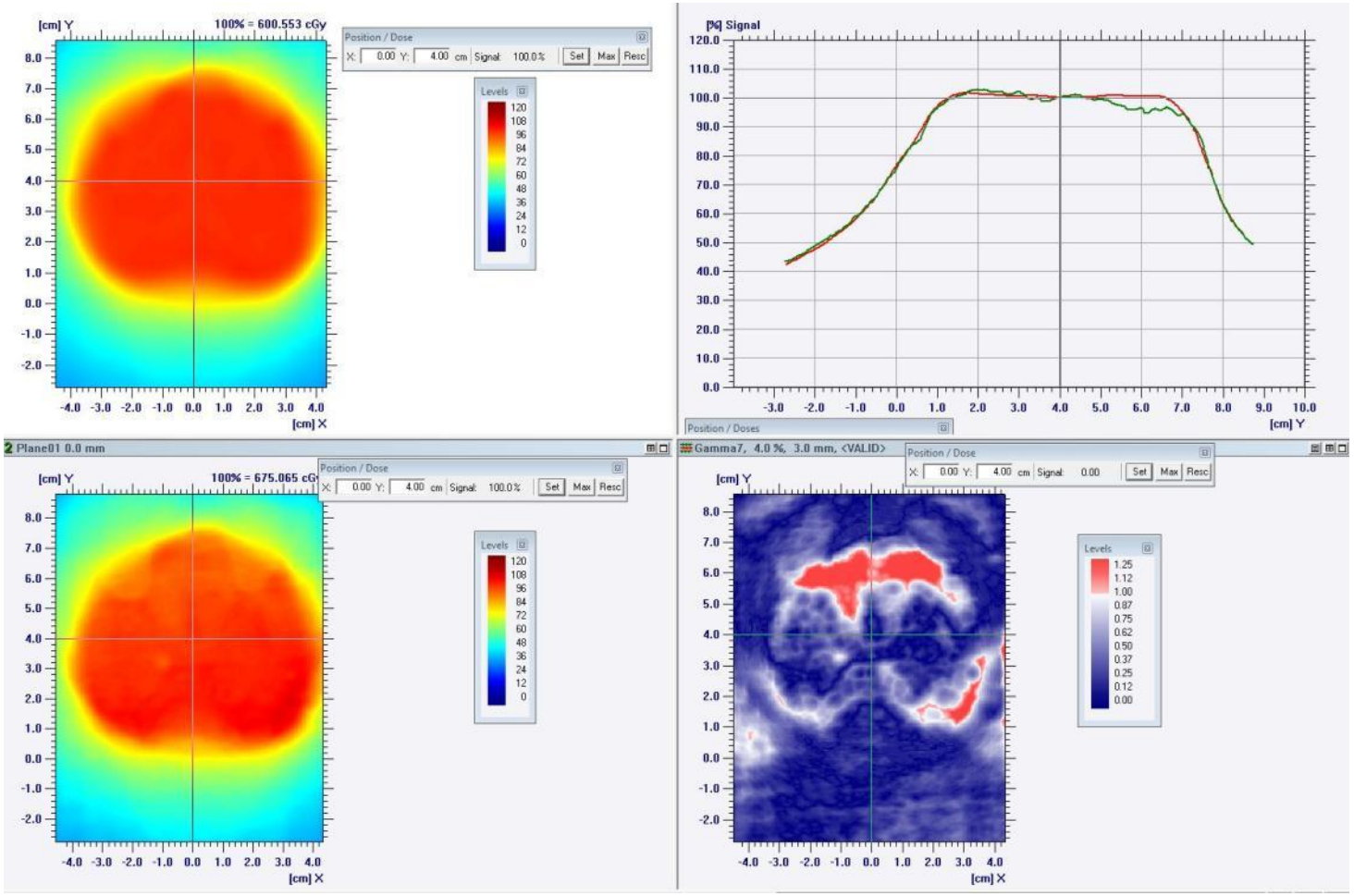

Fig. 3: Film results show the influence of dose algorithm accuracy in present of inhomogeneities (OmniPro software was used for gamma analysis, left up – dose map from TPS, left down – film dose map, right down – gamma map; in the upper part of PTV, inaccurate dose calculation in the present of air cavities is visible).

PTV Glioblastoma

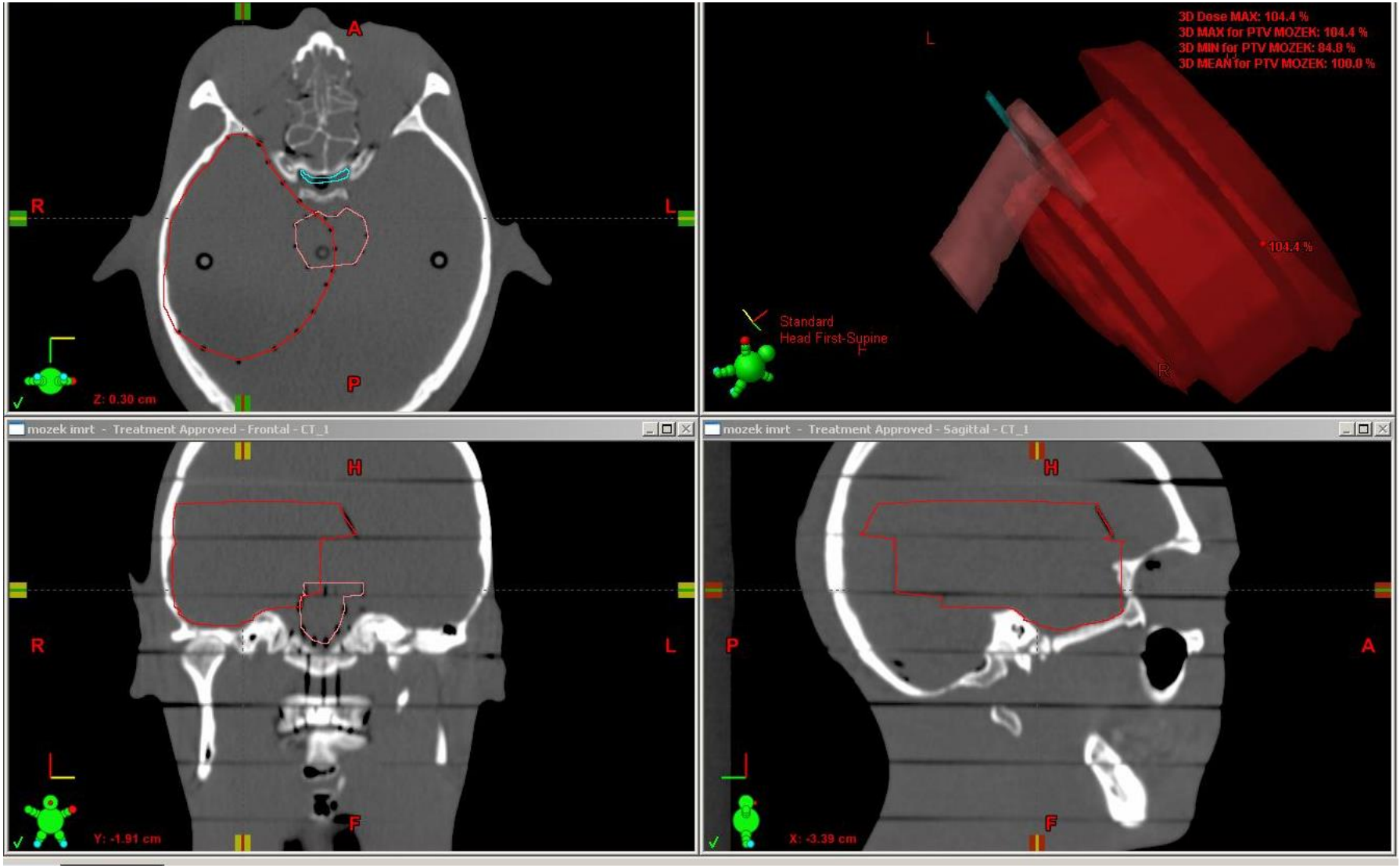

Fig. 4: Contours and 3D Model View for PTV Glioblastoma and Organs at Risk Brain Stem and Chiasma Opticum.

Results

Within pilot study, 6 centres were audited with various treatment units:

- Tomotherapy (2x, both in TomoHelical mode)
- Varian Clinac 2100 C/D (Sliding window IMRT)
- Varian Clinac DHX (Sliding window IMRT)
- Elekta Synergy (VMAT)
- Leksell Gamma Knife (Perfection)
- IBA Proton (Proteus 235 Proton Pencil Beam Scanning System)

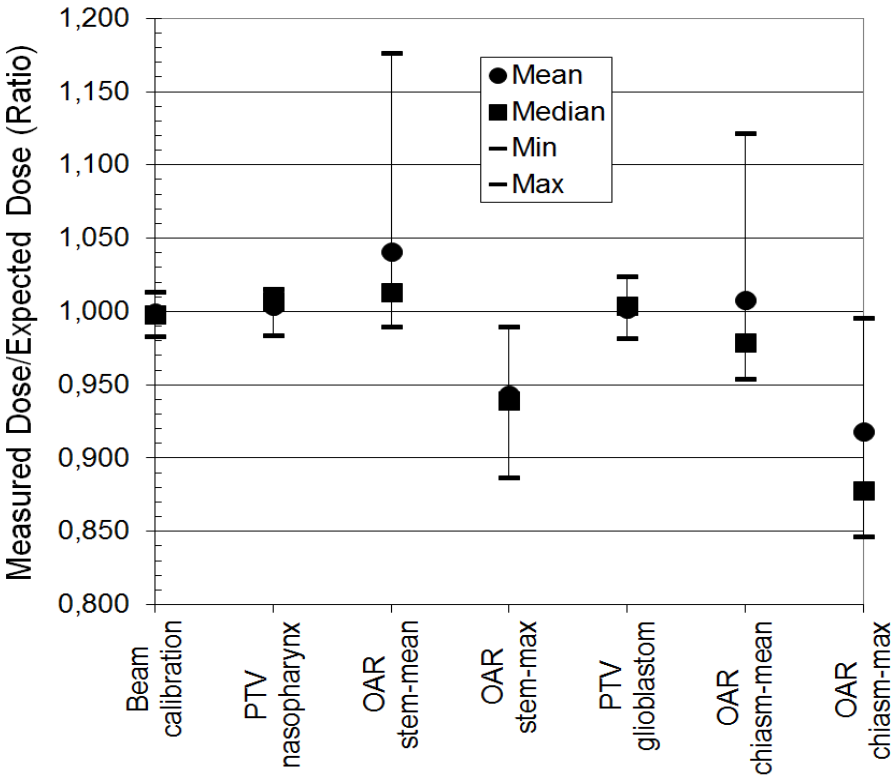

Fig. 5. Ratios of measured to expected doses for PTVs and OARs for audited photon beams. Gamma score for photon beams when maps best matched with 4%/3 mm criteria was usually > 90% (if smaller, problem identified and audit repeated).

Suggestions to audit design

- We don´t use point dose evaluation but volume characteristics for the chamber sensitive volume: mean dose, maximum dose (especially for OARs in large dose gradients). Volume, where chamber cavity will occur, is contoured as a structure based on PMMA inserts visible on CT phantom scan.
- Tolerances were set based on pilot study results but serve only as quick indicator. All results are evaluated carefully and in the context of other results.
- RTT or other specialty who is responsible for patient set-up is recommended to participate at the audit. Large uncertainties arose from the inaccurate (or absolutely wrong in one case) phantom set-up on the treatment couch.
- On the phantom, any positioning marks are not provided to the centre. Phantom set-up is challenging as it is really close to the patient geometry so there is a high degree of probability that head will be rotated in all axes. Due to limited possibility of oblique dose plane export from various TPS, phantom slices should be positioned orthogonally to the couch except proton audit, where phantom must be rotated to minimize film energy dependence for proton beams.
- EBT3 films enabled to be loaded in the phantom prior the audit and could be CT scanned as the sensitivity to kV radiation was negligible. Verification set-up images (2D, 3D with kV beams) are allowed to the centre.
- Verification of beam calibration in water is part of the audit to assess daily output fluctuation as well as accurate inhomogeneity and phantom material correction by the treatment planning system.
- DVHs, structure volumes, CT numbers, and REDs are evaluated as a part of the audit.

Conclusion

Methodology of end-to-end head audit has been tested within the pilot study at 5 centres with photon beams (C-arm accelerators Varian and Elekta, Tomotherapy units, Leksell Gamma Knife) and one centre with proton beams.

The audit can be performed globally. It can evaluate various steps in the radiotherapy chain. The results might show interesting intercomparison among centres covering dosimetry part of treatment as well as differences in contouring standards, planning standards, plan evaluation parameters, patient set-up accuracy.

Authors have no potential conflict of interest to disclose.