Treatment Planning for Pituitary Adenomas – A Comparison of Flatness Filter Free and Flat Beam Plans

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Introduction

Radiotherapy of pituitary adenomas is often applied as postoperative therapy of tumors that cannot be removed completely. Fluence modulating techniques like IMRT or VMAT support the use of the flatness filter free (FFF) mode in modern linear accelerators. In this mode a considerably higher dose rate is achieved by omitting the flatness filter. This planning study compares different plans for patients with pituitary adenoma. The plans were optimized using both modes: flattened beam (FB) and FFF. The aim of this study is to evaluate the plan quality.

Material and methods

Data sets of 11 patients with pituitary adenoma were used for this retrospective planning study. The objectives for the PTV were set to a minimum dose of 49.4Gy and a maximum dose of 51.4Gy in 28 fractions, aiming for a fraction dose of 1.8Gy. Further objectives were set for the following regions of interest (ROI): brain, brainstem, chiasm, and both lenses, bulbs, lacrimal glands, and parotids (table 1). The planning was performed with the treatment planning system (TPS) Oncentra External Beam v4.5 (Elekta AB, Sweden) using the collapsed cone algorithm. In both modes (FB and FFF) IMRT plans with nine equispaced coplanar fields were generated (IMRT9); in a second variant a tenth non-coplanar field was added (IMRT10). Similarly two VMAT plans were optimized: one single arc rotation (182°-178°)(VMAT1), and the second with an added half rotation in the sagittal patient plane (0°-180°)(VMAT2). The applied linac Synergy Agility (Elekta AB, Sweden) offers a dose rate of 550MU/min (FB) and 1700MU/min (FFF). The leaves have a width of 5mm projected to the isocenter.

Organ at Risk	max Dose in Gy	max Volume in %
Brain	20	20
	30	10
	40	5
Brainstem	51.4	0
Chiasm	50	0
Lens	15	0
Bulb	35	50
Lacrimal gland	20	50
Parotid	30	50

Table 1. Treatment Planning Objectives

The following parameters were evaluated: the average dose D_{Av} to the PTV, homogeneity index HI, and the conformity index CI. For all plans the observance of the objectives for the organs at risk given in table 1 was investigated. The data were analyzed with SPSS® (IBM, USA) to generate diagrams and visualize statistical parameters.

Results

For both modes FB and FFF the dose volume statistics are very close. With some minor exceptions the objectives for the ROIs are met. Only the maximum dose to the chiasm is slightly exceeded in most cases, as it is part of the PTV. Regarding the PTV (HI and CI) pronounced differences are found in the comparison of IMRT and VMAT (diagram 1 and 2) showing a benefit for VMAT. The distinction between coplanar and non-coplanar techniques is less important.

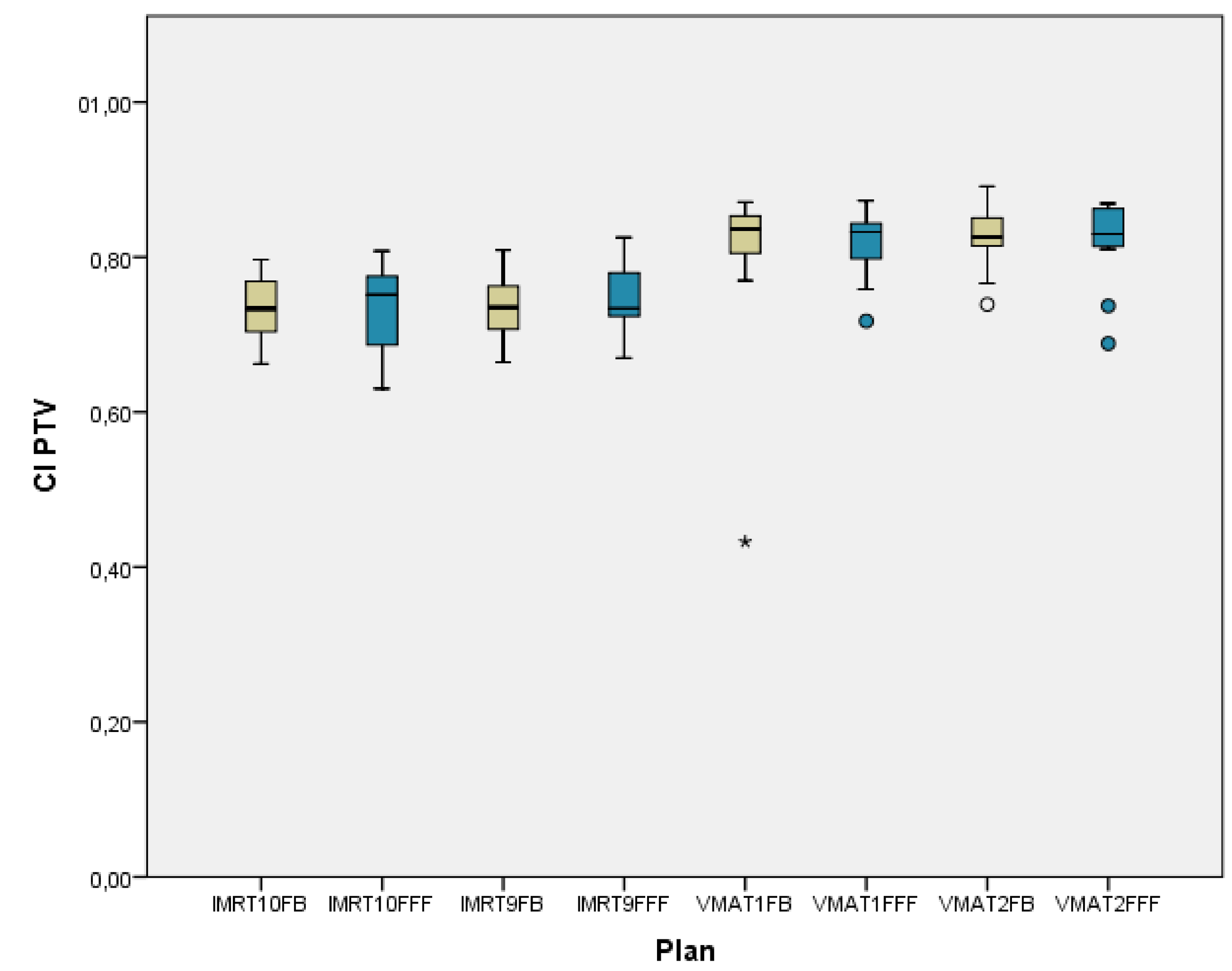

Diagram 1. Boxplot of the conformity index CI of the different plan variants, showing mean value, inner quartile (box) and outer quartile (bar), and a few outliers (circles) and extreme value (asterisk). FB yellow, FFF blue.

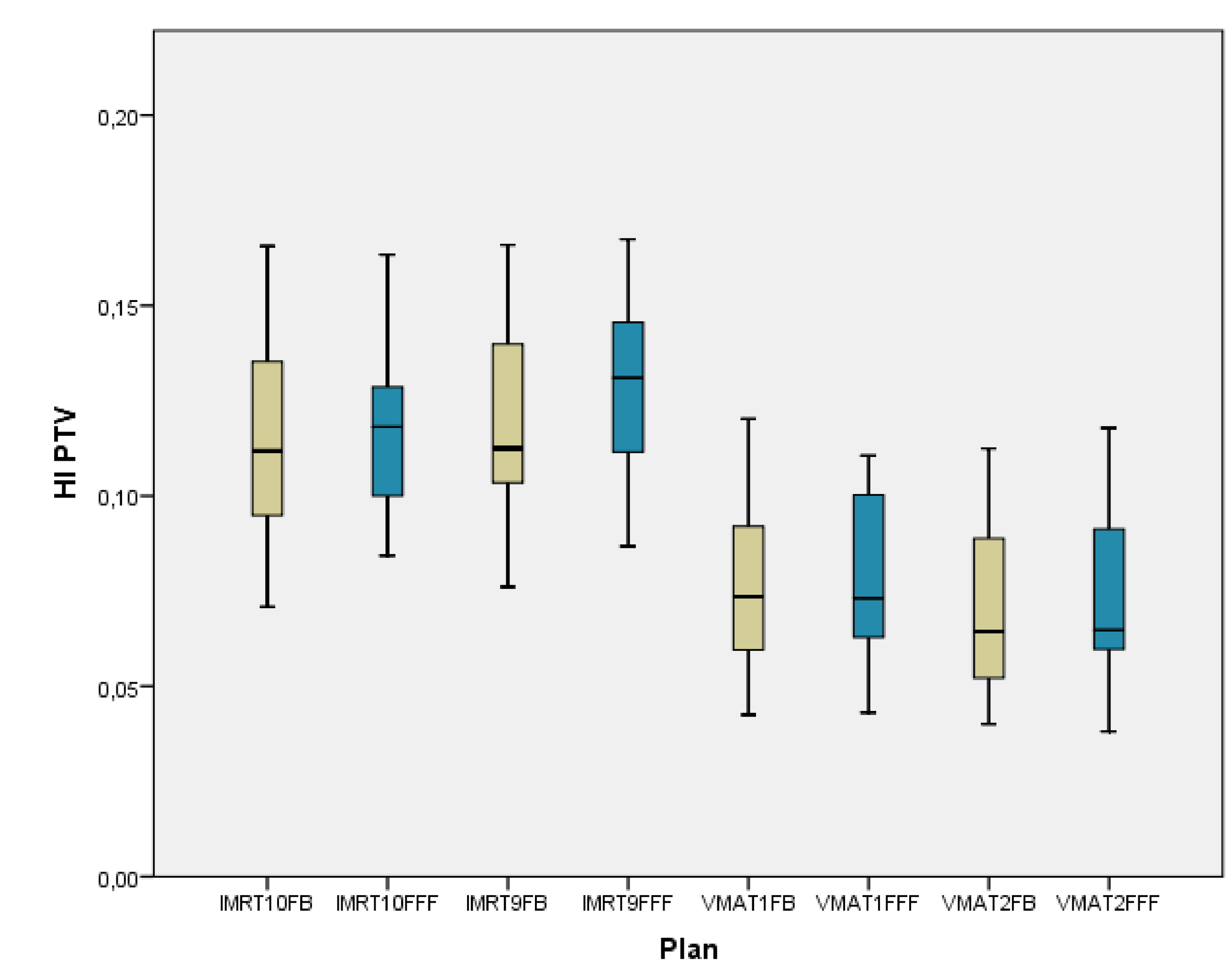

Diagram 1. Boxplot of the homogeneity index HI of the different plan variants, showing mean value, inner quartile (box) and outer quartile (bar). FB yellow, FFF blue.

Discussion

The difference in the plan quality of FB and FFF plans is of no clinical importance. A decision for the preferred treatment technique will therefore be taken based on measurements of the delivery time and peripheral dose which will follow. As the plan quality of VMAT is superior to IMRT, the decision will be made between VMAT FB and VMAT FFF. All non-coplanar techniques will require more linac time due to couch rotations without showing advantages in plan quality.

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