

# A Study on the Comparison of Planned and Delivered Dose Volume Histogram for VMAT Patients

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**Abstract**—The objective of this study is comparing the planned and delivered Dose Volume Histogram (DVH) for Volumetric Modulated Arc Therapy (VMAT) patients. Using “DVH 4D” option provided by the software Veri Soft with the help of Octavius 4D phantom, DVH of all selected plans are compared. The tool DVH is used to compare doses from different plans or structures. The DVH curve is a plot of graph showing percentage volume of structure on Y-axis and dose in term of Gy on X-axis. VMAT techniques that delivered conformal radiation to the target volume. These techniques require complex Treatment Planning System (TPS) algorithms as well as sophisticated irradiation methods. As a result, the use of quality assurance tools for the verification of the planned dose distribution prior to the treatment of the patient is required for all VMAT cases. In this study, we have used OCTAVIUS detector 729, which is a 2D array of ion chambers used for pretreatment verification and QA. All the measurement is done in Elekta Versa HD Linear accelerator. For this study Ca. Breast, Head and neck case, Pelvic, were selected and planned with VMAT. Compared the dose obtained from TPS and from the patient specific QA.

**Keywords:** DVH, Octavius Phantom, Patient-Specific QA.

## I. INTRODUCTION

In Volumetric Modulated Arc Therapy (VMAT) technique dose is delivered dynamically with Multi Leaf Collimator (MLC) as gantry rotated in the form of arc, based on the treatment plan MLC shapes the tumor and dose rates. The aim of the delivery technique is to easily attain Tumor Control Probability (TCP) and reduce Normal Tissue Complication Probability (NTCP) and it has high monitor unit (MU)

calculation and treatment delivery efficiency [1]-[4], [5]-[7].

This project shows the comparison of delivered and planned Dose Volume Histogram (DVH) for VMAT patients. The use of DVH is to compare doses from different plans or structures. It is also used as plan evaluation tool. It is representation of the 3D dose distributions in a graphical 2D format [8], [9]. The main purpose of patient specific Quality Assurance (QA) is to ensure that the overall performance of the machine is good or not [10],[11]. In this study, we have used OCTAVIUS detector 729, which is a 2D array of ion chambers used for pretreatment verification and QA. All the measurement is done in Elekta Versa HD Linear accelerator.

For this study each Ca. Breast, Head and neck case, Pelvic, are selected and planned with VMAT. Compared the dose obtained from TPS and from the patient specific QA. The Monaco system is used to planning selected cases. It optimizes the plan using biological models [12], [6]. The quality of the treatment plan depends on the number of sectors used for planning [4].

To comparing two dose distributions gamma analysis is the common method used widely, taking into accounts both dose and spatial differences between them. It gives information about a numerical quality index, gamma value ( $\gamma$ ), it is used to measuring disagreement in the regions that shows the acceptance criteria fall to fail and shows acceptance criteria falls to pass [10], [13], [9]. For analyzing the gamma values the sphere having value unity indicates that region where the comparison test passes.

Thus, it shows the test passes only if the reference distribution is inside the unit sphere, otherwise it shows fails [6].

## II. MATERIALS AND METHODS

In this study all the CT simulation and treatment planning has done using Monte Carlo algorithm in Monaco Treatment planning system. All cases 6 MV photon energy is used. To the accurate measurement of dose distribution in patient Monte Carlo algorithm is used.

The Monaco treatment planning system uses Monte Carlo dose calculation algorithm with delivering technique has greater accuracy, high performance and high precision. It is used in photon based and electron-based plans. The system optimizes dose distributions in two stages. The optimization of ideal fluence distribution of the beam is carried out in first stage and segmentation is carried out in second stage. Monaco has unique features such as biological constraint optimization and physical constraint optimization. user can change the calculation, accuracy and time of the treatment by changing parameters such as dose rate, Monte Carlo grid spacing and variance [14], [4].

A total number of 15 patients with cancers in Brain, Head and Neck and Pelvic cases are planned with VMAT technique. The QA plans are made for all 15 cases and transferred to the Octavius 4D phantom and done patient specific QA.



Fig: 1 Array Detector 729

The Octavius 4D phantom with detector 729 are used to patient-specific QA. Detector Seven29 consists of 729 vented plane-parallel ion chambers located in a matrix on 27 x 27cm. it has an advantage of large field coverage and gold standard ionization chamber are used. Wireless Inclinometer is a device used to measure the gantry angle, and it measures the dose relative to time or gantry angle.

The Veri Soft (PTW, Freiburg, Germany) is a software package for data acquisition and analysis of the measured dose volumes. The Software acquires the dose inside the entire, cylindrical volume and allows dose planes to be extracted for the further analysis. All gamma analyses were done with Veri soft. Only with the help of DVH analyzing software tool “DVH 4D” we can analyze the DVH curves for various plans with help of Software called Veri Soft [15], [16].

Elekta HD Versa is a machine with photon energy 6MV, 10 MV, 15 MV, 6 MVFFF, 10 MVFFF and electron energy 4 MeV, 6 MeV, 8 MeV, 10 MeV, 12 MeV and 10 MeV. It has 80 pairs of multi leaf collimators (MLC) which has a width of 5 mm and deliver two times faster than other MLC. 3DCRT, IMRT, VMAT, SRS, SBRT technique can be executed with LINAC [17]-[19].

The verification of dose distribution within a real patient is not possible, so to verify we use phantom substitute method. In the planning system we will transfer the patient plan to the phantom either field by field or all together. The dose distribution of the patient plan is recalculated in the phantom without changing any relevant parameters. A QA plan for approved plan will be made and will be transferred to the PTW dosimetric laptop. The phantom, which is equipped with appropriate dosimeter, in this case 2D array seven29 is irradiated with IMRT fields of real patient plans without changing any relevant parameters The measured dose compared with the approved plan which will be delivered on the PTW Octavius detector [16]. All measurements are done on Elekta HD Versa with 6 MV photon. The detector, OCTAVIUS Seven29 along with OCTAVIUS 4D phantoms was used in this study.



Fig:2 standard setup of patient specific QA with Octavius 4D

During the delivery of dose through factor the cylindrical phantom rotates with a detector panel synchronously with the gantry of accelerator, to eliminate the application of angular correction factor [16]. The Mephisto PTW Veri Soft software was used to collect the data from the OCTAVIUS 4D detector. Before all measurements of delivering known dose, a warmup is given for a 24 cm × 24 cm field size under reference conditions. The expected gamma index passing rates calculated in Veri Soft. with 3%/3 mm. All the three spatial dimensions and reference level methods like maximum, local dose and volume analysis, gamma passing rates are checked [20], [21]. With the help of a DVH 4D option, it calculates DVHs according to the patient anatomy, patient contours and densities derived from the patient's CT. The comparison of DVHs is carried out by comparing the DVHs calculated by "DVH 4D" with the DVHs calculated by the TPS. Cumulative DVHs of PTV and OAR can be calculated within 5 min and minimum, maximum and mean doses for each structure are displayed from RT Structure. The dose absorbed to each point of a given structure can be calculated. DVH calculation takes very little time and DVH curves can be saved for further references or printouts.

III.RESULTS AND DISSCUSSION

All the 15 cases are compared with parameters such as conformity number, Homogeneity Index, gamma analysis and planned and delivered DVH for selected cases.

Calculation of Conformity Number (CN) is defined as follows:

$$CN = (TVRI / TV) \times (TVRI / VRI)$$

Where CN is the confirmation number, TVRI is the reference isodose covering the target volume, TV is the volume of target and VRI is the volume of reference isodose. The TVRI/TV provides the coverage of the target volume, TVRI/VRI the dose received by the given volume of tissue that is greater than or equal to the prescribed reference dose. The CN varies from 0 to 1. The ideal value is 1. The value near to zero indicates that the target volume is not irradiated. Homogeneity index (HI) can be calculated using formula

$$HI = (D5\%)/(D95\%)$$

Where D5% and D95% are minimum dose to 5% and 95% of the target volume respectively. The ideal value of HI is 1. If HI is closer to 1, Homogeneity of dose distribution is good and if the value of HI is more than 1 the homogeneity of dose distribution becomes less.

The statistical analysis of all 15 cases in terms of conformity, homogeneity number and gamma passing analysis are shown in table 1& 2. Gamma 2D Analysis of 15 cases are tabulated in table 2 with 3 for 3mm DTA, 3% DD% has a pass percentage greater than 90 % for evaluated dose points.

Parameters	Cases	Planned	Delivered	P-Value
Homogeneity-index	Brain	1.106±0.03	1.087±0.02	0.020
	Head & Neck	1.075±0.02	1.099±0.07	0.267
	Pelvic	1.079±0.01	1.100±0.02	0.019

Table1: Statistical analysis of Homogeneity number

Parameters	Cases	Value
Conformity number	Brain	0.689±0.081
	Head & Neck	0.703±0.047
	Pelvic	0.753±0.065
Gamma passing rates	Brain	98.64±1.253
	Head & Neck	98.64±1.113
	Pelvic	96.86±3.482

Table: 2 statistical analysis CN & Gamma passing rates.

All the 15 cases are evaluated using mainly in the term of DVHs and different parameters such as conformity index, homogeneity index, and gamma passing rates. Table 2 shows average gamma pass rates here were 98.64 ±1.25% for brain cases, 98.64 ± 1.13% for Head and neck cases and 96.86 ±3.48% for Pelvic cases. Most cases achieved good gamma pass rates higher than 98% except for one pelvic case with gamma pass rates of 90.5%, one Brain case with passing rates of 96.2% and one HN case of gamma passing rates of 96.5%.

IV.CONCLUSION

All 15 patients are planned with VMAT and done patient specific QA for each case with help of OCTAVIUS 4D phantom. The DVH comparison

showed that, in case of PTV delivered dose not below the planned one and in case of normal structures actual dose delivered not exceeded the planned one. The VMAT plan helped in achieving better homogeneity and conformity. All cases achieving better gamma passing rates. This study summarizes in the case of PTV, there is no significant difference in dose parameters but in the case of OAR's it shows significant differences.

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