Study of Physical and Dosimetric Aspects of Intensity Modulated Radiotherapy

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Abstract

The aims and objectives of this research work were; a) to study the dosimetric and quality assurance (QA) aspects of compensator based IMRT (cIMRT), b) to study Imatrixx utility for QA of IMRT, c) to study the dosimetric impact of photon beam energy on IMRT plans and to study and analyze the results of cIMRT for head and neck cancer.

The technical details of compensator material, design, milling, fabrication, dose calculations with regard to inverse treatment planning, QA and dosimetric results with regard to tumor coverage and normal tissue sparing are presented in Chapter 2 of the thesis. We have analyzed 48 patients' data, compensators revealed a deviation in central axis dose of 2% ±1.8% range was 0 to 7%, in terms of cumulative calculated versus measured dose. Target coverage was adequate in terms of volume receiving 93% and 95% of the prescription dose, which was 98.5% and 97.5% respectively. Parotid and other critical organs were spared adequately.

The results of a dosimetric evaluation of a 2D ionization chamber array (ImatriXX IBA Dosimetry, Sweden) with the objective of its implementation for quality assurance and dosimetric verification of segmental IMRT in the clinical environment are presented in Chapter 3 of the thesis. *In total 356 modulated beams were measured using ImatriXX. Dosimetric analysis was done using gamma, distance to agreement (DTA) and coefficient of correlation. We found that gamma and DTA were adequate in more than 97% of the studied beams with a 3% and 3 mm passing criteria. The coefficient of correlation was found to be 0.987 (SD 0.047).*

In the fourth chapter, we presented the effect of photon beam energy on the IMRT plans for cervix carcinoma. A cohort of 16 patients was selected for this study. All patients were planned to receive a 50 Gy dose in 25 fractions. IMRT plans were generated for 6 and 15 MV photon energies using the same dose-volume constraints. Our result showed comparable coverage of planning target volumes (PTV) for both energies. The volumes of the PTV receiving prescription dose is 97.82% (SD +0.50) and 98.8% (SD +0.43) for 6 MV and 15 MV plan respectively. The Volume of the PTV receiving a dose of 107% is 4.45% (SD +7.81) and

16.1% (SD +22.18) respectively. Bladder and rectum mean doses for 6 MV and 15 MV plans were 39.83 Gy (SD +3.06) and 40.06 Gy (SD +3.17) and 35.79 Gy (SD +3.14) and 36.01 Gy (SD +3.14) respectively. The Homogeneity Index (HI) for both energies was the same. Conformity index (CI 98) were 1.29 (SD +0.10) and 1.35 (SD +0.11) for 6 MV and 15 MV respectively.

In the fifth chapter, we have validated our results of cIMRT based on RTOG consensus guidelines for head and neck cancer. We have presented our results with special emphasis on the pattern of failure and its correlation with dosimetric parameters. At 2 and 3 years, the locoregional relapse-free survival rates were 68.3% and 60.8%, respectively, while the overall survival rates were 84.1% and 81.7%, respectively. There were no failures in the elective nodal volume, substantiating both the nodal selection criteria and the RTOG consensus guidelines for neck node level delineation.

In the sixth chapter, we have concluded that cIMRT is useful and presented its usefulness in terms of target coverage and organ at risk sparing. We have found MatriXX to be a useful device for IMRT pre treatment QA as it is time saving, efficient, easy to use and it can be used for both relative and absolute dose measurements. Our study indicated that 6 MV plans produce relatively less hot spots than 15 MV plans though the clinical impact of these dosimetric improvements remain unanswered. Our results revealed that 6 MV is a good choice of energy for IMRT plans. Our target selection and delineation approaches are validated in this analysis.

Keywords- IMRT, compensator, photon energy, quality assurance,

List of Publications-

1. **Tyagi A** , Nangia S, Chufal K, Mishra MB, Ghosh D., Supe SS, Singh MP. Quality Assurance and Dosimetric Analysis of Intensity Modulation Radiotherapy using Compensators for Head and Neck cancers. ***Pol J Med Phys Eng.*** 14(4), 193-208; 2009.

2. **Tyagi A**, Singh MP. Quality Assurance of Intensity Modulated Beam Using MatriXX. ***Med Phys***. 36 (6), 2578; 2009.

3. **Tyagi A,** Supe SS, Kaushik S, Singh MP. Influence of Photon Energy on Carcinoma of Cervix IMRT Plans. ***Int. J. Radiat. Oncol. Biol. Phys.*** 78(3), S761; 1 November 2010.

4. Nangia S, Chufal KS, **Tyagi A**, Bhatnagar A, Mishra MB and Ghosh D. Selective nodal irradiation for head and neck cancer using intensity modulated radiotherapy: Application of RTOG consensus guidelines in routine clinical practice. ***Int. J. Radiat. Oncol. Biol. Phys.*** 76(1), 146-153; 2010.

5. **Tyagi A**, Supe SS, Sandeep, Singh MP. A dosimetric analysis of 6 MV versus 15 MV photon energy plans for intensity modulated radiation therapy (IMRT) of carcinoma cervix. ***Rep Pract Oncol Radiother*** 15, 125-131; 2010.