CHAPTER 9

SUMMARY AND CONCLUSION

In complex treatment techniques like IMRT and volumetric modulated arc therapy, patient specific QA plays a key role of the treatment process because of the complexity of treatment plan, calculation and dose delivery. A small error can cause a large discrepancy in the radiation dose delivery.

Daily assessment of beam characteristics is mandatory to check the behavior of beams and to reduce the uncertainties in dose calculation and treatment delivery. Periodic MLC tests such as ionometric gravity test and dynalog file analysis are useful to rule out random and systematic MLC positional errors and ensure accurate delivery of the planned radiation dose to the target. The analysis of the daily measurements such as flatness, symmetry, beam quality factor and beam output showed good stability, with the values lying well within the tolerance level of < 3% throughout the study period. In 95% of the instances they were within +/- 2%. In quantification of MLC positional errors using ionometric gravity test and dynalog file analysis, the test results showed good consistency in the output of static and dynamic MLC fields in a period of one year. Test results for MLC positional errors were also well within the limits, specified in the published reports.

Establishing baseline performance characteristics of dosimetric equipment are essential before employing them in clinical use. The performance characteristics of an aSi1000 electronic portal imaging device and ImatriXX 2-D array system for patient specific QA measurements
were studied and baseline values were established. Dependence on source to detector distance (SDD), temperature, field size, dose rate, short term stability and dose linearity were studied and the results were comparable with ion chamber measurements. For all the parameters the correlation coefficient has shown good agreement and linear relationship with value of more than 0.9. Both aSi1000 EPID and IMatriXX 2-D array system were validated for patient specific QA measurements for IMRT and VMAT. The patient specific QA results obtained with the portal dosimetry system were found to be relatively more consistent compared to those obtained with ImatriXX 2-D array system.

In the study of the angular response characteristics of aSi1000 EPID and ImatriXX 2-D array system, Flatness, symmetry and output values measured at gantry angle increments of 10 degrees for a 10x10 cm\(^2\) field were compared with those for the reference 0 degree gantry angle measurements. Both systems showed consistency in output. Flatness and symmetry values for profiles did not exhibit any gantry angle dependence and so was the output. From the gamma evaluation of patient specific plans, P-values in students paired t-test for true gantry angles vs. zero gantry angles (portal dosimetry and ImatriXX system) were more than 0.05, indicating no significant variation in gamma value due to angular changes. Both the detectors can be used for the patient specific QA of IMRT with fields placed at true gantry angle positions. Compared to ImatriXX 2-D array system, the portal dosimetry system is easier to use for the measurements at true gantry angle positions.

In the study of optimization of IMRT patient specific QA using portal dosimetry and ImatriXX 2-D array system, at the relatively liberal gamma criteria of 3%-3 mm, the two QA systems (portal dosimetry system and ImatriXX 2-D array system) did not exhibit any obvious difference.
However at the tighter criteria of 2%-2 mm, differences in the results were seen. With an inter detector distance of 7.62 mm, the inherent poor resolution characteristics of the 2-D array probably affected accuracy of the results. The aSi1000, with its sub-millimeter resolution, is expected to yield more accurate results enabling one to adapt tighter gamma criteria. Significant variation in test results of comparison study indicates that the QA results are influenced by factors like complexity of plans, number of target volumes, number of fields, mode of delivery, movement of multi leaf collimators carriage etc.

For the optimization of VMAT patient specific QA process, the ImatriXX 2-D array system was used in the analysis of dosimetric measurements for thirty patients. The p-values in student’s t-test indicate that that the optimization of QA should take into account all the influencing factors like type of delivery (fixed beam IMRT or rotational), number of arcs (single or double), complexity (treatment site – simple pelvic or complex head and neck), number of target volumes (SIB or non-SIB), and inclusion/exclusion of couch in the plans.

In the study of the performance evaluation and validation of a Compass 3-D verification system, its collapsed cone algorithm was evaluated by comparing it with the Eclipse analytical anisotropic algorithm with a correlation coefficient of more than 0.8 in complicated head and neck IMRT cases and more than 0.9 in cases of simple pelvic IMRT plans. This study results showed good agreement in comparison of Eclipse TPS calculated vs. Compass calculated dose map with average dose difference less than 1% and average gamma less than 0.5. Compass is an efficient and reliable DVH based 3-D dose quality assurance tool for IMRT that can compare TPS calculation with independent 3-D dose calculations. Such an independent system can serve as a redundant dose verification mechanism.
for improving the QA standard in an institution and bring the confidence in treatment delivery using advanced techniques.

Two hypotheses were made. The null hypothesis (H0) was that “the patient specific QA results are not influenced by the QA systems, type of plans, complexity of plans, number of fields or arcs, number of target volumes, movement of carriage, inclusion or exclusion of couch insert etc., and institutional local optimization of QA for IMRT and VMAT is not needed”. The alternate hypothesis (H1) was that “the patient specific QA results are influenced by the QA systems, type of plans, complexity of plans, number of fields or arcs, number of target volumes, movement of carriage, inclusion or exclusion of couch insert etc., and institutional local optimization of QA for IMRT and VMAT is needed”. Based on the results of the studies the null hypothesis H0 is rejected and the alternate hypothesis H1 is found valid. This study has proved that in clinical scenario tighter tolerance criteria can be adopted in suitable situations and the liberal criteria be reserved for plans involving complex situations. This can be useful when new techniques are implemented.

Currently no recommendations are available for DVH based 3-D dose evaluation. Optimization of patient specific QA using Compass 3-D verification system in our study is a stepping stone in this direction. Use of DVH based detectors opens the possibility of exploring the use of tumor control probability (TCP) and normal tissue control probability (NTCP) based evaluation of patient specific QA results, rather than following a particular pass-fail gamma passing criteria. Treatment machines equipped with transmission detectors are another promising feature, which enable online monitoring of beam and leaf positions with and without patient in place.