CONCLUSIONS AND SCOPE FOR FUTURE STUDY
Conclusions

Cancer is one of the major killer diseases today in the human population throughout the world. World Health Organization (WHO) estimates that if these trends continue, cancer will be the leading cause of death everywhere and most victims will be in the 50-60 years age group. Radiotherapy is a medical speciality where ionizing radiations are used to destroy cancer cells by damaging or completely breaking DNA strands hence stopping the cancer cells from reproducing. Radiotherapy is often used to treat cancer at all stages either curative or palliative management. It can be used as treatment by itself or in combination with surgery or chemotherapy. In general radiotherapy provides the advantage of organ preservation, better quality of life, palliation for symptoms and good survival rates. Modern radiation therapy relies on an accurate dose delivery to the prescribed target volume.

The International Commission on Radiation Units and Measurements (ICRU) has recommended an overall accuracy in tumor dose delivery of ± 5% based on an analysis of dose response data and on an evaluation of errors in dose delivery in a clinical setting. Many factors contribute to both random and systematic deviations in dose delivery, including daily patient setup, target delineation, and dose calculation. Radiation dosimetry, selection of treatment techniques and accurate patient positioning for treatment play very crucial role for delivering specified radiation dose to the desired tumor volume accurately.

Correct dose delivery to the tumor is limited by the uncertainties in various stages of radiotherapy treatment process. The uncertainty in the radiotherapy treatment includes the radiation dose measurement and input the same at the time of
commissioning of TPS, patient immobilization methods, evaluation of optimized
treatment plans, and radiotherapy treatment field verification. All the commercially
available systems are very expensive and also not available in many radiotherapy
centres to deliver accurate radiation dose to the cancer patients.

The present investigation deals with the fabrication of inexpensive radiotherapy
quality improvement devices indigenously for accurate radiation dose delivery to the
cancer patients. The dosimetric studies were carried out to check the accuracy and
performance characteristics of the fabricated devices. An attempt has been made to
fabricate radiotherapy quality improvement devices such as mini-phantoms for
measuring the head scatter factor for different telecobalt machines, fabrication of 3-D
CRT whole devices for executing conformal radiotherapy, fabrication of micro-switch
controller circuit based automatic patient’s movement monitoring device for
monitoring patient movement during radiation treatment. A dosimetric comparison
study between 3-D CRT and IMRT techniques was also carried out for cervical cancers
to analyze potential clinical advantages of the techniques.

**The present investigation leads to the following major conclusions:**

Head scatter factor \( (S_c) \) data is very essential for beam modelling in treatment
planning system for accurate dose delivery in radiotherapy. The effect of variation of
\( S_c \) values for change in field sizes, interchange of collimator jaws and introduction of
wedges for three different telecobalt machines of same manufacturer were measured
using different shape mini-phantoms and compared with published data. It has been
found that the shape of the mini-phantoms does not have any significant effect on
\( S_c \) values. Our study indicates that \( S_c \) values vary as the field sizes increases and
variation has been observed between different units of same models. The $S_c$ data for clinical use should be measured for each and every unit. The collimator exchange effect on $S_c$ values is negligible for smaller fields and more for larger fields and the percentage of deviation was $\pm 1.5\%$. Our results indicate that $S_c$ values measured for open fields and wedge fields shows any appreciable variation and the percentage of deviation was $\pm 0.5\%$. Therefore $S_c$ values measured for open fields can be used for wedged field also. The $S_c$ data can be measured directly and accurately in telecobalt machines using indigenously fabricated mini-phantom which is simple, inexpensive and reliable tool.

In order to deliver the conformal radiotherapy treatment accurately to the cancer patients in the absence of MLC and EPID, an in-house low cost Styrofoam cutter and alloy melting oven to fabricate divergent shielding blocks have been developed. We have also developed a multidirectional CR imaging plate holder which can be used for verification of the treatment in the absence of EPID system. DRR beam's eye view 3-D TPS images were compared with CR images for different sites for fabricated shielding blocks of different shapes. The shift between DRR and CR images was found to be a maximum of 0.2 cm within the tolerance value. The dosimetric verification was also carried out with MOSFET dosimeter and compared with 3-D TPS dose values. The percentage variation has been found less than $\pm 2\%$ and within the acceptable limit. The system is simple and cost effective and can be easily implemented in any radiotherapy departments to deliver conformal radiotherapy.

Accurate patient positioning and monitoring play a vital role in radiotherapy to achieve maximum tumor control and minimal normal tissue complications. To achieve this we have fabricated an indigenous micro-switch controller circuit based APMMD
used with the radiotherapy machine that immediately halts the Teletherapy treatment if patient moves claiming accurate field treatment. This equipment was utilized for observing the movement of 130 patients with different types of cancer. Our preliminary clinical results indicate that 77 patients were moved from their position during the treatment, whereas the rest received the radiation without movements. This low cost electronic compact device and alarm system can detect patient movements with a sensitivity of less than 0.5 cm within the tolerance limit. This device is an inexpensive electronic compact device and can be used with any radiotherapy machine to monitor the cancer patient movements during radiotherapy treatment to maintain accuracy in radiation dose delivery.

Advances in radiation treatment delivery technology allow precise shaping and positioning of the patient's dose distribution. These improved dose distributions potentially lead to improved tumor control and reduced normal tissue toxicity. A comparison of two treatment techniques Intensity Modulated Radiotherapy (IMRT) and 3-Dimensional conformal radiotherapy (3-D CRT) for external-beam radiation treatment for cervical cancer was performed using dose statistics, dose-volume histograms, homogeneity and conformity values and dose constraint to organ at risk has been carried out. For this study nine patients of cervical cancers treated with 3-D CRT and retrospective study of the same patients with IMRT planning were carried out. The study results indicate that for IMRT plans with V95 > 95% in all cases than 3-D CRT. The mean dose values were significantly reduced in IMRT when compared with 3-D CRT plan. IMRT plan had significantly lower maximal doses to the PTV compared with 3-D CRT plans. Further it was observed that V95% for IMRT plan increased slightly compared to 3-D CRT plans. The variation between minimum and maximum
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dose is also reduced significantly in IMRT. The conformity value was close to 1 for IMRT technique in comparison to 3-D CRT plan. The homogeneity index value is going closer to 0 for IMRT in comparison to 3-D CRT plans. The results of this study show that the use of IMRT technique in cervical cancer patients was associated with 66% and 78% reduction in the BV irradiated to 45 Gy and 50 Gy respectively compared to 3-D CRT technique. This study indicates that the BV irradiated and 50 Gy was 13.45 cm$^3$ for IMRT in comparison with 67.3 cm$^3$ and 20.18 cm$^3$ for 3-D CRT.

Small bowel average dose has been slightly higher for most of the patients in 3-D CRT than IMRT. The percentage of small bowel volume for V40% of volume receiving 40% of prescribed dose was less for IMRT plan in comparison with 3D-CRT plans. Same trend was observed for V50%, V60 %, V80%, V90%, V100% except V70%. From the clinical study and analysis it has been also observed that IMRT delivers the prescribed dose to target volume with excellent target coverage and conformity.

We have also found that for the treatment of cervical cancers the IMRT technique provides better homogeneity index value, conformity index value and sparing of small bowel in comparison with 3-D CRT technique. This study suggests that dosimetric advantages of IMRT over 3-D CRT in the treatment of cervical cancer. The advantages include improved PTV coverage and improved sparing of small bowel during the IMRT treatment.

Scope for future study

Head Scatter Factor measurement study can be extended to mini-phantoms made of different tissue equivalent material for different model radiotherapy machines operating at different energies. Improvements in the Automatic cancer patient’s
movement monitoring device (APMMD) can be studied and also use of sensor devices
to incorporate the detection of changes in breathing motion of patients during
radiotherapy treatment can also be investigated. Fabrication of 3-D CRT shielding
blocks can be extended for IMRT treatment fields.