TASK GROUP 116
Radiological Protection Aspects of Imaging in Radiotherapy

ICRP 2023
6-9 NOVEMBER 2023 • TOKYO, JAPAN

Image Guided Radiation Therapy

Dramatic improvements have been made in the ability of radiotherapy equipment to conform radiation treatment fields to any shape of tumour. (figure 1). Treatments in the form of dose distributions are calculated and planned using computed tomography (CT) and other x-ray images. External beam radiotherapy linear accelerators (linacs) can potentially limit irradiation induced cell death to the tumour and spare surrounding normal tissue by moving suitably shaped treatment beams around the patient to deliver radiation from different angles.

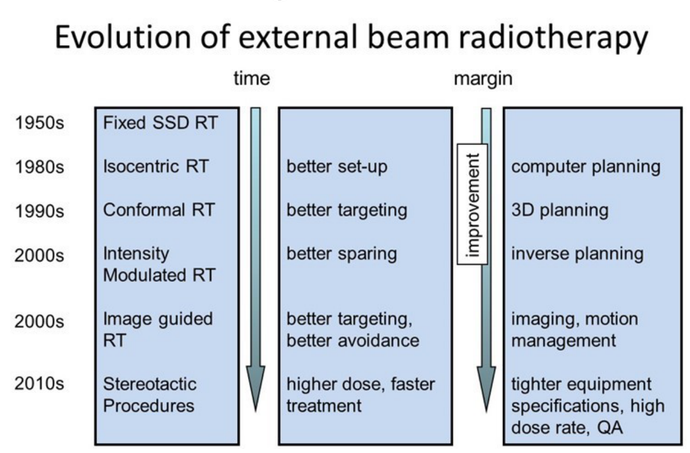

Fig 1. Advances in radiation treatment technology in recent decades

Improvements can be achieved if the patient's position corresponds precisely to the treatment plan. This can often only be accomplished if images are taken when patients are set-up at many, if not all, of the fractions in which treatment is delivered. This image guided radiation therapy (IGRT) uses kV x-ray imaging systems predominantly, which are incorporated into linacs (figure 2) and can take planar or cone-beam CT (CBCT) images that are compared to the planning images . This allows:

- Changes in patient anatomy to be monitored and modifications made, and ensure any differences are clinically insignificant
- Motion to be taken into account by recording of multiple images through breathing or other motion cyclesvw

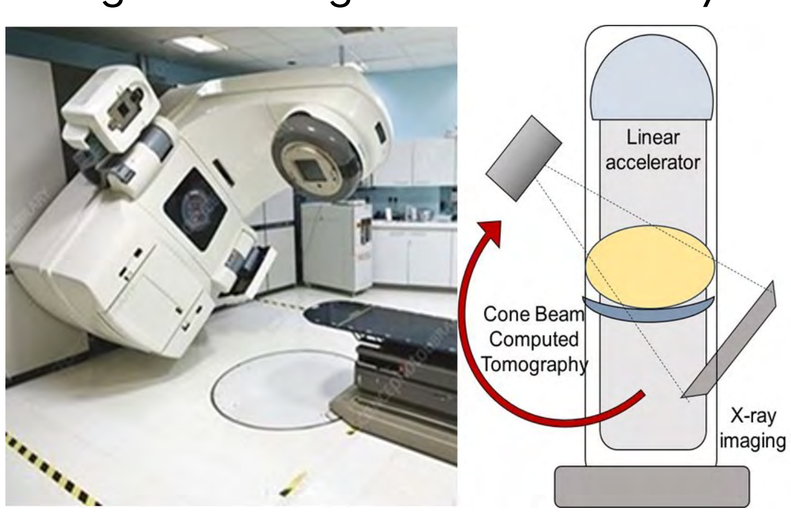

Fig 2. Cone beam CT imaging system on a linear accelerator

Reduced Treatment Margins but Added Imaging Dose

Increased imaging exposes patients to doses from x-rays that carry a risks of inducing cancers in tissues surrounding the target volume. Therefore, reductions in treatment margins and alignment errors that can be realised from IGRT need to be balanced against detriments from larger imaging doses. Less effort has been put into optimisation of imaging doses in radiotherapy and doses to some adjacent organs can be significant. The Task Group is considering the optimisation of radiological protection for imaging in both planning and treatment delivery, including alternatives using non-ionising radiations and the frequency with which imaging is carried out during treatment.

Recording of Imaging Doses in Radiotherapy

A survey undertaken through the ICRP Mentorship programme has shown that many radiotherapy centres do not measure the dose output from their imaging equipment and even fewer record patient imaging doses (Figure 3) [1]. There is a need to raise awareness of doses from CBCT imaging, but even if radiotherapy centres wanted to measure the doses, many do not have equipment to do this. A ICRP Mentorship project is now investigating methods for CBCT dose measurement.

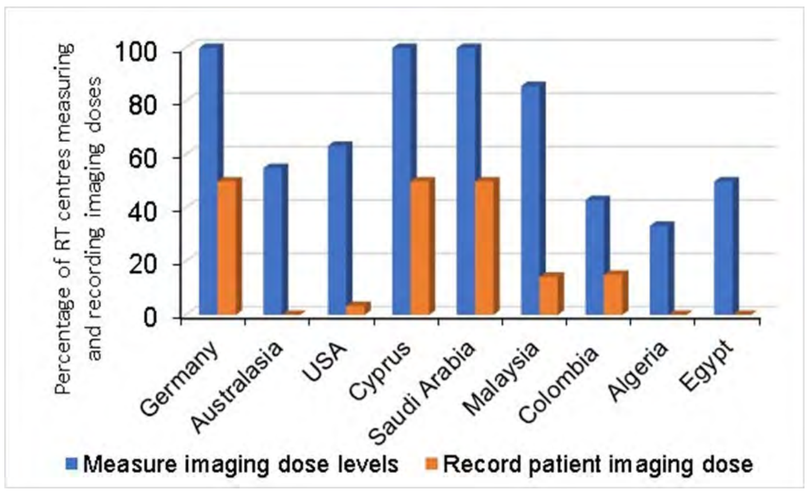

Fig 3. Percentage of centres that measure and record patient imaging doses in the countries surveys through the mentorship programme.

TG 116 Report on Imaging in Radiotherapy

A report is being prepared by TG116 to give an overview of imaging use in radiotherapy and provide guidance on optimizstion of imaging practices. This will contain recommendations for users, managers, and equipment vendors to facilitate improvements in the application and optimisation of radiological protection aspects in the use of imaging in radiotherapy. The main imaging modality employed during treatment is CBCT, which is frequently used at every treatment fraction in most centres. However, there are significant differences in what available imaging techniques can offer in terms of the amount of information provided and the dose level, so decisions are required about optimum choices for different types of treatment, and particular treatment sites. The sections in the report are:

1. INTRODUCTION
2. RADIOTHERAPY TREATMENT PLANNING AND DELIVERY
3. IMAGING REQUIREMENTS FROM A CLINICAL PERSPECTIVE
4. THE PROCESS OF OPTIMISATION OF IMAGING
5. TREATMENT PLANNING EXPOSURES
6. IMAGING DURING THE TREATMENT CYCLE
7. IMAGING FOR BRACHYTHERAPY
8. PAEDIATRIC RADIOTHERAPY
9. EVALUATION AND APPLICATION OF DOSES FROM IMAGING
10. THE IMAGING EQUIPMENT LIFE CYCLE
11. AVOIDANCE OF ERRORS ORIGINATING FROM IGRT
12. EDUCATION AND ONGOING TRAINING OF RADIOTHERAPY STAFF
13. RECOMMENDATIONS TO IMPROVE OPTIMISATION

This will contain guidance on methods for optimisation of radiological protection, including information on optimisation of exposures and the frequency of imaging. Approaches in different centres and countries will depend on the facilities that are available. Greater use of non-ionising radiations such as optical surface guidance, ultrasound and magnetic resonance imaging will be important.

[1] Martin, et al. (2021) An International Survey of Imaging Practices in Radiotherapy. Physica Medica, 90, 53-65.