IAEA guidelines on transition from conventional to 3-D conformal radiotherapy programme

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IAEA TECDOC- 1040 (1998)
[extension (2008) includes linear accelerators and HDR brachytherapy]

- Staff requirements
- Radiotherapy facility design
- Equipment
- QA of the radiotherapy programme and patient radiation protection
- Radiation protection and safety of sources
- Appendices
Main differences between conventional RT and 3D-CRT

**Conventional RT**
- Tumor volume and critical structures are drawn on orthogonal sim films or on few CT images
- Simple setups with 3-4 fields
- Treatment planning with isodose plans on 1-3 planes
- Broad margins are used

**3D-CRT**
- Tumor volume and critical structures are drawn on slice-by-slice CT or MR images. BEVs are created from DRRs
- Complex setups of 4-6 fields with precise immobilization
- 3D treatment planning with 3D visualization and plan analysis
- Tight margins are used
Evolution of dose delivery

2-D RT

3-D CRT

IMRT
IAEA TECDOC- 1588 (2008)

- Milestones
- Approaches to 3D-CRT/IMRT
- Clinical implementation
- Education and training requirements
- Staffing requirements
- QA and QC
- Appendices
Initial milestones for transition to 3D-CRT

• Facilities are in place for the provision of conventional radiotherapy

• Adequate diagnostic imaging facilities are in place for diagnosis and staging

• Adequate imaging facilities are in place for planning CT scans

• There is an intention to deliver curative radiotherapy

• Demonstration by audit that satisfactory setup accuracy can be achieved.
Milestones in the process of transition to 3-D CRT

• Appointment of sufficient staff that the existing programme of conventional RT will not be compromised

• Academic and practical training of all staff (RO, MP/D, RTT)

• Specification, purchase and commissioning of necessary additional equipment for 3-D CRT

• Extension of QA programme to cover 3-D CRT

• Establishment of clinical treatment protocols
3D-CRT process

Patient Scheduled for RT → Positioning and immobilization → Image Acquisition (Sim CT MRI) → Structure Segmentation

3D CRT Treatment Planning → File Transfer to Treatment Machine → Position Verification and Beam Placement → Treatment Delivery
Positioning and immobilization

• Determine optimum treatment position (RO, MP)

• Decision on immobilization method of the patient (RO, D, MP)

• Study reproducibility of the immobilization system to determine realistic margin for planning (RO, MP)

• Using radio-opaque markers to establish reference points on the patient or the immobilization device (RTT, D)
Imaging and target localization

Each RT department should develop protocols for image acquisition for various body sites: the goal is to determine GTV, CTV, PTV and PRV.

- Obtain high quality CT images in the treatment position (RTT, MP/D)

- Fuse CT dataset with any other available studies such as MRI, PET etc (RO, MP/D)
TPS capabilities for 3D-CRT planning

- Image registration and fusion capabilities, efficient delineation of anatomy and target volume in 3D

- Design of treatment fields and treatment aids (MLC shape or shielding blocks etc)

- Accurate 3D dose calculation algorithms

- Display of 3D anatomy and dose distributions

- Treatment plan evaluation tools

- DRR and data transfer
3D Treatment planning: dose calculation

• Contour all targets, critical structures, skin surface and other regions of interest (RO/D/MP)

• Grow structures in 3D by adding appropriate margins (RO, MP)

• Use 3D planning systems to select beam arrangements (D, MP)

• Perform 3D dose calculations (MP/D, RO)
3D Treatment planning: plan evaluation

• Evaluate dose uniformity in the target. Check if the stated plan goals for hot spots and target coverage satisfied (RO/MP)

• Evaluate plan using DVH, and visual examine dose distribution on every slice (RO, D, MP)

• Approve final plan (RO)

• Determine monitor unit settings (D, MP)

• Verify monitor unit calculation manually or with secondary calculation software, if available (MP)
3D-CRT delivery techniques: blocks
3D-CRT delivery techniques: Multileaf Collimators (MLC’s)
File transfer to accelerator and treatment verification

• Enter or electronically transfer all treatment parameters into R&V system (MP/D)

• Port film or EPID to verify isocenter placement as well as beam shape determination prior to start of treatment (RTT)

• *in vivo* dosimetry to verify accuracy of dose delivery (RTT)
Patient Setup and Verification
Treatment delivery

- Deliver treatment (RTT)
- Document all treatment parameters and record daily treatment in patient’s chart (RTT)
- Obtain weekly port films to document isocenter placement (RTT)
Radiation oncologists

• Need to understand how to set treatment goals and constraints, how to select treatment modalities for 3D-CRT

• Need to be familiar with CT scanning procedures and immobilization

• Need to understand beam shaping methodologies – leaf fitting

• Well trained to contour structures precisely and accurately

• Well trained in image-based 3D treatment planning and analysis
Medical physicists

Have much more significant impact and direct role in 3D-CRT planning and delivery than in conventional radiotherapy

• Need to have practical training in image-based 3D treatment planning with MLC (or customized blocks), in treatment setup and immobilization

• Need to have practical training in contouring critical structures and 3-D plan analysis

• Need to have good understanding of QA/QC of 3D-CRT, computer controlled delivery systems, etc
Dosimetrists

Need to be trained and have experience in 3D-CRT

- Immobilization for 3D-CRT

- Need to understand beam shaping methodologies – leaf fitting

- Well trained to contour target volumes and critical structures

- Well trained in image-based 3D treatment planning
Radiation therapy technologists

Need to be trained and have experience in additional requirements for 3D-CRT

- CT operation for treatment planning
- Immobilization techniques
- Portal imaging and registration techniques
- MLC and R&V System operation
- Daily QA for MLC or customized blocks set up
TAKE HOME MESSAGES

3D-CRT is a more complex approach in both treatment preparation and in treatment delivery phase:

- requiring well-defined steps to be followed within the whole process

- is only practically achievable due to better imaging and 3-D treatment planning, automated treatment machines and rigorous QA programmes

- requiring well-trained and qualified staff