44th Annual Meeting of the AAPM, July 15th, 2002 CE-IMRT 1: Quality Assurance of IMRT Delivery Systems - Elekta

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Outline

- Introduction
- Anatomy of an Elekta Accelerator and MLC
- MLC Calibration
- Beam Stability
- Dosimetry of Small Fields
- Summary

Introduction

- Step-and-shoot approach with MLC.
- Non-uniform intensity profiles generated with a series of discrete, uniform beam segments.
- MLC leaves are stationary when beam is on.
- Beam is off when leaves are moving.

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Introduction

Considerations:

- Geometric calibration and constraints of MLC.
- Beam stability for short irradiation times (few MUs).
- Dosimetry of small fields (i.e., as small as 1x1 cm²).
- Small fields offset from central axis.
- Fewer segments and MLC backup jaws allow less concern for inter-leaf leakage, tongue & groove effects, and curved leaf face.

Elekta Linear Accelerators

- Traveling wave accelerator
- Mounted on drum structure.
- Magnetron RF supply.
- Diode electron gun: no grid.
- Integrated MLC



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Fast Tuning Magnetron (FasTraq)

- New magnetron with instantaneous frequency capture
- Reduces initial start up and inter segment times
- Standard on new machines
- Available as upgrade



Elekta MLC

- 40 leaf pairs (10mm pitch)
 Replaces upper jaws
- Replaces upper jaws
 Backup jaws (30mm W)
- 40 x 40 cm² field size
- Total of 32.5 cm leaf travel
- 12.5 cm travel over central axis
- Opposing leaf-pairs do not touch
- Optical tracking (real time).
- Integral auto-wedge



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Optical Leaf Tracking System ILLUMINATION SYSTEM Incident Light ILLUMINATION SYSTEM Reflected Light Camera 7525Baam Splitter Wedge Minor Camera Vedge Minor Vedge Winor







IMRT QA and Commissioning

- Considerations:
 - MLC calibration
 - MLC reproducibility
 - Beam stability for short irradiation times (few MUs).
 - Small fields (i.e., as small as 1x1 cm²).
 - Fields offset from central axis.













Beam Stability: Dose Rate

- With step-and-shoot delivery, there is the potential for short irradiation times (MUs).
- Dose rate stability influences the treatment precision.
- Measure dose per MU versus total MU.
- Check short, and long term stability.
- For > 2MU, dose rate is within $\pm/-2\%$ (2 σ).

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Beam Symmetry and Flatness





Beam Stability: Flatness, Symmetry

- Stability of flatness and symmetry affects dose rate for small fields directed off the central axis.
- For an open 20x20cm² field, measure profiles for irradiations ranging from 1 to 100 MU.
 Sun Nuclear Profiler (46 diodes, 10 profiles/sec).
- Flatness is +/-3% if more than 5MU delivered.
- Symmetry +/-3% if more than 4MU delivered.

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Relative Dose Rate vs Field Size

- Collimation of head scatter affects dose rate "in-air".
- Dose rate in vivo is further affected by photon scatter and e⁻ transport.
- Beam weights calculated by inverse planning must be adjusted to account for head scatter.

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Relative Output in Water (6MV)

Output Factors for Small Fields

- Profiles measured in water (10cm depth) using a pinpoint ion chamber (0.015cm³).
- Calculated with pencil-beam convolution and extrafocal source model.
- Verified radiation field size and offsets.
- Calculations & measurement agree to within 1% on average, 2.5% max.

Output Factors for Small Fields



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Output Factors for Small Fields

- Typically measure in water (10cm depth) using a pinpoint ion chamber (0.015cm³) and beam scanning system
- Scan profiles to verify leaf positioning radiation field size and offsets



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IMRT QA with EPID (iViewGT)

- - Flat-panel imager
 41cm² a-Si panel
 - 41cm- a-Si panei
 - 26cm² field at isocentre
 - 15cm offset in all quadrants
 - 16 bit gray scale resolution
 - 3 frames per sec readout
 - Primary function is to ve patient position



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iViewGT: IMRT QA Possibilities

- Dosimetry QA
- QA beam flatness and symmetry
- MLC calibrationQA leaf position
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MLC Calibration

- Extremely time-consuming using film, especially if adjusting gain & offset.
- Possibly requires tighter tolerances / more frequent checking for IMRT
- iViewGT has 0.25 mm resolution at isocentre – ought to be sufficient for MLC calibration



Matched step & shoot fields



Spot the errors







Conclusions

- Low MU images and template matching enable easy patient position verification
- Require access to raw images for dosimetry applications
- Looks promising for QC applications and MLC calibration

Summary

- Commissioning:
 - Range of clinical operation to 1x1 cm² fields, and 1-2 MU irradiations
 - Verify beam stability for short exposures
- Quality Assurance:
 - Enhance monthly QA to test MLC operation, accuracy and precision.
- A-Si EPID: Intergated QA device.

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