Overview of TG225 - Medical Physics Practice Guideline #1

Evaluation and quality assurance of x-ray based image guided radiotherapy systems

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MPPG #1

Evaluation and Quality Assurance of X-ray Based Image Guided Radiotherapy Systems

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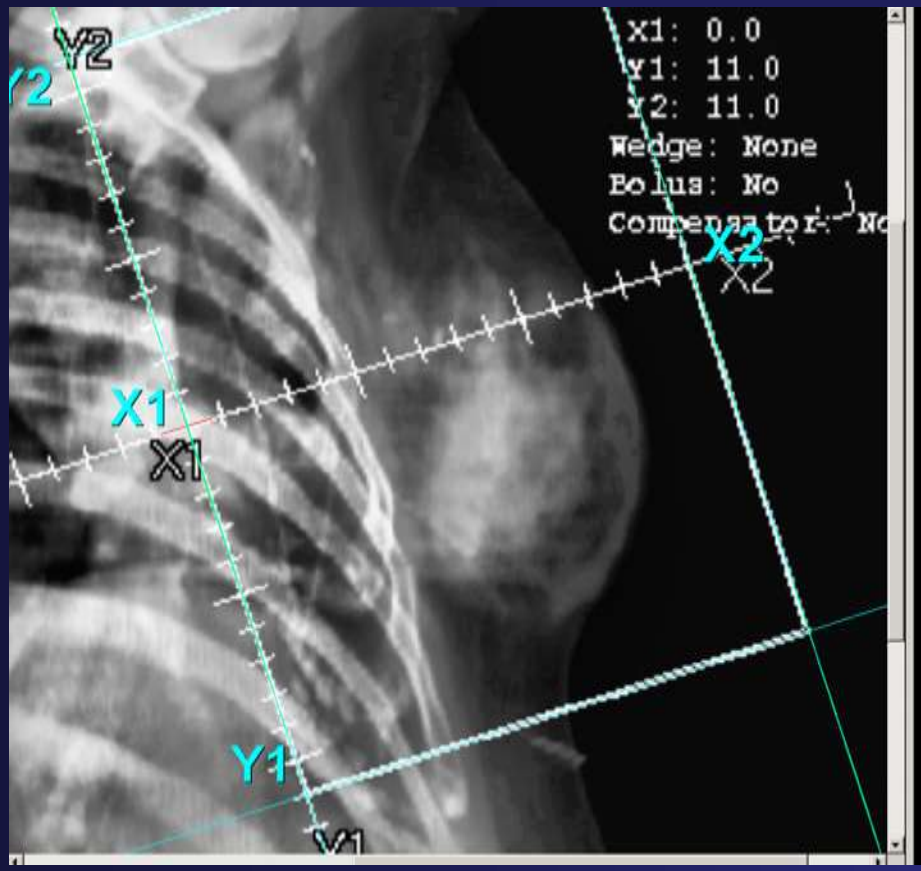
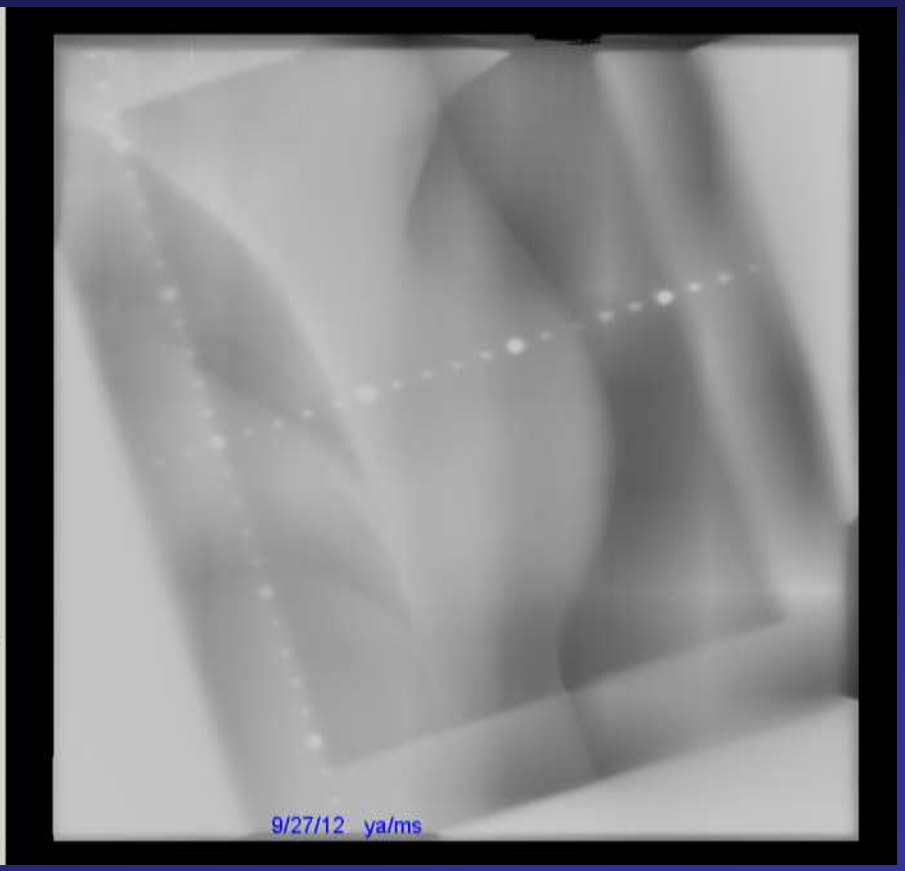
Elements of Guidelines

- Introduction
  - Goals and rationale
  - Intended users
- Definitions/abbreviations
- Staff Responsibilities
- Implementation Guidelines
  - Required resources
    - Staffing
    - Equipment
  - Staff training
  - Process descriptions
- Recommended minimum requirements
- Conclusions

Background

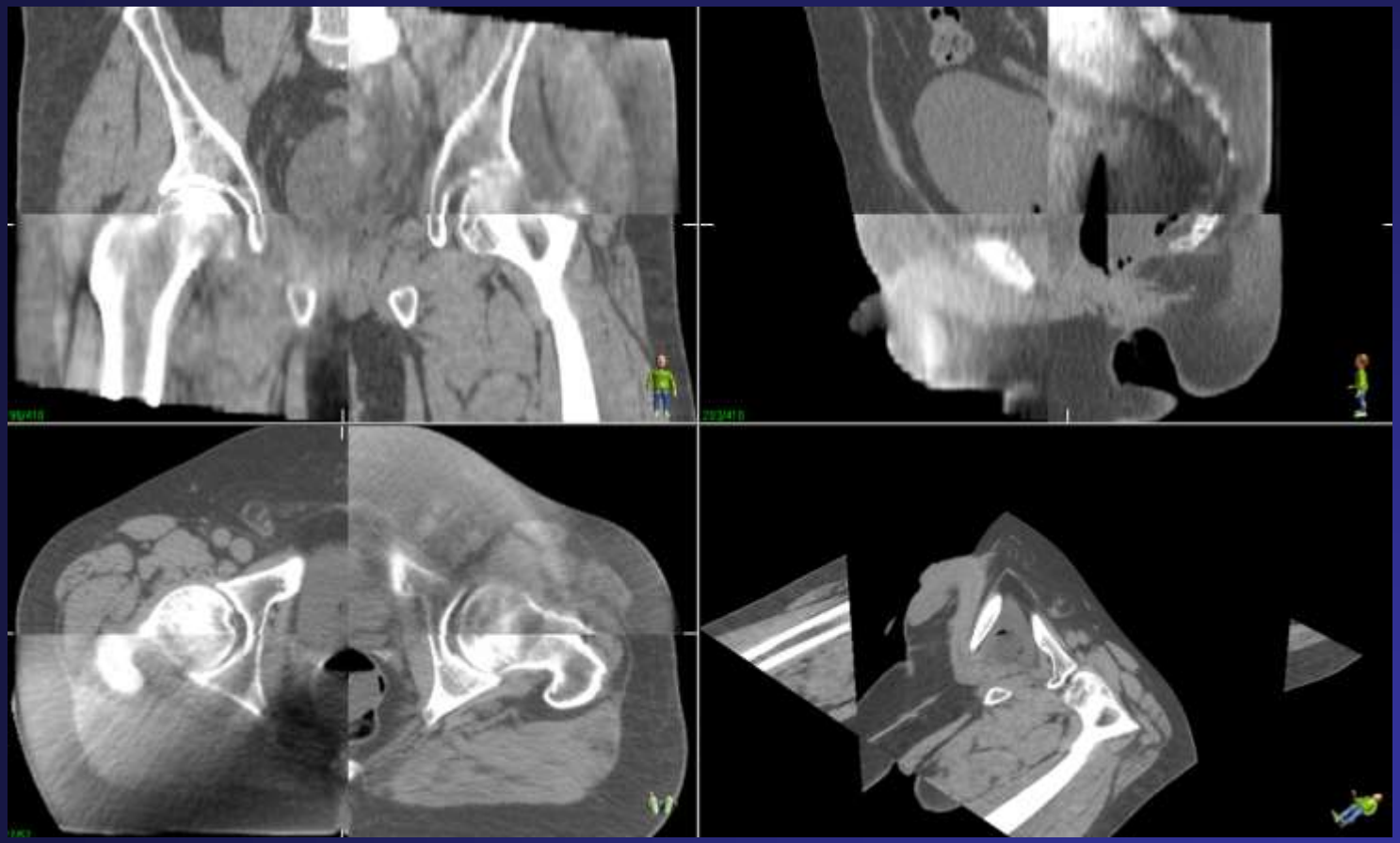
- IGRT is not a new concept





Background

- IGRT is now more complex and heavily-utilized than ever before



Background

- IGRT is now more complex and heavily-utilized than ever before
  - In our clinic
    - Pre-2008
      - No OBI
      - SSD checks were primary metric for localization quality
    - Current
      - All linacs have OBI
      - Frequency of SSD checks > 1 cm has increased
    - Conclusions
      - IGRT has changed the way we align our patients
      - We have de-emphasized traditional localization methods

Background

- Use of imaging systems for daily alignment and localization in radiation therapy IGRT is expanding rapidly
- Challenges for the therapy physicist
  - New technology
  - Not traditionally associated with clinical therapy physics

Rationale

- IGRT systems come in many flavors
  - Megavoltage imaging systems
    - Two-dimensional
    - Three-dimensional
  - Kilovoltage imaging systems
    - Two-dimensional
      - Gantry-mounted
      - Room-mounted
    - Three-dimensional
      - Gantry-mounted
      - Room-mounted

Rationale

- Guidance documents are available
  - TG-58
  - TG-75
  - TG-101
  - TG-104
  - TG-135
  - TG-142
  - TG-148
  - TG-179
- Obstacles to successful implementation of an IGRT program
  - Unfamiliarity with technology
  - Variety/complexity of guidance documents
  - Few process descriptions
  - What is required?

Rationale

Task Group 142 report: Quality assurance of medical accelerators

TABLE VI. Imaging.

Procedure	Application-type tolerance: non-SRS/SBRT	Application-type tolerance: SRS/SBRT
Daily[a]		
Planar kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤2 mm	≤1 mm
Imaging and treatment coordinate coincidence (single gantry angle)	≤2 mm	≤1 mm
Cone-beam CT (kV and MV)		
Collision interlocks	Functional	Functional
Imaging and treatment coordinate coincidence	≤2 mm	≤1 mm
Positioning/repositioning	≤1 mm	≤1 mm
Monthly		
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence	≤2 mm	≤1 mm

Rationale

Task Group 142 report: Quality assurance of medical accelerators

- Repeated and deliberate use of recommended QA practices
- Institutional deviations from TG-142 QA are expected

Several authors have attempted to develop a systematic approach to developing QA frequencies and action levels.[37–39] More recently the work being performed by Task Group 100[40] of the AAPM. TG 100—A method for evaluating QA needs in radiation therapy [based on "Failure modes and effects analysis (FMEA)"]—promotes individual departments to be responsible for development of unique QA programs based on procedures and resources performed at individual institutions. Institutional deviations from some of these recommendations are expected based upon the institution's policy and procedures; the clinical significance of these deviations may be mitigated by other control methods that are not anticipated in this document. In the case of decreasing the frequency of a particular test, the results of the test must be examined and be validated with an appreciable history of that test and based on sound statistical principles. That decision must also be correlated with the documented analysis of the potential impact of catastrophic results in the event of an occurrence. By FMEA analysis, an institution can estimate the degree of harm due to a failure along with (lack of) detection and occurrence probabilities. We reiterate the

Rationale

Task Group 142 report: Quality assurance of medical accelerators

- Where is the floor?
  - Clinical practice
  - Accreditation
  - Regulation

Several authors have attempted to develop a systematic approach to developing QA frequencies and action levels.[37–39] More recently the work being performed by Task Group 100[40] of the AAPM. TG 100—A method for evaluating QA needs in radiation therapy [based on "Failure modes and effects analysis (FMEA)"]—promotes individual departments to be responsible for development of unique QA programs based on procedures and resources performed at individual institutions. Institutional deviations from some of these recommendations are expected based upon the institution's policy and procedures; the clinical significance of these deviations may be mitigated by other control methods that are not anticipated in this document. In the case of decreasing the frequency of a particular test, the results of the test must be examined and be validated with an appreciable history of that test and based on sound statistical principles. That decision must also be correlated with the documented analysis of the potential impact of catastrophic results in the event of an occurrence. By FMEA analysis, an institution can estimate the degree of harm due to a failure along with (lack of) detection and occurrence probabilities. We reiterate the

Goals

- Succinctly state the minimum acceptable standards for using IGRT, similar to ACR-ASTRO technical standards
- “Clinical recipe” for the solo physicist
- Inform the reader of the needs of this particular technology (time, effort, resources)
- Provide necessary references for further investigation

Intended Users

- Medical physicists
  - What is required for safe and effective use?
    - Tools
    - Time/effort
    - Procedures
- Administrators
  - How much will it cost (hard/soft)?
- Accrediting bodies
- Regulatory agencies

Approach

- Survey existing TG recommendations
- Survey IGRT practices/observations at MPPG members' institutions
  - University clinics
  - Community clinics
- Rank, prioritization of minimally acceptable practice
- Expansion of process descriptions, categorized by IGRT approach
- Address applicable areas of need identified by SPG

Approach

- Timeline of activities
  - 2/13/12: MPPG TG formed
  - 3/19/12: Scope and Timeline submitted to SPG
  - 3/27/12: IGRT program questionnaire submitted to MPPG member institutions (who, what, when, where, how)
  - 5/15/12: IGRT program data collected from MPPG member institutions
  - 7/01/12: Working draft of report submitted to SPG
  - 7/29/12: Face-to-face meeting at AAPM
  - 8/21/12: teleconference
  - 8/28/12: teleconference
  - 9/11/12: teleconference
  - 9/18/12: teleconference
  - 10/2/12: teleconference
  - 10/7/12: Report submitted for internal review
    - SPG, PC, TPC, QASC, EXCM, Chairs of TG 75, 104, 111, 135, 179
  - 11/13/12: Internal review comments received (95)
  - 12/3/12: teleconference
  - 12/7/12: teleconference
  - 12/15/12: Report submitted for public comment
  - 1/28/13: Public review comments received (34)
  - 2/05/13: teleconference
  - 3/11/13: Report approved by MPPG members for formal process approval

Staff Responsibilities

- IGRT implementation requires a team approach
  - Radiation Oncologist
  - Medical Physicist
  - Medical Dosimetrist
  - Radiation Therapist
  - Information Technologist

Staff Responsibilities

- Medical physicist
  - Must be competent to practice independently in the subfield of therapeutic radiological physics. The individual **must** be certified (ABR, ABMP, CCPM).
  - Responsibilities of the qualified medical physicist in an IGRT program include:
    - Performs acceptance testing and commissioning
    - Implements and manages of a quality assurance program
    - Develops and implements standard operating procedures (including imaging protocols and repositioning thresholds)

Staff Responsibilities

- Radiation Oncologist
  - Manages patient positioning procedures
  - Specifies imaging modalities and frequencies
  - Identifies registration targets and repositioning thresholds
  - Performs timely review of clinical IGRT images
  - Conducts regular reviews of the IGRT program

Staff Responsibilities

- Medical Dosimetrist
  - Creates and transfers to the OIS all patient-specific data necessary for IGRT implementation
- Radiation Therapist
  - Understands the use of positioning devices in IGRT
  - Prepares the IGRT system for acquisition of patient-specific positioning verification images
  - Implements the IGRT treatment protocol under the supervision of the radiation oncologist and medical physicist
  - Acquires positioning verification images for review by the radiation oncologist
  - Assists in periodic review of the stability of the IGRT system (e.g., daily QA)

Staff Responsibilities

- Information technologist
  - Provides and maintains resources necessary for storing, archiving and retrieving images generated during IGRT.
  - May be accomplished by a dedicated Information Specialist or duties assigned to another team member.

Implementation Guidelines

- Required resources
  - Staffing/time
    - Two dimensional MV imaging systems
      - Acceptance/Commissioning/Documentation: 18-36 hours
      - Ongoing support: 25-50 hours annually
    - Two dimensional kV imaging systems
      - Acceptance/Commissioning/Documentation: 18-36 hours
      - Ongoing support: 25-50 hours annually
    - Three dimensional MV imaging systems
      - Acceptance/Commissioning/Documentation: 18-36 hours
      - Ongoing support: 100-125 hours annually
    - Three dimensional kV imaging systems
      - Acceptance/Commissioning/Documentation: 18-36 hours
      - Ongoing support: 100-125 hours annually

Implementation Guidelines

- Required resources
  - Equipment
    - Quality tools **must** provide reliable values of the measured parameters.
      - Image quality
      - Spatial accuracy (scaling)
      - Congruence of imaging and treatment isocenters
      - Accuracy of registration/couch movements
      - Imaging dose
    - Phantoms specifically designed for IGRT are available and, when coupled with automated image analysis tools, can improve efficiency.

Implementation Guidelines

- Required resources
  - Training
    - Training for the operation of the IGRT system must be provided
    - Prior to initial use of IGRT, the treatment team should meet to discuss staff responsibilities, clinical goals and process workflows.
    - Physicist should also review the image acquisition procedures with the therapists and radiation oncologists.

Recommendations

Procedure	Tolerance
Acceptance/Commissioning	
Customer acceptance procedures	-
TPS integration	-
OIS integration	-
Establish routine QA baselines	-
Documentation	-
Daily	
Safety/interlocks	Functional
Imaging-treatment isocenter coincidence (SRS only)	1 mm
Positioning/repositioning (SRS only)	1 mm
Imaging-treatment isocenter coincidence (SBRT only)	2 mm
Positioning/repositioning (SBRT only)	2 mm
Weekly	
Imaging-treatment isocenter coincidence (non-SRS/SBRT)	2 mm
Positioning/repositioning (non-SRS/SBRT)	2 mm

Recommendations

Semi-Annually	
Image scaling	2 mm
Annually	
Imaging dose	
2D MV	± 1 cGy of acceptance value
2D kV (static imaging mode)	± 3.0 mGy of acceptance value
2D kV (fluoroscopy mode)	± 1 cGy/min of acceptance value
All 3D imaging modes	± 1 cGy of acceptance value
Image quality	
2D (spatial resolution, contrast)	Acceptance value
3D (uniformity, spatial resolution, contrast)	
Upgrade/Repair/Service	
Verify / Re-establish QA baselines (as appropriate)	-

450 Abbreviations: SRS = stereotactic radiosurgery, SBRT = stereotactic body radiation therapy

Recommendations

- "Acceptance value"
  - refers to the IGRT system manufacturer's minimum performance standard stated in the customer acceptance procedure documentation.
  - If unavailable or not specified, then "acceptance value" can be taken as the value measured at the time of commissioning.
    - Most IGRT system manufacturers have stated performance specifications for image quality and, in such cases; those may serve as the tolerance values for routine QA measurements of image quality.
    - Some IGRT system manufacturers do not have stated performance specifications for imaging dose and, in such cases, the imaging dose measured at the time of commissioning may serve as the baseline value to which future measurements are compared.

Recommendations

- In general, the frequency of routine QA tests is proportional to the importance of their performance for the purpose of patient alignment
  - imaging-treatment isocenter coincidence, positioning/repositioning are considered critical
  - daily checks of these parameters are preferred, but weekly checks are considered acceptable for IGRT save SRS/SBRT
- Imaging dose
  - measured for at least one (conservative) acquisition technique of each mode of clinical operation.
- Augmented with procedures required by state regulation
- IGRT systems with known recurring problems should be subjected to more frequent QA at the discretion of the QMP.

Process Descriptions

- Sample process description for each required QA task

xxi. Imaging dose (2D kV systems)

Imaging dose from 2D kV systems is most typically characterized using entrance surface air kerma (skin exposure). Measurement equipment used to measure the entrance air kerma includes a calibrated ionization chamber and a phantom. The ionization chamber is placed between the source and the phantom in such a way as to minimize scatter radiation to the ionization chamber. The field size is set to cover the detector. A clinically relevant beam is delivered, and the air kerma rate is calculated for static and fluoroscopic imaging modes, respectively.

Measured imaging dose **should** be documented and its management **should** be approached with the goal of keeping it as low as necessary to achieve clinically useful images. (Time: 15-60 minutes, depending on the number of techniques measured)

Conclusions

- IGRT implementation and QA is challenging
- There are QA elements common to all x-ray based IGRT systems
  - Safety
  - Image quality
  - Geometric fidelity
    - Scaling
    - Treatment-imaging isocenter coincidence
    - Registration/table shifts
  - Dose
- A successful MPPG1 will improve the quality of clinical support for various IGRT strategies

References

- AAPM TG-179: Quality assurance for image-guided therapy utilizing CT-based technologies
- AAPM TG-75: The management of imaging dose during image-guided radiotherapy
- AAPM TG-104: The role of in-room kV X-ray imaging for patient setup and target localization
- AAPM TG-148: QA for helical tomotherapy
- AAPM TG-58: Clinical use of electronic portal imaging
- AAPM TG-135: Quality assurance for robotic radiosurgery
- AAPM TG-142: Quality assurance of medical accelerators
- AAPM TG-111: Comprehensive methodology for the evaluation of radiation dose in x-ray computed tomography
- ACR-ASTRO Practice guideline for image-guided radiation therapy
- AAMD Scope of Practice for a Medical Dosimetrist link: http://www.medicaldosimetry.org/generalinformation/scope.cfm
- ASRT *Radiation Therapy Practice Standards*; Link: http://www.asrt.org/docs/practice-standards/GR11_RT_PS.pdf

Acknowledgements

- MPPG members
  - Andrew Jensen
  - Jack Yang
  - Hassaan Alkhatib
  - Jeff Garrett
  - Steve McCullough
  - Brent Parker
  - Art Olch
- Maria Chan
- Per Halvorsen
- Joann Prisciandaro
- SPG members
- All commenters

Thank You