Quality Control for the Use of IGRT in Clinical Trials

James M. Galvin, DSc
Thomas Jefferson University Hospital
Jefferson Medical College
Philadelphia, PA

and

The Radiation Therapy Oncology Group

RADIATION THERAPY ONCOLOGY GROUP - RTOG 0236

Phase II Trial of Stereotactic Body Radiation Therapy (SBRT) in the Treatment of Patients with Medically Inoperable Stage I/II Non-Small Cell Lung Cancer

Principal Investigator/Radiation Oncology
Robert D. Timmerman, M.D.
University of Texas Southwestern, Dallas, TX

Medical Physics Co-Chair
James M. Galvin, D.Sc.
Thomas Jefferson University Hospital, Philadelphia, PA

Image-Guided Radiotherapy Co-Chair
Jeff Michalski, M.D.
Mallinckrodt Institute of Radiology, St. Louis, MO

Prescription and Margins as Defined in RTOG 0236

- 20 Gy x 3 fractions = 60 Gy
- Heterogeneity Corrections were not used
- An additional 0.5 cm in the axial plane and 1.0 cm in the longitudinal plane (craniocaudal) will be added to the GTV to constitute the PTV

RADIATION THERAPY ONCOLOGY GROUP - RTOG 0618

Phase II Trial of Stereotactic Body Radiation Therapy (SBRT) in the Treatment of Patients with Operable Stage I/II Non-Small Cell Lung Cancer

Principal Investigator/Radiation Oncology
Robert D. Timmerman, M.D.
University of Texas Southwestern, Dallas, TX

Medical Physics Co-Chair
James M. Galvin, D.Sc.
Thomas Jefferson University Hospital, Philadelphia, PA

Other RTOG IGRT Protocols that are Recently Opened or Under Development

- **Lung SBRT (RTOG 0813)**
- **Sarcoma (RTOG 0630)**
- **Spine (RTOG 0631)**
- **Head & Neck (x2)**

Using IGRT in RTOG Protocols

- The RTOG has developed Guidelines for the use of IGRT in their protocols
- The Advanced Technology Consortium (ATC) is working on having a uniform set of guidelines for all cooperative groups using radiation in studies

Definition of IGRT used for RTOG Protocols

- Process extending from CT-simulation imaging through the step of imaging the patient on the treatment unit
  - Process includes the following steps:
    - Manual or automatic registration of the two datasets as a computerized process
    - Determination of a series of mechanical movements of the patient support system to correct for detected positioning errors

IGRT Techniques

- **In-room diagnostic quality CT scanner**
- **MV and kV cone-beam CT attachments**
- **MV helical CT capabilities**
- **Stereoscopic 2D images obtained with kV x-rays**

Internal Organ Motion Control (as defined in RTOG #0236)

- Acceptable maneuvers include reliable abdominal compression, accelerator beam gating with the respiratory cycle, tumor tracking, and active breath-holding techniques

Many Different Approaches to IGRT

- There are many different ways of imaging the patient in the treatment room
- There are many different ways for registering the CT-sim and IGRT datasets
- There are many different ways for adjusting the patient's position based on registration information

IGRT Methodologies Not Currently Included

- The guidelines presented here do not include IGRT techniques that use ultrasound or infrared systems that place fiducial markers on the patient's skin
- Deformable fusion techniques are not included at this time

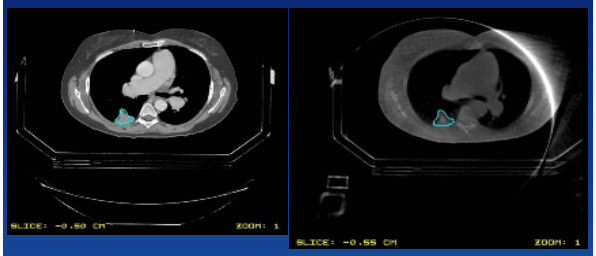
Procedure for including IGRT in RTOG Protocols

- Protocol must include:
  - IGRT Specifications
  - IGRT Questionnaire
  - Phantom Irradiation
    - Treatment units that do not include a robotic couch
    - Test to evaluate the performance of robotic couches with pitch and roll capabilities
  - Image Registration Software Tests
    - Tests that use patient datasets

Localization Verification for RTOG Protocols

- The Verification credentialing process used for some RTOG protocols that use IGRT is designed to check an institution's image registration procedure

ITC Remote Review Tool



Is IGRT QC Understood?

- **Existing guidelines (e.g., the ACR SBRT Practice Guideline) indicate that separate checking of the delivery system, treatment planning system and the IG system is acceptable**
  - However, there is the possibility of serious error when the performance of the combined systems is not checked using a single test
- **Thus, it is critically important that the performance of these systems is verified as a single process**

What is the Solution to this Problem?

- **There are simple phantoms that can be used to check the combined system**
  - The procedure must use the IG system to locate markers in the phantom at know positions in space
  - The procedure must use the treatment planning system to target these points in space
  - The procedure must use an imaging technique to demonstrate that the points are properly positioned in the treatment beam
- **Frequency for this test must be established**
  - SBRT requires more frequent testing compared to treatments with standard fractionation

Phantom Requirements

- **Phantom must work for IGRT technologies that use either dual radiographic imaging or volume imaging**
  - Both kV and MV imaging must be accommodated
  - All images must be artifact-free
- **Using the treatment beam, markers must be visable when using EPID, radiographic film, or radiochromic film**

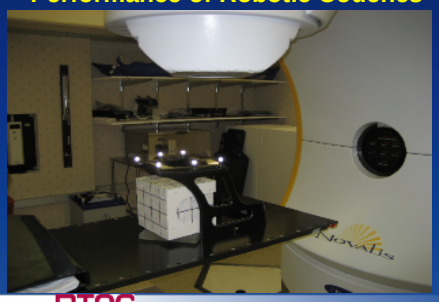
Phantom Requirements (continued)

- **Phantom must check both linear and rotational couch adjustments**
- **Phantom must work for collimators with a restricted field size (e.g., Novalis or Synergy S)**
- **Phantom must work for robotic systems like the CyberKnife unit**

Design Features for IGRT Phantom

- **A simple commercially available phantom**
- **Precision slide that holds three stainless steel balls (approx. 4 mm dia.)**
  - Holes where ball markers are placed are used for artifact-free kV CT imaging
  - One ball is placed at the phantom center and the other two balls are shifted 4 cm from the center
- **Phantom has extra base so that rotational errors of 3 degrees along a diagonal can be introduced at the treatment unit**

Using Phantom to Check Performance of Robotic Couches



Using Phantom to Check Performance of Robotic Couches

Jefferson RTOG Radiation Therapy Oncology Group

2008 AAPM Annual Meeting
Houston, TX

Using Phantom to Check Performance of Robotic Couches

Jefferson RTOG Radiation Therapy Oncology Group

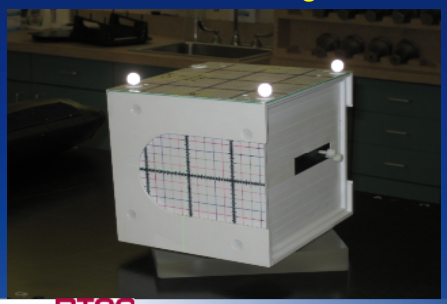
2008 AAPM Annual Meeting
Houston, TX

Using Phantom to Check Performance of Robotic Couches

Jefferson RTOG Radiation Therapy Oncology Group

2008 AAPM Annual Meeting
Houston, TX

Phantom Design



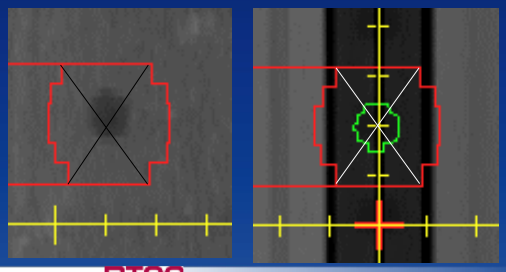
Jefferson RTOG Radiation Therapy Oncology Group

2008 AAPM Annual Meeting
Houston, TX

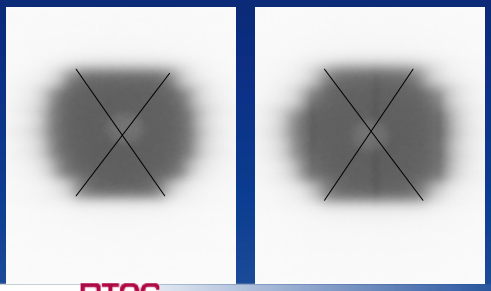
Phantom Design

Phantom Design

DRRs



Orthogonal Pair Shows Deviation Compared to DRR



Conclusions

- Image Guided Radiation Therapy, like IMRT, represents a significant QA hurdle for Cooperative Groups
- However, although the challenge is significant, many of the techniques used for IMRT can be modified and applied to IGRT

Jefferson RTOG Radiation Therapy Oncology Group

2008 AAPM Annual Meeting
Houston, TX

RTOG protocols strictly define IGRT when this technology is used in their protocols. This definition is:

25% a. The process of comparing images obtained in the treatment room to CT information obtained during the treatment planning process.

25% b. A process of imaging the patient on the treatment table and including a manual or computerized method of extracting shift information from the available image datasets.

25% c. The process of using a computerized technique to compare the image information obtained in the treatment room with the treatment planning CT scan information, and including the automatic generation of shift data for the patient support system.

25% d. The use of in-room imaging for patient localization that includes measurements taken from radiographic portal images.

Jefferson

10

Answer: c

Reference: Go to the RPC web site http://rpc.mdanderson.org/rpc and click on Credentialing and then RTOG. Find Parts I and II of the Facility Questionnaire.

Jefferson

A phantom used for Quality Control for an IGRT system must do which of the following:

25% a. Demonstrate that at least two orthogonal treatment beams can hit a number of targets in space that are positioned using the IGRT system.

25% b. Verify the position of the treatment unit isocenter with a star pattern test that uses the treatment beam to irradiate a film placed at the isocenter.

25% c. By observing the results of a repeat image guided procedure, show that there is essentially zero correction needed after required shifts have been applied from an initial IG procedure.

25% d. By testing, using a block phantom, that the image guided system can bring a phantom that is placed incorrectly on the treatment table to the correct position.

Jefferson

10

Answer: a

Reference: J. M. Galvin and G. Bednarz "Quality Assurance Procedures For Stereotactic Body Radiation Therapy," Int J Radiat Oncol Biol Phys 71, S122-125 (2008)

Jefferson

The RTOG uses a "Verification Study" as part of the Credentialing process to determine:

25%	a. That the treatment planning CT can map contours to the daily IGRT image.
25%	b. That there is little or no image deformation for the daily images compared to the image obtained at the time of simulation.
25%	c. If the lesion can be seen on the IGRT image datasets.
25%	d. That the image registration procedure used by the particular institution is appropriate relative to protocol guidelines.

Jefferson

10

Answer: d

Reference: Go to www.rtog.org and click on Active Protocols and then by Number. Select protocol #0236.

Jefferson

My mother's first name is:

20%	a. Mary
20%	b. Joann
20%	c. Elizabeth
20%	d. Umbertina
20%	e. Hillary

Jefferson

10

Answer: d

Reference: My birth certificate

Jefferson