**Surface Imaging to Inform Statistical Quality Control for SRS Treatments**

**Disclosures**

I have provided Physics Consultation Services to

- Varian and Vision RT

**Some Concepts you can take Home**

- Characterization of SGRT systems for high precision SRS Treatments
- How to use your SGRT system to inform your Quality Assurance goals
- Statistical Methods for system characterization and the differences between loose and simple tolerances
The goal is to turn data into information and information into insight

-Carly Fiorina, Former CEO of HP
It is important to keep in mind that acceptance tests demonstrate only that the equipment is working as per the specification. This includes measuring the system accuracy, determining system limitations, and developing operating procedures and QA schedules.

Some of these tests will be completed as part of the acceptance tests with the vendor; however, TG-147 states that acceptance tests is the discretion of the vendor and may not satisfy all clinical recommended quality assurance.

Validation of software and analysis tools under as many clinically relevant conditions as possible (not directly listed in TG-147).

Use TG-147 tests to characterize your system's performance.

Vendor recommended testing and determination of failure modes:
- Spatial reproducibility and drift
- Dynamic localization accuracy and gating
- Static localization accuracy
- Integration of peripheral equipment
- Vendor recommended testing and determination of failure modes.
Monthly QA by or under the supervision of a QMP should include all tests performed daily with the addition of:

- Gating
- Static Localization (Hidden Target)
- Dynamic Localization
- Vendor Recommended

A QMP should perform the following daily QA tests or delegate them to another member of the radiation therapy team, like a radiation therapist. If the tests are delegated, a QMP needs to review the test results in regular intervals:

- Safety
- Static Localization
- Documentation
- Vendor Recommended

In addition to the tests performed daily and monthly, the following tests should be performed annually by or under the supervision of a QMP:

- System Stability
- System Integrity
- Extended System Performance
- Positioning Accuracy
- Extended Gating
- Data Transfer
- Vendor Recommended

Commissioning

This includes measuring the system accuracy, determining system limitations, and developing operating schedules with QA schedules.

Performance Validation

An assessment of the performance of the system under various clinically relevant conditions and is an ongoing process. Examples: Deformable Surfaces, DIBH SBRT, SRS in BOS and High Neck... etc.

The definition of insanity is doing the same thing over and over and expecting different results.

- The Universe

-Albert Einstein-
SGRT as an Observer Based Pattern

Computer vision systems are widely used in other fields/disciplines as part of a quality control systems to gather and process large amounts of data.

SGRT systems are no different and can be used to direct and further refine your treatment delivery and quality management process.

Statistical Process Control

Let's start with what we know

Walter A. Shewhart and W. Edwards Deming

SPC in Radiation Oncology

- Has been shown to identify systematic change in a process where standard deviation methods or the use of established industry standards cannot
- Using SPC control charts allows one to evaluate a system in an objective and quantifiable manner
- Control limits are constructed in a way that de-emphasizes random variation in the data

Using SGRT to Determine Margin and Tolerances

- SGRT can and has been used to determine systematic and random errors for interfraction positioning and intrafraction motion allowing for statistically derived planning margins.

- Statistical evaluation of the SGRT system output for various treatment sites and techniques can help drive quality by using properly computed control limits in an effort to limit both Type I and Type II errors.

SRS Tolerance Determination

QA and Phantoms

Your commissioning will help you develop a starting point for tolerances for various applications of SGRT in your clinic.

System Setup

A base-set of statistically reviewed tolerance levels can be set as defaults. If your SGRT software allows, set that you can use best practices to drive quality.

Isocenter Offset by Location

Calibration of the system and location of isocenter can affect the perceived offset of the system. More advanced calibration techniques can provide better convergence which can then be monitored for drift.

Advanced Calibration (Off)

Advanced Calibration (On)

Patient Specific Phantom QA

- Running the system under ideal conditions can give you an indication of system performance.
- This can help you determine expected clinical action levels.

Real Life application

- The tolerances should be evaluated over time.
- Tolerances should be adjusted to give you and your team useful information (i.e. not too many false positives).

SRS Tolerance Evolution
Feature based registration of the two traces suggests we can develop better action levels based on patient/plan-specific tolerances obtained during the standard QA measurement procedure or customize plans to avoid regions where the system is less stable.

Planes with similar or identical couch rotational setups can have similar QA RTD traces suggesting a "real" couch offset that can be calibrated out to locate "true" patient motion.

Obstruction characteristics of your cameras can exhibit differences based on location of isocenter.
Data to Insights for SRS Treatments

Two Quick SRS Concepts

Couch Walk
My reported couch walkout doesn’t match between my radiographic images and my SGRT system.

Winston-Lutz
What does my Winston-Lutz really tell me and is it a real measure of my treatment accuracy?

SGRT vs Radiographic Offset

Correcting radiographic images for gantry sag and collimator walk shows good agreements between the SGRT-reported couch walk and radiographic couch walk making SGRT a quick and easy check for this metric.
Multiple Mets Single Isocenter Validation

Very small rotational uncertainties can result in large displacements of the dose relative to the targets if the distance to isocenter is large.

- For small tumors this is a real issue.

Calculated Uncertainties vs System Performance

- The system's performance under standard metrics like WL are hard to determine.

- The SGRT system should be evaluated end-to-end and in light of other mechanical limitations and uncertainties that may exist on the machine.

SRS Information for Planning

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Using our SGRT Data

1. Known Geometry
   - Import known geometry with multiple target volumes and center of gravity.

2. Planning
   - Create a single isocenter multiple mets based plan on all targets.

3. Simulation
   - Input plan data and statistical uncertainty data or direct input from the SGRT system.

4. Quality Analysis
   - Generate both real and synthetic images for direct comparison of system accuracy at all target locations.

Insights for Planning

Query & Crash Rotation

- Query and crash rotation of the target volume.

- Using the SGRT system for accurate target localization.

- Direct comparison of system accuracy at all target locations.
Key Takeaways for SGRT and SRS

- SGRT systems are capable of meeting the accuracy demands of modern stereotactic treatments but their unique features and differing implementations require an understanding of both the system and the desired treatment types to derive the proper QA metrics.
- Proper QA of SGRT systems should not only give you data about the system’s state but should give you ongoing information to draw insights on expected states during its use.
- The SGRT system is itself an excellent source of rich information and can be used to inform your quality management program.

Thanks!

Any questions?

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