Surface Imaging to Inform Statistical Quality Control for SRS Treatments

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Quality Improvement and Safety Applications of Surface Imaging

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Disclosures

I have provided Physics Consultation Services to

- Varian and Vision RT

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Some Concepts you can take Home

Characterization of SGRT systems for high precision SRS Treatments

SGRT **Commissioning** and ongoing **Performance Evaluation**

How to use you SGRT system to inform your Quality Assurance goals

Statistical Methods for system characterization and the differences between those and simple tolerances

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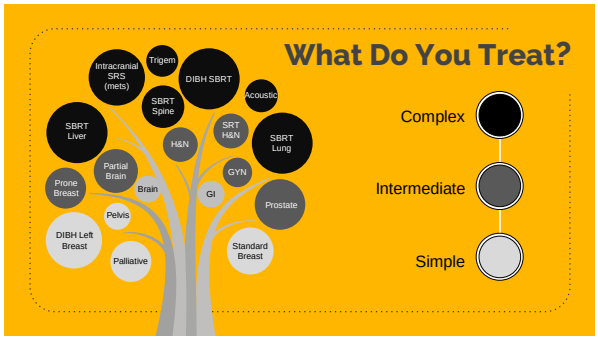
What Do You Treat?
Intracranial SRS (mets)
Trigem
DIBH SBRT
Acoustic
SBRT Spine
SBRT Liver
SRT H&N
SBRT Lung
H&N
Partial Brain
GYN
Prone Breast
Brain
GI
Prostate
Pelvis
DIBH Left Breast
Standard Breast
Palliative
Complex
Intermediate
Simple


Quality &
Information
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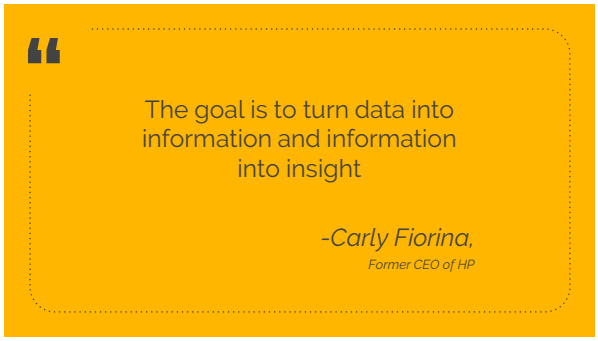
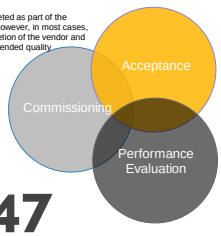

The goal is to turn data into information and information into insight
-Carly Fiorina,
Former CEO of HP

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 test with the vendor; however, in most cases, the acceptance test is at the discretion of the vendor and may not satisfy all clinical recommended quality assurance

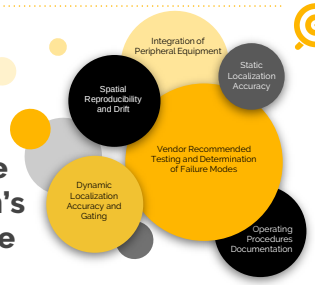


It is important to keep in mind that acceptance tests demonstrate only that the equipment is working as per the specification.

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

TG-147

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



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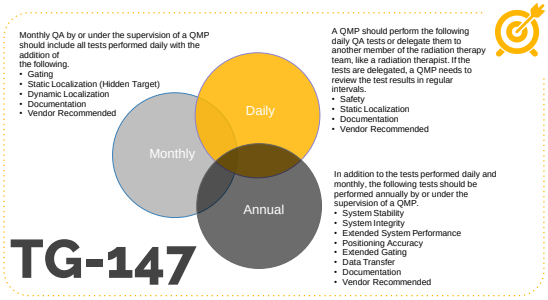
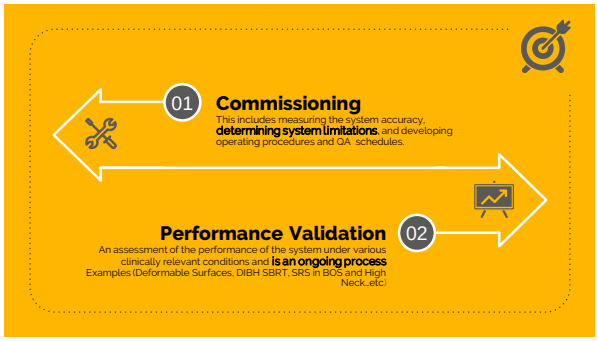
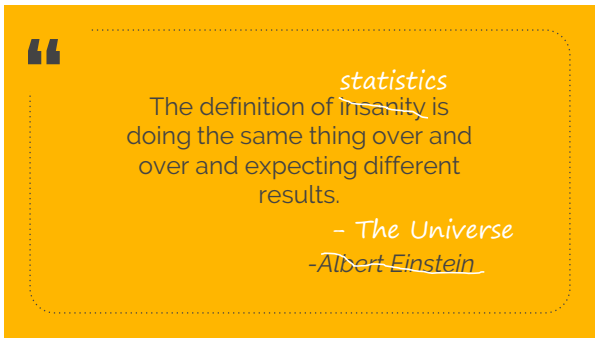

Monthly QA by or under the supervision of a QMP should include all tests performed daily with the addition of the following.
• Gating
• Static Localization (Hidden Target)
• Dynamic Localization
• Documentation
• Vendor Recommended
Daily
Monthly
Annual
TG-147
A QMP should perform the following daily 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
• Documentation
• Vendor Recommended

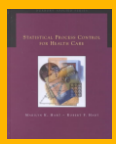

01
Commissioning
This includes measuring the system accuracy, determining system limitations, and developing operating procedures and QA schedules.
Performance Validation
02
An assessment of the performance of the system under various clinically relevant conditions and is an ongoing process
Examples (Deformable Surfaces, DIBH SBRT, SRS in BOS and High Neck..etc)


"
statistics
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

- Pawlicki T, Whitaker M, Boyer A-L. Statistical process control for radiotherapy quality assurance, Med Phys , 2005, vol. 32 (pg. 2777-86)
- Breen S-L, Moseley D-J, Zhang B, et al. Statistical process control for IMRT dosimetric verification, Med Phys , 2008, vol. 35 (pg. 4417-25)
- Pawlicki T, Yoo S, Court L-E, et al. Moving from IMRT QA measurements toward independent computer calculations using control charts, Radiother Oncol , 2009, vol. 8 (pg. 330-7)
- Gerard K, Grandhaye J-P, Marchesi V, et al. A comprehensive analysis of the IMRT dose delivery process using statistical process control (SPC), Med Phys , 2009, vol. 36 (pg. 1275-85)

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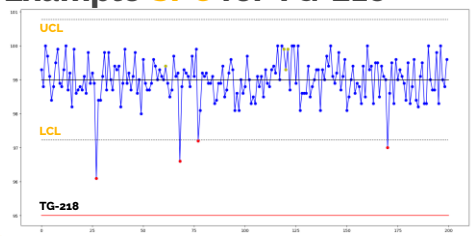
Example SPC for TG-218



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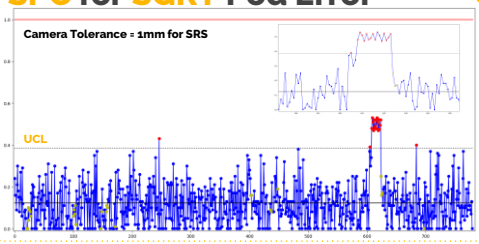
SPC for SGRT Pod Error



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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

• Gierga DP, Turcotte JC, Tong LW, Chen YL, DeLaney TF. Analysis of setup uncertainties for extremity sarcoma patients using surface imaging., Pract Radiat Oncol. 2014 Jul-Aug;4(4):261-6

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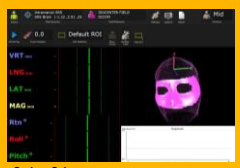
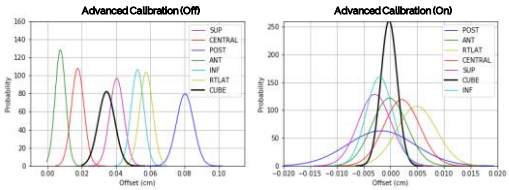
SRS Tolerance Determination



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) so that you can use best practices to drive quality.

Isocenter Offset by Location



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

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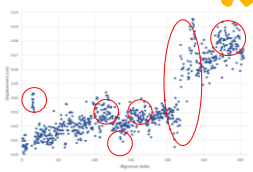
SRS Tolerance Evolution



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)

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Information for SRS Planning

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.

Feature Exploration

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

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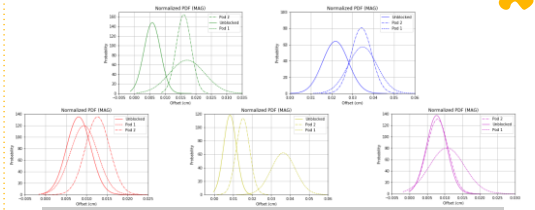
Obstruction Characteristics



Obstruction characteristics of your cameras can exhibit differences based on location of isocenter

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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?

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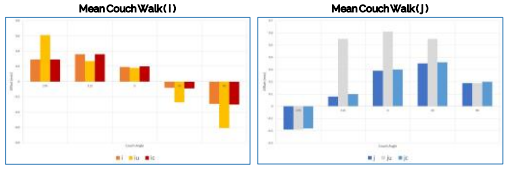
SGRT vs Radiographic Offset



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.

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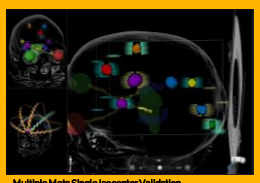
SRS Information for Planning



	1.0	1.1	1.2	1.3	1.4
2.0	0.913	0.904	0.895	0.887	0.878
2.1	0.908	0.899	0.890	0.881	0.872
2.2	0.904	0.895	0.885	0.875	0.866
2.3	0.900	0.890	0.880	0.870	0.860
2.4	0.895	0.885	0.875	0.864	0.854
2.5	0.891	0.880	0.869	0.859	0.848
2.6	0.887	0.875	0.864	0.853	0.842
2.7	0.882	0.871	0.859	0.847	0.836
2.8	0.878	0.866	0.854	0.842	0.830
2.9	0.874	0.861	0.849	0.836	0.824
3.0	0.869	0.856	0.843	0.831	0.818

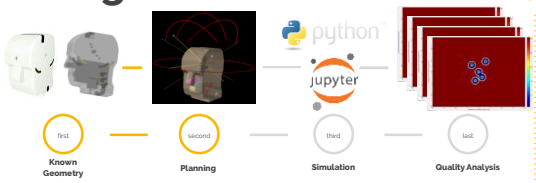
Multiple Mets Single Isocenter Validation

- 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.

Using our SGRT Data



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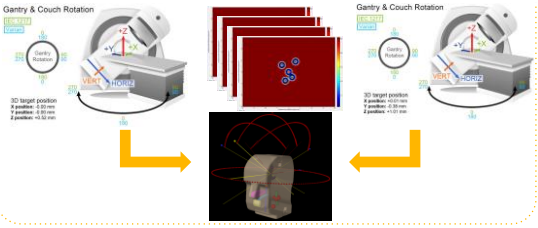
Insights for Planning



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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 systems 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.

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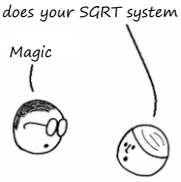
Thanks!

Any questions?



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