PATIENT-SPECIFIC QA

Unique Error Sources & Appropriate QA Methods

IN FOCUS

ERROR SOURCES

Beam Modeling
Transfer Corruption
Plan Deliverability
Patient Setup
Anatomy Changes

QA METHODS

3D Secondary Calculations
Measurement-based QA
In-vivo QA

ALGORITHM NEEDS

Accuracy & Independence

Beam modeling errors can be a pervasive and systemic source of error, often overlooked due to poor or inaccessible QA methods. A **3D Secondary Calculation**, if fully independent, may be excellent at catching modeling errors, but it can never detect errors related to data transfer and a linear accelerator's delivery of the plan, nor can it detect in-vivo errors resulting from patient setup issues or anatomy changes. Detecting beam modeling errors with 3D measurements is both possible and proven, given appropriate gamma criteria are used.

Transfer and deliverability errors can be clinically significant and adversely affect patient outcomes. Both types of errors are seen frequently in the clinic, as documented by several publications. **Measurement-based QA** is required to detect transfer and deliverability errors, and measurement-based QA is required per ACR/ASTRO guidelines.

High resolution 3D QA is by far the most sensitive and clinically useful QA method, and is recommended by AAPM Task Group 218 (TG-218). Importantly, a 3D measurement is also the most efficient approach, in that all error sources can be detected with one QA event.

TG-218 recommends that 3%/2mm or tighter criteria should be used, and specifically recommends the ArcCHECK®. ArcCHECK is a proven solution, with numerous sensitivity publications demonstrating that -- with appropriate gamma criteria -- even small MLC errors can be detected. It's important to note that in a recent Kry et al paper[1] and related presentations, TG-218's recommendations are unheeded in all of the data tables (Tables II, III, and IV) and ~80% of the methods discussed are ones explicitly "not recommended" by TG-218 for VMAT.

While pre-treatment QA is important and does occasionally catch catastrophic errors, the proportion of errors detected through pre-treatment QA is small when compared to in-vivo QA. **Patient setup errors and anatomy changes** are a frequent and (historically) difficult to detect source of treatment errors that often significantly impact patient outcomes. In several recent studies, in-vivo errors have been automatically detected using SunCHECK™ Patient software, with one noting 4,000 clinically impactful errors detected in 2 years (out of 56,000 fractions)[2]. Automated **in-vivo QA** is a revolution in patient safety that the Radiation Oncology community is adopting, because it represents the best use of a physicist's time.

It is important to examine the accuracy and **independence** of any algorithm used for secondary checks and beam model QA. In order to detect beam modeling errors, the 3D algorithm and beam models must be equal or superior to the TPS algorithm, and must be independent. The SunCHECK Dose Calculator (SDC) has been shown to have superior beam models with respect to small fields, MLC-modeling, and heterogeneity, and is fully independent.

For more context, see page 2.

For an in-depth look at these topics based on the review of nearly 30 publications, see Sun Nuclear's whitepaper: *Addressing Misconceptions on IMRT Quality Assurance.*

[1] S.F. Kry, M.C. Glenn, C.B. Peterson, et al. ***Independent recalculation outperforms traditional measurement-based IMRT QA methods in detecting unacceptable plans***, Med. Phys. 46 (8), August 2019: 3700-3708

[2] E. Bossuyt, et al, ***Evaluation of automated pre-treatment and transit in-vivo dosimetry in radiotherapy using empirically determined parameters*** Physics and Imaging in Radiation Oncology 16 (2020) 113–129

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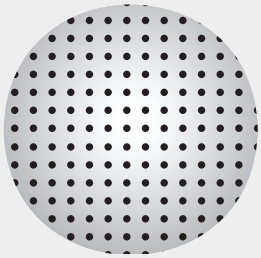
Sources of Error & "Field of View"

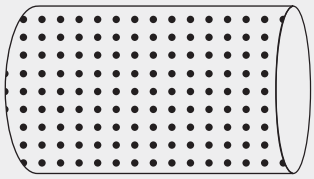
There are hazards in focusing on only one type of error, and selecting a QA method based on that narrow focus. (For example: a calculation only approach, while sensitive to TPS modeling, can miss some of the most common errors.) By broadening intended scope, other QA methods clearly become more appropriate — and clinically actionable.

Beam Modeling
Transfer Corruption
Plan Deliverability
Patient Setup
Anatomy Changes



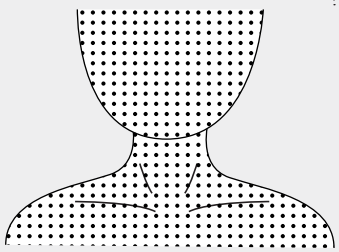
High Resolution
3D Secondary Calculations
100% sensitivity to one error type

Beam Modeling
Transfer Corruption
Plan Deliverability
Patient Setup
Anatomy Changes



High Resolution 3D
Measurement-based QA
Sensitivity to three types of error

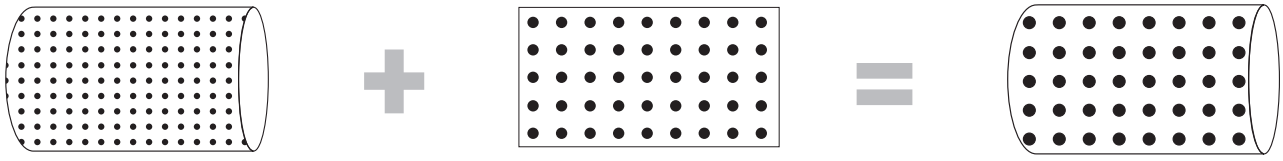
Beam Modeling
Transfer Corruption
Plan Deliverability
Patient Setup
Anatomy Changes



EPID-based In-vivo QA
Sensitivity to four types of error

Reminders: Clinical Use & Research Review

For optimal QA, use current and published criteria. Even the most trusted QA strategies will less sensitive if outdated criteria are applied. When researching strategies to implement, always ensure you differentiate between TG 218-compliant and non-compliant methods. Mixing results leads to misinterpretations of data.

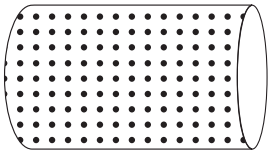


High Resolution
3D Measurement-based QA

Loose Criteria
Applied

Sub-optimal QA

TG 218-compliant

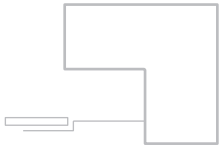


High Resolution
3D Measurement-based QA

Not TG 218-compliant

Single
Ion Chamber

Ion Chamber-based 2D Arrays
without Angular Corrections



2D Perpendicular
Composite Measurements