# Investigation on the portability of patient-specific quality assurance between matched linear accelerators

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## INTRODUCTION

Patient-specific IMRT quality assurance (QA) is routinely performed using the delivery system intended for treatment despite several systems being matched dosimetrically. Using any available matched delivery system can improve the efficiency and timeliness of the performance of the QA. The purpose of this work was to determine if IMRT QA can be safely performed on any of the matched delivery systems.

## METHOD

- Three VMAT plans of varying complexity were created and re-planned for each available energy
  - Sites were neck, SBRT lung, and right chestwall
  - Energies were 6MV, 6FFF, 10MV, 10FFF, 15MV
- Plans delivered with each of three matched Varian TrueBeams to the same diode array - Scandidos Delta4+
  - Same measurement device calibrations, corrected for output at each linac
- Gamma analysis used to compare measurements to TPS calculation
- Round-robin comparison between linacs used:
  - Point-by-point dose differences
  - Median dose differences
  - Percent of point dose differences within 2% of mean

## RESULTS

- All plans had >95% of points passing a TPS-to-measurement gamma (3% global, 3mm, 20% threshold) analysis
- Tightest symmetrical criteria where a plan still passed >95% were similar across delivery systems – within 0.5%/0.5mm across delivery systems for all but three plan and energy combinations
- Median dose deviations in measurement-to-measurement comparisons were within 0.7% and 1.0% for global and local normalization, respectively
- 90% of all point differences were within 2%

*Tables I-III. As an example, passing rates for various criteria for the neck plan using the 6MV beam energy on each machine using a global dose deviation normalization. The smallest symmetric criteria with >95% passing rate is highlighted.*

| Neck Plan, 6MV, Linac 1 | | | |
|---|---|---|---|
| Dist. dev (mm) | Gamma Index Pass Rates (%) | | |
| 3 | 97.1 | 98.9 | 99.9 |
| 2.5 | 95 | 97.9 | 99.9 |
| 2 | 92.6 | 96.5 | 99.9 |
| 1.5 | 84.8 | 94.7 | 99.6 |
| 1 | 74.9 | 90.8 | 99.3 |
| 0.5 | 61.7 | 83.8 | 97.3 |
| Dose dev (%) | 0.5 | 1 | 1.5 |

| Neck Plan, 6MV, Linac 2 | | | | |
|---|---|---|---|---|
| Dist. dev (mm) | Gamma Index Pass Rates [%] | | | |
| 3 | 96.3 | 98.6 | 100 | 100 |
| 2.5 | 93.6 | 97.3 | 99.9 | 100 |
| 2 | 88.2 | 96.4 | 99.9 | 100 |
| 1.5 | 78.8 | 92.5 | 99.4 | 100 |
| 1 | 65.8 | 86.8 | 97.9 | 100 |
| 0.5 | 48.7 | 77.9 | 94.5 | 99.6 |
| Dose dev (%) | 0.5 | 1 | 1.5 | 2 |

| Neck Plan, 6MV, Linac 3 | | | | |
|---|---|---|---|---|
| Dist. dev (mm) | Gamma Index Pass Rates [%] | | | |
| 3 | 93.6 | 98.3 | 99.9 | 100 |
| 2.5 | 89.6 | 96.9 | 99.5 | 99.9 |
| 2 | 84.6 | 94.6 | 99.4 | 99.9 |
| 1.5 | 76.6 | 90 | 98.8 | 99.9 |
| 1 | 65.4 | 84.3 | 97.0 | 99.9 |
| 0.5 | 46.4 | 73.3 | 91.4 | 97.3 |
| Dose dev (%) | 0.5 | 1 | 1.5 | 2 |

*Tables IV-VI. The tightest symmetric criteria where gamma analysis (global normalization) passed as well as the passing rate using that criteria for each plan, energy, and machine.*

| Neck Plan, Global Normalization | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6MV | | 6FFF | | 10MV | | 10FFF | | 15MV | |
| TrueBeam | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) |
| Linac 1 | 1.5 | 99.4 | 1.5 | 96.2 | 1.0 | 95.5 | 1.5 | 98.8 | --- | --- |
| Linac 2 | 1.5 | 99.6 | 1.5 | 97.2 | 1.5 | 99.9 | 1.5 | 98.6 | 2.0 | 97.7 |
| Linac 3 | 1.5 | 98.8 | 1.5 | 95.6 | 1.5 | 98.2 | 2.0 | 98.5 | 2.0 | 98.3 |

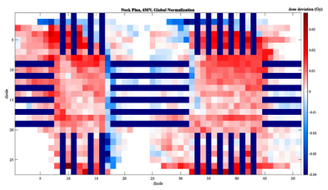
| SBRT Lung Plan, Global Normalization | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6MV | | 6FFF | | 10MV | | 10FFF | | 15MV | |
| TrueBeam | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) |
| Linac 1 | 0.5 | 97.3 | 1.0 | 96.7 | 1.0 | 100.0 | 1.0 | 100.0 | --- | --- |
| Linac 2 | 1.0 | 100.0 | 1.0 | 96.7 | 1.0 | 100.0 | 1.0 | 100.0 | 1.5 | 100.0 |
| Linac 3 | 1.5 | 96.5 | 1.0 | 98.6 | 1.0 | 100.0 | 1.0 | 100.0 | 1.5 | 100.0 |

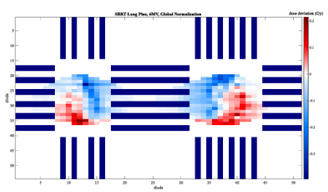
| Chestwall Plan, Global Normalization | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6MV | | 6FFF | | 10MV | | 10FFF | | 15MV | |
| TrueBeam | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) | Criteria (% & mm) | Pass Rate (%) |
| Linac 1 | 2.0 | 98.1 | 2.0 | 98.7 | 1.5 | 95.9 | 2.0 | 97.2 | --- | --- |
| Linac 2 | 2.0 | 98.0 | 2.0 | 96.9 | 2.0 | 97.2 | 2.5 | 99.2 | 3.0 | 99.7 |
| Linac 3 | 2.0 | 96.8 | 2.0 | 95.2 | 2.5 | 99.5 | 2.5 | 97.9 | 3.0 | 99.0 |

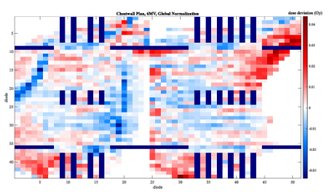
*Table VII. Median dose deviations and the percent of points with deviations within 2% (global normalization) are given.*

| Energy | 6MV | | | | 6FFF | | | | 10MV | | | | 10FFF | | | | 15MV | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plan | Neck | | Lung | | Chestwall | | Neck | | Lung | | Chestwall | | Neck | | Lung | | Chestwall | | Neck | | Lung | | Chestwall | |
| Linac1-Linac2 | 0.23 | 100 | -0.19 | 96 | 0.01 | 100 | 0.11 | 99 | -0.25 | 89 | -0.18 | 99 | -0.20 | 99 | -0.21 | 90 | -0.43 | 99 | -0.10 | 98 | -0.25 | 89 | -0.30 | 98 |
| Linac3-Linac2 | 0.27 | 97 | -0.13 | 89 | 0.22 | 99 | 0.35 | 97 | 0.09 | 96 | 0.22 | 99 | 0.20 | 98 | 0.07 | 93 | 0.22 | 99 | 0.26 | 98 | -0.09 | 91 | 0.26 | 99 |
| Linac3-Linac1 | 0.04 | 93 | 0.11 | 86 | 0.23 | 98 | 0.19 | 94 | 0.47 | 90 | 0.39 | 96 | 0.40 | 93 | 0.43 | 92 | 0.69 | 96 | 0.40 | 92 | 0.34 | 93 | 0.59 | 94 |

*Figure I-III. Several examples of dose deviation (Linac 1 – Linac 2) maps for the neck, lung, and chestwall plans with 6 MV beam energy for each diode in the Delta4+. The dark lines are gaps in the diode array; differences in gaps are due to merging a second, shifted measurement with the original measurement.*




## IMPACT

This work positively impacts the clinic by removing barriers to the prompt and efficient delivery of patient specific IMRT QA. While three delivery systems at this institution have been considered matched in the TPS, this work more extensively characterized the ability of the systems to deliver the same dose distribution, well-within clinical tolerances, during IMRT QA. There are several operational benefits. First, the QA measurement task load can be better balanced across machines. Second, staffing at physically separated satellites becomes more flexible, as physics support is not required on-site to measure all IMRT QA. Finally, urgent treatments planned for delivery on one of the busier systems will benefit, as IMRT QA can be measured on any matched system that has a break in treatments during clinic hours.

## CONCLUSIONS

A set of plans across energies and levels of complexity were measured at three matched delivery systems. Comparisons of TPS-to-measurement and measurement-to-measurement showed that the dose distributions delivered by each system using the same plan file are similar and meet tolerances much smaller than typical clinical criteria for a plan to pass IMRT QA. Therefore, IMRT QA for patients to be treated on these systems can be performed on any of the three linacs.

## CONTACT INFORMATION

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