An Investigation into VMAT Patient-Specific QA Pass Rates

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BACKGROUND

Patient-Specific VMAT QA Measurement is designed to identify discrepancies between planned and delivered doses and detect gross errors in the radiation delivery. It is to ensure the safety of patient, treatment integrity.

Patient specific measurements for VMAT treatments are an important part of our QA process. A successful test requires correct functioning from many pieces of our therapy chain such as the TPS physics model, the planning algorithm, the Linac performance, and the setup and operation of the test phantom. When some QA tests in our clinic began regularly having lower passing scores, we investigated potential causes. Even though all the plans were passing with the gold standard – 3%/3mm, an unusual number of QAs were passing with low rates per our department policy. This suggested a change in some component in our QA process.

This study describes that investigation, the causes we've identified, the magnitudes of corrective remedies applied. We consider this study to have an impact for investigating the low pass rates.

MATERIALS & METHODS

To ensure the treatment delivery is accurate and per approved plan, all parameters for modulated plans are QA'ed before patient treatment. Plans are computed in Pinnacle TPS and recomputed on Arccheck digital phantom for dose analysis. Measured and calculated doses are compared for gradient compensation (GC) analysis using the SNC Patient software. Since the Linac commissioning, our pass rates were steady with 90% pass rate-2%/2mm and 20% threshold with no measurement uncertainty criteria applied. That is our department policy. The presented cases were investigated for passing rate below 90% using the above criteria. Possible changes in MLC leaf bank calibration, beam tuning and output fluctuations were investigated.

The PSQA measurements with the low pass rate, were repeated after the parts of the MLC drive system were replaced and the calibration was done. Even though our monthly and daily machine QA parameters were within tolerances, beam tuning was done and PSQA measurements were repeated. Plan complexity calculations were also carried out by using Dan Cutright's MLC Analyzer code to investigate the impact on low pass rates.

Figure 1: % ArcCheck QA Pass Rate per Patient

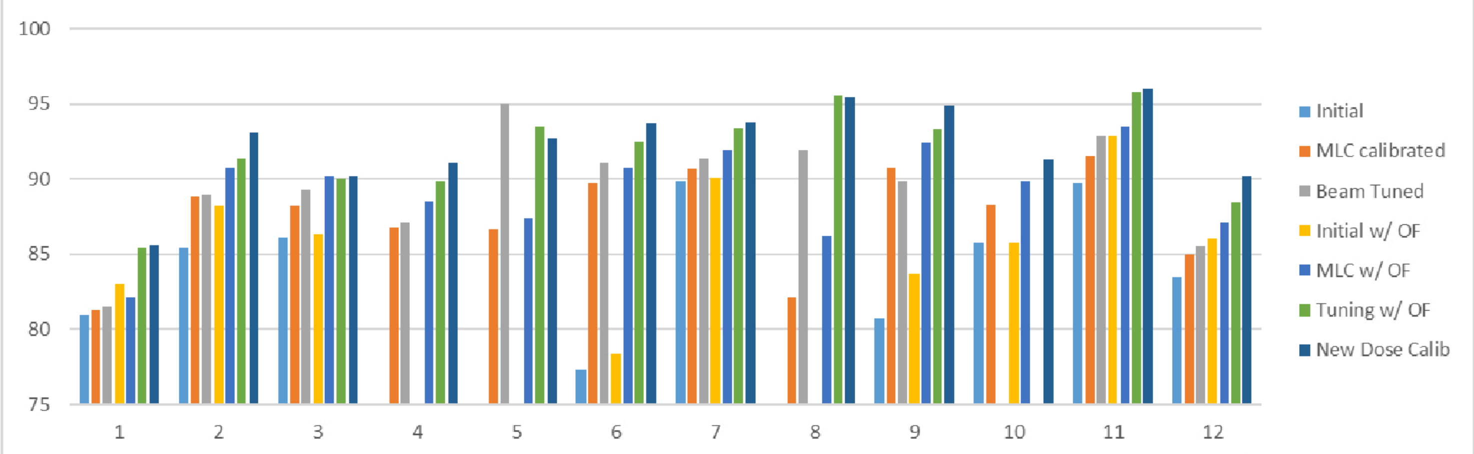
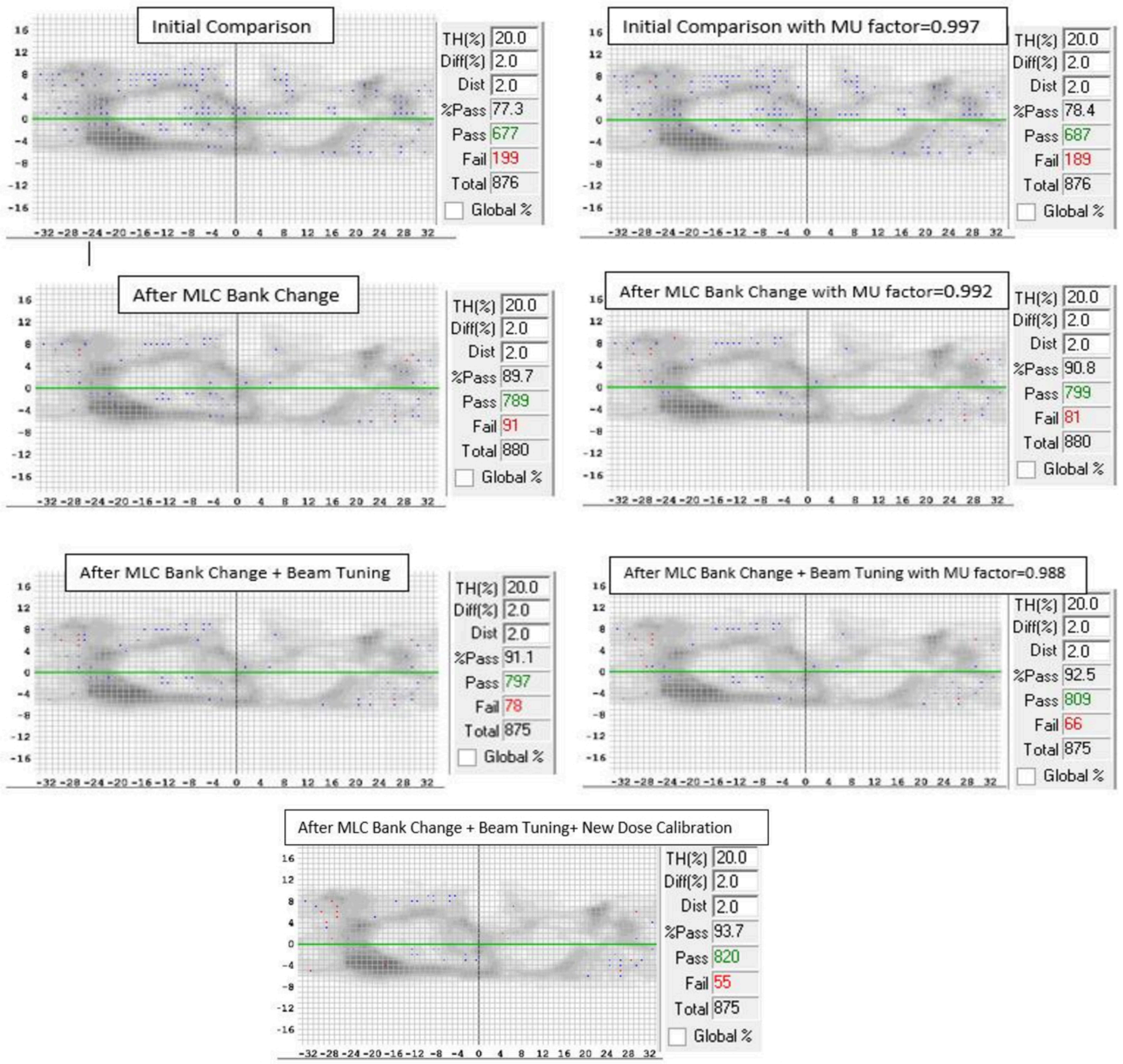


Figure 2:



RESULTS

Twelve clinical VMAT plans were evaluated. Initial pass rate average was 84.4% with a range of 77.3%-89.7%. Adjusting for daily output variation improved pass rates by an average of 1.7% (0%-3.2%) with a pass rate range of 78.4%-92.9%. MLC bank recalibration improved rates by 3.8%(-0.9%_+12.4%) with a pass rate range of 81.3%-91.5%, and adjusting for daily output variation improved these rates with a range of 82.1%-93.5%. The second step was beam tuning. The beam tuning improved pass rates another 2.6%(-0.2_+9.4%) with a pass rate range of 81.5%-95% and adjusting these results for daily output fluctuation improved these pass rates with a range of 85.4%-95.8%. The last step was to get a new dose calibration for the Arccheck. The new dose calibration improved these rates another 3.1% (3.9-16.4%) with a pass rate range of 85.6%-96%. As an example, one patient started with 77.3% passing, which rose to 78.4% with output correction, then 90.8% after MLC correction, and then 92.5% with beam tuning. With the new dose calibration, the pass rate went up to 93.7%.

Figure 1 shows gamma pass-rates for each patient with the different component remedies. To account for MU factor correction, we took a 10cmx10cm measurement for each measurement day and was applied for both measured and calculated dose comparison. The process increased our gamma pass-rates by between 3.5% and 15.2%. Figure 2 is an example of comparison fluence maps for one patient showing the improvements.

Plan complexity scores were also carried out to investigate the impact on low pass rates. In order to calculate the plan complexity scores, we used Dan Cutright's MLC Analyzer Code from DVHA. In this code, the complexity score based on: Med Phys. 2012;39(11):7160–70. We ran the code for these 12 low pass rate patients. We also ran the code for an additional 12 patients who have very high pass rates according to our criteria. From the complexity scores that we got each plan, we concluded that the complexity of the plans didn't have an impact on the PSQA pass rates, meaning that we have a correct beam modeling in our TPS.

CONCLUSION

Tracking the trend of QA pass rates in the clinic per AAPM 218 can help identify Linac performance issues when the trend does not follow set bounds. From our subset of studied plans we found that MLC, beam tuning, beam output calibration, and a new dose calibration for PSQA measurements have a significant impact on QA pass rates whereas the complexity of the plans didn't have an impact on these pass rates.