# Complexity-based traffic light protocol for VMAT plans deliverability using log file analysis

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## Introduction

To evaluate the potential of log-files analysis of fluence and a modulation complexity score to predict plan delivery accuracy of VMAT treatments.

## Material and Methods

105 consecutive VMAT plans of different complexity (head-neck, pelvis, prostate, SBRT) for a total of 190 arcs were analyzed. Treatment planning was performed with Pinnacle Autoplanning v16.1.0 (Philips, UK). For each arc, a modulation complexity score (MCS) was calculated according to McNiven et al., taking into account both leaf sequence and aperture area variability. Log files analysis and MCS calculation was performed by the LinacWatch software (Qualiformed, Roche-sur-Yon, FR). This software collects and analyze 4Hz log files data from an Elekta VersaHD linac supplying the gamma-index passing rate (γ%) between the expected TPS fluence and the actual fluence obtained by log files after irradiation. Fluences were also correlated with dose distributions measured using the PTV Octavius phantom and 1500 2D-ion chamber array. Correlation between γ% at various criteria (local 1mm-1%, 1.5mm-1.5% and 2mm-2%) and MCS values was assessed using Pearson's coefficient. Receiver operator curves (ROC) were used to determine the optimal threshold values for plan classification and the sensibility of the method. In particular, two ROC curves were created to find two separate thresholds, one for a plan that should pass without pre-treatment verification, and another for a plan that should fail and then must be replanned.

## Results

Average MCS for the 190 arcs was 0.244 (SD: 0.088). The ROC analysis performed for the three different gamma criteria reported that the 1%-1mm criteria had the better sensitivity and specificity, with MCS highly correlated with the γ% passing-rate (Figure 1). For the 1mm-1% criteria, a traffic light protocol was adopted: plans with MCS≥0.35 can be considered as safe to treatment (green-light), plans with 0.15<MCS<0.35 must be subjected to pre-treatment QA (yellow-light) and plans with MCS≤0.15 must be re-planned (red-light) because they failed pretreatment QA. These MCS thresholds are reported in Figure 2, showing the γ% passing-rate thresholds for fluence at 1mm-1% criteria in function of MCS ..

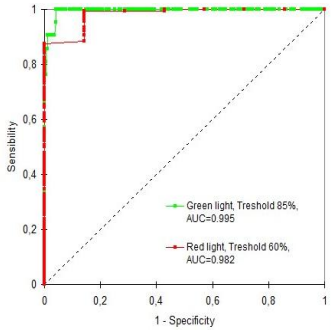


**Figure 1. ROC analysis for different gamma criteria**

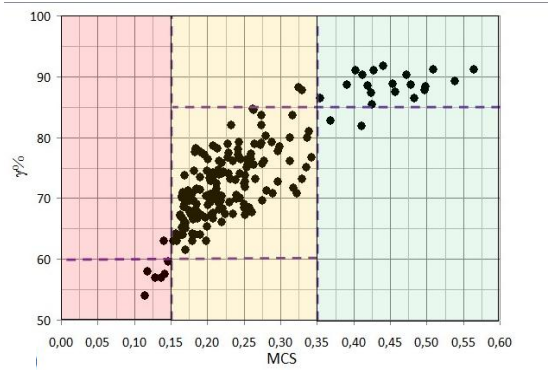


**Figure 2. Plans scatterplot in the γ%-MCS space for 1%-1mm criteria**

## Conclusion

A model for the prediction of plan delivery accuracy has been successfully implemented using the correlation between the modulation complexity score and the gamma-index pass rate for VMAT fluence. A traffic light protocol is able to differentiate over-modulated plans before pre-treatment QA from high-modulated and moderate-modulated plans.

## References

1. Andrea L McNiven, Michael B Sharpe, Thomas G Purdie, "A new metric for assessing IMRT modulation complexity and plan deliverability" Med Phys .2010 Feb;37(2):505-15. doi: 10.1118/1.3276775.