



# Modulation Complexity Score Evaluation for Multitarget Site Planning Using VMAT and IMRT Technique

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## INTRODUCTION

The complexity metrics aids in analyzing behaviour of TPS optimizer, compare TPS, operators and plan properties. The complexity level of a modulated plan is variable according to patient anatomy, dosimetric constraints, optimization algorithm and linac capabilities.

## AIM

To evaluate modulation complexity score for multitarget site planning with single-arc-VMAT, double-arc-VMAT, 7-field-IMRT and 9-field-IMRT techniques.

## METHOD

- An in-house human head mimicking phantom (PMMA Material) incorporated with four PTV cylinders - 3 cm diameter and 5 cm length, HU values 290, 70, 50, -35 respectively simulated multiple brain lesion plan. A critical organ of 1cm diameter and 5cm length was delineated in-between four PTV's.

**Machine Parameters:** Synergy-S Linac (Elekta) with 6MV Photons, field size 16x21cm<sup>2</sup> and MLC (Beam modulator).

**Plan Parameters:** Monaco TPS (Version 5.11), 3 mm grid resolution, Prescription Dose – 66Gy/33 fractions for each PTV.

**Plan Methods –**

- Single-arc-VMAT (sVMAT)
- Double-arc-VMAT (dVMAT)
- 7-Field-IMRT
- 9-Field-IMRT plan

- An in-house developed MATLAB program computed:

✓ Leaf sequence variability (LSV)

✓ Aperture area variability (AAV)

✓ Modulation complexity score (MCS) score for VMAT and IMRT by acquiring following plan information :

- Jaws position
- Number of control points
- MLC leaf positions per control point
- Cumulative MU weights per control point
- MU per arc/field

## RESULTS

Following are the values for **sVMAT**, **dVMAT**, **7-Field-IMRT** and **9-Field-IMRT** plans :

- Number of control points** - 98,217,262,350;
- LSV** - 0.7659,0.7312,0.6976,0.7180;
- AAV** - 0.1733,0.1437,0.1756,0.1639;
- MCS** - 0.1504,0.1295,0.1385,0.1299;
- MU** -738.2,798.25,940.46,1029.05.

The sVMAT showed higher MCS value among four plans. The MCS of dVMAT was nearly equal to that of 9-Field-IMRT. The mean dose to critical organ and body was lowest in dVMAT plan.



Figure 1 (a) In-house Developed human head shape phantom with thorax assembly. (1b) Head portion of the phantom having provision to insert four cylinders of varying density values.

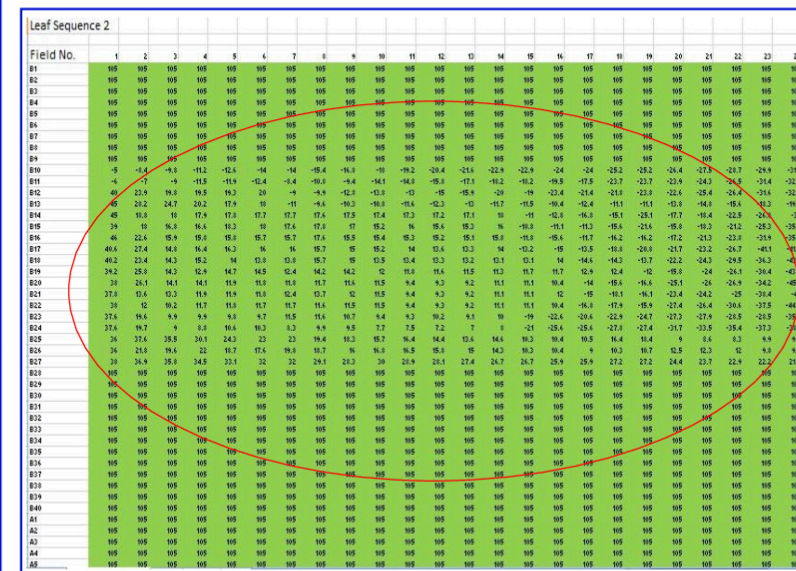


Figure 5: A sample leaf sequence showing control points and leaf positions.

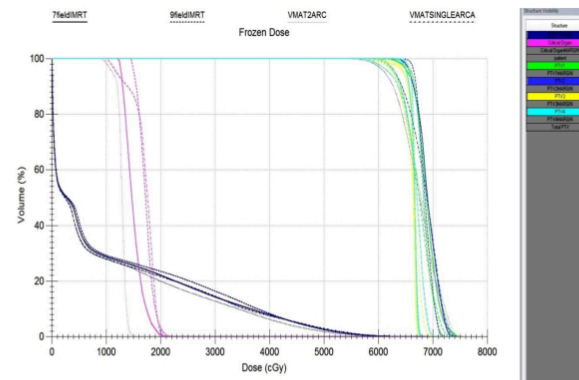


Figure 2: DVH comparison between various plans.

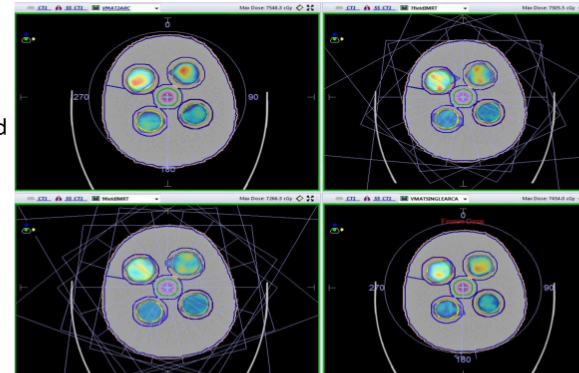


Figure 3: Planning for multitarget lesion (Four PTV's) on head phantom done in Monaco TPS version using Single Arc VMAT, Double Arc VMAT, 7 Field IMRT and 9 Field IMRT showing 95 % isodose colorwash.

| Treatment Technique | No of fields | No of Control Points | AAV    | LSV    |
|---------------------|--------------|----------------------|--------|--------|
| VMAT                | Single Arc   | 98                   | 0.1733 | 0.7659 |
|                     |              | 105                  | 0.1475 | 0.7344 |
| VMAT                | Double Arc   | 112                  | 0.1400 | 0.7281 |
|                     |              | 38                   | 0.1988 | 0.7431 |
| 7 Field IMRT        | 7            | 37                   | 0.1786 | 0.7412 |
|                     |              | 39                   | 0.1379 | 0.6747 |
| 9 Field IMRT        | 9            | 36                   | 0.2182 | 0.6138 |
|                     |              | 36                   | 0.1184 | 0.6772 |
| 9 Field IMRT        | 9            | 37                   | 0.2399 | 0.8052 |
|                     |              | 39                   | 0.1373 | 0.6277 |
| 9 Field IMRT        | 9            | 44                   | 0.1197 | 0.7460 |
|                     |              | 35                   | 0.2197 | 0.7985 |
| 9 Field IMRT        | 9            | 43                   | 0.1191 | 0.6850 |
|                     |              | 36                   | 0.1986 | 0.6071 |
| 9 Field IMRT        | 9            | 41                   | 0.1130 | 0.6786 |
|                     |              | 34                   | 0.1928 | 0.7707 |
| 9 Field IMRT        | 9            | 38                   | 0.1866 | 0.7804 |
|                     |              | 43                   | 0.1180 | 0.6369 |
| 9 Field IMRT        | 9            | 36                   | 0.2074 | 0.7584 |

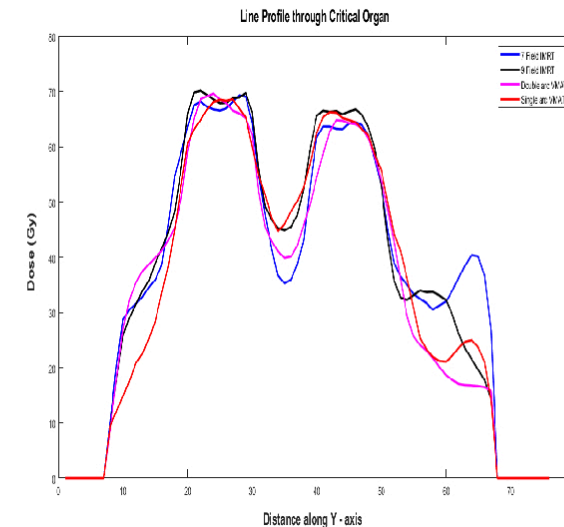


Figure 4 : Line Profile through critical organ showing dose effect of various plans. Maximum reduction in dose was done by doublearc-VMAT followed by 7-Field-IMRT.

## CONCLUSIONS

MCS analysis performs quantitative assessment of plan complexity and provides comprehensive information on dose delivery than simple beam parameters such as monitor units.

## ACKNOWLEDGEMENTS

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## REFERENCES

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Table 1: AAV, LSV and MCS calculated using in-house developed matlab codes.