HyperArc Deliverability: A Comparison to Clinical Plans Using Gamma Analysis

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Introduction

HyperArc: Automated planning and delivery technique for single and multiple-target stereotactic radiosurgery (SRS) treatments[1].

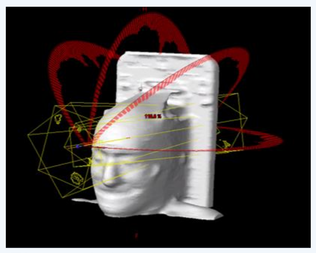

Figure 1. *HyperArc uses a non-coplanar beam geometry.*

Gamma Analysis: Indicates deliverability of an SRS plan with gamma passing rate (GPR). Compares geometric and dosimetric agreement between planned and delivered radiation doses.

Do HyperArc SRS plans have a non-inferior deliverability compared to manually created clinical plans?

Methods

1. Plan Creation

Verification plans for 14 previously treated patients (HyperArc and Clinical plans).

2. EPID + Octavius Plan QA:

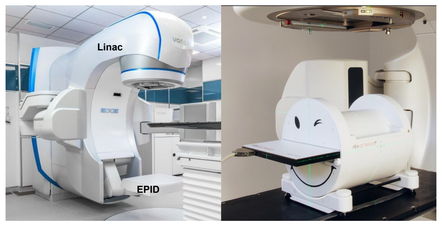

Figure 2. *Dose measurement devices for plan QA.*
EPID (left): Integrated flat panel detector.
Octavius (right): Independent phantom based system.

3. Deliver Verification Plans

Delivered on Varian EDGE linear accelerator.

4. Gamma Analysis

Find gamma passing rates (GPRs) of delivered plans from both EPID and Octavius measurements.

5. Compare HyperArc to Clinical Results

Compare HyperArc GPRs to clinical GPRs using two-tailed Wilcoxon signed-rank test, significance level of 5%.

Results

GPR Results: High GPRs found for both clinical and HyperArc plans (see Table 1 and Figure 3).

- **Clinical Acceptability:** GPR ≥ 95% typically required to be clinical acceptable for patient treatment[2].
- **EPID vs. Octavius:** Octavius measurements give higher GPR values compared to EPID measurements.

Table 1. *Clinical and Hyperarc GPRs results from measurements with EPID and Octavius. All GPRs calculated with 3%/1mm criteria and 10% dose threshold.*

Measurement Type	EPID		Octavius	
	Average (%)	Standard Deviation (%)	Average (%)	Standard Deviation (%)
Clinical	96.2	8.7	99.4	0.4
HyperArc	95.0	8.6	99.6	0.3

Outliers Found: Three specific patients with high numbers of targets (>7) found to be outliers compared to other patient GPR values (see Figure 3).

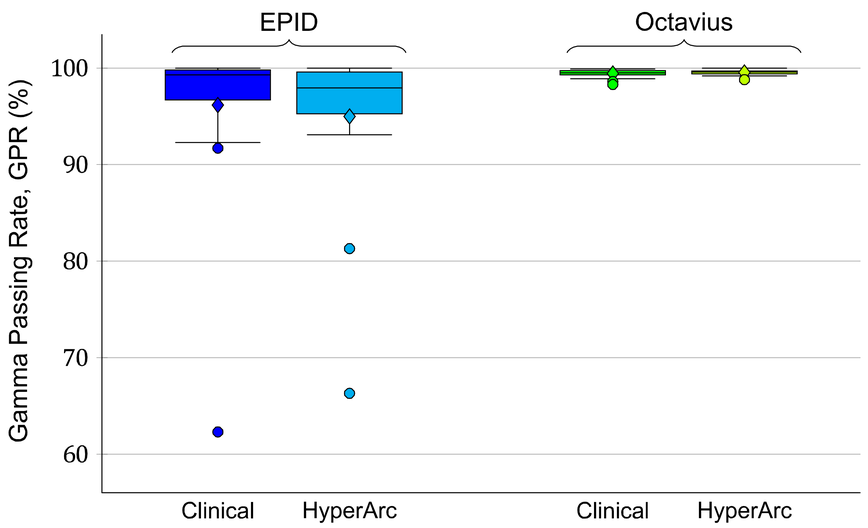

Figure 3. *Clinical and HyperArc verification plan GPR results for both EPID and Octavius measurements as boxplots. Whiskers are restricted to a length no more than 1.5 times the interquartile range. Outliers beyond this are plotted as circles. The average GPR of each plot is represented by a diamond.*

Wilcoxon Signed Rank Test:

- No significant difference found between HyperArc and Clinical plan GPRs
- This is the case regardless if we compare our results from EPID measurements or from Octavius measurements.

Discussion

No statistically significant difference in GPR values between clinical and HyperArc plans.

- ➢ Thus, clinical implementation of HyperArc is feasible from a deliverability perspective.

Higher GPRs with Octavius: Detector resolution

- Octavius has lower detector resolution compared to EPID.
- ➢ Makes SRS plans' characteristicly rapid dose fall-off harder to capture using Octavius.

Boxplot Outliers:

- ➢ Believe to be reflection of increased plan complexity due to their higher numbers of targets compared to other plans.

Conclusion

High gamma passing rates were found for HyperArc and manually created clinical plans.

Based on these gamma analysis results, no significant differences between HyperArc plans and clinical plans were found.

We have shown that HyperArc SRS plans have non-inferior deliverability compared to clinical plans.

This indicates the viability of HyperArc in SRS treatments.

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More Info

Please scan to read the full abstract

References

1. Wong FH,Moleme PA, Ali OA, Mugabe KV. Clinical implementation of HyperArc. Phys. Eng. Sci. Med. 2022;45(2):577–587.
2. Miften M, Olch A, Mihailidis D, et al.Tolerance limits and methodologies for IMRT measurement based verification QA: Recommendations of AAPM Task Group No. 218. Med. Phys. 2018;45(4):e53–e83.