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JOINT AAPM | COMP MEETING

Spatially Fractionated Radiation Therapy (SFRT) Dosimetric Parameters from High Dose Rate (HDR) Interstitial Gynecologic Brachytherapy

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PURPOSE

- Spatially Fractionated Radiation therapy (SFRT) and brachytherapy both have high dose heterogeneity featuring localized high-dose regions and steep dose gradients.
- While SFRT techniques such as GRID and Lattice intentionally create heterogeneous dose distribution, the dose heterogeneity of brachytherapy comes from the intrinsic properties of radioactive sources which deliver high doses near the source while quickly fall off with distance.
- This study evaluates commonly used SFRT dosimetric parameters for HDR interstitial gynecologic brachytherapy.

METHODS

- Seven patients with gynecologic malignancies were retrospectively selected.
- Five patients received treatments with a central tandem plus 2-9 interstitial needles, while two were treated with needles alone (7 and 9 needles).
- All patients received 8.8 Gy per fraction for three fractions. One representative fraction from each patient was analyzed.
- SFRT dosimetric parameters, including Equivalent Uniform Dose (EUD), doses covering 5%, 10%, 50%, 90%, 95% of target (D5, D10, D50, D90, D95), and dose heterogeneity indices (D5/D95 and D10/D90), were evaluated for the high-risk clinical target volume (CTV_HR).

RESULTS

- The mean CTV_HR volume was 22.2±14.7 cc (range: 3.9-50.0 cc).
- EUD values for radiosensitive, semi-radiosensitive, and radioresistant tumor assumptions were 11.3±0.3 Gy, 12.3±0.4 Gy, and 13.4±0.6 Gy, respectively, representing a 28-40% increase compared to the prescription dose.
- Mean values for D5, D10, D50, D90, D95 were 39.4±10.4 Gy, 28.7±6.6 Gy, 14.1±0.9 Gy, 9.5±0.3 Gy, 8.8±0.3 Gy, respectively.
- The heterogeneity indices of D5/D95 (4.5±1.2) and D10/D90 (3.0±0.7) were comparable to reported GRID (~3-7) and LATTICE (~2.5-5) values.

Table 1: SFRT Dosimetric Metrics for Interstitial Gynecologic Brachytherapy (n=7).

Case #	Applicators	Volume of CTV_HR (cc)	EUD (Gy) radiosensitive	EUD (Gy) Semi-sensitive	EUD (Gy) radioresistant
1	Tandem + 2 Needles	22.2	11.38	12.41	13.77
2	Tandem + 3 Needles	14.0	11.68	12.64	13.76
3	Tandem + 9 Needles	50.0	11.33	12.26	13.3
4	Tandem + 2 Needles	22.2	11.49	12.76	14.4
5	Tandem + 4 Needles	14.1	11.34	12.18	13.18
6	7 Needles	29.1	10.65	11.6	12.68
7	9 Needles	3.9	11.34	12.13	13.05
Mean		22.2	11.3	12.3	13.4
Standard Derivation		14.7	0.3	0.4	0.6

Case #	D5 (Gy)	D10 (Gy)	D50 (Gy)	D90 (Gy)	D95 (Gy)	D5/D95	D10/D90
1	46.88	34.60	14.53	9.49	8.93	5.25	3.65
2	36.49	27.26	14.45	9.80	9.15	3.99	2.78
3	30.52	24.44	13.92	9.47	8.84	3.45	2.58
4	59.57	40.94	15.77	9.68	8.80	6.77	4.23
5	34.39	24.47	13.49	9.53	8.97	3.83	2.57
6	31.12	24.12	13.37	8.92	8.29	3.76	2.71
7	36.76	24.80	13.29	9.48	8.94	4.11	2.62
Mean	39.4	28.7	14.1	9.5	8.8	4.5	3.0
Std	10.4	6.6	0.9	0.3	0.3	1.2	0.7

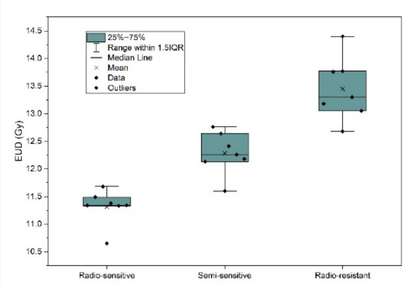

Fig 1: EUD values of all cases

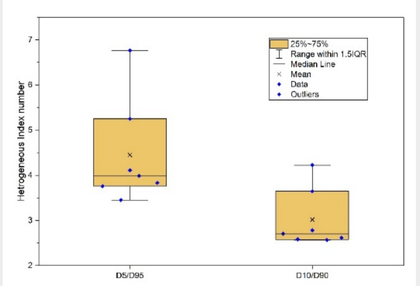

Fig 2: Heterogeneous indices of all cases

SUMMARY

- HDR Interstitial gynecologic brachytherapy demonstrated dosimetric parameters comparable to external beam SFRT.
- Elevated EUDs and large D5/D95 and D10/D90 indices indicated better tumor control than implied by the prescription dose and strong spatial dose modulation which may enhance radiation response as seen in SFRT.
- These findings suggested that the interstitial gynecologic brachytherapy is indeed an SFRT-like treatment with strong spatial dose modulation.

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