

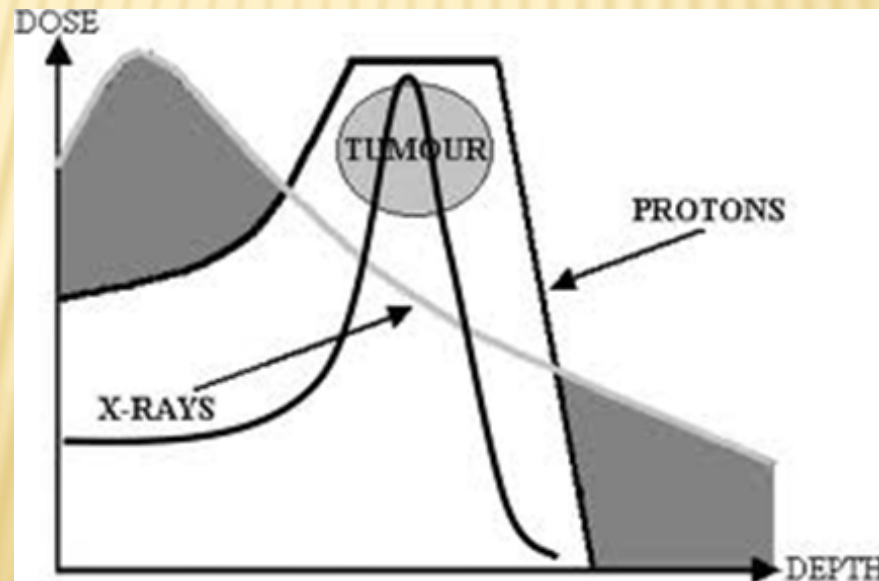


Dosimetric Comparison of HDR Brachytherapy and Intensity Modulated Proton Therapy (IMPT)

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RATIONAL (1)

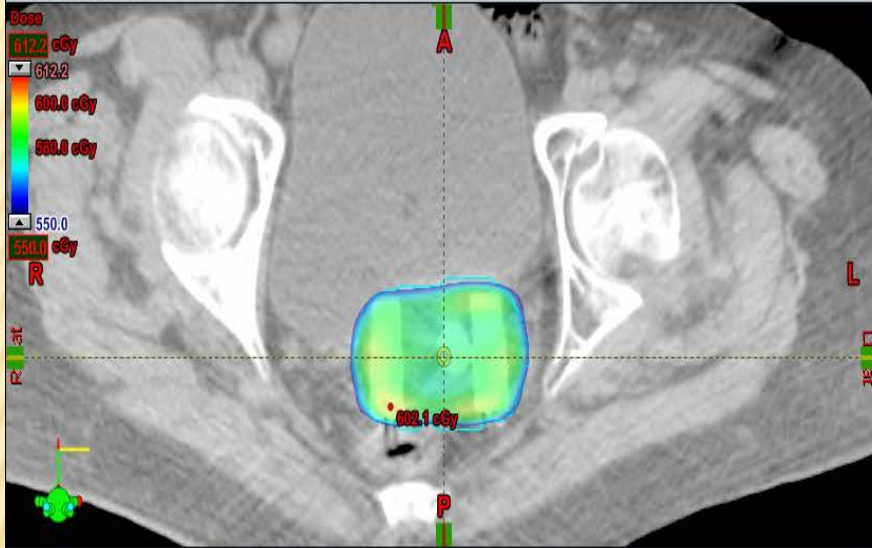
- ❖ HDR Brachytherapy is known for quick dose drop off to spare the normal tissues.
- ❖ Proton therapy is also benefit from sharp dose distribution provided by the Bragg peak.



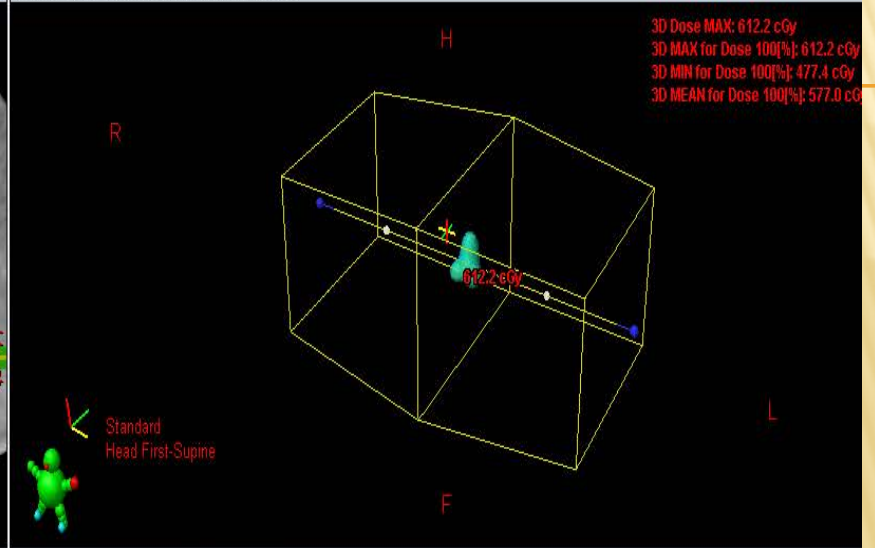
RATIONAL (2)

- ❖ EBRT followed by T&O HDR Brachytherapy has been standard treatment for advanced stage cervix cancer.
- ❖ Some patients can't get the HDR treatment.
 - ❖ Unfavorable anatomy,
 - ❖ Intolerance to anesthesia procedure or
 - ❖ Inability to be at dorsal lithotomy position.
- ❖ Explore the feasibility of replacing HDR boost with IMPT.
- ❖ Since SBRT was also investigated to replace HDR Brachytherapy, SBRT plans were added for comparison.

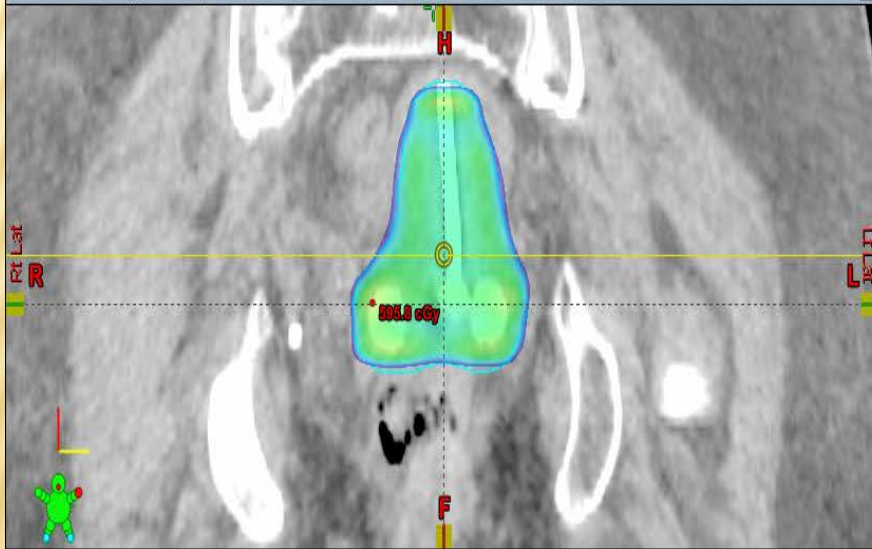
Proton HDR1 - Unapproved - CT_1



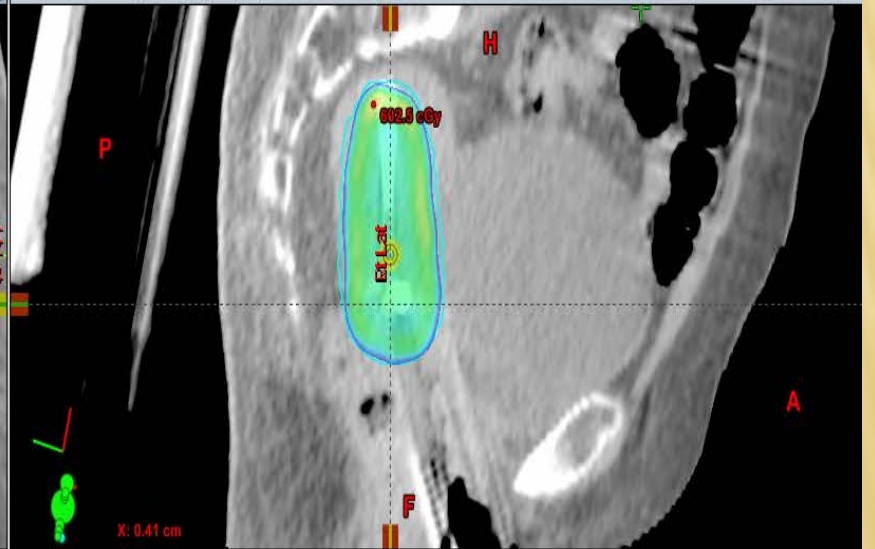
Proton HDR1 - Unapproved - Model View - CT_1



Proton HDR1 - Unapproved - CT_1



Proton HDR1 - Unapproved - Sagittal - CT_1



METHODOLOGY

- ❖ Choose five T&O HDR Brachytherapy patients. Export 100% dose volume as new CTV of IMPT plan.
- ❖ To have a fair comparison, the same HDR CT dataset was used for both IMPT and SBRT planning.
- ❖ CTV were optimized to have a minimum dose of prescription dose (5.5Gy x 5 fractions).

IMPT TREATMENT PLANNING

- ❖ Planning philosophy is to generate similar pear-shaped dose distribution as HDR while sparing the normal tissues as much as possible.
- ❖ Varian Cyclotron accelerator with max energy of 250MeV.
- ❖ Two lateral proton beams were used.
- ❖ Eclipse proton treatment planning.

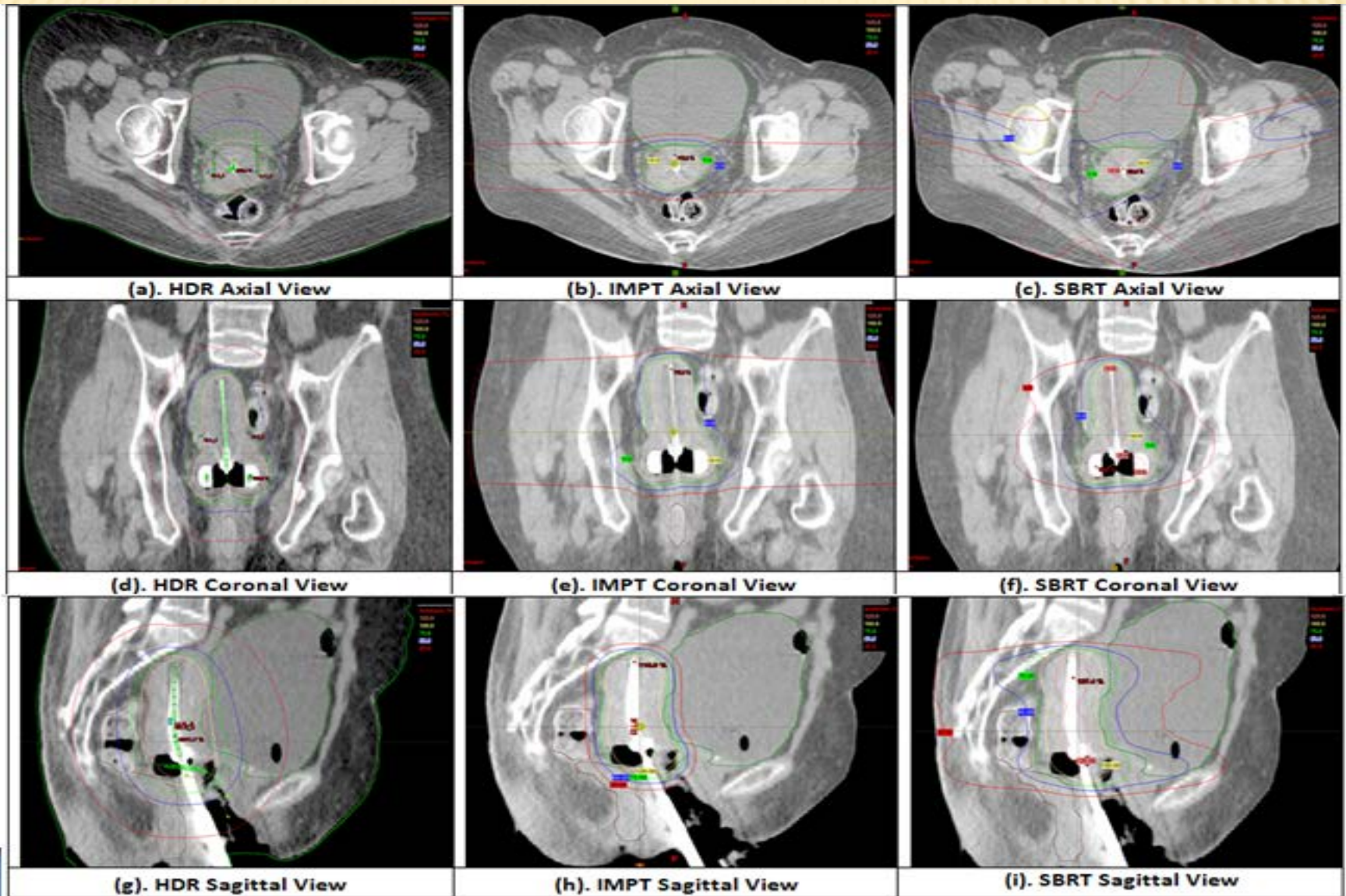
SBRT TREATMENT PLANNING

- ❖ Same philosophy as IMPT planning.
- ❖ Seven co-planar SRS 6MV photon beams on Varian Trilogy LINAC.
- ❖ Eclipse photon treatment planning.

DATA ANALYSIS

- ❖ A set of predetermined criteria with paired T test with a threshold for statistical significance (p value of 0.05) was used to analyze the difference.

A REPRESENTATIVE COMPARISON OF PLAN COVERAGE WITH HDR, IMPT, AND SBRT, RESPECTIVELY



COMPARISON OF CTV COVERAGE AMONG HDR, IMPT AND SBRT

Metrics	HDR		IMPT		SBRT		p-values		
	Average	Stdev	Average	Stdev	Average	Stdev	HDR vs IMPT	SBRT vs IMPT	HDR vs SBRT
D_{mean} (%)	210.1	5.8	110.7	2.6	119.9	1.4	<.0001	0.001	<.0001
$D_{2\%}$ (%)	847.3	37.1	117.7	2.1	137.1	2.9	<.0001	0.0008	<.0001
$D_{98\%}$ (%)	100.9	0.5	99.2	2.1	100.0	0.1	0.2875	0.0829	0.0341
D_{max} (%)	5995.1	2229.0	124.7	3.9	142.7	3.7	0.0042	0.0027	0.0042
$V_{95\%}$ (cm ³)	117.1	41.1	146.9	49.4	147.6	51.5	0.0014	0.8438	0.0067
$V_{50\%}$ (cm ³)	313.4	107.1	323.5	94.0	1008.8	502.0	0.238	0.0202	0.0173
$R_{50\%}$	2.9	0.1	3.1	0.2	9.0	1.7	0.1456	0.0021	0.0015
HI Index	3.55	0.13	0.17	0.03	0.31	0.02	<.0001	0.0045	<.0001
CI Index	1.09	0.00	1.37	0.02	1.37	0.08	<.0001	1.0	0.0016

COMPARISON OF OARS SPARING AMONG HDR, IMPT AND SBRT

Volume	Metric	HDR		IMPT		SBRT		p-value ¹	p-value ²	p-value ³
		Average	STDEV	Average	STDEV	Average	STDEV			
Rectum	D _{mean} (%)	39.7	5.8	18.7	9.9	36.0	2.3	0.0012	0.0121	0.2076
	D _{50%} (%)	37.0	5.6	8.5	12.5	36.2	4.8	0.0019	0.003	0.7916
	D _{35%} (%)	43.0	6.2	18.0	17.0	47.1	4.1	0.0118	0.0074	0.0564
	D _{25%} (%)	45.4	8.3	28.8	17.3	53.7	4.9	0.0432	0.0115	0.0288
	D _{15%} (%)	55.3	7.4	45.3	16.6	60.8	6.0	0.1073	0.0413	0.0189
	D _{2cc} (%)	72.5	10.3	74.8	13.9	75.0	7.0	0.3613	0.9626	0.3666
Bladder	D _{mean} (%)	24.1	5.3	8.0	4.2	27.3	1.0	0.0005	0.0003	0.2532
	D _{50%} (%)	18.5	4.7	0.00	0.00	23.5	2.2	0.0009	<.0001	0.155
	D _{35%} (%)	24.0	5.8	0.3	0.6	31.0	2.8	0.0006	<.0001	0.1362
	D _{25%} (%)	29.6	6.7	3.2	4.4	37.4	3.0	0.0003	0.0002	0.1267
	D _{15%} (%)	38.8	8.4	16.8	14.9	46.5	4.1	0.007	0.006	0.1211
	D _{2cc} (%)	97.4	13.5	97.3	16.0	94.5	12.3	0.9501	0.321	0.0735
Small Bowel	D _{mean} (%)	9.3	3.8	3.0	2.3	11.9	7.3	0.0016	0.0247	0.23
	D _{200cc} (%)	10.3	7.1	2.8	6.2	15.7	16.1	0.0291	0.072	0.2515
Femoral Heads	D _{mean} (%)	6.7	2.1	11.4	7.4	28.9	7.9	0.0016	0.0247	0.23
	D _{5%} (%)	13.6	3.9	40.4	11.9	64.4	11.1	0.0291	0.072	0.2515
Body minus CTV	D _{mean} (%)	6.7	0.6	4.1	0.5	10.1	1.1	<.0001	<.0001	0.0005

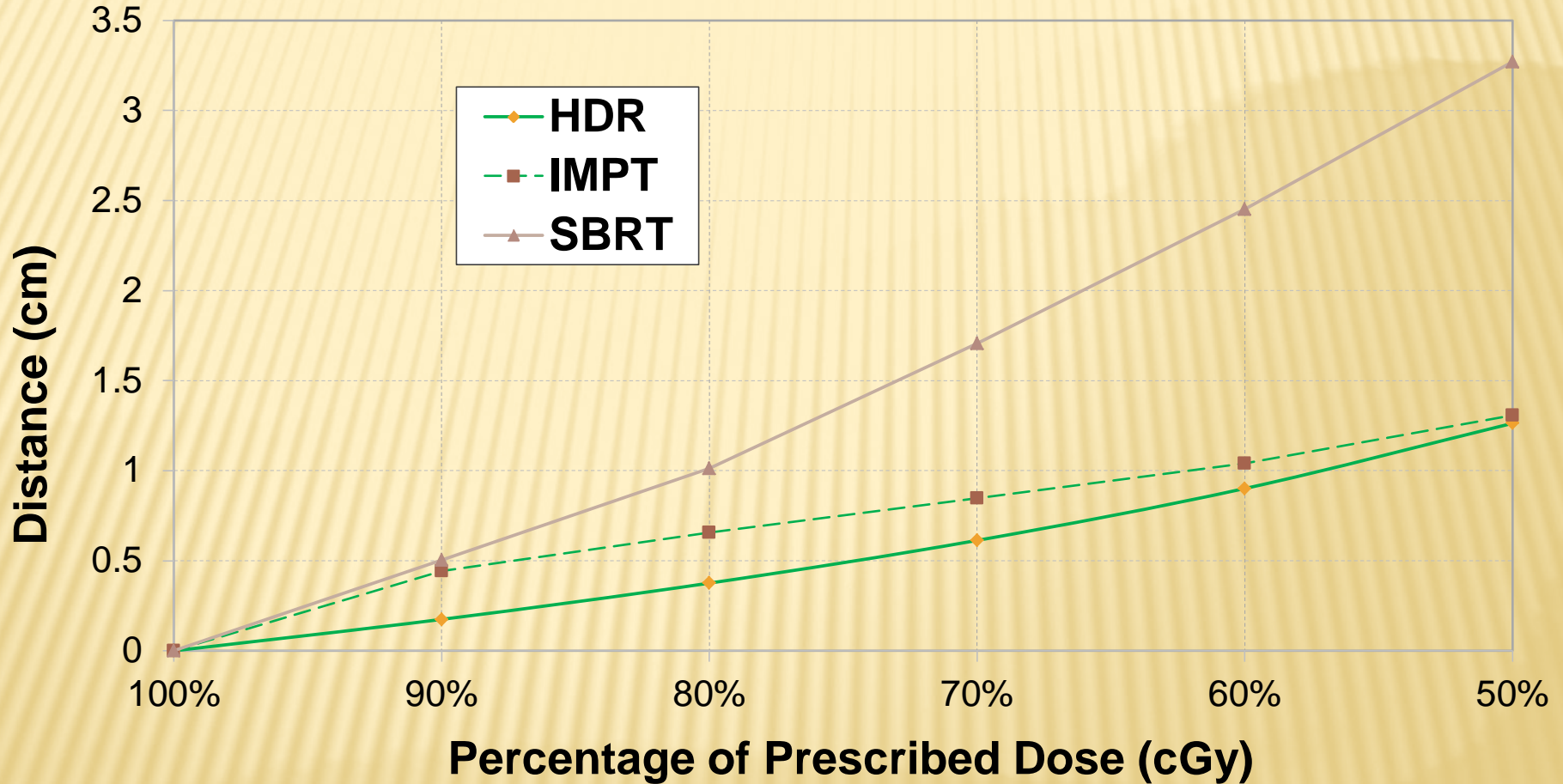
RESULT (1)

- ❖ The percentage of CTV volume that was covered by 100% of the prescribed dose was 99.6% and 99.5 for IMPT and SBRT respectively.
- ❖ The mean rectal dose decreases from 39.7% for HDR Brachytherapy to 18.6% for IMPT of the prescribed doses.
- ❖ The mean bladder dose decreases from 24.1% for HDR Brachytherapy to 8% for IMPT of the prescribed doses.

RESULT (2)

- ❖ Mean dose of volume “Body-CTV” are 6.7%, 4.1% and 10.1% of the prescribed dose for HDR, IMPT and SBRT respectively.
- ❖ Small bowel mean dose are 9.3%, 3%, and 11.9% respectively.

RESULT (3): DOSE GRADIENT DROP OFF COMPARISON AMONG HDR, IMPT AND SBRT PLANS



DISCUSSION

- ❖ No radiobiological issues. All the plans have a fraction dose of 5.5 Gy. Treatment time: 15 minutes.
- ❖ Patient motion can be an issue. But it can be solved by Diacor Zephyr patient positioning and transfer system with air bearing technology.

FUTURE RESEARCH

- ❖ Application of IMPT to other types of HDR Brachytherapy.
- ❖ Double scattering proton beam could also be applied.

CONCLUSION

- ❖ This study is the first direct dosimetric comparison between HDR Brachytherapy and IMPT plans on the same CT dataset.
- ❖ IMPT provided comparable dose drop off as HDR plans. Both are better than SBRT plans.
- ❖ IMPT plans provided more normal tissue sparing and less integral dose.

Thank you!

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