

Theme: Clinical

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Abstract Title: Evaluating the impact of robust treatment planning on Single-Field Optimization (SFO) and Multi-Field Optimization (MFO) using proton therapy in left-sided breast cancer with internal mammary node chain involvement: A pilot study

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Background / Aims:

Advanced techniques like intensity-modulated radiotherapy (IMRT) and volumetric-modulated therapy (VMAT) deliver high radiation doses to organs-at-risk (OARs) in left-sided breast cancer patients with internal mammary node involvement. In contrast, proton therapy (PT) uses the Bragg peak for improved target coverage and reduced OAR toxicity. This pilot study compares Single-Field Optimization (SFO) and Multi-Field Optimization (MFO) methods in terms of target coverage, OAR sparing, plan robustness, and linear energy transfer (LET) deposition.

Subjects and Methods:

Aspect	Details
Patients	15 with left-sided breast cancer and internal mammary node involvement
Center	Hong Kong Sanatorium & Hospital
Period	2021 - 2022
Target Volumes (CTV)	Whole breast, axilla, supraclavicular, IMN
Planning System	RayStation
Prescription	40.5 Gy_RBE in 15 fractions (Gantry 10° and 40°)
Coverage Criteria	NRG RTOG 1005 protocols
Evaluation	Dose-volume parameters, OAR doses, robustness analysis, LET contributions

Target Dose	Criteria/Goal	Variation Acceptable
Breast/Chestwall CTV		
	V95 >=95% Dmax <= 110%	V90 >= 90% Dmax <= 115%
Lumpectomy CTV (Mastectomy Scar CTV for ref only)		
	V95 >= 95% V110% <= 5 %	V90 >= 90% V110% <= 10%
Axillary & supraclavicular CTV		
	V95 >= 95% Dmax <= 110%	V90 >= 90% Dmax <= 115%
Internal mammary nodes CTV		
	V90 >= 90% Dmax <= 110%	V80 >= 90% Dmax <= 115%
OAR constraints 15fra		
1st Priority		Acceptable
Ipsilateral Lung		
	V16Gy <= 15% V8Gy <= 30% V4Gy <= 50%	V16Gy <= 20% V8Gy <= 40% V4Gy <= 55%
Contralateral Lung		
	V4Gy <= 10%	V4Gy <= 15%
Heart		
	Dmax < 40Gy Dmean <= 1.5% V16Gy <= 5% (Lt) V8Gy <= 30% (Lt) V16Gy <= 0% (Rt) V8Gy <= 10% (Rt)	Dmean <= 3% V20Gy <= 5% (Lt) V8Gy <= 35% (Lt) V20Gy <= 0% (Rt) V8Gy <= 15% (Rt)
Contralateral Breast		
	Dmean <= 5Gy	/
Spinal Cord		
	D0.01cc <= 72%	/
Larynx		
	Dmean <= 30Gy	Dmean <= 35Gy
Oesophagus		
	D1cc <= 29Gy D0.01cc <= 90%	D1cc <= 34Gy D0.01cc <= 105%
Rib Cage		
	D0.03cc <= 95% V50% <= 30cc	D0.01cc <= 105% V50% <= 100cc
Humeral Head (Ipsilateral)		
	D1cc <= 25Gy D0.01cc <= 70%	D1cc <= 38Gy D0.01cc <= 86%
Skin/Skin SCF (5mm Lumpectomy / 3mm Mastectomy)		
	D1cc <= 96%	D1cc <= 105%
LAD/RCA		
	Dmax <= 17Gy Dmean <= 7Gy V15Gy <= 10%	/

Table 1. The target dose and OARs criteria for PT breast planning in left-sided breast cancer with lymph nodes involvement.

Result:

Nominal plan comparison:

- SFO plans showed significantly better hotspot control (lower V105%) in the CTV IMN compared to MFO plans (p=0.018).
- MFO plans showed significantly better homogeneity (lower HI) in the CTV compared to SFO plans (p=0.038).
- MFO plans exhibited significantly better sparing of the heart, LAD, lungs, contralateral breast, and oesophagus compared to SFO plans (p<0.05).
- SFO plans showed significantly better sparing of the rib cage D2% compared to MFO plans (p=0.020).

Plan Robustness:

- MFO plans had significantly smaller variations in CTV coverage (V95%, D98%, Dmean) under uncertainties compared to SFO plans (p≤0.013).
- SFO plans had significantly smaller variations in CTV IMN hotspot control (V105%, D2%) under uncertainties compared to MFO plans (p≤0.042).
- MFO plans had significantly smaller variations in heart, LAD, and lung doses under uncertainties compared to SFO plans (p≤0.011).
- SFO plans had significantly smaller variations in rib cage and oesophagus doses under uncertainties compared to MFO plans (p≤0.024).

LET Deposition:

- SFO plans had significantly lower relative volumes of high LET (>6 keV/μm) in the rib cage and oesophagus compared to MFO plans (p≤0.017).
- MFO plans had significantly lower relative volumes of high LET in the heart and left lung compared to SFO plans (p≤0.013).