Controlled modulation planning techniques in intensity modulated proton therapy (IMPT) for breast cancer

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Purpose: To report the intensity modulated proton therapy (IMPT) planning techniques implemented on 82 breast cancer patients treated at a proton therapy center from January 2018 to February 2020. To maximize the robustness of intensity modulated proton therapy (IMPT) for comprehensive breast/chest wall treatments while minimizing dose to the normal tissues, controlled modulation planning techniques tailored to individual patient's anatomy were implemented for 82 treated patients at our proton center.

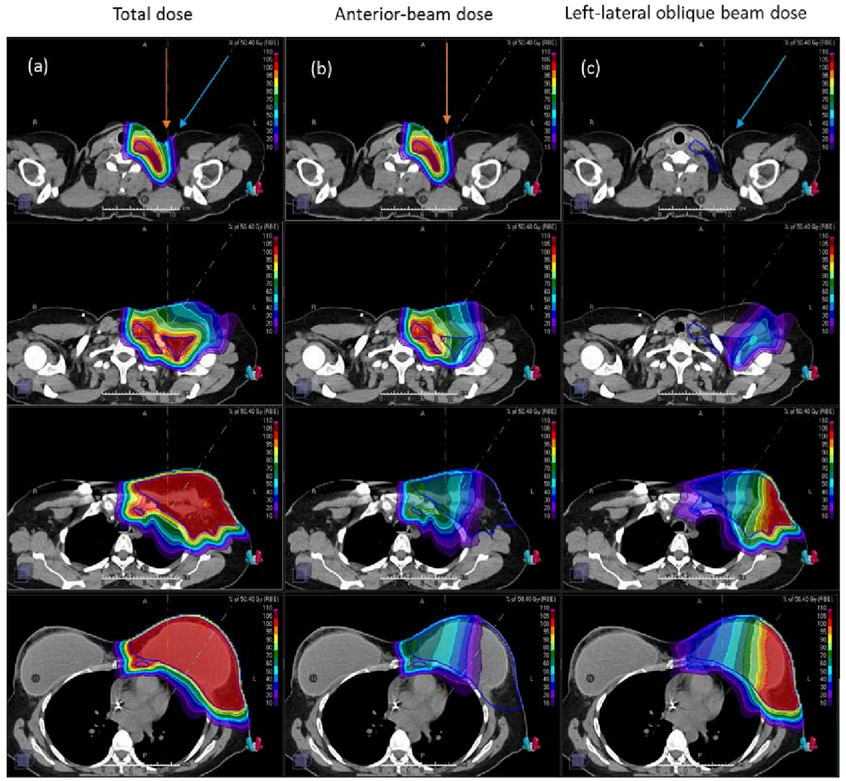

Figure 1 shows a hybrid single-field optimization plan as an example. Column (a) shows the total dose from anterior and left-lateral oblique (LLO) beams at different axial planes. Column (b) and (c) show the field dose from the anterior and LLO beam, respectively.

Methods: The plans were created using 1 or 2 en-face beams for unilateral (left/right) breast or chest wall target volume with regional nodes (IM, SCV and AX); 3 or 4 beams for bilateral chest wall with nodes. To control the degree of modulation, simple single-field optimization (S-SFO) and hybrid SFO (H-SFO) were mainly used. For S-SFO, each field delivers a uniform dose to the entire volume. For H-SFO, one field delivers a uniform dose to a portion of the target volume, and in between the fields, a gradient junction is created. The junction can be along superior-inferior direction where the SCV was treated with an anterior(ish) beam, and the lateral oblique beam was avoided such not to treat through shoulder and skin folds.

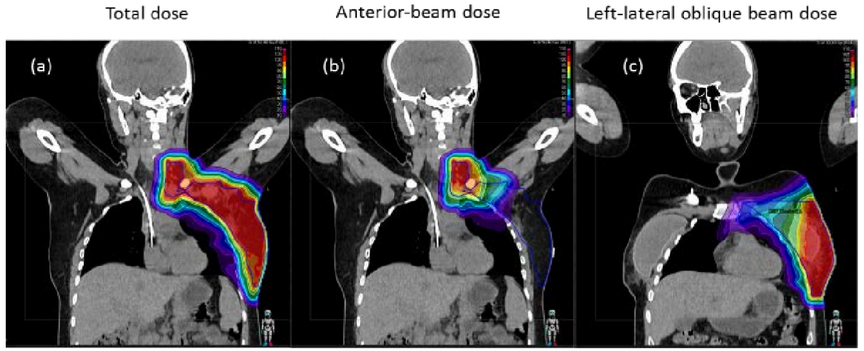

Figure 2 shows this junction along superior-inferior direction (longitudinal junction).

Number of fields	Number of patients	Planning Modulation		Number of patients
2	61	SFO		53
1	18	Hybrid SFO		28
3	2	Gradient junction	Longitudinal	12
			Transversal	2
			Both	14
4	1	MFO		1

Table: A summary for the 82 patients

For the rest of the target volume, both SFO beams were used. The junction can also be along medial to lateral direction, where medial and lateral portion of the target volume is treated by an anterior beam and a lateral oblique beam, respectively. The longitudinal and transversal junctions can be used simultaneously depending on the patient anatomy.

Results: 1 and 2 fields were used for 18 and 61 patients, respectively; 3 and 4 fields were used for 2 and 1 bilateral chest wall patients. S-SFO and H-SFO plans were used for 53 and 28 patients, respectively. Only 1 patient was treated with MFO. For H-SFO, longitudinal, transverse and both junctions were used for 12, 2, and 14 patients. Average heart mean dose and lung V20Gy is 0.7 Gy and 12.2%.

Conclusion: The implemented S-SFO and H-SFO techniques maximize the control of field modulation, which yield an optimal robustness and dosimetric benefits tailored to individual patient's anatomy.