A Hybrid Transmission-IMPT Planning Approach for Efficient Proton Treatment of Extremity and metastatic Bone Targets

Laura Buchanan, Isabella Pfeiffer, Shayan Rastegari, Matthew Boring, Samantha G. Hedrick, Chester R. Ramsey
Covenant Health Proton Center, Knoxville TN 37909

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

INTRODUCTION

Proton transmission —defined as high-energy proton fields that traverse the target without placing a Bragg peak within it—offer an inherently robust dose contribution due to their reduced sensitivity to range uncertainty and setup errors[1]. While conventional IMPT relies on precise distal edge placement, prior work has shown that avoiding reliance on the Bragg peak can substantially improve robustness and simplify delivery[2]. Transmission-like field strategies have been discussed in the context of uncertainty mitigation and delivery efficiency, particularly through reduced energy layer requirements[3]. Despite these advantages, clinical adoption of proton transmission beams has been limited, and their integration with modern IMPT workflows remains underexplored. **This study demonstrates a clinically practical hybrid planning workflow that integrates proton transmission fields with IMPT into a single deliverable plan to substantially accelerate treatment delivery—reducing delivery time by nearly 40%—while fully preserving dosimetric quality and robustness offering an efficient, patient-friendly approach for palliative and metastatic cases involving extremity targets.**

METHODS AND MATERIALS

Patient Cohort
- Ten previously treated proton therapy patients
- Extremity and bony targets

Treatment Planning System
- RayStation v23b (RaySearch Laboratories, Stockholm, Sweden)
- Retrospective replanning performed for all cases

Hybrid Planning Approach
- High-energy beams traversing the target delivered ~30–35% of prescription dose
- IMPT field optimized to deliver remaining (~65–70%) of prescription dose

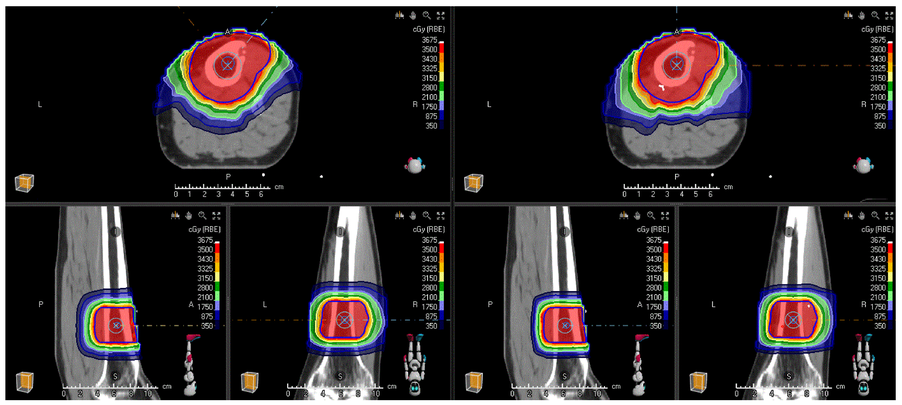
Dosimetric Evaluation
- Compared hybrid vs. original IMPT-only plans
- Evaluated target coverage (e.g., V100%, D95%)
- Dose homogeneity
- Overall dose distribution quality

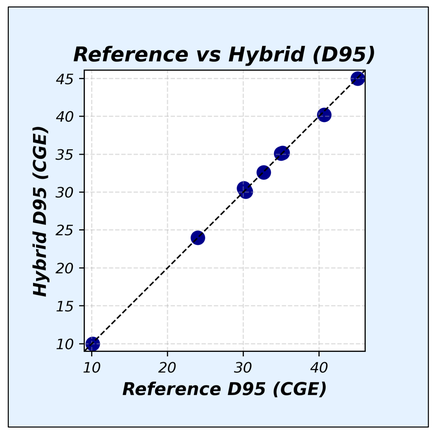
Robustness Assessment
- Evaluated under setup and range uncertainties
- Standard institutional uncertainty parameters applied

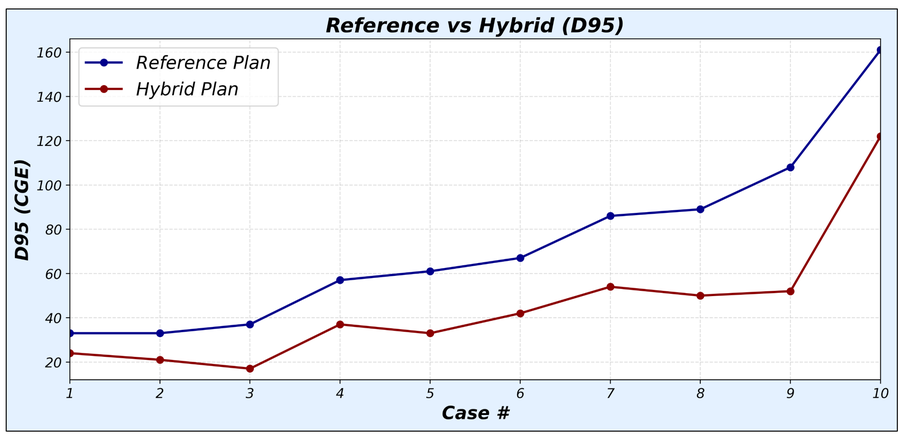
Delivery Efficiency Analysis
- Machine-recorded treatment delivery times
- Compared between hybrid and IMPT-only plans
- Metrics included total delivery time and # of energy layers

RESULTS

Hybrid plans achieved target coverage and robustness comparable to IMPT-only plans. Dosimetric quality was preserved across all cases, with no clinically meaningful differences in target coverage. As expected, integral dose increases in the hybrid plans, but the treatment sites were sufficiently far from critical OARs. Delivery time was reduced by an average of 39.3%, driven by a substantial decrease in energy layers.







		# of Energy Layers	
Case	Treatment Site	Reference Plan	Hybrid Plan
1	L Tibia	18	12
2	R Femur	20	12
3	R Femur	26	9
4	L Femur	26	14
5	R Tibia	36	19
6	L Humerus	36	18
7	L Femur	36	21
8	R Femur	45	20
9	R Thigh	42	21
10	L+R Femurs	80	45

CONCLUSIONS

Key takeaway: A hybrid proton planning approach that combines transmission fields (delivering ~30-35% of dose) with a single IMPT field maintains target coverage and robustness comparable to IMPT alone while reducing treatment delivery time by ~40%, primarily due to fewer energy layers. These findings highlight the practicality of integrating proton transmission fields and IMPT fields in clinically appropriate scenarios.

REFERENCES

1. Vai A, Mirandola A, Pavanello V, et al. *Phys Imaging Radiat Oncol*. 2025; 34
2. Kong W, Huiskes M, Habraken S.J.M., et al. *Radiotherapy and Oncol.* 2024; 198
3. Water S, Kooy H, Heijmen B, et. al. *International Journal of Radiation Oncology*Biology*Physics.* 2015; 92.

CONTACT

Laura Buchanan, PhD, DABR
lbuchan2@covhlth.com