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Assessing the Need for Verification Imaging in Proton Therapy for Brain and HN Patients

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ABSTRACT

Purpose: To evaluate the necessity of verification imaging at couch-angle positions for brain and head-and-neck (HN) patients treated with immobilization masks by analyzing setup accuracy and reproducibility using a year-long retrospective dataset.

Method: We retrospectively reviewed images and applied couch delta for 28 patients treated with noncoplanar proton therapy plans. The study includes 11 brain and 17 HN patients, who underwent approximately 300 and 500 fractions, respectively. To verify patient alignment, kV image was acquired upon a 6-degree-of-freedom couch that was rotated to the treatment angle. Couch delta was applied when patient realignment exceeded thresholds based on proton plan robustness, 3 mm translational shifts and 2° rotational shifts in any direction. We assessed frequency of couch delta applications to realign patients. Furthermore, we recorded time dedicated to imaging and patient alignment verification.

Results: Our results revealed that patient realignment at couch treatment angles was negligible: 99.3% of brain fractions and 98.5% of HN fractions did not require any adjustment. This indicates that additional verification image between treatment fields is largely unnecessary. Elimination of this step reduces patient imaging dose. In addition, it shortens treatment time by up to 15%, translating into cumulative savings of 26 clinical hours over 12 months on the proton machine schedule.

Conclusion: Verification imaging at couch-angle positions for brain and HN patients treated with immobilization masks is largely unnecessary, as realignment was required in less than 2% of fractions. Based on these findings, our clinical protocol was updated to discontinue verification image between treatment fields for patients who consistently remain within realignment tolerances during their first three fractions. This change reduces unnecessary imaging, minimizes patient dose, and improves treatment efficiency without compromising setup accuracy.

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INTRODUCTION

Verification imaging is routinely used during noncoplanar proton therapy to confirm patient positioning after couch movement between treatment fields, ensuring the patient is correctly aligned for treatment (**Fig. 1**). While this practice improves confidence in patient setup, it increases imaging dose and treatment time due to the required gantry movement to avoid panel collision (**Fig. 2**) and the time needed for imaging acquisition and acceptance.
The purpose of this study was to determine whether intermediate verification imaging provides meaningful clinical benefit for brain and head-and-neck patients treated with immobilization masks.

METHODS

Verification images obtained of 28 proton therapy patients were reviewed retrospectively over a 12-month time period. The review included 11 brain patients (300 fractions) and 17 head and neck (HN) patients (500 fractions). Verification images were deemed necessary when applied couch shifts exceeded the tolerance used for proton plan robustness: 3 mm translational shifts and 2° rotational shifts. Images taken with shifts below this tolerance, or with no movements at all, were deemed unnecessary. The total time spent due to unnecessary imaging was added across all 800 fractions to estimate the potential time saved by eliminating verification imaging for these plan types.

RESULTS

Patient realignment between couch treatment angles was negligible. 99.3% of brain fractions and 98.5% of HN fractions did not require any couch shifts as a result of verification imaging, indicating that additional verification imaging between treatment fields is largely unnecessary. **Table 1** provides a representative example of the couch shifts applied for an HN patient across 4 fractions. In all cases of applied couch shifts, the shifts were well within the proton plan robustness tolerances of 3 mm translational / 2° rotational.
Each verification image required an average of 2 minutes to perform, and images with applied couch shifts averaged an additional 4–5 minutes in treatment time. **Table 2** shows the cumulative treatment time in comparison to the time saved. The removal of verification imaging for brain and HN treatment workflows shortens treatment time by up to 15%, resulting in a cumulative savings of 26 clinical hours over 12 months on the proton machine schedule.

Figure 1. Example of verification imaging for patient setup.

Figure 2. Example of patient setup for verification imaging. The treatment gantry must be positioned at either 90 or 180 degrees for orthogonal kV imaging.

Table 1. Example of Patient Movement

HN	Beam 1			Beam 2		
Fraction	Lng (cm)	Lat (cm)	Rot (deg)	Lng (cm)	Lat (cm)	Rot (deg)
1	0	0	0	-0.28	0	0
2	0.26	0.12	0.6	N	N	N
3	N	N	N	0.15	0	1.00
4	0.21	0.11	0	0	0	0

Table 2. Example of Potential Time Saved

Fraction	Treatment Time (hh:mm:ss)	Time Saved Beam 1 (hh:mm:ss)	Time Saved Beam 2 (hh:mm:ss)	Total time Saved (hh:mm:ss))
1	00:16:00	00:02:30	00:05:00	00:07:30
2	00:14:43	00:05:00		00:05:00
3	00:31:52		00:04:30	00:04:30
4	00:32:39	00:05:30	00:02:30	00:08:00
Total Time	01:35:14			00:25:00

DISCUSSION

This study shows that verification imaging at noncoplanar couch angles adds little value for brain and head-and-neck patients treated with standard immobilization masks during proton therapy. Fewer than 2% of fractions needed realignment, showing that intermediate verification imaging rarely catches a clinically meaningful shift. Cutting this imaging step lowers unnecessary imaging dose, shortens treatment time, and improves workflow efficiency without sacrificing setup accuracy. The time saved increases machine availability, supports higher clinical throughput, and reduces how long patients stay immobilized on the treatment table.

These findings give a solid, evidence-based case for streamlining proton therapy workflows while keeping patient positioning safe and reliable. Based on the setup reproducibility observed, the institution updated its clinical protocol to stop verification imaging between treatment fields for patients who stay within established tolerances during their first three treatment fractions. One limitation of this study is that it was limited to patients treated with immobilization masks and reflects the workflow of a single proton therapy institution.

CONCLUSIONS

Verification imaging between couch movements for brain and HN cases was deemed unnecessary, based on fewer than 2% of fractions having verification imaging with an essential realignment. With this change in protocol, the clinic has been able to limit the exposure and reduce the patient treatment time without reducing positional accuracy.