Clinical Implementation and Preliminary Patient Outcomes of Flattening Filter Free Irradiation at an Extended Distance for Total Body Irradiation (FIRE-TBI)

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Objectives

To implement a flattening filter free (**FFF**) total body irradiation (**TBI**) technique that uses a higher dose rate (**FIRE-TBI**), and determine if it reduces treatment time.

To prospectively track TBI patient outcomes to ensure technique safety.

Background

A. TBI Technique at the Tom Baker Cancer Centre

- Extended SSD delivery with AP/PA patient orientation using a custom couch
- Sweeping arcs between 310° and 60°/70° (short/tall patients)
- Dose homogeneity achieved using inverse-square-law-based control point weighting and VMAT optimization
- Beam spoiler to increase surface dose
- Most common prescription is 400 cGy delivered in two fractions BID

FIG 1: Patient set-up for TBI treatment at the Tom Baker Cancer Centre (Pierce et al. 2019).

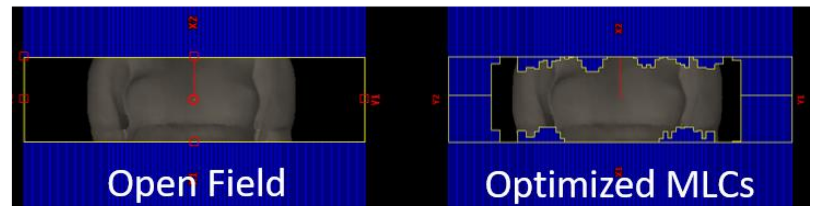

FIG 2: Beam's eye view example of light MLC modulation in TBI plans.

B. FIRE-TBI Technique

- Same patient setup and equipment but with 6 MV FFF substituted
- Nominal dose rate 1400 MU/min vs 600 MU/min for standard technique
- FIRE-TBI requires pre-set multi-leaf collimator (**MLC**) leaves based on height and anteroposterior (**AP**) width (Frederick et al. 2020)
- Treatment planning facilitated by the Eclipse scripting application programming interface (**ESAPI**) (Frederick et al. 2023)

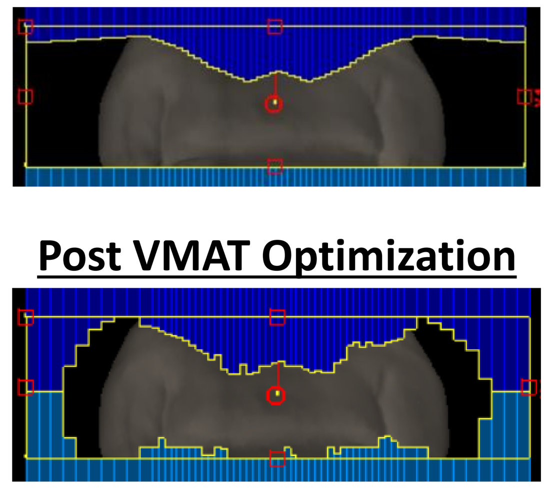

FIG 3: Beam's eye view examples of MLC modulation for FIRE-TBI plans

Methods

Randomized Prospective Study Design

RO Consult — Study introduction (REB approved). Criteria: fulfill general transplant/TBI eligibility, first transplant, no previous irradiation, age ≥18 years, Rx 4 Gy/2 fx. Block randomization to FIRE-TBI or standard TBI technique

Day -1 — Both TBI fractions timed with stopwatch

Day 0 — Post-treatment questionnaire on treatment satisfaction completed

Inpatient Follow Up — Chart review:
- Stomatitis severity over time (WHO Oral Toxicity scale) (WHO 1979)
- Narcotic usage over time

Outpatient Follow Up — Chart review and transplant physician contact:
- Non-infectious pneumonitis (any grade) at 3 and 6 months (Panoskaltsis-Mortari et al. 2011)
- OS and RFS at 6 months

13 patients accrued between Mar and Dec 2022 (6 FIRE-TBI, 7 standard TBI)

Results

Dosimetry

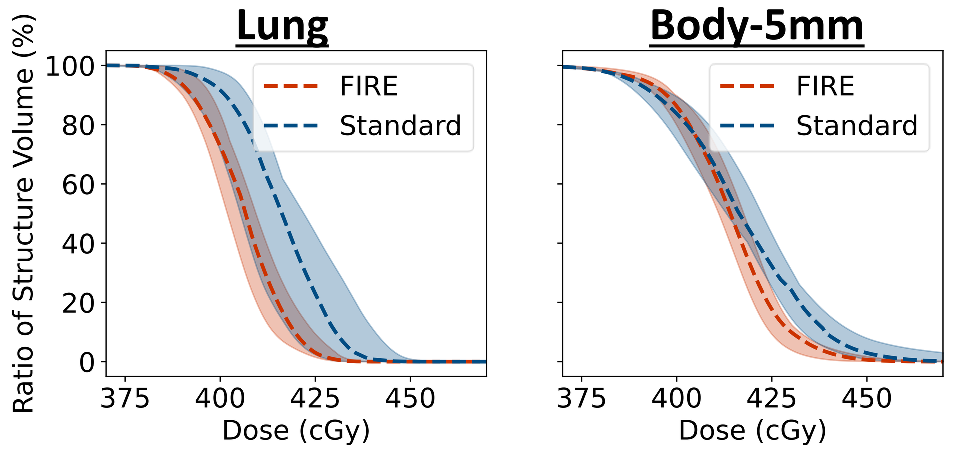

FIG 4: Median Lung and Body-5mm dose-volume histograms over all patients by TBI technique.

- FIRE-TBI more modulated and significantly improved

Results (Continued)

Treatment Timing

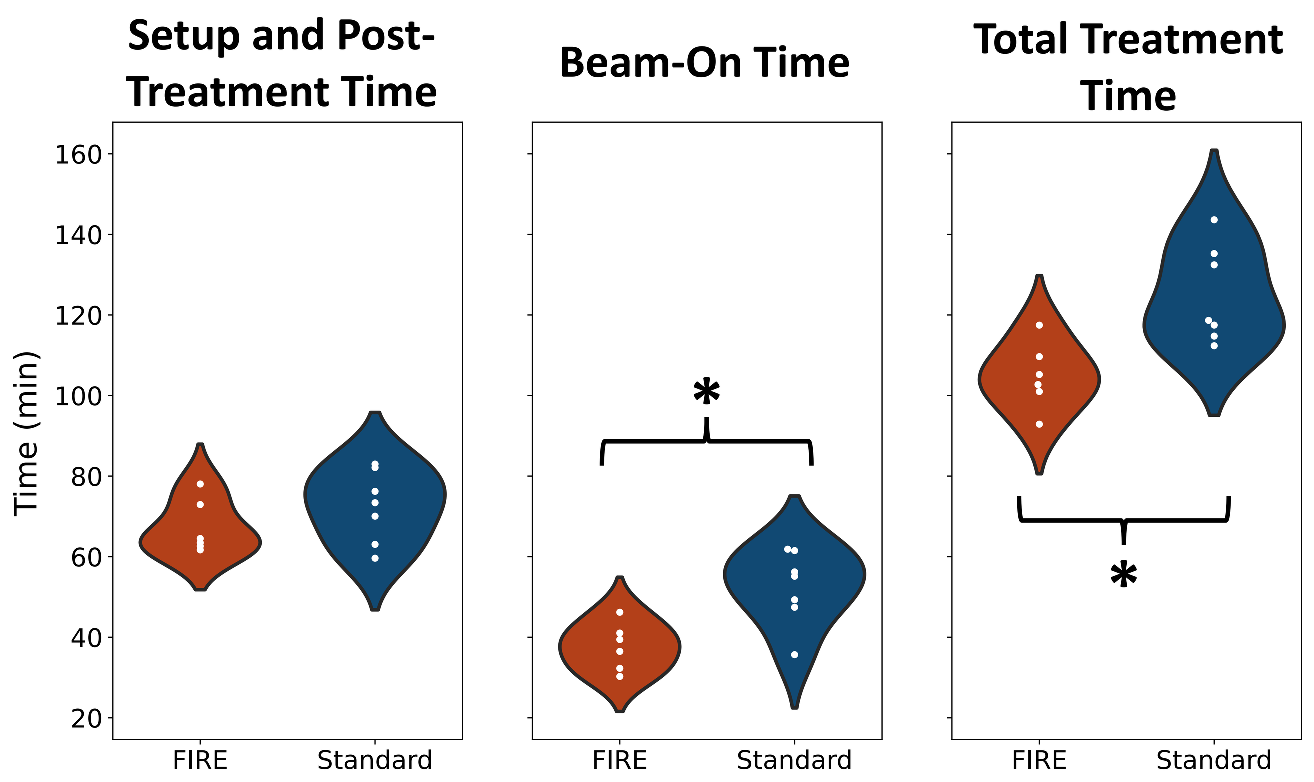

FIG 5: Comparisons of measured treatment times between TBI techniques. Total treatment time is a sum of setup, post-treatment, and beam-on times. Asterisks indicate statistically significant differences.

- Significant decrease in treatment time over both fractions of 118.7 min (standard) to 104.0 min (FIRE)
- Attributed to decreased beam-on time
- 9/13 patients completed treatment experience questionnaire, with greater proportion of FIRE-TBI ranking their treatment as feeling faster

Acute and Sub-Acute Outcomes

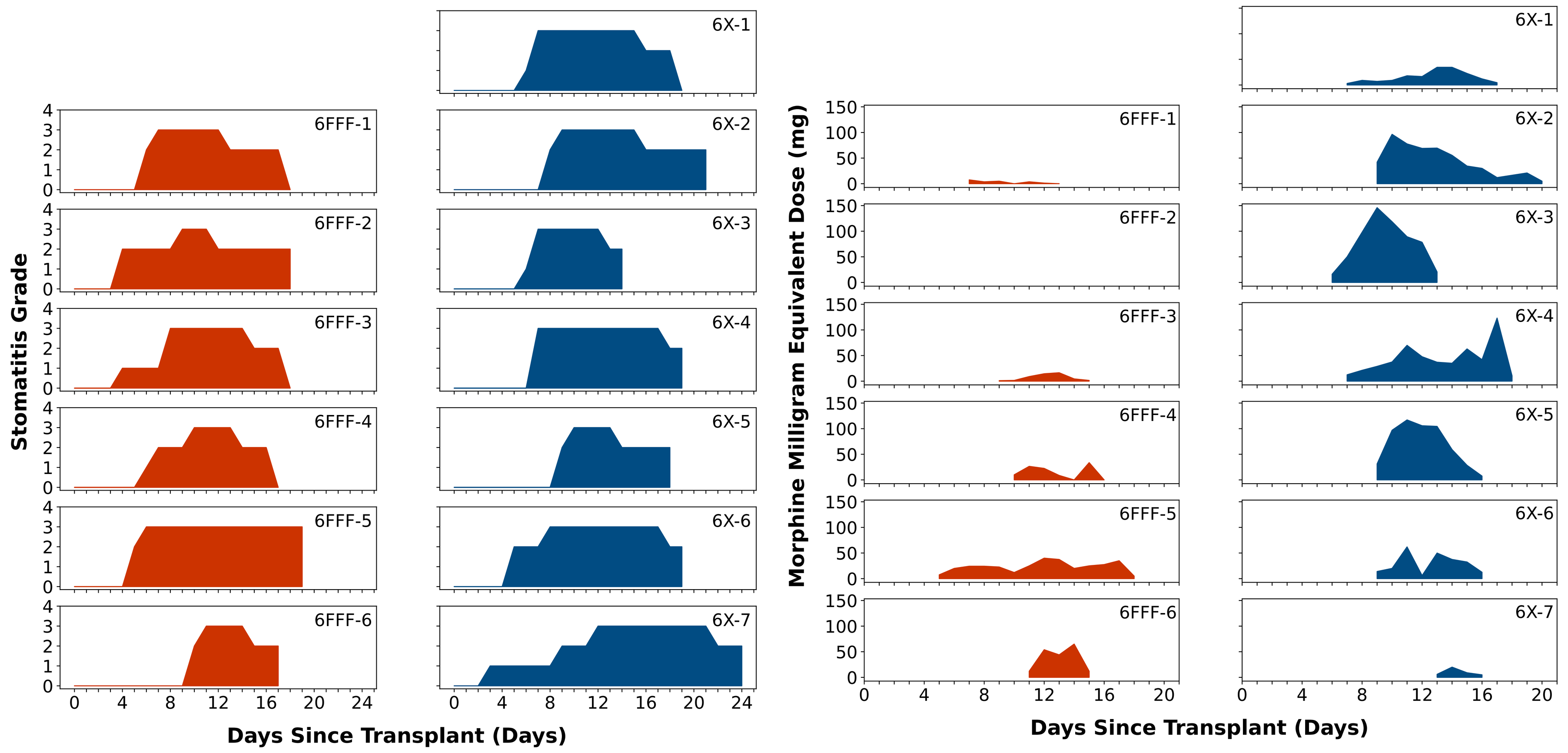

FIG 6 and 7: Stomatitis severity and patient-controlled analgesia (**PCA**) usage over time for each patient by TBI technique.

- No difference in duration of severe or ulcerative stomatitis
- Total PCA dose higher in standard TBI cohort, but duration of use not different
- No cases of non-infectious pneumonitis with median follow up of 12.2 months
- No significant differences in OS or RFS

Conclusions

Institutional experience with higher dose rate low-dose TBI (FIRE-TBI) was well received and well tolerated, with significantly reduced treatment time and no apparent increase in acute or pulmonary complications.

A larger sample size is needed to confirm these results.

Contact Information

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