

Predicting Adaptive Radiotherapy Session Duration Using Reference Plan Calculation Metrics

Dennis N. Stanley, PhD¹; Rex A. Cardan, PhD¹; Richard A. Popple, PhD¹; Udbhav S. Ram^{1,2}; Courtney Bosse Stanley¹; Natalie N. Viscariello, PhD¹; Joel A. Pogue, PhD¹; Carlos E. Cardenas, PhD, MS¹

¹The University of Alabama at Birmingham, Department of Radiation Oncology, Birmingham, AL · ²Juravinski Cancer Centre, Hamilton, ON, Canada

PURPOSE

CT-guided online adaptive radiotherapy (CTgART) introduces substantial per-patient variability in session duration, complicating prospective scheduling. This study evaluates whether system-reported reference plan calculation metrics, specifically reference plan optimization and calculation times, can be combined into a predictive metric to prospectively assign adaptive patients to appropriately sized treatment time slots.

METHODS

- **Reference Calculation Metric (RCM)** = combined reference-plan optimization + dose-calculation time.
- Session-level data was extracted from Varian Ethos treatment logs.
- Extracted automatically from reference-plan reports by a custom **computer-use agent** (visual-language models: Fara-7b / Qwen3-8b).
- **187 CTgART patients** (2021–2025) from Varian Ethos treatment logs.
- **Complexity model:** intent-specific median D2D with patient-level deviation adjustment.
- RCM was evaluated for correlation with adaptive D2D duration, session planning time, and session calculation time.

DATA ACQUISITION

- Visual-language driven automation framework, utilizing Fara-7b and Qwen3-8b, was employed to interact directly with the graphical user interface.
- The system evaluated application state prior to each action using visual interpretation of the screen content and executed modular interface interactions to navigate patient records, export plan reports, and reset the application state between iterations.
- This approach enabled automated extraction of reference plan optimization and calculation times and could be deployed to get additional metric.

COMPLEXITY MODEL

BIN	RCM	SLOT	N (%)
Simple	≤ 2.6 min	30 min	58 (32%)
Moderate	2.6–8.2	45 min	84 (44%)
Complex	> 8.2 min	60 min	45 (24%)

KEY RESULTS

187

CTgART patients

6.1min

Median RCM

36.6min

Median D2D

90.2%

Allocated correctly (vs 80.4%)

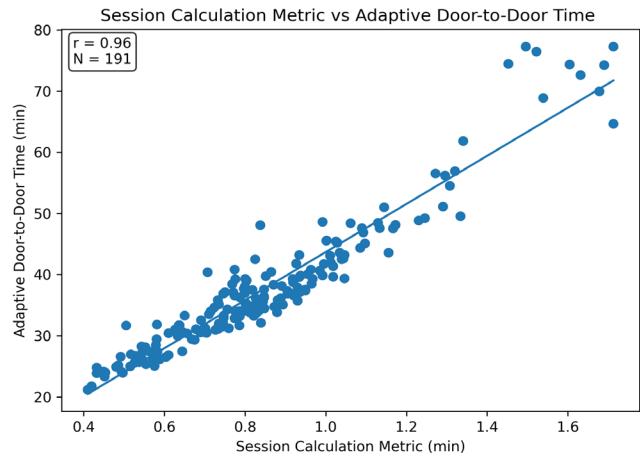


Figure 2. Session calculation metric vs D2D (r = 0.96) — strong, but only available intra-session.

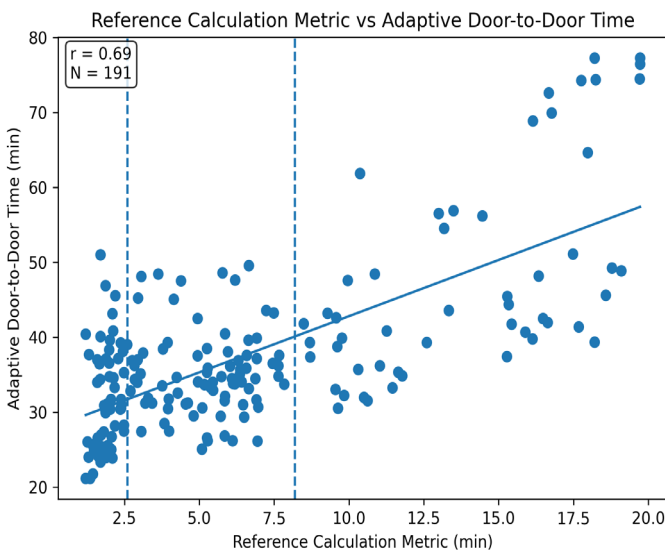


Figure 1. Adaptive D2D vs RCM (r = 0.68). Dashed lines mark complexity cutpoints.

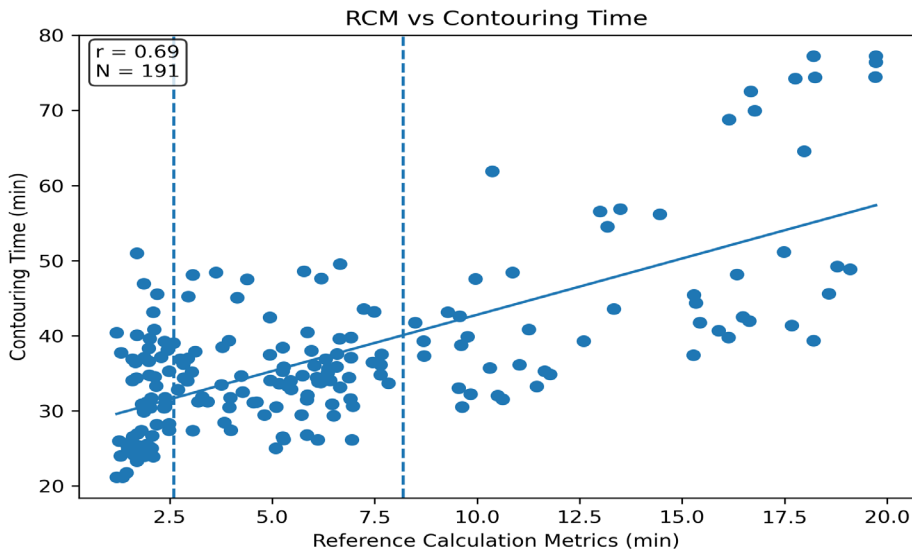


Figure 3. RCM vs contouring time (r = 0.69) — reference-plan computation tracks intra-session contouring effort.

FINDINGS

- RCM positively correlates with adaptive D2D duration — reference-plan computation carries meaningful signal for downstream session length.
- Increasing RCM category is associated with progressively longer D2D, supporting RCM as an upstream complexity surrogate.
- Model-based scheduling: **8.2 min** unused / fraction vs **11.4 min** uniform — a 28% reduction in wasted slot time.

Reference calculation metrics are a robust surrogate for adaptive treatment complexity and treatment time. RCM-informed prospective scheduling improves time-slot utilization and allocation accuracy versus uniform scheduling — using data available **before the first fraction**, with no reliance on historical adaptive performance or manual case review.

CONCLUSIONS