Initial Experience with Cherenkov Imaging: From Clinical Workflow to a Retrospective Image Review Trial

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ABSTRACT

Purpose: Cherenkov imaging (CI) provides direct, real-time visualization of dose on a patient's surface and has been used for treatment verification and error detection. Clinical adoption of CI is in its infancy; existing image review studies are either limited by having been conducted where the technology was developed, creating a learning bias, or by lacking comprehensive analysis of all collected data because of gaps in clinical workflows, making it hard to decipher the true impact CI can have. The primary objectives of this study are to develop a clinical workflow to enable routine Cherenkov image collection and review and to conduct a retrospective analysis of images acquired directly following CI implementation.

Methods: A retrospective, quality-based clinical trial was approved to begin following the installation of a CI system (DoseRT, VisionRT London UK) in February 2026. Patients treated on a designated linear accelerator will receive CI as part of their standard-of-care treatment, and the clinical team will use the developed workflow to review CI data. A dedicated study team will also review all Cherenkov images monthly to identify potential treatment delivery deviations that went undetected. Incidents will be flagged and investigated by correlating Cherenkov data with treatment plans, diagnostic imaging, and patient positioning metrics to determine their etiology and reduce their impact.

Results: We will report on the frequency and types of treatment delivery errors identified through CI, real-time and retrospectively. This will include categorization of incidents, such as unintended dose to non-target areas due to patient positioning, sub-optimal planning, or other delivery anomalies. The findings will be compared to published data.

Conclusion: The implementation of the developed workflow and analysis of Cherenkov images taken following the introduction of CI into our clinic will provide critical insights into the incidence and nature of suboptimal radiation deliveries and how CI can be used to prevent them.

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INTRODUCTION

- **Cherenkov imaging (CI)** allows direct visualization of external beam radiation therapy (EBRT) treatment on the patient's surface for the first time, and it has been used to **identify cases of suboptimal treatments or delivery errors** that would have otherwise gone **undetected** (Figure 1)[1-7].
- Despite the potential to improve treatment quality and efficacy, CI technology remains **underutilized** in clinical EBRT, with few clinical workflows established and few clinical studies completed, apart from those done at the institution that developed the technology[8].
- This project aims to address these challenges by **developing and implementing clinical workflows** to aid the team (physician, therapists, physicists, etc.) in CI data collection and review after CI system installation.
- With the established workflow, a **retrospective image review trial** will be conducted to better understand how the technology is being employed in the clinic, how this changes with time, and what is being learned from this new data.

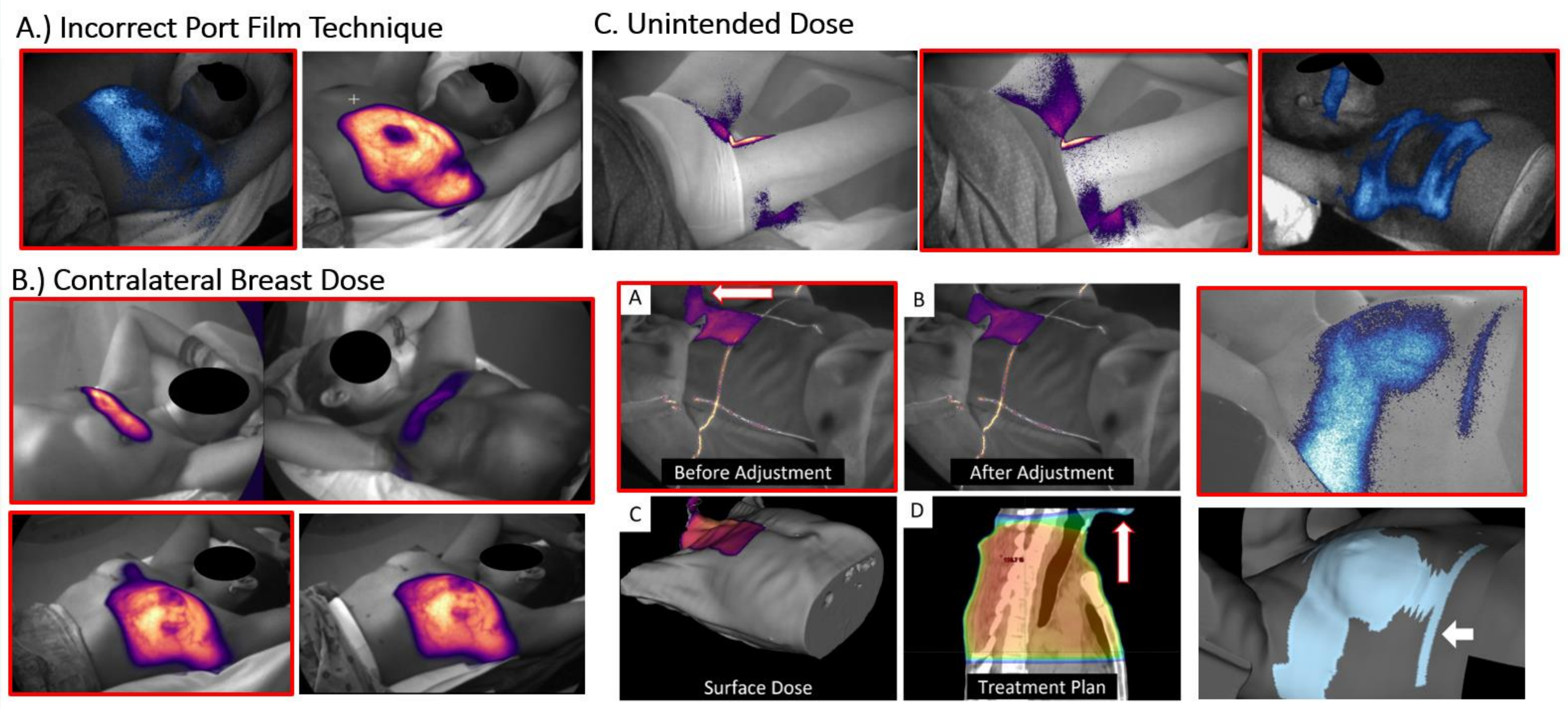


Figure 1. Example errors detected via CI.A.) Incorrect port film technique used, B.) Contralateral breast dose observed, and C.) other instances of unintended dose.
Figures adapted from: Rombison A et al. Pract Radiat Oncol. 2026; Jarvis et al. Int J Radiat Oncol Biol Phys. 2021; Alexander, Decker, et al Pract Radiat Oncol. 2022 Jun. [5-7]

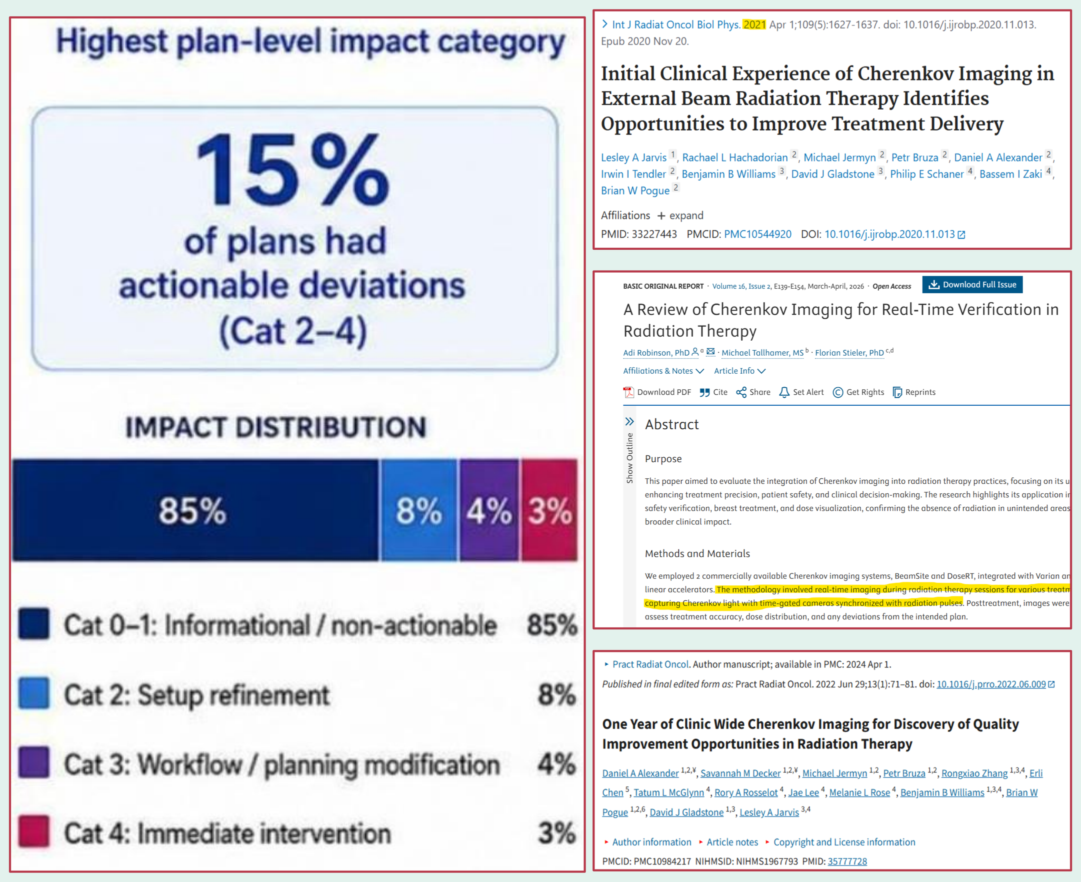


Figure 2. Three most prominent image review studies and analysis of CI data and their role in detecting deviations in radiation therapy[5-7].

Limitations of Existing Image Review Studies: Do not report on CI usage for ALL patients immediately following system installation (inherent learning bias possible), 2 conducted at institution where technology was developed, etc.

Current challenges with the clinical workflow integration of CI….

- **Patient skin exposure** is required for strong/representative Cherenkov signal (not standard of care at our clinic).
- doseRT measures **relative** dose; it is not a quantitative *in vivo* dosimetry tool.
- Members of clinical team need to **review images** during AND/OR after treatment fraction **manually.**
- Thorough **training** on what is being visualized and camera limitations will help optimize utility.
- Clear **procedure** / standard-of-work of what to do **if incident is detected.**

METHODS AND MATERIALS

- Goals: Address the lack of data surrounding the impact of Cherenkov imaging (CI) on the clinic with a retrospective image review trial investigating errors detected with CI immediately following install on LA16 (at Stanford).
- Before install: anticipate and address challenges that exist with this being a new technology, in order to achieve realistic study, proposed above.

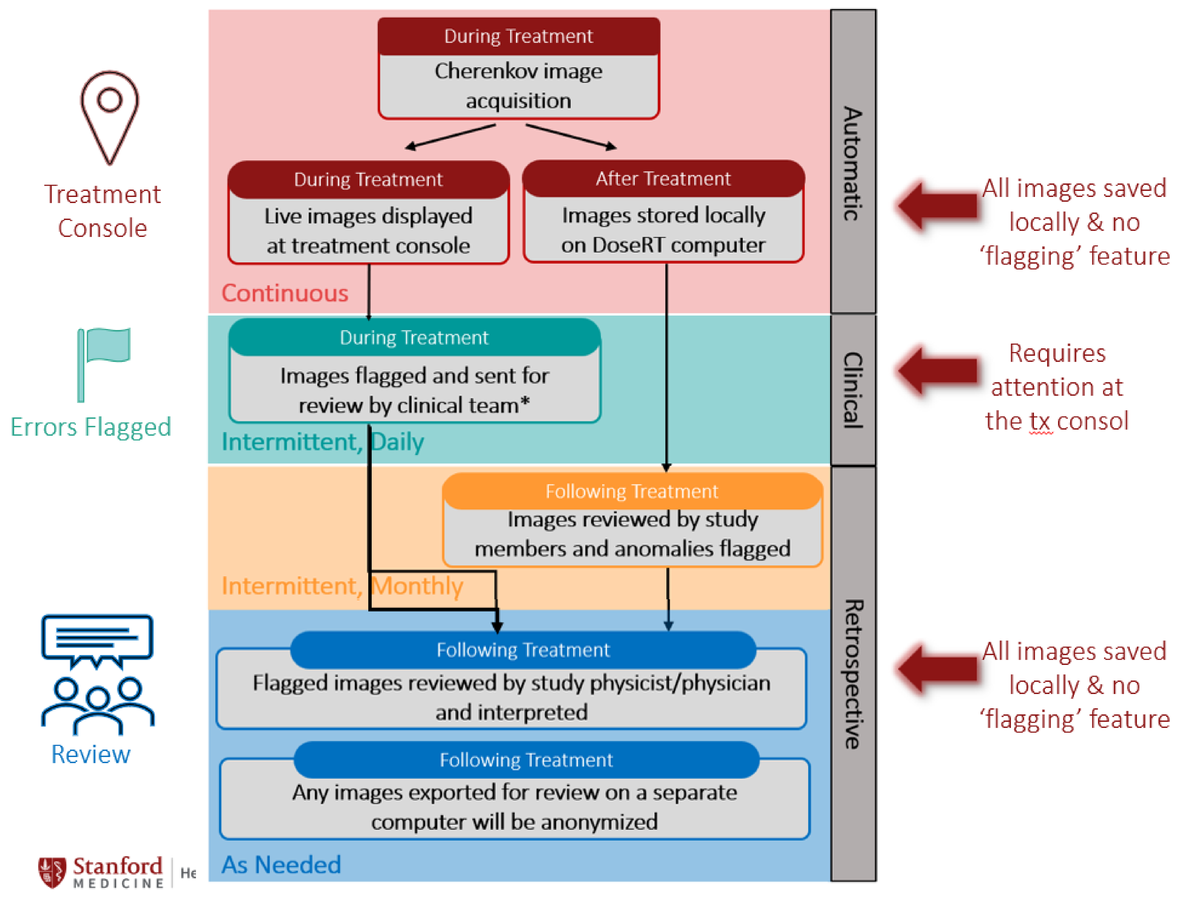
Metrics of Interest:

Basic Learning

- How much usable image data do we collect? Which treatments (t)x lend themselves best to CI? Worse?
- What are our major challenges to implementation? Are they what we expect?

To Quantify

- How many 'incidents' do we detect in the first three months of install? Do these change with time / learning?
- How many 'incidents' are caught at tx console or by physician/physics review vs by formal retrospective review study?
- How do the type of 'incidents' we see compare with what has previously been published?



- No disruption to real-time review capabilities at the treatment console, continued to enable natural error detection.
- Custom script will be used to export compiled PDF report of treatment (doseRT/AlignRT screenshot) and upload to patient's ARIA documents folder (5fx increments).
- For errors potentially missed at the console, all patient images will be completed at one-month intervals for first three months of system use.
- All 'flagged' incidents will be formally reviewed by designated study team: Beth Neilsen, MD PhD (physician perspective) and Amy Yu, PhD (physics perspective).

Figure 3. Proposed workflow for retrospective image review study. Highlighting current capabilities & system limitations.

DISCUSSION

- VisionRT information was successfully exported to patient documents folder and will be scheduled for periodic 'pushes' for 'offline review' style access to CI data.
- Due to construction limitations, doseRT has not yet been installed in our clinic. Pending install, we will initiate the retrospective image review trial via the devised workflow here.

Future Directions

- Test / implement automated incident detection algorithm.
- Scintillation imaging testing and implementation .

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