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

Progression-Free Survival Prediction Using Computed Tomography Foundation Models in Stereotactic Ablative Radiotherapy-Treated Oligometastatic Renal Cell Carcinoma

Bowen Jing[1]; Yajun Yu[1]; Asim Afaq[2]; Raquibul Hannan[3]; Jing Wang[1]

[1]Medical Artificial Intelligence and Automation (MAIA) Laboratory, Department of Radiation Oncology, UT Southwestern Medical Center
[2]Department of Radiology, UT Southwestern Medical Center; [3]Department of Radiation Oncology, UT Southwestern Medical Center

ABSTRACT

PURPOSE
Predict progression-free survival (PFS) for SAbR-treated oligometastatic RCC to identify patients who may need early systemic therapy.

METHODS
We analyzed 130 patients treated from Nov 2007-Jul 2022 with planning CT and clinical/treatment variables. Merlin extracted 3D CT features, which were combined with clinical features in an MTLR survival model. Frozen feature extraction was compared with cohort-specific fine-tuning using a 60%/20%/20% train/validation/test split.

RESULTS
Fine-tuning improved test-set C-index from 0.53 to 0.69.

CONCLUSION
Task-specific adaptation improved PFS risk stratification and may guide combined local/systemic therapy decisions.

KEY TAKEAWAY

Fine-tuning improved test-set discrimination from C-index 0.53 to 0.69, suggesting CT foundation models benefit from cohort-specific adaptation for survival prediction.

CONTACT

Jing Wang, Ph.D., FAAPM
MAIA Laboratory
Department of Radiation Oncology
UT Southwestern Medical Center
Jing.Wang@UTSouthwestern.edu

INTRODUCTION

- Stereotactic ablative radiotherapy (SAbR) is an important local therapy for oligometastatic renal cell carcinoma (omRCC).
- Some patients experience limited benefit from SAbR alone and may require earlier systemic therapy.
- Objective: predict progression-free survival (PFS) using planning CT representations plus clinical information.

DATA

Study population
- 130 patients with SAbR-treated omRCC
- Treatment dates: Nov 2007-Jul 2022

Model inputs
- Planning CT images for all patients
- Demographic, clinical, and treatment-related variables

Prediction target
- PFS risk score; low- vs high-risk stratification in the testing cohort

METHODS

Workflow
1. Extract 3D CT image embeddings with Merlin.
2. Combine imaging embeddings with clinical features.
3. Train MTLR survival model to produce PFS risk scores.
4. Compare frozen feature extraction vs. cohort-specific fine-tuning:
   - Frozen: Merlin encoder fixed; only MTLR layers trained.
   - Fine-tuned: Merlin encoder and MTLR layers both trained.

Training split:
60% training / 20% validation / 20% testing.

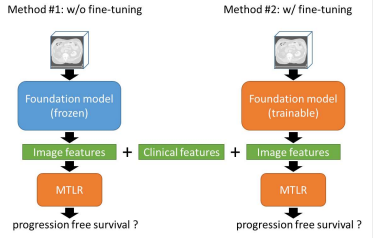


Figure 1. Frozen CT feature extraction was compared with end-to-end fine-tuning of the foundation model with MTLR.

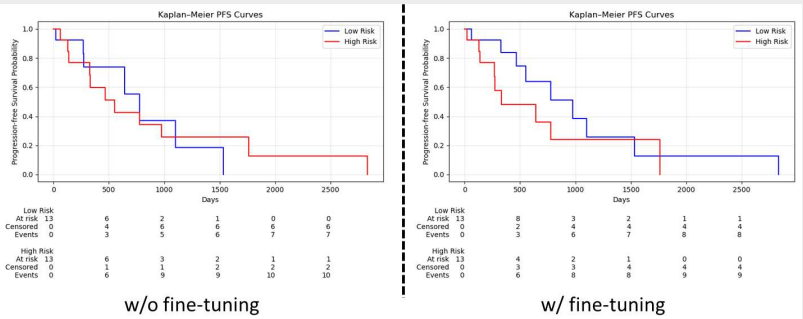
INNOVATION

- Integrates CT foundation-model embeddings with clinical information for PFS prediction.
- Evaluates whether task-specific fine-tuning improves performance in a focused omRCC cohort.
- Designed to support earlier identification of patients who may need systemic therapy.

RESULTS

Frozen CT model	Fine-tuned model	Gain
0.53	0.69	+0.16
test C-index	test C-index	C-index improvement

Fine-tuning the foundation model on the SAbR-treated omRCC cohort improved discrimination on the independent test set. Kaplan-Meier analysis of model-predicted low- and high-risk groups showed better visual separation after fine-tuning.



w/o fine-tuning w/ fine-tuning

Figure 2. Kaplan-Meier PFS curves for model-predicted low- and high-risk groups. Left: frozen foundation model. Right: fine-tuned foundation model.

DISCUSSION

- Using the CT model only as a fixed feature extractor produced near-random test-set discrimination.
- Fine-tuning likely adapted image representations to disease site, treatment context, and PFS endpoint.
- Results support task- and dataset-specific adaptation when applying imaging foundation models to survival analysis.

CLINICAL IMPACT

Potential use case
- Identify patients unlikely to benefit from SAbR alone.
- Support timely addition of systemic therapy alongside local treatment.

Next steps
- Expand fine-tuning and validation on larger, multi-institutional cohorts.
- Evaluate calibration, decision thresholds, and prospective utility.

CONCLUSIONS

- A fine-tuned CT foundation-model + MTLR framework improved PFS prediction for SAbR-treated omRCC.
- Test-set C-index increased from 0.53 to 0.69 after cohort-specific fine-tuning.
- With external validation, this approach may enable earlier identification of patients who require combined local and systemic treatment strategies.

REFERENCES

Blankemeier, L., Kumar, A., Cohen, J.P. et al. Merlin: a computed tomography vision–language foundation model and dataset. Nature 652, 1318–1328 (2026). https://doi.org/10.1038/s41586-026-10181-8