A VALIDATED PROSTATE CANCER PROBABILITY MAP TO AID IN FOCAL TREATMENT PLANNING

Alan Priester[1,2], Richard Fan[3], Joshua Shubert[2], Jonhas Colina[2], Mirabela Rusu[3], Sulaiman Vesal[3], Wei Shao[3], Yash Samir Khandwala[3], Shyam Natarajan[1,2], Geoffrey A. Sonn[3]

[1]University of California, Los Angeles; [2]Avenda Health, Inc; [3]Stanford University

BACKGROUND, **INTRODUCTION, AND AIMS**: Successful prostate cancer focal therapy requires application of a treatment margin around MRI-visible regions of interest (ROIs). Standard of care (SOC) typically entails hemi-gland margins (HG) or isotropic expansion (IsoEx) of the ROI, which are not optimal for efficient and effective treatment. A data-driven method of defining patient-specific margins is needed.

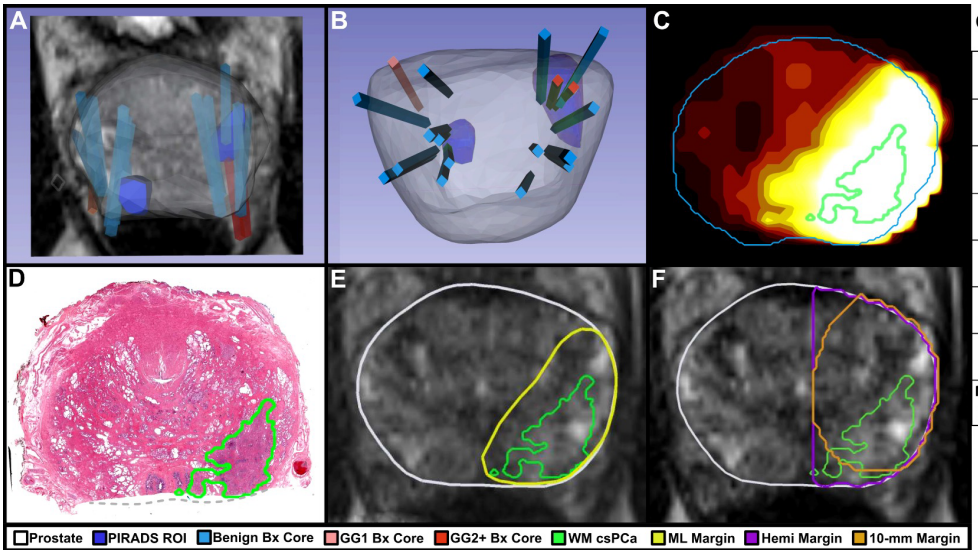
A machine learning (ML) model was developed to estimate voxel-level risk of clinically significant prostate cancer (csPCa), resulting in a 3D cancer probability map (CPM). Treatment margins created by thresholding the CPM were retrospectively assessed using whole mount (WM) prostatectomy data as ground-truth. The study objective was to demonstrate that ML margins compared favorably to HG and 10-mm IsoEx margins.

MATERIALS AND METHODS: The ML model was developed using multi-institutional data from 875 patients. Input data consisted of T2-weighted MRI, surface models of the prostate, ROIs defined using PI-RADS v2, and tracked biopsy cores (Fig A-B). The model combined a convolutional neural network with a gradient-boosted decision tree, and was trained using 5-fold cross validation.

WM prostatectomy data from two institutions (N = 100) was used to evaluate the ML model. All test cases bore MRI-visible, biopsy-confirmed Gleason Grade Group (GG) 2-3 disease apparently isolated to a single hemisphere or the anterior gland. CPMs were generated for each case (Fig C), then thresholded to generate a ML margin (Fig E). SOC margins were generated (Fig F) for comparison. Using WM (Fig D) to define csPCa-bearing voxels, ML and SOC margins were compared using Wilcoxon signed-rank tests for sensitivity and specificity, and chi-squared tests for the complete csPCa encapsulation rate.

RESULTS: Fig G summarizes study outcomes. ML margins had a greater mean sensitivity (98% vs 94-96%) and csPCa encapsulation rate (84% vs 70%-71%) than both IsoEx and HG margins, with p<0.001. ML margins were larger and less specific than IsoEx margins, but smaller and more specific than HG margins.

DISCUSSION AND CONCLUSION: A ML model produced margins that were superior to hemi-gland margins across all measures, improving csPCa identification while reducing margin size. The ML model also performed favorably compared to 10-mm isotropic ROI expansion, improving sensitivity and csPCa encapsulation. This approach shows promise and is being assessed in a prospective focal therapy trial.



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	Hemi-Gland Margins	10-mm ROI Expansion	ML Model Margins
Mean Sensitivity	96.2%	94.4%	98.1%
Sensitivity Vs ML (Signed Rank)	p < 0.001 *(significant)*	p < 0.001 *(significant)*	–
Mean Specificity	53.6%	67.6%	58.7%
Specificity Vs ML (Signed Rank)	p = 0.005 *(significant)*	p < 0.001 *(significant)*	–
csPCa Encapsulation	71/100 (71%)	70/100 (70%)	84/100 (84%)
Encapsulation Vs ML (Chi Squared)	p = 0.03 *(significant)*	0.02 *(significant)*	–
Margin Volume (% of Prostate)	50.0%	36.3%	44.8%
Margin Volume Vs ML (Signed Rank)	p = 0.004 *(significant)*	p < 0.001 *(significant)*	–

Figure: Example case (A-B) input data on T2-MRI and in 3D; (C) CPM, with black->white for low->high csPCa risk; (D) WM Slide defining ground-truth csPCa; (E) ML margin; (F) SOC margins; (G) summary statistics

First author contact email: alan@avendahealth.com