NHS Fellowship in Clinical AI
NHS Digital Academy Programme

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Prediction of recurrence risk in oral squamous cell carcinomas; an AI-based assessment of whole slide histological images

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THE PROBLEM

Oral cavity squamous cell carcinoma (OSCC) is aggressive 5-year survival only ~50%

30% of patients relapse locally despite surgery + adjuvant radiotherapy or chemoradiotherapy (RT/CRT)

Currently, clinicians cannot predict who will benefit from adjuvant RT/CRT — leading to unnecessary treatment toxicity and poor outcomes

THE AI SOLUTION

Deep learning-based multiple instance learning applied to routine H&E whole slide images (WSI) of primary tumour.

Aims to predict treatment response by providing a relative risk of recurrence

Builds on validated pipelines from HPV+ oropharyngeal cancer and breast cancer lymph node studies

THE PIPELINE

Cohort: 99 OSCC patients treated at Guy's & St Thomas' NHS Foundation Trust (2010–2018)

Treatment: Surgery + post-operative radiotherapy (60–66 Gy IMRT); 30% also received chemotherapy

Demographics
- Median age 62.5 yrs (range 31–82), 61% male
- Primary sites: Tongue (40%), alveolar ridge (22%), floor of mouth (18%)
- TNM8 stage: 95% stage IVA–IVB
- 48% experienced disease recurrence

Methods
- Attention-based multiple instance learning to highlight areas of interest
- Visual analysis by consultant histopathologist to review areas of interest and suggest biological reasoning

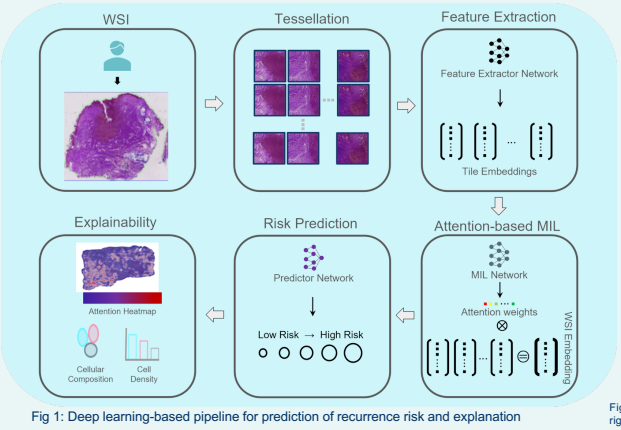

Fig 1: Deep learning-based pipeline for prediction of recurrence risk and explanation

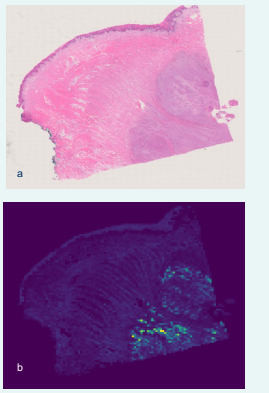

Fig 2: Sample WSI with primary tumour seen at bottom right (a), with heat map overlay showing regions of interest suggesting higher risk for recurrence (b)

IN PARALLEL

- We tested a previously developed AI model, the H&E Profiling Tool (HEPT)
- HEPT can segment, classify and measure individual cells and subcellular features in H&E sections
- We tested HEPT on a subset of 10 OSCC cases
- For each case, we selected 10 representative image tiles from the WSI
- HEPT outputs quantitative inter and intra cell features. E.g. number of tumour invading lymphocytes or nuclear density and heterogenicity
- With hopes of utilising on the heat map areas of interest for granular assessment

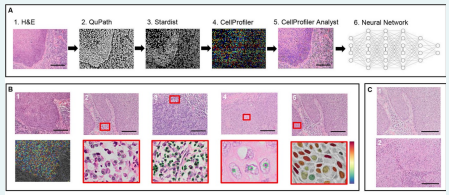

Fig 3: HEPT deep learning-based pipeline for histological analysis. Steps include pixel classification, nuclear mask overlay and feature extraction. Image taken from original paper Hue et al. 2023

WHAT'S NEXT?

- Validate the deep learning model with an external data set from Malaysia
- Add additional data modalities (clinical data, RNA expression) to improve model accuracy
- Improving explainability of results:
  - Visual analysis of heatmaps
  - Utilising the HEPT (H&E profiling tool) model to gain granular information on the of areas of interest in the heatmaps.
- Improve interpretability to support future clinical trust & adoption
- Explore integration into clinical trial stratification and NHS clinical pathways

RESULTS SO FAR..

- Successfully predict recurrence risk with C-index > 0.7 within internal test data.
- Able to identify clinically explainable regions of a WSI salient to a risk prediction.

MY MILESTONES

Completed high-quality slide annotation in QuPath (a application which allows WSI annotation)
Tested the HEPT (H&E profiling tool) model on our data set, in preparation of its use in explainability
Acted as clinical-technical liaison across KCL, GSTT and CSC groups

Sambasivan K, Sassoon I, Thavaraj S, Kennedy R, Doss G, Michaelidou A, Odell E, Sandison A, Hall G, Morgan P, Collins LHC, Lyons A, Cascarini L, Fry A, Oakley R, Simo R, Jeannon JP, Petkar I, Reis Ferreira M, Kong A, Lei M, Guerrero Urbano T. TNM 8 staging is a better prognosticator than TNM 7 for patients with locally advanced oral cavity squamous cell carcinoma treated with surgery and post-operative radiotherapy. Radiother Oncol. 2021 Jul;160:54-60. doi: 10.1016/j.radonc.2021.04.003. Epub 2021 May 3. PMID: 33845044.

Hue J, Valinciute Z, Thavaraj S, Veschini L. Multifactorial estimation of clinical outcome in HPV-associated oropharyngeal squamous cell carcinoma via automated image analysis of routine diagnostic H&E slides and neural network modelling. Oral Oncol. 2023 Jun;141:106399. doi: 10.1016/j.oraloncology.2023.106399. Epub 2023 Apr 23. PMID: 37098302.