A novel methodology to differentiate shrinkage vs erosion in CBCT images of lung tumours

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INTRODUCTION:
- Lung cancer tumours treated with radiotherapy may display elastic (true shrinkage) or non-elastic (erosing) changes, see figure 1.
- Adapting treatment fields to non-elastic shrinkage can lead to a potential treatment failure due to underdosage of residual microscopic disease.
- Our hypothesis is that, at the lung/tumour boundary, erosion will lead to a gradual decrease in Hounsfield units (HU) while true shrinkage will result in faster HU changes on cone-beam computed tomography (CBCT) images, as low-density lung tissue is returning to replace tumour tissue.
- In this project, we develop a methodology to determine density changes in the region of interest (ROI) surrounding the tumour.

MATERIALS AND METHODS:
- The dataset consisted of CBCTs from 8 non-small cell lung cancer (NSCLC) patients treated with 55Gy in 20 fractions.
- The tumour was segmented, using the clinician-generated GTV and excluding all voxels < 500 HU, allowing the edge of the tumour to be found.
- Next, an annular ROI (2mm inside and 2mm outside the segmented contour) was created and rigidly propagated across all CBCTs.
- Histograms of HU within these ROIs were fitted with a bimodal Gaussian distribution. It is assumed that the lower HU peak corresponds to healthy lung tissue and the higher HU peak corresponds to cancerous tissue.
- The rate of change in the relative heights of the peaks was used to determine the mode of regression of the tumour.

RESULTS:
- Figure 2 shows the output from this methodology for one representative patient.
- Visual evaluation of the motion of anatomical landmarks (e.g. bronchioles) classified 5 tumours as, predominately, displaying non-elastic changes (erosing) while 3 displayed elastic changes (shrinking).
- Shrinking tumours displayed a larger and more consistent change in relative peak heights throughout the treatment course, with changes appearing rapidly.
- Eroding tumours showed a more gradual change in relative peak heights.
- Additionally, eroding tumours showed a lower correlation coefficient than shrinking tumours, i.e. greater variability in relative heights.

CONCLUSIONS:
- This project demonstrates a novel, but simple methodology to explore elastic and non-elastic tumour changes.
- We believe that change of statistics of the HU in the tumour rim has the potential to differentiate between eroding and shrinking tumours.
- The small patient numbers prevented robust statistical analysis of these differences and we will now apply this method in a much larger patient cohort.