

Patterns in the Diffusion Characteristics of Brain Metastases in Stereotactic Radiosurgery Patients

J. Madamesila^{1,3}, N. Ploquin^{1,2,3}, E. Tchistiakova^{1,2,3}

¹University of Calgary, Department of Physics and Astronomy

²University of Calgary, Department of Oncology

³Alberta Health Services, Tom Baker Cancer Centre, Department of Medical Physics

Question

Can we use **Diffusion Weighted Imaging to identify patterns in diffusion changes** within brain metastases before and after Stereotactic Radiosurgery (SRS) treatment?

Introduction

Diffusion Weighted Imaging (DWI)

- Magnetic resonance imaging technique that measures the diffusion of water in the body, allowing the probing of its microstructure [1].
- Apparent Diffusion Coefficient (ADC) maps are calculated from DWI. Lower ADC values are linked to high cellularity and restricted diffusion [2].

Methods

Imaging Parameters and Analysis

- Analysis of ADC maps was performed on 6 patients with multiple SRS treatments (total 52 metastases).
- b-values of 0 and 1000 s/mm² were used.
- Histograms of ADC values within each metastasis were calculated over multiple pre and post scans.
- Low dose regions (<2 Gy) of the brain within patients were chosen as control. Patients who received whole brain radiation therapy used control regions <40% dose_{max} of their received lifetime dose.
- Major peaks were analyzed and an algorithm (Figure 1) was used to identify patterns.

Methods: Classification Algorithm

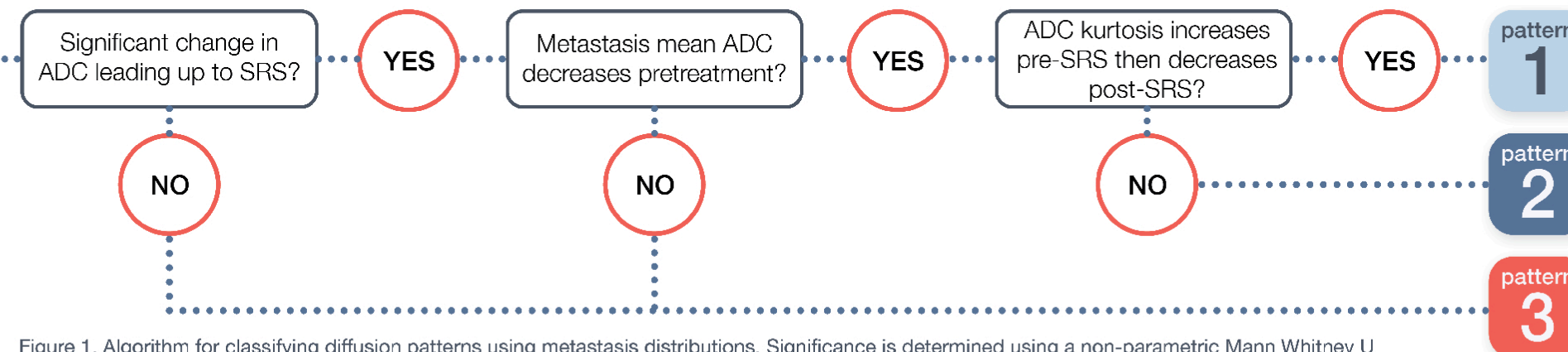


Figure 1. Algorithm for classifying diffusion patterns using metastasis distributions. Significance is determined using a non-parametric Mann Whitney U test, with $p < 0.05$ as significant differences between ADC distributions.

Results

Metastasis ADC Histograms before and after Stereotactic Radiosurgery (lower ADC means restricted diffusion)

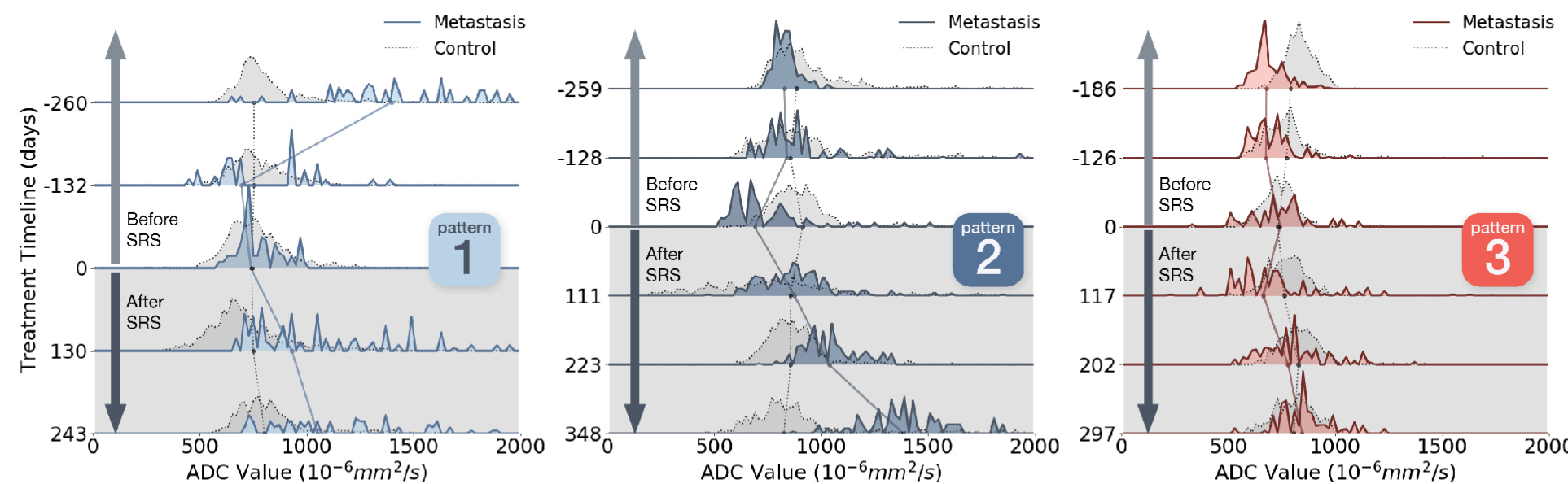


Figure 2. Representative metastasis showing (left) an ADC distribution that trends towards restricted diffusion leading up to treatment day. Following SRS treatment, ADC values flatten and diffusion increases. (middle) Follows a diffusion trend similar to pattern 1 but with ADC values staying homogeneous. (right) No distinct distribution pattern change.

Results and Discussion

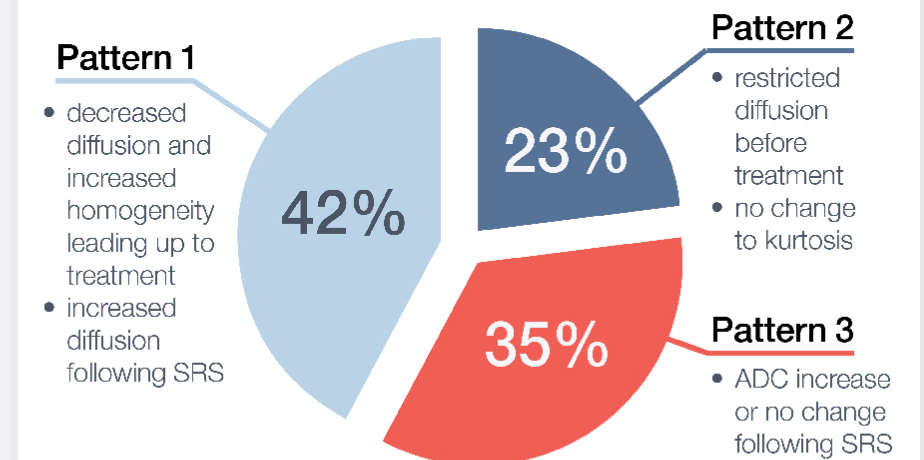


Figure 3. Percentage of metastases observed in each pattern group

- In 22 metastases the distributions tended towards positive skewness and increased kurtosis leading up to treatment (pattern 1). This corresponds to increasingly restricted diffusion within the region. 12 and 18 metastases were observed to follow patterns 2 and 3, respectively.
- Control regions, including patients who received whole brain radiation therapy, presented no significant change in ADC distributions.

Conclusion

Analysis of ADC maps **identified 3 patterns of diffusion change within metastases regions over the course of multiple SRS treatments.** These patterns may help improve our understanding of metastases progression before and after SRS using DWI.

References

- 1 Balyan V et al. Diffusion weighted imaging: Technique and applications. *World J Radiol* 2016; 8(9): 785-798
- 2 Hayashida Y et al. Diffusion-weighted Imaging of Metastatic Brain Tumors: Comparison with Histologic Type and Tumor Cellularity. *American Journal of Neuroradiology*; 27(7): 1419-1425

