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Correlation of apparent diffusion coefficient ratio on 3.0 T MRI with prostate cancer Gleason score

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ABSTRACT

Introduction: The purpose was to investigate the usefulness of ADC_{ratio} on Diffusion MRI to discriminate between benign and malignant lesions of Prostate.

Methods: Images of patients who underwent in-gantry MRI guided prostate lesion biopsy were retrospectively analyzed. Prostate Cancers with 20% or more Gleason score (GS) pattern 3 + 3 = 6 in each core or any volume of higher Gleason score pattern were included. ADC_{ratio} was calculated by two reviewers for each lesion. The ADC_{ratio} was calculated for each lesion by dividing the lowest ADC value in a lesion and highest ADC value in normal prostate in peripheral zone (PZ). ADC_{ratio} values were compared with the biopsy result. Data was analysed using independent samples T-test, Spearman correlation, intra-class correlation coefficient (ICC) and Receiver operating characteristic (ROC) curve.

Results: 45 lesions in 33 patients were analyzed. 12 lesions were in transitional zone (TZ) and 33 in perpheral zone PZ. All lesions demonstrated an ADC_{ratio} of 0.45 or lower. GS demonstrated a negative correlation with both the ADC value and ADC_{ratio}. However, ADC_{ratio} ($p < 0.001$) demonstrated a stronger correlation compared to ADC value alone ($p = 0.014$). There was no significant statistical difference between GS 3 + 4 and GS 4 + 3 mean ADC_{tumour} value ($p = 0.167$). However when using ADC_{ratio}, there was a significant difference ($p = 0.032$). ROC curve analysis demonstrated an area under the curve of 0.83 using ADC_{ratio} and 0.76 when using ADC_{tumour} value when discriminating Gleason 6 from Gleason ≥7 tumours. Inter-observer reliability in the calculation of ADC ratios was excellent, with ICC of 0.964.

Conclusion: ADC_{ratio} is a reliable and reproducible tool in quantification of diffusion restriction for clinically significant prostate cancer foci.

1. Introduction

Diffusion weighted imaging (DWI) is one of the important components of the multi-parametric MRI (mpMRI) examination of the prostate. DWI can be quantitatively measured by Apparent Diffusion Coefficient (ADC). There is wide evidence in current literature that clinically significant prostate cancer foci demonstrate a reduction in apparent diffusion coefficient (ADC_{tumour}) and show restricted diffusion relative to normal prostate tissue [1,2]. ADC_{tumour} values obtained from these maps correlate inversely with the histologic Gleason score for the tumour [3–5] and are also associated with clinical outcomes [6,7].

According to the latest Prostate Imaging Reporting and Data System (PIRADS) version 2 guidelines, interpretation and scoring of DWI and ADC maps on mpMRI examination is based primarily on qualitative visual assessment of the signal intensity of a lesion compared with that of the surrounding normal prostatic tissue in the same anatomic zone, to determine a significant reduction in ADC value within a suspected lesion [2,8].

The guidelines acknowledge substantial overlap of ADC values among different pathologies in prostate like stromal hyperplasia, low-grade cancer, and high-grade cancer. Also, there is substantial variability in ADC values depending on multiple technical factors such as vendor, field strength, and DWI acquisition parameters [2,8]. The ADC values of Prostate Cancer (PCa) also vary according to age and race of the patient [9]. There is no agreed ADC_{tumour} value cut-off that could be reliably used to determine abnormally low ADC within a lesion [4,5]. Nonetheless, in PI-RADS version 2, a threshold of 750–900 mm^2/s is suggested as lesions with an ADC value that is less than this range tend

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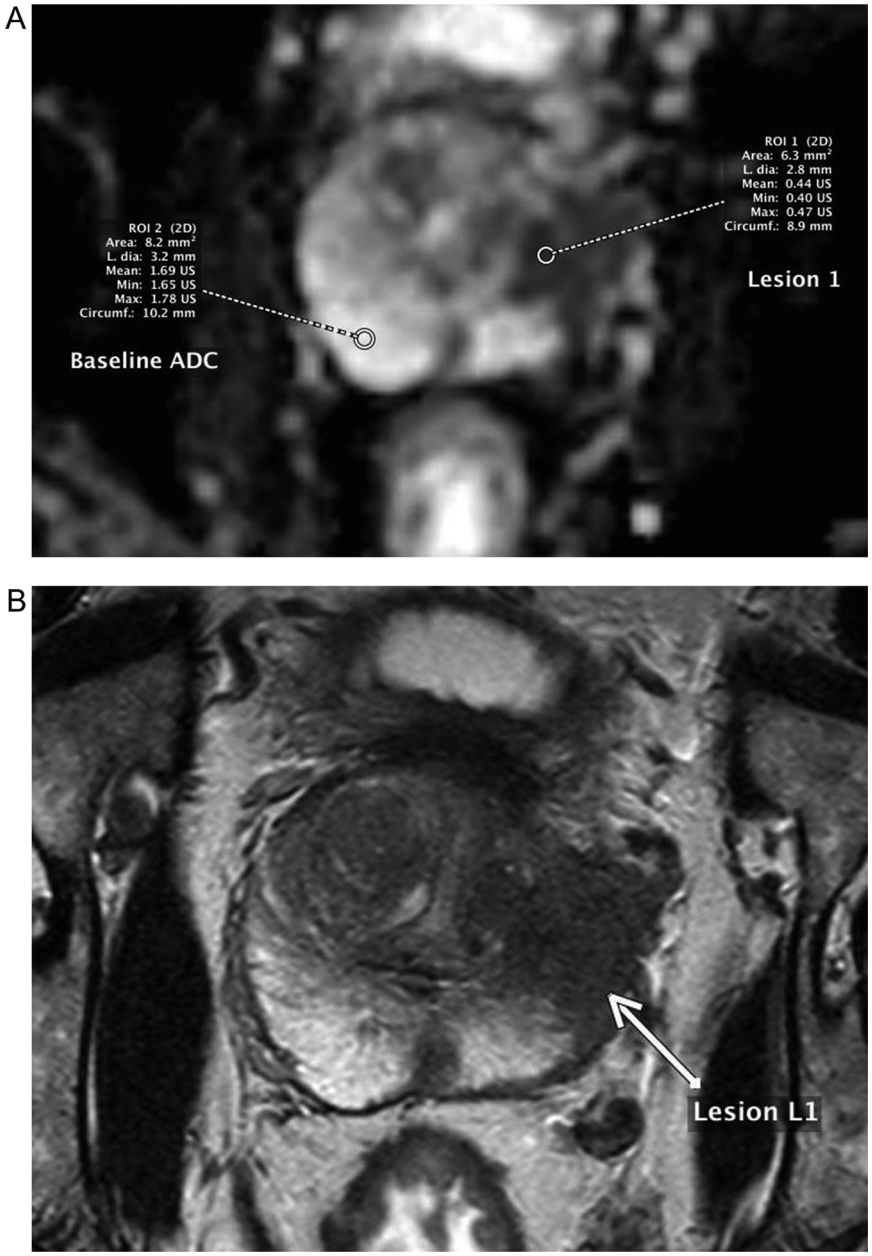

Fig. 1. A. Peripheral Zone lesion with Gleason score 4 + 5 tumor. Axial ADC image with ADC ratio of 0.26. B. Corresponding Axial T2 image of a TZ/PZ lesion.

to represent clinically significant prostate cancer. However, given the noted variability, it has been recommended that each center should identify its own thresholds that are based on internal data and comparisons with histopathologic findings. [2,8]. This independent verification of appropriate threshold can be difficult to establish. Also, comparison between studies from two different centres would be difficult. Previous studies have shown wide variation in ADC_{tumour} values of both PCa as well as normal prostate [10].

A ratio of ADC values (ADC_{ratio}) between a lesion and the background prostate can potentially negate these external factors and provide a more accurate representation of change in the diffusion in a tumour with respect to normal tissue. We calculated ADC_{ratio} for each lesion by dividing the lowest ADC value in a lesion and highest ADC value in PZ of normal prostate.

The aim of this study is to investigate the usefulness of ADC_{ratio} values of a prostatic lesion to background prostate parenchyma to discriminate between benign and malignant lesions. Also, we aim to establish whether ADC_{ratio} is easily reproducible.

2. Material and methods

2.1. Patients

Our institutional review board (Human research and ethics committee) approved this retrospective study. We searched our database for lesions that underwent in-gantry MRI guided biopsy between February 2013 and December 2014. 229 lesions that were biopsied via in-gantry MR guided biopsy were retrospectively evaluated. Significant lesions were considered to be lesions which demonstrated 20% or more Gleason score (GS) pattern 3 + 3 = 6 in each core or any volume of higher Gleason score pattern. Finally, 45 lesions in 33 patients were included in the analysis. 33 tumours were in peripheral zone, and 12 were in transitional zone. Patient cohort characteristics are demonstrated in Table 2. All the MRI studies were performed before any prostate biopsy (biopsy-naïve lesions). Median PSA in this cohort was 7.8 ng/mL (range 1.8–26.0) and mean age was 67 years (range 49–81 years).