

Factors that Influence the Permeability Analysis in Magnetic Resonance Studies of the Prostate

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Abstract

Methods: The permeability analysis was performed using the IntelliSpace portal, manufactured by PHILIPS with the Permeability package. The variables changed during processing were the AIF, temporal and spatial smoothing filters. For each equipment field strength a processing protocol was created informing the injection time, the relaxativity and the concentration of the contrast agent.

Results and Discussion: There is a significant difference in the values of permeability between the Manual and Automatic AIF processing. Temporal smoothing filters showed greater variation when using the medium setting. This variation occurs for all examined criteria (k_{trans} , k_{ep} , V_e and V_p). Spatial smoothing filters do not alter substantially the results of the permeability analysis.

Conclusion: There is a big difference in the result of permeability obtained comparing the Automatic and Manual AIF analysis, and may be in the order of 250%. Temporal and spatial smoothing filters have small, non-significant variations in the results.

Keywords: Prostate MRI; Multiparametric analysis; Prostate cancer; Prostate multiparametric; Permeability; Prostate permeability

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Objective

The objective of this study is to demonstrate some possible results variations that occur in MRI permeability studies of the prostate, taking into account the post processing variables that can be adjusted by the operator on the IntelliSpace Portal, manufactured by PHILIPS Healthcare [1,2].

Materials and Methods

The permeability analysis was performed using the IntelliSpace portal, manufactured by PHILIPS Healthcare with the Permeability package. The variables changed during processing were the AIF (manual or disabled), temporal and spatial smoothing filters. For each equipment field strength a processing protocol was created informing the injection time, the relaxivity and the concentration of the contrast agent (Tables 1 and 2).

The spatial and temporal filters were altered for all four configurations (none, weak, medium, strong). For the manual AIF processing, the region of interest was positioned on the common iliac artery. The Figures show the results for both disabled and

Manual AIF processing (no temporal or spatial filter were used) in a suspicious nodule (PIRADS V) in the left peripheral zone (Figures 1 and 2).

The permeability analysis was made using a dynamic sequence with high temporal resolution (approximately 5 seconds) and 65 dynamic phases. To obtain a T1 MAP of the prostate tissue the

Table 1 Preset for post-processing on 1.5T equipment.

1.5 T Magnetic Field Strength	
Contrast Relaxivity	3.9 s ⁻¹ .mmol ⁻¹
Injection Dose	0.2 mmol/kg
Injection Duration	<5 seconds (shortest)
Hematocrit	45%

Table 2 Preset for post-processing on 3T equipment.

3T Magnetic Field Strength	
Contrast Relaxivity	3.9 s ⁻¹ .mmol ⁻¹
Injection Dose	0.1 mmol/kg
Injection Duration	<5 seconds (shortest)
Hematocrit	45%

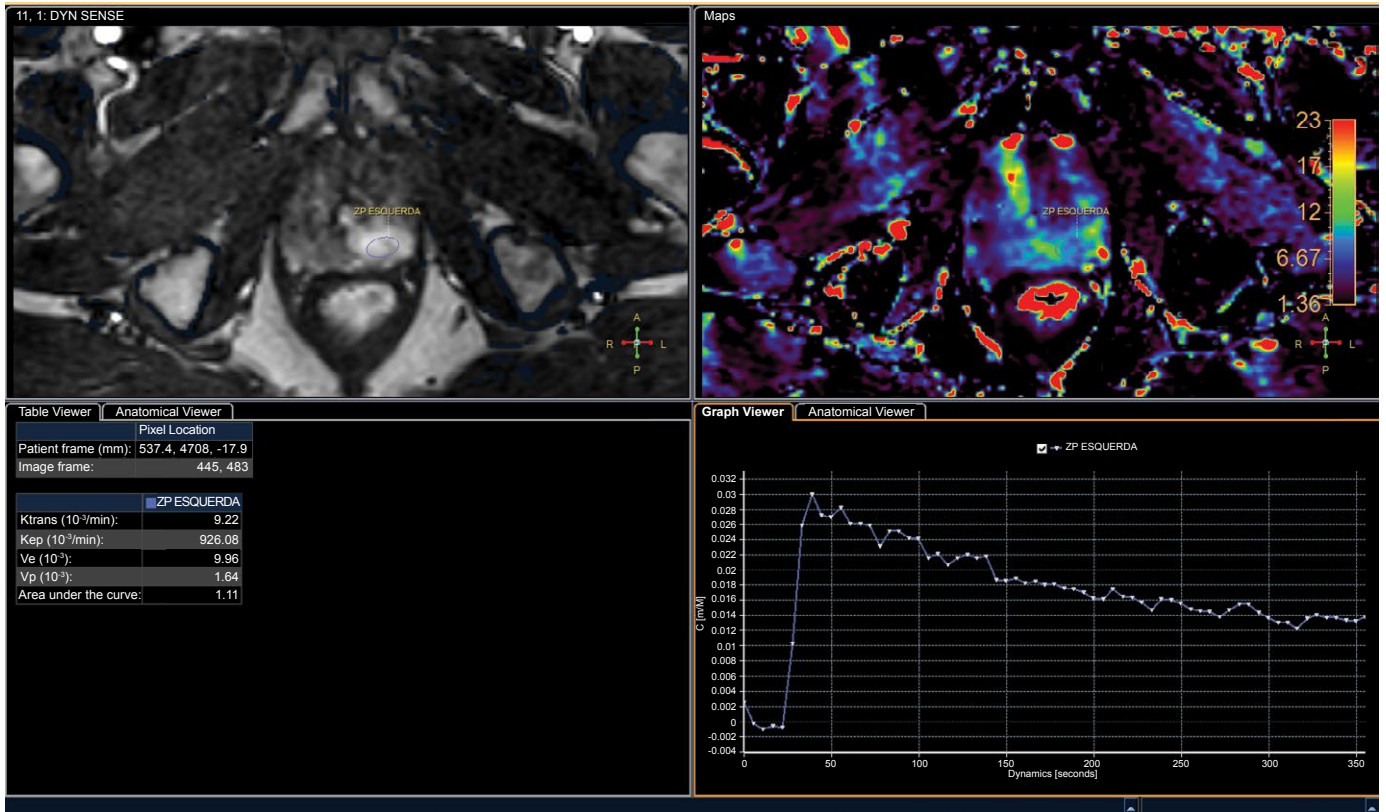


Figure 1 AIF Disabled.

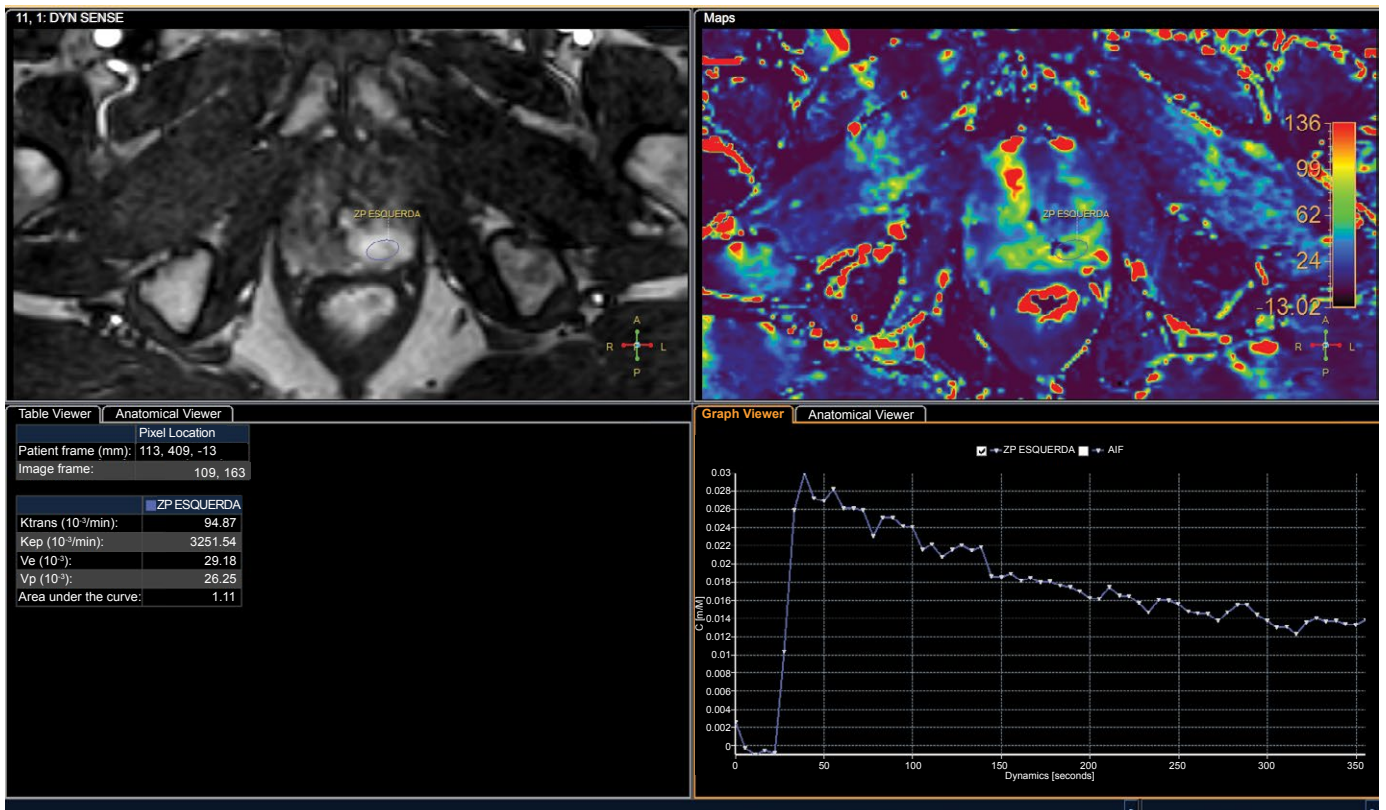


Figure 2 Manual AIF were used.

same sequence was acquired before the administrations of IV contrast with one dynamic and different flip angles of 5 and 15 degrees (Figures 3-5).

Results and Discussion

Thirty patients were submitted to prostate MRI for permeability analysis and the results obtained were:

- The difference, in percentage, between the manual AIF and the disabled AIF processing were $(83.66 \pm 19.82)\%$ for ktrans $(51.84 \pm 10.95)\%$ for kep, $(68.86 \pm 32.96)\%$ for Ve and $(91.99 \pm 4.02)\%$ for Vp



Figure 3 Axial FFE with flip angle of 5 degrees.



Figure 4 Axial FFE with flip angle of 15 degrees.



Figure 5 Axial FFE for permeability analysis.

- The effective difference for ktrans processing using different temporal and spatial filters, compared with the result without any filter (Table 3).
- For the kep, the effective difference was (Table 4).
- For the Ve, the effective difference was (Table 5).
- For Vp, the difference was (Table 6).

The Figures 6-8 shows some of these differences obtained after three different types of processing.

Discussion

- The use of temporal or spatial smoothing filters alters the results of all permeability parameters with differences superior than 100% [3].
- One of the greatest contribution for these variations is due to noise fluctuation of the dynamic acquisitions, more evident in equipments of higher field strength.
- In general, the use of temporal and spatial smoothing filter doesn't alter the behavior of the perfusion curve (plateau), even with Manual or disabled AIF processing.
- Temporal smoothing filters presented a bigger variation in the results compared with spatial smoothing filters;
- There was a great difference between the results of manual AIF and disabled AIF processing [4-8].

Conclusions

The analysis concluded that there is a wide variation in the results of permeability using different post-processing techniques. Spatial smoothing filters do not exhibit so significant variations in the results compared to temporal smoothing filters. The

Table 3 Effective difference for ktrans processing using different temporal and spatial filters.

Temporal Smoothing	Weak	Medium	Strong	Spatial smoothing	Weak	Medium	Strong
		9.86 ± 28.34	13.64 ± 25.06		5.93 ± 21.74		1.07 ± 24.54

Table 4 For the kep, the effective difference.

Temporal Smoothing	Weak	Medium	Strong	Spatial Smoothing	Weak	Medium	Strong
		-9.21 ± 213.57	-5.65 ± 34.92		-22.63 ± 236.48		11.01 ± 148.90

Table 5 For the Ve, the effective difference.

Temporal Smoothing	Weak	Medium	Strong	Spatial Smoothing	Weak	Medium	Strong
		18.74 ± 65.19	25.24 ± 61.47		20.53 ± 48.30		0.18 ± 8.69

Table 6 For Vp, the difference.

Temporal Smoothing	Weak	Medium	Strong	Spatial Smoothing	Weak	Medium	Strong
		-0.32 ± 1.53	-2.12 ± 3.55		-5.11 ± 9.06		-2.75 ± 7.54

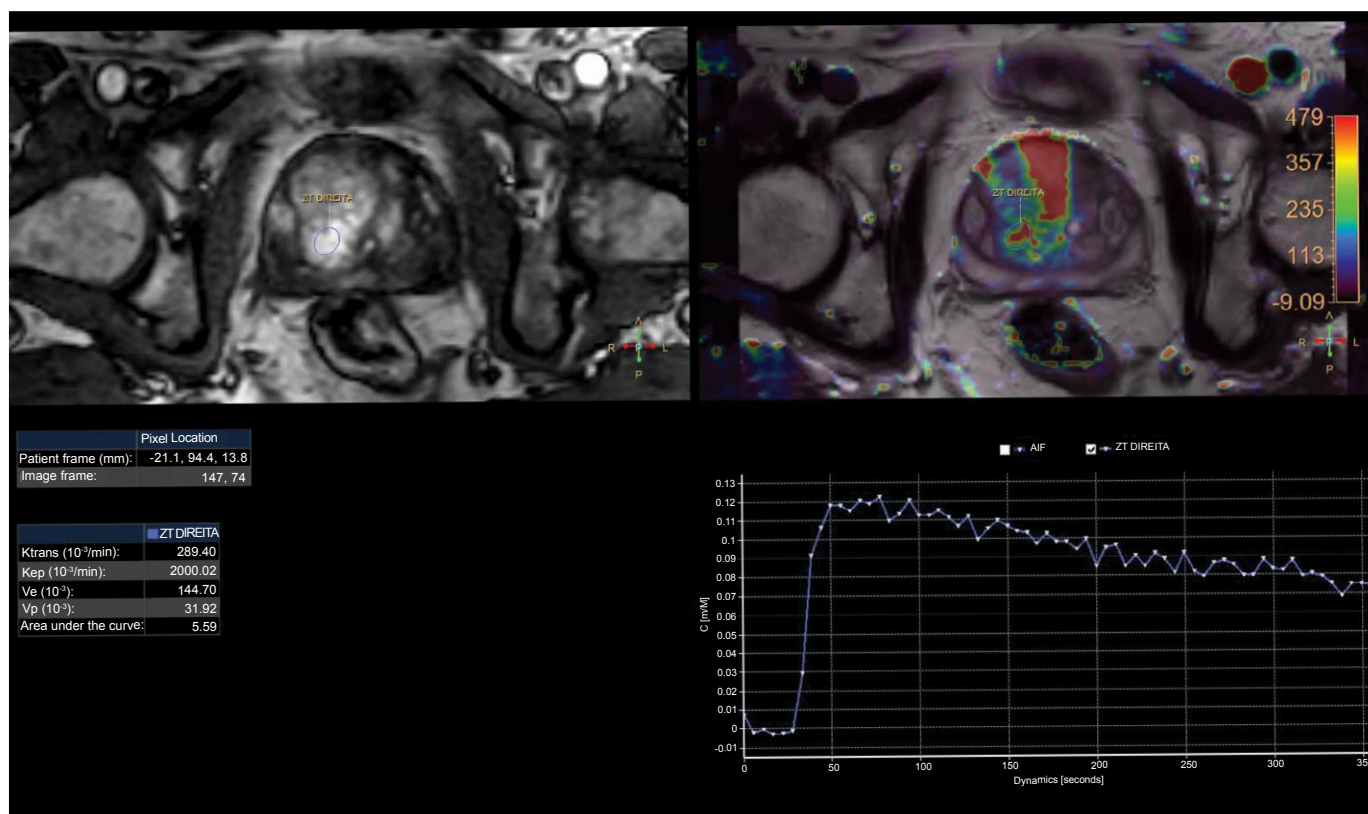


Figure 6 Manual AIF processing without temporal or spatial filter.

difference in the obtained results with disabled and manual AIF are very considerable, which can lead to discrepant results for patients who are in active surveillance.

General Considerations

- The use of pulse sequences with CENTRA and Keyhole helps to minimize the noise fluctuation, allow to increase the spatial and temporal resolution on dynamic acquisitions.
- In general, even with more noise fluctuation, the image quality of 3T MRI equipment's is better compared with 1.5T. The Signal-to-Noise Ratio is quite bigger, generating

more detailed images, with better contrast and definition of tissues.

- For follow-up studies we recommend to use the same processing as the first exam, including filters and AIF region of interest positioning, minimizing possible results variations.
- The AUC (area under the curve) is exactly the same for both Manual and disabled AIF processing, so, it was not analyzed on this study.
- The study showed just the results variations of different sorts of processing on the permeability analysis and not the normal thresholds.

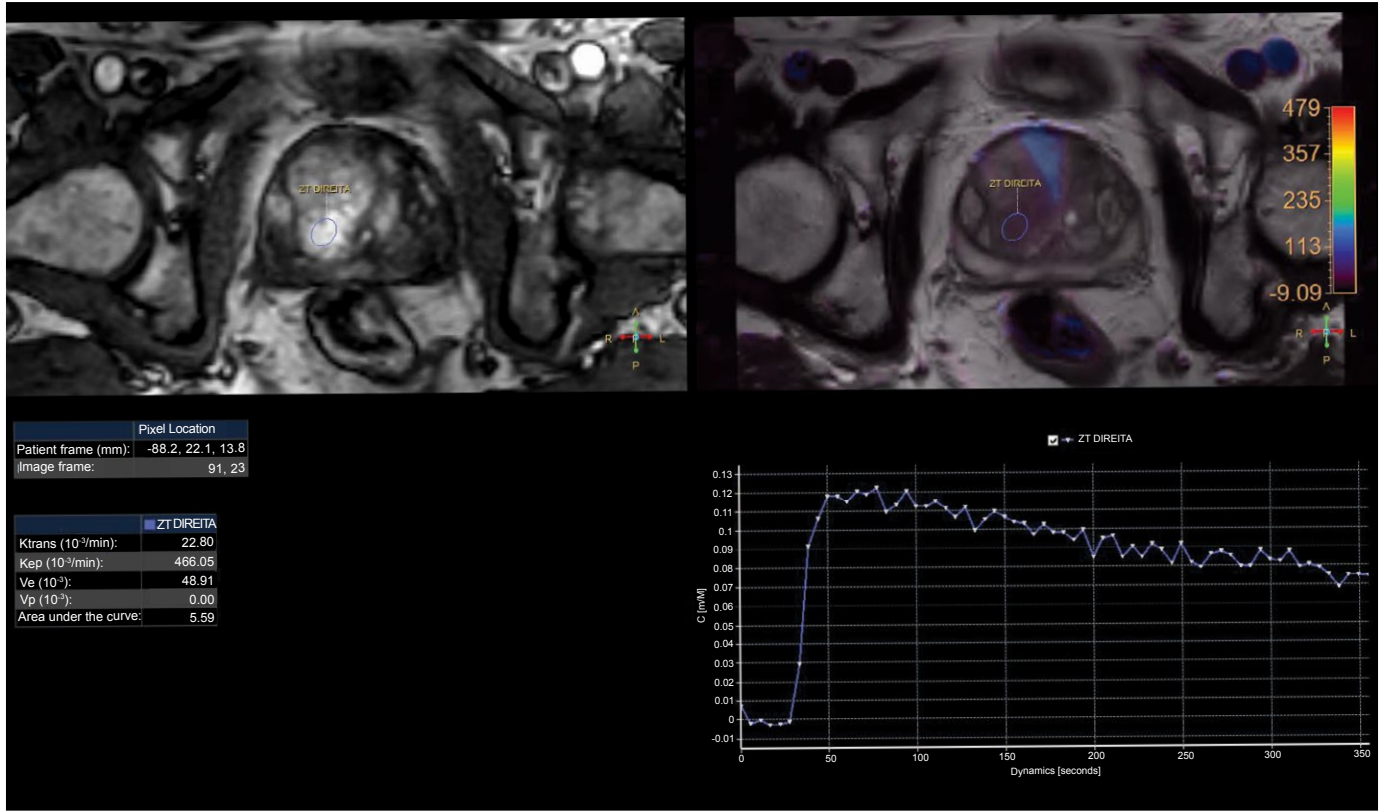


Figure 7 AIF disabled without temporal or spatial filter.

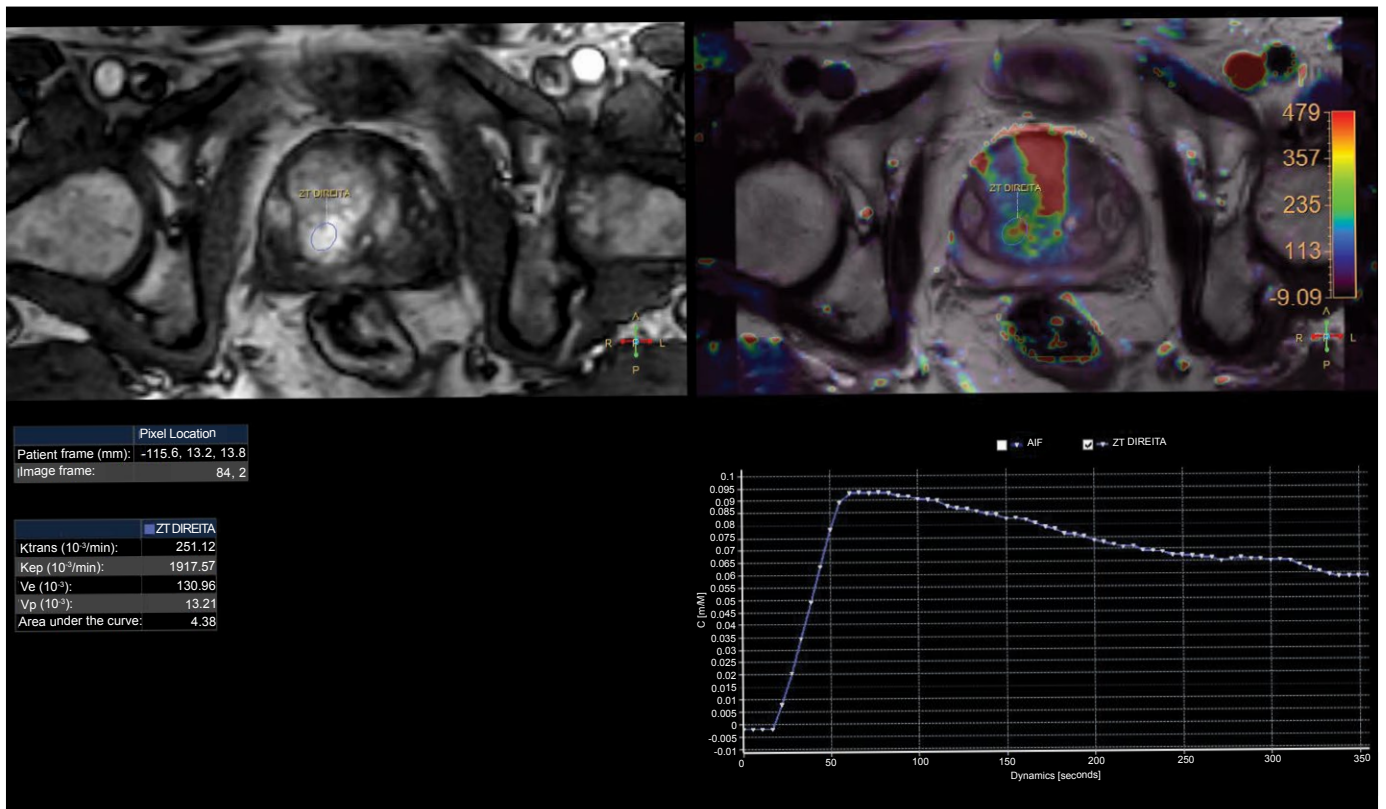


Figure 8 Manual AIF with strong temporal smoothing filter.

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