# Effect of Saturation Pulse Duration and Strength on Parallel Transmission Based Amide Proton Transfer MRI of the Prostate

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## Introduction

Chemical exchange saturation transfer (CEST) MR imaging has emerged as a new molecular imaging technique in which the contrast is determined by a change in water intensity due to chemical exchange with saturated solute protons (1). The CEST approach, using endogenous amide protons (resonance frequency offset at 3.5 ppm downfield of the water signal) in tissue, was termed amide proton transfer (APT) MR imaging and could be clinical useful for prostate cancer detection (2). In the technique, the duration and power strength of saturation pre-pulse are important factors for APT-MRI signal sensitivity (3). Recently, parallel transmission based APT-MRI has been developed to allow a long pulse duration and homogeneous $B_1$ field (4). This study is to optimize the pulse duration and power strength for optimal diagnostic capability of prostate cancer.

## Materials and methods

61 prostate cancer patients were included in this study. The patients were divided into three groups with different saturation pulse duration: 0.5 sec (N = 20), 1 sec (N = 18), and 2 sec (N = 23). All patients were imaged on a 3 T MR system (Achieva, Philips Healthcare, Cleveland, OH) using a 32-channel phased array coil for signal reception and 2-channel parallel transmission via the body coil. APT-MR imaging was based on single-slice single-shot TSE with the following parameters: TR/TE = 6100/56 ms; TSE factor = 47; Field of view = $140 \times 140$ mm$^2$; Matrix = $80 \times 64$; Slice thickness = 6 mm; Number of signal averages = 1. For the 0.5 sec duration group, the saturation pre-pulse was composed of a train of sixteen block pulses, each with a pulse length of 31 ms and saturation amplitude of 1 to 4 µT. For the 1 and 2 sec groups, the software patch provided by Philips Company enabled long RF irradiation by using two amplifiers from a parallel transmission (pTX) MR system in alternation during the saturation pulses. The pTX-APT-MRI saturation pulse was composed of a train of ten or twenty block pulse, each with a pulse length of 100 ms and saturation amplitude of 1 to 4 µT. $B_0$ map was acquired based on a dual-echo FFE sequence with the same resolution as the APT-MRI. Normal peripheral zone and central gland ROIs were carefully placed with diagnostic T2-weighted images as reference. $MTR_{asym}$(3.5ppm) values from the normal regions were compared among the three groups.

## Results and Discussion

For all three groups with different pre-pulse duration, $MTR_{asym}$(3.5ppm) of normal peripheral zone and central gland showed an increasing trend with higher pre-pulse power strength. Under the same power strength, pre-pulse with 1 sec duration showed higher $MTR_{asym}$(3.5ppm) then pre-pulse with 0.5 sec and 2 sec.

*For the group with 0.5 sec duration*, $MTR_{asym}$(3.5ppm) of normal peripheral zone increased from 1.5 µT to 3 µT and reached a plateau at 3.5-4 µT. $MTR_{asym}$(3.5ppm) of central gland increased from 1.5 µT to 2 µT and reached a plateau at 2-4 µT. However larger standard deviation at 4 µT was found in both normal peripheral zone and central gland than at 3.5 µT, which corresponds to the over-saturation on MT-spectrum and increase of noise level.

*For the group with 1 sec duration*, a consistent increase in $MTR_{asym}$(3.5ppm) was shown from 1 to 3.5 µT in both peripheral zone and central gland. *For the group with 2 sec duration*, $MTR_{asym}$(3.5ppm) of the peripheral gland showed a plateau from 1.5 to 3.5 µT, and $MTR_{asym}$(3.5ppm) of the central gland showed an increase from 1 to 2.5 µT and reached a plateau. $MTR_{asym}$(3.5ppm) with 2 sec duration was smaller at any fixed power strength than those with 0.5 and 1 sec duration. Furthermore, $MTR_{asym}$(3.5ppm) with 2 sec duration reached minimum at 1 µT for both normal peripheral zone (-0.13% ± 1.17%) and central gland (-0.07% ± 1.51%), which can facilitate APT-MRI signal suppression from normal tissues. Figure 2 demonstrates a representative case with 2 sec duration. The tumor in the right posterior peripheral zone can be better visualized at 1 µT with relatively low APT-MRI signal from normal prostatic tissues.

## Conclusion

Parallel transmission based APT-MRI enables long saturation pre-pulses as well as homogenized (adaptively shimmed) RF saturation pulses. The APT contrast in the prostate can be enhanced by using a longer pre-pulse (2 sec) and weak power strength (1 µT), in which normal prostatic tissues showed minimum $MTR_{asym}$(3.5ppm). This study shows the importance of APT-MRI contrast optimization based on pulse duration and power strength in clinical prostate cancer patient examinations and its benefits to further develop this methodology into an imaging biomarker.

## References

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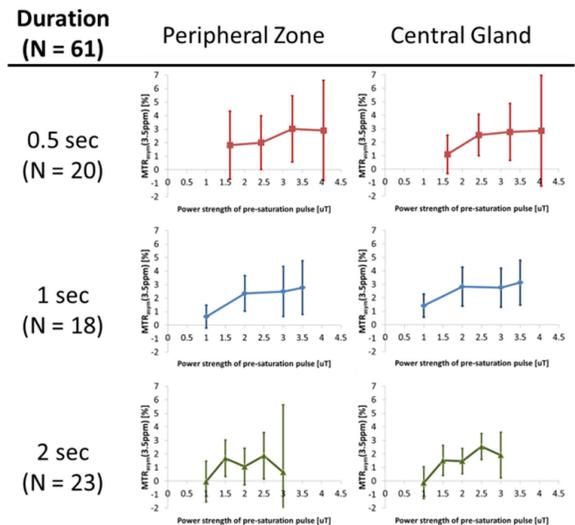4. Keupp J et al, ISMRM 19:710 (2011)

Figure 1. Parallel transmission (pTX) APT-MRI enables longer saturation duration such as 1 or 2 sec for prostate cancer patient scan. The maximal APT-MRI signal appeared at 3.5 µT and 1 sec; and the minimal APT-MRI signal was measured at 1 µT and 2 sec. The latter can suppress normal prostatic tissues, thus improving prostate cancer detection.
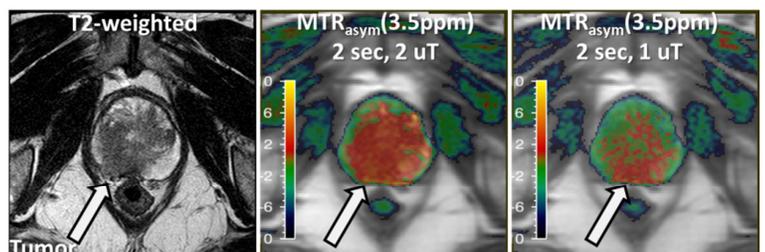


Figure 2. 63 year-old patient with prostate cancer in right posterior peripheral zone. The tumor shows higher APT signal. APT-MRI contrast is increasing with 1 µT and 2sec by $MTR_{asym}$(3.5ppm) decrease in normal peripheral zone and central gland.