Improved Image Quality and Reduced Acquisition Time in Prostate T2-weighted Spin-echo MRI Using a Modified PI-RADS-adherent sequence

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BACKGROUND

The Prostate Imaging and Reporting Systems (PI-RADS) guideline[1] recommends a 0.40 mm (frequency) × 0.70 mm (phase) in-plane resolution for T2-weighted imaging; however, achieving this resolution often requires trade-offs such as prolonged scan time or reduced signal-to-noise ratio (SNR), and adherence remains inconsistent across institutions[2,3,4].

This study evaluates whether adjusting the resolution, reducing frequency, and increasing phase resolution while maintaining the same pixel area can **preserve image quality**, **reduce acquisition time**, and **enhance workflow efficiency** without compromising prostate cancer detection.

METHODS

The standard ADH T2-weighted sequence used a fixed in-plane resolution, requiring a high matrix and two signal averages to maintain SNR, which resulted in longer scan times. To address these limitations, we developed a **modified (MOD) sequence** using a **flexible resolution strategy based on pixel area. This approach preserved spatial resolution, improved SNR, and reduced scan time by 23% with only one signal average** (Table 1). Phantom studies evaluated SNR, spatial resolution, and image consistency under matched acquisition parameters, and 62 clinical cases were reviewed by four radiologists. Image quality was rated using a 4-point **Diagnostic Quality (DQ) scale** and **binary PI-QUALv2[5] criteria assessing SNR, delineation, and artifact presence.** Statistical comparisons between ADH and MOD were performed using the Wilcoxon signed-rank test ($p < 0.05$).

Parameters	ADH	MOD
Matrix Size	400 × 230	320 × 280
In-Plane Resolution (mm)	0.40 × 0.70	0.50 × 0.57
Pixel Area (mm²)	0.28	0.285
Bandwidth (kHz)	64	32
Signal Averages (NEX)	2	1
Acquisition Times (Median)	3:55	3:01

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RESULTS

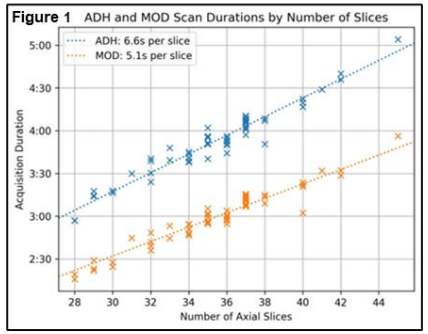


Figure 1. Plot of acquisition times of the ADH and MOD sequences vs. the number of axial slices used for the 62 subjects. Lines of regression show the mean acquisition times per acquired slice, 6.6 sec/slice for ADH and 5.1 sec/slice for MOD. The difference, 1.5 sec/slice, is a **23% reduction in acquisition time per slice provided by the MOD vs. ADH sequence.**

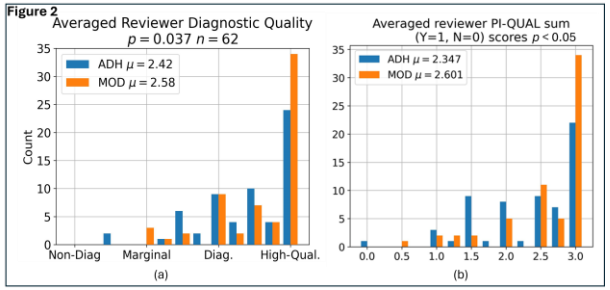


Figure 2. Comparison of DQ and PI-QUALv2 scores between PI-RADS-ADH and MOD sequences. (a) Histogram of reader-averaged DQ ratings (Non-Diagnostic to High-Quality). (b) Histogram of summed PI-QUAL v2 scores (0–3), including SNR, delineation, and artifact assessment. Color-coded bars represent the ADH (blue) and MOD (orange) sequences. Mean values (μ) are indicated in the legends. **Both DQ and PI-QUAL v2 scores show significantly higher values for the MOD sequence compared to ADH, suggesting superior image quality with the modified protocol**

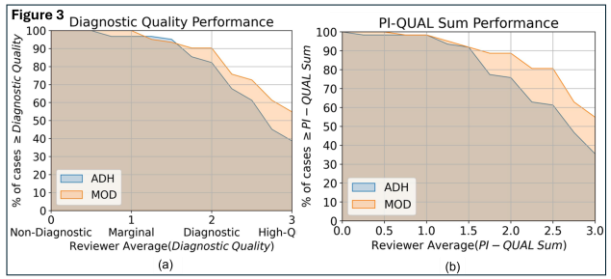


Figure 3. Plot of performance of ADH and MOD sequences as a function of the DQ score (a) and PI-QUALv2 scores (b). **At higher scores (>2), MOD shows a consistent ~10% performance gain**, though both are diagnostically acceptable. **At lower scores (<2), MOD's modest advantage becomes clinically relevant, helping to reduce the need for rescans.**

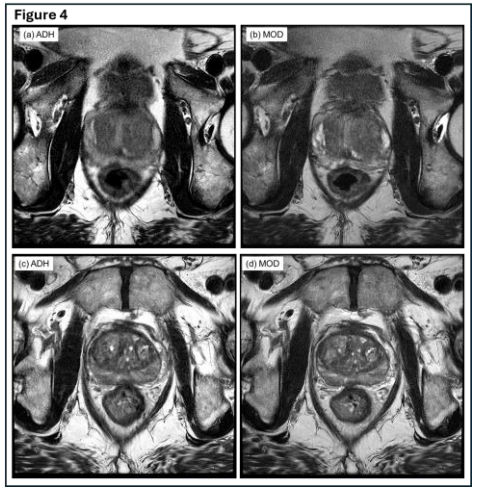


Figure 4. Examples of improvement in diagnostic quality provided by MOD vs. ADH sequence. Side-by-side axial T2WI images (16 cm FOV) show ADH images in (a) and (c), and MOD images in (b) and (d). In the first example, **the ADH series had a low average DQ score of 0.5, requiring rescan, while the MOD image scored 2.0, adequate for diagnosis**. In the second example, **the ADH series was rated 2.25, whereas the MOD image received a DQ score of 3.0 from all four readers.**

DISCUSSION

A modified T2-weighted spin-echo sequence with **isotropic in-plane resolution** (0.50×0.57 mm²) was developed as an alternative to the standard PI-RADS resolution (0.40×0.70 mm²), maintaining an equivalent pixel area (0.28 mm²). This adjustment allowed for **reduced frequency sampling**, enabling a **two-fold bandwidth reduction** and **restoration of SNR**. As a result, **signal averaging was no longer required**, leading to a **median acquisition time reduction of 54 seconds** per scan. These technical improvements were achieved without compromising image quality or resolution.

Diagnostic performance of the MOD sequence was **statistically superior** to the reference ADH sequence across multiple metrics. The MOD images received **higher PI-QUALv2 scores**, especially in **prostate delineation** and **artifact suppression**, with **comparable SNR**. Reader preference strongly favored the MOD sequence (**$p < 0.0005$**). In cases with borderline quality, MOD was more likely to produce **diagnostic-quality images**, thereby **reducing the need for rescans**, which typically take 5 minutes each and negatively affect workflow.

The MOD protocol provided a **23% reduction in acquisition time**. These findings demonstrate the potential of **area-based in-plane resolution targeting** over fixed dimension constraints, offering both **technical flexibility** and **clinical efficiency**. This supports the MOD sequence as a **high-performance alternative** to the current PI-RADS-compliant protocol.

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