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Concurrent multiparametric MR with PET/MR for prostate cancer

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In the past 10 years, there have been groundbreaking developments in the field of prostate cancer. Among these, developments in PET and MR radiopharmaceuticals specific to receptors stand out. Multiparametric MR (mpMR) helps in the detection and localization of prostate cancer, as well as biopsy guidance. Although mpMR is an effective imaging method, the false negative rates of up to 20 percent may create challenges.

The ability of Gallium-68 (^{68}Ga) prostate-specific membrane antigen (PSMA)[†] PET imaging, offering up to 90 percent detection sensitivity, complements MR when mpMR falls short. Thus, PET/MR systems combining ^{68}Ga PSMA PET and mpMR provide a substantial increase in lesion detection rates[1,2]. It has been shown that ^{68}Ga PSMA PET/MR has a higher accuracy rate with respect to mpMR in primary lesion detection[3,4].

It is expected that mpMR performed concurrently with ^{68}Ga PSMA PET/MR may have more prominent significance in clinical practice. The following cases demonstrate, although not yet with histopathological confirmation, how PET and MR reinforce (cases 1 and 5) or complement (cases 2-4) each other.

SIGNA™ PET/MR - prostate protocol

	Axial T2 PROPELLER	*Sagittal T2 PROPELLER*	*Coronal T2 PROPELLER*	*FOCUS DWI*	*T1 DCE FSPGR*
FOV (cm):	20 x 20	20 x 20	20 x 20	28 x 11.2	25 x 21.3
Slice thickness (mm):	3	3.5	3	4	4
Frequency:	352	320	320	160	128
Phase:	352	320	320	164	100
Scan time (min.):	4:04	4:28	2:59	6:08	4:05
Options / other (b-value, no-phase wrap, etc.):				b50, b800, b1400	7 sec./phase

[†]^{68}Ga PSMA is not approved by the US FDA and may not be available for clinical use in all markets.

Case 1

Consistent with both mpMR and ^{68}Ga PSMA PET scans, a prostatic lesion (red arrow) is observed at the left posteromedial peripheral zone with a suspicion of malignancy that could indicate prostate cancer.

A less significant PSMA uptake (blue arrow) with cancer suspicion that was observed in the ^{68}Ga PSMA PET images of the prostatic gland right peripheral zone were non-existent in the multi-parametric prostatic MR sequences.

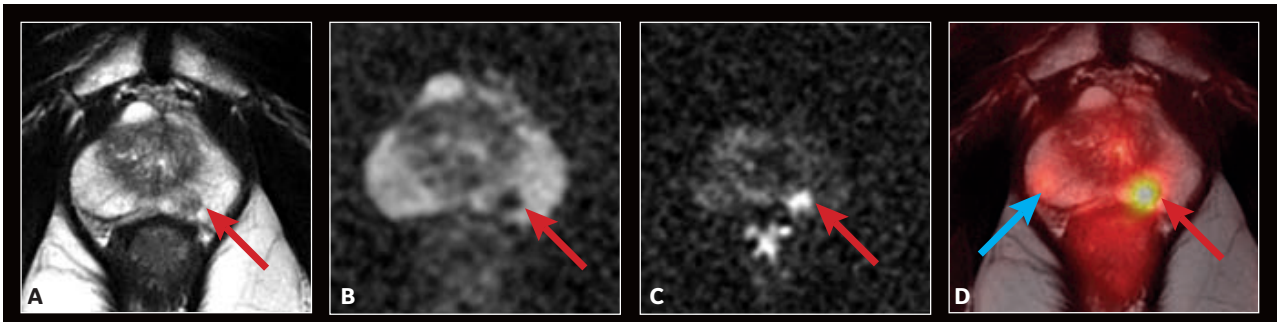

Figure 1. (A) Axial T2w, (B) ADC map, (C) high b-value DWI and (D) ^{68}Ga PSMA PET/MR fused image.

Case 2

The ^{68}Ga PSMA PET images of the left peripheral zone posteromedial show PSMA uptake with prostatic cancer suspicion. In the mpMR sequences, the same lesion is not clearly visible among the hemorrhage foci.

The patient's pathology results indicate a Gleason Score of 3+3 on two foci after transrectal ultrasound biopsy (TRUS) biopsy.

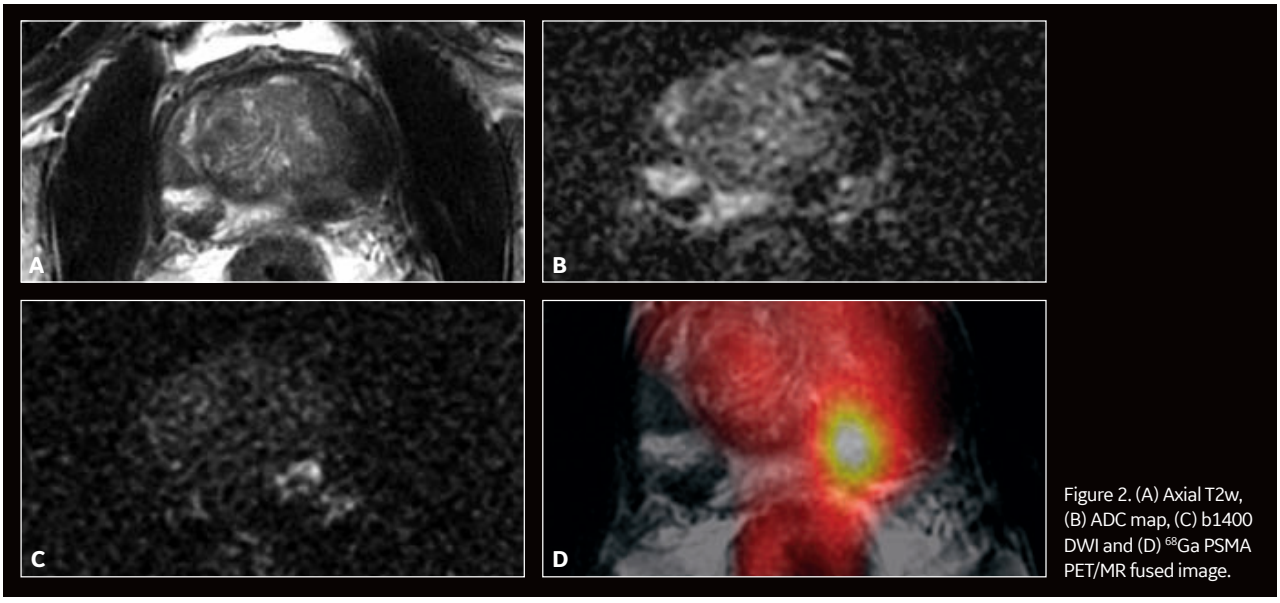

Figure 2. (A) Axial T2w, (B) ADC map, (C) b1400 DWI and (D) ^{68}Ga PSMA PET/MR fused image.

All mpMR images taken concurrently with ^{68}Ga PSMA PET/MR images are courtesy of Cerrahpaşa School of Medicine, Nuclear Medicine Department.

Case 3

The ^{68}Ga PSMA PET images of the left transition zone show PSMA uptake with prostatic cancer suspicion. The same lesion cannot be observed in the mpMR sequences.

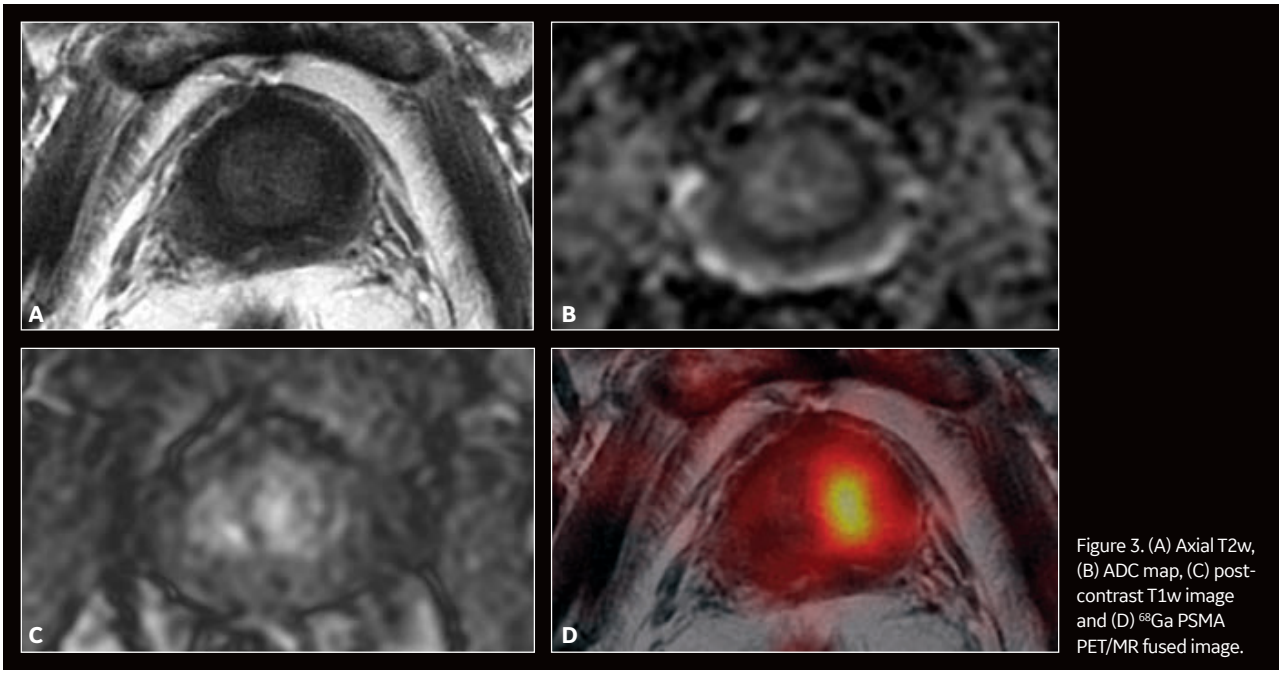

Figure 3. (A) Axial T2w, (B) ADC map, (C) post-contrast T1w image and (D) ^{68}Ga PSMA PET/MR fused image.

Case 4

In the sections that intercept the mid-gland level at the prostatic gland, the presence of two recurrent tumoral lesions in both posteromedial peripheral zones indicate growth in the follow-up mpMR assays, observed due to prostate cancer and after brachytherapy. Lesions in the diffusion-weighted MR image are observed as hyperintense. Distinct early arterial contrast uptake is observed at the post-contrast subtraction T1 images. Lesions are observed with a different color code at the perfusion k-trans mapping. At the ^{68}Ga PSMA PET/MR fused image, only the right lesion can be observed while the one on the left is non-existent.

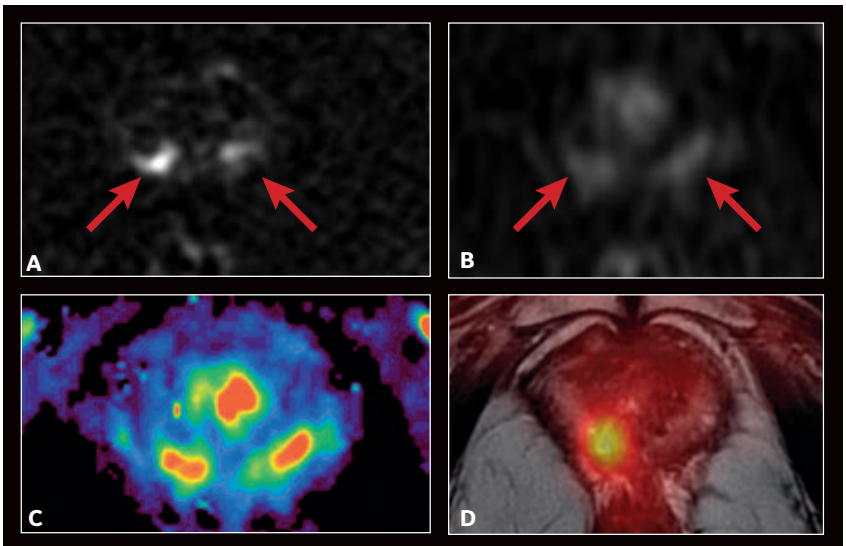

Figure 4. (A) DWI, (B) T1 post-contrast, (C) perfusion k-trans mapping and (D) ^{68}Ga PSMA PET/MR fused image.

Case 5

A 64-year-old patient with a Gleason Score 3+5 prostate cancer after radical prostatectomy operation was referred for PET/MR. The patient had metastatic pelvic lymph nodes and bone lesions, which showed complete or near-complete regression on the ^{68}Ga PSMA PET after hormone therapy. A 23 x 12 x 10 mm sized residual prostatic lesion on the left side of the bladder neck with diffusion restriction was observed on mpMR. The lesion also showed increased perfusion (not shown). The ^{68}Ga PSMA PET image exhibited no uptake on the residual mass, likely due to response to therapy similar to the other metastatic foci.

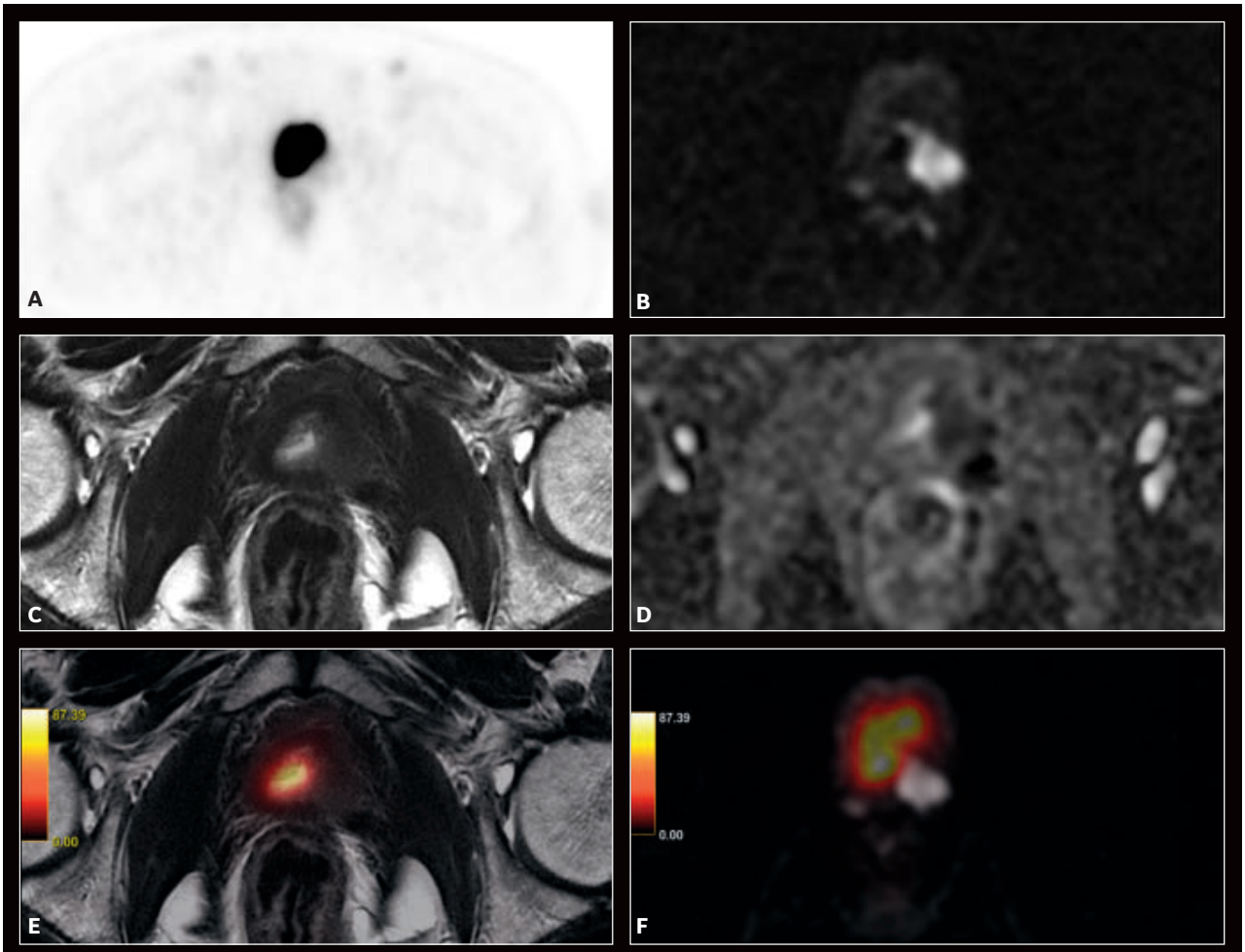

Figure 5. (A) ^{68}Ga PSMA PET, (B) b1400 DWI, (C) axial T2w, (D) ADC map and ^{68}Ga PSMA PET fused with (E) T2w and (F) DWI.

Case 6

A 69-year-old patient with Gleason Score 4+4 prostate cancer after TRUS biopsy. mpMR shows a PI-RADS® 5 lesion extending from the left transitional zone to the left peripheral zone of the prostate gland. ^{68}Ga PSMA uptake is observed only on left transitional zone, underestimating the tumor extension in the peripheral zone.

Histopathology results after radical prostatectomy operation revealed Gleason Score 4+3 prostate cancer extending from the transitional zone to the peripheral zone of the gland, which was in accordance with the mpMR images.

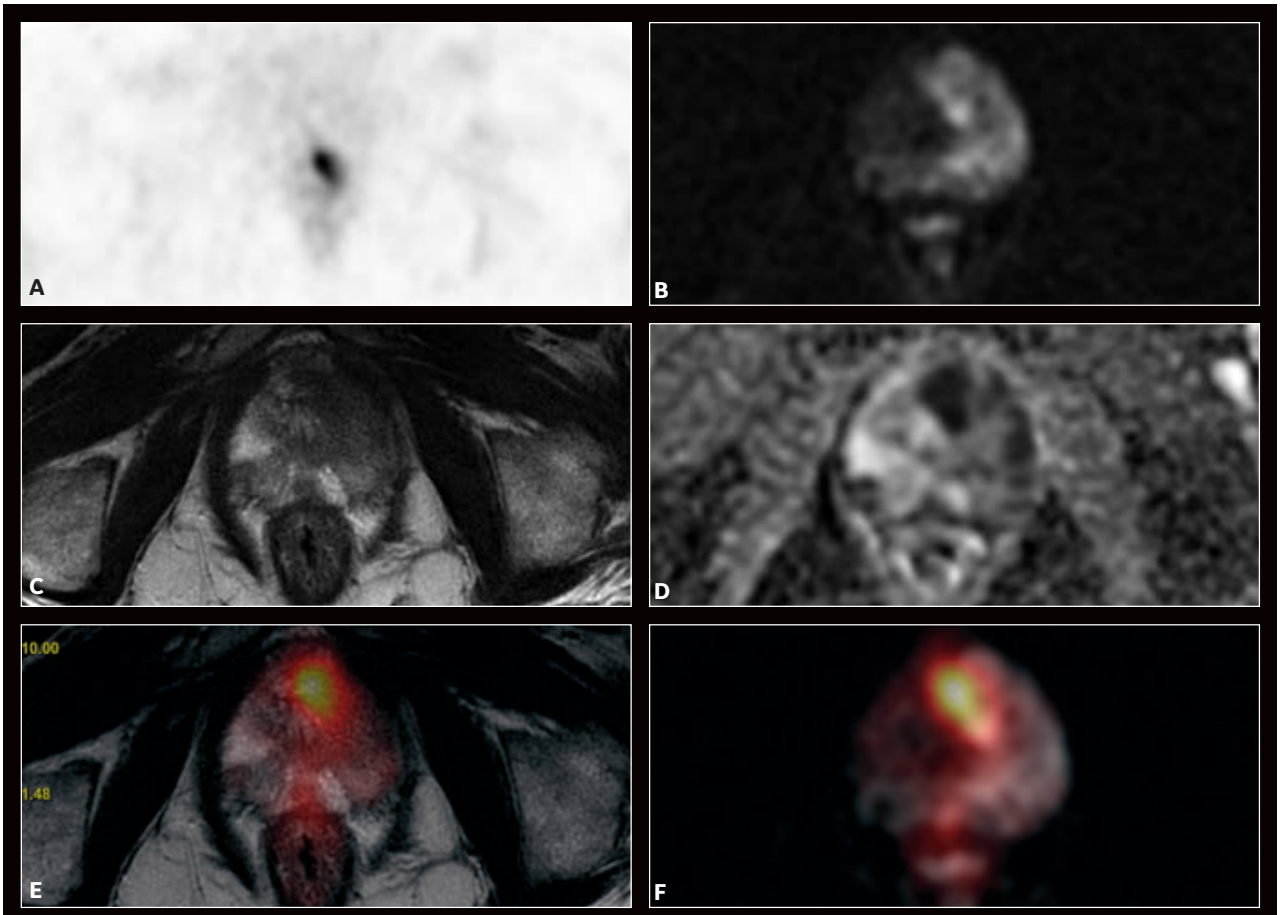

Figure 6. (A) ^{68}Ga PSMA PET, (B) b1400 DWI, (C) axial T2w, (D) ADC map and ^{68}Ga PSMA PET fused with (E) T2w and (F) DWI.

Discussion

^{68}Ga PSMA PET/MR imaging offers a significant advancement in the diagnosis and management of prostate cancer, including for the detection of primary lesions and designation of prognosis and staging. We anticipate the simultaneous ^{68}Ga PSMA PET and mpMR method will be an effective component of our diagnostic and treatment algorithms in the near future.

References

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