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ORIGINAL

TO CONSTRUCT A THREE-CATEGORY RADIOMICS MODEL BASED ON MULTI-PARAMETER MAGNETIC RESONANCE IMAGING TO DISTINGUISH PROSTATITIS FOR ATHLETIC PATIENTS

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ABSTRACT

Prostatitis is a very common disease, with the growth of age, in addition to wrinkles, weight in the longer, the male prostate may also become longer, so there is prostatic hyperplasia (BPH), when its gradual proliferation compression bladder outlet and urethra, will cause dysuria and other symptoms. Simply put, prostatitis causes hyperplasia of the prostate, and prostatitis increases the risk of prostate cancer (Pca). Prostate disease afflicts many men. Therefore, accurate diagnosis of prostate disease is very important for athletic patients to seek medical treatment in time. Multiparametric magnetic resonance imaging (mp-MRI) is a non-invasive imaging technique with superior diagnostic performance compared to other imaging modalities, such as ultrasound and computed tomography. It is widely used in the diagnosis of prostate disease. Advances in science and technology, high-field magnets and new magnetic coil designs (including intra-rectal coils and multichannel surface coils), as well as more advanced software and computational algorithms, allow more sophisticated functional imaging to be incorporated into clinical imaging. The diagnosis of prostate disease has also become faster and more accurate,

bringing good news to athletic patients.

KEYWORDS: prostate disease; mp-MRI; Clinical diagnosis

1 INTRODUCTION

At present, digital rectal examination (DRE) and prostate specific antigen (PSA) are the common clinical methods for screening prostate cancer. However, these methods have different degrees of limitations. Imaging examination is often used for the diagnosis of prostate diseases because of its relatively high accuracy. For the preoperative imaging diagnosis of prostatic hyperplasia, prostate cancer and prostatitis, ultrasound and magnetic resonance imaging are mainly used (Lerner et al., 2021; Nickel et al., 2015).

Transrectal ultrasound (TRUS) is a commonly used imaging method for prostate examination. Because the detection rate of TRUS lesions is only 50%-70%, and the sensitivity of TRUS to small prostate cancer lesions is low, it is difficult to distinguish benign and malignant prostate nodules, so it is not recommended to use TRUS alone for diagnosis (Silva et al., 2017). However, with the development of ultrasound technology, the functions of contrast-enhanced ultrasound and elastography can also be realized on the transrectal ultrasound probe, but it is still in the exploratory stage (Pisco et al., 2016; Schoots et al., 2018). Contrast-enhanced ultrasound (CEUS) can reflect the dynamic microvascular perfusion of the tissue. Yingying Li et al. showed that there were benign lesions suggestive of non-prostate cancer in the simultaneous isoenhancement, homogeneous enhancement and synchronous regression of CEUS (Rajwa et al., 2021). The shear wave elastography (SWE) can evaluate the stiffness of prostate tissue, both of which are helpful for the diagnosis of prostate cancer. Most current studies have shown that prostate cancer tissues are usually harder than benign tissues. However, the cut-off values of elastic modulus for the diagnosis of prostate cancer vary greatly (such as 35kPa, 50kPa or 43.9kPa), and a unified standard is still needed (Greer et al., 2019; Liu et al., 2017).

Mp-MRI can improve the diagnostic ability by combining imaging parameters, and can directly assess the location, size and staging of different prostate lesions. Their combination has been shown to improve the diagnostic ability of each individual. Careful histopathological studies using radical prostatectomy specimens showed that the identified lesions had a positive predictive value of 98% and a good sensitivity. Prostate guided biopsy may cause some discomfort to athletic patients, so mp-MRI is increasingly used in clinical practice (Vanaja et al., 2009; Weinreb et al., 2016).

Clinically, the diagnostic power of mp-MRI can also be used for targeted biopsy. MpMRI provides reliable imaging basis for the diagnosis and differential diagnosis of prostate diseases by providing information about water molecular

diffusion, blood perfusion and microcirculation of prostate cancer (Aerts et al., 2014; Litjens, Barentsz, Karssemeijer, & Huisman, 2015). In this study, mp-MRI technology was used to distinguish the types of prostate diseases, which were mainly judged by PSA value, ADC value and prostate volume. The reliability of mp-MRI was confirmed by combining the biopsy results. It is believed that mp-MRI will become an accurate detection tool for prostate cancer with clinical significance.

2 METHODS AND DATA

The data collected in the trial were retrospectively analyzed. AW4.6 workstations was used to collect the raw cross-sectional images of all athletic patients with small FOV T2WI-MRI, small FOV DWI-MRI (Diffusion-weighted imaging, b=100、500、1000、1500 s/mm ^{2}) and DCE-MRI (Dynamic contrast enhanced). Two experienced radiologists delineated regions of interest (ROIs) on T2WI-MRI (T2-weighted imaging), DWI-MRI, and DCE-MRI images at each lesion level. Intra-class and inter-class correlation coefficients (ICC) were used to determine the repeatability of ROI delineation between and within observers. GE software was used to preprocess the original images of the lesions and the images with ROI markers, and then match them one by one. The high-throughput information of the characteristic parameters of the lesions on each sequence was collected.

In this study, we recruited 180 athletic patients with suspected prostate cancer and required them to meet the following criteria :(1) PSA levels or abnormal signal nodules; (2) histopathologic confirmation; (3) no previous biopsy; and (4) complete renal function. The scan sequences included T2WI, T1WI (T1-weighted imaging,), DWI and DCE. Mp-MRI sequence parameters include repetition time (TR), echo time (TE), field of view (FOV), matrix, parallel imaging factor and so on.

2.1 Assessment of magnetic resonance imaging results

Scans of each athletic patient were presented to five specialists on a single screen in the same location. Experts give their opinions based on their own experience and Prostate Imaging Reporting and Data System Version 2. Each expert should observe the images three times and give a conclusion. The final conclusion is given based on the opinions of various experts.

2.2 The pathological biopsy

After MRI examination, all athletic patients underwent prostate biopsy, and tissue samples were taken for histopathological examination. Each specimen was individually labeled according to its location and subjected to histological analysis. Target biopsies in the experiments were performed using an ultrasound system, GE L8, equipped with an intraluminal probe and an 18G

core biopsy needle. A urologist with years of experience performed the biopsy. The results were evaluated by another experienced urogenital pathologist who was unaware of the MRI findings.

3 RESULTS

3.1 Characteristics of athletic patients

A total of 180 athletic patients were enrolled, with a mean age of about 61 years (range :42-75 years). The mean BMI of the sample was about 25 (range:22-28 years). As shown in Table 1, no significant difference between the characteristics of athletic patient groups.

Table 1: Characteristics of athletic patients in the study

Characteristics	prostatitis group	BPH group	PCa group	P value
Age (years)	60.3±4.2	60.4±3.8	62.3±5.1	0.351
BMI (kg/m^2)	24.2±5.1	25.1±4.3	24.8±4.3	0.203

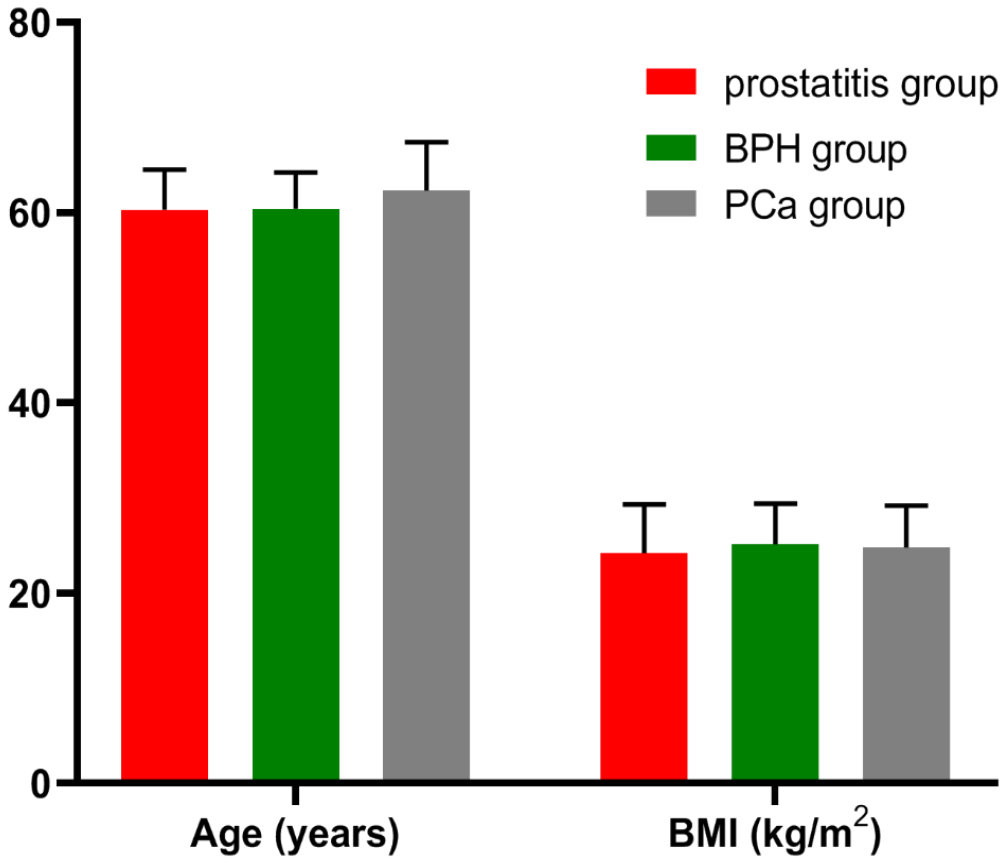

Fig1: Characteristics of athletic patients in the study. Statistical significance was obtained by the Student's t-test.

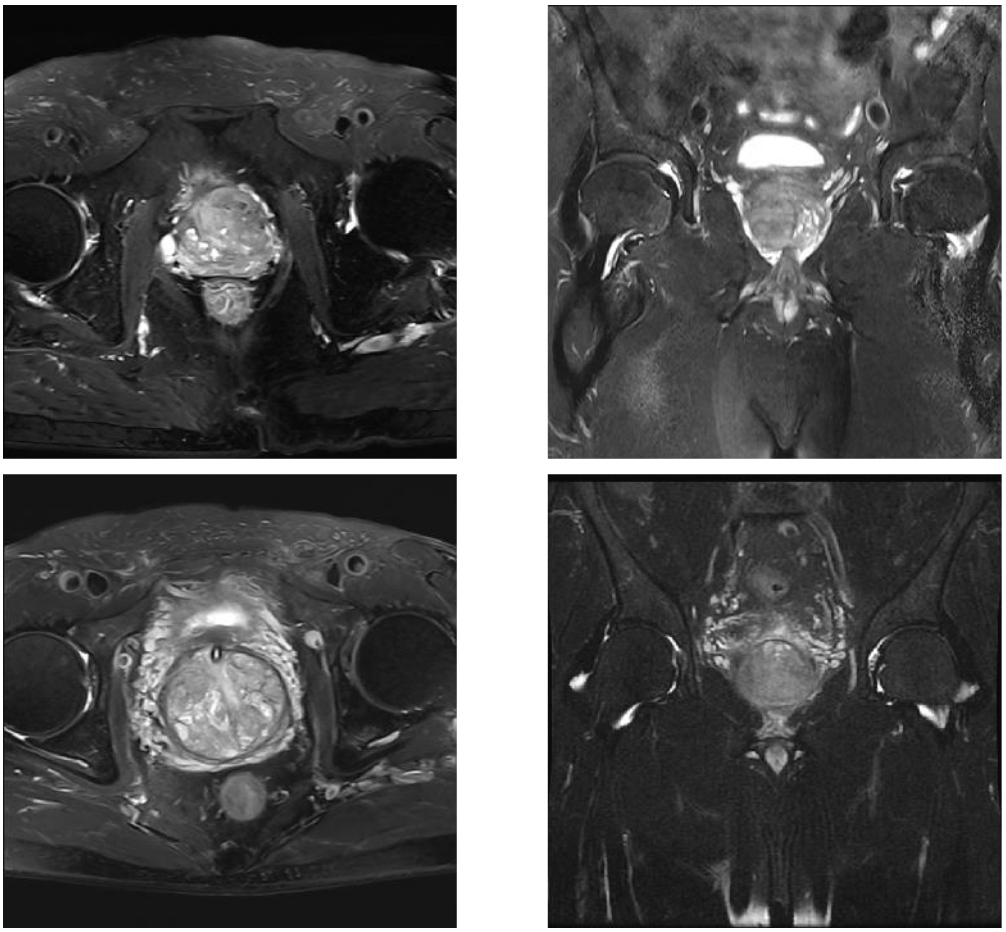

Fig2: Imaging of prostate cancer and non-prostate cancer based on multi-parameter magnetic resonance. (A) and (B), prostate cancer. (C) and (D), non-prostate cancer.

3.2 Three-category radiomics model based on multi-parameter magnetic resonance imaging to distinguish PCa and non-cancer

The PSA level was 13.48±10.97 ng/ml in non-cancer group and 146.28±220.56 ng/ml in PCa group. Mp-MRI can identify prostate tissue by detecting cell density, size, shape, and arrangement that affect tissue-water mobility, as shown in Figure 2. In this study, the apparent diffusion coefficient (ADC) was calculated to distinguish tumor areas from healthy tissues. The ADC value of PCa group was 880.28±300.26, and that of non-cancer group was 1230.14±279.31, showing a significant difference. Therefore, mp-MRI can distinguish whether the prostate is cancerous.

Table 2: Distinguish between PCa and non-cancer

Characteristics	PCa group	Non-cancer group	P value
PSA (ng/ml)	146.28±220.56	13.48±10.97	＜0.05
ADC (d)	880.28±300.26	1230.14±279.31	＜0.05

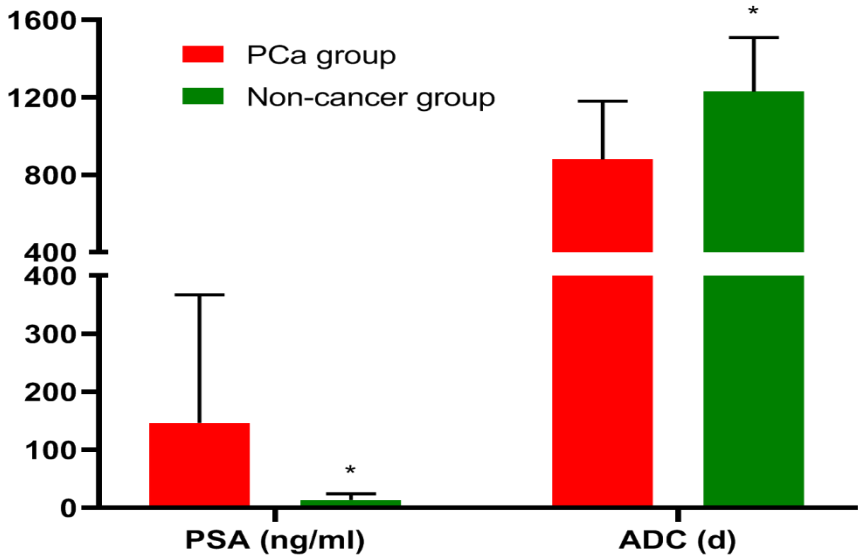

Fig3: Distinguish between PCa and non-cancer. Statistical significance (*P <0.05 vs PCa group) was analyzed by student's t-test.

3.3 Prostate volume can be detected to identify BPH and prostatitis

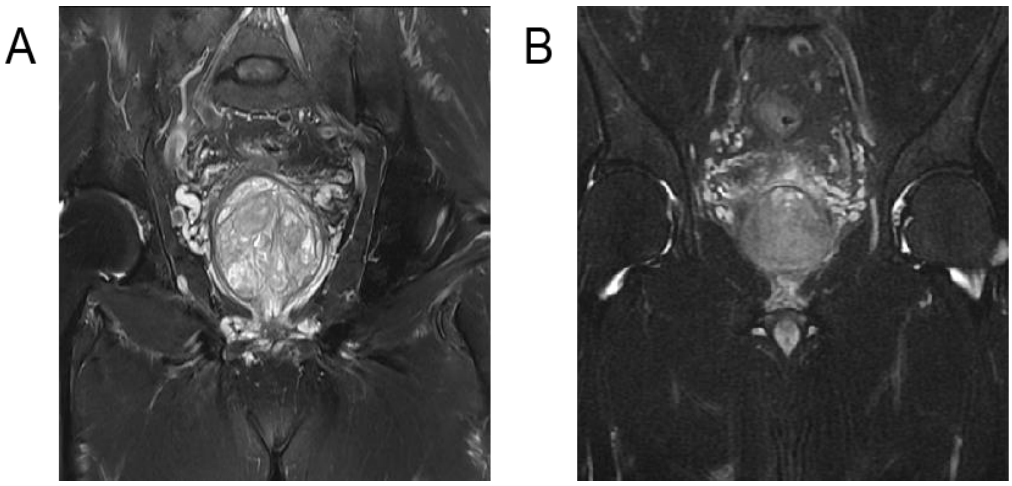

Fig4: Imaging of prostatic hyperplasia and prostatitis based on multi-parameter magnetic resonance. (A) Prostatic hyperplasia. (B) Prostatitis.

The histological manifestations of BPH are increased epithelial cells and stromal cells around the prostatic urethra. MRI shows that the central lobe of the prostate is enlarged, the anteroposterior diameter is widened, and the margins are circular and symmetrical. The prostate volume was 47.79±6.73 ml in the prostatitis group and 59.86±5.19 ml in the BPH group, showing significant differences between the two groups in Table 3.

Table 3: Volume comparison of prostatic hyperplasia and prostatitis

Characteristics	prostatitis group	BPH group	P value
Prostate volume (ml)	47.79±6.73	59.86±5.19	＜0.001

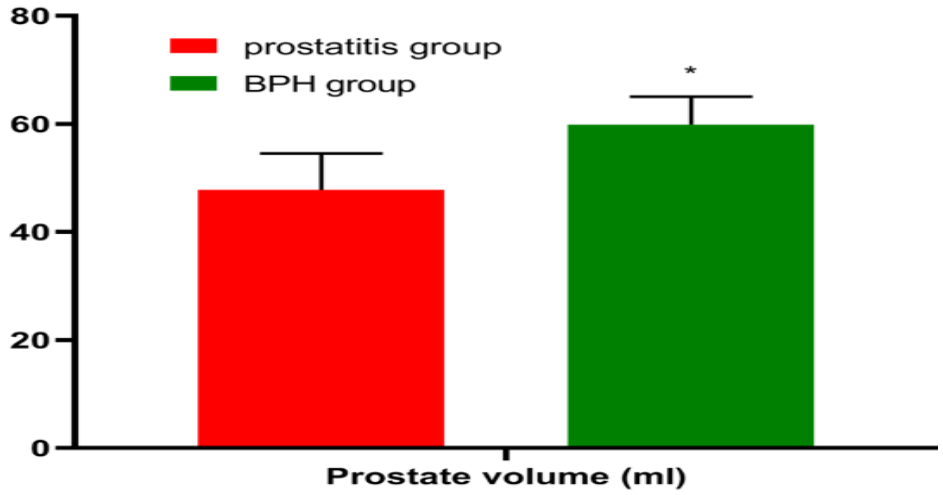

Fig5: Volume comparison of prostatic hyperplasia and prostatitis. Statistical significance (*P<0.05 vs prostatitis group) was obtained by the Student's t-test.

3.4 The pathological findings were consistent with the MRI findings

Under the premise of unknown MRI findings, the pathological biopsy of the athletic patient is performed, and the expert can judge the type of prostate disease based on experience and parameters. The results of the two methods were compared, and the results showed that the conclusions of biopsy and MRI were basically consistent.

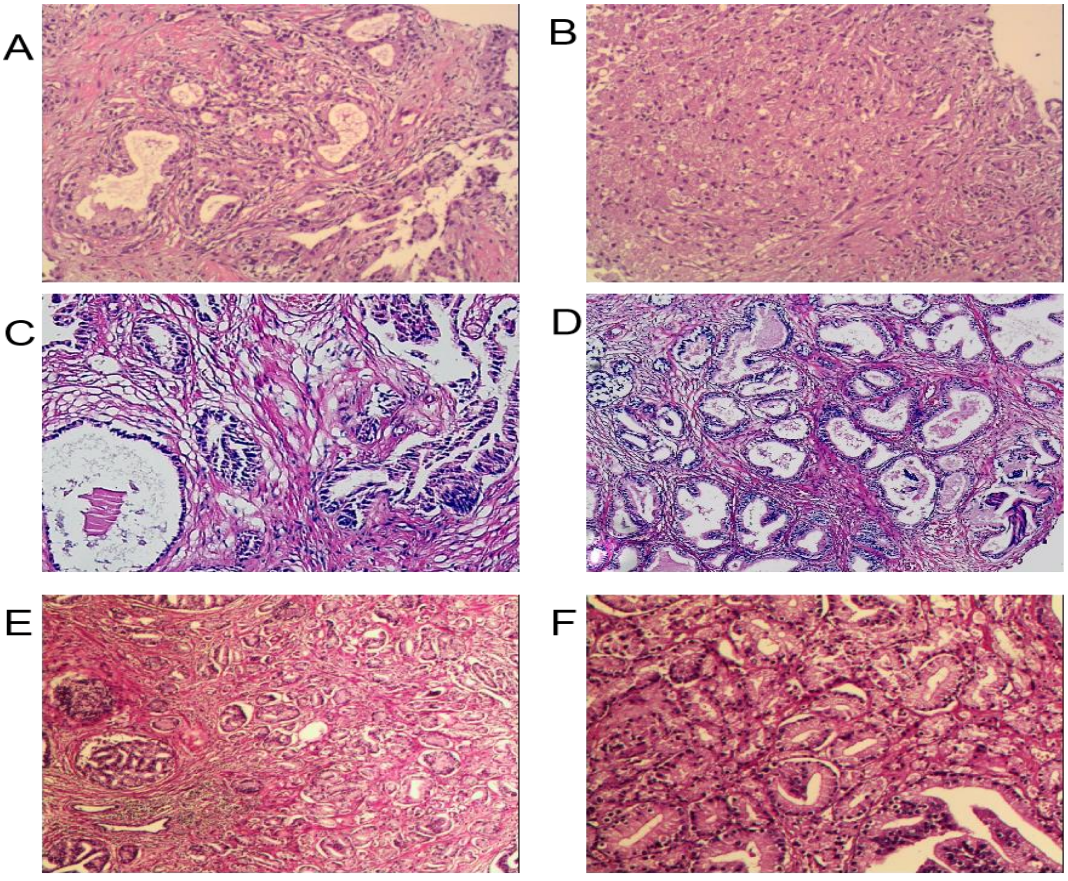

Fig6: Tissue section results of prostate disease .

Table 4: Conclusion of pathological biopsy and MRI.

Detection means	prostatitis group	BPH group	PCa group
Mp MRI (n)	69	63	48
Biopsy (n)	67	63	50
P value	＞0.05	＞0.05	＞0.05

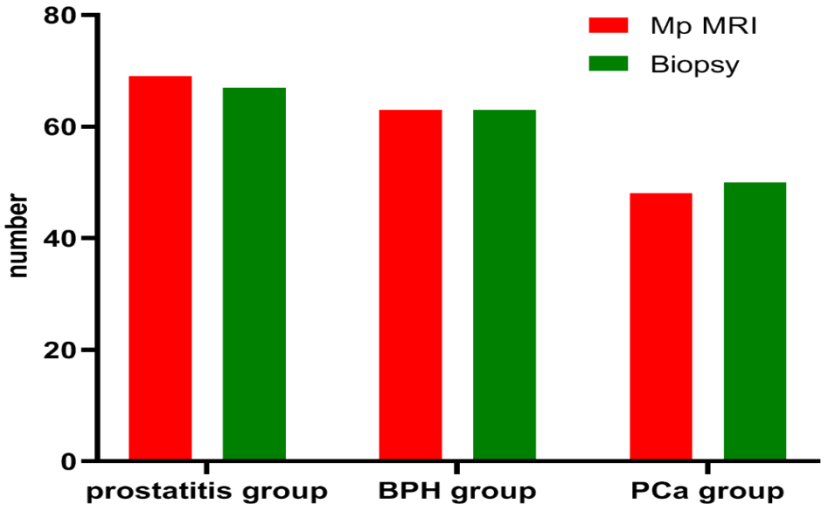

Fig7: Conclusion of pathological biopsy and MRI.

4 DISCUSSION

The aim of this study was to develop and validate a novel three-class MRI radiomics model based on T2WI, DWI, and DCE-MRI for the preoperative differentiation of BPH, prostate cance and prostatitis (Park, Choi, Lee, Kim, & Kim, 2020; Platt, Patel, Humphrey, Al-Booz, & Bailey, 2019). The diagnostic model based on radiomics in this study was compared with the efficacy of prostate PI-RADS in distinguishing benign and malignant prostate lesions to reflect the value of radiomics in the diagnosis of prostate cancer, in order to help doctors improve the accuracy of preoperative diagnosis and individualized treatment selection (de Rooij et al., 2020).

Prostate disease afflicts many men. It is mainly divided into three categories: prostatitis, prostatic hyperplasia, and prostate cancer. Prostatitis can lead to hyperplasia of the prostate, and prostatitis can increase the risk of prostate cancer. Prostatitis can lead to the damage of prostate cells, cause chronic inflammatory reaction, lead to the change of prostate tissue structure, and then may cause prostate hyperplasia or even more serious hyperplasia (Bleker et al., 2020; Wang & Wang, 2020). Chronic inflammatory microenvironment contains some cytokines and inflammatory factors, which may be related to carcinogenesis. Therefore, athletic patients need regular check-ups no matter what stage of the disease they are in. In this way, even prostate cancer can be found and treated early.

Compared with other imaging modalities, mp-MRI is a non-invasive imaging technique with superior diagnostic performance. T2WI is the most commonly used and widely used imaging sequence (Woźnicki et al., 2020). In this way, the anatomy of the prostate is clearly visible, and the borders of the gland and surrounding tissue are clearly visible. DWI can detect and quantify Brownian motion of water in tissues in the body. Since this is related to cell density, cell permeability, and free water diffusion in the space, DWI can assess the tissue structural architecture and distinguish between benign and malignant tissues (Favero et al., 2014). Benign tissue exhibits high signal intensities because it usually allows free water to diffuse with relative ease. In malignant environments, the relative decrease in DWI signal intensity is caused by reduced free water diffusion due to higher nucleoplasm ratio and loss of extracellular space due to cell proliferation (Keys et al., 2003; Landoni et al., 1997). DCE can assess tissue vascular supply. This was achieved by sequential acquisition of T1WI before, throughout, and after injection of MRI-detectable contrast material. It is possible to distinguish between normal and malignant tissues because of the disordered angiogenesis of tumors with typical imaging features (Hong et al., 2004; Shibata et al., 2009; Touboul et al., 2001).

In conclusion, mp-MRI can provide information about water molecule diffusion, blood perfusion and microcirculation of prostate cancer, which can provide reliable imaging basis for the diagnosis and differential diagnosis of prostate diseases, and also become an accurate detection tool of prostate cancer with clinical significance. Mp-MRI faces many challenges in prostate cancer research. First, the available clinical data, while very compelling, cannot be described as reliable evidence because it comes mainly from single-institution studies. More research is needed before mpMRI becomes the standard of care.

REFERENCE

Aerts, H. J., Velazquez, E. R., Leijenaar, R. T., Parmar, C., Grossmann, P., Carvalho, S., . . . Rietveld, D. (2014). Decoding tumour phenotype by noninvasive imaging using a quantitative radiomics approach. *Nature communications, 5*(1), 4006.

Bauckneht, M., Bertagna, F., Donegani, M. I., Durmo, R., Miceli, A., De Biasi, V., . . . Baldari, S. (2021). The prognostic power of 18F-FDG PET/CT extends to estimating systemic treatment response duration in metastatic castration-resistant prostate cancer (mCRPC) patients. *Prostate Cancer and Prostatic Diseases, 24*(4), 1198-1207.

Bleker, J., Kwee, T. C., Dierckx, R. A., de Jong, I. J., Huisman, H., & Yakar, D. (2020). Multiparametric MRI and auto-fixed volume of interest-based radiomics signature for clinically significant peripheral zone prostate cancer. *European Radiology, 30*, 1313-1324.

de Rooij, M., Israël, B., Tummers, M., Ahmed, H. U., Barrett, T., Giganti, F., . . . Panebianco, V. (2020). ESUR/ESUI consensus statements on multi-parametric MRI for the detection of clinically significant prostate cancer: quality requirements for image acquisition, interpretation and radiologists' training. *European Radiology, 30*, 5404-5416.

Favero, G., Pierobon, J., Genta, M. L., Araújo, M. P., Miglino, G., Diz, M. D. C. P., . . . Carvalho, J. P. (2014). Laparoscopic extrafascial hysterectomy (completion surgery) after primary chemoradiation in patients with locally advanced cervical cancer: technical aspects and operative outcomes. *International Journal of Gynecologic Cancer, 24*(3).

Greer, M. D., Shih, J. H., Lay, N., Barrett, T., Bittencourt, L., Borofsky, S., . . . Shebel, H. (2019). Interreader variability of prostate imaging reporting and data system version 2 in detecting and assessing prostate cancer lesions at prostate MRI. *AJR. American journal of roentgenology*, 1.

Hong, J.-H., Tsai, C.-S., Lai, C.-H., Chang, T.-C., Wang, C.-C., Chou, H.-H., . . . Hsueh, S. (2004). Recurrent squamous cell carcinoma of cervix after definitive radiotherapy. *International Journal of Radiation Oncology* Biology* Physics, 60*(1), 249-257.

Keys, H. M., Bundy, B. N., Stehman, F. B., Okagaki, T., Gallup, D. G., Burnett, A. F., . . . Fowler Jr, W. C. (2003). Radiation therapy with and without extrafascial hysterectomy for bulky stage IB cervical carcinoma: a randomized trial of the Gynecologic Oncology Group☆. *Gynecologic oncology, 89*(3), 343-353.

Landoni, F., Maneo, A., Colombo, A., Placa, F., Milani, R., Perego, P., . . . Mangioni, C. (1997). Randomised study of radical surgery versus radiotherapy for stage Ib-IIa cervical cancer. *The Lancet, 350*(9077), 535-540.

Lerner, L. B., McVary, K. T., Barry, M. J., Bixler, B. R., Dahm, P., Das, A. K., . . . Martin, L. (2021). Management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline part II—surgical evaluation and treatment. *The Journal of urology, 206*(4), 818-826.

Litjens, G. J., Barentsz, J. O., Karssemeijer, N., & Huisman, H. J. (2015). Clinical evaluation of a computer-aided diagnosis system for determining cancer aggressiveness in prostate MRI. *European Radiology, 25*, 3187-3199.

Liu, W., Pantoja-Galicia, N., Zhang, B., Kotz, R. M., Pennello, G., Zhang, H., . . . Zhang, Z. (2017). Generalized linear mixed models for multi-reader multi-case studies of diagnostic tests. *Statistical Methods in Medical Research, 26*(3), 1373-1388.

Nickel, J. C., Brock, G. B., Herschorn, S., Dickson, R., Henneges, C., & Viktrup, L. (2015). Proportion of tadalafil-treated patients with clinically meaningful improvement in lower urinary tract symptoms associated with benign prostatic hyperplasia–integrated data from 1 499 study

participants. *Bju International, 115*(5), 815-821.

Park, K. J., Choi, S. H., Lee, J. S., Kim, J. K., & Kim, M.-h. (2020). Interreader agreement with prostate imaging reporting and data system version 2 for prostate cancer detection: a systematic review and meta-analysis. *The Journal of urology, 204*(4), 661-670.

Pisco, J. M., Bilhim, T., Pinheiro, L. C., Fernandes, L., Pereira, J., Costa, N. V., . . . Oliveira, A. G. (2016). Medium-and long-term outcome of prostate artery embolization for patients with benign prostatic hyperplasia: results in 630 patients. *Journal of Vascular and Interventional Radiology, 27*(8), 1115-1122.

Platt, S. L., Patel, A., Humphrey, P. J., Al-Booz, H., & Bailey, J. (2019). Completion surgery after chemoradiotherapy for cervical cancer–is there a role? UK Cancer Centre experience of hysterectomy post chemo-radiotherapy treatment for cervical cancer. *Journal of Obstetrics and Gynaecology, 39*(1), 68-73.

Rajwa, P., Pradere, B., Quhal, F., Mori, K., Laukhtina, E., Huebner, N. A., . . . Baltzer, P. A. (2021). Reliability of serial prostate magnetic resonance imaging to detect prostate cancer progression during active surveillance: a systematic review and meta-analysis. *European Urology, 80*(5), 549-563.

Schoots, I. G., Nieboer, D., Giganti, F., Moore, C. M., Bangma, C. H., & Roobol, M. J. (2018). Is magnetic resonance imaging-targeted biopsy a useful addition to systematic confirmatory biopsy in men on active surveillance for low-risk prostate cancer? A systematic review and meta-analysis. *Bju International, 122*(6), 946-958.

Shibata, K., Kajiyama, H., Yamamoto, E., Terauchi, M., Ino, K., Nomura, S., . . . Kikkawa, F. (2009). Effectiveness of preoperative concurrent chemoradiation therapy (CCRT) for locally advanced adenocarcinoma of cervix. *European Journal of Surgical Oncology (EJSO), 35*(7), 768-772.

Silva, A. R., Ferreira, O. C., Sá, R. S., Correia, A. L., Silva, S. G., Carvalho, M. A. L., & Pôrto, L. C. (2017). HBV and HCV serological markers in health professionals and users of the Brazilian Unified Health System network in the city of Resende, Rio de Janeiro, Brazil. *Jornal Brasileiro de Patologia e Medicina Laboratorial, 53*, 92-99.

Touboul, E., Belkacémi, Y., Buffat, L., Deniaud-Alexandre, E., Lefranc, J.-P., Lhuillier, P., . . . Antoine, M. (2001). Adenocarcinoma of the endometrium treated with combined irradiation and surgery: study of 437 patients. *International Journal of Radiation Oncology* Biology* Physics, 50*(1), 81-97.

Vanaja, D. K., Ehrich, M., Van den Boom, D., Cheville, J. C., Karnes, R. J., Tindall, D. J., . . . Young, C. Y. (2009). Hypermethylation of genes for diagnosis and risk stratification of prostate cancer. *Cancer investigation, 27*(5), 549-560.

Wang, Y., & Wang, M. (2020). Selecting proper combination of mpMRI sequences for prostate cancer classification using multi-input convolutional neuronal network. *Physica Medica, 80*, 92-100.

Weinreb, J. C., Barentsz, J. O., Choyke, P. L., Cornud, F., Haider, M. A., Macura, K. J., . . . Tempany, C. M. (2016). PI-RADS prostate imaging–reporting and data system: 2015, version 2. *European Urology, 69*(1), 16-40.

Woźnicki, P., Westhoff, N., Huber, T., Riffel, P., Froelich, M. F., Gresser, E., . . . Schoenberg, S. O. (2020). Multiparametric MRI for prostate cancer characterization: Combined use of radiomics model with PI-RADS and clinical parameters. *Cancers, 12*(7), 1767.

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