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Original Article

Radiology Section

Diagnostic Efficacy of Transrectal Ultrasound vs Magnetic Resonance Imaging in the Diagnosis of Carcinoma Prostate: A Cross-sectional Study

K LOHITH[1], VINAYA MANOHARA GOWDA[2], SANJANA SATISH[3]

ABSTRACT

Introduction: The high incidence and increasing awareness of prostate cancer, along with ongoing development of new and improved treatment methods have generated considerable need for imaging techniques that allow for accurate detection and staging of tumour prior to treatment.

Aim: To compare the findings of Transrectal Ultrasound (TRUS) and Magnetic Resonance Imaging (MRI) in the diagnosis and localisation of carcinoma prostate.

Materials and Methods: This cross-sectional study was conducted in the Department of Radiodiagnosis, Mysore Medical College, Mysore, Karnataka, India from April 2018 to June 2019. This study included 43 male patients, with age ranging from 49 to 76 years. They underwent TRUS, MRI and TRUS guided 12-core biopsies after being suspected with prostate cancer based on high Prostate Specific Antigen (PSA) values (greater than 4.0 ng/mL) or abnormal Digital Rectal Examination (DRE) findings. A cross table was used to compare the histopathology results, TRUS and MRI findings, from which sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were calculated.

Results: Total of 43 male patients were included with mean age of 64.8 years. The sensitivity, specificity, PPV and NPV of TRUS for detection of malignancy was 69.70, 80, 92 and 44.44 respectively and for MRI, it was 87.88%, 70%, 90.63% and 63.64% respectively. In addition, MRI detected lymphadenopathy in three patients and skeletal metastasis in four patients.

Conclusion: MRI can improve the false negative biopsies resulting due to the inability of TRUS in the detection of abnormal areas, by showing the exact area of abnormality.

Keywords: Extracapsular extension, Malignancy, Seminal vesicle invasion

INTRODUCTION

In adult males, pathologies of the prostate gland like benign prostatic hyperplasia, prostatitis, and prostatic cancer contribute to significant morbidity and mortality [1]. Out of which prostate cancer is one of the most common malignancies encountered in adult males [2]. In a study of recent year, the usage of TRUS has been remarkable for screening, diagnosis of prostate cancer along with guidance in biopsy from suspicious lesions [3]. Also,the usage of multiparametric MRI as a screening tool has led to a significant increase in the early detection of prostate cancer. The extra-prostatic extension and regional metastatic spread of the local disease have been assessed accurately by the MRI. This proves useful in planning biopsy and disease targeting therapies that are currently being developed since the MRI technique can locate the site of intraprostatic disease [3].

Many studies comparing the efficacy of TRUS and MRI for detection of prostate cancer were done in past in the Western population [4-6]. In India, similar studies done in North Indian population also showed that TRUS along with colour doppler flow cytometry is highly sensitive and specific in detection prostate malignancy [7]. Very few studies have been done addressing the South Indian population [8,9]. More and more research work on different population, was advised in all these previous studies due to the low sample size for better credibility of the results. Hence, the present study, was conducted as the first one to be done in the district of Mysore, Karnataka, India and aimed to compare the findings of TRUS and MRI in the well as diagnosis and localisation of carcinoma prostate.

MATERIALS AND METHODS

This was a cross-sectional study conducted in the Department of Radiodiagnosis, Mysore Medical College, Mysore, Karnataka, India from April 2018 to June 2019. Approval from the Institutional Ethical Committee was obtained (ECR/134/Inst/KA/2013/RR-19).

Inclusion criteria: Those patients who were suspected with prostate cancer based on high prostate specific antigen (greater than 4.0 ng/mL) or abnormal digital rectal examination were included in the study.

Exclusion criteria: Patients who have previously undergone prostate surgery or those patients with piles, anal fissures which are contraindications for TRUS and those subjects with metallic implants, pacemakers, claustrophobia, renal impairment which are contraindications for MRI were excluded from the study.

Sample size calculation: The sample size was calculated using the formula

$n=Z^2\ pq/d^2$

Where

p= Prevalence of carcinoma prostate, which was 5% in our hospital, q= (1-p) = 95%, d=Level of precession measured as absolute error, which is 7%, z=Standard normal variate for 95% confidence interval, which is 1.96%. Therefore, the minimum sample size according to the above data was 37. Due to availability of the cases, data was collected from 43 male patients with age range between 49-76 years, proven cases of carcinoma prostate.

Procedure

All the included participants underwent TRUS, MRI and TRUS guided 12-core biopsies, after being suspected with prostate cancer; based on high PSA values (greater than 4.0 ng/mL) or abnormal DRE findings.

Transrectal Ultrasonography (TRUS) Protocol: TRUS was performed on PHILIPS affinity 70, using a BP10-5ec frequency

endocavity transducer. A standard sequence of axial images from apex to base was included in the examination. Identification of a suspicious malignant lesion; as a focal hypoechoic area with an irregular border in the Peripheral Zone (PZ) was done. Bulging or irregularity of the capsule adjacent to a hypoechoic lesion was the criteria used for identifying Extracapsular Extension (ECE). A hypoechoic lesion that is visibly extended at the base of the prostate into a seminal vesicle or echogenic cancer, within the normally fluid-filled seminal vesicle indicates the Seminal Vesicle Invasion (SVI). Solid hypoechoic masses, within the seminal vesicles or asymmetry of the seminal vesicles are an indirect indicator of disease extension.

Biopsy protocol: The risks and benefits of the biopsy procedure were explained to each patient, and written informed consent was obtained prior to the biopsy. Using 18-G trucut biopsy needles, the biopsies were taken during longitudinal scanning. The 12-core biopsies were taken as follows; from the base, midlobe and near the apex of the prostate. Three cores were taken from each side, from lateral area in the prostate, from the base, midlobe and apex and, 3-core were taken from each side from the far lateral areas of the prostate at the base, midlobe and near the apex. Patients were subjected to additional directed two biopsies after their hypoechoic areas were visible on ultrasound. To identify the biopsy location, all biopsy cores were labelled and the uropathologist evaluated all these specimens.

Magnetic Resonance Imaging (MRI) Protocol: MRI examination was performed in all patients, before the biopsy. Using 16 channel phased array TORSO coil, MRI was performed on a 1.5 Tesla MR Scanner [GE medical systems]. The details of the MRI sequences used are given in [Table/Fig-1].

Intravenous injection of 0.2 mmol per kg body weight of gadolinium, at the rate of 2 mL/sec [as a bolus] followed by a 10 mL of saline flush was given and thereafter, a dynamic contrast study was obtained [4].

MRI sequences	Specifications and Details
T1 axial	
TR	4300 ms
TE	90 ms
Slice	3 mm thickness [slice gap zero]
Matrix	400×220
FOV	200/200
No. of slices	19
T2 axial	
TR	4300 ms
TE	90 ms
Slice	3 mm thickness [slice gap zero]
Matrix	360×170
FOV	180/180
No. of Slices	20
T2 coronal	
TR	4300ms
TE	90 ms
Slice thickness	3 mm [slice gap zero]
Matrix	400×220
FOV	200/200
No. of slices	19
T2 sagittal	
TR	520 ms
TE	15 ms
Slice thickness	3 mm [slice gap zero]
Matrix	240×180
FOV	180×80
No. of Slices	19
T1 axial	
TR	2500 ms
TE	89ms
No. of Slices	10
Slice thickness	6 mm
Matrix	80×61
FOV	160/144
B value	0,50, 2000
Diffusion	
Volume methods	3 slices
Method	PRESS [Point resolved spectroscopy]
TR	1500
TE	120

[Table/Fig-1]: The sequences used and their details.
T1: longitudinal relaxation time; T2: transverse relaxation time; TE: Time to echo; TR: repetition time; FOVL Field-of-view

MRI image interpretation: The prostate demonstrates homogeneous medium signal intensity on T1-weighted images, which makes it impossible for the tumours to be recognised. Prostate cancer on T2-weighted images appears as area of low signal intensity in the PZ, that is easily differentiated from high signal-intensity normal tissue. Asymmetry of the neurovascular bundle, obliteration of the recto-prostatic and vesico-prostatic fat plane, an irregular or speculated margin, capsular retraction, tumour envelopment of the neurovascular bundle and a breach of the capsule with evidence of direct tumour extension are the criteria for ECE. Focal low signal intensity within the seminal vesicle, obliteration of the angle between the prostate and the seminal vesicle (best seen on sagittal images), disruption or loss of the normal architecture of the seminal vesicle, and demonstration of direct tumour extension from the base of the prostate into and around the seminal vesicle are some of the features included in SVI.

STATISTICAL ANALYSIS

A cross-table was used for comparing the histopathology results, TRUS and MR imaging findings from which sensitivity, specificity, and positive and negative predictive values were calculated. The p-value of < 0.05 was considered statistically significant. The data was entered and analysed by Microsoft (MS) Excel, Statistical Package for Social Sciences (SPSS) version 22.0 (IBM SPSS Statistics, Somers NY, USA).

RESULTS

Present study group included 43 male patients. There was one patient (2.33%) in the age group of 41-50 years, 7 patients (16.28%) in the age group of 51- 60 years, 29 (67.44%) patients in the age group of 61-70 yrs, 6 patients (13.9%) in the age group of 71 to 80 years. The Mean age was 64.8 years.

The majority of patients in this study has symptoms of urinary retention 29 (68%), few presented with haematuria 12 (27%) and the remaining were asymptomatic at the time of study.

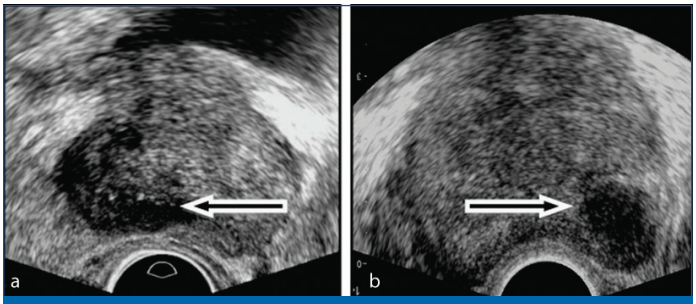
Out of 43 patients in our study, TRUS identified a hypoechoic lesion in one or both PZ in 25 (58.14%) patients and 33 (76.74%) patients were detected to have carcinoma of the prostate on histopathology [Table/Fig-2].

On TRUS, the malignant lesion was hypoechoic with an irregular margin as shown in [Table/Fig-3].

Out of 33 patients, who were having histopathology proven malignancy, 19 patients were detected to have ECE. The sensitivity, specificity of TRUS in the detection of ECS was 63.16% and 83.33% respectively [Table/Fig-4]. Ultrasound image of ECE detected by TRUS is shown in [Table/Fig-5].

TRUS findings	Histopathology findings		Total
	Positive	Negative	
Positive	23	2	25
Negative	10	8	18
Total	33	10	43
Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
69.70%	80%	92%	44.44%

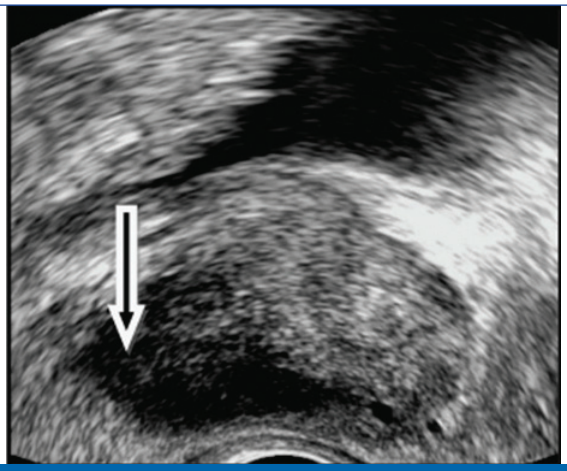
[Table/Fig-2]: Efficacy of TRUS in the detection of malignancy.



[Table/Fig-3]: Appearance of malignant lesion on TRUS; a) Hypoechoic lesion with irregular borders is seen in right peripheral zone; b) Hypoechoic lesion with irregular borders is seen in left peripheral zone.

TRUS findings	Histopathology findings		Total
	Positive	Negative	
Positive	12	4	16
Negative	7	20	27
Total	19	24	43
Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
63.16%	83.33%	75.00%	74.07%

[Table/Fig-4]: Efficacy of TRUS in the detection of Extracapsular Extension (ECE).



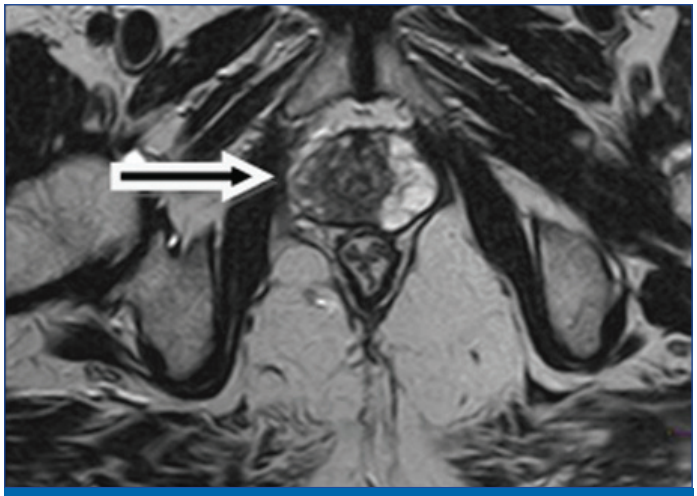
[Table/Fig-5]: Appearance of ECE on TRUS-Bulging and irregularity of prostatic capsule overlying the right peripheral zone lesion suggestive of ECE.

Out of 43 patients in the study, MRI identified a malignant lesion in one or both PZ in 32 (74.42 %) patients [Table/Fig-6]. Image of the lesion on MRI is shown in [Table/Fig-7].

MRI findings	Histopathology findings		Total
	Positive	Negative	
Positive	29	3	32
Negative	4	7	11
Total	33	10	43
Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
87.88%	70.00%	90.63%	63.64%

[Table/Fig-6]: Efficacy of MRI in the detection of malignancy.

[Table/Fig-8,9] show the efficacy of MRI in the detection of ECE and SVI. Images of the lesion with ECE and SVI on MRI has been



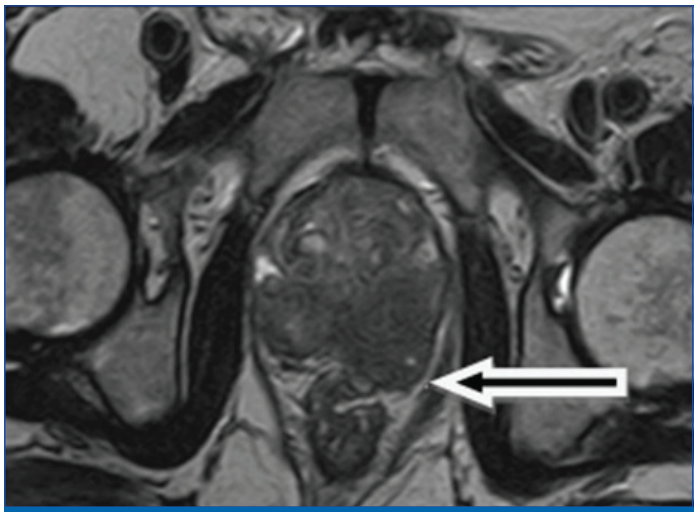
[Table/Fig-7]: Appearance of malignant lesion on T2 W axial images-Hypointense lesion is seen in right peripheral zone.

MRI findings	Histopathology findings		Total
	Positive	Negative	
Positive	15	4	19
Negative	4	20	24
Total	19	24	43
Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
78.95%	83.33%	78.95%	83.33%

[Table/Fig-8]: Efficacy of MRI in the detection of ECS.

MRI findings	Histopathology findings		Total
	Positive	Negative	
Positive	12	3	15
Negative	2	26	28
Total	14	29	43
Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
85.71%	89.66%	80.00%	92.86%

[Table/Fig-9]: Efficacy of MRI in the detection of SVI.

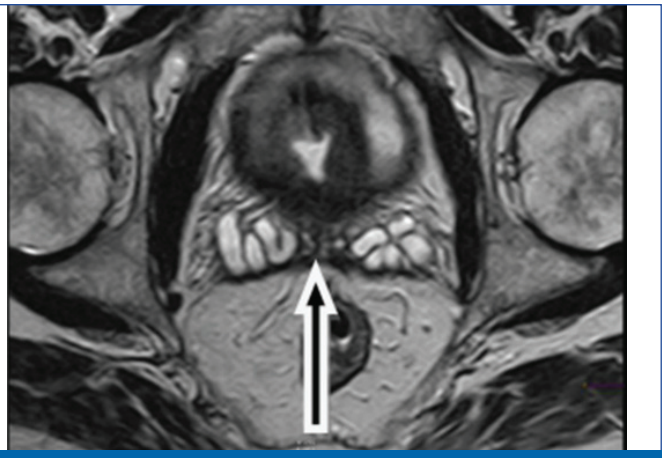


[Table/Fig-10]: T2 W axial image showing -Appearance of extracapsular extension on MRI.

shown is shown in [Table/Fig-10,11]. In addition, MRI detected lymphadenopathy in three patients and skeletal metastasis in four patients.

[Table/Fig-12] summarises the distribution of patients with respect to detection of malignancy and ECE on TRUS, MRI and Histopathology; and distribution of patients with respect to SVI on MRI and histopathology.

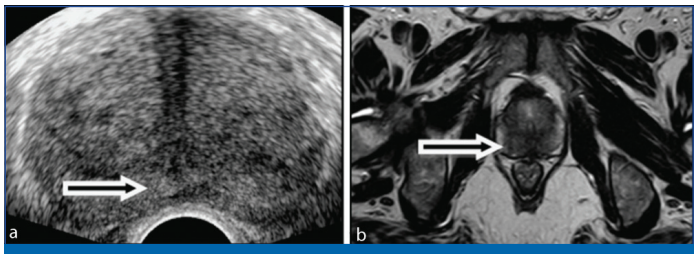
[Table/Fig-13]: shows suspicious lesion not detected on TRUS but picked on MRI.



[Table/Fig-11]: T2W axial-appearance of seminal vesicle invasion on MRI.

	Distribution of patients with respect to PZ lesion		
	Positive	Negative	Total
TRUS	25 (58.14%)	18 (41.86%)	43
MRI	32(74.42%)	11 (25.58%)	43
Histopathology	33 (76.74%)	10 (23.26%)	43
	Distribution of patients with respect to ECE		
	Positive	Negative	Total
TRUS	16 (37.21%)	27 (62.79%)	43
MRI	19 (44.19%)	24 (55.81%)	43
Histopathology	19 (44.19%)	24 (55.81%)	43
	Distribution of patients with respect to SVI on MRI		
	Positive	Negative	Total
MRI	15 (34.88%)	28 (65.12%)	43
Histopathology	14 (32.56%)	29 (67.44%)	43

[Table/Fig-12]: Distribution of patients with respect to detection of malignancy and ECE on TRUS, MRI and Histopathology; and distribution of patients with respect to SVI on MRI and histopathology.



[Table/Fig-13]: a) TRUS not showing any lesion; b) MRI showing the malignant lesion.

DISCUSSION

The new advancement in ultrasound imaging has given hope for better prostate cancer diagnosis. It has been well known that cancers have neovascularity and can provoke a vascular response [7]. The results of this study are in agreement with several other studies as summarised in [Table/Fig-14]. This study showed a higher sensitivity for TRUS to detect ECE as compared to most of previous studies as summarised in [Table/Fig-15].

The findings of this study as compared to previous studies as summarised in [Table/Fig-16]. The Extracapsular extension (ECE) of the malignancy was detected as asymmetry of neurovascular bundle, obliteration of the rectoprostatic and vesicoprostatic fat plane, capsular retraction, tumour envelopment of the neurovascular bundle, an irregular or speculated margin and a breach of the capsule with evidence of direct tumour extension. The findings of this study as compared to previous studies as summarised in [Table/Fig-17].

The SVI was detected as the obliteration of the angle between the prostate and the seminal vesicle (best seen on sagittal images), focal low signal intensity within the seminal vesicle, disruption or loss of the normal architecture of the seminal vesicle, and demonstration of direct tumour extension from the base of the prostate into and around the seminal vesicle. The findings of this study as compared to previous studies as summarised in [Table/Fig-18].

Authors	Place of the study	Year	Sensitivity	Specificity
Mou JH et al., [5]	China	2012	64.9%	92.9%
Soggia P et al., [6]	Italy	2012	65%	32%
Khanduri S et al., [7]	India	2017	100%	92.6%
Kanagaraju V et al., [8]	India	2020	78.57%	81.25%
Sharma M et al., [9]	India	2021	70.5%	87.9%
Present study	India	2023	69.7%	80%

[Table/Fig-14]: TRUS in the detection of malignancy.

Authors	Place of the study	Year	Sensitivity	Specificity
Mangiappa F et al., [10]	Italy	2007	26%	-
Eisenberg ML et al., [11]	USA	2009	31%	92%
Novis MI et al., [12]	Brazil	2011	33.3%	92%
Dell'atti L et al., [13]	Italy	2014	95 %	-
Present study	India	2023	63.16%	83.33%

[Table/Fig-15]: Comparison of sensitivity and specificity of TRUS for detecting ECE as compared similar studies.

Authors	Year	Sensitivity	Specificity	PPV	NPV
Ahmed HU et al., [14]	2017	93%	41%	51%	89%
Simmons LAM et al., [15]	2017	80.6%	68.5%	64.3%	83.3%
Martins M et al., [16]	2020	86%	99%	94%	97%
Pesapane F et al., [17]	2021	84%	76.5%	-	-
Ahmed IHAE et al., [3]	2022	100%	96.6%	-	-
Present study	2023	87.7%	70%	90.63%	63.64%

[Table/Fig-16]: Comparison of sensitivity and specificity of MRI with other similar studies.

Authors	Year	Sensitivity	Specificity	PPV	NPV
Min BD et al., [18]	2012	65%	87.5%-	76.5%	80%
Davis R et al., [19]	2016	12.5%	93.1%	36.4%	77%
Dominguez C et al., [20]	2018	54.9%	90.9%	81%	74%
Zhang F et al., [21] (meta analysis)	2019	55%	87%	-	-
Present study	2023	78.95%	83.33%	78.95%	83.33%

[Table/Fig-17]: Comparison of sensitivity and specificity of MRI for detecting ECE with other similar studies.

Authors	Year	Sensitivity	Specificity	PPV	NPV
Novis MI et al., [22]	2011	40%	83%	15.4%	94.7%
Grivas N et al., [23]	2018	75.9%	94.7%	62%	97%
Dominguez et al., [20]	2018	19 %	100%	100	76.1%
Popita C et al., [24]	2020	57-85%	86-97.7%	40-85%	92.5-97.7%
Present study	2023	85.71%	89.66%	80%	92.86%

[Table/Fig-18]: Comparison of sensitivity and specificity of MRI for detecting SVI with other similar studies.

Limitation(s)

There were more percentage of positive cases in this study as compared to other studies, which may affect sensitivity and specificity. Pelvic phased array coils were used in this study as compared to endorectal coils in other studies.

CONCLUSION(S)

Though the initial work-up of prostate cancer involves serum PSA levels, DRE and prostate biopsy, imaging plays an important role in pre-treatment staging of prostate carcinoma, help to differentiate clinically localised prostate cancer from an advanced disease that

requires multimodality therapy.This study highlights the fact that compared to TRUS, MRI is the better modality that improves detection and plays an important role in the management of patients.

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PARTICULARS OF CONTRIBUTORS:

1. Senior Resident, Department of Radiodiagnosis, Mysore Medical College, Mysore, Karnataka, India.
2. Senior Resident, Department of Radiodiagnosis, Mysore Medical College, Mysore, Karnataka, India.
3. Junior Resident, Department of Radiodiagnosis, Mysore Medical College, Mysore, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
K Lohith,
9A/80, 10th Cross, Vishweshwaraiah Road, Vijayashreepura, Manasa Gangothri Post, Mysore-570006, Karnataka, India.
E-mail: lohithk.neela@gmail.com

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