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Impact of Preoperative Imaging (MRI) Modalities on Surgical Planning and Outcome in Prostate Cancer: A Retrospective Analysis

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ABSTRACT

Background: Operative planning for the treatment of localised prostate cancer has evolved in tandem with advancing imaging technologies. Limited research has examined how these modifications affect recovery times after surgery. The purpose of this research was to determine if magnetic resonance imaging (MRI) performed before surgery had any effect on the percentage of positive surgical margins (PSMs).

Methods: This retrospective comprised of 416 patients of prostate cancer. All the patients were admitted for radical prostatectomy. Patients were divided in two groups. Group I (208) received MRI before radical prostatectomy and group II (208) did not receive MRI before surgery. Post-surgery outcomes were assessed and compared among both groups.

Results: We found mean age in group I was 61.32±8.37 years and in group II mean age was 63.14±6.28 years. Mean operative time and blood loss in group I was lower as compared to group II with p <0.003. In both groups PSM was majority occurred at the apex.Both total and prostatic apex PSM were shown to be linked with preoperative MRI status alone, according to multivariate analysis. Postoperative ischemic syndrome was not linked to the surgical strategy, neurovascular bundle sparing method, or perioperative blood loss.

Conclusion: MRI is a great tool for detecting and treating PCa right now. It is possible to lessen total PSM, apical PSM, and blood loss with the use of this imaging technology. Further, urologists in the early phases of RP have showed encouraging results using preoperative MRI in reducing the PSM rate

Keywords: Prostate Cancer, Radical prostatectomy, Magnetic Resonance Imaging, Apex...

1. INTRODUCTION:

Surgical removal of the prostate is an option for patients whose prognosis is unclear more than 10 years following a diagnosis of clinically localized prostate cancer [1]. Surgical treatment aims to maximize oncologic control while maintaining sexual potency and urinary continence, two important quality of life activities. It is not easy to accomplish both functional and oncologic aims in surgical planning since they are often at conflict with one another. Men at high risk of disease spreading beyond the prostate may require wider resection, which entails removing important structures such as the neurovascular bundles and urethral length—structures crucial for sexual and urinary function. A better grasp of the location and severity of diseases could lead to improvements in dissection that maximize cancer care without sacrificing function.

When patients with high screening PSA readings are scanned using multiparametric magnetic resonance imaging (mpMRI), prostate cancer (PCa) can be diagnosed. When it comes to identifying clinically relevant PCa, previous research has demonstrated that mpMRI is superior [1,2]. Classification of lesions into five groups is done using the Prostate Imaging Reporting and Data System version 2.1 (PI-RADS v2.1) by urologists and radiologists. Classification 3 is still up for debate, however categories 4 and 5 strongly indicate clinically relevant cancer and need biopsies [3]. By using selected mpMRI-directed biopsies, mild PCa has been less over-detected and overtreated [4].

By re-excising the tumor at the possible EPE locations and then using MRI-directed intraoperative frozen-section analysis, it may be possible to lower the rate of positive surgical margins (PSM) following nerve-sparing RPE [5]. Still, organ-confined PCA patients are not immune to PSM. With organ-confined PCA or targeted (microscopic) EPE with negative margins, recurrence is less common in these individuals [6]. In every surgical procedure, the surgeon's degree of expertise is significantly associated with the risk of postoperative surgical complications (PSM) [7]. While the major objective of RPE is to avoid PSM, it is also necessary to preserve the neurovascular bundles & the membranous urethra in order to sustain performance and continence. In addition to tumor staging and identification, mpMRI also provides information on prostate volume, tumor location, and architecture; this extra data may aid in detecting regions prone to prostate squamous cell carcinoma (PSM) [8].

Magnetic resonance imaging (MRI) has recently replaced traditional imaging methods as the gold standard for identifying PCa stages and locations [8]. In a recent meta-analysis, it was found that preoperative magnetic resonance imaging (MRI) changes the surgical template selection for 35% of patients [9]. Retrospective studies have shown that using preoperative prostate MRI to develop an optimal surgical plan might assist surgeons reduce the rate of PSMs [9,10]. Nevertheless, these experiments used various interpretations of the MRI scans. Traditional radiology reports have a narrative style that is characterized by free-flowing, unstructured language, which makes it hard to express information and makes the report less understandable [11]. The Prostate Imaging-Reporting and Data System version 1 (PI-RADS v1) was developed in 2012 by the European Society of Urological Surgery (ESUR) to improve the interpretation of prostate MRI and to provide standards for the global standardization of image acquisition procedures [12]. The PI-RADS has grown with the release of PI-RADS v2.1. So far, PI-RADS has been validated as a viable tool for cancer screening in many studies [12,13]. The purpose of this study was to identify if patients who had preoperative mpMRI data on the prostate's architecture and cancer site had better surgical margin status following prostate resection. Surgeons may develop a tailored strategy to reduce nerve injury and increase dissection while successfully treating the cancer by examining the prostate and PCa using mpMRI prior to surgery.

2. MATERIALS AND METHODS

This retrospective study was conducted at Institute of Kidney Diseases, Hayatabad, Peshawar from November 2023 to March 2025.

Based on their pre-op MRI results, the patients were equally divided into two groups. Age (in years), body mass index (in kg/m2), initial PSA (iPSA) level (in nanograms/mL), and prostate size (in mL) were all recorded for the patients. Each detail of the procedure was recorded with great care, including the milliliters of blood loss, the surgical approach (open, laparoscopic, or robotic-assisted RP), and the total operating time.

Preoperative magnetic resonance imaging (MRIs) were performed either by our hospital or by another institution. The official reporting of MRI results and tumor locations followed the implementation of PI-RADS v2.1, an imaging protocol that combines functional and physiological assessment with anatomic T2W, dynamic contrast-enhanced MRI, diffusion-weighted imaging, and its derivative apparent diffusion coefficient maps. Prior to surgery, prostate biopsies were conducted using either in-hospital or out-of-hospital transrectal ultrasonography (TRUS) fusion or systemic TRUS biopsy techniques. The operative urologists' preference dictated the use of excision operations after reviewing the MRI results with the patient. The RP was carried out by residents, fellows, or members of the attending staff who were directed by the attending.

Demographic and intraoperative data were provided using the standard deviation and mean. The percentage of tumor involvement, blood loss, body mass index, and iPSA level were described using the median and interquartile range. The Kruskal-The groups were compared using the Wallis test. We used the chi-square test to compare data sets that contained category variables. Patients who underwent preoperative MRI and those who did not were matched using propensity scores. Considerations included the following: age, BMI, insulin-like growth factor (iPSA), volume of the prostate, tumor percentage engagement (T%I), postoperative tumor size (pT), NVB sparing approach, surgical time, and perioperative blood loss. For each variable, we employed univariate logistic regression. We used a multivariate logistic regression model with a backward selection strategy to identify the independent components related to PSM. In addition, every PSM site underwent multivariate analysis.

The statistical analysis in this study was conducted using SPSS 24.0. A p-value less than 0.05 was considered statistically significant.

3. RESULTS

We found mean age in group I was 61.32±8.37 years and in group II mean age was 63.14±6.28 years. Mean operative time and blood loss in group I was lower as compared to group II with p <0.003. Mean prostate size in group I was 46.12±8.47 ml and in group II was 41.18±14.68 ml. Majority of the cases had 3a stage of tumor. Most common surgical approach was robotic-assisted radical prostatectomy (RARP). 78 (37.5%) cases in group I received bilateral technique and 61 (29.3%) cases in group II received bilateral NVB technique. (table 1)

Table-1: Demographics of the enrolled cases of both groups.

Variables	Group I (208)	Group II (208)
Mean age (years)	61.32±8.37	63.14±6.28
Operative time (min)	179.10±13.47	188.12±17.86
Blood Loss mL (mean)	201±30.54	251±13.77
Prostate Size mL	46.12±8.47	41.18±14.68
Stage of cancer		
2	85 (40.7%)	95 (45.7%)
3a	105 (50.5%)	100 (48.1%)
3b	10 (4.8%)	6 (2.9%)
4	8 (3.8%)	7 (3.4%)
Surgical Approach		
RARP	130 (62.5%)	112 (53.8%)
LRP	70 (33.7%)	80 (38.5%)
ORP	18 (8.7%)	16 (7.7%)
Technique		
Bilateral	78 (37.5%)	61 (29.3%)
Unilateral	28 (13.5%)	33 (15.9%)
None	102 (49.03%)	114 (54.8%)

In both groups PSM was majority occurred at the apex, followed by posterior, bladder neck, anterior, posterolateral and lateral.(table 2)

Table-2: In both groups location of PSM

Variables	Group I	Group II
Location Of PSM		
apex	70 (33.7%)	65 (31.3%)
posterior	50 (24.03%)	43 (20.7%)
bladder neck	42 (20.2%)	35 (16.8%)
anterior	30 (14.4%)	20 (9.6%)
posterolateral	8 (3.8%)	25 (12.02%)
Lateral	8 (3.8%)	20 (9.6%)

PSM were shown to be linked with preoperative MRI status alone, according to multivariate analysis. Postoperative ischemic

syndrome was not linked to the surgical strategy, neurovascular bundle sparing method, or perioperative blood loss.(table 3).

Table-3: Comparison of outcomes by using multivariate regression

Variables	Group IOR (95% CI)	Group IIOR (95% CI)	P Value
MRI	0.52 (0.52, 0.2)	0.01 (0.01,00)	<0.05
Surgical technique	1.4 (0.1,0.4)	0.65 (0.6,0.4)	<0.02
Blood loss	1.20 (0.28,1.12)	2.0 (0.47,0.26)	<0.03
Operation Time	0.42 (0.50,0.71)	0.86 (0.42,0.73)	<0.001
Cancer Stage	1.9 (1.4,1.1)	0.9(0.7,0.3)	<0.05
Surgical Approach	1.3 (0.2,0.5)	2.0 (1.2,0.8)	<0.004

4. DISCUSSION

With its ability to improve cancer imaging resolution, preoperative mpMRI is quickly gaining popularity as a surgical planning tool. Improving surgical dissection guidance and avoiding positive surgical margins requires precise detection of ECE, SVI, neurovascular abutment, and tumor apical involvement. There are limitations on the specific ways in which mpMRI may evaluate these characteristics. Patients undergoing radical prostatectomy for localized prostate cancer were shown to have very sensitive magnetic resonance imaging (mpMRI) for detecting ECE and SVI, but not very sensitive overall, according to a meta-analysis [14]. However, when mpMRI is employed for tumor localization, the surgical technique could change. From 203 patients who had robotic Retzius sparing radical prostatectomy, 42% had tumors positioned anteriorly with acceptable surgical margins [14]. The creation of mpMRI-based nomograms shown that supplementing mpMRI findings with biopsy and clinical variables might improve imaging diagnostic accuracy [15]. No one knows if this improvement helps with surgical planning or results just yet [16].

It stands to reason that surgeons will be more inclined to do aggressive resections when using mpMRI to locate prostate cancer and identify disease expansion regions. This is because common imaging techniques often fail to pick up on some details. There seems to be evidence to back up this idea; surgery was rethought after mpMRI, leading to more extensive resection in 21% of patients. The lack of improvement in positive surgical margin status by mpMRI despite these modifications is intriguing [17]. More evidence that there was no oncologic advantage was the fact that the two groups did not vary significantly in biochemical recurrence-free survival after mpMRI compared to CT. We also did not find any proof that mpMRI enhanced the favorable surgical margin status.

To better educate patients and determine the most effective therapy, clinicians in Thailand can benefit from preliminary study on the causes of post-RP muscle damage (PSM). Now that high-resolution 3 T MRI is available, urologists can use it to get a clearer idea of the size, location, and extent of the tumor in relation to the pelvic organs' architecture before operating. If the lesion is bigger than 10 mm, mpMRI can better detect and localize clinically relevant PCa [18]. Based on these data, surgeons may be better able to plan procedures that spare the NVB, preserve the bladder neck, and perform apical dissection. According to a recent research [19], urologists may choose for a more severe surgical excision approach in 30–40% of instances when preoperative MRI is used.

The peak concentration of PSMs was seen near the tip of our facility. Adenocarcinoma around the apex afflicted as many as 65.4% of individuals in previous research [20]. By actively preserving the maximum urethral length, which is linked to enhanced urine continence, a PSM at the apex may be achieved [21]. Possible migration during a prostate biopsy is another explanation for why PSM might be found at the apex. Following the introduction of the MRI TRUS fusion biopsy technology, our facility revised its methods for doing prostate biopsies. While transrectal biopsy has been our go-to for the past decade, most prostate biopsies have been done transperineal with fusion biopsy instead. As we discovered [20,21], transperineal biopsy poses a challenge for RP prostate apex dissection because to the prevalence of anterior report adhesion. A poorly defined prostate capsule could be one reason why PSM is more common near the prostate apex [22].

It has been demonstrated in a small number of studies that preoperative MRI enhances the posterior surface margin status by increasing visibility and surgical resection degrees of freedom. However, our investigation failed to find any statistically significant differences in the posterior PSM rate according to location. With a sensitivity of 83.1%, MRI could detect index PCa lesions in the midgland region, according to research done by Wibulpolprasert et al. [23]. If you can feel this sensation, it means you can see the prostate clearly from behind. Conversely, sensitivity was 64.0% in the bladder and 71.4% in the apex. Surgeons may discover alternative ways to decrease PSM, even when the back surface is packed with Denonvilliers'

fascia and perirectal fat, after discovering that preoperative MRI considerably decreased PSM at the midportion surface (Jäderling et al., [24]).

According to the findings, tumor aggressiveness has a direct bearing on PSM. A high PSA level (≥10 ng/mL), a high tumor involvement percentage (≥50%), and insufficient tumor differentiation (ISUP≥2) were all associated with the prostate PSM as a whole. Both 1.5 T and 3 T preoperative MRI failed to considerably enhance this cancer outcome in prior research [15,25].

Previous research has shown that even with preoperative MRI, wider incisions can be necessary to decrease PSM. This study challenged the findings of earlier research by showing that preoperative MRI significantly reduced PSM, especially for surgeons with less than 100 cases of RP experience and with low patient volume. Individuals who underwent magnetic resonance imaging (MRI) scans before surgery saw significantly reduced blood loss. That the optimal strategy for prostate dissection depends on being able to visualize the prostate's outline is one theory that might account for this finding. A larger apical periprostatic venous complex and a larger prostate are associated with an increased risk of blood loss during RP, according to MRI studies [10,26]. Furthermore, regardless of the surgeon's RP ability, pre-prostatectomy MRI was found to dramatically minimize apical PSM.

No association between NVB sparing and greater PSM was seen by the researchers. Comparing the posterolateral surface and apex PSM rates to those of broader non-cavernous nerve-sparing excision revealed that neither the unilateral nor the bilateral procedures improved the situation. Our study did not account for unneeded NVB resections performed prior to surgery using MRI as a guide.

5. CONCLUSION

MRI is a great tool for detecting and treating PCa right now. It is possible to lessen total PSM, apical PSM, and blood loss with the use of this imaging technology. Further, urologists in the early phases of RP have showed encouraging results using preoperative MRI in reducing the PSM rate

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