

Role of Diffusion Weighted Imaging in Localization of Non-palpable Undescended Testes Taking Laparoscopic Finding as Gold Standard

Rukhsana Nasim,¹ Abeer Yasin,² Muhammad Kaleem³

Abstract

Objective: To ascertain the accuracy of diffusion-weighted imaging (DWI) in the localization of undescended testes.

Material & Methods: This prospective cross-sectional study was conducted in the radiology department of a tertiary care hospital from 01-06-2022 to 15-12-2023. Total of 150 patients were included in the study. Two experienced radiologists independently examined, one observing conventional MRI alone and the other observing DWI-MRI. Following that, all of the patients underwent laparoscopic examination. The data was entered into a proforma. The findings of conventional MRI alone and DWI-MRI were correlated with laparoscopic findings. A 2 x 2 table was used to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of DWI in comparison to laparoscopy.

Results. The average age was 10.37 +/- 5.663. Conventional MRI imaging localized 50.6 % of the cases in our study, 55% of cases via DWI-MRI and 60% by laparoscopy. Sensitivity, specificity, PPV, NPV, and accuracy of conventional MRI were 72 %, 83 %, 86 %, 66 % and 76 % respectively, while for DWI-MRI was 82 %, 86 %, 93 %, 89 %, and 78 % respectively.

Conclusion: The detection of undescended testes is improved by DWI-MRI. DWI-MRI is a recommended imaging tool for improving MRI's preoperative diagnostic accuracy in localization and identification of nonpalpable undescended testes.

Keywords: Radiology; Magnetic Resonance imaging; diffusion weighted imaging; laparoscopy

How to cite: Nasim R, Yasin A, Kaleem M. Role of Diffusion Weighted Imaging in Localization of Non-palpable Undescended Testes Taking Laparoscopic Finding as Gold Standard. *Esculapio - JSIMS* 2023;20(01):43-47.

DOI: <https://doi.org/10.51273/esc24.25132019>

Introduction

Cryptorchidism, also known as undescended testes (UT), is the absence of one or both testes in the scrotal sac.¹ It affects about 1 - 4.5 percent of newborns, with the incidence rising to 30 - 45 percent in preterm babies.² During infancy, 75 percent of full-term neonates and 90 percent of preterm neonates have UT, which drops to 0.8 - 1.2 percent by one year of age.^{1,3,4}

Untreated cryptorchidism has been linked to a variety of complications. 10% of infertile males had a history of UT, with the risk increasing up to six-fold in bilateral UT compared to unilateral UT or the normal population.⁵ If the patients are not treated, the risk increases.⁶ UT is estimated to be responsible for 10% of testicular malignancy, increasing the risk by up to 35 to 48 times when compared to the general population, with seminoma being the most commonly diagnosed malignancy in these patients.^{7,8} Torsion has also been reported in these patients, and it has a positive correlation with the length of UT.⁹ Early intervention is critical for reducing infertility and lowering the risk of cancer in the future.¹⁰

Because of its non-invasiveness and ease of access, sonography is first line and popular imaging modality for the evaluation of UT. However, poor diagnostic accuracy

1,2. Department of Radiology, PGMI/ Lahore General hospital, Lahore, Pakistan

3. PGMI/ Lahore General Hospital, Lahore, Pakistan

Correspondence:

Rukhsana Nasim: Assistant Professor, Department of Radiology, PGMI/ Lahore General hospital, Lahore, Pakistan dr_ruxana@yahoo.com

Submission Date:	10-01-2024
1st Revision Date:	25-01-2024
Acceptance Date:	05-03-2024

because of location of UT in pelvic/ abdominal cavity necessitates further evaluation with MRI and diagnostic laparoscopy.¹ Laparoscopy remains the gold standard tool for detecting non-palpable UT with 100% sensitivity and specificity, but it is an invasive procedure.¹

Conventional MRI has a somewhat poor sensitivity for detecting non-palpable UT. Sometimes, it is unable to localize the atrophied testes, making conventional MRI less reliable in distinguishing who require intervention from those who do not. So more research is required.^{6,7}

The combination of DWI with conventional MRI sequences has become the area of interest in order to improve diagnostic accuracy in UT localization.^{8,9} In a Recent study carried out in Pakistan, analysis of 416 UT patients reported that the location of UT for DWI using laparoscopy as the gold standard had sensitivity (SN)=65% and specificity (SP)=98%.¹⁰ Additionally, a research conducted in 2010, enrolled 36 patients concluded that the combination of DWI and conventional MRI sequences, with SN=0.91, SP=1 for observer 1 & SN=0.88, SP=0.75 for observer 2, had a higher diagnostic accuracy than either technique alone (SN=0.85, SP=1 for observer 1 & SN=0.85, SP=0.75 for observer 2) or with DWI alone (SN=0.88, SP=0.75 for observer 1 & SN=0.82, SP=0.75 for observer 2).¹⁰ Since there are few comparative studies in the area, more research is necessary to establish an early diagnosis based on evidence and to intervene promptly in the care of UT. Our hypothesis was that the sensitivity and specificity of imaging non-palpable undescended testes in the abdomen would be increased by including DWI in conventional MRI. The goal of this study was to determine the diagnostic accuracy of DWI by comparing it to traditional MRI sequences, with laparoscopic findings serving as the reference.

Material & Methods

This prospective cross-sectional study was carried out at Lahore General Hospital's Department of Radiology, Lahore, Pakistan. From 01-06-2022 to 15-12-2023, samples were taken using a non-probability consecutive technique. Informed and written consent was taken from patients or guardians of the patients as applicable. All male patients referred from the surgical OPD due

to the absence of palpable testes in one or both scrota and inguinal canal, age ranged from 1 to 30 years were included. Patients with ambiguous genital, previous history of scrotal, inguinal, or lower abdominal surgery, Diagnosed case of any renal malformation, Claustrophobic patients, and patients refusing laparoscopic evaluation were excluded from the study. After taking approval from institutional review board (IRB) of PGMI / Lahore General Hospital, Lahore, Pakistan a total of 150 patients were enrolled and data was collected. MRI was performed on 3 Tesla machine (G.E manufacturer) and protocols included multiplanar T2WI, T1WI, T2 FATSAT, and the addition of a DWI sequence with b values of 0, 400, and 800 s/mm². A consultant radiologist with 5 years of experience reviewed the conventional MRI images on PACS and filled proforma. Another consultant radiologist with same experience reviewed DWI-MRI images of same patient and added his findings in proforma. Postop findings were taken from surgical ward. It was recorded in the proforma. The collected data were entered into the Statistical Package for Social Sciences (SPSS) version 22 and analyzed. Mean \pm SD was calculated for quantitative variables, and frequency and percentage were used for qualitative variables. A 2 X 2 table was used to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of conventional MRI alone and DWI+MRI conventional sequences using laparoscopy as the gold standard.

Results

The average age was 10.37 \pm 5.663 years. In our study, 50% of cases were diagnosed using only the conventional MRI, 55% were localized by DW-MRI, and 60% by laparoscopy, as shown in Tables 1 and 2. The sensitivity, specificity, positive and negative

Table 1: 2x2 table of Conventional MRI

MRI	Laparoscopy		Total	SN=72% Sp=83% PPV=86% NPV=66% Accuracy=76%
	Positive (n=91)	Negative (n=59)		
Positive(n=76)	66 (TP)	10 (FP)	76	
Negative(n=74)	25 (FN)	49 (TN)	74	
Total	91	59	150	

Table 2: 2x2 table of DWI-MRI

DWI- MRI	Laparoscopy		Total	S _N =82% S _P =86% PPV=93% NPV=89% Accuracy=78%
	Positive (n=91)	Negative (n=59)		
Positive(n=83)	75 (TP)	8 (FP)	83	
Negative(n=76)	16 (FN)	51 (TN)	67	
Total	91	59	150	

predictive values, and diagnostic accuracy of DW-MRI for undescended testes were calculated using laparoscopy as the gold standard.

Discussion

Undescended testes, also known as cryptorchidism, necessitate prompt treatment due to the risk of complications such as testicular malignancy, testicular torsion, infertility, and trauma. Furthermore, it may result in psychological stigma, making both parents and patients concerned about the condition.⁶ There is no definitive agreement on the primary management of undescended testes. Radiological approaches such as USG, CT, and MRI, as well as surgical approaches such as laparoscopy, have been widely used. Laparoscopy, despite being widely regarded as the most conclusive diagnostic approach, is an invasive procedure and many complications can occur. So, there is need of non-invasive procedure. An ultrasound examination, as being considered first line imaging modality, is always performed if the testis is impalpable. Ultrasound has a high positive predictive value for inguinal located testes in expert hands, such as 91 % with a sensitivity of 78%.¹² According to some studies, even when a pediatric surgeon and urologist diagnosed a nonpalpable testis, an inguinal testis was discovered in 21-85 percent of patients during surgery.¹⁴ When testis is found in an inguinal location by ultrasound, a primary inguinal exploration can be considered, avoiding a diagnostic laparoscopy.¹³ But when testis is not localized in inguinal canal, it become very difficult to identify it. In some cases, differentiation from inguinal lymph nodes become difficult during ultrasonography. As a non-invasive, non-radiation, and non-contrast diagnostic tool, MRI has a truly great potential to be the most reliable and widely accepted diagnostic instrument.^{3,4} It has excellent soft tissue contrast with fine spatial resolution. The overall mean age of the patients in our study was 10.37 ±/− 5.663 years,

which differs from the mean age of 7.21 ±/− 1.43 years as calculated by Zainab et al.¹ Because the risk of developing testicular cancer and infertility increases with age, the age at diagnosis is an important prognostic factor in the case of undescended testes. In our study, the sensitivity, specificity, and accuracy of DWI-MRI for diagnosis of non-palpable undescended testes were 82 %, 86 %, and 78 % respectively.

Numerous prior researches have determined the DW-specificity, MRI's sensitivity, and diagnostic accuracy in identifying cryptorchidism. Overall sensitivity, specificity, and diagnostic accuracy of DW-MRI in detecting cryptorchidism have been reported by Fazal et al. to be 65.1%, 98.1%, and 81.3 percent, respectively.¹⁰ According to Zainab et al., the overall DW-MRI diagnostic accuracy, specificity, and sensitivity for diagnosing cryptorchidism are 91.40 percent, 84.35 percent, and 93.51%, respectively.¹

An additional investigation by Kantarci et al. using a conventional MRI sequence alone and in conjunction with DWI found that the combination of DWI and conventional MRI sequences had a higher success rate (SN = 0.91, SP = 1 for observer 1 & SN = 0.88, SP = 0.75 for observer 2) than did MRI (SN = 0.85, SP = 1 for observer 1 & SN = 0.85, SP = 0.75 for observer 2) and DWI (SN = 0.88, SP = 0.75 for observer 1 & SN = 0.82, SP = 0.75 for observer 2) alone.⁴ Our analysis yielded lower values than this. Using conventional MRI, Abd-El Gawad et al. reported 87 percent, 50 percent, and 83 percent sensitivity, specificity, and accuracy. He reported sensitivity, specificity, and accuracy of 91.5%, 66.7%, and 88.67%, respectively, using DWI.¹¹

Similar studies that combined the use of conventional and DWI reported 95.8%, 100%, and 96.2 % in terms of sensitivity, specificity, and accuracy. Laparoscopy revealed that atrophic testes were the cause of false-negative cases, particularly in patients who were older.¹¹

Higher results were recorded by Emad-Eldin et al.¹⁶; they verified that a sensitivity of 93%, specificity of 87%, and accuracy of 91.5 percent were obtained when MRI was utilized alone. The results improved to a sensitivity of 93%, specificity of 100%, and accuracy of 95.70% when DWI was added to traditional MRI. DWI also has main role in the many clinical situations i.e. the identification of cancer in a variety of viscera,

including the liver, kidney, prostate, and other organs, when using abdominal MRI. The way DWI works is that it uses the diffusion of water molecules to show how cellular the tissue is, which results in different images than when using traditional MRI sequences to help characterize the tissue at the microscopic level.

The degree of water diffusion restriction in biological tissue is inversely correlated with tissue cellularity. In tissues with intact membranes and strong cellularity, there is more restriction of water molecules. Because the testicles inside the abdomen have more cells than the surrounding organs, they can be identified on DWI as having a higher signal intensity. Therefore, in order to detect non-palpable undescended testes, we supplemented standard MRI sequences with DWI.¹⁵

In order to validate the clinical findings, all of the patients in our study who were sent to our department due to clinically non-palpable testes underwent local grey scale and doppler USG imaging. Following that, the patients were advised to undergo a standard hospital MRI sequence along with a DWI sequence.

Conclusion

With a sensitivity of 82% and specificity of 86%, the study found that conventional MRI in conjugation with DWI offer significantly superior diagnostic accuracy when compared to conventional MRI sequences. Diffusion-weighted imaging can therefore be a very useful tool in the localization of non-palpable undescended testes. So that early intervention should be done for reducing infertility and lowering the risk of cancer in the future.

Sources of funding: *None*

Conflict of interest: *None*

References

1. M. Zahra, A.M. Javed, A. Noreen, H. Bushra, U. Saeed, M. Amin, Diagnostic accuracy of conventional MRI with diffusion weighted imaging (DWI) in detection of cryptorchidism taking diagnostic laparoscopy as gold standard, Pak. J. Med. Health Sci. 10 (2)(2016) 471–474.
2. Kim JK, Chua M, Braga L, Langer JC, Hancock BJ, Lorenzo AJ, Bagli D, Farhat WA, Koyle MA. A Canadian national survey: understanding the differences in management of cryptorchidism among pediatric surgeons and pediatric urologists. J Pediatr Surg. 2019 Sep;54(9):1820-1824.
3. Igarashi A, Kikuchi K, Ogushi K, Hasegawa M, Hatanaka M, Fujino J, Kishi Y, Ikeda H. Surgical exploration for impalpable testis: Which should be first, inguinal exploration or laparoscopic abdominal exploration? J Pediatr Surg. 2018 Sep;53(9):1766-1769.
4. Kantarci M, Doganay S, Yalcin A, Aksoy Y, Yilmaz-Cankaya B, Salman B. Diagnostic performance of diffusion-weighted MRI in the detection of nonpalpable undescended testes: comparison with conventional MRI and surgical findings. AJR Am J Roentgenol 2010;195: W268–73.
5. Kato T, Kojima Y, Kamisawa H, Takeuchi M, Mizuno K. Findings of fat-suppressed T2-weighted and diffusion-weighted magnetic resonance imaging in the diagnosis of non-palpable testes. BJU Int 2010; 107:290–4.
6. Pellegrin MC, Spinelli AM, Tornese G et al (2019) Unilateral testicular enlargement in a teenager with Beckwith-Wiedemann syndrome: a case report. Ital J Pediatr 45(1):P79-83.
7. Maki D, Watanabe Y, Nagayama M, Ishimori T, Okumura A. Diffusion-weighted magnetic resonance imaging in the detection of testicular torsion: a feasibility study. J Magn Reson Imaging 2011; 34:1137–42.
8. Muna AG, Hanon N, Riadh H (2017) Cryptorchidism: diagnostic performance of magnetic resonance imaging in comparison with ultrasound. Med J Tikrit Univ 23(1):95–104
9. Al-Kayat RH. The role of diffusion-weighted MRI in the evaluation of non-palpable undescended testis. Mustansiriyah Med J. 2013 Dec;12(2):200-5.
10. Fazal K, Hussain S, Khan F, Ullah I, Tahir MJ, Mehmood Q, Yousaf Z. To determine the sensitivity, specificity, and diagnostic accuracy of diffusion-weighted MRI in localization of non-palpable undescended testes taking laparoscopic findings as the gold standard: A cross-sectional study from Pakistan. Ann Med Surg (Lond). 2021 Dec 18;73:103161.
11. E.A. Abd-ElGawad, E.A. Abdel-Gawad, M. Magdi, S.M. Al-Minshawy, Magnetic resonance imaging for detection of non-palpable undescended testes: diagnostic accuracy of diffusion-weighted MRI in comparison with laparoscopic findings, Egypt J. Radiol Nucl. Med. 46 (2015) 205–210.
12. Vos A, Meij-de Vries A, Smets A, Verbeke J, Heij H, van der Steeg A. The value of ultrasonography in boys with a non-palpable testis. Journal of pediatric surgery. 2014 Jul 1;49(7):1153-5.

13. Nijs SM, Eijsbouts SW, Madern GC, Leyman PM, Lequin MH, Hazebroek FW. Nonpalpable testes: is there a relationship between ultrasonographic and operative findings? *Pediatr Radiol*. 2007 Apr;37(4):374-9.
14. Diamond DA, Caldamone AA. The value of laparoscopy for 106 impalpable testes relative to clinical presentation. *J Urol*. 1992 Aug;148(2 Pt 2):632-4.
15. Mohammed NE, Badwey ME, Nagla SA, Dawoud RM. Diffusion-weighted imaging and conventional magnetic resonance imaging for detection of non-palpable undescended testis. *Egyptian Journal of Radiology and Nuclear Medicine*. 2022 Aug 2;53(1):169.
16. Emad-Eldin S, Abo-Elnagaa N, Hanna SA et al (2016) The diagnostic utility of combined diffusion-weighted imaging and conventional magnetic resonance imaging for detection and localization of non-palpable undescended testes. *J Med Imaging Radiat Oncol*0(3):344–351.

Authors Contribution

RN, AY: Conceptualization of Project

RN, AY, MK: Data Collection

RN, AY, MK: Literature Search

MK, AY: Statistical Analysis

RN: Drafting, Revision

MK, AY: Writing of Manuscript