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Diagnostic Value of Combined Diffusion Weighted MRI and Conventional MRI in The Diagnosis of Non-Palpable Undescended Testes

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ABSTRACT

Background: Additional MRI assessments, as DWI are useful methods to improve the accuracy and sensitivity of diagnosis of non-palpable testes. **Objective:** The aim of this work was to assess diagnostic value of combined diffusion weighted MRI and conventional MRI in the diagnosis of non-palpable undescended testes before laparoscopy.

Patients and Methods: This was a prospective study during a period of 12 months duration from January 2018 to December 2018 including 30 male patients with 33 non-palpable undescended testes (unilateral in 27 cases and bilateral in three cases). They were prospectively enrolled in this study. Their ages ranged from 6 months to 21 years old (mean age = 4.04 ± 4.004 years, mood=1 years). The research was carried on the Radiology Department, Al Azhar University Hospital and AlAhrar Teaching Hospital. All patients underwent ultrasound then underwent magnetic resonance imaging included different pulse sequences and scanning planes.

Results: Conventional MRI showed sensitivity of 79.31%, specificity of 100% and overall accuracy of 81.82%; DWI had higher sensitivity (82.76%) but lower specificity (75%) and similar overall accuracy (81.82%) compared to conventional MRI; combined assessment had the highest sensitivity (86.21%), specificity (100%) and accuracy (87.88%). **Conclusion**: DWI findings complement the information on the location and viability of undescended testes obtained with conventional MRI before laparoscopy.

Keywords: Conventional MRI, DWI, UDT.

INTRODUCTION

Cryptorchidism is the absence of one or both testes in the scrotum and is generally synonymous with undescended testes [(1)]. Undescended testis is the most common genital disorder identified at birth. Undescended testes occur in 1–3% of full-term and up to 45% of preterm male neonates [(2)].

The term 'non-palpable testes' implies that the testes cannot be detected on physical examination; they are intra-abdominal, absent, vanishing or atrophic. In **Kato** [(3)] study, 18% of these testes could be palpated during physical examination under anaesthesia, and 12.6% of viable testes discovered on exploration were distal to the inguinal canal and simply missed on physical examination [(3)].

The cardinal reasons for treatment of undescended testis (UDT) include increased potential risks of testicular malignancy, infertility, together with testicular torsion and associated inguinal hernia [(2, 3)].

Preoperative identification and location of testicles can help to determine the optimal type of procedure and allow for appropriate advance planning. On the basis of the imaging findings, the surgeon can appropriately counsel the patient and alter the operative approaches needed. In the case of absent or vanishing testicles, imaging findings could obviate the need for surgical exploration [(4)].

Different imaging techniques have been implied in localizing non-palpable UDTs preoperatively, with varying limitations. Imaging techniques include ultrasonography (US), computed tomography (CT), conventional magnetic resonance imaging (MRI), magnetic resonance angiography (MRA) and magnetic resonance venography (MRV) [(2)]. Ultrasound is the least expensive, does not involve ionizing radiation and frequently used technique of all imaging tools. However it had been shown to have low sensitivity in identifying non-palpable testicles preoperatively [(5)]. CT is noninvasive but is unreliable and carries the risk of radiation [(6)]. Conventional MRI has low sensitivity for localization of non-palpable UDT. It has apparently low efficiency in the detection of intra-abdominal functioning testes. Moreover, it fails to locate most of the atrophied testes, thus, rendering the utilization of conventional MRI less reliable in distinguishing children needing surgery from those who do not [(2)].

In DWI technique, information is extracted on the diffusion of water molecules, which reflects the degree of cellularity of tissue. Use of DWI therefore facilitates characterization of tissue at the microscopic level in a mechanism different from T1 and T2 relaxation [(6)]. The degree of restriction of water diffusion in biologic tissue is inversely related to tissue cellularity and the integrity of cell membranes. The motion of water molecules is more restricted in tissues with the high cellularity associated with numerous intact cell membranes (e.g. tumor tissue). Concordantly, intra-abdominal testes are considerably more cellular than the adjacent organs and tissues and can be detected easily on DW images owing to their increased signal intensity [(6)].

AIM OF THE WORK

The aim of this work was to assess diagnostic value of combined diffusion weighted MRI and conventional MRI in the diagnosis of non-palpable undescended testes before laparoscopy.

PATIENTS AND METHODS

Patients:

This was a prospective study conducted during a period of 12 months duration from January 2018 to December 2018 including 30 male patients with 33 non-palpable undescended testes (unilateral in 27 cases and

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bilateral in three cases). Their ages ranged from 6 months to 21 years old (mean age = 4.04 ± 4.004 years, mood=1 years). Referred for MRI evaluation of clinically diagnosed 33 nonpalpable undescended testes with non-conclusive ultrasonography findings. 27 cases were diagnosed of unilateral UDT (15 on the right side and 18 on the left side) with 3 cases clinically diagnosed of bilateral UDT. Our inclusion criteria, included all patients who were clinically diagnosed with absence of a palpable testis in the scrotum, perineum or inguinal canal, while all patients with disorders of sexual development or ambiguous genitalia were excluded.

Ethical approval: The study was approved by the Ethics Board of Al-Azhar University and an informed written consent was taken from each participant in the study.

MR imaging

All MRI studies were performed with a 1.5-T MRI system (Achieva; Philips Medical Systems, Best, the Netherlands) using body coil (a phased-array coil T1, T2-weighted imaging as well as STIR imaging and DWI at b value of 50, 400 and 800 s/mm^2. They were performed during the same MRI examination. Images were acquired with the patient in supine position with head pointing to the magnet (headfirst supine; HFS). The body coil was securely tightened using straps to prevent respiratory artifacts. The center of the laser beam localizer was placed over symphysis pubis, from lower pole of kidney to 1 cm blew scrotum sac. Only 14 of our patients needed sedation using oral chloral hydrate syrup at a dose of 1 ml/kg body weight for MRI examination. There were no post sedation problems. Conventional MRI examination included axial and coronal spin-echo T1-weighted sequence, axial T2-weighted sequence, axial and coronal fat suppressed spin-echo T2-weighted sequence and axial DWI. Slice thickness was 4 mm, interslice gap was 1 mm and field of view was 50 cm^2. DWIs were performed using three sets of b value of 50, 400, and 800 s/mm^2. All MRI images including diffusion-weighted image sequences were transferred to an independent workstation.

Image analysis

All MRI images including diffusion-weighted image sequences were transferred to an independent workstation (Philips MR extended workspace). Our team consultant radiologist reviewed the MR images and recorded the presence or absence and the location of UDT. First the diffusion-weighted images, including the images with b value of 50, 400 and 800 s/mm^2 were reviewed alone, then the conventional MR images separately and finally the combined DW and conventional MR images. In routine DWI of the scrotum and the testes have high signal intensity due to their high cell density. At DWI, the abdomen was imaged for focal areas of hyperintensity. Elliptic areas of hyperintensity were recorded as testes, and the location of a non-palpable testis was classified into three anatomic regions; intracanalicular, low intraabdominal and high intraabdominal. Testes close to and below the inguinal internal ring were considered intracanalicular and so have low location. Testes above the internal ring were classified as having low intraabdominal location around the iliac vessels. Testes more than 3cm away from the internal ring were classified as having a high intraabdominal location.

On conventional MR images, elliptical areas of homogeneous low to intermediate signal intensity on T1-WI and high signal intensity on T2-WI and STIR were recorded as testes in the forementioned locations. The atrophic testis showed a low signal intensity on T1WI, T2WI and STIR as well as on DWI compared to viable testis which elicits high signal intensity.

On the combined DWI and conventional MR images, the conventional MRI was used for anatomic location of hyperintense elliptic areas on the DW images. On DW images, testes were recorded for focal areas of hyperintensity that did not represent T2 shine-through from fluid-containing structures.

The results of MRI were confirmed by laparoscopic findings. The mean duration between MRI and surgery was about 1 month ± 2 weeks. During laparoscopy, both internal inguinal ring and abdominal spaces were inspected by laparoscopic tools. The blood vessels, nature of the testes and termination of the vas were determined. If the vas and testicular vessels entered the internal inguinal ring, an open inguinal exploration and conventional orchiopexy were performed. Atrophic testes and cases of short vas were treated by laparoscopic orchiectomy.

Our team of research performed laparoscopic observation and subsequent laparoscopic orchiopexy for intra-abdominal testes, open orchidopexy for intra-canalicular testes and open or laparoscopic orchidectomy for testicular nubbins ending blindly at the cord structure depending on the presence and location of the testes. The results of MRI were considered positive when a testis was identified before the operation and finally diagnosed by surgeon.

Statistical analysis

Data were statistically described in terms of mean ± standard deviation and range, or frequencies (number of cases) and percentages when appropriate. Comparison of sensitivity and overall accuracy between the different techniques was done using Chi square test (McNemar test). Accuracy was represented using the terms sensitivity, specificity, +ve predictive value, -ve predictive value and overall accuracy. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc, Chicago, IL, USA) release 19 for Microsoft Windows.

RESULTS

This study included 30 patients with undescended testes. Age of patients ranged from 6 months to 21 years (Mean = 4.04 ± 4.004 years). 27 patients had unilateral undescended testes while three patients had bilateral undescended testes, with a total of 33 undescended testes that were included in the study. 15 (45.5%) were on the right side and 18 (54.5%) were on the left side.

Final laparoscopy revealed 10 testes in the abdomen, 4 of these were atrophic and 19 were found in the inguinal canal and 4 were absent (Table 1 & 2).

Table (1): Location and distribution of undescended testes according to laparoscopic findings

	Absent		Low Intra-abdominal		High Intra-abdominal		Inguinal		Total	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Right testes	**3**	**9.1**	**2**	**6.06**	**1**	**3**	**9**	**27.3**	**15**	**45.5**
Left testes	**1**	**3.0**	**4**	**12.1**	**3**	**9.1**	**10**	**30.3**	**18**	**54.5**
Total	**4**	**12.1**	**6**	**18.2**	**4**	**12.1**	**19**	**57.6**	**33**	**100**

N: Count - %: Percentage

Table (2): Viability of detected undescended testes according to laparoscopic findings

	Inguinal				Low Intra-abdominal				High Intra-abdominal			
	Viable		Atrophic		Viable		Atrophic		Viable		Atrophic	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Right testes	**9**	**27.3**	**0**	**0**	**3**	**9.1**	**0**	**0**	**0**	**0**	**0**	**0**
Left testes	**9**	**27.3**	**1**	**3**	**1**	**3**	**2**	**6.1**	**2**	**6.1**	**2**	**6.1**
Total	**18**	**54.6**	**1**	**3**	**3**	**12.1**	**2**	**6.1**	**2**	**6.1**	**2**	**6.1**

Assessment with MRI (Conventional sequences + DWI) was able to detect 26 undescended testes (78.8%), and was unable to detect 7 testes (21.2%). Of the detected group, 7 were seen in the abdomen (including 1 false positive) and 19 were seen in the inguinal canal (Table 3).

Table (3): Location and distribution of undescended testes according to MRI findings:

	Absent		Low Intra-abdominal		High Intra-abdominal		Inguinal		Total	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Right testes	**2**	**6.1**	**2**	**6.1**	**2**	**6.1**	**9**	**27.3**	**15**	**45.5**
Left testes	**5**	**15.2**	**1**	**3**	**2**	**6.1**	**10**	**30.3**	**18**	**54.5**
Total	**7**	**21.2**	**3**	**9.1**	**4**	**12.1**	**19**	**57.6**	**33**	**100.0**

MRI assessment using only conventional sequences was able to detect 23 (out of 33) undescended testes, while MRI assessment using only DWI was able to detect 25 (out of 33) testes. Combined assessment had the highest count (N = 26) of detected testes. Of these; 13 were right testes, and 13 were left testes (Table 4).

Table (4): Detected undescended testes in Conventional MRI vs DWI vs combined assessment

	Conventional MRI				DWI				Combined			
	Detected		Absent		Detected		Absent		Detected		Absent	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Right testes	**11**	**33.3**	**4**	**12.1**	**13**	**39.4**	**2**	**6.1**	**13**	**39.4**	**2**	**6.1**
Left testes	**12**	**36.4**	**6**	**18.2**	**12**	**36.4**	**6**	**18.2**	**13**	**39.4**	**5**	**15.2**
Total	**23**	**69.7**	**10**	**30.3**	**25**	**75.8**	**8**	**24.2**	**26**	**78.8**	**7**	**21.2**

Conventional MRI was able to detect 4 (out of 6) testes that were later found in the abdomen during laparoscopy, and 19 (out of 19) of the inguinal testes. DWI was able to detect all viable abdominal testes, while only detecting 18 (out of 19) inguinal testes. Combined assessment was able to detect all viable abdominal and inguinal testes. On the other hand no method of assessment by MRI was able to detect any of the atrophic abdominal testes that were later found in laparoscopy (N = 4) (Table 5).

Table (5): Detected undescended testes in MRI in comparison to laparoscopic findings

	Abdominal		**Abdominal (Atrophic)**		**Inguinal**		**Total**	
	N	***%***	***N***	***%***	***N***	***%***	***N***	***%***
Conventional	**4**	**66.7**	**0**	**0.0**	**19**	**100.0**	**23**	**69.7**
DWI	**6**	**100.0**	**0**	**0.0**	**18**	**94.7**	**25**	**75.8**
Combined	**6**	**100.0**	**0**	**0.0**	**19**	**100.0**	**26**	**78.8**

Diagnostic performance of MRI in detection of undescended testes was calculated in terms of sensitivity, specificity and overall accuracy. Conventional MRI showed sensitivity of 79.31%, specificity of 100% and overall accuracy of 81.82%. DWI had higher sensitivity (82.76%) but lower specificity (75%) and similar overall accuracy (81.82%) compared to conventional MRI. Combined assessment had the highest sensitivity (86.21%), specificity (100%) and accuracy (87.88%) (Table 6).

Table (6): Diagnostic performance of conventional MRI vs DWI vs combined assessment

	TP	***FP***	***TN***	***FN***	***Sn.***	***Sp.***	***PPV***	***NPV***	***Acc.***
Conv.	**23**	**0**	**4**	**6**	**79.31%**	**100.00%**	**100.00%**	**40.00%**	**81.82%**
DWI	**24**	**1**	**3**	**5**	**82.76%**	**75.00%**	**96.00%**	**37.50%**	**81.82%**
Comb.	**25**	**0**	**4**	**4**	**86.21%**	**100.00%**	**100.00%**	**50.00%**	**87.88%**

Conv: Conventional MRI - DWI: Diffusion weighted imaging - Comb: Combined assessment - TP: True positive (N) - FP: False positive (N) - TN: True negative (N) - FN: False negative (N) – Sn.: Sensitivity (%) - Sp.: specificity (%) - PPV: Positive predictive value (%) - NPV: Negative predictive value (%) - Acc.: Accuracy (%)

ADC values were obtained for 24 undescended testes and 33 nearby lymph nodes. Mean ADC values for the testes was 1.167 ± 0.341, while mean ADC values for lymph nodes was 0.947 ± 0.389 (Table 7).

Table (7): Mean ADC values of undescended testes and lymph nodes

	N	*M*	*SD*
Testes	24	1.167	0.341
Lymph node	33	0.947	0.389

M: Mean - SD: Standard deviation

Comparing the means of ADC values of undescended testes and lymph nodes reveled no significant difference (p = 0.0818) in this study. The mean difference between testes and lymph nodes showed that the average ADC value of the testes could be less than (up to -0.0292) or more than (up to 0.4682) the average ADC value of a nearby lymph node. These findings imply that ADC values cannot be used to differentiate between undescended testes and lymph nodes in MRI (table 8).

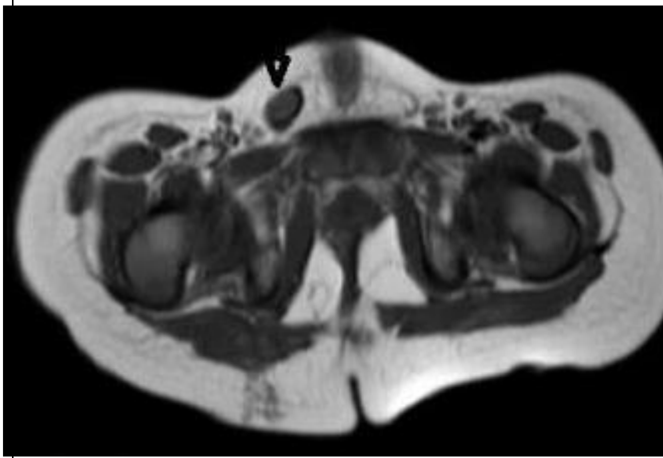
Table (8): Comparison of mean ADC values of undescended testes and lymph nodes

	Levene's Test*	**t-test for Equality of Means**			
	Sig.	***Sig.***	***M Diff.***	***95% CI of M Diff.***	
				Lower	***Upper***
Equal variances assumed	**0.9128**	**0.0818**	**0.2195**	**-0.0292**	**0.4682**
Equal variances not assumed		**0.0768**	**0.2195**	**-0.0250**	**0.4640**

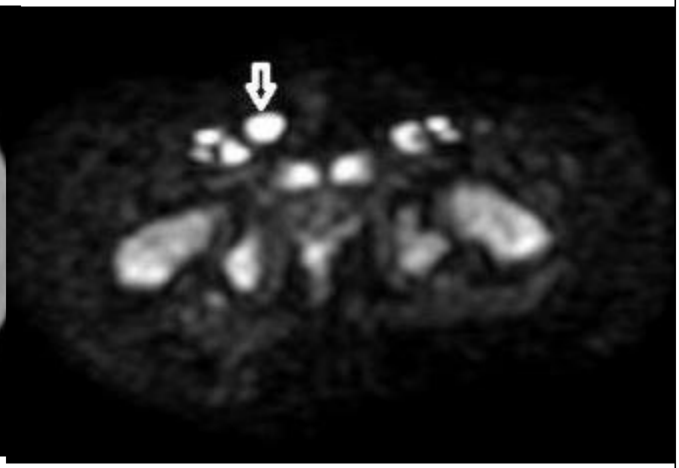
Sig.: Significance - M Diff.: Mean difference (difference between means of both groups) - CI: Confidence interval

*Tests the equality of variances of both groups

CASE 1



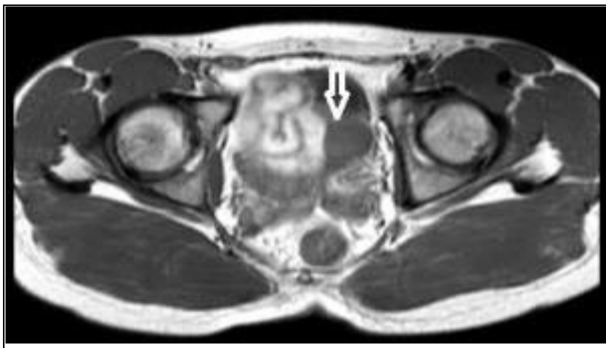
(A)axial T1WI



(B)axial DWI at b-value=800s/mm2

2 years old male patient, presented with right non palpable undescended testes, right intracanalicular UDT and low signal intensity on T1WI (a) **On DWIs:** it showed high signal intensity at b value of 800s/mm^2.

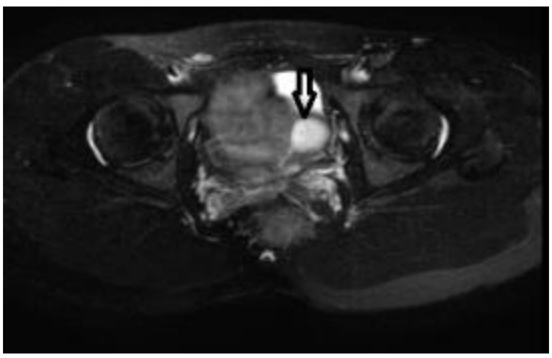
CASE 2



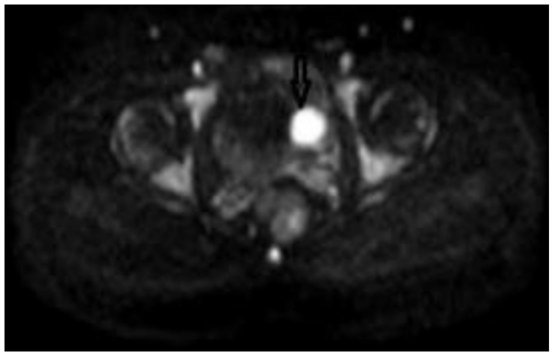
(a) axial T1WI

(b)axial T2WI

(c) Coronal Fat suppressed T2WI



(d)axial STIR

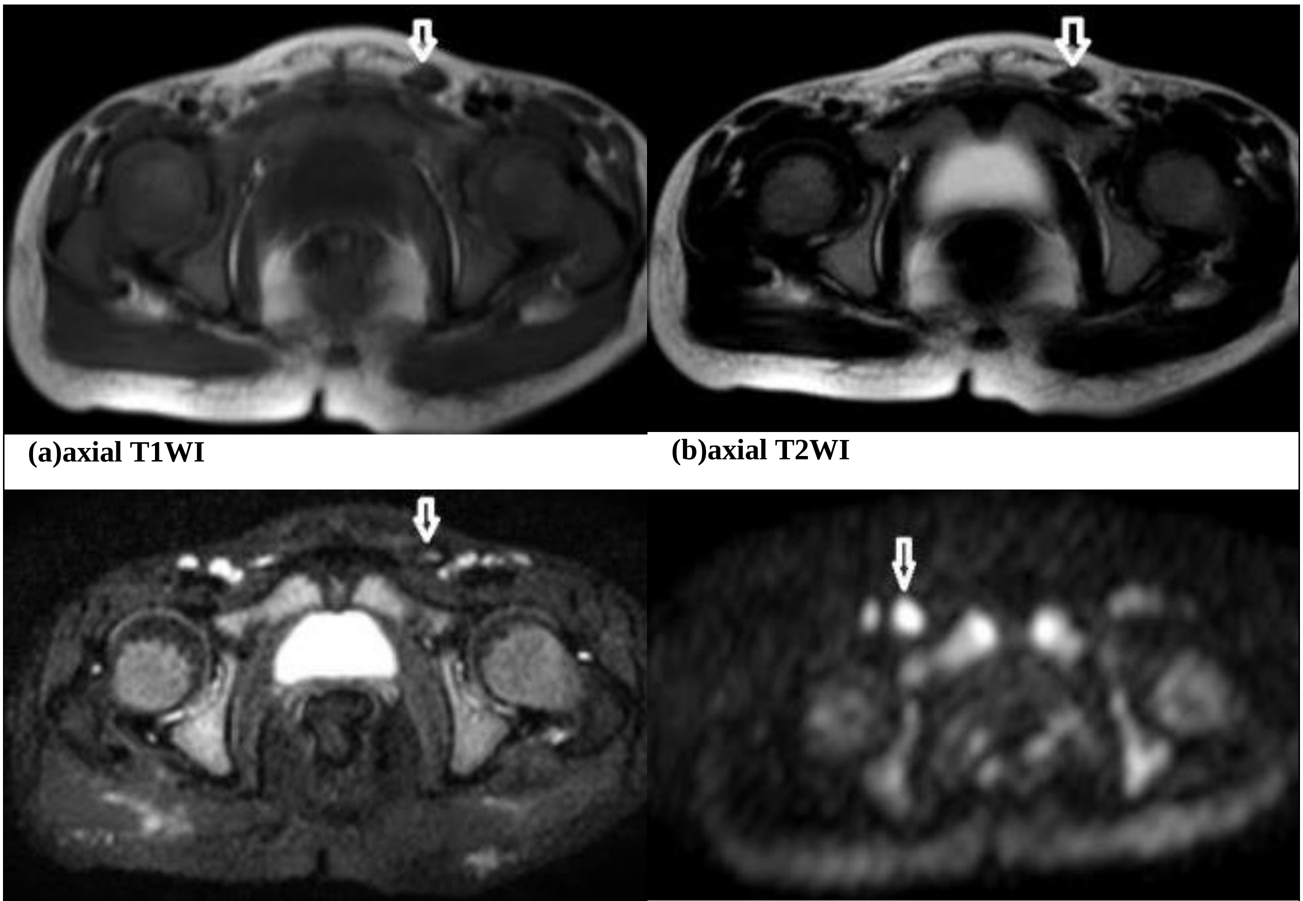


(e) axial DWI at b-value=800s/mm2

Axial T1WI shows a low-intensity testis (a), while the axial T2WI shows a high-intensity testis (b).

Fat-suppressed T2-weighted coronal and axial images shows the left intra-abdominal testis, bladder and bowel loops rich in fluid at almost the same high signal intensity(c &d). While DWI showed the testis at a markedly higher signal intensity (e).

CASE 3



(a)axial T1WI **(b)axial T2WI**

(c) axial STIR **(d) axial DWI** at b-value=800s/mm2
Left UDT did not shows any SI in DWI while inguinal LN shows high SI in the right side (arrow)

3 years old male patient, presented with left non palpable undescended testis, which seen atrophic intra-canalicular with low signal intensity on T1WI, T2WI (b) and STIR(c). On DWIs**:** not seen at b value = 800s/mm^2 however showed multiple high signal intensity lymph nodes (d).

DISCUSSION

Our study included 30 patients with 33 UDT (three patients had bilateral UDT), who were clinically diagnosed with non-palpable UDT. MRI including T1WI, T2WI, STIR and diffusion-weighted images at different b- values 50, 400 and 800 s/mm^2 were performed to all patients. The results of MRI were compared to laparoscopic findings. According to the laparoscopic evaluation, the final diagnoses of the location of UDT were 19 intracanalicular (57.6%), 10 intraabdominal (30.3%) and the testes were absent (testicular agenesis) in 4 cases (12.1%).

Adesanya *et al.* [(7)] found that ultrasonography is more accurate (86.5%) than clinical examination in the preoperative localization of undescended testes in children. This is true for intracanalicular testis, however ultrasonography cannot reliably localize abdominal testis or atrophic testis**.** However, Ultrasound is the least expensive and frequently used technique of all imaging tools. It had been shown to have low sensitivity in identifying non-palpable testicles preoperatively [(8)]**.**

In this study, all patients were initially diagnosed with US before MRI examination, where US detected only 18/33 cases of UDT, with diagnostic accuracy of 54.5%, sensitivity of 43%, and specificity of 87.7%. This is in agreement with findings of **Tasian *et al.*** [(9)] who found that US was poor at localizing non-palpable undescended testes, with reported sensitivity and specificity of 45% and 78% respectively. They stated that the site of undescended testis had a bearing effect on the benefit of ultrasound. Ultrasound was unable to differentiate nonviable nubbins from inguinal tissue and was adversely affected by the presence of bowel gas**.**

MRI is a noninvasive diagnostic technique and holds great potential for abdominal imaging. It does not entail ionizing radiation or intravascular contrast medium [(8)]**.** Even for MRI, which has greater sensitivity and specificity compared to ultrasound, if not identifying a testis it does not completely exclude its absence [8]. **Krishnaswami *et al.*** [8], reported that MRI has a fairly low sensitivity for identifying the presence of nonpalpable cryptorchid testicles (sensitivity of 62%). MRI is poor at locating both atrophied and intra-abdominal testicles but performs modestly well (expected sensitivity of 86%) in locating those in the inguino-scrotal regions.

In the current study, we found that conventional MRI had an accuracy of 81.8%, a lower sensitivity of 79.3%, and a higher specificity of 100% for diagnosing UDT. MRI diagnosed one case as testicular nubbin in the inguinal region, which was treated by orchiectomy. Histopathologic examination was performed after orchiectomy in this case, and confirmed diagnosis. In addition, it failed to detect three atrophic intra-abdominal cases which were confirmed by laparoscopy.

To increase the preoperative sensitivity in identifying nonpalpable UDT, conventional MRI alone may not be beneficial. Additional study is needed to determine if other forms of MRI such as, diffusion-weighted MRI may improve false-negative rates in order to make this form of imaging more useful in assessing boys with cryptorchidism [6].

The use of DWI as a non-invasive method aimed to facilitate the characterization of tissues at the microscopic level in a mechanism different from T1 and T2 relaxation. DWI depends on the diffusion of water molecules, which reflects the degree of cellularity of tissue [7].

In the testes, edematous tissue rich in intracellular water or highly cellular tissue composed of Sertoli and Leydig cells can show altered patterns of water diffusion. So, intra-abdominal testes are considered more cellular than the adjacent organs and tissues and can be detected easily on DWI to identify the non-palpable testes [10]. On images with a b value of 50 s/mm^2, fluid-containing structures such as the bowel contents, urinary bladder, and gallbladder have high signal intensity, and the testes have mild to low signal intensity. On images with a b value of 800 s/mm^2, the bowel contents are suppressed, and the testes have high signal intensity. Therefore, we can easily visualize undescended testes using DWI with a b value of 800 s/mm^2. High cellularity is best appreciated on images with a b-value of 800 s/mm^2 without a T2 shine-through effect. Therefore, this high b value is better in visualization of testicular tissue. However, there is an element of anatomic distortion at such a high b value. Therefore, anatomic pilot images (e.g. T1WI, T2WI and STIR) are useful in this situation for differentiating anatomic landmarks and borders [6].

In this study, T1WI, T2WI, STIR and DWI were performed during the same MRI examination. We compared the diagnostic performance of each MRI sequences for identification and localization of UDT. First the diffusion weighted images were reviewed alone. Then, the conventional MR images separately and finally the combined DWI and conventional MR images. Using DWI alone, we accurately localized 25/33 testes, which reported accuracy, sensitivity and specificity of 81.8%, 82.7% and 75% respectively. DWI failed to detect one case in inguinal canal, which appeared low SI in all conventional MRI sequences and in laparoscopy diagnosed as testicular nubbin. Therefore, DWI SI can be used as indicator for testis viability.

Using conventional MRI alone (T1WI, T2WI and STIR sequences). We localized 23/33 testes. They reported accuracy and sensitivity of 81.82%, 79.31% respectively. However, when we added DWI to conventional MRI, we localized 26/33 testes and both sensitivity, and accuracy were greater (sensitivity 86.21% specificity, 100% and accuracy 87.88%). This is in agreement with the previous findings of **Kantarci *et al.*** [6] who investigated the diagnostic performance of DWI and MRI in localizing non-palpable undescended testes. When they used conventional MRI alone, they identified 29/38 testes with a sensitivity of 85%, a specificity of 100 % and accuracy of 84% respectively. Using DWI alone, they found a sensitivity of 82%, a specificity of 75% and accuracy of 84%. A combination of DWI and MRI enabled the accurate identification of 31/38 testes with a sensitivity of 88%, accuracy of 86% and specificity 100%.

Emad-Eldin *et al.* reported higher results. They found that when DWI was used alone, a sensitivity of 93%, a specificity of 87% and accuracy of 91.5% were reported. Adding DWI to conventional MRI, the results increased to a sensitivity of 93%, a specificity of 100%, and accuracy of 95.70%. It was difficult in some cases to differentiate between reactive lymph nodes and testes at the inguinal region utilizing DWI alone as both structures display high signal. However, the combined conventional and DWI proved to be efficient in these cases as the testes showed higher signal intensity than lymph nodes on STIR [2].

There was a sharp contrast between the testes and surrounding tissues obtained by adding fat-suppressed T2-WI. However, they found that it was difficult to identify the testes by fat-suppressed T2-WI when the amount of fluid retained in the intestinal tract was large. In this situation, DWI was the most effective technique [3].

In this study, we found that adding DWI to the conventional MRI in assessment of UDT before laparoscopy was helpful in detection of testicular viability before the operation. One case was diagnosed as testicular nubbin by MRI in inguinal canal because of its smaller size than the contralateral normal descendent testis and displayed low SI on T1WI, T2 WI and on DWI. The diagnosis was confirmed by laparoscopy. It was treated by orchiectomy. However, combination between DWI and conventional MRI failed to detect four atrophied testes intraabdominal, two diagnosed as testicular nubbins and two dysplastic testes by laparoscopy both of them treated by orchiectomy.

ADC values were obtained for 24 undescended testes and 33 nearby lymph nodes. Mean ADC value for the testes was 1.167 $x10^{-3}mm^2/s \pm 0.341$, while mean ADC value for lymph nodes was 0.947 $x10^{-3}mm^2/s \pm 0.389$. Comparing the means of ADC values of undescended testes and lymph nodes reveled no significant difference (p = 0.0818) in this study. The mean difference between testes and lymph nodes showed that the average ADC value of the testes could be less than (up to -0.0292) or more than (up to 0.4682) the average ADC value of a nearby lymph node. These findings imply that ADC values cannot be used to differentiate between undescended testes and lymph nodes in MRI. This is in disagreement with the results of **Al-Gebally *et al.*** [(11)] who found that Mean testicular ADC value of undescended testes was 1.037 X $10^{-3}mm^2/s \pm 0.107$, and the mean ADC value of the neighboring nodes was 1.412 X $10^{-3}mm^2/s \pm 0.16$. When they used the independent Samples *t*-test and the difference was statistically significant (*p*-value <0.005). Therefore, they suggested that ADC value difference is helpful to differentiate lymph nodes from undescended testes. Moreover, they suggested that 1.2 X $10^{-3}mm^2/sec$ can be used as a cutoff value to differentiate between testes and lymph nodes**.**

In current study, we found some cases have ADC values higher than contralateral normal testis, however; these testes displayed normal SI on conventional MRI (low on T1WI and high on T2WI) and have normal size. Moreover, after laparoscopy, these testes were found normal shape and size with orchiopexy was done. Therefore, we recommended that these cases need further follow up by conventional MRI and DWI to follow the changes that will affect them.

Based on our findings, we suggest that a combination of DWI and conventional MRI including fat-supp. T2WI sequence is the most accurate means of detecting and localizing non-palpable undescended testes. The findings of DWI complement the information on the location of undescended testes obtained with conventional MRI. In addition, DWI is helpful in detection of testicular viability or atrophy properly before the operation.

CONCLUSION

We found that by adding DW images to the conventional MR images enabled the accurate identification of the undescended testes. In addition, DWI was helpful in detection of testicular viability or atrophy properly before the operation. Our results confirm that DWI findings complement the information on the location and viability of undescended testes obtained with conventional MRI before laparoscopy.

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