Research Article

The role of diffusion–weighted MRI in the evaluation of non-palpable undescended testis

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Abstract

Background: Cryptorchidism is the absence of one or both testes in the scrotum and is generally synonymous with undescended testis, in 20% of these cases undescended testis is clinically nonpalpable, we employed diffusion weighted imaging (DWI), as well as conventional magnetic resonance imaging (MRI) to increase sensitivity of diagnosis of the non-palpable testis. **Objective:** To evaluate role of diffusion weighted MRI in the detection of non-palpable undescended testes. **Patients and Methods:** twenty boys with unilateral undescended testis underwent preoperative abdominal and pelvic MRI to identify the location of the testis. MRI included free-breathing Diffusion-weighted imaging (DWI) with b values of 300 and 600 s/mm2, T1 and T2-weighted sequence, and T2-weighted fat-suppressed sequence, after surgical operation, two observer groups reviewed the preoperative images, starting with DW images alone, then the conventional MR images alone and after that the conventional-MR and the DW images together. Sensitivity, in the identification of nonpalpable undescended testis was calculated for DWI, conventional MRI, and the combination of DWI and conventional MRI. ***Results:*** The combination of DWI and conventional MRI was the most sensitive for detection of non-palpable undescended testis. The two observers detected 12 testes with this technique. Sensitivity 92.3 % for two observers, and. With DWI alone, observer 1 located 11 testes, and observer 2, located 12 testes (sensitivity 84.6% and 92.3%) respectively, by using conventional MRI alone, both observers located 10 testes (sensitivity, 76.9%). The sensitivity for locating testis was superior with the combination of DWI and conventional MRI for both observers. ***Conclusion:*** Use of DWI with a high b value gives information that complements conventional MRI findings, improving identification and location of non-palpable undescended testes. We recommend the use of DWI in addition to conventional MRI to increase the preoperative sensitivity of identifying and locating non-palpable testes.

Keywords: non-palpable undescended testes, MRI, DWI

INTRODUCTION

Cryptorchidism is the absence of one or both testes in the scrotum and is generally synonymous with undescended testis.[1]

Most of undescended testis will be corrected spontaneously by the age of 1 year, but 0.8% of boys continue to have undescended testis.[2] The incidence of undescended testis varies from 21% in preterm infants to 1.8-4.0% in term boys.[3] 80% of undescended testes clinically palpable and 20% are non-palpable.[4] The term non-palpable testis implies that the testis cannot be detected on physical examination.[5]

The literature reports that nearly half of viable non-palpable testes (NPT) are in an abdominal position and 5% are in the inguinal canal, The remaining 45% are atrophic

or absent, mostly as a result of in utero spermatic cord torsion and are located abdominally, inguinally or scrotally.[6,7] Accurate diagnosis and appropriate treatment lead to the highest chance of proper testicular function in an endocrine capacity, that is, with regard to fertility; in addition, accurate diagnosis can facilitate early detection of malignant tumors.[8, 9]

Preoperative location of the testis aids in a planned surgical approach, reducing the extent of exploration and anesthesia time, Imaging techniques for locating undescended testes therefore are important.[1]

Different diagnostic modalities have been used for detection and localization of non-palpable testis including ultrasonography, computed tomography (CT) and magnetic resonance imaging (imaging techniques) and laparoscopy (visualization).[10]

Ultrasound proved to be useful in localizing the testes within the inguinal canal but it shows difficulty in differentiating enlarged inguinal lymph node and testis. It usually fails to visualize intra-abdominal testes.[11]

Also, difficulties arise in fatty and uncooperative young patients; furthermore, the accuracy of ultrasound depends on the skill of the operator.[12]

With CT the non-palpable testis is more easily identified and can be distinguished from the contents of the cord and enlarged lymph nodes.[13]

However, CT has never been reported to have enabled identification of high abdominal testis, its main disadvantage is the associated radiation hazard to the testes.[14]

MRI is noninvasive, does not involve ionizing radiation, does not entail intravenous contrast and has the potential for tissue characteristic and yields multi-planar images.[15] Laparoscopy has been established as the most reliable diagnostic technique for the identification of nonpalpable testes However, it is invasive.[1, 16-17]

MR images of both normal and undescended testes show ovoid appearance which is hypo intense to fat on T1-weighted images while on T2-weighted images typically they are hyper intense or iso-intense to fat with surrounding black out-line. The mediastinum testis is visualized as a low-signal-intensity band within the testis which improves the specificity in diagnosis. The atrophic testis is diagnosed by its small size and the low signal intensity on both T1 and T2-weighted images. On coronal views, an inguinal testis is located along the course of a linear low-signal-intensity structure which extends to the scrotum.[18]

With DWI technique, information is extracted on the diffusion of water molecules, which reflects the degree of cellularity of tissue. A different image is produced than with conventional MRI sequences. Use of DWI therefore facilitates characterization of tissue at the microscopic level in a mechanism different from T1 and T2 relaxation.[19]

DWI is a non-invasive method to visualize changes in the translational (Brownian) motion of water molecules, and can provide tissue contrast, thus differing from conventional MRI.[20] 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.[21]

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.[22]

Atrophic testes show low signal intensity on the T2 – weighted images, the signal intensity of the testes was low because of its smaller size and remarkable atrophy in the seminiferous tubules, on diffusion, however, the signal intensity was low owing to the hypocellularity of the atrophic testes, so it can be speculated that testes with low signal intensity on DW are no longer viable.[23]

Fat-suppressed T2- weighted imaging was considered suitable for distinguishing between the testes and lymph nodes, as the lymph node has lower signal intensity than the testes.[24]

Non-malignant lymph nodes have homogeneous high signal intensity on images obtained at a b value of 0 s/mm^2, whereas they have low signal intensity at a b value of 1,000 s/mm^2.[25]

Diffusion-weighted MRI (DWI) of the abdomen and pelvis, which has been widely used for diagnostic purposes, entails a contrast mechanism for evaluating pathologic changes in solid abdominal and pelvic organs.[26] On images with low b value, 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 high b value of 800-1000 s/mm2, the bowel contents are suppressed, and the testes have high signal intensity, therefore, we can

easily visualize undescended testes using DWI with a high b value.[23]

Studies have shown that adding DWI to a routine MRI examination increases diagnostic accuracy of undescended testis.[27, 28] Our aim is to evaluate the role of diffusion- weighted MRI in the evaluation of non-palpable undescended testes.

PATIENTS AND METHODS

This prospective study was conducted in the department of radiology MRI unit of Al-Yarmouk teaching hospital from November 2012 to the end of February 2013. Twenty boys with age range between 4-13years, mean age 7 year were suspected having undescended testes by clinical and ultrasound examination. All those patients were referred from pediatric surgery department in pediatric hospital center, surgical department in Al-Yarmouk teaching hospital & all patients-parents provided informed verbal consent.

All MRI examinations were performed with a 1.5-T MRI system (Achieva Philips) with high performance gradient the patients underwent MRI with a free breathing axial turbo spin-echo T1- weighted sequence (TR/TE, 498 /10), axial T2 and coronal fat-suppressed turbo spin echo T2-weighted sequence (1073 /80), and an axial DWI image , slice thickness =3-5 mm ; gap =2 mm including the images with b value of 300 ,and 600 s/mm^2 ,were reviewed DW image alone ,then the conventional MR ,and finally the combined DW and conventional MR image .

- Two observer groups reviewed images. Each group was composed of two specialist radiologists. Three sets of images were reviewed by each observer group for each of the 13 cases included in the study (MRI only, DWI only, MRI + DWI). The image sets for each case was separately presented to observer groups, and in a random fashion, with the observer groups blinded to case identity. Decision on each set of images was reached by consensus within each observer group.

- Statistically: McNemar test was used to compare different MR protocols for both observer-groups. Inter-observer agreement was tested with Kappa statistics. Differences with a p-value of less than 0.05 were considered statistically significant.

RESULTS

This is a prospective study of 20 healthy-boys with unilateral non-palpable undescended testis their age ranges of (4-13 years) and mean age was 7 years ,all the boys underwent MRI image for identification of the non-palpable testes and the result were compared with surgical findings, Two observer groups reviewed the images. About 7 cases were negative on all MRI protocols while 13 cases were with positive findings; three sets of images were reviewed by each observer group for each of the 13 cases included in our study (MRI only, DWI only, MRI + DWI). The two observers detected 12 /13 testes with (MRI +DWI). With DWI alone, observer **1** located 11/13 testes, and observer **2**, located 12/13 testes, while by using conventional MRI alone, both observers located 10/13 testes.

The two observer-groups show that the combination of DWI and conventional MRI was the most sensitive technique ,facilitating visualization and location of 12 testes by two observer 92.3 %,using diffusion alone ,observer **1** and **2** visualized and located 11 and 12 testes with sensitivity 84.6 % and 92.3% respectively ,both observer-groups visualize and located 10 with conventional MRI the sensitivity 76.9%. [table1]

Table 1: Sensitivity of protocols in the two observer groups.

Protocol	Sensitivity	95% Confidence Interval
Observer Group 1		
MRI	76.9%	(46.0% - 93.8%)
DWI	84.6%	(53.7% - 97.3%)
MRI + DW	92.3%	(71.7% - 95.3%)
Observer Group 2		
MRI	76.9%	(46.0% - 93.8%)
DWI	92.3%	(62.1% - 99.6%)
MRI + DW	92.3%	(71.7% - 95.3%)

Using McNemar test, we found statistically non-significant differences in sensitivity between different protocols:
DWI and MRI (p = 1.00 for observer group 1, p = 0.62 for observer group 2),
MRI + DW and MRI (p = 0.25 for observer group 1, p = 0.25 for observer group 2),
MRI + DW and DWI (p = 0.48 for observer group 1, p = 1.00 for observer group 2). [Table 2]

Table 2: Comparison of protocol sensitivity in the two observer groups.

Protocol	Sensitivity	McNemar Test p-value
Observer Group 1		
DWI vs. MRI	DWI > MRI	1.00
MRI + DW vs. MRI	MRI + DW > MRI	0.25
MRI + DW vs. DWI	MRI + DW > DWI	0.48
Observer Group 2		
DWI vs. MRI	DWI > MRI	0.62
MRI + DW vs. MRI	MRI + DW > MRI	0.25
MRI + DW vs. DWI	MRI + DW > DWI	1.00

Kappa Analysis

The two observers agreed on 38 of 39 assessments (97.4%) (κ = 0.88). Using the DW images, the two observers agreed on 13 of 13 assessments (100%) (κ = 1.00) compared with 37 of the conventional MR images (0.97) (κ = 0.89) and 36 of the combined conventional MR and DW images (0.94) (κ = 0.95)

Table 3: Kappa test for inter-observer agreement between the two observer groups.

Agreement	Percent Agreement	Kappa	Strength of Agreement
MRI	100% (13 of 13)	1.00	Perfect
DWI	92.3% (12 of 13)	0.63	Good
MRI + DW	100% (13 of 13)	1.00	Perfect
Total	97.4% (38 of 39)	0.88	Very good

At surgical finding, testes were identified in intra-canalicular location in 9 (69.2%) as seen in (fig. 1),

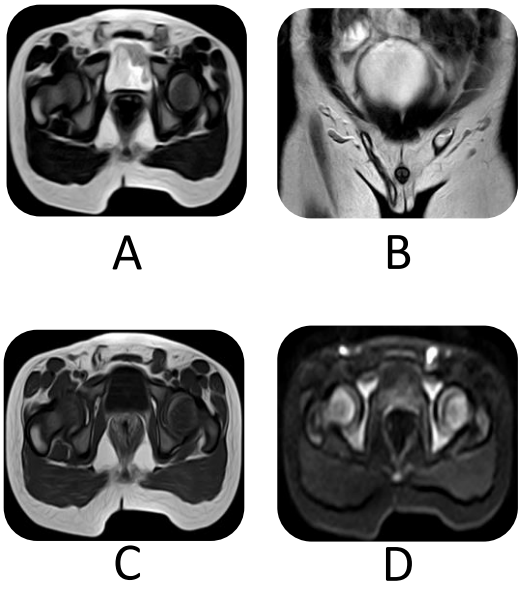

Fig.1- 6-years boy with intra-canalicular non-palpable Undescending testes (left testis) A. axial T2 weighted MR image B. coronal T2 weighted MR image C. axial T1 weighted MR image (show hypo intense on T1 and Iso to hyper intense in T2) D .diffusion-weighted MR image with b value of 600 s/mm show markedly hyper intense testis.

Lower intra-abdominal location 3 cases (23.1 %) as seen in figure (fig. 2),

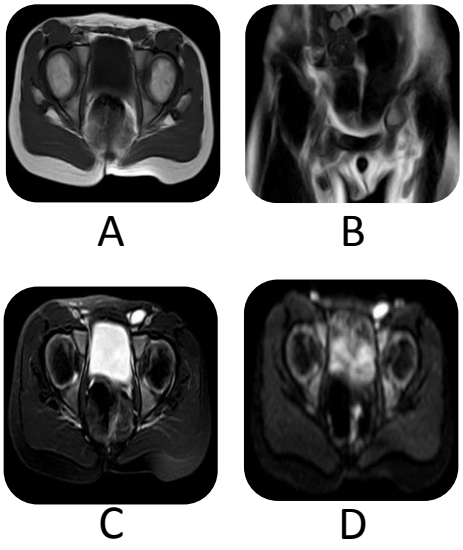

Fig 2. 11-years boy with low intra-abdominal non-palpable undescended testis (left testis) Axial T1 weighted MR image B. coronal T2 weighted MR image C. fat suppression T2 weighted MR image (testis show hypo-intense in T1 , hyper intense on T2 , testis just proximal to left internal ring) D. diffusion-weighted MR image with b value of 600 s/mm show markedly hyper intense testis.

& lastly one case presented with high intra-abdominal location (7.7%). Of the 13 cases, 4 right sided (30.8%) and 9 left sided (69.2%) [Table 4]

Table 4: Location-based distribution of nonpalpable undescended testes according to surgical findings.

Location	Intracanalicular	Lower intra-abdominal	High intra-abdominals	Total
Right sided	2	1	1	4 (30.8)
Left sided	7	2	0	9 (69.2)
Total	9 (69.2)	3 (23.1)	1 (7.7)	13 (100)

Note: Values in parentheses are percentages.

DISCUSSION

Twenty boys with non-palpable undescended testes were included in our study. age ranges between (4-13 yrs.) ; 7 cases had negative finding (4 with bilateral testes and 3 of them unilateral),13 cases show positive finding ; for each patient, MRI were performed as a noninvasive diagnostic technique that hold great potential for abdominal imaging as well as it does not entail ionizing radiation or intravascular contrast media , T1- and T2 and fat-suppressed T2- weighted imaging , as well as DWI, axial and coronal view were performed during the same MRI examination, and the imaging results of positive finding were compared with surgical findings.

According to surgical finding about 9 cases identify intra-canalicular location 69.2 % , and 3 just proximal to internal ring 23.1% and one of them intra-abdominal 7.7%, 69.2% left sided and 30.8% right sided; compared with other study done by Mecit Kantarci et al.[23] which identify 50% intracanalicular , 29% lower intra-abdominal, 10.5% high intra-abdominal , 55.3% right sided and 34.2% left sided .

We compared the performance of two observers with different levels of experience in interpreting the MRI findings. With MRI alone, the two observer detected 10/13 cases, the sensitivity was 76.9% for both observers; Kanemoto et al.[16] used MRI for the diagnosis of nonpalpable testis found that MRI can be expected to have sensitivity of 86%; Sarihan et al.[29] found that MRI had sensitivity of 78.6% ; Mecit kantarci et al.[23] show that sensitivity of MRI 85 % ; Desireddi et al. [30] shows that the sensitivity of 74% in the detection of non-palpable undescended testis, only conventional MRI techniques were used in these studies ,and their results are consist with our study .

The sensitivity of detection of non-palpable testes increase with the use of DWI alone as observer 1 detected 11/13 and observer 2 detected 12/13 therefore the sensitivity was 84% and 92.4 % for observer 1 &2 respectively and 92.3 % after the use of combined DWI and MRI ,this result consistent with the study done by Mecit Kanarci et al.[23] ;as they found a sensitivity of 91%.

By comparing the sensitivity of three protocol in this study we found that the combined DWI+MRI more sensitive than using DWI alone and DWI more sensitive than MRI alone also by using McNemar test there was no statistically significant differences in sensitivity between MRI protocols this due to small sample size used in this study compared with other studies, and the inability to use the laparoscopy as a gold standard for diagnosing undescended testis.

In this study all patients had known non-palpable undescended testis and were otherwise completely healthy, therefore misdiagnosis of an infected lymph node with undescended testis in the inguinal region was unlikely, so there were no false positive cases detected, for these reasons we were unable to calculate specificity and accuracy.

In conclusion combining DWI with conventional MRI sequences improve the sensitivity for detection of nonpalpable undescended testis; however, in this study there were no significant differences in sensitivity among different protocols used (MRI only, DWI only, MRI with DWI), due to small sample size recruited for this study. We conclude that the information from DWI with high b value complements that from conventional MRI to improve visualization of undescended testis.

References

1. Williams EV, Appanna T, Foster ME, et al. Managementof the impalpable testis: a six year reviewtogether with a national experience. ***Postgrad Med J*** 2001; 77:320–322
2. Elder, J.S.: Disorders and anomalies of the scrotal contents. In:Nelson Textbook of Pediatrics. Eds. Behrman, R.E.; Kliegman,R.M. and Jenson, H.B,. W.B. Saunders Co., Philadelphia, 2000, P. 1650-165.
3. Poenaru D, Homsy YL, Peloquin F, Andze GO. Laparoscopic management of the impalpable abdominal testis. ***Urology*** 1993;42: 574-578.
4. Elder JS**.**The undescended testis:hormonal and surgical management*Surg* ***Clin North Am*****1988**;68: 983–1006
5. Schneck FX, Bellinger MF**.** Abnormalities of the testes and scrotum and their surgical management. In Wein AJ, Kavoussi LR, Novick AC, Partin AW, Peters CA eds. *Campbell-Walsh Urology*, 9th edn,Vol.

IV.Chapt127.Philadelphia: Saunderes Company, 2007: 3761–98

6. Elder JS (2002) Ultrasonography is unnecessary in evaluating boys with a nonpalpable testis. ***Pediatrics*** 110:748–751.
7. Moore RG, Kavoussi LR, Bloom DA et al (1995) Postoperative adhesion formation after urological laparoscopy in the pediatric population. ***J Urol*** 153:792–795.
8. Kucheria R, Sahai A, Sami TA, et al. Laparoscopic management of cryptorchidism in adults. ***Eur Urol*** 2005; 48:453–457
9. Chew G, Hutson JM. Incidence of cryptorchidism and ascending testes in trisomy 21: a 10 year retrospective review. ***Pediatr Surg Int*** 2004; 20:744–747
10. Ho, K.M.; Nicholson, M.L.; Wastie, M.L. and Wenham, P.W.: Localization of intra-abdominal testis by magnetic resonance imaging. ***Br. J. Urol.;*** 1992, 70(2) : 215.
11. Hrebinko, R.L. and Bellinger, M.F.: The limited role of imaging techniques in managing children with undescended testes. ***J. Urol.;*** 1993, 150 : 458-460.
12. Wolverson, M.K.; Houttuin, E.; Heiberg, E.; Sundaram, M. and Shields, J.B. : Comparison of computed tomography with high resolution real-time ultrasound in the localization of the impalpable undescended testis. ***Radiology,*** 1983, 146 : 133.
13. Kier, R.; McCarthy, S. and Rosenfield, A. : Non-palpable testes in young boys : Evaluation with MR imaging. ***Radiology***, 1988, 169 : 429-433
14. Troughton, A.H.; Waring, J. and Longstaff, A.: The role of magnetic resonance imaging in the investigation of undescended testes. ***Clinical Radiology***, 1990, 41 : 178-181.
15. Fritzsche PJ, Hricak H, Kogan BA, et al. Undescended testis: value of MR imaging. ***Radiology*** 1987; 164:169–173
16. Kanemoto K, Hayashi Y, Kojima Y, et al. Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of nonpalpable testis. ***Int J Urol*** 2005; 12:668–672
17. Mathers MJ, Sperling H, Rübben H, et al. The undescended testis: diagnosis, treatment and longterm consequences. ***Dtsch Arztebl Int*** 2009; 106:12
18. Dalia Nabil and Hatem Gaafar. Localization of non-palpable testes in childhood : magnetic resonance imaging vs. laparoscopy. ***Egyptian Journal of Surgery*** 2000,Vol. (19), No. (4).
19. Kato H, Kanematsu M, Tanaka O, et al. Head and neck squamous cell carcinoma: usefulness of diffusion-weighted MR imaging in the prediction of a neoadjuvant therapeutic effect. ***Eur Radiol*** 2009;19:103–109
20. Umeoka S, Koyama T, Saga T*et al*.Ectopically located gonads in a patient with mixed gonadal dysgenesis: detectionby diffusion-weighted MRI. Abdom Imaging***. AJR*** 005;30: 637–40
21. Gauvain KM, McKinstry RC, Mukherjee P*et al*. Evaluating pediatric brain tumor cellularity diffusion-tensor imaging. ***AJR*** 2001; 177 : 449–54
22. Koh DM, Collins DJ. Diffusion-weighted MRI in the body: applications and challenges in oncology. ***AJR*** 2007; 188:1622–1635
23. Mecit Kantarci, Selim Doganay, Ahmet Yalcin, Yilmaz Aksoy, Bahar Yilmaz-Cankaya, Bedii Salman. Diagnostic Performance of Diffusion-Weighted MRI in the Detection of Nonpalpable Undescended Testes: Comparison With Conventional MRI and Surgical Findings. ***AJR***:195, October 2010.
24. Joseph PM, Shetty **A.** A comparison of selective saturation and selective echochemical shift imaging techniques. ***Magn Reson Imaging*** 1988; **6**: 421–30
25. 25. Abdel Razek AA, Soliman NY, Elkhamary S,Alsharaway MK, Tawfik A. Role of diffusionweighted MR imaging in cervical lymphadenopathy. ***Eur Radiol*** 2006; 16:1468–1477
26. Matsuki M, Inada Y, Tatsugami F, et al. Diffusion weighted MR imaging for urinary bladder carcinoma: initial results. ***Eur Radiol*** 2007; 17:201–204
27. Bammer R, Auer M, Kelling SL, et al. Diffusion tensor imaging using single-shot SENSE-EPI. ***Magn Reson Med*** 2002; 48:128–136.
28. 28. Naganawa S, Sato C, Kumada H, et al. Apparent diffusion coefficient in cervical cancer of theuterus: comparison with the normal uterine cervix. ***Eur Radiol*** 2005; 15:71–78
29. Sarihan H, Sari A, Abeş M, et al. Nonpalpable undescended testis: value of magnetic resonance imaging. ***Minerva Urol Nefrol*** 1998; 50: 233–236.
30. Desireddi NV, Liu DB, Maizels M, Rigsby C, Casey JT, Cheng EY.Magnetic resonance arteriography/venography is not accurate to structure management of the impalpable testis. ***J Urol*** 2008;180:1805–9.