Role of MRI Versus Ultrasonography in Localization of Undescended Testicles

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Abstract:Objective: Evaluate role of Ultrasonography versus Magnetic Resonance Imaging in localization of undescended testes.
Patients and Methods: This prospective study included 50 patients with age ranges from 3 months to 25 years presenting with undescended testes. Scrotal, pelvis and abdominal ultrasonography was done with superficial linear 7.5 MHZ and deep curved 3-5 MHZ transducers. MRI examination was done without contrast from the renal area above to the scrotal region below will be covered for localization undescended testes. Testes were classified according to location into three anatomic regions: intracanalicular, low intra-abdominal and high intra-abdominal. Laparoscopy was done for all cases as diagnostic and therapeutic tool and was considered as a golden standard.
Results: Ultrasonography revealed a sensitivity, specificity and accuracy of 45.71%, 91.67% and 64.41% respectively. MRI showed a sensitivity, specificity and accuracy of 91.43%, 87.50% and 89.83% respectively in localization undescended testes.
Conclusion: MRI is considered as an accurate examination for detection and localization of the undescended testes in comparing with ultrasonography. However, laparoscopy would be recommended as diagnostic and therapeutic tool.[Mohammad Mostafa Sayed,Sherief Kamal Hussein Eid, Mohammed Ramadan Rihan and Mohammed Gamal Moustafa Alashry.
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1.Introduction

Undescended testicle, is a condition in which one or both testicles are not appropriately positioned in the scrotum at birth. It is the most common congenital genitourinary anomaly in boys and has an incidence of 1-3% in term and 15-30% in premature male infants **(Ehab Ali Abd-ElGawad et al., 2015)**.Accurate pre-surgical localization of the testicle could spare a child an operation in the setting of an absent testicle or limit the extent of surgery if the testicle can be definitively identified. However, the potential benefits of imaging must be weighed against its risks, costs, and whether it provides information critical to the care of the child with undescended testicle **(Gregory E. Tasian et al.,2011)**. At present, (US) and (MRI) are used for diagnosing a non-palpable testis, because they are basically non-invasive, and do not involve ionizing radiation (**Ehab Ali Abd-ElGawad et al., 2015)**.MRI does not involve ionizing radiation and thus makes it a more attractive imaging modality for pediatric patients. However, MRI is expensive, not as readily available, and often requires that children are sedated or anesthetized **(Gregory E. Tasian, et al.,2011)**.The aim of this study is to evaluate therole of MRI versusultrasound in localization undescended testicles.

2. Patient and method

This prospective study was conducted during the period between April 2016 andMarch 2017 at the Radiodiagnosis Department, Al-AzharUniversity, New Damietta on 50 patients who clinically diagnosed asundescended testes. Written and verbal consents were obtained from all patients, parents of the young patients (less than 16 yrs old) as well as an agreement of the local ethics committee. Additional informed consent for sedation before MRI examination was obtained from 15 patients parents.

Inclusion criteria:

Patients who diagnosed by physician with absence of testis in the scrotum.

Exclusion criteria:

Patients above 25 years or below 3 months, patientswith contraindication to MRI andpatients with disorders of sexual development or ambiguous genitalia.

All patients were subjected to the following:

***1*-History taking:** Patient's age and complaints of empty scrotal sac on one or both sides.

***2*-Clinical examination:**Was done by the referring physician.

***3*-Ultrasound examination:**

Patient preparation for ultrasound:

Patient fasting for 3-6 hours before the examination. The ultrasound was performed with TOSHIBA (Xario200) with superficial transducer linear 7.5 MHZ anddeep curved 3-5 MHZ transducer. Scrotal,pelvis and abdominal ultrasound was done. On ultrasound normal undescended testis seen as oval structures having a homogeneous granular echo texture with uniform medium-level echoes along the path of testicular descent parallel to the course of gonadal vessel. The atrophied/small testis may appears normal, hypoechoic or of mixed normechoic and hypoechoic pattern due to ischemia.

***4*-MRI examination:**

Patient preparation for MRI:

1. Explain to the patient (or their parents) the procedure and make sure there is no contraindication for MRI.

2. Children below 6 years were well sedated with chloral hydrate with dose according to body and well immobilized during the examination.

Patient position during MRI examination:

Patient lie on supine position with his arms around his head and body coil around the abdomen and pelvis covering the renal area above to the scrotum region below.MRI examinations were performed with a 1.5-T MRI system (Achieva; Philips Medical Systems) using a body coil. Abdomen from the renal area above to the scrotal region below was covered. MRI protocol parameter was demonstrated in (Table1).

Table (1): MRI protocol parameters.

MRI Protocol Sequences	TR (ms)	TE (ms)	Matrix	FOV* (mm)	No.of acquisitions(NXA)	No. of slices	Slice thickens (mm)	Inter-slice gap (mm)
Axial T1	400-600	10-20	256X256	300-350	2-5	25	3-5	0.5-1
Axial T2	3000-4000	80-100	256X256	300-350	2-5	25	3-5	0.5-1
Axial T2STIR	3000-4000	80-100	256X256	300-350	2-5	25	3-5	0.5-1
Coronal T1	400-600	10-20	256X256	300-350	5	25	3-5	0.5-1
Coronal T2	3000-4000	80-100	256X256	300-350	5	25	3-5	0.5-1
Coronal T2 STIR	3000-4000	80-100	256X256	300-350	5	25	3-5	0.5-1
Diffusion	3000-4000	70-90	256X256	250-300	5	25	3-5	0.5-1

FOV*: Field of view

***5*- Image analysis:**

All MRI images were transferred to radiologist which recorded the presence or absence and the location of UDT.First the diffusion weighted images, including the images with b value of 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, 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 intra-abdominal. Testes close to and below the inguinal internal ring were considered intra-canalicular and so have low location. Testes above the internal ring were classified as having low intra-abdominal location around the iliac vessels. Testes more than 3cm away from the internal ring were classified as having a high intra-abdominal location. On conventional MR images, elliptic areas of homogeneous low to intermediate signal intensity on T1, high signal intensity on T2 and fat-suppressed T2-WIswere recorded as undescended testes. The atrophic testis showed a low signal intensity on T1, T2, Fat-Suppressed T2WIs and on DWI compared to viable testis. On the combined DWI and conventional MR images, the conventional MRI was used for anatomic location of hyperintense elliptic areas on the DW images. The results of MRI were confirmed by laparoscopic findings, the latter is considered the golden standard. The mean duration between MRI and laparoscope was about 1 month ± 2 weeks. The results of ultrasound and MRI were considered positive when a testis was identified before the laparoscope.

***6*-Statistical analysis:**

Data were statistically described in terms of mean ± standard deviation (± SD), and range, or

frequencies (number of cases) and percentages when appropriate. Agreement between observers was done using Kappa statistic. Comparison of sensitivity and overall accuracy between the different techniques was done using Chi squared 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 15 for Microsoft Windows (2006).

3.Result

This prospective study include 50 patients with age ranged from 3 months to 25 years and mean age 7.98 years ± SD 6.92 (Table 2). Forty one cases were clinically diagnosed as unilateral UDT (15 on the right side and 26 on the left side) with 9 cases clinically diagnosed as bilateral UDT.

Table 2: Age groups.

Age groups	Number	Percentage
3 months-8 years.	29 case	58%
8 years -17 year	15 case	30%
17 year – 25 year	6	12%

All patients underwent laparoscopy to determine the actual location of UDTs.According to the laparoscopic evaluation, the final diagnoses of the location of UDT were: intracanalicular (number = 24, 40.6%), lower intra-abdomen (number =6, 10.1%), high intra-abdominal (number = 5, 8.4%), absent (number =24,40.6%) as shown in (Table 3).

Table 3: Location-based distribution of undescended testes according to laparoscopic findings (number = 59).

Location	Intracanalicular	Lower abdomen	Higher abdomen	Absent
Number	24	6	5	24
%	40.6%	10.1%	8.4%	40.6%

Abdominal, pelvic and scrotal US scans were performed to all patients. US detected 38/59 cases of UDT, with diagnostic accuracy of 64.41% (14 in intracanalicular location, 1 in the lower abdomen intimately related to iliac vessels, 1 in the high abdomen and 22 cases not visualized at all, along the pathway of testicular descent in the abdomen, pelvis, inguinal canal and scrotum as shown in (Table 4).

Table 4: Identification of UDT by ultrasonography (number = 59).

Location	Intracanalicular	Lower abdomen	Higher abdomen	Absent	Total
Identified	14 (23.7%)	1 (1.6%)	1 (1.6%)	22 (37.2%)	38 (64.4%)
Not identified	10 (10.9%)	5 (8.4%)	4 (6.7%)	2 (3.3%)	21 (35.5%)
Total	24 (40.6%)	6 (10.1%)	5(8.4%)	24 (40.6%)	59 (100%)

The accuracy, sensitivity, specificity, NPP and PPV were calculated for ultrasoundlocalization of UDT, results are demonstrated in (Table 5).

Table 5: The accuracy, sensitivity, specificity, NPP and PPV for ultrasoundlocalization of UDT.

Imaging tool	TP	FN	TN	FP	PPV	NPV	Sensitivity	Spesifity	Acuracy
US	16	22	19	2	88.98%	53.66%	45.71%	91.67%	64.41%

Note: TP= True positive, FN= False negative, TN= True negative, FP= False positive, PPV=Positive predictive value, NPV=Negative predictive value.

Ultrasound could not identify 19 of undescended testis (False negative) which were detected by laparoscopy and misidentified 2 cases as UDT. (False positive), however, no testes were found along the pathway of testicular descent in the abdomen, pelvis & inguinal region during laparoscopy.

MRI examination were performed to all patients. MRI detected 53/59 cases of UDT, with diagnostic accuracy of 89.83% (24 in intra-canalicular location, 5 in the lower abdomen intimately related to iliac vessels, 3 in the high abdomen and 21 cases not visualized at all along the pathway of testicular descent in the abdomen, pelvis, inguinal canal and scrotum as shown in (Table 6).

Table 6: Identification of UDT by MRI (number = 59).

Location	Intracanalicular	Lower abdomen	Higher abdomen	Absent	Total
Identified	24 (40.6%)	5 (8.4%)	3 (5.08%)	21(35.5%)	53 (89.8%)
Notidentified	0 (0%)	1 (1.6 %)	2 (3.3%)	3 (5.08%)	6 (10.1%)
Total	24 (40.6%)	6 (10.1%)	5(8.4%)	24 (40.6%)	59 (100%)

The accuracy, sensitivity, specificity, NPP and PPV were calculated for MRI localization of UDT, results are demonstrated in (Table 7).

Table 7: The accuracy, sensitivity, specificity, NPP and PPV for MRIlocalization of UDT.

Site	Ultrasound				MRI			Laparoscope		
	Negative		Positive		Negative		Positive			
	No.	%	No.	%	No.	%	No.	%	No.	%
Intra-canalicular	10	10.9%	14	23.7%	0	0.0%	24	40.6%	24	40.6%
Lower abdomen	5	8.4%	1	1.6%	1	1.6%	5	8.4%	6	10.1%
Higher abdomen	4	6.7%	1	1.6%	2	3.3%	3	.5.08%	5	8.4%
Absent	2	3.3%	22	37.2%	3	5.08%	21	35.5%	24	40.6%

Note: TP= True positive, FN= False negative, TN= True negative, FP= False positive, PPV=Positive predictive value, NPV=Negative predictive value.

MRI could not identify 3 of undescended testis (False negative) which were detected by laparoscopy and misidentified 3 cases as UDT(False positive),however, no testes were found along the pathway of testicular descent in the abdomen, pelvis, inguinal canal and scrotum.

Table 8: Comparison between the localization of UDT by ultrasound, MRIand laparoscopy (number = 59)

Imaging tool	TP	FN	TN	FP	PPV	NPV	Sensitivity	Spesifity	Acuracy
MRI	32	21	3	3	91.43%	87.50%	91.43%	87.50%	89.83%

There were significant differences in sensitivity and accuracy between ultrasound and MRI($P > 0.000$) which is highly significant. We used ultrasound and MRI to detect the viability of testes. It was an accurate method for detection of testicular viability before the operation. The atrophied/small testis may appears on ultrasound as normal, hypoechoic or of mixed normechoic and hypoechoic pattern, but on MRI appearsas low signal intensity on T1 and slight highsignal on T2 and Fat Suppressed T2WIs together with slightly restricteddiffusion in comparing with normal testis. When detected during laparoscopy, it was treated by orchiectomy.In our study, we could identify 3 cases of atrophic testes by ultrasound and 4 cases by MRI. The results of ultrasound and MRI in detection of viable and atrophied testes compared to laparoscopy are demonstrated in (Table 9).

Table 9: Detection of viability of undescended testes by ultrasound and MRI in comparison with laparoscopy (n = 59).

Modality	Ultrasound		MRI		Laparoscope	
	Number	%	Number	%	Number	%
Atrophic	3	5.1%	4	6.8%	5	8.5%
Viable	13	22.03%	28	47.4%	30	50.8%

Case (1)
Clinical history: A twenty years old male patient, presented with bilateral undescended testes since birth.
Abdomino-pelvic and scrotal US findings: Both testes are not visualized along its course from kidney to scrotum.
MRI findings:

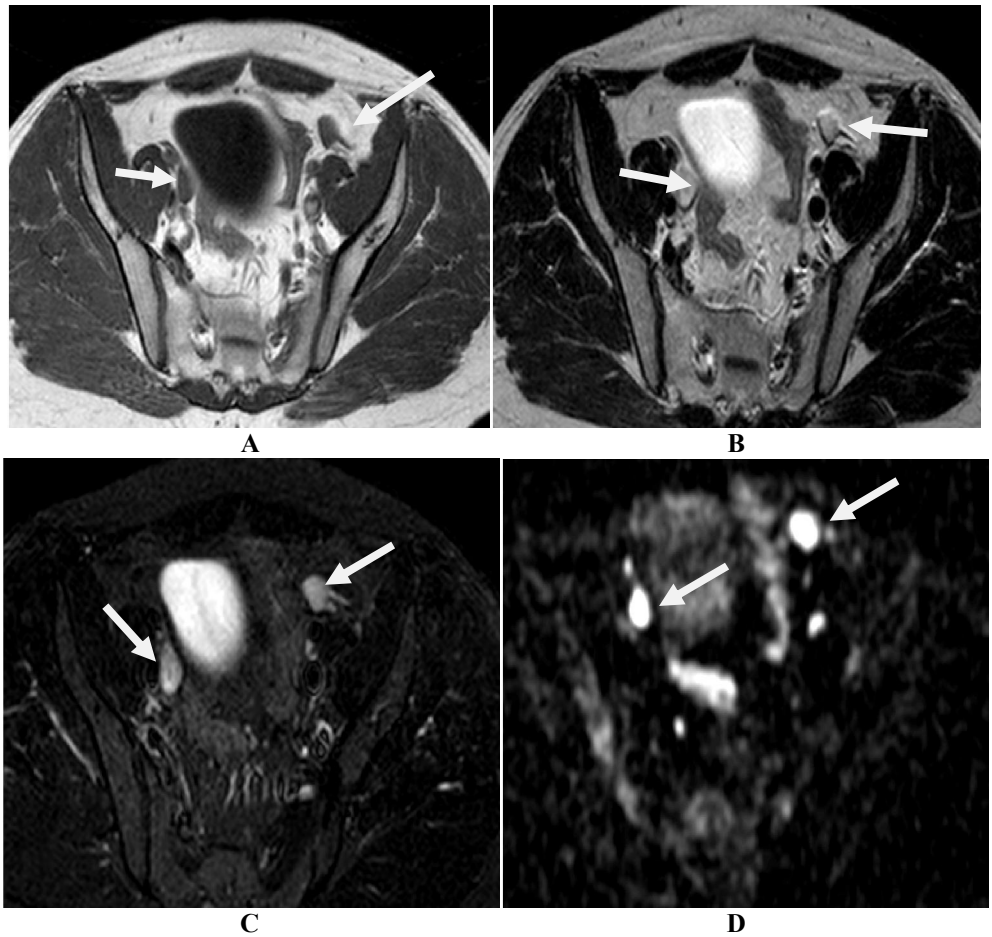

Fig.1: AxialT1, axial T2 andaxial STAIR WIsshowing bilateral intra-abdominalUDT appearof relative low signal on T1 (a) and high signal on T2 and STAIR WIs(b &c). Diffusion axial image at b value of 800 s/mm^2 shows high signal intensity of the UDTs (restricted diffusion) denoting viable testes (d).

MRI diagnosis: Bilateral intra-abdominal UDT.
Laparoscopic findings: Laparoscopy confirmed the MRI findings and orchiopexy was done to the patient.
Final diagnosis: Bilateral intra-abdominal UDT.

Case (2)
Clinical history: Male patient thirteen years old with bilateral undescended testes since birth.
Abdomino-pelvic and scrotal US findings:

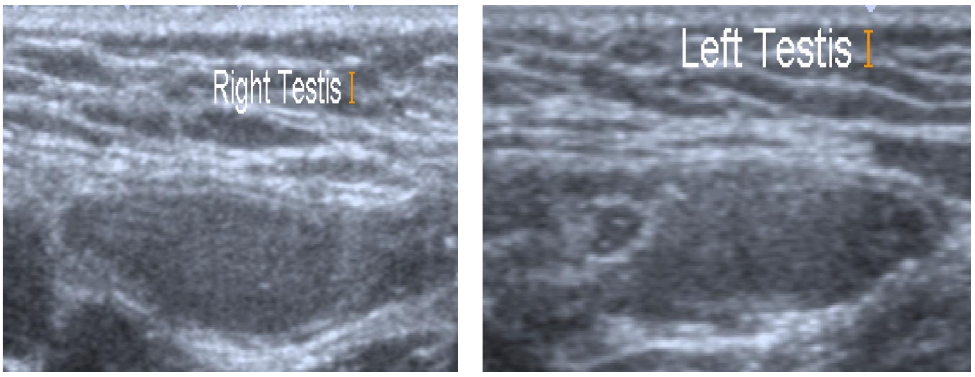

Fig.2*:* Abdomino-pelvic and scrotal ultrasound reveled bilateral UDT are seen in both inguinal canal.

MRI findings:

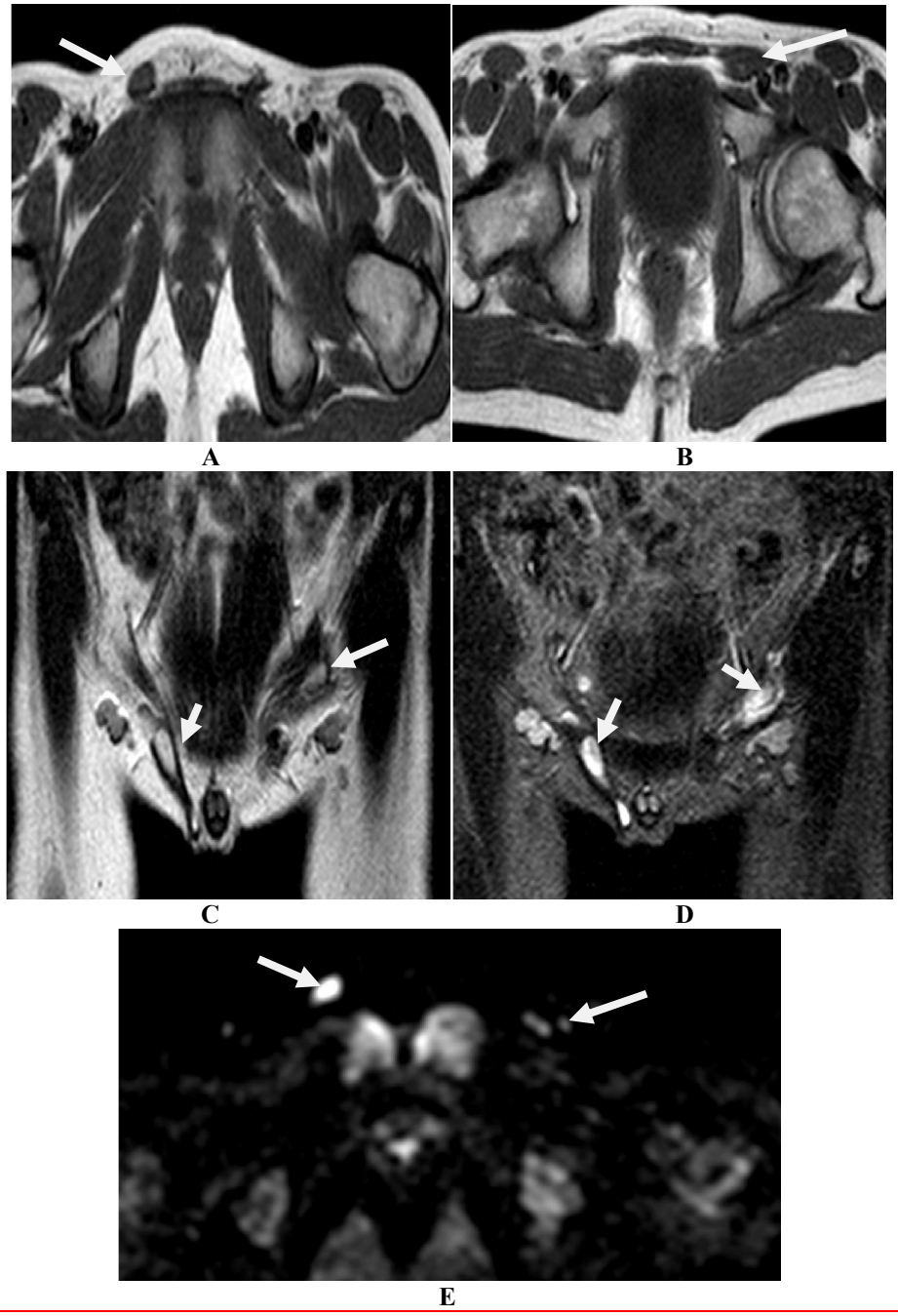

Fig.3: Axial T1,coronal T2 and coronal STAIR WIs showing both testis seen in the both inguinal canalright testis appears of relative low signal on T1 (a) and high signal on T2 and STAIR WIs(c &d). Diffusion axial image at b value of 800 s/mm^2 showing high signal intensity of the right UDT (restricted diffusion) denoting viable testis (e). Left testis appears of relative low signal on T1 (b) and slight high signal on T2 and STAIR WIs. DWI showing slight high signal intensity of the left UDT (slight restricted diffusion) denoting atrophied testis.

MRI diagnosis: Bilateral inguinal both testicle (left testis is atrophied).

Laparoscopic finding: Revealed bilateral inguinal both testicle the right one is viable and underwent orchiopexy and the left one is atrophied and underwent orchioectomy.

Final diagnosis: Bilateral intra-canalicular UDT right one is viable and the left one is atrophied.

Case (3) Clinical history: A seven years old male patient, presented with left undescended testis since birth.

Abdomino-pelvic and scrotal USfindings:

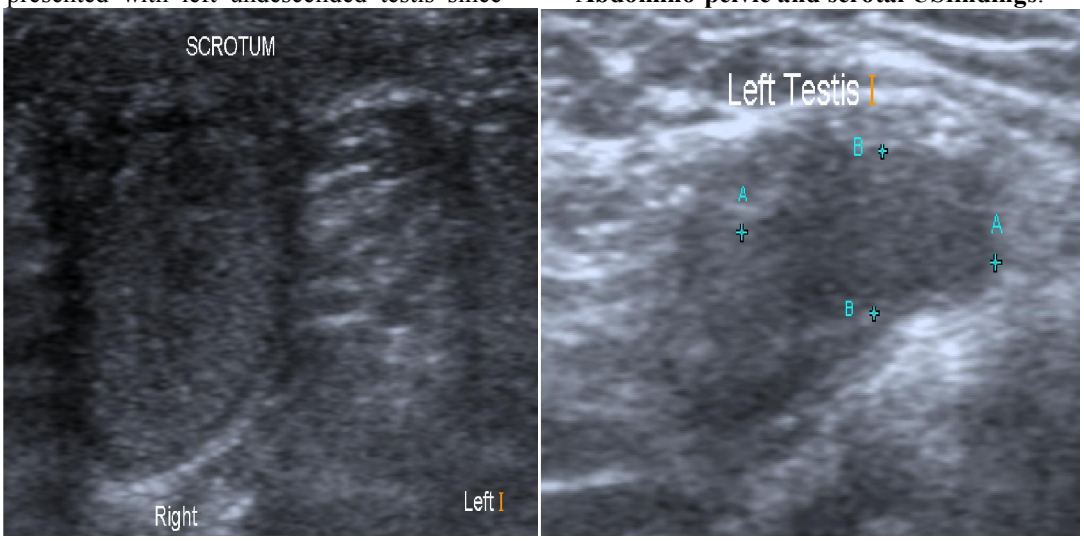

Fig.4: Abdomino-pelvic and scrotal ultrasound reveled empty left hemi-scrotum with left testis in the left inguinal canal associated with inguinal hernia.

MRI findings:

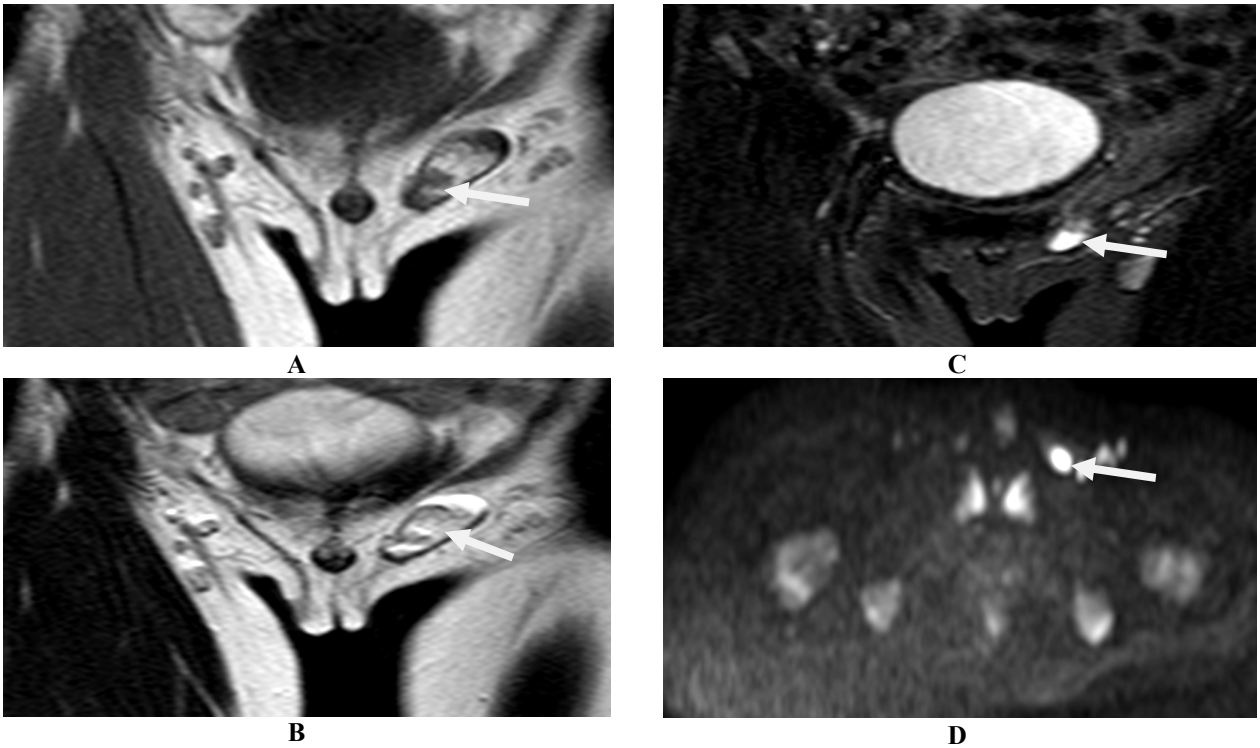

Fig.5: Coronal T1, T2 and STAIR WIs showing left intra-canalicular UD of relative low signal on T1 (a) and high signal on T2 and STAIR WIs associated with inguinal hernia (b &c). Diffusion axial image at b value of 800 s/mm^2 showing high signal intensity of the left intra-canalicular UDT (restricted diffusion) denoting viable testis (d).

MRI diagnosis: Left intra-canalicular UDT.

Laparoscopic findings: Laparoscopy confirmed the MRI findings and orchiopexy was done to the patient.

Final diagnosis: Left intra-canalicular UDT.

4. Discussion

Cryptorchidism is the absence of one or both testes in the scrotum and is synonymous with undescended testes (UDT). It is a common anomaly in pediatrics that often needs early surgical management for fear of its future complications as testicular malignancy, infertility problems, testicular torsion, trauma or inguinal hernia if not treated **(Williams et al., 2001).** Location of testis is also important in deciding whether patient will need abdominal or inguinal surgery **(Shubha and Kuldeep, 2016)** Preoperative awareness of the testicular position in cases ofnon-palpable undescended testis is valuable for planning surgical strategy, facilitating the placement of the surgical incision, as well as the choice of operative technique, especially when performing laparoscopic orchiopexy in cases of intra-abdominal gonads**(Kanemotoet al.,2005).**There are radiologic examinations which could be used for the diagnosis of undescended testis, such as ultrasound, computed tomography, magnetic resonance imaging, and venography. However, it has been shown that laparoscope is the definitive investigation**(Ximenaet al., 2016)**. Treatment of the cryptorchid testis is justified due to the increased risk of infertility and malignancy as well as the risk of testicular trauma and a possible psychological stigma on patients and their parents **(Budiantoet al.,2014).** Definitive diagnosis is made by laparoscopy. Laparoscopy provides direct visualization of testicular vessels and locates intra-abdominal testes and allows treatment of this pathology **(Ximenaet al., 2016)**. According to the laparoscopic evaluation, the final diagnoses of the location of UDT were: intra-canalicular (number = 24, 40.6 %), low intra-abdominal (number=6, 10.1%), high intra-abdominal (number = 5, 8.4%) and absent (number= 24, 40.6%).Ultrasound is the least expensive and frequently used technique of all imaging tools. However, it had been shown to have a low sensitivity in identifying undescended testes preoperatively **(TasianandCopp, 2011).**In this study, all patients were initially diagnosed with US. US detected only 38/59 cases of UDT, with diagnostic accuracy of 64.41%, sensitivity of 45.71%, and specificity of 91.67%.It correctly localize 1 out of 5 high abdomen testes (20%), 1 out of 6 lower abdomen testes (16.6%)14 out of 24 intra-canalicular testes(58.3%). The NPP 53.6%, and PPV 88.8%.**Yasser et al., 2016** give the same results that say out of 53 undescended testes ultrasonography could identified 24 (45.2%) testes as intra-canalicular, 10 (18.8%) as intra-abdominal,1/53 (1.8%) as scrotal, and 18/53 (33.9%) as absent, ultrasound agree with laparoscopic in 35 out of 53 with total accuracy 66.03%.Importantly, the ultrasound showed 96% sensitivity and 56% specificity for testes surgically confirmed to be located in the inguinal canal. This was agreement with finding of **Alexander et al., 2014** that shows accuracy of ultrasound on localization of undescended testis 73%,PPV, NPV, sensitivity and specificity of abdominal testis 67%, 89%, 48% and 95% respectively and of inguinal testis 91%, 66%, 78% and 85% and of absent testis 47%, 100%, 100% & 83%.This was in agreement with findings of **Tasian and Copp, 2011** who recently performed a systematic review and meta-analysis of literature on ultrasound evaluation of non-palpable undescended testes**.** They found that US was poor at localizing non-palpable undescended testes, with reported sensitivity and specificity 45% and 78% respectively. They stated that the site of undescended testis had a bearing effect on the benefit of ultrasound. As ultrasound was unable to differentiate nonviable testis from inguinal tissue, and was adversely affected by the presence of bowel gas. In addition there was also a significant risk of intra-abdominaltestis being present even though US suggested that this was not the case. Our findings are comparable with the results of **Nijs et al., 2007** which could be locate 103 /152 undescended testes with diagnostic accuracy 67.7%, 97% sensitivity of US for inguinal testes and 48% sensitivity for abdominal testes with PPV 97%.MRI is a non-invasive diagnostic technique and has great chance for abdominal imaging. It does not depend on ionizing radiation or intravascular contrast medium **(Kantarci et al., 2010)**.MRI with or without angiography has been more widely used with greater sensitivity and specificity but is deterred by cost, low availability and need for anesthesia**(Thomas et al., 2014)**.MRI could stand alone and perform better in identifying and locating cryptorchid testicles even without IV gadolinium contrast injection. Even though MRI is more expensive than either ultrasound or CT scan, it may be clinically preferable to ultrasound because it allows global, multiplanar depiction of the anatomy of the structures and can distinguish testicles from lymph nodes by using specific orientation and sequences in axial or coronal planes **(Kato et al., 2011)**.In current study, MRI detected only 53/59 cases of UDT, with diagnostic accuracy of 89.83%,sensitivity of 91.43%, and specificity of 87.50%.It correctly localize3 out of 5 high abdomen testes (fig.1) (60%), 5 out of 6 lower abdomen testes (83.3%),24 out of 24 intra-canalicular testes(fig.2) (100%). The NPP 87.50%, and PPV 91.43%. This was agreement with finding of **Sally et al.,2016** that show MRI detected correctly 45/47 cases of UDT with diagnostic accuracy of 95.70%,sensitivity of 93.50%, and specificity of 100%.It correctly localize 3 out of 5 high abdomen testes (60%), 6 out of 6 lower abdomen testes (100%), 18 out of 18 intra canalicular testes(100%).The NPP 88.80%, and PPV 100.00%.This also have an

agreement with finding of **Ehab et al.,2015** that show MRI detected correctly 51/53 cases of UDT with diagnostic accuracy of 96.2%,sensitivity of 95.8%, and specificity of 100%.Its accuracy of high abdomen testes (83.36%),lower abdomen testes (86.6%),intra-canalicular testes(88%).**Kanemoto et al., 2005**had found that MRI had an accuracy of 85%, sensitivity of 86%, and specificity of 79% for diagnosis of UDT. **Kato et al., 2011** reported similar performance characteristics, they found that sensitivity, specificity, positive and negative predictive values for combined DWI and conventional MRI versus the operative findings were100 %, 97.3%, 96.3% and 100%. The overall prediction accuracy as 98.4%.In my study one case of low intra-abdominal and two casesof high intra-abdominal testis which could not be identified by using all MRI images. Could be detected on laparoscope.This study is in agreement with study **Sally et al.,2016** it could not identify two cases of high intra-abdominal testes (False negative). Both testes were detected by laparoscopy. Similarly in previous study by of **Ehab et al.,2015** MRI could not detect two undescended testicle and both were detected by labaroscope. Similarly in a previous study by **Kantarci et al., 2010** laparoscopic examination revealed one intraabdominal testis (2.6%) was atrophic, had abnormal morphologic features, that was missed by MRI. Laparoscopic orchiectomy was performed. In the present study, the distinction between the lymph nodes at the inguinal region and testes using DWI was not easy in some cases as both structures display similar signal, yet their signal intensity varies with fat-suppressed T2WI, as lymph nodes were imaged at a lower signal intensity than the testes. This was supported by the previous findings of **Kato et al., 2011** who found that, there was a sharp contrast between the testes and surrounding tissues obtained by adding fat-suppressed T2WI. However they found that it was difficult to identify the testes by fat-suppressed T2WI when the amount of fluid retained in the intestinal tract was large. In this situation, DWI was the most effective technique I report that, MRI appears to be more sensitive than US in the localization of the undescended testes. This agree with **Amar and Anirudh, 2006** who say MRI ismore accurate in identifying an undescended testis than ultrasound. Similarly in a previous study by **Thomaset al., 2014** study that show US cannot reliably localize a non palpable testis or confirm an absent/vanished testis however MRI has been more widely used with greater sensitivity and specificity. **Gregory et al.,2011**reported similar result statet hat MRI has a greater sensitivity and specificity compared to ultrasound in localization of undescended testes. My study demonstrated few limitations. First, the patient sample was relatively small. Our results have to be confirmed with a larger prospective study. Second, ultrasound is operator dependent and the accuracy of its result depend on the experience of the operator. Third, patients younger than 6 years needed sedation or general anesthesia for an optimal MRI examination. Fourth, there was a lack of enteric contrast, which plays an important role in the detection of intra-abdominal undescended testes. We believe that with technical improvements, some of these disadvantages may be overcome. The limitations of DWI include relatively poor spatial resolution and its poor anatomic location.

Conclusion

Based on our findings, we suggest that MRI including Fat-supp. T2WIs and Diffusion sequences is the most accurate means of detecting and localizing non-palpable undescended testes in comparing with ultrasound. However, laparoscopy is still needed to confirm absent rather than undetected undescended testes.

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