Role of Diffusion-Weighted Magnetic Resonance Imaging and ADC Value Measurement in Identification and Differentiation of Non-Palpable Undescended Testes

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Abstract

Objective: To evaluate the role of diffusion-weighted magnetic resonance imaging and ADC value measurement in the identification of non-palpable testes and its differentiation from neighboring lymph nodes.

Patient and Methods: Fifty patients with 64 non-palpable testes were included in this study. Conventional MRI including T1 and T2 WI and DWI were done for all patients. The imaging results were compared with the laparoscopic surgical findings. Mean ADC values of both undescended testes and related lymph nodes were compared.

Results: Conventional MRI identified 40 intra-canalicular testes and 8 intra-abdominal testes while 16 testes were not identified. Combined conventional MRI and DWI identified 40 intra-canalicular testes and 12 intra-abdominal testes while 12 testes were not identified. The sensitivity, specificity, and accuracy for the conventional MRI and combined conventional MRI and DWI were 88.5%, 83.3%, and 90% respectively. There was significant difference between mean ADC value of undescended testes and related lymph nodes (p-value <0.005), a cut off value of 1.2 X 10-3mm2/s is suggested for its differentiation.

Conclusion: Adding DWI and ADC value to conventional MRI increases its accuracy in the identification and differentiation of undescended testes.

Key Words: DWI – ADC – MRI – Undescended testes.

Introduction

APPROXIMATELY 1 % of newborn males have un-descended testes, 80% of which are clinically palpable and 20% of which are non-palpable [1]. The term 'non-palpable' is used when the testes cannot be detected on physical examination. Non-palpable testes either located intra-abdominally, intra-canalaricular, vanishing or atrophic [2]. Accurate diagnosis is crucial for appropriate treatment which causes preservation of testicular function and its endocrinial capacity preserving adequate fertility; in addition, accurate diagnosis allows early detection of malignant tumors [3]. Conventional Magnetic Resonance Imaging (MRI) and Ultrasonography (US) have been used in children with non-palpable testes for preoperative diagnosis. The accuracy rates of diagnosis and localization of a non-palpable testis with MRI and ultrasound are equally moderate (85% and 84%) [4,5]. Diffusion weighted magnetic resonance imaging (DWI) depends on visualization of changes in the translational (Brownian) motion of water molecules and supply tissue contrast thus differing from conventional MRI [6]. Many studies have shown that adding DWI to a routine MRI examination increases its diagnostic accuracy [7-9]. The aim of the present study is to evaluate the value of adding diffusion-weighted magnetic resonance imaging and ADC map to conventional MRI examination in the identification and differentiation of non-palpable testes in both visual and quantitative ways.

Patients and Methods

Fifty patients with 64 non-palpable testes were included in this study. Patients were referred from urology and General Surgery Departments to the Radiology Department to perform MRI of the abdomen and pelvis to localize the un-descended testes as a diagnostic and pre-operative assessment. Age ranged from 1-29 years (mean 10 years). The study duration was between March 2010 and December 2014. Inclusion criteria were patients with non-palpable testes (unilateral or bilateral) who had MRI examination and surgical feedback reports, no certain age limits. Exclusion criteria were patients with MRI and having no surgical feedback
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(did not do operation nor had incomplete surgical data). Informed consent was obtained from all patients and the study had institutional review board approval.

**MRI protocol:**

Abdominal and pelvic MRI examinations were performed with a 1.5-T MRI system (Magnetom Avanto, Siemens Healthcare) with an 18-channel body coil and high performance gradient. The patients underwent conventional MRI with a free-breathing axial and coronal turbo spin-echo T1-weighted sequence, axial and coronal fat-suppressed turbo spin-echo T2-weighted sequence. Axial DWI single-shot spin-echo echo-planar sequence with chemical shift selective fat-suppression technique (4,900/93; matrix size, 192 X 192; slice thickness, 3-5mm; field of view 45; number of signals averaged 4) was performed with \( b \)-values of 50, 400, and 800s/mm\(^2\). Findings of conventional MRI and DWI (\( b \)-value 800) examinations were reviewed and compared with the results of surgical and laparoscopic evaluation. Statistical analysis was done, the sensitivity, specificity, and accuracy for the conventional MRI and combined conventional MRI and DWI was calculated. Because the testes and lymph nodes have similar signal intensity by DWI, it was not easy to differentiate them in some patients. ADC value was subjected to study if it can help to distinguish testes from surrounding lymph nodes. Multiple ROIs are calculated of the suspected testicular tissues and nearby lymph nodes. The mean of ADC value of previous measurements of testicular tissue and lymph nodes was used to calculate if there is a significant difference can be used in clinical application. Statistical analysis was done using the independent samples \( t \)-test.

**Results**

From a total of 64 non-palpable testes, conventional MRI identified 40 intra-canalicular (inguinal) testes, 8 intra-abdominal testes and 16 testes could not be identified. Combined assessment using T1- and T2-weighted imaging, fat-suppressed T2-weighted imaging, and DWI, it was possible to identify 40 intra-canalicular testes and 12 intra-abdominal testes, however; 12 testes could not be identified (Table 1). Total of four intra-abdominal testes were more identified by conventional MRI and DWI.

The entire 40 intra-canalicular testes Fig. (1) diagnosed by conventional MRI alone or combined with DWI were confirmed as such by laparoscopy. Six out of the 8 testes located by conventional MRI as intra-abdominal and 10 out of the 12 testes located by combined MRI and DWI as intra-abdominal and pelvic Figs. (2,3) were confirmed by laparoscopy. Labaroscopy detected 2 small intra-abdominal atrophic testes that were not indentified either by conventional MRI or combined conventional MRI and DWI. Conventional MRI was true positive in 46 testes, false positive in 2 testes, true negative 10 testes and false negative in 6 testes while combined conventional MRI and DWI were true positive in 50 testes, false positive in 2 testes, true negative in 10 testes and false negative in 2 testes (Table 2). The sensitivity, specificity, and accuracy for conventional MRI were 88.5%, 83.3% and 86% respectively while for combined conventional MRI and DWI they were 96.1%, 83.3%, and 90% respectively.

![Table 1: Identification of un-descended testes by DWI.](image)

<table>
<thead>
<tr>
<th>Non-palpable testes</th>
<th>Conventional MRI</th>
<th>Conventional MRI and DWI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-canalicular testes</td>
<td>40 (62.5%)</td>
<td>40 (62.5%)</td>
</tr>
<tr>
<td>Intra-abdominal testes</td>
<td>12 (18.75%)</td>
<td>8 (12.5%)</td>
</tr>
<tr>
<td>Not identified</td>
<td>12 (18.75%)</td>
<td>16 (25%)</td>
</tr>
<tr>
<td>Total</td>
<td>64 (100%)</td>
<td>64 (100%)</td>
</tr>
</tbody>
</table>

![Table 2: Sensitivity, specificity and accuracy for conventional MRI and combined conventional MRI and DWI.](image)

<table>
<thead>
<tr>
<th>Group</th>
<th>True positive</th>
<th>False negative</th>
<th>True negative</th>
<th>False positive</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional MRI</td>
<td>46</td>
<td>6</td>
<td>10</td>
<td>2</td>
<td>88.5%</td>
<td>83.3%</td>
<td>86%</td>
</tr>
<tr>
<td>Conventional MRI and DWI</td>
<td>50</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>96.1%</td>
<td>83.3%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Retrospectively after having the previous calculations were done. A total of 50 cases were proved to be true positive by using conventional MRI and DWI. They were subjected to a study by comparing mean ADC value of the descended testes and neighboring lymph nodes. The mean ADC value of the undescended testes located in MRI was 1.037 X 10-3mm\(^2\)/s ± 0.107. The mean ADC value of the neighboring nodes was 1.412 X 10-3mm\(^2\)/s ± 0.16 (Table 3). Using the independent
Samples t-test (Table 4), this difference was statistically significant (p-value <0.005). In this study, the best value to consider as a cutoff value to differentiate between testes and lymph nodes was 1.2 X 10-3mm²/s.

Table (4): Comparison between mean ADC values of LNs and undescended testes using independent samples t-test.

<table>
<thead>
<tr>
<th></th>
<th>Levene’s test for equality of variances</th>
<th>t-test for equality of means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>7.041</td>
<td>.009</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>15.375</td>
<td>.000</td>
</tr>
</tbody>
</table>

Table (3): Mean ADC values of LNs and undescended tests.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. error mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNs</td>
<td>50</td>
<td>1.4119</td>
<td>.15925</td>
<td>.02022</td>
</tr>
<tr>
<td>Testes</td>
<td>50</td>
<td>1.0369</td>
<td>.10735</td>
<td>.01363</td>
</tr>
</tbody>
</table>

Fig. (1): Bilateral inguinal undescended testes: A) Coronal T2WI FS showing oval shaped hyperintense structures at both inguinal regions. B) Axial DWI b-800 showing hyperintense signal of the testes in comparison with surrounding structures, C) ADC map image where the testes show slightly hypointense signal.

Fig. (2): Right side undescended testis located at right para-median aspect of the lower abdomen: A) and B) coronal T2WI and T2WI FS show oval shaped hyperintense structure. C) DWI b-800 showing hyperintense signal of the testis in comparison with surrounding structures.
Fig. (3): Right side pelviabdominal undescended testis, located anterior to right iliopsoas muscle: A) Axial T2WI showing oval shaped hyperintense structure. B) DWI b-800 showing hyperintense signal of the testis in comparison with surrounding structures. C) ADC map image where the testis show slightly hypointense signal.

**Discussion**

Imaging is considered of crucial importance in diagnosis and pre-operative localization of undescended testes. It helps in planning the surgical approach reducing extent of exploration and anesthesia time. The current routine algorithm for localization of a non-palpable testis is to perform scrotal and abdominal ultrasonography and MRI of abdomen and pelvis is usually done if US failed to localize the non-palpable testes [10]. MRI is a non-invasive diagnostic technique and has great advances for abdominal and pelvic imaging. The advantage of MRI are simultaneous imaging of abdomen, pelvis, scrotal and inguinal regions due its wide field of view, multiplanar capabilities, high contrast and spatial resolution helping in the distinction of testicular tissue from surrounding structures [11]. It does not entail ionizing radiation or intravascular iodinated contrast medium. Studies done using conventional MRI for the diagnosis of non-palpable testes are expected to have an accuracy of 85 to 89%, sensitivity of 78% to 86%, and specificity of 79% to 100% [4,5].

DWI of the abdomen is broadly used in the evaluation of hepatic, renal, prostatic, colonic and uterine cervical lesions [9]. Viscosity of fluid, changes in the balance between intra-and extracellular fluid, and cellularity are factors which influence DWI signals [12,13]. Testis is hyperintense on DWI referring to restriction of water molecules movement within densely packed seminiferous tubules of normal testicular parenchyma. Intra-abdominal testes are considerably more cellular than the adjacent organs and can be detected easily on DW images [14]. In the present study adding DWI to conventional MRI increases its sensitivity and accuracy in identification of non-palpable undescended testes from 88% to 96% and from 86% to 90% respectively. Our results are concordant with those of Kantarci et al., [14] who found that adding DWI to conventional MRI increases its sensitivity and accuracy in locating undescended testes from 85% to 91% and from 86% to 92% respectively. On the other hand our results were lower than those of Kato et al., [15] who used DWI with conventional MRI and reported a sensitivity of 100% and accuracy 98%. In our study DWI failed to identify two intra-abdominal testes due its small size and atrophic changes as it was confirmed by laproscopy. Also in the present study conventional MRI and DWI diagnosed two intra-abdominal testes that were proved by laparoscopy to be infected lymph nodes. Kantarci and his colleagues [14] had a similar condition in their study and they stated that in spite of this weak point we can not ignore the role of DWI in increasing the accuracy of MRI in locating the undescended testis. Lymph nodes are the most frequent structures that can be mistaken as un-descended testes in MRI search for testicular localization. It has similar contour and high signal in T2WI and DWI. In the current study we tried to use quantitative DWI in the form of ADC value of the proved cases of undescended testes and compare it with neighboring lymph nodes. Mean testicular ADC value of undescended testes was $1.037 \times 10^{-3} \text{mm}^2/\text{s} \pm 0.107$. The mean ADC value of the neighboring nodes was $1.412 \times 10^{-3} \text{mm}^2/\text{s} \pm 0.16$. Using the independent Samples $t$-test, this difference was statistically significant ($p$-value <0.005). Many studies were
done to evaluate the use of ADC value in evaluation of lymph nodes diseases and differentiation between normal and pathological lymph nodes. Averages of mean ADC of the benign lymph nodes were (1.51 ± 0.36 X 10-3 mm²/s) [16], (1.42 ± 0.57 X 10-3 mm²/s) [17] and (1.443 X 10-3 mm²/s) [18] which are considered similar to our results. Tsili et al., [19] study stated that the mean ADC values of the normal testis is (1.11 ± 0.18 X 10-3 mm²/s) which is close to our study value. These data suggest that ADC value difference is helpful to differentiate lymph nodes from un-descended testes. We suggest that 1.2 X 10-3 mm²/s. Can be used as a cutoff value to differentiate between testes and lymph nodes.

**Conclusion:**

Adding DWI and ADC value calculations to conventional MRI increases its sensitivity and accuracy in locating undescended testes pre-operatively and its differentiation from relevant neighboring structures.

**References**

الملخص العربي

المقدمة: عدم نزول الخصائص إلى كيس الصفن يحدث في 1% من الأطفال حديثي الولادة. وفي 20% من هؤلاء لا يمكن تحديد مكان الخصائص الغير نازلة بالفحص الإكلينيكي وتحتاج إلى وسائل تشخيصية أخرى لتحديد مكان الخصائص كالفحص بالموجات الصوتية والتصوير بالرنين المغناطيسي التقليدي.

الهدف من البحث: تقديم دور التصوير بالرنين المغناطيسي الإنتشاري وقياس معامل تخفيف الانتشار في الكشف عن عدم نزول الخصائص في كيس الصفن.

الوسائل المستخدمة: تتضمن هذا البحث أربعة وستون خصائص غير محسوسة أكليكيا في خمسون مريض، تم عمل فحص بالرنين المغناطيسي العادي والانتشاري لكل المرضى لمنطقة البطن والجهاز مع قياس معامل التخفيف الانتشاري. تم مقارنة تنافئ فحص الرنين المغناطيسي مع نتائج المناظر الجراحية الذي تم عمله لكل المرضى كما تم مقارنة قيمة معامل تخفيف الانتشار لكل من الخصائص الغير نازلة والفيدة الليمفاوية المجاورة.

نتائج البحث: تم تحديد مكان الخصائص بالرنين المغناطيسي العادي. في 48 خصية ولم يتم التعرف على 16 خصية بينما نجح الرنين المغناطيسي العادي والانتشاري في تحديد 52 خصية ولم يتم التعرف على 12 خصية وكان هناك فرق كبير بين قياس تخفيف معامل الانتشار لكل من الخصائص الغير نازلة والفيدة الليمفاوية مع قيمة فاصلة تساوي 0.12-0.3/ثانية.

الخلاصة: يساعد التصوير بالرنين المغناطيسي الإنتشاري على زيادة نفد الفحص بالرنين المغناطيسي في التعرف على الخصائص الغير نازلة.