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COMPARATIVE ANALYSIS OF ULTRASOUND AND MAGNETIC RESONANCE IMAGING FOR THE EARLY DETECTION OF CRYPTORCHIDISM IN CHILDREN AND ITS CORRELATION WITH ORCHIDOPEXY FINDINGS

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Abstract

Objective: This study aimed to investigate the diagnostic accuracy of ultrasound (US) and magnetic resonance imaging (MRI) in detecting cryptorchidism in pediatric patients and to compare these imaging modalities with classic orchidopexy findings.

Materials and Methods: Conducted between 2018 and 2019 at the PHI University Institute of Radiology - Skopje in collaboration with the PHI Clinic for Children's Surgery at the Mother Teresa University Clinical Centre - Skopje, this cross-sectional study included pediatric patients up to 14 years old with suspected cryptorchidism. B-mode ultrasound and MRI, including DW-MRI sequences, were employed for localization of undescended testes. These imaging findings were compared with those obtained from classic orchidopexy, serving as the gold standard.

Results: A total of 41 male pediatric patients (≤14 years old) with suspected cryptorchidism were enrolled, with a mean age of 6.76±3.74 years. MRI demonstrated superior detection and visualization of undescended testes compared to ultrasound. Specifically, MRI significantly improved the preoperative diagnostic accuracy, especially in localizing non-palpable undescended testes, when compared to ultrasound.

Conclusion: The findings suggest that MRI is more effective than ultrasound in detecting undescended testes in pediatric patients. Furthermore, MRI enhances the preoperative diagnostic accuracy, particularly in localizing non-palpable undescended testes, thereby potentially serving as a recommended imaging modality for this purpose.

Keywords: Cryptorchidism, Ultrasound, Magnetic Resonance Imaging, Diagnostic Accuracy, Orchidopexy, Pediatric Radiology.

Introduction

Cryptorchidism, a common congenital anomaly observed in the pediatric male population, poses a significant clinical challenge due to potential complications if left untreated. It is characterized by the absence of one or both testes in the scrotum and is generally synonymous with undescended testis [1,10]. Defined as the failure of one or both testes to descend into the scrotum, cryptorchidism necessitates early detection and precise localization for optimal therapeutic interventions.

Undetected or untreated cases may lead to long-term consequences, including impaired fertility and an increased risk of testicular malignancies. In approximately 4% of patients, the undescended testis is non- palpable due to being intraabdominal, intra- canalicular, or possibly atrophic or absent [2,3,11, 12].

In the diagnostic landscape of cryptorchidism, imaging modalities such as ultrasound and magnetic resonance imaging (MRI) have garnered increasing attention for their pivotal roles in accurate localization and characterization. While ultrasound serves as the frontline imaging modality, benefiting from its widespread availability, non-invasiveness, and cost-effectiveness, MRI offers unparalleled advantages in providing detailed soft tissue characterization and multi- planar imaging capabilities.

The integration of these imaging techniques into the diagnostic algorithm of cryptorchidism holds immense promise in enhancing clinical decision-making, preoperative planning, and postoperative management. However, despite their utility, challenges persist in optimizing the diagnostic accuracy and clinical utility of these imaging modalities, particularly in cases of non- palpable or atypical presentations of undescended testes.

In this study, we aim to investigate the diagnostic value and accuracy of ultrasound and MRI in the early detection and localization of cryptorchidism in pediatric patients.

Through a comprehensive evaluation of imaging findings and their correlation with classic orchidopexy, we seek to elucidate the comparative strengths and limitations of these imaging modalities, ultimately contributing to the refinement of diagnostic strategies and the optimization of patient outcomes in the management of cryptorchidism [4].

Material and method

This cross-sectional study spanned from 2018 to 2019 and was conducted at the PHI University Institute of Radiology - Skopje, in collaboration with the PHI Clinic for Children's Surgery at the Mother Teresa University Clinical Centre - Skopje. It encompassed pediatric patients up to 14 years old referred from the PHI Clinic for Children's Surgery - Skopje with suspected cryptorchidism.

The locations of cryptorchidism were categorized as agenesis/absence, scrotum, intra-canalicular, intraabdominal, and proximal-pelvic***, Figure 1 and 2.***

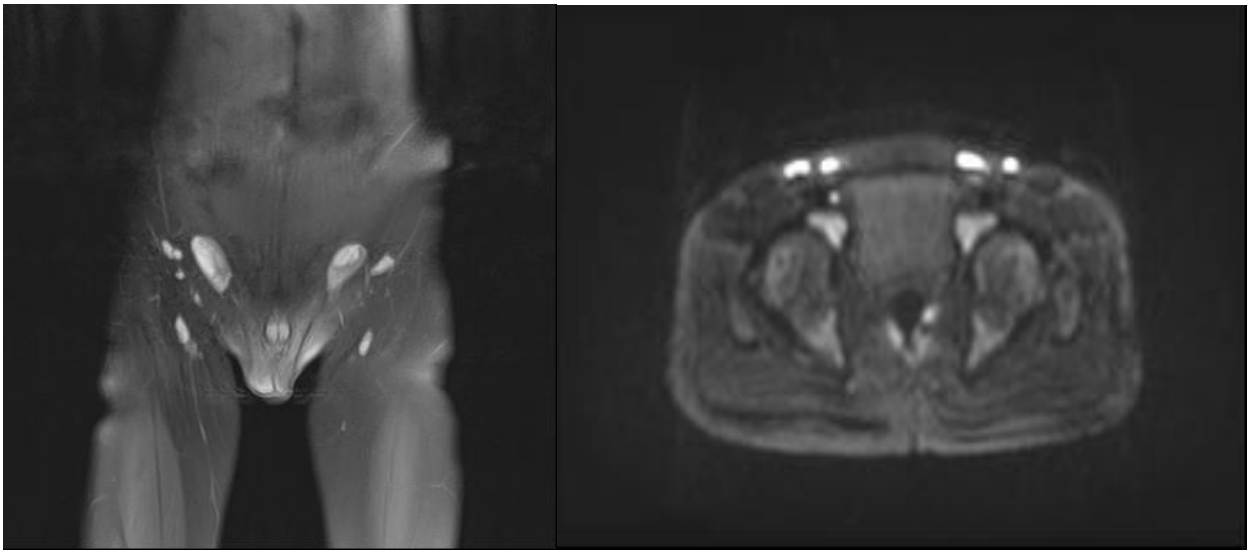


Figure 1. 6 year old boy with undescended testicles on both sides

A. T2-weighted MR image shows isosignal testis

B. Diffusion-weighted MR image with b value of 800 s/mm2 shows markedly hypersignal testicles.

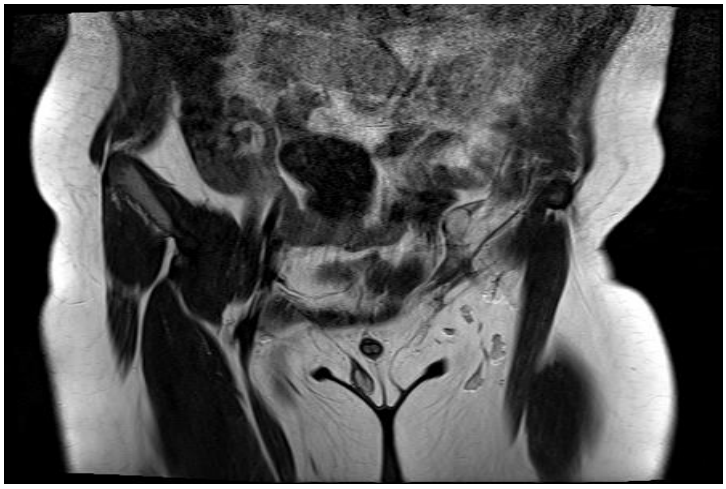


Figure 2. 10 year old boy with intra-canalicular non-palpable undescended left testis, T1-weighted MR image shows isosignal testis.

Imaging techniques included echo and MRI, with comparisons made to orchidopexy findings, considered as the gold standard. The MRI protocol we employed is detailed in ***Table 1.***

Table 1. MRI protocol employed in the evaluation of testicles.

MR protocols in the evaluation of testicles	Duration of exam: 15 mins
T1 tse cor	**T1 coronal**
T2 tse cor	**T2 coronal**
T1 tse tra	**T1 transverse**
T2 tse tra	**T2 transverse**
T2 fat sat	**T2 fat suppression**
DWI	**Diffusion values: 50, 800, 1500**

Purpose

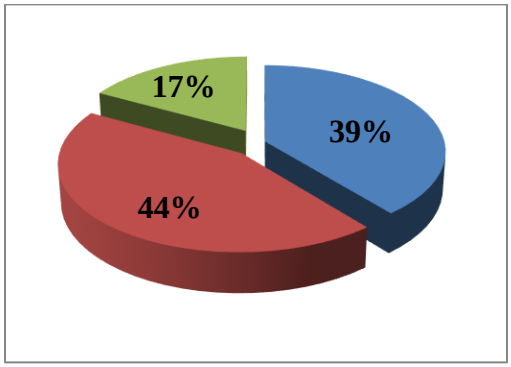
The aim was to compare imaging findings from echo and MRI with those obtained from classic orchidopexy for the early diagnosis of cryptorchidism and to determine the diagnostic accuracy of these modalities.

Statistical process

Data analysis was performed using SPSS version 26.0. Attributive series were analyzed for absolute and relative numbers, while patient age was assessed for measures of central tendency and dispersion. Comparisons between echo, MRI, and orchidopexy findings were made using multiple response tables, with statistical significance set at $p<0.05$.

Results

Demographics: The study enrolled a total of 41 male pediatric patients aged ≤14 years with suspected cryptorchidism. The average age was 6.76±3.74 years, ranging from 1 to 14 years. Notably, 50% of the patients were under 6 years old, while 25% were older than 10 years, ***Graph 1.***



Graph 1. Distribution by age: 39% were of age under 5 years old, 44%under 10years old and 17% under 15 years old.

Cryptorchidism Localization: According to orchidopexy findings, 31 (75.61%) patients presented with bilateral cryptorchidism, whereas none had cryptorchidism solely on the left side. Eight (19.51%) patients were diagnosed with cryptorchidism only on the right side. Interestingly, one 4-year-old patient showed no evidence of cryptorchidism bilaterally.

Left-sided Cryptorchidism: Among patients with confirmed left-sided cryptorchidism, the scrotum was the most prevalent site (31.71%), followed by intra-abdominal (21.95%) and proximal small pelvic (9.76%) locations. Notably, 9 (21.95%) cases suspected of left-sided cryptorchidism were not confirmed by orchidopexy, ***Table 2***.

Table 2. Comparative Analysis of Left Testicular Localization by Imaging Modalities and Orchidopexy.

	Agenesis/ None	Scrotum	Intra canalicular	Abdominal	Pelvic
US left testicle	**11(55%)**	**5(25%)**	**3(15%)**	**1(5%)**	**0**
MR left tiesticle	**10(50%)**	**5(25%)**	**3(15%)**	**2(10%)**	**0**
MR+DWI left testicle	**7(35%)**	**5(25%)**	**2(10%)**	**5(25%)**	**1(5%)**
Orchydopexy left testicle	**7(35%)**	**5(25%)**	**1(5%)**	**5(25%)**	**2(10%)**

Right-sided Cryptorchidism: For patients with confirmed right-sided cryptorchidism, the intra-abdominal location was most common (39.02%), followed by scrotal (31.70%) and intra-canalicular (2.44%) locations. Similar to left-sided cases, one patient (2.44%) suspected of right-sided cryptorchidism did not have confirmation via orchidopexy, ***Table 3***.

Table 3. Comparative Analysis of Right Testicular Localization by Imaging Modalities and Orchidopexy.

	Agenesis/ None	Scrotal	Intra canalicular	Abdominal	Pelvic
US right testicle	**11(55%)**	**6(30%)**	**2(10%)**	**0**	**1(5%)**
MR right testicle	**2(10%)**	**6(30%)**	**3(15%)**	**6(30%)**	**3(15%)**
Mr+DWI right testicle	**1(5%)**	**6(30%)**	**2(10%)**	**7(35%)**	**4(20%)**
Orchydopexy right testicle	**1(5%)**	**6(30%)**	**1(5%)**	**9(45%)**	**3(15%)**

Comparison of Imaging Modalities: Multiple comparisons between echo and magnetic resonance (MR) findings for left-sided cryptorchidism revealed complete agreement for four locations: scrotum, intra-canalicular, intra-abdominal, and proximal in the small pelvis.

The concordance rate for left-sided agenesis was 82.35%. Similarly, comparisons for right-sided cryptorchidism showed complete agreement for scrotal and proximal small pelvic locations, with a concordance rate of 11.11% for right-sided agenesis.

Comparison between echo and orchidopexy findings for left-sided cryptorchidism showed complete agreement for scrotal and intra-abdominal locations, with a concordance rate of 52.94% for left-sided agenesis. Conversely, comparison of MR findings with orchidopexy findings indicated complete agreement for scrotal and intra-abdominal locations, with a concordance rate of 64.29% for left-sided agenesis.

For right-sided cryptorchidism, MR findings matched those of orchidopexy for intra-abdominal locations, with a concordance rate of 50% for right-sided agenesis.

These findings underscore the diagnostic utility of both imaging modalities in identifying cryptorchidism and determining its localization, with MRI showing promising accuracy in preoperative localization.

Discussion

The findings of our study underscore the pivotal role of imaging modalities, particularly ultrasound and magnetic resonance imaging (MRI), in the diagnosis and management of cryptorchidism in pediatric patients.

Accurate localization and characterization of undescended testes are essential for guiding therapeutic interventions and minimizing long-term sequelae associated with this congenital anomaly. Accurate diagnosis and appropriate treatment lead to the highest chance of proper testicular function in an endocrine capacity, particularly regarding fertility, and facilitate early detection of malignant tumors [6,7].

Our results highlight the complementary nature of ultrasound and MRI in evaluating cryptorchidism. While ultrasound remains the initial imaging modality of choice due to its widespread availability, real-time imaging capabilities, and non-invasiveness, MRI emerges as a valuable adjunct for cases with complex anatomical variations or non- palpable testes.

The superior soft tissue contrast and multi- planar imaging capabilities of MRI facilitate precise localization of undescended testes, particularly in cases where ultrasound may yield inconclusive or equivocal results. MRI is a noninvasive diagnostic technique with great potential for abdominal imaging. It does not entail ionizing radiation or intravascular contrast medium. Kanemoto et al. [4] utilized MRI for diagnosing non- palpable testes and found MRI to have an accuracy of 85%, sensitivity of 86%, and specificity of 79%.

Furthermore, correlating imaging findings with those of classic orchidopexy serves as a crucial benchmark for validating the diagnostic accuracy of ultrasound and MRI. By comparing imaging results

with surgical outcomes, we can enhance our understanding of the strengths and limitations of each modality, thereby refining diagnostic algorithms and optimizing patient care pathways. Sarihan et al. [5] reported MRI sensitivity of 78.6% and specificity of 100% in detecting non- palpable undescended testis. Only conventional MRI techniques were employed in those studies.

Despite the inherent advantages of ultrasound and MRI, several challenges persist in the diagnostic evaluation of cryptorchidism. These include interpreting imaging findings in the context of patient age, anatomical variations, and operator expertise.

Additionally, the cost and accessibility of MRI may limit its widespread use, particularly in resource-constrained settings. Addressing these challenges requires a multidisciplinary approach involving radiologists, pediatric surgeons, and urologists to ensure timely and accurate diagnosis and management of cryptorchidism [8,9].

Suggestions for Further Research: Future research endeavors should focus on addressing the limitations identified in our study and advancing the diagnostic capabilities of imaging modalities for cryptorchidism. Longitudinal studies examining the prognostic implications of imaging findings on long-term outcomes, such as fertility and testicular malignancies, are warranted.

Moreover, comparative studies evaluating emerging imaging techniques, such as contrast-enhanced ultrasound and diffusion-weighted MRI, may provide further insights into their utility in the diagnosis of cryptorchidism.

Additionally, efforts to standardize imaging protocols and establish consensus guidelines for the evaluation of cryptorchidism are essential to ensure consistency and reproducibility across different healthcare settings.

Collaborative research initiatives involving international consortia can facilitate the pooling of data and the development of evidence-based guidelines for the optimal utilization of imaging modalities in the diagnosis and management of cryptorchidism.

Conclusion

In conclusion, our study demonstrates the indispensable role of ultrasound and MRI in the diagnostic evaluation of cryptorchidism in pediatric patients. Through comprehensive imaging assessment and correlation with surgical outcomes, we have elucidated the strengths and limitations of each modality, paving the way for optimized diagnostic strategies and improved patient care.

By addressing existing challenges and advancing research efforts, we can enhance our ability to diagnose and manage cryptorchidism effectively, thereby minimizing long-term complications and improving the overall health outcomes of affected individuals.

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