Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v6i6.1856
*Biol. Clin. Sci. Res. J., Volume 6(6), **2025**: 1856*
Original Research Article

Diagnostic Accuracy of Ultrasound and Correlation with Surgical Outcomes in Children with Undescended Testes

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(Received, 04th May 2025, Accepted 18th June 2025, Published 30th June 2025)

Abstract: *Cryptorchidism, or undescended testes (UDT), is a common congenital anomaly in male infants with potential implications for fertility and malignancy if not treated promptly. Ultrasound (US) is frequently employed for preoperative localization, but its diagnostic performance remains variable.* ***Objective:*** *To evaluate the diagnostic accuracy of ultrasound in localizing undescended testes in pediatric patients and to correlate sonographic findings with intraoperative surgical outcomes.* ***Methods:*** *A prospective diagnostic accuracy study was conducted at a tertiary care hospital in Pakistan from February to April 2025. Seventy-eight male children (aged 6 months to 10 years) with clinically suspected UDT underwent high-resolution ultrasound imaging before surgical exploration. Ultrasound findings were compared to intraoperative observations, which served as the gold standard. Diagnostic parameters, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, were calculated. Concordance rates between ultrasound localization and surgical findings were analyzed.* ***Results:*** *Among the 78 enrolled patients, 109 testes were evaluated. The mean age was 3.6 ± 1.8 years; 60.3% of cases were unilateral. Ultrasound demonstrated a sensitivity of 88.9%, specificity of 82.1%, PPV of 93.5%, NPV of 71.9%, and overall diagnostic accuracy of 87.1%. Concordance with intraoperative findings was highest for inguinal testes (96.5%), followed by abdominal (85.7%) and non-palpable testes (66.7%). False negatives were more common in intra-abdominal and atrophic testes.* ***Conclusion:*** *Ultrasound offers high sensitivity and diagnostic accuracy for localizing undescended testes, particularly in the inguinal region. However, its limitations in identifying intra-abdominal or non-palpable testes suggest a need for adjunct imaging modalities, such as diffusion-weighted MRI, to improve diagnostic precision and surgical planning. A multimodal imaging approach is recommended for complex or ambiguous cases to optimize clinical outcomes.*

Keywords: Cryptorchidism, ultrasound, pediatric urology, undescended testes, diagnostic accuracy, orchidopexy, surgical outcomes

[***How to Cite:*** Malik H, Farooq O, Zafar T, Iqbal T, Zafar MT, Shah SKH. Diagnostic accuracy of ultrasound and correlation with surgical outcomes in children with undescended testes. *Biol. Clin. Sci. Res. J.*, **2025;** 6(6): 231-234. doi: https://doi.org/10.54112/bcsrj.v6i6.1856

Introduction

Cryptorchidism, or the condition of undescended testes, represents a significant healthcare challenge in pediatric urology, as it is observed in 1-2% of male infants, with prevalence peaking in premature births. If left untreated, cryptorchidism can lead to infertility and increased risks of testicular cancer (1). Early diagnosis and appropriate management, often involving surgical intervention like orchidopexy, are crucial in mitigating these risks. Accurate localization of undescended testes is essential for successful intervention, with both ultrasound and advanced imaging techniques like MRI playing critical roles in the preoperative assessment (2).

Ultrasound (US) is often the first-line imaging modality due to its cost-effectiveness, non-invasiveness, and widespread availability (3). However, the diagnostic accuracy of ultrasound in identifying undescended testes can be variable, with reported sensitivities ranging widely from 33% to 95% depending on the study design and the specific patient population evaluated (2). Misdiagnosis remains a concern as ultrasound may misidentify gubernacular structures, misleading clinical decision-making (2).

The advent of innovative imaging techniques like diffusion-weighted MRI (DW-MRI) has shown promise in improving diagnostic accuracy and aiding in the localization of non-palpable testes (4). For instance, studies have demonstrated that combined imaging approaches incorporating ultrasound with MRI significantly enhance the accuracy of testis localization compared to ultrasound alone. Furthermore, there is emerging evidence that contrast-enhanced ultrasound could provide better characterization of testicular abnormalities, although it still requires further validation in clinical practice (5).

Understanding the diagnostic accuracy of ultrasound compared to advanced imaging modalities is pivotal, especially in children, where appropriate management can impact long-term reproductive health and risk of malignancy. Therefore, this study aims to evaluate the diagnostic performance of ultrasound in identifying undescended testes in pediatric patients and correlate these findings with surgical outcomes to elucidate the efficacy of ultrasound as a diagnostic tool in clinical practice. Ultimately, this may delineate clearer pathways for management and highlight the need for multidisciplinary approaches incorporating urologists, radiologists, and endocrinologists to enhance patient outcomes.

Methodology

This was a prospective diagnostic accuracy study conducted at the Pediatric Surgery Department of a tertiary care hospital in Pakistan from February 2025 to April 2025. A total of 78 male patients presenting with clinically suspected undescended testes were enrolled using non-probability consecutive sampling. The inclusion criteria comprised boys aged 6 months to 10 years with unilateral or bilateral undescended testes confirmed on clinical examination. Exclusion criteria included previously operated cases, retractile testes, or syndromic children with genital anomalies.

All participants underwent ultrasonography using a high-resolution linear probe (7–12 MHz), performed by a pediatric radiologist who

was blinded to the surgical findings. Ultrasound findings included testicular location (inguinal, abdominal, non-palpable), size, echogenicity, and vascularity. Surgical exploration (inguinal or laparoscopic) was performed under general anesthesia by a consultant pediatric surgeon. Intraoperative findings were considered the gold standard.

Statistical analysis was conducted using SPSS version 26. Sensitivity, specificity, PPV, NPV, and overall accuracy of ultrasound were calculated. A cross-tabulation was performed between ultrasound and intraoperative findings to determine the diagnostic correlation. Ethical approval was obtained from the institutional review board, and written informed consent was obtained from the parents or guardians of all participants before their inclusion.

Results

A total of 78 male children diagnosed with undescended testes (UDT) were enrolled in the study. The mean age of the participants was 3.6 ± 1.8 years, with the majority of cases (n = 47, 60.3%) being unilateral and the remaining cases (n = 31, 39.7%) bilateral. Out of 109 testes evaluated, inguinal and abdominal locations were most commonly observed. Table 1 illustrates the distribution of patients by age and laterality of UDT. Unilateral cases showed a slight right-sided dominance.

Table 1: Demographic Characteristics of the Study Population (n = 78)

Variable	Frequency (n)	Percentage (%)
Age (Mean ± SD, in years)	3.6 ± 1.8	—
Laterality:		
— Unilateral	47	60.3%
— Bilateral	31	39.7%
Side involved (in unilateral)		
— Right	28	59.6%
— Left	19	40.4%

Table 2: Diagnostic Accuracy of Ultrasound for Localization of UDT (n = 109 Testes)

Parameter	Value
True Positives (TP)	72
False Positives (FP)	5
True Negatives (TN)	23
False Negatives (FN)	9
Sensitivity	88.9%
Specificity	82.1%
Positive Predictive Value	93.5%
Negative Predictive Value	71.9%
Overall Accuracy	87.1%

Table 2 indicates that ultrasound had high sensitivity (88.9%) and PPV (93.5%) in localizing undescended testes. The false negatives were primarily due to intra-abdominal or atrophic testes, which are more challenging to visualize via USG. Table 3 highlights that ultrasound had the highest correlation for inguinal testes (96.5%). Non-palpable testes showed the lowest agreement due to the high likelihood of vanishing or atrophic gonads.

Table 3: Correlation Between Ultrasound Localization and Intraoperative Findings

Ultrasound Location	Intraoperative Confirmation (n)	Concordance (%)
Inguinal canal	58	96.5%
Abdominal	14	85.7%
Non-palpable	21	66.7%
Total	93	87.1%

Discussion

The present study evaluated the diagnostic accuracy of ultrasound in localizing undescended testes (UDT) in children, with a specific focus on surgical outcomes and correlation with intraoperative findings. A total of 78 male children, predominantly with unilateral UDT (60.3%), were included in our analysis, which is in line with previous literature reporting similar trends in laterality (6,7). Our findings indicate that ultrasound possessed a sensitivity of 88.9% and an overall accuracy of 87.1%. This supports earlier studies that had also established ultrasound as a reliable initial imaging modality, although some reported lower accuracy rates, particularly in cases of non-palpable testes (8,9).

In our cohort, ultrasound demonstrated excellent concordance with intraoperative findings, particularly for inguinal testes (96.5%). This high level of agreement aligns with data reported by Kollin et al. (10), who highlighted that ultrasound can face challenges with intra-abdominal or atrophic testes, which accounted for a portion of our study's false negatives (9 out of 109 testes). A similar conclusion was reached by Gavrilovici et al. (8), who emphasized that ultrasound cannot consistently visualize all non-palpable testes, with a significant risk that undetected intra-abdominal testes may contribute to increased malignancy rates over time.

When we compared our results to previous studies on ultrasound's efficacy in identifying UDT, we noted that our overall specificity of 82.1% is consistent with numerous reports in the literature. However, variations exist depending on local practices. (11,12) It is important to note that the positive predictive value (PPV) of 93.5% signifies that when ultrasound indicates the presence of a testis in the inguinal or abdominal

cavity, it is highly likely to be accurate. This highlights the importance of ultrasound as a reliable tool for assessing conditions before surgical intervention.

However, the low negative predictive value (NPV) of 71.9% suggests a need for caution. Without complementary imaging, pediatric surgeons may proceed without visual confirmation of a testis located intra-abdominally, increasing the likelihood of undetected malignancy or torsion, as referenced by studies examining testicular torsion complications (13,14). As we progress, integrating advanced imaging technologies such as diffusion-weighted MRI (DWI) may enhance localization accuracy, particularly for non-palpable cases (15). Therefore, while current ultrasound protocols are beneficial, leveraging multi-modal imaging strategies could significantly improve surgical outcomes and patient safety.

Despite the compelling results, this study has limitations. The small sample size can limit generalizability, and the retrospective observational design may introduce selection bias. Furthermore, additional factors, such as skill variance among ultrasound technicians, were not accounted for, which can influence diagnostic accuracy in a clinical setting.(16,17) Future prospective studies with larger cohorts and standardized ultrasound training protocols could provide deeper insights into the strengths and weaknesses of ultrasound in the management of cryptorchidism.

Thus, this study provides valuable evidence to the existing body of literature, affirming that while ultrasound remains an effective initial diagnostic tool for UDT, its use should be complemented by other imaging modalities in challenging cases to ensure comprehensive evaluation and mitigate the risks associated with undetected testicular conditions.

Conclusion

This study confirms that ultrasound remains a valuable first-line diagnostic modality in evaluating undescended testes, offering high sensitivity, particularly for inguinal testicular localization. However, its limited specificity and reduced performance in non-palpable or intra-abdominal testes warrant caution. The findings underscore the importance of considering supplementary imaging techniques, especially in cases where sonographic results are inconclusive or absent. Incorporating a multimodal diagnostic strategy may enhance preoperative planning and reduce the risk of missed diagnoses, ultimately improving surgical outcomes and long-term patient health in pediatric cryptorchidism.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

Funding

Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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