RESEARCH PAPER

COMPARISON BETWEEN MAGNETIC RESONANCE IMAGING AND TRANSRECTAL ULTRASOUND IN ASSESSING THE STRUCTURAL CAUSES OF MALE INFERTILITY IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background- Male infertility contributes to nearly half of all infertility cases worldwide and remains a major reproductive health concern. Structural abnormalities involving the ejaculatory ducts, seminal vesicles, vas deferens, prostate gland, and associated pelvic structures are important causes of infertility and often require imaging for accurate diagnosis. Transrectal ultrasonography (TRUS) is widely used as a first-line imaging modality because it is inexpensive, readily available, and minimally invasive. Magnetic resonance imaging (MRI), on the other hand, provides superior soft-tissue contrast and multiplanar anatomical visualization. Determining the relative diagnostic performance of these modalities is important for optimizing infertility evaluation and improving patient management.

Materials and Methods- This hospital-based cross-sectional analytical study was conducted in the Department of Radiodiagnosis and Imaging at a tertiary care teaching hospital over a period of 18 months. Fifty male patients aged 20–45 years presenting with primary or secondary infertility were enrolled consecutively after satisfying the eligibility criteria. All participants underwent both TRUS and pelvic MRI within one week. Imaging findings were independently interpreted by experienced radiologists blinded to each other's observations. Structural abnormalities including ejaculatory duct obstruction, seminal vesicle abnormalities, varicocele, midline prostatic cysts, and congenital abnormalities of the vas deferens were evaluated. Diagnostic performance parameters including sensitivity and positive predictive value were calculated using MRI as the reference standard.

Results- Among the 50 participants, 52% belonged to the 30–39 years age group and 78% presented with primary infertility. Clinically proven azoospermia was observed in 40% of patients. MRI identified varicocele as the most common abnormality (30%), followed by ejaculatory duct obstruction (24%), seminal vesicle abnormalities (20%), midline prostatic cysts (12%), congenital abnormalities of the vas deferens (6%), and other abnormalities (8%). TRUS demonstrated comparable findings, detecting varicocele in 28%, ejaculatory duct obstruction in 24%, seminal vesicle abnormalities in 18%, midline prostatic cysts in 12%, and congenital vas deferens abnormalities in 6% of patients. Overall, TRUS correctly identified 47 of 50 MRI-confirmed abnormalities, yielding a sensitivity of 94% and a positive predictive value of 100%. Sensitivity of TRUS was 91.7% for ejaculatory duct obstruction, 90% for seminal vesicle abnormalities, 93.3% for varicocele, and 100% for both midline prostatic cysts and congenital vas deferens abnormalities.

Conclusion- TRUS demonstrated excellent agreement with MRI in detecting structural causes of male infertility and showed high diagnostic sensitivity across all major abnormalities evaluated. While MRI remains superior for comprehensive anatomical characterization and evaluation of complex pelvic pathology, TRUS provides a reliable, cost-effective, minimally invasive, and readily accessible first-line imaging modality for routine infertility assessment. MRI may be reserved for equivocal cases, congenital anomalies, and situations requiring detailed preoperative anatomical mapping. Adoption of an imaging-based diagnostic algorithm utilizing TRUS as the primary investigation and MRI as a complementary modality can improve diagnostic efficiency and optimize management of infertile men.

Keywords- Male infertility; Transrectal ultrasonography; Magnetic resonance imaging; Ejaculatory duct obstruction; Seminal vesicle abnormalities; Varicocele; Azoospermia; Structural abnormalities.

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INTRODUCTION

Infertility is recognized as a major global public health concern affecting millions of couples worldwide and exerting significant psychological, social, and economic consequences. The World Health Organization estimates that approximately one in six individuals experiences infertility during their reproductive lifespan, highlighting the growing magnitude of the problem across both developed and developing nations. Increasing age at marriage, environmental exposures, lifestyle modifications, obesity, metabolic disorders, and reproductive tract diseases have contributed substantially to the rising prevalence of infertility worldwide. Consequently, early identification of reversible causes of infertility has become an important priority in reproductive medicine and public health practice [1].

Male factor infertility contributes to nearly 40–50% of all infertility cases and may occur either independently or in combination with female factors. Advances in reproductive medicine have demonstrated that male infertility is a heterogeneous condition resulting from endocrine abnormalities, genetic disorders, testicular dysfunction, infections, immunological factors, and structural abnormalities of the reproductive tract. Contemporary guidelines from the American Urological Association and the American Society for Reproductive Medicine emphasize a comprehensive evaluation involving clinical examination, semen analysis, hormonal assessment, genetic testing, and appropriate imaging studies to identify the underlying etiology accurately and facilitate targeted treatment strategies [2].

Among the various diagnostic modalities available for male infertility assessment, imaging plays a crucial role in identifying anatomical and obstructive abnormalities affecting the male reproductive tract. Structural abnormalities involving the seminal vesicles, ejaculatory ducts, vas deferens, prostate gland, and peri-prostatic tissues may significantly impair sperm transport and ejaculation, leading to infertility. Transrectal ultrasonography (TRUS) has emerged as an important first-line imaging technique because of its ability to provide real-time visualization of the prostate, seminal vesicles, and ejaculatory ducts with high spatial resolution. Since its introduction into infertility evaluation, TRUS has demonstrated considerable utility in detecting ejaculatory duct obstruction, seminal vesicle abnormalities, prostatic cysts, calcifications, and congenital anomalies of the distal reproductive tract [3].

Recent developments in diagnostic imaging have further enhanced the evaluation of male infertility. Contemporary urological practice increasingly incorporates multimodal imaging approaches to improve diagnostic accuracy and facilitate individualized patient management. The latest edition of Campbell-Walsh-Wein Urology emphasizes that imaging investigations have become integral components of infertility work-up, particularly in patients with azoospermia, low ejaculate volume, suspected obstructive pathology, or congenital reproductive tract abnormalities. Appropriate imaging not only assists in diagnosis but also guides therapeutic planning and prognostication [4].

Ejaculatory duct obstruction (EDO) represents one of the most important surgically correctable causes of male infertility. Obstruction may result from congenital abnormalities, inflammatory strictures, cystic lesions, calculi, or fibrosis involving the ejaculatory ducts and adjacent structures. Patients frequently present with low semen volume, azoospermia, oligospermia, painful ejaculation, or hematospermia. Accurate diagnosis is essential because timely intervention may restore fertility and improve reproductive outcomes. Recent studies have highlighted the importance of advanced imaging techniques in detecting EDO and differentiating complete obstruction from partial obstruction, thereby enabling appropriate therapeutic intervention [5].

Advances in reproductive medicine have also contributed to a better understanding of male infertility and the role of imaging in its evaluation. Contemporary research demonstrates that combining clinical assessment with high-resolution imaging significantly improves diagnostic precision and facilitates early identification of treatable structural abnormalities. Modern imaging technologies have therefore become indispensable tools in infertility clinics and specialized andrology centers worldwide [6].

Current evidence suggests that male infertility should be approached using a multidisciplinary strategy incorporating clinical, laboratory, genetic, and imaging investigations. Recent reviews emphasize that imaging contributes substantially to identifying obstructive lesions, congenital abnormalities, and acquired reproductive tract disorders that may otherwise remain undetected during routine clinical evaluation. Such comprehensive assessment enables clinicians to select appropriate medical, surgical, or assisted reproductive interventions based on individual patient characteristics [7].

The epidemiology of male infertility has also attracted considerable attention in recent years. Studies indicate a global decline in semen quality accompanied by increasing prevalence of reproductive disorders among men. Environmental pollutants, occupational exposures, obesity, smoking, alcohol consumption, and lifestyle-related factors have been implicated in this trend. These observations underscore the importance of developing accurate diagnostic pathways capable of identifying both functional and structural causes of infertility at an early stage [8].

Structural abnormalities are increasingly recognized as important contributors to male infertility. Conditions such as ejaculatory duct obstruction, seminal vesicle anomalies, congenital absence of the vas deferens, and varicocele may impair fertility through disruption of normal sperm transport mechanisms. Comprehensive evaluation and accurate anatomical characterization are therefore essential for successful management. Recent advances in reproductive science have highlighted the value of imaging modalities in detecting these abnormalities and improving patient outcomes [9].

Professional societies continue to advocate evidence-based diagnostic approaches for infertile men. Current recommendations emphasize the use of targeted imaging investigations in patients presenting with azoospermia, low semen volume, abnormal semen parameters, or clinical suspicion of obstructive pathology. Such strategies improve diagnostic efficiency while minimizing unnecessary invasive procedures [10].

Among available imaging modalities, TRUS remains the most widely used first-line investigation for evaluating distal male reproductive tract abnormalities. It offers several advantages, including accessibility, affordability, absence of ionizing radiation, real-time assessment, and the ability to perform image-guided interventions when necessary. TRUS provides detailed visualization of seminal vesicles, ejaculatory ducts, vas deferens, and peri-prostatic structures, facilitating the detection of obstructive lesions and congenital anomalies [11].

Despite the utility of TRUS, certain complex abnormalities may require additional imaging for precise characterization. MRI provides excellent soft-tissue contrast, multiplanar imaging capability, and superior anatomical delineation. MRI is particularly valuable in evaluating congenital anomalies, peri-ductal fibrosis, seminal vesicle abnormalities, and equivocal findings detected on TRUS. Furthermore, MRI contributes significantly to preoperative planning and assessment of surgically correctable lesions [12,13].

Varicocele represents another common structural abnormality associated with male infertility. It is characterized by abnormal dilatation of the pampiniform venous plexus and has been associated with impaired spermatogenesis, oxidative stress, and reduced semen quality. Early detection and appropriate management of varicocele can improve reproductive outcomes, emphasizing the importance of accurate imaging evaluation in infertile men [14].

Standardized semen analysis remains an essential component of infertility evaluation and provides critical information regarding sperm concentration, motility, morphology, and seminal fluid characteristics. Imaging findings should always be interpreted in conjunction with semen analysis results to achieve a comprehensive understanding of reproductive function and guide individualized treatment planning [15].

Although both TRUS and MRI are widely utilized in evaluating structural causes of male infertility, evidence comparing their diagnostic performance in the Indian population remains limited. Establishing the relative strengths and limitations of these modalities is important for developing cost-effective diagnostic algorithms and optimizing patient care. Therefore, the present study was undertaken to compare Magnetic Resonance Imaging and Transrectal Ultrasound in assessing the structural causes of male infertility and to determine their clinical utility in routine practice.

RESULTS

Table 1. Demographic Characteristics of Study Participants (n = 50)

Variable	Frequency	Percentage (%)
Age Group (Years)		
20–29	12	24.0
30–39	26	52.0
40–45	12	24.0
Duration of Marriage (Years)		
<3	18	36.0
3–5	20	40.0
>5	12	24.0

Finding

Among the 50 study participants, the majority belonged to the 30–39 years age group (52%), followed by equal proportions in the 20–29 years and 40–45 years age groups (24% each). Regarding duration of marriage, 40% had been married for 3–5 years, 36% for less than 3 years, and 24% for more than 5 years. This indicates that most participants were in the peak reproductive age group and had experienced infertility despite several years of marital exposure.

Table 2. Clinical Characteristics of Study Participants (n = 50)

Variable	Frequency	Percentage (%)
Primary infertility	39	78.0

Variable	Frequency	Percentage (%)
Secondary infertility	11	22.0
Prior empirical infertility treatment	17	34.0
Clinical varicocele	13	26.0
Clinically proven azoospermia	20	40.0

Finding

Primary infertility was the predominant clinical presentation, accounting for 78% of cases, while secondary infertility constituted 22%. Previous empirical treatment for infertility had been received by 34% of participants. Clinical examination revealed varicocele in 26% of subjects, whereas azoospermia was documented in 40%, suggesting a considerable burden of structural reproductive abnormalities.

Table 3. Distribution of MRI Findings (n = 50)

MRI Finding	Frequency	Percentage (%)
Varicocele	15	30.0
Ejaculatory duct obstruction (EDO)	12	24.0
Seminal vesicle dilatation/anomaly	10	20.0
Midline prostatic cyst	6	12.0
Congenital absence/abnormality of vas deferens (CAVD)	3	6.0
Other abnormalities	4	8.0
Total	50	100

Finding

MRI detected structural abnormalities in the majority of participants. Varicocele was the most frequently identified abnormality (30%), followed by ejaculatory duct obstruction (24%) and seminal vesicle abnormalities (20%). Midline prostatic cysts accounted for 12% of cases, while congenital vas deferens abnormalities were observed in 6%.

Table 4. Distribution of TRUS Findings (n = 50)

TRUS Finding	Frequency	Percentage (%)
Varicocele	14	28.0
Ejaculatory duct obstruction (EDO)	12	24.0
Seminal vesicle dilatation/anomaly	9	18.0
Midline prostatic cyst	6	12.0
Congenital absence/abnormality of vas deferens (CAVD)	3	6.0
Other abnormalities	4	8.0
Normal study	3	6.0
Total	50	100

Finding

TRUS demonstrated findings comparable to MRI. Varicocele remained the most common abnormality (28%), followed by ejaculatory duct obstruction (24%) and seminal vesicle abnormalities (18%). Only 6% of examinations were reported as normal, reflecting the high prevalence of structural abnormalities among infertile men.

Table 5. Overall Diagnostic Performance of TRUS Using MRI as Reference Standard

Parameter	Value
True Positive (TP)	47
False Positive (FP)	0
False Negative (FN)	3
True Negative (TN)	0
Sensitivity (%)	94.0
Positive Predictive Value (%)	100.0

Finding

TRUS correctly identified 47 of 50 MRI-confirmed abnormalities, yielding a sensitivity of 94%. No false-positive findings were observed, resulting in a positive predictive value of 100%. These findings demonstrate excellent agreement between TRUS and MRI in detecting structural causes of male infertility.

Table 6. Correlation of Ejaculatory Duct Obstruction Detection Between MRI and TRUS

TRUS Findings	MRI Positive	MRI Negative	Total
Positive	11	0	11
Negative	1	0	1
Total	12	0	12

Finding

Among 12 MRI-confirmed cases of ejaculatory duct obstruction, TRUS correctly identified 11 cases and missed only one case. The sensitivity of TRUS for detecting ejaculatory duct obstruction was therefore 91.7%, indicating excellent diagnostic agreement with MRI.

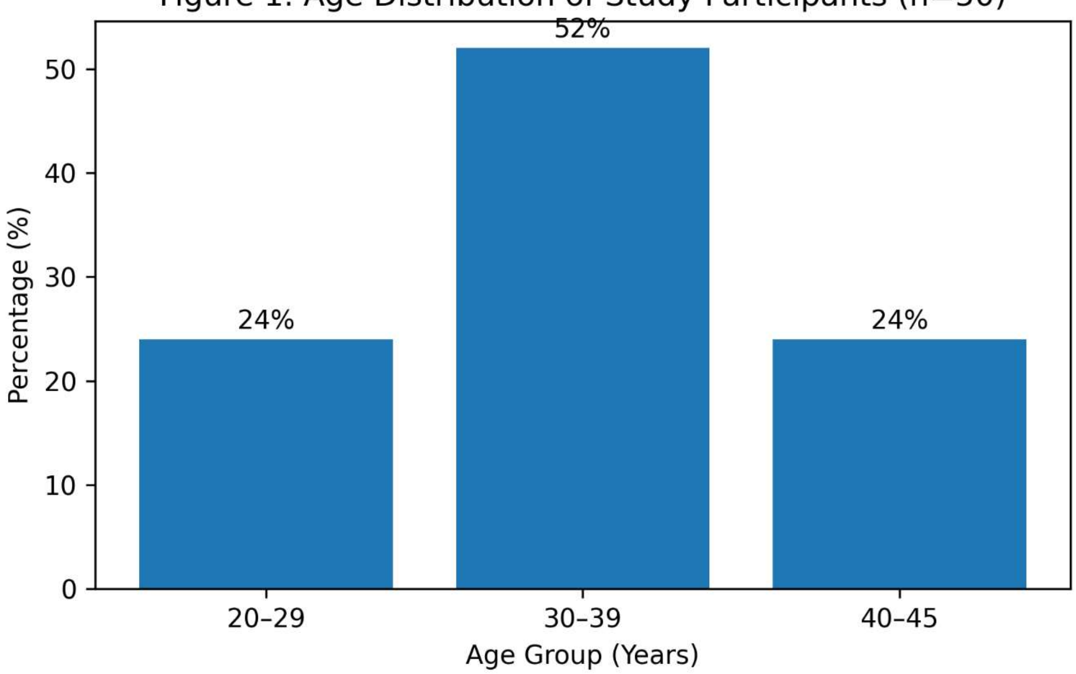
Table 7. Correlation of Other Structural Abnormalities Detected by MRI and TRUS

Abnormality	MRI Cases (n)	TRUS Cases (n)	Sensitivity (%)
Seminal vesicle dilatation/anomaly	10	9	90.0
Varicocele	15	14	93.3
Midline prostatic cyst	6	6	100.0
CAVD	3	3	100.0

Finding

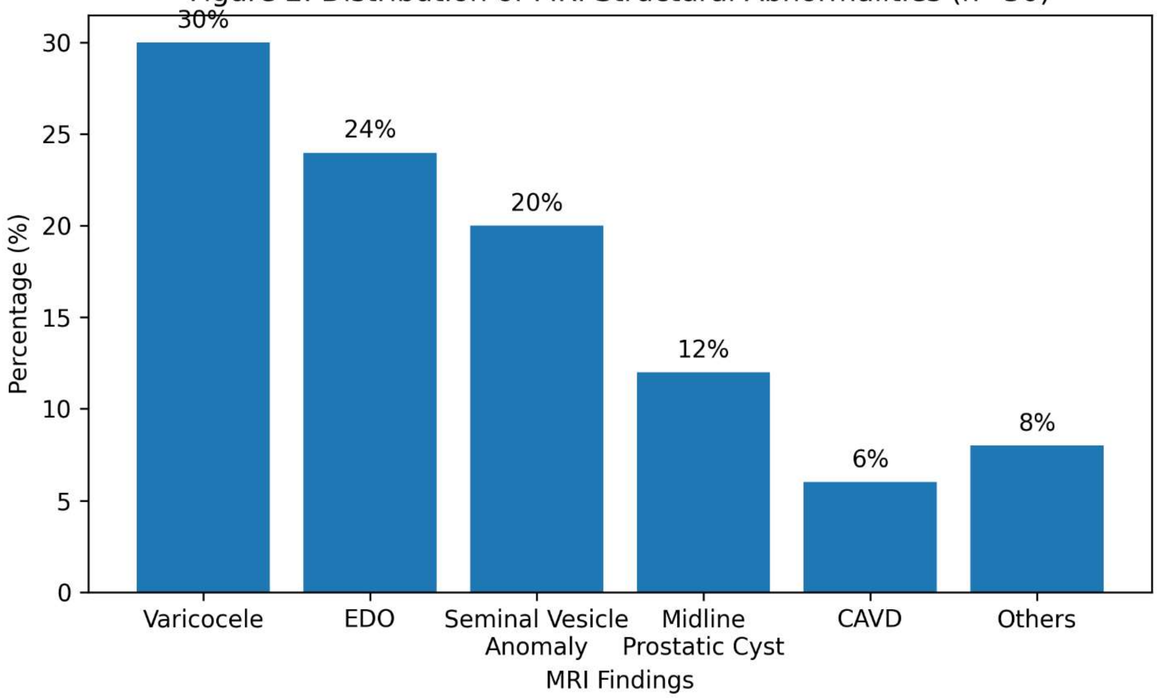
TRUS demonstrated high sensitivity for detecting all major structural abnormalities. Complete agreement with MRI was observed for midline prostatic cysts and congenital vas deferens abnormalities (100%). Sensitivity was also high for varicocele (93.3%) and seminal vesicle abnormalities (90%), confirming the reliability of TRUS as a first-line imaging modality.

Figure 1. Age Distribution of Study Participants (n=50)



The majority of study participants belonged to the **30–39 years age group (52%)**, indicating that most patients sought infertility evaluation during the peak reproductive years. Participants aged **20–29 years** and **40–45 years** each accounted for **24%** of the study population. The predominance of men in the 30–39-year category suggests delayed presentation for infertility assessment and highlights the clinical importance of evaluating structural causes of infertility during this age period.

Figure 2. Distribution of MRI Structural Abnormalities (n=50)



MRI identified a wide spectrum of structural abnormalities among infertile men. **Varicocele was the most common abnormality (30%)**, followed by **ejaculatory duct obstruction (24%)** and **seminal vesicle abnormalities (20%)**. Midline prostatic cysts accounted for 12% of cases, while congenital abnormalities of the vas deferens constituted 6%. Other minor or combined abnormalities were observed in 8% of participants.

Figure 3. Sensitivity of TRUS for Detection of Structural Abnormalities

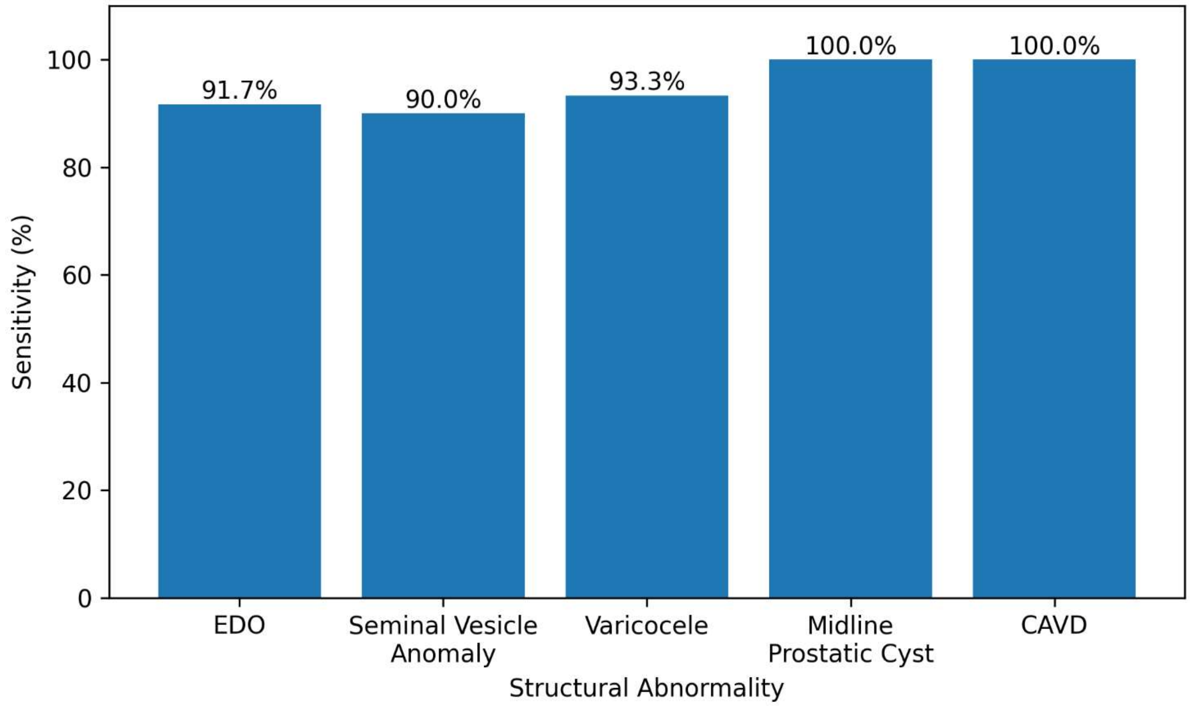


Figure 3 demonstrates the diagnostic sensitivity of TRUS for detecting major structural causes of male infertility using MRI as the reference standard. The highest sensitivity was observed for **midline prostatic cysts (100%)** and **CAVD (100%)**, indicating complete concordance between TRUS and MRI for these abnormalities. TRUS also demonstrated excellent performance in identifying **varicocele (93.3%)** and **ejaculatory duct obstruction (91.7%)**, missing only a very small number of MRI-confirmed cases. Sensitivity for **seminal vesicle abnormalities was 90%**, which remained clinically acceptable and reflected strong diagnostic agreement.

DISCUSSION

The present study was undertaken to compare Magnetic Resonance Imaging (MRI) and Transrectal Ultrasonography (TRUS) in assessing structural causes of male infertility and to evaluate the diagnostic performance of TRUS using MRI as the reference standard. Structural abnormalities were identified in a substantial proportion of infertile men, emphasizing the importance of imaging in the diagnostic evaluation of male reproductive disorders.

In the present study, the majority of participants belonged to the 30–39 years age group (52%), while 24% each were aged 20–29 years and 40–45 years. Most participants had been married for 3–5 years (40%), indicating prolonged infertility before specialized evaluation. Furthermore, primary infertility constituted 78% of cases, whereas secondary infertility accounted for 22%. These findings suggest that infertility evaluation is most commonly sought during the peak reproductive years and that primary infertility remains the predominant clinical presentation.

The predominance of primary infertility observed in our study is consistent with the observations of Du et al., who reported that obstructive causes of infertility are more frequently encountered among men presenting with primary infertility than among those with secondary infertility [16]. Similarly, Moon et al. demonstrated that azoospermic men undergoing imaging evaluation predominantly belonged to the primary infertility category, highlighting the importance of structural assessment in this population [17]. Roberts and Jarvi also emphasized that prolonged infertility associated with low semen volume or azoospermia frequently warrants imaging investigations to identify underlying obstructive pathology [18].

MRI evaluation in the present study revealed varicocele as the most common abnormality, detected in 30% of participants, followed by ejaculatory duct obstruction (24%), seminal vesicle dilatation or anomalies (20%), midline prostatic cysts (12%), congenital absence or abnormality of the vas deferens (6%), and other minor abnormalities (8%). Figure 2 further demonstrated that varicocele and ejaculatory duct obstruction constituted the major structural abnormalities among infertile men.

These findings are comparable to those reported by Peikert et al., who observed that seminal vesicle abnormalities and ejaculatory duct pathology represented important structural causes of male infertility detectable by both MRI and TRUS [19]. Han et al. similarly reported that MRI provides excellent visualization of distal male genital tract obstruction and accurately identifies congenital anomalies and peri-ductal abnormalities responsible for infertility [20]. Donkol et al. demonstrated that MRI is particularly valuable in evaluating complex pelvic reproductive tract diseases because of its superior soft-tissue contrast and multiplanar imaging capabilities [21]. Likewise, Engin et al. emphasized that MRI allows detailed assessment of seminal vesicle and vas deferens abnormalities that may not be fully characterized using conventional ultrasound techniques alone [22].

TRUS findings in the present study closely mirrored MRI findings. Varicocele was identified in 28% of cases, ejaculatory duct obstruction in 24%, seminal vesicle abnormalities in 18%, midline prostatic cysts in 12%, and congenital vas deferens abnormalities in 6%. The close agreement between the two modalities suggests that TRUS is highly effective in detecting major structural abnormalities responsible for male infertility.

The diagnostic performance analysis demonstrated that TRUS correctly identified 47 of 50 MRI-confirmed abnormalities, yielding an overall sensitivity of 94% and a positive predictive value of 100%. These findings indicate excellent agreement between TRUS and MRI. Similar observations were reported by Paick et al., who found TRUS to be highly effective in detecting ejaculatory duct dilatation, seminal vesicle enlargement, and prostatic cystic lesions among infertile men [23]. Popken et al. also reported high sensitivity and specificity of TRUS in identifying ejaculatory duct obstruction and associated abnormalities, supporting its role as a first-line imaging modality [24]. Likewise, Yagci et al. demonstrated that TRUS achieved diagnostic accuracy exceeding 85% in patients suspected of having ejaculatory duct obstruction, with excellent visualization of seminal vesicle enlargement and ductal dilatation [25].

In the present study, MRI-confirmed ejaculatory duct obstruction was observed in 24% of patients. TRUS correctly detected 11 of the 12 MRI-confirmed cases, resulting in a sensitivity of 91.7%. Table 6 demonstrates the strong agreement between both imaging modalities in diagnosing this condition. Ejaculatory duct obstruction remains one of the most important surgically correctable causes of male infertility, and its accurate diagnosis has significant therapeutic implications.

Our findings are consistent with those of Alayman et al., who emphasized that TRUS remains the preferred initial investigation for ejaculatory duct obstruction because of its accessibility, affordability, and ability to identify ductal dilatation, seminal vesicle enlargement, and associated cystic lesions [26]. The high sensitivity observed in the present study supports the recommendation that TRUS should be utilized as the first-line imaging modality in patients suspected of having obstructive infertility.

Varicocele was the most common abnormality detected on MRI (30%) and TRUS (28%) in our study. The sensitivity of TRUS for detecting varicocele was 93.3%, indicating excellent diagnostic performance. Figure 3 demonstrated that TRUS reliably identified the majority of MRI-confirmed varicoceles. These findings support the growing body of evidence indicating that vascular abnormalities contribute significantly to male infertility.

Wang et al., in their meta-analysis of microsurgical varicocelectomy, reported that varicocele represents one of the most frequent correctable causes of male infertility and that accurate imaging is essential for patient selection and treatment planning [27]. Similarly, Esteves et al. emphasized that varicocele remains one of the most commonly encountered abnormalities among infertile men and highlighted the importance of imaging in identifying clinically significant disease and improving fertility outcomes [28]. The prevalence observed in our study is therefore consistent with current international evidence.

Midline prostatic cysts were detected in 12% of participants on both MRI and TRUS. Notably, TRUS demonstrated 100% sensitivity in identifying these lesions. Similarly, congenital abnormalities of the vas deferens were identified in 6% of cases by both modalities, again yielding 100% sensitivity. These findings suggest that TRUS possesses excellent capability for identifying well-defined cystic and congenital abnormalities of the distal reproductive tract.

Galosi et al. proposed an ultrasonographic classification of prostatic cystic lesions and demonstrated that TRUS provides high-resolution visualization of intraprostatic cysts, facilitating accurate diagnosis and classification [29]. The complete agreement observed in our study supports their conclusions and highlights the effectiveness of TRUS in detecting such lesions. Likewise, congenital abnormalities involving the vas deferens and seminal tract structures are readily visualized by TRUS when performed by experienced operators.

Seminal vesicle abnormalities were identified in 20% of patients on MRI and 18% on TRUS. The sensitivity of TRUS for detecting these abnormalities was 90%, indicating strong but not perfect agreement with MRI. Although MRI demonstrated slightly superior detection capability, the difference was clinically small. Zhao et al. reported similar findings and concluded that combined MRI and TRUS evaluation offers comprehensive assessment of seminal vesicle pathology and associated infertility-related abnormalities [30]. Their study emphasized that MRI provides superior anatomical delineation, whereas TRUS remains highly effective for routine clinical evaluation.

The figures included in the present study further support these findings. Figure 1 demonstrated that infertility evaluation was most frequently undertaken among men aged 30–39 years. Figure 2 highlighted varicocele and ejaculatory duct obstruction as the predominant MRI-detected abnormalities. Figure 3 showed that TRUS sensitivity exceeded 90% for all major structural abnormalities evaluated, with perfect sensitivity for midline prostatic cysts and congenital vas deferens abnormalities.

Overall, the present study demonstrates excellent concordance between MRI and TRUS in assessing structural causes of male infertility. Although MRI remains superior for detailed anatomical characterization and evaluation of complex pelvic pathology, TRUS achieved an overall sensitivity of 94% and a positive predictive value of 100%, confirming its utility as a reliable, cost-effective, minimally invasive first-line imaging modality. MRI may therefore be reserved for equivocal, complex, or surgically challenging cases, while TRUS can serve as the primary imaging investigation in the majority of infertile men presenting with suspected structural abnormalities.

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