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Diagnostic Accuracy and Surgical Outcomes of Deep Infiltrating Endometriosis Involving the Urinary Tract: A Systematic Review

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ABSTRACT

Deep infiltrating endometriosis (DIE) involving the urinary tract represents a severe phenotype of endometriosis that poses major diagnostic and surgical challenges. Accurate preoperative imaging and optimal surgical management are essential to prevent silent obstruction and long-term renal damage. **Objectives:** To evaluate the diagnostic accuracy of imaging modalities and to summarize surgical outcomes in patients with urinary tract deep infiltrating endometriosis. **Methods:** This systematic review was conducted in accordance with PRISMA 2020 guidelines. PubMed, Scopus, and the Cochrane Library were searched for studies published between January 2018 and March 2025. Diagnostic-accuracy studies and outcome-only surgical cohorts were synthesized as distinct evidence streams. Methodological quality was assessed using QUADAS-2 for diagnostic studies and the Newcastle–Ottawa Scale for surgical cohorts. **Results:** Twelve studies were included, comprising two formal diagnostic-accuracy studies and ten surgical outcome cohorts. Transvaginal ultrasonography using the IDEA protocol demonstrated high diagnostic performance (sensitivity 93.9%, specificity 99.4%, accuracy 98.7%), while magnetic resonance imaging showed good sensitivity (83.3%) and excellent negative predictive value (93.5%). Most surgical cohorts reported favorable postoperative outcomes with low urinary tract–specific recurrence when managed in specialized centers. However, none of the studies reported confidence intervals or complete diagnostic contingency matrices. **Conclusions:** Transvaginal ultrasonography and magnetic resonance imaging are complementary and highly specific modalities for diagnosing urinary tract DIE, and minimally invasive surgery yields favorable outcomes. Standardized diagnostic reporting and prospective multicenter diagnostic-accuracy studies are required to strengthen evidence-based clinical pathways.

INTRODUCTION

Endometriosis is a chronic estrogen-sensitive inflammatory disease characterized by the presence of functional endometrial glands and stroma outside the uterine cavity, affecting approximately 6–10% of women of reproductive age worldwide [1]. One of its most severe and clinically aggressive phenotypes is deep infiltrating endometriosis (DIE), defined by endometriotic tissue infiltrating more than 5 mm beneath the peritoneal surface. DIE is commonly associated with severe pelvic pain, infertility, and multisystem involvement, frequently affecting pelvic organs such as the bowel, bladder, and ureters [2, 3]. Urinary tract endometriosis (UTE) accounts for approximately 1–2% of all cases of endometriosis and up to 20–50% of DIE presentations, with the bladder and ureters being the most commonly involved sites [4]. Ureteric involvement is of particular clinical concern because it may remain asymptomatic until significant obstruction or hydronephrosis develops, leading to

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progressive renal impairment. Delayed diagnosis, therefore, represents a serious risk for irreversible renal damage, underscoring the critical importance of accurate preoperative identification [5, 6]. Urinary tract DIE is primarily managed by surgical excision, with minimally invasive laparoscopic approaches increasingly favored because of improved postoperative outcomes and organ preservation [7]. Recent advances, including the standardization of imaging protocols such as the International Deep Endometriosis Analysis (IDEA) consensus, have improved lesion mapping and surgical planning. Nevertheless, despite their widespread use, there remains substantial heterogeneity in diagnostic reporting, and only a limited number of studies provide complete parameters of diagnostic accuracy for urinary tract DIE. This lack of standardized diagnostic data hinders quantitative synthesis and the development of robust evidence-based guidelines [8]. Urinary-tract DIE, symptomatic management of which remains based on surgical excision, is becoming more popular using minimally invasive laparoscopic methods because of enhanced postoperative outcome and retention of organs [9].

However, reported recurrence rates, complication profiles, and long-term functional outcomes vary considerably across published series, reflecting differences in surgical techniques, patient selection, and outcome definitions. Given these diagnostic and therapeutic challenges, an updated systematic synthesis of contemporary evidence is required. Therefore, this systematic review was conducted to evaluate the diagnostic accuracy of imaging modalities and to summarize surgical outcomes of urinary tract deep infiltrating endometriosis, to inform standardized diagnostic pathways and optimize multidisciplinary surgical management. This study aims to assess the diagnostic performance of transvaginal ultrasonography and magnetic resonance imaging for the detection of deep infiltrating endometriosis of the urinary tract; to describe postoperative outcomes, recurrence rates, and complications following surgical management; and to identify gaps in standardized diagnostic reporting and priorities for future research.

METHODS

The systematic review was performed according to the Preferred Reporting Items on Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The aim of the review was to summarize the current evidence on the diagnostic quality of imaging modalities and the surgical outcome of deep infiltrating endometriosis of the urinary tract. Diagnostic-accuracy studies and outcome-only surgical cohorts were considered as two distinct evidence streams and were synthesized separately. A systematic literature review was conducted in PubMed, Scopus, and the Cochrane Library to find the relevant studies published between January 2018 and March 2025. The PubMed search strategy included the Medical Subject Headings (MeSH) and free-text keywords with the following syntax ("Endometriosis"[Mesh] OR "Deep Infiltrating Endometriosis" OR "Urinary Tract Endometriosis" OR "Bladder Endometriosis" OR "Ureteral Endometriosis") AND ("Ultrasonography"[Mesh] OR "Transvaginal Ultrasonography" OR "Magnetic Resonance Imaging"[Mesh] OR MRI) AND ("Diagnosis"[Mesh] OR "Diagnostic Imaging"[Mesh] OR "Sensitivity and Specificity"[Mesh]). Treatment- and surgery-related terms were used only to capture combined diagnostic–surgical studies and were not prioritized to define diagnostic accuracy evidence. Scopus and Cochrane were adjusted to equivalent keyword combinations and Boolean operators. Included studies reference lists were also screened manually to provide full coverage. Research articles that were original and provided diagnostic imaging results and/or surgical outcomes in patients with bladder or ureteric deep infiltrating endometriosis were eligible to be included in the research. These were prospective cohorts, retrospective cohorts, diagnostic accuracy studies, and retrospective case series of surgery. Articles written in English that are published after 2018 and before 2025 were only taken into account. The exclusion criteria were narrative reviews, systematic reviews, meta-analyses, animal studies, conference abstracts, case reports, and studies that did not have urinary tract involvement or quantitative clinical outcomes. Diagnostic-accuracy studies were required to use surgery and/or histopathology as the reference standard. Two reviewers independently screened titles and abstracts after duplicate removal. Potentially relevant articles underwent full-text assessment for eligibility, and disagreements were resolved by consensus. The PRISMA 2020 flow diagram summarizes the study selection process. Reasons for full-text exclusion were explicitly recorded and reported. Reasons for full-text exclusion were explicitly recorded and reported. Data were extracted through the use of standardized data collection form that constituted author details, year of publication, country, study design, size of the sample used, location of the urinary tract that was involved, type of imaging modality used, reference standard, type of surgical procedure, postoperative complications, recurrence rates, and duration of follow-up. Where applicable, diagnostic accuracy parameters such as sensitivity, specificity, positive predictive value, negative predictive value, accuracy, and area under the curve were extracted; confidence intervals were recorded when

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reported. Diagnostic accuracy claims were restricted to formal diagnostic studies reporting numerical sensitivity and specificity and/or ROC-based analyses; outcome-only surgical cohorts were not used for diagnostic inference. Methodological quality was assessed using modality-appropriate tools. Formal diagnostic accuracy studies were evaluated using the QUADAS-2 tool, while observational surgical outcome cohorts were assessed using an adapted Newcastle–Ottawa Scale. This instrument assessed four areas, including selection of study groups, comparability of cohorts, outcome assessment, and sufficiency of follow-up. Each study was classified as having low, moderate, or high risk of bias. As a result of high heterogeneity in study design, imaging protocols, surgical procedure, outcome definitions, and lack of uniform reporting of diagnostic contingency matrices, statistical pooling of data was not possible. Very few studies provided full sensitivity and specificity, and the majority of cohorts were not created to determine the accuracy of diagnosing, but to determine surgical results. Thus, no meta-analysis was conducted, and the results were synthesized descriptively and presented in table form. A qualitative GRADE-based certainty assessment was performed, as formal domain-based GRADE profiling was not feasible due to the absence of meta-analysis, high heterogeneity, and predominance of observational study designs, indicating overall low-to-moderate certainty of evidence. A total of 330 records were identified through database searching (PubMed 148, Scopus 132, Cochrane 50). Before screening, 120 records were removed (94 duplicates and 26 removed for other reasons), leaving 210 records for title/abstract screening; 160 were excluded at this stage, and 50 reports were sought for retrieval. Six reports were not retrieved, 44 full-text articles were assessed for eligibility; 32 were excluded for predefined reasons (not quantitative/insufficient outcomes n=10, case reports/reviews n=14, and no urinary-tract involvement n=8), resulting in 12 studies included in the qualitative synthesis (Figure 1).

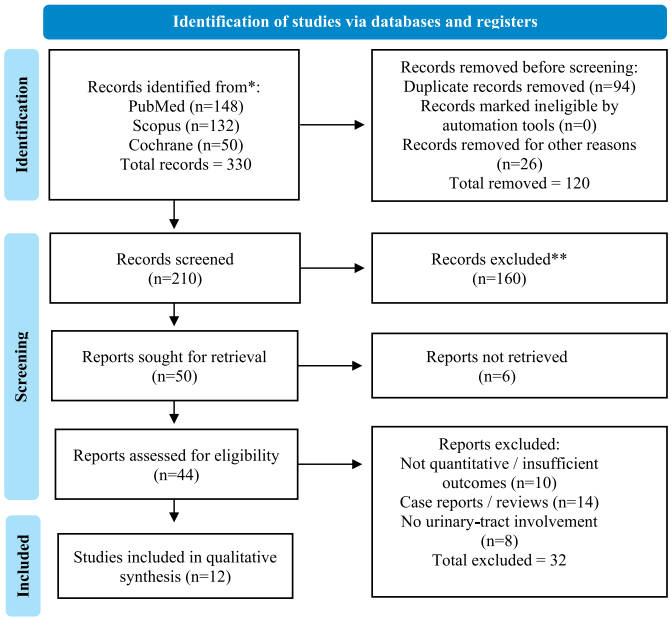

Figure 1: The Study Selection Process from Identification to Final Inclusion

RESULTS

Results summarize the characteristics of the included studies. The evidence base was predominantly composed of prospective and retrospective observational surgical cohorts conducted in tertiary referral centers, reflecting the complexity of urinary-tract deep infiltrating endometriosis (DIE). Only two studies were formal diagnostic-accuracy designs and were analyzed separately from outcome-only surgical series to avoid mixing evidence streams. Sample sizes varied widely, ranging from small case series to multicenter cohorts exceeding 200 participants, indicating heterogeneity in study power and population representativeness (Table 1).

Table 1: Characteristics of Included Studies on Urinary-Tract Deep Infiltration Endometriosis, Retrospective Cohort Studies, Diagnostic Accuracy Studies and Surgical Technique / Case Series (2018–2025)

Sr. No.	References	Country / Setting	Study Design, Modality Assessed	Sample Size	Urinary Tract Site	Reference Standard, Surgical Technique	Follow-up
Prospective / Multicenter Cohort Studies							
1	[10]	Italy, tertiary referral center	Prospective cohort	160	Ureter	Surgery + Histology	36 Months
2	[11]	France, multicenter	Prospective cohort	232	Bladder and ureter	Surgery	24 Months
Retrospective Cohort Studies							
3	[12]	Portugal	–	55	Bladder and ureter	Laparoscopic Excision; Recurrence and Complications	120 Months
4	[13]	Italy	–	105	Bladder and ureter	Predictors of Recurrence	48 Months
5	[14]	China	–	68	Ureter	Ureterolysis/Ureterectomy	36 Months
6	[15]	Germany	–	25	Bladder	Partial Cystectomy Outcomes	24 Months
Diagnostic Accuracy Studies							
7	[16]	–	TVUS (IDEA protocol)	74	Bladder and ureter DIE	Surgery	–
8	[17]	–	MRI	33 lesions	Intrinsic ureter DIE	Histology	–

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Surgical Technique / Case Series							
9	[18]	Japan	–	12	Bladder	"See-Through" Partial Cystectomy	–
10	[19]	Thailand	–	41	Bladder	Laparoscopic Partial Cystectomy	–
11	[20]	Italy	–	98	Bladder	Laparoscopic Bladder Wall Resection	–
12	[21]	USA	–	37	Ureter	Laparoscopic Ureterolysis	–

The study summarizes diagnostic accuracy reporting across included studies. Only two studies were formal diagnostic-accuracy investigations and reported numerical diagnostic performance metrics. The remaining cohorts primarily evaluated surgical outcomes and did not provide diagnostic contingency matrices, limiting comparative assessment of imaging performance. Therefore, diagnostic performance statements in this review are restricted to the two studies reporting numerical diagnostic accuracy metrics (Szabó 2022 and Rennan 2024), and outcome-only surgical cohorts were not used to infer diagnostic accuracy. In the two diagnostic studies, transvaginal ultrasonography (TVUS) using the IDEA protocol demonstrated sensitivity 93.9%, specificity 99.4%, PPV 95.8%, NPV 99.1%, and accuracy 98.7%, while MRI showed sensitivity 83.3%, specificity 77.8%, PPV 55.6%, NPV 93.5%, and AUC 0.806. No study reported 95% confidence intervals for sensitivity/specificity, and TP/FP/TN/FN numerical counts were not presented in the extracted results, despite both diagnostic studies indicating that diagnostic matrices were available. These reporting limitations precluded a pooled quantitative synthesis of diagnostic accuracy outcomes (Table 2).

Table 2: Diagnostic Accuracy Reporting in Included Studies

Sr. No.	References	Imaging modality	Did Study Report TP/FP/TN/FN?	Sensitivity	Specificity	PPV	NPV	Notes
1	[10]	MRI / US	No	NR	NR	NR	NR	Surgical outcome cohort; imaging used for preoperative assessment only; no diagnostic accuracy statistics reported
2	[20]	MRI / US / CT	No	NR	NR	NR	NR	Imaging used for surgical planning only; no contingency diagnostic analysis
3	[11]	MRI	No	NR	NR	NR	NR	Multicenter pilot outcome study; no diagnostic accuracy statistics reported
4	[12]	MRI/CT	No	NR	NR	NR	NR	Surgical outcome cohort
5	[13]	MRI	No	NR	NR	NR	NR	Recurrence-prediction cohort
6	[14]	CT / MRI	No	NR	NR	NR	NR	Surgical series
7	[15]	MRI	No	NR	NR	NR	NR	Bladder DIE surgical outcomes
8	[21]	MRI	No	NR	NR	NR	NR	Surgical recurrence cohort
9	[18]	MRI	No	NR	NR	NR	NR	Case series
10	[19]	TVUS	No	NR	NR	NR	NR	Descriptive verification only (no diagnostic matrix)
11	[16]	TVUS (IDEA protocol)	Yes (formal diagnostic accuracy study)	93.9%	99.4%	95.8%	99.1%	98.7% accuracy
12	[17]	MRI	Yes (ROC analysis)	83.3%	77.8%	55.6%	93.5%	AUC 0.806

95% confidence intervals and TP/FP/TN/FN counts were not reported in the extracted results for any included study; NR indicates not reported

The study summarizes postoperative outcomes and recurrence after surgical management of urinary-tract DIE. Across cohorts, minimally invasive approaches, particularly laparoscopic techniques, were the dominant surgical modality. Reported postoperative morbidity was generally low in specialized centers, and several studies documented low urinary-tract–specific recurrence during follow-up. However, outcome definitions, complication reporting, and follow-up duration varied across studies, limiting direct comparability and preventing pooled estimation of surgical outcomes (Table 3).

Table 3: Surgical Outcomes and Recurrence After Surgery for Urinary-Tract Deep Infiltrating Endometriosis (2018–2025)

Sr. No.	References	N	Urinary Tract Site	Key Surgical Approach (Reported)	Post-Op Complications	Recurrence / Relapse	Follow-up
1	[10]	160	Ureter (intrinsic/extrinsic)	Laparoscopic ureteroneocystostomy (many with extensive ureterolysis; psoas hitch described)	No major complications reported; bladder dysfunction/bladder dyskinesia 15% (reported as related to parametrial disease/parametrectomy)	1.2% recurrence + significant symptom regression ($p<0.001$)	–
2	[11]	232	Bladder + ureter	Surgical management patterns (laparoscopy/laparotomy/robot; ureterolysis/resection nephrectomy/cystectomy)	NR	NR	12 months

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3	[12]	55	Bladder/ureter / mixed	All managed laparoscopically (1 conversion mentioned)	10.9% overall complications (6/55); Clavien-Dindo: Grade I (2), Grade II (2), Grade IIIb needing surgery (2)	10.9% recurrence (overall); no urinary-tract recurrence observed	Long-term cohort (10-year frame stated; specific follow-up distribution not required if not explicit)
4	[13]	105	Ureter (50.5%) + bladder (49.5%)	Partial cystectomy 49.5%; ureteral reimplantation 23.8%; ureterolysis 15.3%; ureter end-to-end 6.7%; nephrectomy 4.7%	NR	28.6% overall relapse; 13.3% urinary-tract recurrences; median time to urologic recurrence 12 months d	Median 39 months (IQR 22–51)
5	[14]	68	Ureter	Ureterolysis/ureterectomy	NR	NR	NR
6	[15]	25	Bladder	Laparoscopic partial cystectomy / shaving discussed	NR	NR	NR
7	[20]	264	Bladder (some ureter obstruction)	Laparoscopic bladder resection; bowel resection in 53%; ureteroneocystostomy in 9.5%	Major complications <28 days: 7.2% (19/264)	2.3% recurrence	Follow-up visits at 1, 6, 12 months
8	[18]	12	Bladder	"See-through" laparoscopic partial cystectomy	NR	NR	NR
9	[19]	18	Bladder	Laparoscopic partial cystectomy (LPC)	NR	NR	NR
10	[16]	74	Bladder + ureter DIE	(Mainly imaging study; surgery mentioned as management)	NR	NR	NR
11	[17]	33 lesions	Intrinsic ureter DIE	Diagnostic paper (ROC)	NR	NR	NR
12	[21]	37	Ureter	Laparoscopic ureterolysis	NR	NR	NR

The results present the risk of bias assessment of included studies. Larger prospective and multicenter cohorts generally demonstrated low-to-moderate risk of bias, whereas small case series and early surgical technique reports tended to show higher risk, mainly due to limited comparability and incomplete follow-up reporting. Overall, the methodological quality was acceptable for qualitative synthesis, but the predominance of observational designs limits certainty of inference (Table 4).

Table 2: Risk of Bias Assessment of Included Studies

Sr. No.	References	Selection Bias	Comparability	Outcome Assessment	Follow-Up Adequacy	Overall Risk of Bias
1	[10]	Low	Moderate	Low	Low	Low
2	[11]	Low	Moderate	Moderate	Low	Moderate
3	[12]	Low	Moderate	Low	Low	Low
4	[13]	Low	Moderate	Low	Low	Low
5	[14]	Moderate	Moderate	Moderate	Moderate	Moderate
6	[15]	Moderate	Moderate	Moderate	Moderate	Moderate
7	[20]	Low	Moderate	Low	Low	Low
8	[18]	Moderate	High	Moderate	Moderate	High
9	[19]	Moderate	Moderate	Moderate	Low	Moderate
10	[16]	Low	Low	Low	Low	Low
11	[17]	Low	Low	Low	Low	Low
12	[21]	High	High	High	High	High

DISCUSSION

This systematic review indicates that deep infiltrating endometriosis (DIE) involving the urinary tract (bladder and ureters) remains a major challenge in both diagnostic pathways and surgical management because of its complex anatomy and often insidious clinical presentation. The present qualitative synthesis is supported and contextualized by international evidence from the past five years demonstrating substantial advances in diagnostic imaging, surgical outcomes, and multidisciplinary management strategies. Recent comparative imaging studies confirm that transvaginal ultrasonography (TVUS) and magnetic resonance imaging (MRI) are highly specific modalities for identifying urinary tract DIE, although each demonstrates differential performance depending on lesion location. In a 2025 systematic review, the combined use of these two modalities in preoperative planning was shown to improve lesion mapping and surgical decision-making, particularly within multidisciplinary care

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pathways. MRI was superior in delineating complex anatomy, whereas TVUS remained highly specific for selected anatomic compartments [22]. Similarly, high specificity for urinary tract DIE has been reported with structured imaging protocols, including the IDEA consensus, which enables surgeons to better anticipate intraoperative findings [22]. Current evidence supports the use of TVUS as a first-line imaging modality in DIE, particularly for selected ureteric lesions when performed by an experienced operator [23-25]. An innovation in MRI fusion 3D T1/T2 imaging in 2025 demonstrated non-inferior diagnostic accuracy and improved reproducibility compared with conventional MRI sequences, suggesting that imaging technology may continue to enhance preoperative assessment [26]. International imaging studies consistently emphasize that delayed or missed diagnosis may contribute to silent obstructive complications, particularly in ureteral disease, which can progress to hydronephrosis if not detected at an early stage [27]. Recent international cohorts and clinical reviews over the past five years support laparoscopic and minimally invasive approaches for urinary tract DIE, in agreement with the present findings of favorable surgical outcomes and acceptable complication rates when procedures are performed by specialized teams [28-30]. A large retrospective surgical series published in 2025 demonstrated that laparoscopic partial cystectomy or bladder shaving provided symptomatic relief in more than 90% of patients with bladder DIE, with low perioperative morbidity in the setting of interdisciplinary collaboration [31]. Narrative reviews and clinical analyses further support that complete excision of bladder DIE through shaving or partial cystectomy results in sustained symptom reduction and low recurrence rates when performed in high-volume centers [32]. Advanced minimally invasive techniques, including robotic-assisted laparoscopy, are increasingly reported in the literature as feasible alternatives with outcomes comparable to standard laparoscopy in complex DIE cases [33]. Contemporary case-based practice also highlights the role of multidisciplinary approaches, such as combined laparoscopic and ureteroscopic techniques for ureteral DIE with stricture formation, in restoring urinary tract function and preventing irreversible renal damage [34]. Recent studies focusing on patient-reported outcomes emphasize that urinary tract DIE significantly impairs quality of life through chronic pain, dysuria, and storage symptoms, and that surgical and multidisciplinary management leads to meaningful improvements in quality-of-life measures [27]. Symptom-guided diagnostic studies recommend maintaining a high index of suspicion for DIE in women with refractory pelvic or urinary symptoms, as delayed diagnosis is associated with prolonged morbidity [35].

The literature on standardized diagnostic accuracy reporting remains limited, although incremental improvements are evident. Only a small number of studies report complete diagnostic contingency matrices (TP, FP, TN, FN), which precludes quantitative pooling and robust meta-analysis. Structured reporting systems incorporating the Enzian classification or other standardized staging frameworks have therefore been repeatedly recommended for preoperative imaging reports. In addition, although emerging technologies such as 3D fusion MRI appear promising, their performance has so far been demonstrated only in early validation cohorts, and large multicenter studies are still required to establish reproducibility and generalizability across diverse clinical populations. Formal domain-based GRADE profiling was not feasible because of the absence of meta-analysis, high heterogeneity, and the predominance of observational study designs; therefore, only a qualitative assessment of evidence certainty was possible.

CONCLUSIONS

In summary, contemporary evidence indicates that transvaginal ultrasonography and magnetic resonance imaging are complementary imaging modalities with high specificity for the detection of urinary-tract deep infiltrating endometriosis, thereby enhancing preoperative mapping and multidisciplinary surgical planning. Organized imaging procedures, such as the IDEA criteria, and new methods, such as three-dimensional MRI fusion, have proven to show encouraging gains in diagnostic performance. Minimally invasive surgical management performed in specialized centers is associated with favorable postoperative outcomes, low recurrence rates, and significant symptomatic relief. Nevertheless, substantial heterogeneity in diagnostic reporting and surgical outcome definitions persists, limiting quantitative synthesis and comparability across studies. These findings highlight the need for standardized diagnostic-accuracy studies and prospective multicenter registries to strengthen evidence-based clinical pathways for this complex disease phenotype.

Authors' Contribution

Conceptualization: MAK, ZM[2]
Methodology: ZM[1]
Formal analysis: SU
Writing and Drafting: MAK, MUR, SU, ZM[1], ZM[2], SF
Review and Editing: MAK, MUR, SU ZM[1], ZM[2], SF

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

All the authors declare no conflict of interest.

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