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UROLOGY – REVIEW

Long-term renal function post-pyeloplasty: a systematic review

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Abstract

Introduction Ureteropelvic junction obstruction (UPJO) is a significant cause of functional impairment in neonatal kidneys. The gold-standard surgical intervention for UPJO is pyeloplasty, which offers good preservation of kidney function, but long-term renal outcomes and the durability of surgical correction are not fully understood. This systematic review aims to assess the long-term impact of pyeloplasty on renal function, quality-of-life, and complication rates among pediatric patients.

Methods A comprehensive search of PubMed, Embase, Scopus, and Cochrane Library was conducted to retrieve studies reporting long-term outcomes (≥ 2 years) of pediatric pyeloplasty. Inclusion criteria focused on renal function metrics including differential renal function (DRF), estimated glomerular filtration rate (eGFR), and imaging findings. 9 studies encompassing $n = 836$ patients met inclusion criteria. Data were synthesized narratively due to significant heterogeneity of methods and reporting.

Results Most studies reported significant improvements in renal function post-pyeloplasty, particularly in cases with low preoperative DRF (< 20%). DRF improvements ranged from 5 to 15%, with preservation or enhancement of renal function observed in up to 89% of cases. Hydronephrosis resolution and increases in renal parenchymal thickness were also reported frequently. Minimally invasive approaches, such as retroperitoneoscopic one-trocar-assisted pyeloplasty, showed comparable efficacy to open techniques. Complications were predominantly minor, including transient urinary infections and stent-related discomfort, with no significant long-term morbidity noted across studies.

Conclusion Pyeloplasty demonstrates durable success in improving or preserving renal function in pediatric patients with UPJO. Early intervention, particularly in cases diagnosed antenatally, yields the best outcomes. While all surgical techniques reviewed were effective, minimally invasive approaches offer reduced operative times and faster recovery. Further research should aim to standardize evaluation protocols and explore the use of novel biomarkers to enhance long-term patient monitoring.

Keywords Long-term · Pyeloplasty · Renal function · Ureteropelvic junction obstruction

Introduction

Ureteropelvic junction obstruction (UPJO) is a congenital or acquired condition in which urine flow is blocked at the junction of the renal pelvis and ureter, which can lead to significant kidney damage if left untreated. UPJO displays highly variable severity and is more commonly diagnosed in pediatric populations, often via prenatal or postnatal imaging. In pediatric cases, early intervention is critical to preserving renal function, since the developing kidneys are particularly vulnerable to damage from prolonged obstruction [1, 2]. Surgical correction by pyeloplasty involves repair of the UPJ to relieve obstruction and is considered the gold-standard treatment due to high success rates and

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good preservation of kidney function. While the immediate outcomes of pyeloplasty are well documented, there remains a need to understand how this procedure impacts long-term renal function and overall quality of life in patients treated during childhood [1, 3].

Previous analyses of long-term outcomes in pediatric urology have highlighted a need to comprehensively assess renal function following pyeloplasty, particularly glomerular filtration rate (GFR), differential renal function (DRF), and kidney structural changes (observable through imaging modalities such as ultrasound) [4]. Assessing these parameters over extended periods allows researchers and clinicians to gain insight into the durability of different surgical repairs and determine potential for kidney recovery or deterioration after initial intervention [4]. Indeed, even in cases where pyeloplasty successfully alleviates UPJO, there remains a possibility of residual or recurrent defects which may impact kidney function and patient quality-of-life many decades later [5]. Although rare, recurrence of UPJO and secondary hypertension also remain notable concerns [6]. These potential long-term issues underscore the importance of comprehensive follow-up and patient monitoring.

This systematic review aims to address knowledge gaps regarding long-term renal function outcomes post-pyeloplasty, offering insights into the durability of UPJO surgical repair in pediatric patients. We also explore secondary outcomes including complication rates and quality-of-life measures to provide a more comprehensive picture of patient well-being over time. This study will ultimately contribute valuable new insight into UPJO management and long-term patient outcomes, thereby guiding clinical practice and future research in the field.

Materials and methods

Search strategy

A comprehensive search was conducted using the databases PubMed, Embase, Scopus, and Cochrane Library. The search utilized Medical Subject Headings (MeSH) and free-text terms relevant to pediatric pyeloplasty and long-term renal function outcomes, such as "Pediatric Pyeloplasty," "Renal Function," and "Ureteropelvic Junction Obstruction." Search parameters were tailored to each database to ensure comprehensive coverage of all potentially relevant studies (search concluded on November 26, 2024). In addition to database searches, hand searching of reference lists from included studies and relevant reviews was performed to identify additional articles. This combined approach ensured the inclusion of studies with diverse designs, populations, and methodologies. The protocol for this systematic review was registered in PROSPERO under code CRD42024618545. Full details of the search strategy, including keywords and filters applied, are available in Supplementary Table 1.

Eligibility criteria and study selection

Inclusion criteria were defined as follows: (1) pediatric patients (≤ 18 years) undergoing pyeloplasty; (2) a follow-up duration of at least 2 years; and (3) reporting on renal function outcomes (such as differential renal function [DRF], estimated glomerular filtration rate [eGFR], and/or imaging findings). Exclusion criteria included case reports, case series with fewer than 10 patients, and non-English publications without available translations. Two independent reviewers screened titles and abstracts for relevance, with candidate eligible studies undergoing a full-text review to confirm inclusion. Discrepancies in the selection process were resolved through consensus discussions, and a third reviewer was consulted when necessary. The PRISMA flow diagram (Fig. 1) documents the selection process, providing transparency in how studies were identified, screened, and included. This structured approach minimizes bias, ensures consistency, and enhances reliability of study selection.

Data collection and variables

Data were systematically extracted using a standardized form to ensure clarity and consistency when capturing relevant study details. The population included pediatric patients (≤ 18 years old) undergoing pyeloplasty for ureteropelvic junction obstruction (UPJO). Patient demographics such as age, gender, and baseline renal function were recorded to provide a clear understanding of the study populations. Assessed interventions were surgical pyeloplasty performed using various techniques, including open, laparoscopic, and robotic approaches. Detailed procedural information, such as the use of stents or modifications to standard techniques, were documented to capture the diversity of surgical practice. Where available, comparisons focused on pre- and post-operative outcomes, particularly longitudinal assessments of renal function. While some studies included explicit control groups, most relied on within-subject comparisons over time to evaluate surgical efficacy. The primary outcomes of interest included renal function metrics such as differential renal function (DRF), estimated glomerular filtration rate (eGFR), and renal ultrasound findings. Secondary outcomes, including quality-of-life (QoL) measures, long-term complications, surgical complications, and reoperation rates, were also extracted when reported.

Quality assessment

Study quality was evaluated using the Newcastle–Ottawa Scale (NOS), which assesses three domains: (a)

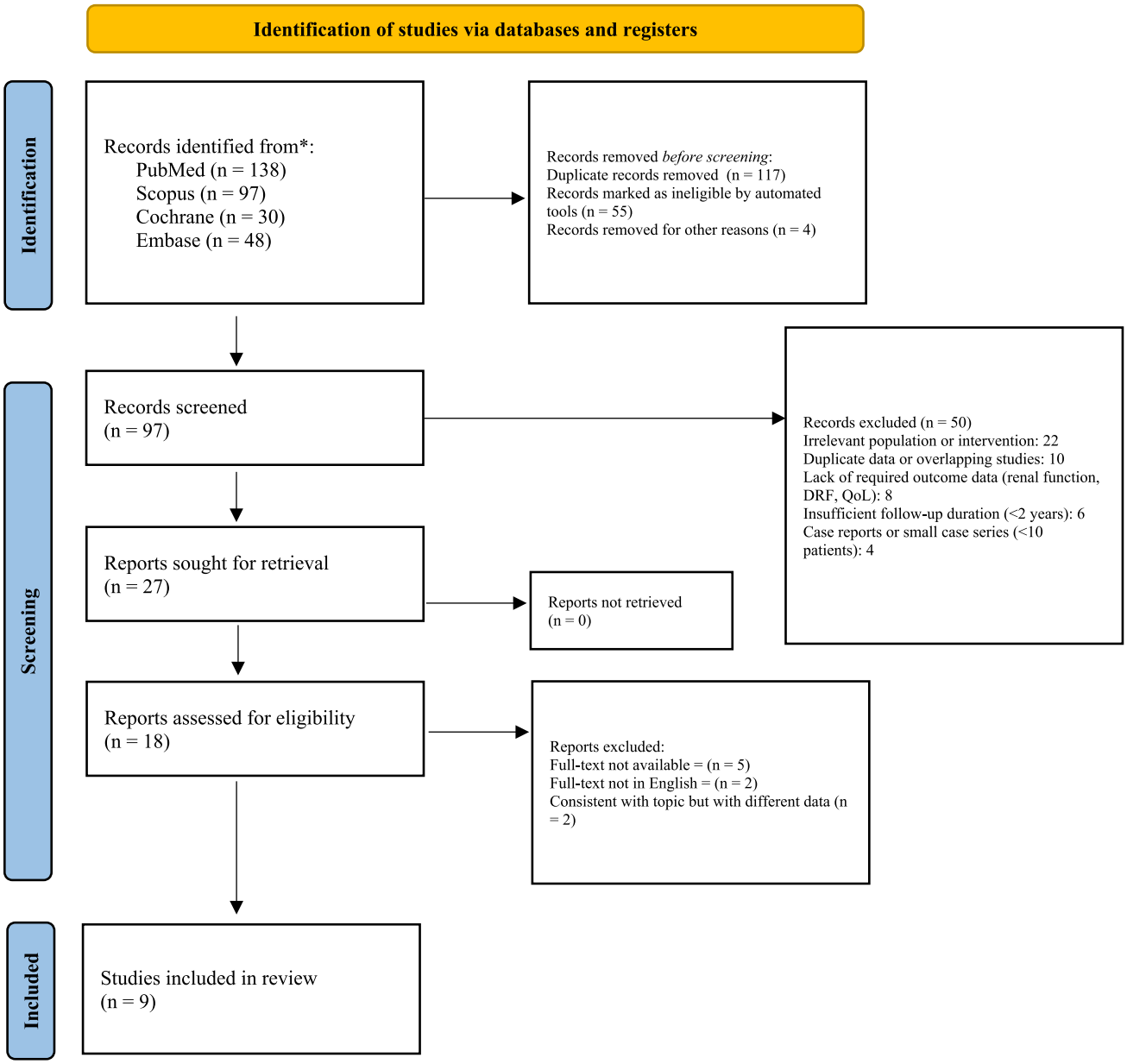

Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart

selection—covering the representativeness of the cohort, selection of the non-exposed cohort, and ascertainment of exposure; (b) comparability—addressing control for confounding factors; and (c) outcome—examining the assessment method, duration of follow-up, and adequacy of follow-up rates. Scores ranged from 7 to 9, indicating moderate to high quality. Detailed NOS assessments are provided in Supplementary Table 2. Discrepancies in quality assessment were resolved through discussion among reviewers.

Data synthesis

Descriptive analysis summarized study characteristics and outcomes, while meta-analysis was conducted when sufficient homogeneity existed. Random-effects or fixed-effects models were used depending on the level of heterogeneity, which was assessed using I^2 statistics. Where meta-analysis was not feasible, narrative synthesis was performed. Subgroup analyses explored potential sources of heterogeneity, such as age or surgical approach. Sensitivity analyses tested

robustness of the findings. Due to significant heterogeneity in patient populations, preoperative DRF thresholds, surgical techniques, and follow-up protocols, a narrative synthesis was performed. Sensitivity and subgroup analyses were considered; however, inconsistent reporting across studies limited quantitative comparisons.

Results

Study selection

The systematic search identified 313 records, of which 117 were duplicates and subsequently removed. After title and abstract screening, 97 records remained for further evaluation. Of these, 27 articles were selected for full-text review, with 9 studies meeting the inclusion criteria. These 9 studies encompassed a total of $n = 836$ pediatric patients with sample sizes ranging from 21 to 196 per study. All included studies were retrospective in design, and follow-up duration varied widely, ranging from 12 to 150 months. The study selection process is detailed in the PRISMA flow diagram (Fig. 1), and exclusions at each stage are clearly documented to ensure transparency.

Study characteristics

The included studies demonstrated variability in patient populations, interventions, and reported outcomes. Most studies employed the Anderson–Hynes dismembered pyeloplasty technique, which was performed using open, laparoscopic, or robotic surgical approaches. Renal scintigraphy with isotopes such as diethylenetriamine pentaacetate (DTPA) or mercaptoacetyltriglycine (MAG3) was the primary modality used to assess differential renal function (DRF). Preoperative DRF varied significantly across studies, with thresholds for intervention ranging from 20 to 55%. DRF improvements ranged from 5 to 15%, with standard deviations reported between ± 5% and ± 14% in several studies. Select studies provided 95% confidence intervals, further supporting the observed improvements. Variability in preoperative conditions, surgical techniques, and postoperative assessments highlighted marked heterogeneity of the included studies. Key findings are summarized in Table 1.

Meta-analysis of DRF improvement

DRF improvement was reported consistently across studies, underscoring the importance of this metric for determining surgical success. However, meta-analysis of DRF improvement was not feasible due to significant heterogeneity of study populations, baseline DRF thresholds, and follow-up protocols. For example, some studies defined significant improvement as an increase of ≥ 5%, while others used absolute postoperative DRF values for classification. Despite these differences, a narrative synthesis revealed that DRF improvement was observed in 60% to 95% of treated patients, depending on the surgical approach and follow-up duration. Improvements in DRF were particularly notable in patients with lower baseline function, emphasizing the potential benefit of early surgical intervention in this subgroup. Furthermore, studies utilizing robotic approaches reported slightly higher success rates, although the sample sizes were smaller, which, therefore, warrants further investigation.

Long-term outcomes

Long-term outcomes across the studies generally favored surgical intervention, with most significant reductions in hydronephrosis and preservation or enhancement of renal function. For example, Nguyen et al. documented a 95.7% success rate, with a significant increase in DRF and resolution of hydronephrosis in most cases. Similarly, Raanan et al. reported 89% preservation or improvement in renal function, and an 81% resolution rate for hydronephrosis. These findings were consistent across studies, regardless of surgical approach, although patients undergoing robotic pyeloplasty demonstrated slightly better outcomes in smaller cohorts. While meta-analysis of long-term outcomes was not feasible, descriptive synthesis highlighted the robustness of these findings. Complication rates were low across all studies, with most issues being minor and resolving during follow-up. Postoperative urinary tract infections and fever were the most frequently reported adverse events, with the recurrence of UPJO requiring redo surgery occurring in only a small proportion of cases.

Quality assessment

Methodological quality of the studies included was assessed using the Newcastle–Ottawa Scale (NOS), with scores ranging from 7 to 9 points indicating moderate to high quality. Most studies demonstrated low risk of bias in selection and outcome assessment domains, but moderate risk in follow-up completeness (Table 1 presents a summary of study characteristics and NOS scores). Risk of bias due to incomplete follow-up data was a concern in two studies, which reported > 10% rate of loss to follow-up. Variability in reporting surgical details and postoperative care protocols also limited direct comparisons across studies. Nonetheless, the quality assessment provided confidence in the reliability of reported findings, with higher scoring studies demonstrating consistent reporting of outcomes and minimal bias. The full quality assessment is presented in Supplementary Table 2.

Table 1 Study characteristics, interventions, and outcomes

Author (year)	Population (pediatric patients with UPJO)	Intervention (surgical approach)	Comparison (pre-op DRF vs. post-op DRF)	Outcome (renal function and other outcomes)	Follow-up (months)	Complications	NOS score
Nordenström et al. (2020) [12]	80 children, antenatal and postnatal groups	Open	Pre: 35 ± 12% Post: 45 ± 14%	45% improved DRF (> 5% versus baseline); antenatal group showed better improvement, 81% resolution of hydronephrosis	18	UTIs, fever (minor)	8
Harraz et al. (2013) [7]	196 children, unilateral UPJO, baseline DRF < 60%	Open	Pre: 35.8 ± 10% Post: 38.7 ± 11%	78% improved DRF, significant GFR increase, no deterioration reported	12	None reported	9
Rickard et al. (2016) [10]	49 children, supranormal DRF[a] (≥ 55%) vs. non-supranormal DRF (< 55%) groups	Open	Pre: 44.3 ± 12% Post: 45.3 ± 15%	75% supranormal DRF loss, significant DRF differences across groups, hydronephrosis resolved in most cases	127	None reported	7
Blanc et al. (2012) [16]	104 children, diagnosed via MAG3 or MRI imaging	Laparoscopic	N/A	81% resolution of hydronephrosis, redo surgery required in 2 cases	25.2	Granuloma, recurrence	8
Sarhan et al. (2021) [8]	21 children, baseline DRF ≤ 20%	Open	Pre: 20 ± 5% Post: 28 ± 7%	38% with > 10% DRF improvement, no postoperative deterioration observed	30	None reported	7
Minki Baek et al. (2010) [14]	167 children, giant hydronephrosis (GH) group vs. non-GH group	Open	Pre: 33 ± 14% Post: 48 ± 12%	95% success rate, improved renal parenchyma, long-term functional improvement	60	None reported	8
Salih et al. (2021) [9]	46 children, obstructive pattern on renal scintigraphy	Open	Pre: 19.7 ± 4% Post: 21.2 ± 5%	Functional recovery in 90% of cases, significant increase in DRF	30	None reported	8
Raanan et al. (2005)	103 children, prenatal UPJO diagnosis	Open	N/A	89% preserved/improved renal function, 81% resolution of hydronephrosis	60	Fever (31%), UTI (12%)	7
Nguyen et al. (2024) [13]	70 children, severe hydronephrosis or recurrent UTIs	Robotic	Pre: 47.9 ± 9.8% Post: 51.2 ± 5.9%	95.7% success rate, significant DRF increase, 3 recurrences (with one requiring redo surgery)	75	Recurrence in 3 cases	9

[a]Supranormal DRF (SNDRF) defined as > 55% differential renal function (DRF) in children with ureteropelvic junction obstruction (UPJO) [13]

Discussion

Across the 9 studies reviewed, a clear pattern emerged that post-pyeloplasty outcomes in children with ureteropelvic junction obstruction (UPJO) are heavily influenced by preoperative factors, surgical techniques, and patient characteristics. Harraz et al. and Sarhan et al. emphasized the potential for recovery even in kidneys with severely impaired function. In their respective cohorts, both studies demonstrated that kidneys with baseline DRF < 20% could achieve notable recovery after surgical intervention [7, 8]. Similarly, Salih et al. reported that 91% of patients with split renal function (SRF) < 20% attained either stability or improvement in renal function following open dismembered pyeloplasty [9]. These findings challenge the historical perspective that nephrectomy is the preferred treatment for kidneys with such low function. This debate persists due to concerns about residual kidney function and compensatory hyperfiltration in cases with supra-normal DRF, making the decision between nephrectomy and pyeloplasty for DRF < 20% complex.

However, these positive results contrast with the findings of Rickard et al., who reported that patients with supra-normal DRF (≥ 55%) frequently experienced a decline in function after surgery. This study suggested that elevated preoperative DRF values often reflect compensatory hyperfiltration rather than genuinely healthy renal tissue [10]. This aligns with earlier studies such as DiSandro et al. (2005), who similarly cautioned that supra-normal DRF may mask underlying renal damage and lead to delays in necessary surgical interventions [11]. In addition, Nordenström et al. highlighted that antenatal diagnosis was a significant predictor of postoperative DRF improvement, with 45% of antenatally diagnosed patients achieving > 5% improvement [12]. Interestingly, Nguyen et al. presented data supporting retroperitoneoscopic one-trocar-assisted pyeloplasty (OTAP) as an effective technique for improving renal function, with a success rate of 95.7% and a statistically significant DRF increase from 47.9% preoperatively to 51.2% postoperatively. This minimally invasive technique shows promise as a viable alternative to traditional open approaches, particularly in younger patients where reducing surgical trauma is critical [13]. Beyond DRF, renal parenchymal thickness (RPT) and the degree of hydronephrosis are other critical markers of renal recovery. Minki Baek et al. demonstrated significant improvement in RPT postoperatively, particularly in younger patients who underwent pyeloplasty before the age of 1 year [14]. This reinforces the importance of early intervention to preserve renal parenchymal integrity. Similarly, Nguyen et al. observed a substantial reduction in renal pelvis size postoperatively, from 34.3 mm to 13.8 mm, indicating effective resolution of hydronephrosis and improved urinary drainage [13]. The findings on RPT are consistent with earlier studies such as Kim et al. (2008), which noted that younger patients exhibited more robust parenchymal recovery due to greater nephron plasticity in early childhood. These results underscore the need for timely surgical intervention to prevent irreversible damage to renal structures [15].

Complications following pyeloplasty were consistently low across all studies, thus confirming the relative safety of this procedure. Notably, complications were minimal regardless of the follow-up duration, suggesting that pyeloplasty is indeed a durable intervention for UPJO. The studies with shorter follow-up times, such as Harraz et al. and Blanc et al., reported no major complications, with only minor issues such as transient postoperative pain or urinary infections [7, 16]. Blanc et al. also reported a 2% rate of redo surgeries with no major intraoperative or postoperative complications [16]. Raanan et al. found no major complications in their cohort [1]. These findings emphasize the reliability of open Anderson–Hynes dismembered pyeloplasty. Nguyen also highlighted the safety of minimally invasive OTAP, with no significant postoperative complications reported. However, minor complications such as stent dislodgement and urinary infections were noted in some studies, albeit at low rates. These findings align with previous literature that reported similar complication rates across both open and minimally invasive approaches [17, 18]. The consistently low rates of major complications across diverse repair techniques also indicate advances in surgical skills and perioperative management within pediatric urology.

Longer follow-up durations provided additional insight into the durability of pyeloplasty and the management of rare late complications. For example, Minki Baek et al., with follow-ups exceeding 60 months, and Raanan et al., with a mean follow-up of 60 months, observed no major complications and a very low incidence of minor issues such as temporary stent-related discomfort [1, 14]. These studies highlight sustained functional stability of the renal system after pyeloplasty, with complications largely confined to the early postoperative period. Similarly, Rickard et al., followed patients for a mean of 127 months and reported no significant long-term complications (beyond the expected postoperative changes in renal function among supra-normal DRF cases) [10]. This suggests that the durability of pyeloplasty extends well beyond the immediate postoperative period, offering reassurance regarding long-term safety. Interestingly, studies focusing on poorly functioning kidneys (DRF ≤ 20%) also showed remarkably low complication rates and even detected substantial recovery of renal function. For instance, Sarhan et al. and Salih et al., with follow-up durations of 30 months, demonstrated no major complications despite operating on kidneys with severely

compromised function [8, 9]. This is particularly significant as poorly functioning kidneys are often associated with higher surgical complexity, yet these studies suggest that meticulous surgical technique and postoperative care can mitigate risk.

Minimally invasive techniques, such as the retroperitoneoscopic one-trocar-assisted pyeloplasty described by Nguyen et al. (median follow-up 75 months), were similarly associated with low complication rates. Nguyen et al. emphasized the benefits of shorter operative times and reduced surgical trauma, which likely contributed to the absence of significant complications during their extensive follow-up period. This aligns with the findings of Blanc et al., where retroperitoneal laparoscopic pyeloplasty also demonstrated minimal complications over 25.2 months of follow-up [13, 16].

Across all studies, the reported complications were largely minor and confined to the immediate postoperative period, including transient urinary tract infections, mild wound infections, or stent-related discomfort. Significant long-term morbidity such as anastomotic strictures or recurrent obstruction was not reported, even in studies with follow-ups exceeding 5 years. This indicates that the success of pyeloplasty is not only immediate but also sustained over time, with minimal risk of complications emerging later in a patient's life.

Choice of pyeloplasty technique plays a crucial role in determining outcomes, including operative time, recovery speed, and long-term success. Blanc et al. advocated for the retroperitoneal laparoscopic approach, citing low morbidity and reliable outcomes. Conversely, Harraz et al. and Raanan et al. favored the traditional open Anderson–Hynes dismembered pyeloplasty, particularly for complex cases or in settings where advanced laparoscopic equipment is unavailable [1, 7]. A notable advance is the minimally invasive OTAP technique described by Nguyen et al. This approach combines the benefits of open and laparoscopic surgery, offering excellent outcomes with reduced operative times and shorter hospital stays. The mean operative time of 74.8 min reported in Nguyen's study is significantly lower than the 185 min observed for laparoscopic approaches in Blanc's cohort. These findings align with a study by Lima et al. (2007), who demonstrated similar advantages of minimally invasive techniques. Despite these advances, adoption of minimally invasive techniques remains limited by the steep learning curve and high costs associated with laparoscopic and robotic-assisted pyeloplasty. Several previous studies have emphasized that open techniques continue to be the gold standard in high-volume centers due to their proven reliability and accessibility [5, 17].

Renal scintigraphy, primarily using MAG3, was the standard imaging modality for assessing DRF across all studies. However, variability in protocols and interpretation were recurring issues. Rickard et al. highlighted the potential for misinterpreting supra-normal DRF as a functional improvement, cautioning against relying solely on scintigraphy without considering clinical and anatomical findings. Similarly, Nordenström et al. raised concerns about the correlation between MAG3 findings and actual glomerular filtration rate [10, 12]. These findings align with earlier critiques by Koff et al. (2012), who emphasized the need for standardized protocols to minimize variability between institutions [19]. While MAG3 remains the most used agent, some studies have explored other commonly used alternatives, such as DTPA and DMSA, although the latter is less commonly employed in pediatric practice.

The findings of Lee et al. suggest that long-term postoperative follow-up is crucial, particularly to monitor for hypertension (HTN) and proteinuria (protU), as these complications tend to emerge many years after surgery [20]. Given that HTN and protU can be detected between 6 and 25 years postoperatively, with the highest incidence between 15 and 20 years, a follow-up duration of at least 20 years postoperatively is recommended. Post-pubertal follow-up is essential, as many of these complications emerge after puberty. In the first decade postoperatively, annual or biennial follow-up should monitor renal function, hydronephrosis, and symptoms of obstruction or urinary issues. In the second decade and beyond, the focus should shift to screening for systemic complications such as HTN and protU, with evaluations every 1–2 years. Routine blood pressure measurements during follow-ups are necessary to detect early signs of HTN, along with regular urinalysis to assess for proteinuria and other markers of renal dysfunction. Periodic serum creatinine (SCr) testing should be performed to identify renal function decline, and renal imaging (e.g., MAG3 scans) should monitor hydronephrosis and differential renal function. Patients with preoperative symptoms or elevated SCr require closer follow-up, as these factors are correlated with a higher risk of HTN. Emphasis on maintaining follow-up continuity during adolescence and adulthood is critical since complications may arise or become apparent during this period. It is also important to educate patients and families about the long-term risks and the importance of adhering to follow-up schedules, while also ensuring a smooth transition to adult healthcare providers familiar with the patient's surgical history for continuity of care.

The findings of the reviewed studies align with broader trends in pediatric urology, highlighting significant progress in surgical techniques, imaging, and postoperative management. Predictors of success, such as antenatal diagnosis and low baseline DRF, were consistently identified across the studies. However, outcome variability based on surgical technique, patient age, and preoperative renal status underscore the need for individualized treatment planning.

A significant limitation noted in the included studies is the variability inherent in the use of MAG3 scintigraphy for

assessing renal function. Differences in imaging protocols between institutions can lead to inter-study variability, which may affect the comparability of differential renal function outcomes.

Differences in surgical techniques, such as open versus minimally invasive approaches, were evident. While minimally invasive procedures (e.g., retroperitoneoscopic one-trocar-assisted pyeloplasty) demonstrated advantages in terms of shorter operative times and faster recovery, these outcomes are tempered by the retrospective design of the studies and the lack of standardized postoperative follow-up protocols. The retrospective design of the included studies and the lack of standardized postoperative follow-up protocols may introduce bias, limiting the comparability of long-term outcomes.

Future research should focus on multicentre randomized trials with standardized methodologies to address current limitations. Integrating novel biomarkers, such as urinary proteomics and microRNA profiling, could also provide more accurate indicators of renal recovery and long-term outcomes. In addition, further exploration of minimally invasive techniques, including robotic-assisted approaches, is warranted to expand their applicability and accessibility.

Conclusion

This systematic review primarily utilized differential renal function (DRF) as the key parameter to evaluate long-term outcomes following pyeloplasty in pediatric patients with ureteropelvic junction obstruction (UPJO). The findings demonstrate substantial recovery in DRF across studies, particularly in cases where early intervention was undertaken, such as antenatally diagnosed UPJO, or in patients with initially low DRF. Regardless of the surgical approach—open, laparoscopic, or retroperitoneoscopic—all techniques yielded high success rates in maintaining or improving renal function. In addition to DRF improvements, other postoperative outcomes, including resolution of hydronephrosis and increased renal parenchymal thickness, further reinforce the efficacy of pyeloplasty. Complications were rare and predominantly minor, reinforcing the safety and durability of this intervention. These results underscore the critical role of early diagnosis, precise surgical execution, and structured long-term follow-up in ensuring optimal renal recovery and reducing the risk of future complications. To enhance clinical practice, future research should focus on standardizing evaluation protocols and exploring the use of novel biomarkers to refine assessment and management strategies. Standardized postoperative follow-up protocols and the investigation of novel biomarkers for renal function monitoring are strongly recommended to improve long-term patient management. Prospective, multicenter trials are needed to address current limitations, particularly in cases with DRF < 20%, where the decision between nephrectomy and pyeloplasty remains controversial.

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Author contributions P.A.R.R. and T.A. conceptualized the study and designed the methodology. R.B.I.C, G.R.S., and I.W. performed the literature search and data extraction. R.B.I.C., P.A.R.R., and G.R.S. conducted the data analysis and interpretation. P.A.R.R., A.I., and T.A. contributed to critical revisions of the manuscript. A.R. and I.W. provided expert insights on urological procedures and clinical implications. R.B.I.C and P.A.R.R. wrote the main manuscript text. All the authors reviewed and approved the final manuscript for submission.

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Declarations

Conflict of interest The authors have no potential conflicts of interest to declare.

Ethical approval This study is a systematic review and does not involve human participants or animal subjects. Therefore, ethical approval was not required.

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