

Urologic complication rates after kidney transplantation using donor kidneys with duplicated or multiple ureters: a systematic review and meta-analysis of case series

Azza Fithra Alhanifa

fithrau@gmail.com

Udayana University

Azza Mi'raj Alfadhila

Udayana University

I Putu Krisna Agastya Artawan

Udayana University

Pande Wisnu Tirtayasa

Udayana University

Systematic Review

Keywords: Kidney transplantation, ureteral duplication, postoperative complications, systematic review, meta-analysis

Posted Date: July 2nd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10150030/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Renal Replacement Therapy on September 7th, 2026. See the published version at <https://doi.org/10.1186/s41100-026-00762-8>.

Abstract

Background

The scarcity of donor kidneys often turns anatomically variant grafts into an allocation problem, with duplicated ureters frequently declined because of concerns about ischemic vulnerability and subsequent urological complications. This systematic review and meta-analysis aimed to estimate pooled rates of urological complications in such grafts to inform acceptance and operative planning.

Methods

Scopus, PubMed, Europe PMC, Epistemonikos, and Web of Science were searched through June 2026. Eligible case series and cohort studies included at least five patients and reported urological outcomes after kidney transplantation using donor kidneys with duplicated or multiple ureters. Pooled prevalence was estimated using a generalized linear mixed model with binomial likelihood, and certainty of evidence was evaluated using GRADE.

Results

Eleven retrospective studies comprising 226 transplant recipients were included. The pooled prevalence of overall structural urological complications was 5.35% (95% CI 2.02–13.4%), with no statistical heterogeneity ($I^2 = 0\%$). Pooled rates were 3.42% for urinary leak, fistula, or urinoma; 0.88% for ureteral stricture or obstruction; and 3.33% for urological surgical revision. Delayed graft function had a pooled prevalence of 9.38%. More recent publication year, younger recipient age, and a higher proportion of living-donor grafts were associated with lower overall complication rates. Certainty of evidence was very low.

Conclusions

Kidney allografts with duplicated or multiple ureters had urological complication rates broadly comparable to those reported for standard single-ureter grafts. Routine discard based solely on ureteral anatomy is not supported by the available evidence, although careful surgical technique remains essential.

Background

Renal transplantation is the recommended therapy for eligible patients with end-stage kidney disease (ESKD) and provides better chances of survival than dialysis [1]. Nevertheless, access remains limited due to organ shortage. The 2023 Kidney Report of the Organ Procurement and Transplantation Network/Scientific Registry of Transplant Recipients (OPTN/SRTR) indicates a substantial burden on the waiting list even with record-high numbers of transplants performed; meanwhile, national-level analyses reveal the significant underutilization of kidneys [2,3]. Thus, anatomical variations often become an allocation problem rather than a strictly technical challenge. Consequently, when a kidney is declined due to unfamiliarity with the required reconstructive procedures, a potentially viable organ is discarded.

Donor anatomical abnormalities present multifaceted challenges. It has been observed in recent literature related to transplantation that donor kidneys with anatomical abnormalities are accepted or rejected based heavily on variable center practices [4]. This discrepancy stems from a gap in evidence, despite the fact that many of these anomalies can be successfully managed surgically.

Urological complications are central to this issue. Post-transplant urological complications remain clinically relevant, as urine leakage, obstruction, and strictures may require percutaneous nephrostomy, repeat endoscopy, or further surgery, jeopardizing allograft function [5]. Although modern surgical techniques have significantly minimized these problems through careful handling of the ureter, tension-free anastomosis, preservation of the periureteral tissue, and ureteral stent insertion, a 2024 Cochrane review recommends routine ureteral stenting during surgery to decrease major urological complications [6]. The issue thus lies not in increased complexity but in the increased risk of morbidity.

The most frequent congenital abnormality of the upper urinary tract is duplication of the ureter or collecting system, reported in 0.8% to 5% of the general population [7]. Duplication necessitates a tailored surgical approach in transplantation surgery. This might include separate ureteroneocystostomies, reconstruction with a single common opening, or ureteroureterostomy. Of even greater importance, however, are the vascular considerations. The blood supply of the distal part of the transplanted ureter depends solely on preserving the delicate periureteral vascular arcade [8,9]. Dissection that may be required during donor nephrectomy and back-table preparation of a kidney with a duplicated collecting system can jeopardize the limited collateral circulation [5,10,11]. This compromise can affect the healing of the ureterovesical junction and predispose the distal ureter to ischemia [5,10,11]. Together with anastomotic tension, misidentification of an accessory ureter, and subsequent stricture formation, distal ureteral ischemia may contribute to graft dysfunction or graft loss.

However, existing literature regarding the use of duplicated or multiple ureters in transplantation is limited to scattered retrospective studies and case reports, demonstrating significant inconsistencies in reconstructive procedures, stenting practices, follow-up protocols, and outcome definitions. Lack of systematic assessment forces centers to rely on anecdotal experience and individual comfort zones, potentially resulting in the unnecessary discard of viable organs. Thus, we performed a systematic review and meta-analysis to calculate the pooled incidence of post-transplant complications including urinary fistula, ureteral stricture, the need for further surgery, and graft dysfunction among patients who received a kidney transplant with duplicated or multiple ureters, as well as to identify possible predictors of complications based on study characteristics.

Methods

Literature search

A literature search was conducted on the databases of Scopus, PubMed, Europe PMC, Epistemonikos, and Web of Science up to 6 June 2026 without imposing any language restrictions, utilizing MeSH terms where appropriate. The selection of literature was based on the Population, Intervention, Comparator, Outcomes, and Study design (PICOS) criteria, and the full search strategy and PICOS elements are presented in Additional file 1. Selected studies included case series or cohort studies presenting urological outcomes following kidney transplantation using donor kidneys with duplicated or multiple ureters. In addition, a manual search of the reference lists of all selected articles was conducted to identify further literature not captured by the electronic search.

Study design and inclusion criteria

This systematic review and meta-analysis was carried out based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement (PRISMA 2020) [12,13]. The protocol was registered in advance in the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD420261417302). Study selection, data extraction, and risk-of-bias assessment were performed independently by two reviewers (AMA and IPKAA); any discrepancies were resolved by consensus or discussion with PMWT.

Inclusion criteria for eligible studies included primary, peer-reviewed studies that evaluated the outcomes of kidney transplantation with renal allografts with duplicated or multiple ureters, with respect to the type of ureteroneocystostomy reconstruction performed. Studies had to provide information regarding at least one of the following variables: total urological complications, urinary leak/fistula/urinoma, ureteral stricture/obstruction, urological surgical revision, and delayed graft function. Both prospective and retrospective studies could be included in the analysis provided they included a minimum of five subjects with availability of numerical values for the outcomes mentioned above.

Studies were excluded if they included single-ureter transplants alone without a separate group consisting of duplicated ureters; if they did not include specific results for the duplicated ureters; if there were fewer than five participants; or if there were duplicate participants from a more valid source study.

Quality assessment

The methodological quality of the included studies was appraised using the critical appraisal checklist for case series provided by the Joanna Briggs Institute (JBI) [14]. A total of ten aspects were assessed: presence of clear inclusion criteria (D1); presence of standardized and reliable condition measurement (D2); validity of condition identification methods (D3); use of consecutive participants (D4); use of complete participation (D5); existence of clear demographic information (D6); existence of clear clinical information (D7); existence of clearly reported outcomes and follow-up (D8); reporting of the presenting site or clinical setting (D9); and existence of appropriate statistical analysis (D10). The two aforementioned reviewers independently assessed each aspect and made an overall risk-of-bias assessment. The certainty of evidence for the five prespecified outcomes was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology [15].

Data extraction

A standardized data extraction protocol was employed. For all studies included, the variables captured were the country of origin, study type, total number of patients, recipient age, cold ischemic time, follow-up period, living donor graft percentage, ureteral stent utilization rate, and the distribution of reconstruction techniques. The number of outcome cases for the five predetermined outcomes was abstracted from either the text, table, or graphs of each article. When the overall number was not explicitly stated, the number was calculated based on available subgroup information; see Table 1 for details.

Table 1
Study characteristics of included studies.

Study	Country	Study design	Follow-up, months	Sample size, n	Recipient age, years	CIT, hours	Reconstruction variant	Stent use, %	Reconstruction approach	Living donor grafts, %
Cylke et al., 2019	Poland	Retrospective	NR	26	46.15 ± 13.17	25.97 ± 10.55	Separate anastomoses, n = 25; uretero-ureterostomy, n = 1	46.2	Common ostium 0%; separate implantation 96.2%	3.8
Ghazanfar et al., 2015	UK and Pakistan	Retrospective	60	76	Median 38 (range 8–61)	NR	NR	56.6	Common ostium 25%; separate implantation 75%	56.6
Gravetz et al., 2025	Israel	Retrospective	63	26	Median 51 (IQR 38–60)	NR	Pantaloon ureteroneocystostomy	100	Common ostium 100%; separate implantation 0%	50.0
Lasaponara et al., 2013	Italy	Retrospective	NR	12	Median 54.5 (range 36–71)	NR	Separate anastomoses, n = 11; ureteroureteral terminolateral anastomosis with single ureteroneocystostomy, n = 1	100	Common ostium 8.3%; separate implantation 91.7%	16.7
Surowiecka-Pastewka et al., 2018	Poland	Retrospective	NR	5	Mean 43	Mean 12	Common ostium, n = 5	80.0	Common ostium 100%; separate implantation 0%	20.0
Alberts et al., 2013	Netherlands	Retrospective	19 ± 11	12	49 ± 17	NR	Separate anastomoses, n = 7; common ostium, n = 4; one ureter ligated, n = 1	66.7	Common ostium 33.3%; separate implantation 58.3%	25.0
Altinel et al., 2023	Turkey	Retrospective	NR	15	NR	NR	NR	100	NR	100
Haferkamp et al., 1999	Germany	Retrospective	55	19	Median 34 (range 6–62)	NR	Separate anastomoses, n = 9; side-to-side anastomosis/single tunnel, n = 10	84.2	Common ostium 52.6%; separate implantation 47.4%	NR
Heidari et al., 2010	Iran	Retrospective	84	12	Mean 48	NR	Common ostium using single common tunnel / modified Lich–Nghiem technique	100	Common ostium 100%; separate implantation 0%	83.3
Sulikowski et al., 2005	Poland	Retrospective	NR	12	Median 34	NR	Common ureteral ostium, n = 8; separate anastomoses, n = 4	83.3	Common ostium 66.7%; separate implantation 33.3%	0
West et al., 2016	UK	Retrospective	NR	11	54.8 ± 13.05	NR	Separate anastomoses, n = 8; ureters spatulated and sutured together, n = 3	72.7	Common ostium 27.3%; separate implantation 72.7%	27.3
Notes: Values are presented as mean ± SD, median with range, or median with IQR, as reported in the original studies. Percentages were rounded to one decimal place. Common ostium includes pantaloon reconstruction, common ureteral ostium, side-to-side ureteral anastomosis with a single tunnel, and ureters spatulated or sutured together before implantation. Separate implantation includes separate ureteroneocystostomies or separate ureteral anastomoses. Percentages may not sum to 100% when an alternative technique was reported, such as ureteroureterostomy or ureteral ligation.										
Abbreviations: CIT, cold ischemia time; IQR, interquartile range; NR, not reported; SD, standard deviation.										

Data synthesis and analysis

Means with standard deviations or medians with ranges were used to describe continuous variables whereas frequencies and percentages were used for categorical variables. A generalized linear mixed model (binomial likelihood with a logit link) was used to generate pooled prevalence estimates for each dichotomous endpoint. This approach is able to handle rare events and does not require the zero-cell continuity correction unlike inverse variance methods.

Between-study variability was estimated using the I² statistic and between-study variance components (τ^2). Four prespecified study-level covariates including year of publication, mean recipient age, ureteral stent utilization rate and percentage of living donor grafts were evaluated for moderating heterogeneity using meta-regression. Heterogeneity post-moderation was estimated using residual τ^2 and residual I². Publication asymmetry was evaluated using Luis Furuya-Kanamori (LFK) statistic for Doi plots with LFK scores from -1 to +1 indicating no asymmetry, values beyond ± 1 and up to ± 2 indicating minor asymmetry, and values beyond ± 2 indicating major asymmetry. All analyses were performed using R software, and statistical significance was set at a two-tailed p-value < 0.05.

Results

Study selection

In total, 207 records were identified through the database search, of which 93 were duplicates. After deduplication, 114 records were screened by title and abstract, resulting in the exclusion of 98. Sixteen reports were assessed for full-text eligibility; five were subsequently excluded due to duplicated patient data ($n = 1$), fewer than five patients per study ($n = 2$), or absence of the intended outcomes ($n = 2$). Eleven studies were retained for quantitative synthesis (Fig. 1).

Study characteristics

Detailed baseline characteristics are presented in Table 1. Across the 11 included studies, 226 transplant recipients were analyzed [11,16–25]. All studies were retrospective case series. Geographic representation encompassed Poland ($n = 3$), the United Kingdom ($n = 2$), and one study each from Italy, the Netherlands, Turkey, Germany, Iran, and Israel. Publication years ranged from 1999 to 2025, and individual sample sizes ranged from 5 to 76 patients (median 12). Cold ischemic time was reported in only two studies [17,25]; follow-up duration was documented in five studies, ranging from 19 to 84 months. Ureteral stent utilization rates ranged from 46.15% to 100% across studies, and the proportion of living donor grafts ranged from 0% to 100%. Reconstruction technique varied considerably; common ostium formation was employed in a portion of cases in eight studies, while separate ureteral implantation was the predominant approach in the remainder (Table 1).

Risk of bias

Methodological quality was appraised using the JBI critical appraisal checklist for case series (Fig. 2). Three studies were rated as having low overall risk [11,18,22], seven as having moderate risk [16,17,19–21,24,25], and one as having high risk [23]. The most frequent methodological concerns were non-consecutive patient enrollment (Domain 4; eight studies) and incomplete follow-up reporting (Domain 8; four studies). The study by Altinel et al. (2023) received a high-risk rating because demographic and reconstruction details were not reported separately for the duplicated-ureter subgroup, and more than 10% of the original cohort was excluded because of missing data.

Primary outcomes

Overall structural urological complications. The pooled prevalence of any structural urological complication across the 11 studies was 5.35% (95% CI 2.02–13.4%), estimated using a generalized linear mixed model with binomial likelihood and logit link. Between-study variance was moderate ($\tau^2 = 0.5549$), while residual heterogeneity was absent ($I^2 = 0\%$; $Q = 9.51$, $df = 18.01$; $p = 0.485$). The LFK index of -1.64 was consistent with minor asymmetry on Doi plot assessment.

Urinary leak, fistula, and urinoma. The pooled prevalence of urinary leak, fistula, or urinoma was 3.42% (95% CI 0.87–12.46%). Between-study heterogeneity was low ($I^2 = 5.3\%$; $\tau^2 = 1.2201$; $Q = 10.56$, $df = 19.82$; $p = 0.393$), and the LFK index of -0.24 indicated no publication asymmetry.

Ureteral stricture and obstruction. The pooled prevalence of ureteral stricture or obstruction was 0.88% (95% CI 0.06–11.32%), the lowest point estimate across the five outcomes examined. Between-study heterogeneity was absent ($I^2 = 0\%$; $\tau^2 = 0.8814$; $Q = 3.02$, $df = 8.46$; $p = 0.981$), and no publication asymmetry was detected (LFK index - 0.62).

Urologic surgical revision. The pooled prevalence of urologic surgical revision was 3.33% (95% CI 1.22–8.8%). Between-study variance was zero ($\tau^2 = 0$; $I^2 = 0\%$; $Q = 2.21$, $df = 9.10$; $p = 0.988$), and the LFK index of + 0.81 did not suggest publication asymmetry.

Delayed graft function. Among the three studies that reported delayed graft function, the pooled prevalence was 9.38% (95% CI 2.73–27.61%). Between-study variance was zero ($\tau^2 = 0$; $I^2 = 0\%$; $Q = 1.09$, $df = 1.43$; $p = 0.579$). The LFK index of -2.59 indicated major asymmetry, and this finding should therefore be interpreted with caution.

Meta-regression of assessed moderators

Meta-regression was conducted for four outcomes with sufficient contributing studies; delayed graft function was excluded given that only three studies reported this endpoint (Table 2).

Table 2
Meta-regression of study-level moderators for post-transplant urological outcomes.

Moderator	Coefficient	95% CI	p-value	τ^2	Residual I^2 (%)
Overall structural urological complications					
Year of publication	-0.0714	-0.1425 to -0.0003	0.049*	0	0.00
Recipient age	-0.1281	-0.2390 to -0.0173	0.024*	0.1420	15.21
Stent utilization rate (%)	-0.0120	-0.0559 to 0.0319	0.592	0.6260	41.55
Living donor grafts (%)	-0.0296	-0.0581 to -0.0010	0.042*	0.1209	11.13
Urinary leak, fistula, and urinoma					
Year of publication	-0.0276	-0.1599 to 0.1047	0.683	1.0271	49.80
Recipient age	-0.1097	-0.2442 to 0.0249	0.110	0.6441	39.83
Stent utilization rate (%)	-0.0202	-0.0782 to 0.0378	0.495	1.3229	55.99
Living donor grafts (%)	-0.0338	-0.0628 to -0.0048	0.022*	0.0676	6.33
Ureteral stricture and obstruction					
Year of publication	-0.1858	-0.3488 to -0.0227	0.026*	0	0.00
Recipient age	-0.4328	-0.9888 to 0.1233	0.127	0	0.00
Stent utilization rate (%)	0.0010	-0.0748 to 0.0767	0.980	0.8645	34.90
Living donor grafts (%)	0.0161	-0.0547 to 0.0869	0.655	0	0.00
Urologic surgical revision					
Year of publication	-0.0394	-0.1400 to 0.0613	0.443	0	0.00
Recipient age	-0.0789	-0.1948 to 0.0371	0.182	0	0.00
Stent utilization rate (%)	-0.0078	-0.0510 to 0.0353	0.723	0	0.00
Living donor grafts (%)	-0.0135	-0.0558 to 0.0289	0.534	0	0.00
* $p < 0.05$. Coefficients are on the logit scale. All models used a generalized linear mixed model with binomial likelihood and logit link. Residual I^2 reflects between-study heterogeneity remaining after inclusion of each moderator. Meta-regression was not performed for delayed graft function because only three studies reported this outcome. τ^2 , between-study variance.					
Abbreviations: CI, confidence interval; I^2 , heterogeneity statistic.					

For overall structural urological complications, three moderators reached statistical significance. Year of publication was inversely associated with the complication rate ($\beta = -0.0714$; 95% CI -0.1425 to -0.0003; $p = 0.049$; residual $I^2 = 0\%$), as were recipient age ($\beta = -0.1281$; 95% CI -0.2390 to -0.0173; $p = 0.024$; residual $I^2 = 15.21\%$) and the proportion of living-donor grafts ($\beta = -0.0296$; 95% CI -0.0581 to -0.0010; $p = 0.042$; residual $I^2 = 11.13\%$). Stent utilization rate was not significant ($p = 0.592$; residual $I^2 = 41.55\%$).

For urinary leak, fistula, and urinoma, the proportion of living donor grafts was the sole significant moderator ($\beta = -0.0338$; 95% CI -0.0628 to -0.0048; $p = 0.022$; residual $I^2 = 6.33\%$). Year of publication, recipient age, and stent utilization rate were each non-significant and did not materially reduce residual heterogeneity.

For ureteral stricture and obstruction, year of publication was the only significant moderator ($\beta = -0.1858$; 95% CI -0.3488 to -0.0227; $p = 0.026$; residual $I^2 = 0\%$), with more recently published studies reporting lower stricture rates. Recipient age, stent utilization, and the proportion of living donor grafts were each non-significant.

For urologic surgical revision, no moderator reached statistical significance. Year of publication, recipient age, stent utilization, and the proportion of living donor grafts were all non-significant, and between-study variance remained fully absent ($\tau^2 = 0$; $I^2 = 0\%$) across all four models (Table 2).

Certainty of evidence

The certainty of evidence for all assessed post-transplant urological outcomes was rated as very low (Table 3). As the body of evidence consists exclusively of retrospective case series, the starting certainty was evaluated as low. Certainty was subsequently downgraded by one level for serious risk of bias due to widespread methodological limitations across the primary studies, including non-consecutive patient enrollment and incomplete follow-up reporting. An additional one-level downgrade was applied for serious imprecision, as the absolute pooled estimates rely on an exceptionally small sample size ($N = 226$) and exhibit wide confidence intervals that cross established clinical decision thresholds. Furthermore, the outcome of delayed graft function was downgraded an extra level for serious dissemination bias due to major publication asymmetry.

Table 3
Certainty of evidence for assessed post-transplant urological outcomes.

Outcome	No. of participants (studies)	Certainty of evidence (GRADE)	Per 1000 recipients (95% CI)	Pooled Prevalence (95% CI)
Overall structural urological complications	226 (11 studies)	⊕●●● Very low ^{a,b}	54 (20–134) per 1000	5.35% (95% CI 2.02% to 13.4%)
Urinary leak, fistula, and urinoma	226 (11 studies)	⊕●●● Very low ^{a,b}	34 (9–125) per 1000	3.42% (95% CI 0.87% to 12.46%)
Ureteral stricture and obstruction	226 (11 studies)	⊕●●● Very low ^{a,b}	9 (1–113) per 1000	0.88% (95% CI 0.06% to 11.32%)
Urologic surgical revision	226 (11 studies)	⊕●●● Very low ^{a,b}	33 (12–88) per 1000	3.33% (95% CI 1.22% to 8.8%)
Delayed graft function	128 (3 studies)	⊕●●● Very low ^{a,b,c}	94 (27–276) per 1000	9.38% (95% CI 2.73% to 27.61%)
^a The body of evidence relies entirely on retrospective case series. JBI appraisal showed that most studies lacked consecutive patient enrollment (8 of 11) and complete follow-up reporting (4 of 11).				
^b The pooled estimates are based on a small sample (226 recipients across 11 studies) and few events. Confidence intervals were wide and crossed clinically important decision thresholds.				
^c Delayed graft function was downgraded one additional level for serious dissemination bias because the LFK index (-2.59) indicated major asymmetry, although this may reflect the small number of contributing studies.				
Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation; JBI, Joanna Briggs Institute; LFK, Luis Furuya-Kanamori.				

Discussion

In our systematic review and meta-analysis involving 11 articles and 226 kidney allograft recipients with duplicated or multiple ureters, the pooled incidence of urological complications was 5.35%, with no statistical heterogeneity among studies ($I^2 = 0\%$). The pooled incidence of urinary leak, fistula, or urinoma was 3.42%, that of ureteral stricture or obstruction was 0.88%, and that of surgical revision was 3.33%. These figures are comparable to those observed in standard single-ureter kidney transplantation, where overall urological complication rates vary from 2% to 15% depending on the time period, center volume, complication definitions, and patient selection [26,27]. The small number of patients must be interpreted in light of the rarity of this anatomical feature, rather than viewed merely as a study limitation. Ureteral duplication occurs in 0.7% to 1% of the general population, and Cylke et al. found only 27 cases of duplicated-ureter grafts among 1,965 kidney transplantations, accounting for 1.4% of their institutional experience [25]. Similarly, Ghazanfar et al. reported 76 cases of duplicated-ureter transplants across two centers during a 15-year time frame [22]. Hence, the presented data reflect this rare exposure and the consequent paucity of transplant-related information.

Because kidneys with duplicated or multiple ureters may be discarded for technical reasons, these results carry significant clinical weight. The pooled complication statistics do not justify the routine rejection of these grafts based on ureteral anatomy alone. According to transplant-specific reports, grafts with duplicated ureters do not exhibit a higher incidence of urological complications compared to single-ureter transplants [22,24,25]. Additionally, these findings align with the European Association of Urology (EAU) Renal Transplantation Guidelines, which advise using prophylactic ureteral stents to avoid serious urinary complications and applying the same surgical principles used for single ureters to duplicated ureters, regardless of whether the anastomoses are separate or combined [28].

Urinary leak had the highest incidence at 3.42%, which concurs with previously reported rates of 2% to 6% following standard kidney transplantation [29]. In grafts with multiple ureters, urinary leak may be associated with distal ureteral ischemia, ureteral tension, excessive manipulation of the ureters, or poor drainage. Thus, preserving periureteral tissue, maintaining a short and well-vascularized ureter, ensuring tension-free ureteral reimplantation, and the selective or routine use of stents remain the primary technical factors to consider [28,30,31]. There was significant variation in stenting rates, ranging between 46% and 100% among the reviewed literature. However, its direct impact on complications could not be formally analyzed due to a lack of patient-level information. The significant negative correlation between the proportion of living-donor grafts and the incidence of urinary leak in the meta-regression ($p = 0.022$) is biologically plausible, likely due to shorter ischemia times and more rigorous preoperative evaluations in living-donor programs; however, this should be treated strictly as a hypothesis-generating finding. Recent patient cohorts do not demonstrate an isolated effect of donor type on early urological complications [32].

At 0.88%, ureteral stricture or obstruction remained rare and fell at the lower end of the 1% to 8% range reported in standard single-ureter transplantation [33]. Because each anastomosis may be vulnerable to ischemic fibrosis or stenosis, late obstruction remains a potential concern when multiple ureters are transplanted. However, the present findings do not reveal a clinically significant increase in this risk. For both ureteral stricture ($p = 0.026$) and total complications ($p = 0.049$), the year of publication acted as an inverse moderator. This is likely due to cumulative advancements in pretransplant computed tomography (CT) and CT angiography, which increasingly enable the identification of anatomical variations in the vascular and collecting systems prior to implantation, as well as improvements in bench assessment, operative techniques, stenting practices, and preservation strategies [28,34].

Only three studies reported delayed graft function, demonstrating a pooled frequency of 9.38% (95% CI 2.73–27.61%). Because there were insufficient contributing studies, a meta-regression was not performed. Although statistical homogeneity is suggested by the consistently low I^2 values, this should not

be mistaken for clinical uniformity. Even when significant clinical variation exists, the statistical power to detect heterogeneity may be limited by rare events and small sample sizes [35]. Publication bias assessment using the LFK index indicated no asymmetry for urinary leak (-0.24), ureteral stricture (-0.62), or surgical revision (+ 0.81); minor asymmetry for overall complications (-1.64); and substantial asymmetry for delayed graft function (-2.59). This substantial imbalance regarding delayed graft function is likely an artifact of the low number of contributing studies.

This analysis has several limitations. First, most of the analyzed articles carry a moderate risk of bias due to their retrospective designs, which often lack consecutive patient sampling. Second, precision was limited by non-standardized follow-up durations, a lack of demographic information for specific subgroups, and case ascertainment that relied on operative reports rather than preoperative imaging. Third, due to the lack of concurrent single-ureter comparator groups in most cohorts, relative risks could not be calculated. Clinical heterogeneity also remained important, there was significant variability in malformation types, reconstructive approaches, and stenting protocols that could not be accounted for in the pooled analyses. Furthermore, ureteral ligation presents a distinct risk profile compared to reimplantation, making its specific impact difficult to isolate. The small sample sizes and the inherent vulnerability of meta-regression to ecological bias mean these results should be interpreted cautiously as hypothesis-generating rather than definitive. Taken together, these factors lower the overall certainty of the evidence to a very low level.

To improve the quality of future data, prospective multicenter registries should explicitly validate consecutive patient inclusion and require uniform documentation of mean or median follow-up duration. Additionally, registries should systematically record specific donor anatomy (verified by bench examination or preoperative imaging), the duplication subtype, the surgical approach (including ligation), stenting protocols, and ischemia times. Incorporating concurrent single-ureter comparator arms within the same centers would allow for stronger, more reliable estimations of relative urological risks.

Conclusions

Kidney allografts with duplicated or multiple ureters can be transplanted with urological complication rates comparable to those seen with standard single-ureter grafts. Acceptable urological outcomes can be consistently achieved through careful ureteral dissection, the preservation of vascularized periureteral tissue, tension-free implantation, and appropriate stenting protocols.

Abbreviations

- CI
confidence interval
- CIT
cold ischemia time
- CT
computed tomography
- DGF
delayed graft function
- EAU
European Association of Urology
- GLMM
generalized linear mixed model
- GRADE
Grading of Recommendations Assessment,Development and Evaluation
- IQR
interquartile range
- JBI
Joanna Briggs Institute
- LFK
Luis Furuya-Kanamori
- MeSH
Medical Subject Headings
- NR
not reported
- OPTN
Organ Procurement and Transplantation Network
- PICOS
Participants,Intervention,Comparator,Outcomes,Study design
- PRISMA
Preferred Reporting Items for Systematic Reviews and Meta-Analyses
- PROSPERO
International Prospective Register of Systematic Reviews
- SD

standard deviation
SRTR
Scientific Registry of Transplant Recipients.

Declarations

PROSPERO registration

CRD420261417302.

Ethics approval and consent to participate

Not applicable. This systematic review and meta-analysis used only data from previously published studies and involved no new recruitment of participants or collection of identifiable human data.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This study received no external funding.

Author Contribution

AFA and PMWT conceptualized the study; AMA and IPKAA performed the literature search and data extraction; AMA and IPKAA assessed risk of bias; AFA analyzed the data and drafted the manuscript. All authors critically revised, read, and approved the final manuscript. Furthermore, all authors agree to be personally accountable for their own contributions and ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Acknowledgements

Not applicable.

Data Availability

All data generated or analyzed during this study are included in this published article and its supplementary information files (Duplex Renal Raw EXTRACT.xlsx).

References

1. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LYC, et al. Comparison of Mortality in All Patients on Dialysis, Patients on Dialysis Awaiting Transplantation, and Recipients of a First Cadaveric Transplant. *N Engl J Med*. 1999;341(23):1725–30. doi:10.1056/NEJM199912023412303.
2. Lentine KL, Smith JM, Lyden GR, Miller JM, Booker SE, Dolan TG, et al. OPTN/SRTR 2023 Annual Data Report: Kidney. *Am J Transplant*. 2025;25(2):S22-137. doi:10.1016/j.ajt.2025.01.020.
3. McKenney C, Torabi J, Todd R, Akhtar MZ, Tedla FM, Shapiro R, et al. Wasted Potential: Decoding the Trifecta of Donor Kidney Shortage, Underutilization, and Rising Discard Rates. *Transplantology*. 2024;5(2):51–64. doi:10.3390/transplantology5020006.
4. Reddy NA, Allam SR, Reyad AI. Donor Kidneys with an Anatomic Anomaly Used for Kidney Transplantation. *Kidney360*. 2024;5(1):170–1. doi:10.34067/KID.0000000000000270.
5. Yamanaka K, Kakuta Y, Nakazawa S, Kobayashi K, Nonomura N, Kageyama S. Surgical and Infectious Complications Following Kidney Transplantation: A Contemporary Review. *J Clin Med*. 2025;14(10):3307. doi:10.3390/jcm14103307.
6. Patterson LG, Tingle SJ, Rix DA, Manas DM, Wilson CH. Routine intraoperative ureteric stenting for kidney transplant recipients. *Cochrane Database Syst Rev*. 2024;7:CD004925. doi:10.1002/14651858.CD004925.pub4.
7. Park MJ, Baek HS, Jang HM, Lee JN, Chung SK, Jeong SY, et al. Clinical Characteristics of Ureteral Duplication in Children. *Child Kidney Dis*. 2019;23(2):100–4. doi:10.3339/jkspn.2019.23.2.100.

8. Friedersdorff F, Weinberger S, Biernath N, Plage H, Cash H, El-Bandar N. The Ureter in the Kidney Transplant Setting: Ureteroneocystostomy Surgical Options, Double-J Stent Considerations and Management of Related Complications. *Curr Urol Rep.* 2020;21(1):3. doi:10.1007/s11934-020-0956-7.
9. Kumata H, Asami K, Tabata T, Sekiguchi S. Stable Outcome After Living Donor Kidney Transplantation Using External Urinary Fistula for a Kidney Graft With Duplicate Ureters: A Case Report. *Transplant Proc.* 2025;57(3):430-4. doi:10.1016/j.transproceed.2025.02.017.
10. Gerken ALH, Nowak K, Meyer A, Kriegmair MC, Weiss C, Krämer BK, et al. Ureterovesical Anastomosis Complications in Kidney Transplantation: Definition, Risk Factor Analysis, and Prediction by Quantitative Fluorescence Angiography with Indocyanine Green. *J Clin Med.* 2022;11(21):6585. doi:10.3390/jcm11216585.
11. Gravetz A, Tennak V, Mezhybovsky V, Gurevich M, Eisner S, Bielopolski D, et al. "Pantaloons" Ureteroneocystostomy for Double Ureter Kidney Grafts: A Matched Single-Center Study of Perioperative and Long-Term Outcomes over 14 Years. *Surg Tech Dev.* 2025;14(3):31. doi:10.3390/std14030031.
12. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 2021;372:n71. doi:10.1136/bmj.n71.
13. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ.* 2021;372:n160. doi:10.1136/bmj.n160.
14. Munn Z, Barker TH, Moola S, Tufanaru C, Stern C, McArthur A, et al. Methodological quality of case series studies. *JBI Database System Rev Implement Rep.* 2019;18(10):2127–33. doi:10.11124/JBISRI-D-19-00099.
15. GRADE Working Group. GRADE book [Internet]. Version 1.0. Neumann I, Schünemann HJ, editors. GRADE Working Group; 2024. Available from: <https://book.grade.pro.org/>. [Accessed date: 12 June 2026].
16. West H, Singh R, Bagul A, Doughman T, Rizzello A. Renal transplantation using donor grafts with complete ureteral duplication. *Int J Surg.* 2016;36:S107. doi:10.1016/j.ijsu.2016.08.379.
17. Surowiecka-Pastewka A, Matejak-Górska M, Frączek M, Durlik M. Duplicated Ureters in Transplantation—A Single-center, Retrospective Study. *Transplant Proc.* 2018;50(6):1662-8. doi:10.1016/j.transproceed.2018.02.103.
18. Sulikowski T, Ziętek Z, Ostrowski M, Kamiński M, Sierko J, Romanowski M, et al. Experiences in Kidney Transplantation With Duplicated Ureters. *Transplant Proc.* 2005;37(5):2096-9. doi:10.1016/j.transproceed.2005.03.041.
19. Lasaponara F, Dalmasso E, Bosio A, Pasquale G, Sedigh O, Santià S, et al. Kidney Transplant Grafts With Complete Ureteral Duplication. *Exp Clin Transplant.* 2013;11(6):507–9. doi:10.6002/ect.2013.0065.
20. Heidari M, Gharaati MR, Iran-Pour E, Simforoosh N, Zare S, Basiri A. Transplantation of kidneys with duplicated ureters. *Scand J Urol Nephrol.* 2010;44(5):337–40. doi:10.3109/00365599.2010.485577.
21. Haferkamp A, Dörsam J, Möhring K, Wiesel M, Staehler G. Ureteral complications in renal transplantation with more than one donor ureter. *Nephrol Dial Transplant.* 1999;14(6):1521–4. doi:10.1093/ndt/14.6.1521.
22. Ghazanfar A, Zaki MR, Pararajasingam R, Forgacs B, Tavakoli A. Outcome of Kidney Transplant With Double Ureter: A Multicenter Study. *Exp Clin Transplant.* 2015;13(2):152–6.
23. Altinel M, Acikgoz O. Standardization of Laparoscopic Donor Nephrectomy Technique in Minimizing Ureteral Complications in Renal Transplant Recipients: 10-Year Experience of a Single Center. *Transplant Proc.* 2023;55(5):1116-20. doi:10.1016/j.transproceed.2023.02.065.
24. Alberts VP, Minnee RC, van Donselaar-van der Pant KAMI, Bemelman FJ, Zondervan PJ, Laguna Pes MP, et al. Duplicated Ureters and Renal Transplantation: A Case-Control Study and Review of the Literature. *Transplant Proc.* 2013;45(9):3239-44. doi:10.1016/j.transproceed.2013.06.012.
25. Cylike R, Karpeta E, Bieniasz M, Kosieradzki M. Urologic Complications After Transplantation of Kidneys With Duplicated Ureter: A Retrospective Study. *Transplant Proc.* 2019;51(3):779 – 82. doi:10.1016/j.transproceed.2018.10.030.
26. Streeter EH, Little DM, Cranston DW, Morris PJ. The urological complications of renal transplantation: a series of 1535 patients. *BJU Int.* 2002;90(7):627–34. doi:10.1046/j.1464-410X.2002.03004.x.
27. Duty BD, Barry JM. Diagnosis and management of ureteral complications following renal transplantation. *Asian J Urol.* 2015;2(4):202–7. doi:10.1016/j.ajur.2015.08.002.
28. Faba OR, Boissier R, Budde K, Figueiredo A, Hevia V, García EL, et al. European Association of Urology Guidelines on Renal Transplantation: Update 2024. *Eur Urol Focus.* 2025;11(2):365–73. doi:10.1016/j.euf.2024.10.010.
29. Hamouda M, Sharma A, Halawa A. Urine Leak After Kidney Transplant: A Review of the Literature. *Exp Clin Transplant.* 2018;16(1):90–5.
30. Wilson CH, Bhatti AB, Rix DA, Manas DM. Routine intraoperative ureteric stenting for kidney transplant recipients. *Cochrane Database Syst Rev.* 2005; (4):CD004925. doi:10.1002/14651858.CD004925.pub2.
31. Karam G, Maillet F, Parant S, Soullilou JP, Giral-Classe M. Ureteral Necrosis after Kidney Transplantation: Risk Factors and Impact on Graft and Patient Survival. *Transplantation.* 2004;78(5):725–9. doi:10.1097/01.TP.0000131953.13414.99.
32. Bruintjes MHD, d'Ancona FCH, Zhu X, Hoitsma AJ, Warlé MC. An Update on Early Urological Complications in Kidney Transplantation: A National Cohort Study. *Ann Transplant.* 2019;24:617–24. doi:10.12659/AOT.920086.
33. Patel S, Denis T, Gaba F, Inouye B, White M, Yamamoto T, et al. Risk Factors and Rates of Occurrence of Ureteral Stricture Formation Following Renal Transplantation: A Literature Review. *Exp Clin Transplant.* 2024;22(9):655–63. doi:10.6002/ect.2024.0191.
34. Ghonge NP, Gadanayak S, Rajakumari V. MDCT evaluation of potential living renal donor, prior to laparoscopic donor nephrectomy: What the transplant surgeon wants to know? *Indian J Radiol Imaging.* 2014;24(04):367–78. doi:10.4103/0971-3026.143899.
35. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ.* 2003;327(7414):557–60. doi:10.1136/bmj.327.7414.557.

Figures

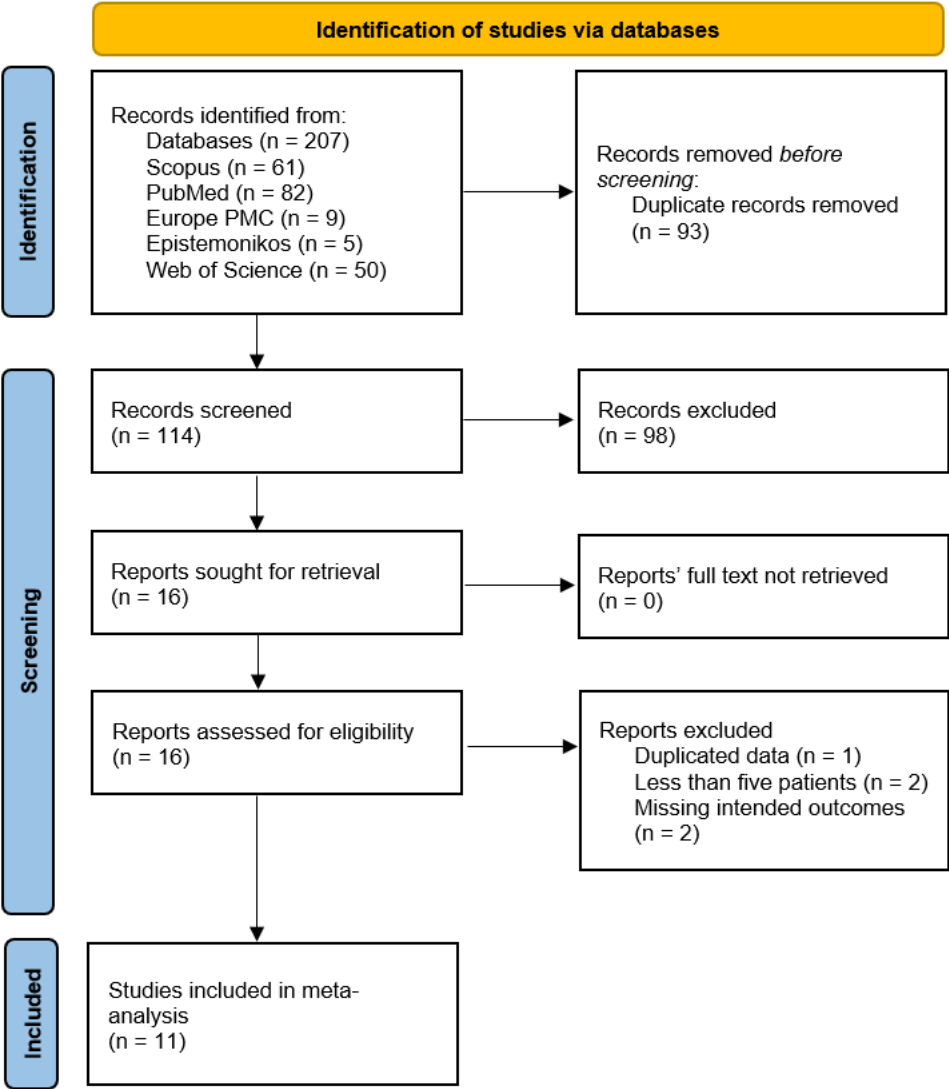
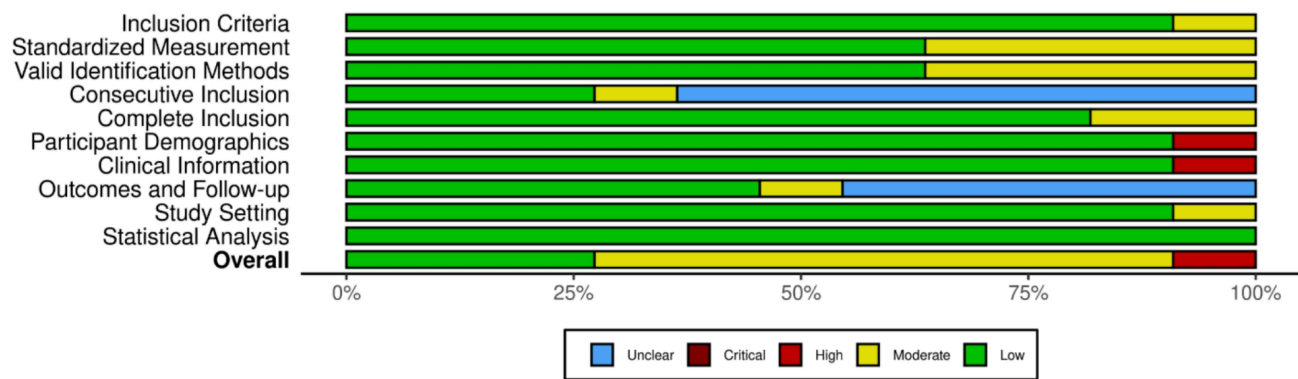


Figure 1

PRISMA 2020 flow diagram. Flow of records through identification, screening, full-text assessment, and inclusion.



Study	Risk of bias										
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Overall
Cylke 2018	+	+	+	+	-	+	+	?	+	+	-
Ghazanfar 2015	+	+	+	?	+	+	+	+	+	+	+
Gravetz 2025	+	+	+	+	+	+	+	+	+	+	+
Lasaponara 2013	+	-	-	?	+	+	+	?	+	+	-
Surowiecka-Pastewka 2018	+	+	+	-	+	+	+	-	+	+	-
Alberts 2013	+	-	-	?	+	+	+	+	+	+	-
Altinel 2023	+	+	+	?	-	X	X	?	+	+	X
Haferkamp 1999	-	-	-	?	+	+	+	+	+	+	-
Heidari 2010	+	+	+	?	+	+	+	+	-	+	-
Sulikowski 2005	+	+	+	+	+	+	+	?	+	+	+
West 2016	+	-	-	?	+	+	+	?	+	+	-

D1: Were there clear criteria for inclusion in the case series?
 D2: Was the condition measured in a standard, reliable way for all participants included in the case series?
 D3: Were valid methods used for identification of the condition for all participants included in the case series?
 D4: Did the case series have consecutive inclusion of participants?
 D5: Did the case series have complete inclusion of participants?
 D6: Was there clear reporting of the demographics of the participants in the study?
 D7: Was there clear reporting of clinical information of the participants?
 D8: Were the outcomes or follow up results of cases clearly reported?
 D9: Was there clear reporting of the presenting site(s)/clinic(s) demographic information?
 D10: Was statistical analysis appropriate?

Judgement
 X High
 - Moderate
 + Low
 ? Unclear

Figure 2

Risk-of-bias assessment of included studies. Summary of methodological quality judgments using the JBI critical appraisal checklist for case series.

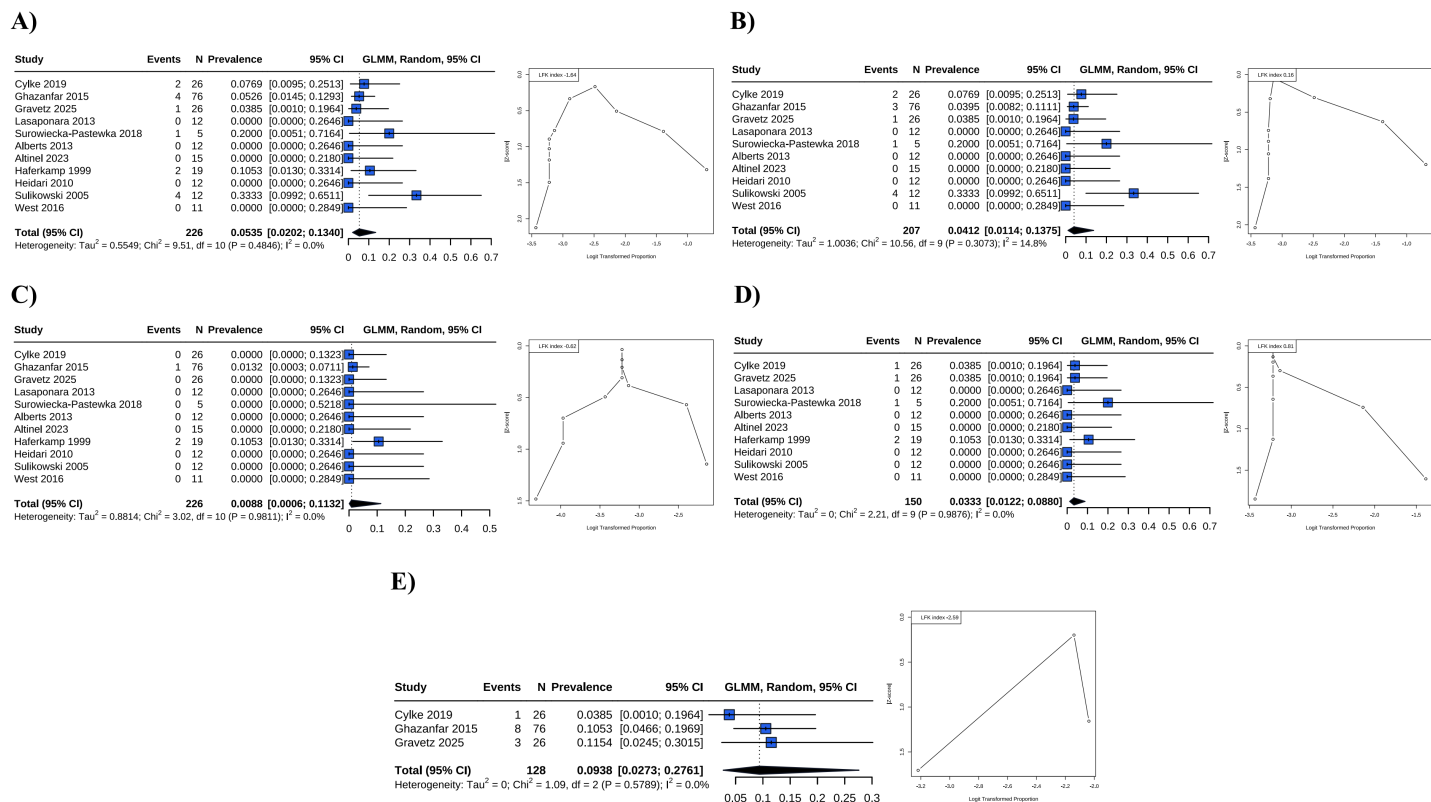
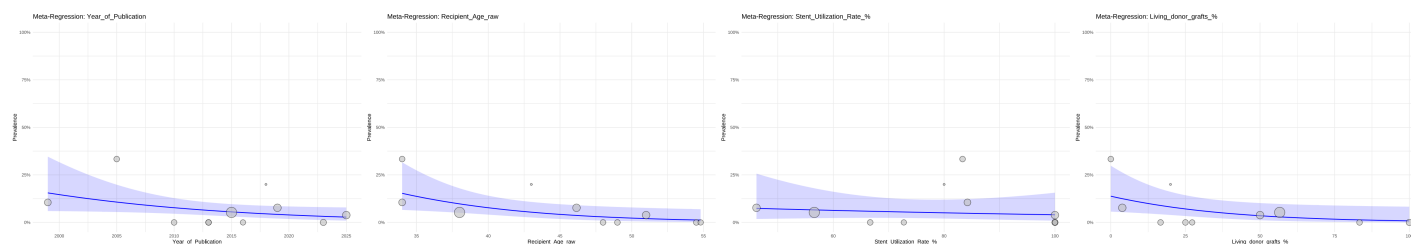


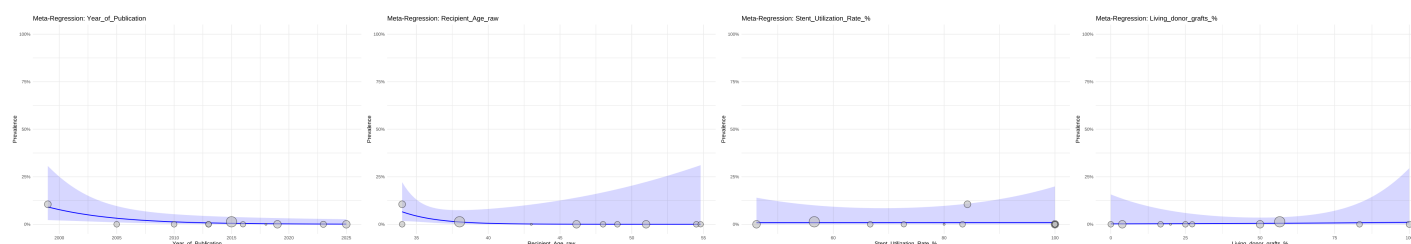
Figure 3

Pooled prevalence and Doi plots for urological outcomes. Panels show (A) overall structural urological complications, (B) urinary leak, fistula, and urinoma, (C) ureteral stricture and obstruction, (D) urological surgical revision, and (E) delayed graft function.

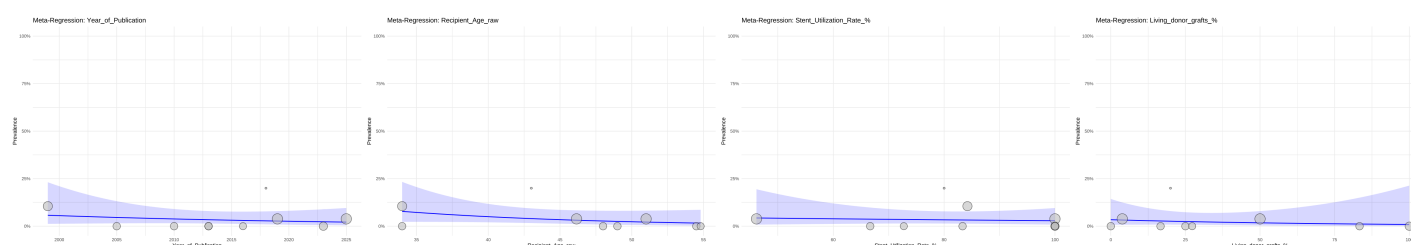
A)



B)



C)



Notes: Meta-regression moderators from left to right were; year of publication, recipient age, stent utilization rate, and proportion of living donor grafts.

Figure 4

Meta-regression of study-level moderators. Bubble plots show moderators for (A) overall structural urological complications, (B) urinary leak, fistula, and urinoma, (C) ureteral stricture and obstruction, and (D) urological surgical revision.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [searchstrategiesfullrenal.docx](#)
- [PRISMA2020checklist.docx](#)
- [DuplexRenalRawEXTRACT.xlsx](#)