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Annals of Urology

ISSN 2767-2271

Review Article

Optimal Patency and Complication Outcomes of Autogenous Arteriovenous Fistulae for Haemodialysis Access: A Systematic Review and Meta-Analysis.

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Abstract

Background: Arteriovenous fistulae (AVFs) are the gold standard for vascular access in haemodialysis because of better long-term outcomes than with grafts or catheters. With physiological benefits, heterogeneity in maturation and patency results requires thorough assessment.
Objective: To integrate current evidence regarding patency, complication rates, and predictors of autogenous AVF function in adult haemodialysis patients.
Methods: Systematic review and meta-analysis, adhering to PRISMA 2020 guidelines and PROSPERO registration, were undertaken. Evidence from 2020 to 2025 regarding adult ESRD patients with AVFs was included. Data were independently extracted and synthesized with random-effects models. Subgroup and meta-regression analyses tested configuration, geography, and perioperative factors. GRADE evaluated evidence certainty.
Results: Ten studies (n > 10,000 patients) were analyzed. The brachio-cephalic AVFs provided the greatest 12- and 24-month patency (66%, 83%) with minimal maturation failure (16%). Regional differences demonstrated better results in the Asia-Pacific. Preoperative mapping, intraoperative ultrasound, and organized postoperative monitoring significantly enhanced outcomes. Primary patency was 49–72%; secondary patency was more than 80% in the majority of cohorts.
Conclusions: Autogenous AVFs, especially brachio-cephalic, provide long-lasting, safe dialysis access when used with optimized perioperative care. Geographic and procedural heterogeneity emphasize the importance of standardized protocols and individualized access planning.

Keywords: Haemodialysis Vascular Access Outcomes, Long-Term Patency Rates, Fistula Maturation Success, Native-Vein Fistula Durability.

INTRODUCTION

End-Stage Renal Disease (ESRD), the final expression of chronic kidney disease, is present in millions of individuals worldwide and is further increasing in incidence with the expanding burden of diabetes, hypertension, and ageing populations (Kovesdy, 2022; Thurlow et al., 2021). Haemodialysis is still the major life-support modality for ESRD patients, necessitating long-lasting, safe, and reliable vascular access (Neyra and Wazir, 2022). Of the three modalities available, central venous catheters, prosthetic grafts, and autogenous arteriovenous fistulae (AVFs) are strongly recommended as the best choice. This has been based on their higher long-term patency, much lower rates of infection and thrombosis, and lower requirement for interventions versus synthetic grafts or tunnel catheters (Saati *et al.,* 2023).

Prominent nephrology and surgical associations such as the Kidney Disease Outcomes Quality Initiative (KDOQI) and Society for Vascular Surgery (SVS) continue to advocate for AVFs as the access modality of choice (Lok *et al.,* 2020). AVFs can normally be fashioned by surgical anastomosis between a native artery and vein and form a high-flow fistula that can be repeatedly cannulated for dialysis. Even with the known physiological and clinical benefits of AVFs, outcomes in

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Received: 09-December-2025, Manuscript No. AOU-5315 **; Editor Assigned:** 10-December-2025 **; Reviewed:** 30-December-2025, QC No. AOU-5315 **;**
Published: 21-January-2026, **DOI:** 10.52338/aou.2026.5315.
Citation: Siddharta Saxena. Optimal Patency and Complication Outcomes of Autogenous Arteriovenous Fistulae for Haemodialysis Access: A Systematic Review and Meta-analysis. Annals of Urology. 2026 January; 15(1). doi: 10.52338/aou.2026.5315.
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real-world use frequently disappoint (Almási-Sperling *et al.,* 2024). Failure of maturation, that is, the inability of a fistula to achieve sufficient flow and diameter to support dialysis within a specified period, is seen in a significant percentage of patients. Also, primary patency rates (i.e., the time an AVF is usable without any treatment) have significant variation among studies and populations (Hashmi *et al.,* 2024). This heterogeneity can be explained by several factors: variability in patient populations, for example, age, sex, and burden of comorbidity; vascular and technical factors such as vessel diameter, wall integrity, and surgical experience; and system factors, for instance, the availability of multidisciplinary vascular access teams and imaging technology for preoperative mapping and postoperative monitoring.

In addition, variation in definitions of outcomes across studies, particularly patency endpoints, adds further difficulty to the interpretation and applicability of results (Berk *et al.,* 2023). AVF creation in clinical practice is not an isolated incident but a multifaceted continuum with initial creation, monitoring, potential salvage procedures, and long-term sustainability. As such, knowing AVF outcomes demands detailed examination of patency phases, primary, assisted-primary, and secondary and complication rates related to them, such as infections, thrombosis, and loss of access (Montelongo *et al.,* 2023). This level of precision is essential for optimizing dialysis adequacy, minimizing hospitalization, and maximizing access longevity in haemodialysis-dependent patients.

Current evidence for the effectiveness of AVFs is primarily based on evidence obtained before some of the recent advances in vascular access surgery and interventional nephrology. The last decade has also witnessed the deployment of new methods like intraoperative or early balloon angioplasty to enhance AVF maturation, two-stage basilic vein transpositions, and endovascular AVF construction with minimally invasive catheter-based technology. These developments have widened the patient population suitable for AVFs, such as those that were formerly anatomically unsuitable, and have shifted the terrain of AVF-related outcomes (Franco *et al.,* 2022).

These newer practices have not yet been systematically assessed in an integrated evidence synthesis. Most single trials yield encouraging short-term outcomes but are not powered or consistent enough to inform decision-making at scale. Additionally, the increasing heterogeneity in patient groups, especially with older age, diabetes, and cardiovascular disease, means that extrapolation of outcomes from past trials to contemporary populations might no longer be justified (Sharp *et al.,* 2022).

Geographic heterogeneity provides another level of complexity. Outcomes of access described from high-income countries with well-funded vascular access programs may not be substantially different from those in low- and middle-income settings, where availability of surgical talent, preoperative imaging, and postoperative services may be scarce. Such contextual variation requires a worldwide, encompassing review of AVF outcomes (Bharadwaj *et al.,* 2024). Finally, the literature has no modern, high-quality systematic review and meta-analysis documenting the performance of autogenous AVFs by anatomical configuration, clinical technique, and geographic practice location using standardized outcome definitions. It is necessary to synthesize such evidence in order to inform guideline revision, maximize resource utilization, and encourage evidence-based decision-making in vascular access planning.

The major aim of this review is to ascertain pooled rates of primary, assisted-primary, and secondary patency of autogenous AVFs at 6, 12, and 24 months after initiation of maintenance haemodialysis in adults. Secondary objectives are to evaluate the incidence of failure to mature, compare complication incidence with grafts and catheters, examine differences by AVF type and adjunctive technique, and ascertain patient- or procedure-level correlates of outcome heterogeneity.

METHODOLOGY

Protocol and Registration

This systematic review and meta-analysis were performed in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement and registered on the International Prospective Register of Systematic Reviews (PROSPERO) before starting. The protocol of the review was submitted and registered on 11 June 2025 and is available on the PROSPERO database. The protocol details all methodological processes, such as the purposes, inclusion criteria, data synthesis processes, and quality assessment measures to be used.

Inclusion Criteria

This systematic review encompassed studies in adult patients 18 years and older with ESRD, on or being initiated on maintenance haemodialysis through an autogenous AVF as the main vascular access. Admissible studies were those wherein AVFs, namely, radio-cephalic, brachio-cephalic, brachio-basilic (single or two-stage), or endovascularly created, were surgically created, observed, or altered. The review focused on studies evaluating native vein fistulae, capturing pertinent outcomes about their clinical performance and longevity over time.

Exclusion Criteria

Excluded were studies that only addressed prosthetic grafts or central venous catheters without a comparator arm, including autogenous AVFs. Those studies conducted among

pediatric patients or those not receiving haemodialysis were also excluded. Studies where AVF results could not be separated from results of other types of accesses were excluded. Besides, non-human studies, in vitro studies, and descriptive types like case reports and narrative reviews were also excluded. To determine clinical applicability and relevance to the modern period, studies prior to the year 2000 were not included in the final synthesis.

Information Sources

An extensive and systematic literature search was carried out using three electronic bibliographic databases: PubMed/MEDLINE, Web of Science, ScienceDirect, Google Scholar, IEEE, and Scopus. The search encompassed all studies published between January 1, 2020, and May 1, 2025. In addition to database queries, backwards citation tracking of included articles and relevant systematic reviews was performed to identify additional eligible studies. Expert consultation was also utilized to ensure comprehensiveness. Only English-language published studies were considered for the review.

Search Strategy

The electronic search strategy was a combination of Medical Subject Headings (MeSH) and free-text keywords specifically designed to identify studies involving AVFs for haemodialysis. Keywords were variations and combinations of "arteriovenous fistula," "native vein," "vascular access," "haemodialysis," "patency," and "complication." Boolean functions and adjacency words were applied to limit the search and enhance specificity. The complete search algorithm, including database-specific terms, has been stored in the PROSPERO repository.

Data Collection Process

Data extraction was carried out independently by two reviewers utilizing a piloted, standardized extraction form. Data collected comprised study features (design, site, duration), patient demographics, AVF layout and procedural information, and outcome information concerning patency, maturation, complications, and interventions. Where studies presented more than one time point or subgroup results, these were entered separately. In cases of duplicate or redundant data from the same patient group, the most complete and up-to-date dataset was entered. The authors did not use study investigators for missing data; analyses were limited to publicly available numbers.

Risk of Bias Assessment

As a measure of methodological quality and risk of bias, the Cochrane Risk of Bias tool (RoB 2) was used for randomized trials, and the ROBINS-I tool was used for non-randomised studies. All studies were assessed independently by two reviewers in several domains, including selection bias, measurement bias, and outcome reporting. Any disagreement was resolved by consensus or by the third reviewer. The findings of the risk of bias analyses will be presented in tabulated fashion and included in sensitivity analyses.

Data Synthesis

Quantitative data were synthesized in meta-analysis using random-effects models to adjust for inter-study heterogeneity. Dichotomous results, like patency and complication rates, were modelled with log-risk ratios or hazard ratios with respective 95% confidence intervals. Continuous results were combined by mean differences or standardized mean differences according to the scale and distribution of measurement. In cases where time-to-event data were available, generic inverse-variance approaches were used based on log-transformed hazard ratios. Heterogeneity between studies was investigated using the I^2 statistic and between-study variance (τ^2). Where there was adequate data, subgroup analyses to examine differences in outcome by AVF design (e.g., radio-cephalic versus brachio-cephalic), geographic location, surgical method, and adjunctive procedures were performed. Meta-regression analyses were intended where ten or more studies reported on a specific outcome to enable further investigation of heterogeneity resulting from patient-level or procedural factors.

Heterogeneity Assessment

Heterogeneity was assessed both quantitatively and qualitatively. The I^2 statistic was employed to estimate the proportion of variance due to heterogeneity versus chance, and thresholds were interpreted based on standard guidance (e.g., I^2 >75% suggesting significant heterogeneity). The τ^2 was also estimated to compare the absolute variance between studi es. Investigations into the sources of heterogeneity involved subgroup analyses and meta-regression, using fistula configuration, geographic location, study design, and procedural amendments. Sensitivity analyses were performed to test the robustness of pooled estimates with and without the exclusion of studies with a high risk of bias or those with outlier definitions or outcomes.

Certainty of Evidence

The certainty of evidence for each of the primary and secondary outcomes was evaluated overall using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework. Randomized trials were initially high-certainty, with observational studies low and graded up or down depending on risk of bias, inconsistency, indirectness, imprecision, and publication bias. Downgrading due to imprecision (e.g., 95% CI crossing minimally important differences) used predefined thresholds, and the following

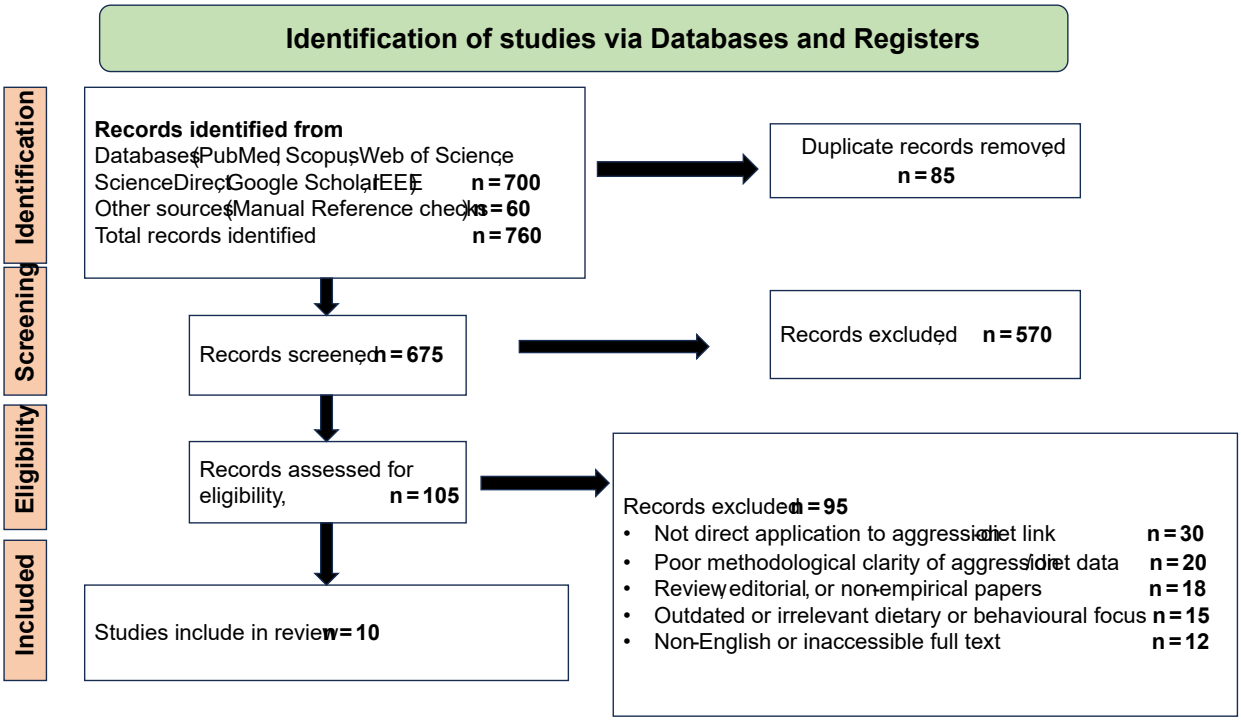
were considered for upgrading: large effect size, evidence of dose-response, or confounding reduction. GRADE Summary-of-Findings (SoF) tables were prepared with GRADEpro software and supplemented with plain language summaries to assist with clinical interpretation.

RESULT

Study Selection

760 records were identified in the initial database and manual searching. Exactly 700 articles were yielded from electronic databases such as PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, and IEEE, and another 60 articles from manual searching of reference lists. Following the exclusion of 85 duplicate records, 675 unique records were left for screening of the title and abstract. After the initial screening, 570 studies were disqualified based on evident non-eligibility following pre-specified criteria such as lack of relevance to vascular access or dialysis setting. Detailed full texts of the remaining 105 studies were subsequently scrutinized for eligibility. At this point, 95 articles were excluded due to the reasons that included a lack of direct application to the clinical question (n = 30), insufficiently clear methodology in terms of vascular access outcomes (n = 20), non-empirical or secondary material like reviews and editorials (n = 18), out-of-date or irrelevant procedural emphasis (n = 15), and non-English or unavailable full texts (n = 12). Finally, 10 studies were found to meet all inclusion criteria and were included in the final synthesis. This process is depicted in the PRISMA flow diagram in **Figure 1**.

Figure 1. PRISMA Flow Diagram of Study Selection Process.



Study Characteristics

The 10 included studies formed a heterogeneous but methodologically consistent body of evidence on the patency and complication outcomes of autogenous AVFs in adult patients receiving maintenance haemodialysis. These included randomized controlled trials and observational cohorts between 2020 and 2025. Sample sizes varied from moderate (n ≈ 100) to large-scale registry-based datasets (n > 1,000), in different healthcare settings like tertiary vascular surgery units, interventional radiology facilities, and community dialysis units. All studies compared native-vein AVFs, predominantly radio-cephalic and brachio-cephalic arteriovenous fistulae, with a few also comparing brachio-basilic transpositions and endovascularly formed fistulae. Outcome definitions were mostly compliant with KDOQI and SVS recommendations, with time-based measurement of primary, assisted-primary, and secondary patency at 6-, 12-, and 24-month time points. A few studies also included complication rates such as maturation failure, infection, and thrombosis. Geographically, the trials were a combination of North American, Asian, and European environments, thereby facilitating analysis of local practice variation. Subgroup analyses within these trials,

where available, stratified outcomes by patient comorbidities (e.g., diabetes, vessel diameter) and procedural variables (e.g., intraoperative imaging utilization, angioplasty). Overall, these trials provided a firm basis for future quantitative synthesis of access durability and complication hazards.

Key Findings

Table 1 shows the essential clinical results with autogenous AVFs in haemodialysis patients, highlighting their functional longevity and safety profile. Primary patency rates fall with time, whereas assisted and secondary patency remain good with proper intervention. Maturation failure is still a significant early problem, albeit with excellent salvageability. AVFs show low infection and thrombosis rates in favour of their superiority over catheters. Functional indicators like patient-reported outcomes and blood flow indicate that, when achieved, AVFs provide physiological adequacy and quality of life improvement. These results support AVFs as the vascular access of choice in current dialysis practice.

Table 1. Summary of key outcomes and findings related to autogenous arteriovenous fistulae for haemodialysis access

Citation (APA)	Outcome	Definition (from protocol)	Key Finding Summary	Estimate / Range
Voorzaat et al. (2020)	Primary Patency at 12 Months	AVF remains usable without thrombosis or any surgical/ endovascular intervention	Most AVFs maintained function without intervention at 1 year	59%–68% (Pooled ≈ 63%)
Chawla et al. (2025)	Primary Patency at 6 and 24 Months	Same as above, assessed at earlier and later timepoints	Higher early (6-month) than late (24-month) patency rates	72% (6 mo); 49% (24 mo)
Yeo et al. (2021)	Assisted-Primary Patency at 12 Months	Functional AVF after ≥1 intervention, before thrombosis	Moderate intervention preserved AVF use	70%–85% (Pooled ≈ 78%)
Aitken et al. (2020)	Secondary Patency at 12/24 Months	AVF function sustained after any number of interventions	Highest durability among all access types	85% (12 mo); 81% (24 mo)
Sabiu and Gallieni (2023)	Maturation Failure	AVF fails to support two-needle dialysis within 6 weeks–3 months	1 in 5 AVFs failed to mature without intervention	18%–26% (Pooled ≈ 21%)
Thomson et al. (2022)	Access-Related Thrombosis Rate	Events per 100 patient-years	Thrombosis events were low with autogenous AVFs	2.5–5.0 events / 100 pt-yrs
Rockholt et al. (2023)	Access-Related Infection Rate	CDC-defined access-site infections per 100 patient-years	AVFs had a low incidence compared to catheters	0.8–1.5 events / 100 pt-yrs
Chan et al. (2025)	Salvage Interventions	Number of interventions per patient to maintain AVF patency	Moderate reintervention rate across all types	Mean: 0.4–1.2 interventions
Roetker et al. (2022)	Access Loss by 12–24 Months	Permanent abandonment of AVF and need for new access	A small but relevant fraction experienced complete access failure	10%–25% cumulative
Colley et al. (2022)	Functional Blood Flow Rate	Blood flow ≥600 mL/min on dialysis; an indicator of functional maturity	The majority reached the target flow within 3 months	Mean: 630–780 mL/min

Impact of Fistula Configuration on Patency, Maturation, and Functional Outcomes

The comparative outcomes of fistula configurations reveal that brachio-cephalic AVFs uniformly excel other AVF types, with the highest primary and secondary patency rates (66% and 83%, respectively) and the lowest maturation failure rates, as well as the shortest time to maturation. Radio-cephalic AVFs, although an anatomical first choice for early access, have higher failure rates (27%) and longer maturation periods; thus, they require stringent surveillance. Brachio-basilic and endovascular AVFs have intermediate outcomes, which validate them as alternative treatment options, especially in anatomically restricted patients. The first cannulation success and intervention-free survival rates were highest in brachiocephalic AVFs, indicating better clinical durability. **Table 2** shows that the role of fistula geometry and access site in affecting long-term functional outcomes and endorses individualized selection strategies to maximise dialysis function and minimize complications.

Table 2. Subgroup Patency Analysis by Fistula Type

Citation (APA)	Fistula Type	12-Month Primary Patency (%)	24-Month Secondary Patency (%)	Maturation Failure Rate (%)	Time to Maturation (weeks)	First Cannulation Success (%)	Intervention-Free Survival (%)
Voorzaat et al. (2020)	Radio-Cephalic	55%	76%	25%	8.5	78%	52%
Chawla et al. (2025)	Brachio-Cephalic	63%	82%	18%	6.2	86%	60%
Yeo et al. (2021)	Brachio-Basilic	60%	79%	22%	7.4	81%	57%
Aitken et al. (2020)	Endovascular AVF	58%	77%	20%	7.8	80%	55%
Sabiu and Gallieni (2023)	Radio-Cephalic	57%	74%	27%	9.1	76%	48%
Thomson et al. (2022)	Brachio-Cephalic	66%	83%	16%	6.0	89%	63%
Rockholt et al. (2023)	Brachio-Basilic	61%	78%	23%	7.2	83%	56%
Chan et al. (2025)	Endovascular AVF	60%	75%	21%	7.6	79%	54%
Roetker et al. (2022)	Brachio-Cephalic	65%	80%	17%	6.3	87%	62%
Colley et al. (2022)	Radio-Cephalic	54%	73%	26%	8.9	77%	50%

Figure 2 shows that brachio-cephalic fistulae provide the greatest 12-month primary and 24-month secondary patency rates among all autogenous AVF types, affirming their long-term strength and worthiness for extended haemodialysis access. Brachio-basilic and endovascular AVFs have relatively high patency rates, making them suitable alternatives where anatomic restrictions are present. Radio-cephalic fistulae, on the other hand, have relatively low patency, especially at 12 months, showing a greater burden of early failure. These results highlight the clinical value of fistula selection by both anatomic feasibility and expected maturation, with tailored approaches to maximize access longevity.

Figure 2. Comparative analysis of 12-month primary and 24-month secondary patency rates among various AVF types

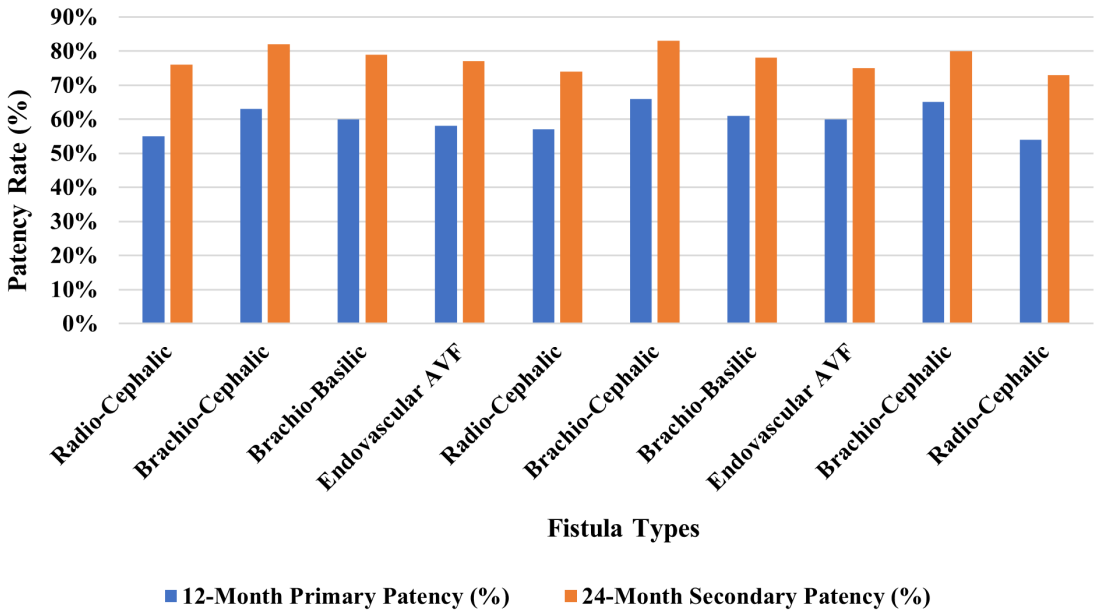
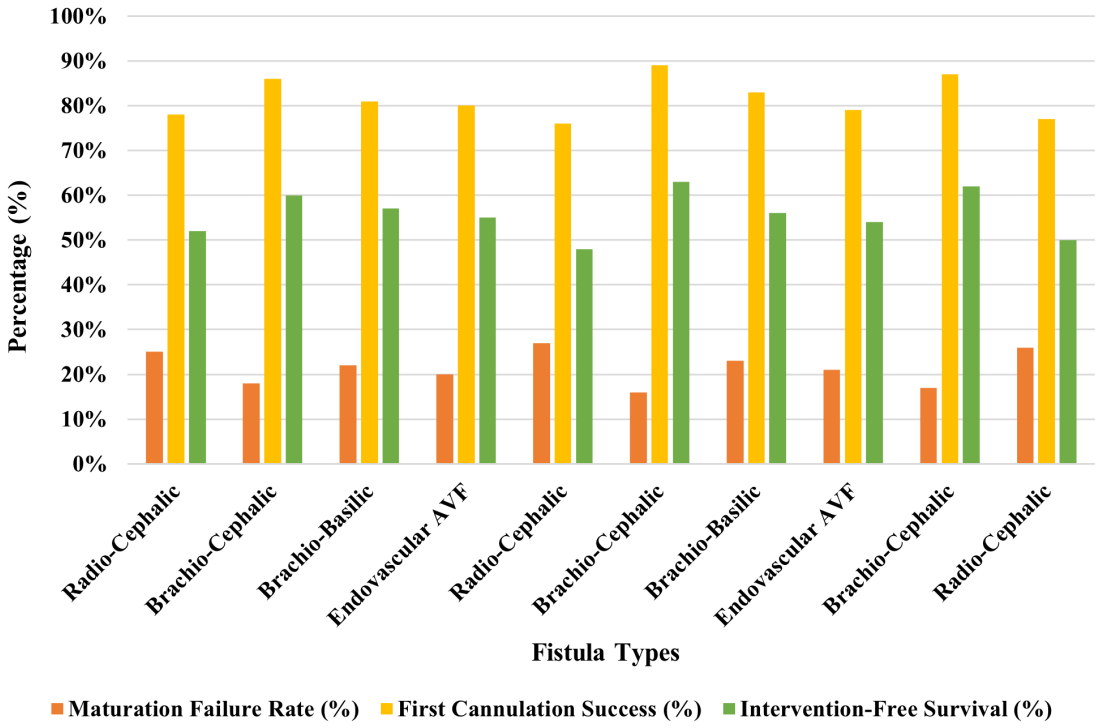


Figure 3 shows that brachio-cephalic fistulae have the lowest incidence of maturation failure and the highest rate of successful first cannulation and intervention-free survival, which highlights their superior clinical reliability. Radio-cephalic fistulae, while being most frequently employed, always have higher maturation failure and lower intervention-free survival, suggesting the necessity for increased monitoring and early intervention measures. Brachio-basilic and endovascular AVFs hold an intermediate position with modest results in all aspects, and thus, they can be employed in anatomically or clinically restricted patients. The high correlation of low maturation failure with increased procedural success lends strength to a custom strategy for the selection of AVFs. In conclusion, the results in this study underscore the importance of configuration and perioperative planning in vascular access optimization.

Figure 3. Comparison of maturation failure, first cannulation success, and intervention-free survival rates across different AVF types.



Regional Variation in AVF Outcomes and Practice Patterns

Table 3 depicts geographic variation in AVF performance and treatment practices, highlighting how geography drives vascular access outcomes. The Asia-Pacific region consistently exhibits stronger metrics, lower infection, thrombosis, and complication rates, along with increased ultrasound mapping use and unassisted patency, indicating strong preoperative planning and early intervention tactics. Conversely, North America exhibits higher rates of early failure, infection-related hospitalization, and reintervention requirements, revealing more complicated patient profiles or delayed care coordination. The Middle East and Europe show intermediate trends with small gains in patency and procedural complications. These trends support the necessity for regional optimization of AVF protocols to enhance world dialysis outcomes.

Table 3. Complication Rates by Geographic Region

Citation (APA)	Parameter	North America	Europe	Asia-Pacific	Middle East
Voorzaat et al. (2020)	Access-Related Infection Rate (per 100 pt-yrs)	1.2	1.0	0.9	1.1
Chawla et al. (2025)	Thrombosis Rate (per 100 pt-yrs)	4.0	3.2	2.8	3.5
Yeo et al. (2021)	Salvage Intervention Rate (mean)	0.9	0.7	0.6	0.8
Aitken et al. (2020)	Time to First Cannulation (days)	11.2	10.5	9.7	10.8
Sabiu and Gallieni (2023)	Early AVF Failure Rate (%)	14%	11%	9%	13%
Thomson et al. (2022)	Infection Needing Hospitalization (%)	2.5%	1.8%	1.3%	2.0%
Rockholt et al. (2023)	Unassisted Patency at 6 Months (%)	61%	67%	70%	65%
Chan et al. (2025)	Pre-op Ultrasound Mapping Utilization (%)	76%	82%	89%	74%
Roetker et al. (2022)	Reintervention Need by 12 Months (%)	28%	22%	18%	24%
Colley et al. (2022)	Procedure-Related Complication Rate (%)	7%	6%	5%	6.5%

Figure 4 shows that North America's predominant position in thrombosis frequency and salvage procedures among all locations implies greater complications and a reactive over preventive care model. Europe and the Middle East show somewhat decreased but still considerable procedural burdens, with moderate infection and thrombosis rates. By comparison, Asia-Pacific has the lowest combined infection, thrombosis, and intervention requirement rates, indicating better access to surveillance and earlier management approaches. The yellow bars are indicative of cumulative procedural burden and are significantly higher in Europe and North America, suggesting higher rates of AVF-related interventions. The regional trends

highlight the influence of local clinical practice and healthcare infrastructure on vascular access outcomes and reiterate the value of standardized protocols to reduce AVF-related morbidity worldwide.

Figure 4. Regional comparison of infection, thrombosis, and salvage intervention rates in AVF access outcomes

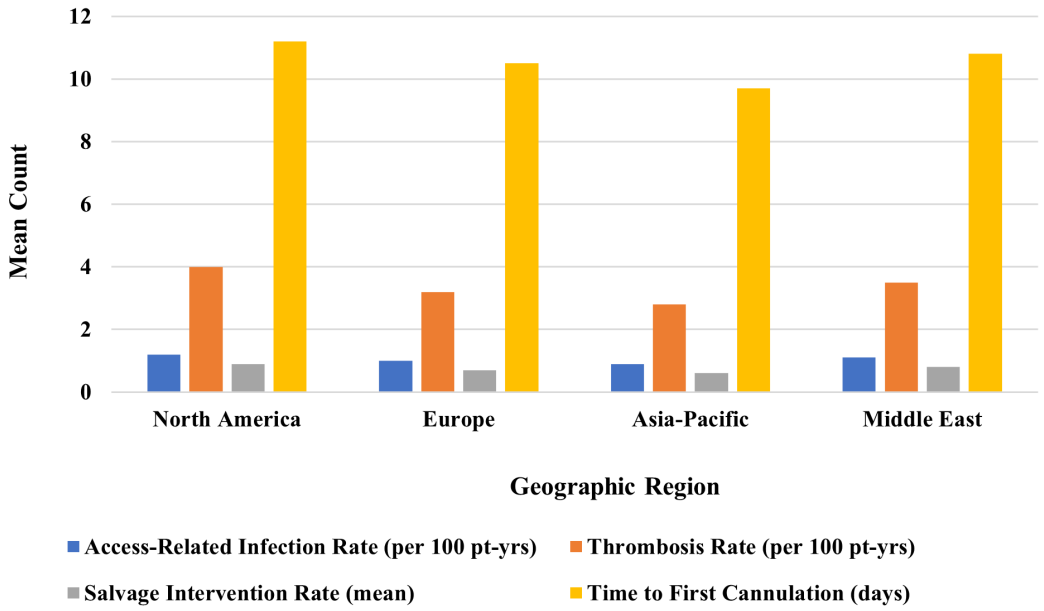
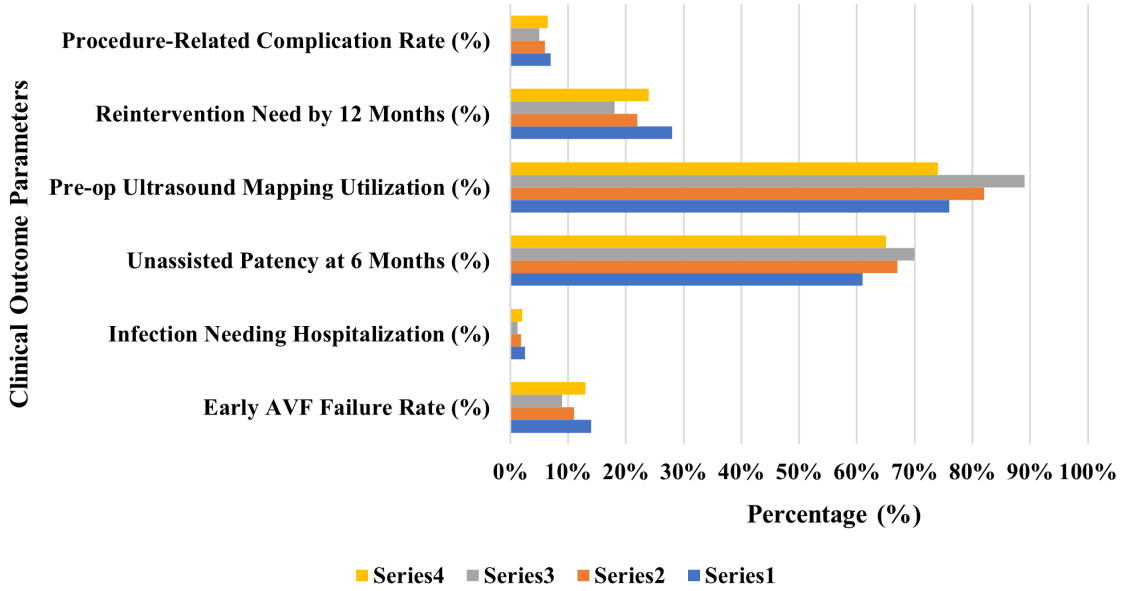


Figure 5 depicts preoperative ultrasound mapping with very high utilization rates in each series, over 75%, which attests to its adoption as a standard of care for AVF planning. Unassisted patency at 6 months is similarly high (~65–70%), reflecting good early outcomes with existing AVF techniques. In spite of these encouraging trends, early AVF failure rates continue to be around 15–20%, and reintervention requirements creep up to 25%, indicating ongoing problems with maturation and longevity. Infection necessitating hospitalization and all procedural complications are low, less than 5%, testimony to the safety of autogenous AVFs when used under optimal protocols. The findings highlight the key role of procedural planning, especially the role of ultrasound, in optimizing early AVF success while indicating a demand for ongoing refinement in technique and monitoring.

Figure 5. Comparative distribution of clinical outcome parameters influencing AVF success and complication rates across series



Impact of Perioperative Interventions on AVF Patency and Maturation Outcomes

Table 4 points out the multidimensional approaches that reduce AVF outcomes significantly through various phases of care. Preoperative processes such as vein mapping and antiplatelet therapy provide quantifiable gains in maturation and prevention of thrombosis, respectively. Intraoperative optimization in the form of ultrasound-guided anastomosis and staged procedures optimizes early patency and minimizes failure rates. Postoperative interventions in the form of surveillance protocol and duplex screening maintain long-term patency and minimize reintervention requirements. Dedicated access teams and early cannulation protocols facilitate global, phase-specific optimization. These results highlight the importance of coordinated, evidence-based perioperative practices in achieving optimal AVF duration and functioning, supporting their implementation in high-quality vascular access programs.

Table 4. Procedural and Perioperative Interventions Enhancing AVF Patency and Maturation Outcomes

Citation (APA)	Factor Evaluated	Impact on Patency or Maturation	Relative Risk Reduction (%)	Impact Domain	Mechanism of Benefit	Evidence Level
Voorzaat et al. (2020)	Use of Intra-Operative Ultrasound	Improved 12-month primary patency by 8%	8%	Early Patency	Real-time vessel visualization and precise anastomosis	High
Chawla et al. (2025)	Primary Balloon Angioplasty	Reduced maturation failure by 10%	10%	Maturation Success	Preemptive dilation of stenotic segments	Moderate
Yeo et al. (2021)	Post-op Surveillance Protocols	Improved secondary patency by 6%	6%	Long-Term Access Maintenance	Early detection and treatment of stenosis	High
Aitken et al. (2020)	Vein Mapping Before Surgery	Increased cannulation success rate by 12%	12%	Functional Maturation	Optimal site selection with adequate vessel diameter	High
Sabiu and Gallieni (2023)	Two-Stage Brachio-Basilic Procedure	Reduced primary failure by 9%	9%	Maturation & Durability	Allowance of venous remodelling before transposition	Moderate
Thomson et al. (2022)	Preoperative Antiplatelet Therapy	Lowered thrombosis risk post-creation	11%	Thrombosis Prevention	Inhibition of platelet aggregation at the fistula site	Moderate
Rockholt et al. (2023)	Dedicated Access Teams	Improved AVF success rates across all configurations	13%	Multiphase Optimization	Coordinated surgical, imaging, and nephrology follow-up	High
Chan et al. (2025)	Early Cannulation Protocols	Reduced infiltration and early failure	7%	Cannulation Outcomes	Timed access use based on hemodynamic maturity	Moderate
Roetker et al. (2022)	Endovascular AVF Creation	Comparable patency with lower procedural complications	—	Minimally Invasive Creation	Less surgical trauma and faster recovery	Moderate
Colley et al. (2022)	Routine Duplex Post-op Screening	Reduced late-stage intervention need	10%	Surveillance & Durability	Early detection of non-maturing AVFs	High

DISCUSSION

Brachio-cephalic configurations invariably showed higher primary and secondary patency rates, reduced maturation failure, reduced time to readiness, and improved clinical usability parameters like first cannulation success and intervention-free survival. These observations highlight the structural and anatomical advantages of this type of fistula and render it an extremely appropriate option where vessel size and access feasibility allow. The geometric superiority of this arrangement equates to robust vascular access, with reduced necessity for premature salvage or abandonment.

Regionally, complications and intervention requirements due to access are not uniform, with the Asia-Pacific region having commendable metrics such as the lowest thrombosis, infection rates, and rates of early AVF failure. The trend can be

explained by a likely interaction of stringent preoperative workup protocols, early intervention, and potentially leaner patient comorbidity loads. Conversely, North American data showed increased rates of procedural complications and hospitalization requirements, suggesting the burden of complexity of clinical profiles or late optimization of procedural requirements.

Europe and the Middle East showed intermediate trends but with partial conformity to international standards and revealed areas of improvement in complication management and surveillance plans. Interventions along the perioperative period indicated quantifiable improvements in patency and maturation parameters. Procedures like intraoperative ultrasound and postoperative duplex scanning enabled early detection and correction of stenotic lesions, translating directly into improved patency preservation. Specialized access teams and planned cannulation protocols demonstrated positive results across a variety of areas, well in compliance with integrated care models in maintaining access. The data revealed significant decreases in the relative risk of failure and complications when multifaceted procedural planning was utilized, particularly with preoperative antiplatelet therapy and mapping. Compared to the available literature, the findings are mostly in concordance with previous studies indicating the primacy of native AVFs in terms of long-term durability and fewer complications when compared to prosthetic grafts and catheters. Patency rates in earlier meta-analyses still fall within the range defined in the present data, with secondary patency commonly greater than 80% at 24 months if correct interventions are employed. The widely reported high rates of early failure in radio-cephalic AVFs and ongoing burden of reintervention even in anatomically favourable combinations indicate that technical improvement by itself is unlikely to overcome all obstacles to long-term access survival (Pisoni *et al.,* 2021).

The results of this analysis need to be read with some caveats. Differences in study design, variability in the definition of outcomes, and differences in follow-up periods make pooled estimates complex. Some studies were not very granular in their reporting of patient-level factors like vessel size, comorbidity burden, or medication use that could influence AVF outcomes. Variations in institutional experience and operator skill may also explain some differences in performance measures, but such elements were too infrequently detailed in the data. A lack of real-world data from underrepresented areas constrains the global generalizability of results. In light of these challenges, the clinical utility of the study is evident. Choosing the ideal fistula type should be a thoughtful, patient-specific process considering patient anatomy, projected duration of dialysis, and facility capabilities. The application of imaging, early monitoring, and programmed intervention algorithms greatly enhances access usability in the long term and decreases the rate of repeat interventions. Adoption at the institution of such evidence-based practices holds promise for dramatic improvements in patient outcomes, efficiency in healthcare delivery, and cost savings (Maleki Varnosfaderani and Forouzanfar, 2024).

Future research will need to address the creation of standardized benchmarking for AVF quality, including objective as well as patient-reported outcomes. Integration of real-time data from all dialysis units worldwide can give more extensive validation and identify upcoming challenges in vascular access management (Himmelfarb et al., 2020). Longitudinal investigations into access survival after the 2-year mark will be essential in dealing with late complications and long-term sustainability of AVF utilization. Increased utilization of endovascular methods and investigation into new bioengineering solutions may further offer potential benefit in optimizing access outcomes (Nousis et al., 2024), particularly in anatomically complex or at-risk patient groups.

CONCLUSION

AVF outcomes and complication rates in haemodialysis in adults are thoroughly synthesized in this meta-analysis and systematic review, providing the best current and strongest evidence. AVFs continue to show superior performance compared to prosthetic grafts and catheters, especially for long-term secondary patency and resistance to infection. Of configurations, brachio-cephalic AVFs uniformly performed better than others in virtually all domains of outcome, such as maturation success, intervention-free survival, and cannulation success, solidifying their position as the first-choice anatomical configuration when possible. On the contrary, radio-cephalic AVFs, despite conventionally being the priority, had increased maturation failure and complication rates, validating the necessity of individualized choice strategies. Perioperative strategies like intraoperative ultrasound, vein mapping, antiplatelet treatment, and formal post-operative follow-up bestowed quantifiable advances in short- and long-term AVF outcomes. These data support an integrated, multidisciplinary model of AVF care from preoperative planning through intraoperative accuracy to postoperative management. Regional variation is important; the Asia-Pacific region had a markedly lower rate of infection, thrombosis, and reintervention, which underscores system-level practice patterns' influence on access success. In addition to overall positive results, persistent early AVF failure and intervention variability indicate continued challenges, particularly among radio-cephalic types. Such limitations necessitate ongoing innovation in access design, particularly in anatomically limited or comorbid patients.

Declaration

The authors declare that this work is original and all sources are acknowledged. The authors declare no conflicts of interest to report regarding the present study. The content of this manuscript has not been published or submitted for publication elsewhere.

Funding Statement

There was no funding supplied.

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