

TIMING MATTERS: COMPARATIVE OUTCOMES OF NATIVE ARTERIOVENOUS FISTULA CREATION BEFORE VERSUS AFTER INITIATION OF HEMODIALYSIS

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Abstract

Background: Timely creation of a native arteriovenous fistula (AVF) is recommended as the preferred vascular access for hemodialysis (HD), yet many patients in resource-limited settings undergo AVF creation only after HD has already begun.

Objective: To compare maturation, complication, and patency outcomes between native AVFs created before versus after HD initiation.

Methods: This prospective observational cohort study was conducted at the Department of Cardiovascular Surgery, Imran Idrees Teaching Hospital, Sialkot, Pakistan (20 February 2025–29 February 2026). Of 700 consecutive patients screened, 244 meeting eligibility criteria were analyzed: 122 with pre-dialysis AVF creation and 122 with post-dialysis AVF creation. Groups were compared using t-tests/Mann–Whitney U, chi-square/Fisher's exact tests, and multivariable logistic regression.

Results: Baseline demographics and comorbidities were comparable between groups. Post-dialysis AVFs showed significantly lower functional maturation (63.1% vs. 84.4%, $p<0.001$), higher early thrombosis (17.2% vs. 5.7%, $p=0.009$) and steal syndrome (9.0% vs. 0.8%, $p=0.008$), markedly longer catheter dependence (median 42.0 vs. 0.0 days, $p<0.001$), and lower primary (45.1% vs. 69.7%, $p<0.001$) and secondary patency (61.5% vs. 82.8%, $p<0.001$). Early AVF failure was more frequent post-dialysis (36.9% vs. 18.0%, $p=0.001$), and post-dialysis timing remained an independent predictor on multivariable analysis (adjusted OR 3.24, 95% CI 1.71–6.15, $p<0.001$).

Conclusion: Pre-dialysis AVF creation is associated with superior maturation, fewer complications, and better patency than post-dialysis creation. Strengthening early nephrology referral and structured pre-ESKD vascular access planning is warranted, particularly in resource-limited settings.

INTRODUCTION

Chronic kidney disease (CKD) has emerged as one of the fastest-growing causes of morbidity and mortality worldwide, and end-stage kidney disease (ESKD) requiring renal replacement therapy now affects a substantial and increasing proportion of the global population [1]. South Asia, and Pakistan in particular, carries a disproportionately heavy burden of CKD driven by a high prevalence of diabetes mellitus, hypertension, consanguinity-related renal disease, and limited access to structured screening programmes [2]. With only a fraction of Pakistani patients with ESKD able to access renal transplantation, hemodialysis (HD) remains the dominant modality of renal replacement therapy in this population, making durable and safe vascular access a cornerstone of survival for thousands of patients every year.

The native arteriovenous fistula (AVF) is universally regarded as the preferred form of hemodialysis vascular access because of its superior long-term patency, lower infection risk, and lower cardiovascular morbidity compared with central venous catheters (CVCs) and prosthetic grafts [3]. The 2019 Kidney Disease Outcomes Quality Initiative (KDOQI) update reinforced this principle while introducing the concept of an individualized End-Stage Kidney Disease Life-Plan, encouraging clinicians to plan vascular access proactively rather than reactively [3]. Despite this guidance, international registry data continue to show that a large proportion of patients still begin hemodialysis via a CVC because their AVF was not created, or had not matured, before dialysis became clinically necessary [4].

The timing of AVF creation relative to the initiation of hemodialysis has therefore become a subject of considerable clinical interest. Fistulas created electively before dialysis initiation (pre-dialysis or "pre-emptive" AVF creation) are thought to benefit from a more physiologically stable, less uremic patient, controlled operative conditions, and an adequate maturation window free of the confounding effects of an indwelling catheter or acute uraemia. In contrast, fistulas created after dialysis has already begun (post-

dialysis AVF creation) are frequently performed in patients who required urgent catheter-based dialysis, often in the setting of late nephrology referral, more advanced uraemia, and greater hemodynamic instability [5,6]. Multiple cohort studies and registry analyses, including the Dialysis Outcomes and Practice Patterns Study (DOPPS), have reported that AVFs created before dialysis initiation achieve catheter independence faster and are associated with lower catheter-related morbidity, although evidence on long-term patency has been more heterogeneous, with some studies reporting no significant patency difference once other risk factors are accounted for [4,5].

Late nephrology referral remains a particularly important driver of post-dialysis AVF creation in low- and middle-income countries. Systematic reviews and regional cohort studies from South Asia have consistently shown that patients referred late to nephrology services are more likely to start dialysis via a catheter, experience longer catheter dependence, and suffer higher rates of access-related complications and mortality [6,7]. In Pakistan specifically, fragmented primary care, low community awareness of CKD, and limited nephrology and vascular access infrastructure outside major urban centres mean that a considerable proportion of patients are referred for AVF creation only after hemodialysis has already been initiated through an emergency catheter [2]. Despite this, locally generated evidence quantifying the real-world impact of AVF timing on maturation, complication rates, and patency in a Pakistani surgical population remains limited.

Given this gap, the present study was designed to compare the clinical, functional, and patency outcomes of native AVFs created before versus after the initiation of hemodialysis in a large, consecutive surgical cohort managed at a tertiary cardiovascular surgery department in Sialkot, Pakistan. We hypothesised that AVFs created before dialysis initiation would demonstrate superior maturation, fewer early complications, shorter catheter dependence, and better patency than those created after dialysis had already

begun, and that these findings would be broadly consistent with, while adding regional context to, the existing international and South Asian literature [1-7].

METHODOLOGY

Study Design, Setting, and Duration

This was a prospective, single-centre, observational cohort study conducted in the Department of Cardiovascular Surgery, Imran Idrees Teaching Hospital, Sialkot, Pakistan. The study was conducted over a 12-month data-collection period, from 20th February 2025 to 29th February 2026. Written informed consent was obtained from all participants or their legal attendants prior to enrolment, and patient confidentiality was maintained throughout data collection, storage, and analysis in accordance with the Declaration of Helsinki.

Study Population and Sampling

During the study period, 700 consecutive patients underwent native AVF creation in the department. Non-probability consecutive sampling was used to screen all patients presenting for first-time native AVF creation for chronic kidney disease stage IV or V. After applying the inclusion and exclusion criteria detailed below, 244 patients meeting full eligibility criteria and having complete perioperative and follow-up data were enrolled in the final analytic cohort. Patients were stratified into two comparison groups according to the timing of AVF creation relative to the initiation of maintenance hemodialysis: Group 1, pre-dialysis AVF creation (fistula created before the first hemodialysis session; $n = 122$), and Group 2, post-dialysis AVF creation (fistula created after hemodialysis had already been initiated, typically via a central venous catheter; $n = 122$).

Inclusion and Exclusion Criteria

Inclusion criteria were: adult patients (age ≥ 18 years) of either sex with CKD stage IV or V undergoing first-time creation of a native (autogenous) AVF at the wrist, forearm, or antecubital fossa, with a minimum intended follow-up of six months. Exclusion criteria were: creation of a prosthetic arteriovenous graft rather

than a native fistula, revision or redo fistula surgery, previous ipsilateral vascular access surgery, active malignancy or life expectancy under six months, incomplete baseline or follow-up records, and patient refusal of consent.

Data Collection

Data were collected prospectively using a structured, pre-piloted proforma covering ten domains: (A) patient demographics (age, sex, height, weight, body mass index, smoking status); (B) clinical characteristics (cause and stage of CKD, duration of CKD, comorbid diabetes mellitus, hypertension, ischemic heart disease, congestive heart failure, peripheral arterial disease, cerebrovascular disease, and dyslipidaemia); (C) preoperative laboratory parameters (hemoglobin, white cell and platelet counts, serum creatinine, blood urea nitrogen, estimated glomerular filtration rate, serum albumin, calcium, phosphate, and HbA1c in diabetic patients); (D) timing of AVF creation relative to hemodialysis initiation, including the interval between AVF creation and first dialysis, central venous catheter use, and duration of catheter use; (E) preoperative vascular assessment (Doppler vascular mapping, artery and vein diameters, vessel calcification and quality, and operative side); (F) operative variables (AVF type, operative duration, and intraoperative complications; anastomosis was end-to-side, anesthesia was local, and all procedures were performed by a single surgeon in every case); (G) early postoperative outcomes at 24 hours and during the index admission (thrill, bruit, hematoma, bleeding, surgical site infection, early thrombosis, limb oedema, steal syndrome, and reoperation); (H) functional outcomes (functional maturation, time to maturation, successful first cannulation, time to first cannulation, dialysis adequacy, catheter dependence, and reintervention); (I) clinical outcomes (early AVF failure and its cause, and 30-day mortality); and (J) long-term follow-up (follow-up duration, AVF functional status, primary patency, and secondary patency).

Surgical Technique and Definitions

All AVFs were created by a single surgeon within the department under local anesthesia, following standard microsurgical technique with end-to-side anastomosis in all cases. Radiocephalic, brachiocephalic, and brachio basilic configurations were used according to preoperative vascular mapping findings and surgeon judgement. Functional maturation was defined, in keeping with KDOQI criteria, as a fistula that could be cannulated with two needles and sustain the prescribed hemodialysis blood flow (≥ 300 mL/min) for the majority of dialysis sessions over a four-week period [3]. Early AVF failure was defined as failure of the fistula to mature or its thrombosis/abandonment within 6–12 weeks of creation. Primary patency was defined as uninterrupted fistula function without any intervention from the time of creation, and secondary patency as continued fistula function through the study follow-up period, with or without intervening corrective procedures.

Statistical Analysis

Data were entered and analyzed using SPSS version 26.0. Continuous variables are presented as mean $\pm$ standard deviation when normally distributed, or median (interquartile range) when non-normally distributed; normality was formally assessed using the Shapiro-Wilk test for each variable within each study group. Normally distributed continuous variables were compared between the pre-dialysis and post-dialysis groups using the independent-samples t-test, while non-normally distributed variables were compared

using the Mann-Whitney U test. Categorical variables are presented as frequencies and percentages and were compared using the chi-square test, or Fisher's exact test where more than 20% of expected cell counts were below 5. Multivariable binary logistic regression was used to identify independent predictors of the primary outcome (early AVF failure), adjusting for age, sex, diabetes mellitus, preoperative artery diameter, vein diameter, and vessel quality; results are reported as adjusted odds ratios (aOR) with 95% confidence intervals (CI). A two-tailed p-value < 0.05 was considered statistically significant throughout.

RESULTS

A total of 244 patients undergoing native AVF creation were included in the analysis and divided into two equal groups according to the timing of AVF creation relative to initiation of HD: 122 patients in whom the AVF was created before HD initiation (pre-dialysis group) and 122 patients in whom the AVF was created after HD had already begun (post-dialysis group).

The two groups were well matched for age, BMI, smoking status, duration of CKD, and the burden of comorbid disease (diabetes mellitus, hypertension, ischemic heart disease, congestive heart failure, peripheral arterial disease, cerebrovascular disease, and dyslipidaemia), with no statistically significant differences (all $p > 0.05$, Table 1). Men were more frequent in the post-dialysis group (68.0% vs. 54.9%, $p = 0.048$).

Table 1. Baseline demographic and clinical characteristics of the study population

Variable	Pre-dialysis AVF (n=122)	Post-dialysis AVF (n=122)	Test statistic	p-value
Age (years), mean $\pm$ SD	55.8 $\pm$ 11.5	55.8 $\pm$ 11.3	t = 0.011	0.991
Male sex, n (%)	67 (54.9)	83 (68.0)	$\chi^2 = 3.90$	0.048*
BMI (kg/m ²), mean $\pm$ SD	25.5 $\pm$ 5.5	24.8 $\pm$ 5.4	t = 1.03	0.304
Current smoker, n (%)	26 (21.3)	33 (27.0)	$\chi^2 = 0.81$	0.370
Duration of CKD (months), median (IQR)	41.5 (26.0–61.0)	39.0 (22.0–58.0)	U	0.547
Diabetes mellitus, n (%)	45 (36.9)	56 (45.9)	$\chi^2 = 1.69$	0.194
Hypertension, n (%)	99 (81.1)	104 (85.2)	$\chi^2 = 0.47$	0.493
Ischemic heart disease, n (%)	29 (23.8)	26 (21.3)	$\chi^2 = 0.09$	0.759

Congestive heart failure, n (%)	17 (13.9)	20 (16.4)	$\chi^2 = 0.13$	0.721
Peripheral arterial disease, n (%)	16 (13.1)	15 (12.3)	$\chi^2 = 0.04$	1.000
Cerebrovascular disease, n (%)	12 (9.8)	7 (5.7)	$\chi^2 = 0.91$	0.339
Dyslipidemia, n (%)	53 (43.4)	60 (49.2)	$\chi^2 = 0.59$	0.441

SD, standard deviation; IQR, interquartile range; BMI, body mass index; CKD, chronic kidney disease. Continuous, approximately normally distributed variables compared with independent-samples t-test; non-normally distributed variables (Shapiro-Wilk $p < 0.05$) compared with Mann-Whitney U test (U); categorical variables compared with chi-square test (or Fisher's exact test when $>20\%$ of expected cell counts were <5). * $p < 0.05$ considered statistically significant.

Preoperative laboratory parameters, including hemoglobin, white cell and platelet counts, renal function indices (serum creatinine, blood urea nitrogen, and eGFR), serum albumin, calcium, phosphate, and HbA1c among diabetic patients, were comparable between the two groups, with no significant differences identified (all $p > 0.05$, Table 2). This confirms that the two-timing groups entered the study with a similar burden of uraemia and metabolic derangement.

Table 2. Comparison of preoperative laboratory parameters between groups

Variable	Pre-dialysis AVF (n=122)	Post-dialysis AVF (n=122)	Test	p-value
Hemoglobin (g/dL)	9.67 $\pm$ 1.22	9.62 $\pm$ 1.27	t = 0.31	0.758
WBC ($\times 10^9/L$), median (IQR)	7.4 (5.9-9.2)	7.8 (6.0-9.1)	U	0.500
Platelets ($\times 10^9/L$)	231.0 $\pm$ 57.6	225.0 $\pm$ 61.9	t = 0.78	0.436
Serum creatinine (mg/dL)	6.75 $\pm$ 1.91	6.98 $\pm$ 2.27	t = -0.83	0.406
BUN (mg/dL)	77.5 $\pm$ 23.3	77.3 $\pm$ 20.1	t = 0.07	0.946
eGFR (mL/min/1.73m ²)	10.63 $\pm$ 3.81	11.26 $\pm$ 3.94	t = -1.28	0.203
Serum albumin (g/dL), median (IQR)	3.9 (3.4-4.2)	3.8 (3.5-4.1)	U	0.837
Serum calcium (mg/dL)	8.51 $\pm$ 0.66	8.62 $\pm$ 0.70	t = -1.32	0.187
Serum phosphate (mg/dL)	5.34 $\pm$ 1.25	5.35 $\pm$ 1.12	t = -0.10	0.919
HbA1c, diabetics only (%)	7.58 $\pm$ 1.35 (n=45)	7.58 $\pm$ 1.19 (n=56)	t = 0.00	0.998

WBC, white blood cell count; BUN, blood urea nitrogen; eGFR, estimated glomerular filtration rate. Preoperative Doppler vascular mapping was performed in a similar proportion of patients in both groups (91.8% vs. 95.1%, $p = 0.438$), and rates of vessel wall calcification did not differ significantly (37.7% vs. 32.8%, $p = 0.503$). However, patients in the post-dialysis group had a significantly larger mean vein diameter (2.60 $\pm$ 0.53 mm vs. 2.45 $\pm$ 0.50 mm, $p = 0.017$) and a significantly less favourable distribution of vessel

quality, with a higher proportion of moderate/poor-quality vessels ($p < 0.001$, Table 3). Artery diameter (2.53 $\pm$ 0.40 mm vs. 2.44 $\pm$ 0.43 mm, $p = 0.073$) and operative duration (58.8 $\pm$ 14.4 vs. 55.3 $\pm$ 15.5 minutes, $p = 0.070$) were numerically higher in the pre-dialysis group but did not reach statistical significance. Distribution of AVF type and operative side were similar between groups (all $p > 0.05$). All procedures in both groups were performed under

local anesthesia via end-to-side anastomosis by a single surgeon.

Table 3. Preoperative vascular assessment and intraoperative variables

Variable	Pre-dialysis AVF (n=122)	Post-dialysis AVF (n=122)	Test	p-value
Preoperative Doppler mapping performed, n (%)	112 (91.8)	116 (95.1)	$\chi^2 = 0.60$	0.438
Artery diameter (mm), mean $\pm$ SD	2.53 $\pm$ 0.40	2.44 $\pm$ 0.43	t = 1.80	0.073
Vein diameter (mm), mean $\pm$ SD	2.45 $\pm$ 0.50	2.60 $\pm$ 0.53	t = -2.39	0.017*
Vessel calcification, n (%)	46 (37.7)	40 (32.8)	$\chi^2 = 0.61$	0.435
Vessel quality: Good / Moderate / Poor, n	62 / 52 / 8	42 / 53 / 27	$\chi^2 = 20.1$	<0.001*
Operative side: Right / Left, n	80 / 42	77 / 45	$\chi^2 = 0.07$	0.789
AVF type: RC / BC / BB, n	80 / 31 / 11	73 / 36 / 13	$\chi^2 = 0.86$	0.650
Operative duration (min), mean $\pm$ SD	58.8 $\pm$ 14.4	55.3 $\pm$ 15.5	t = 1.82	0.070
Immediate thrill present, n (%)	116/122 (95.1)	95/122 (77.9)	$\chi^2 = 14.4$	<0.001*
Intraoperative complication, n (%)	9 (7.4)	11 (9.0)	$\chi^2 = 0.05$	0.815

RC, radiocephalic; BC, brachiocephalic; BB, brachiobasilic.

Patency signs at 24 hours were less consistently present in the post-dialysis group, with a significantly lower rate of palpable thrill at 24 hours (77.9% vs. 91.0%, p = 0.008); bruit at 24 hours did not differ significantly (82.0% vs. 86.9%, p = 0.377). Early thrombosis (17.2% vs.

5.7%, p = 0.009) and steal syndrome (9.0% vs. 0.8%, p = 0.008) were significantly more common after post-dialysis AVF creation. Rates of hematoma, bleeding, surgical site infection, limb oedema, and reoperation were numerically higher in the post-dialysis group but did not reach statistical significance (Table 4).

Table 4. Early postoperative complications by timing of AVF creation

Complication	Pre-dialysis AVF (n=122)	Post-dialysis AVF (n=122)	Test	p-value
Thrill at 24 hours, n (%)	111 (91.0)	95 (77.9)	$\chi^2 = 7.03$	0.008*
Bruit at 24 hours, n (%)	106 (86.9)	100 (82.0)	$\chi^2 = 0.78$	0.377
Hematoma, n (%)	18 (14.8)	10 (8.2)	$\chi^2 = 1.97$	0.160
Bleeding, n (%)	9 (7.4)	6 (4.9)	$\chi^2 = 0.28$	0.594
Surgical site infection, n (%)	3 (2.5)	10 (8.2)	$\chi^2 = 2.93$	0.087
Early thrombosis, n (%)	7 (5.7)	21 (17.2)	$\chi^2 = 6.83$	0.009*
Limb oedema, n (%)	14 (11.5)	15 (12.3)	$\chi^2 = 0.00$	1.000
Steal syndrome, n (%)	1 (0.8)	11 (9.0)	$\chi^2 = 7.06$	0.008*
Reoperation, n (%)	4 (3.3)	12 (9.8)	$\chi^2 = 3.28$	0.070

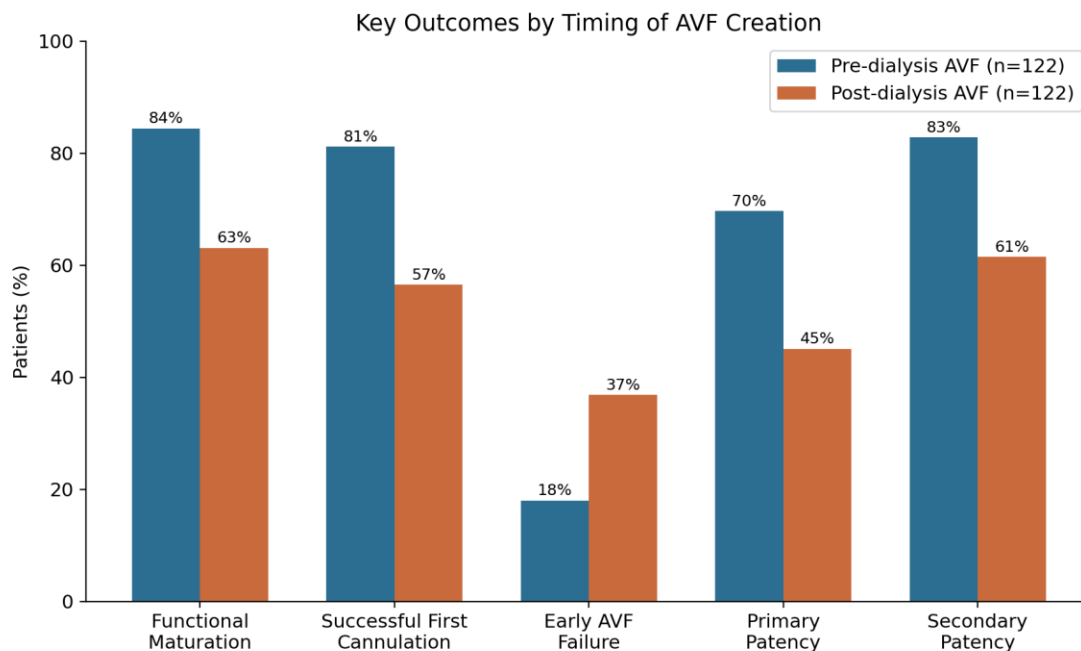


Figure 1. Comparison of key clinical outcomes between patients undergoing pre-dialysis versus post-dialysis AVF creation

Functional maturation was achieved significantly less often in the post-dialysis group (63.1% vs. 84.4%, $p < 0.001$), as was successful first cannulation (56.6% vs. 81.1%, $p < 0.001$) and achievement of adequate dialysis dose through the AVF (73.8% vs. 88.5%, $p = 0.005$). Among fistulas that did mature, time to functional maturation was significantly longer in the post-dialysis group (8.63 ± 1.91 vs. 6.70 ± 1.33 weeks, $p < 0.001$), and time to first successful cannulation was similarly prolonged (63.2 ± 17.0 vs. 48.7 ± 11.7 days, $p < 0.001$; Figure 2).

As expected given the study design, central venous catheter uses and catheter dependence

differed markedly by definition of the groups: patients in the post-dialysis group relied on a catheter for dialysis access both before AVF creation and while awaiting fistula maturation, whereas most pre-dialysis patients avoided catheter use altogether. Duration of catheter dependence after AVF creation was substantially longer in the post-dialysis group (median 42.0 [IQR 21.0–60.8] days vs. 0.0 [0.0–0.0] days, $p < 0.001$; Figure 3), and post-AVF reintervention was required more frequently (30.3% vs. 15.6%, $p = 0.010$).

Variable	Pre-dialysis AVF (n=122)	Post-dialysis AVF (n=122)	Test	p-value
Functional maturation, n (%)	103 (84.4)	77 (63.1)	$\chi^2 = 13.3$	$<0.001^*$
Time to functional maturation (weeks)	6.70 ± 1.33 (n=103)	8.63 ± 1.91 (n=77)	$t = -8.34$	$<0.001^*$
Successful first cannulation, n (%)	99 (81.1)	69 (56.6)	$\chi^2 = 16.2$	$<0.001^*$
Time to first cannulation (days)	48.7 ± 11.7 (n=99)	63.2 ± 17.0 (n=69)	$t = -6.42$	$<0.001^*$

Dialysis adequacy achieved, n (%)	108 (88.5)	90 (73.8)	$\chi^2 = 7.75$	0.005*
Catheter-dependent after AVF, n (%)	27 (22.1)	96 (78.7)	$\chi^2 = 78.4$	<0.001*
Duration of catheter dependence (days), median (IQR)	0.0 (0.0–0.0)	42.0 (21.0–60.8)	U	<0.001*
Reintervention required, n (%)	19 (15.6)	37 (30.3)	$\chi^2 = 6.72$	0.010*

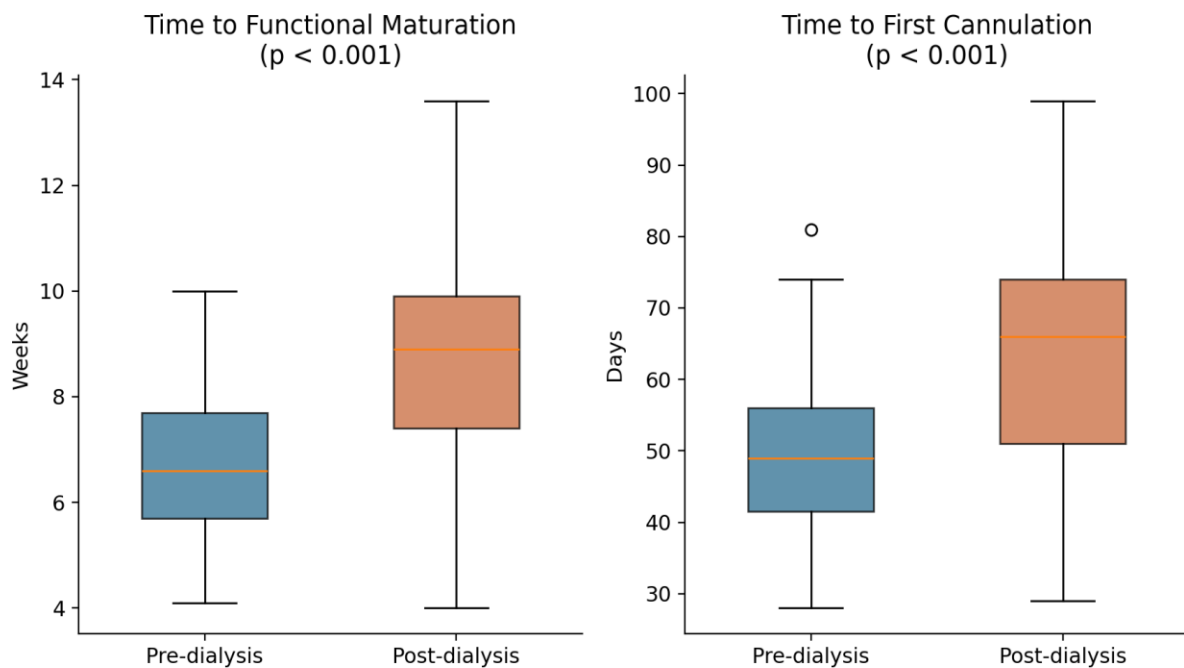


Figure 2. Time to functional maturation and time to first successful cannulation, by study group

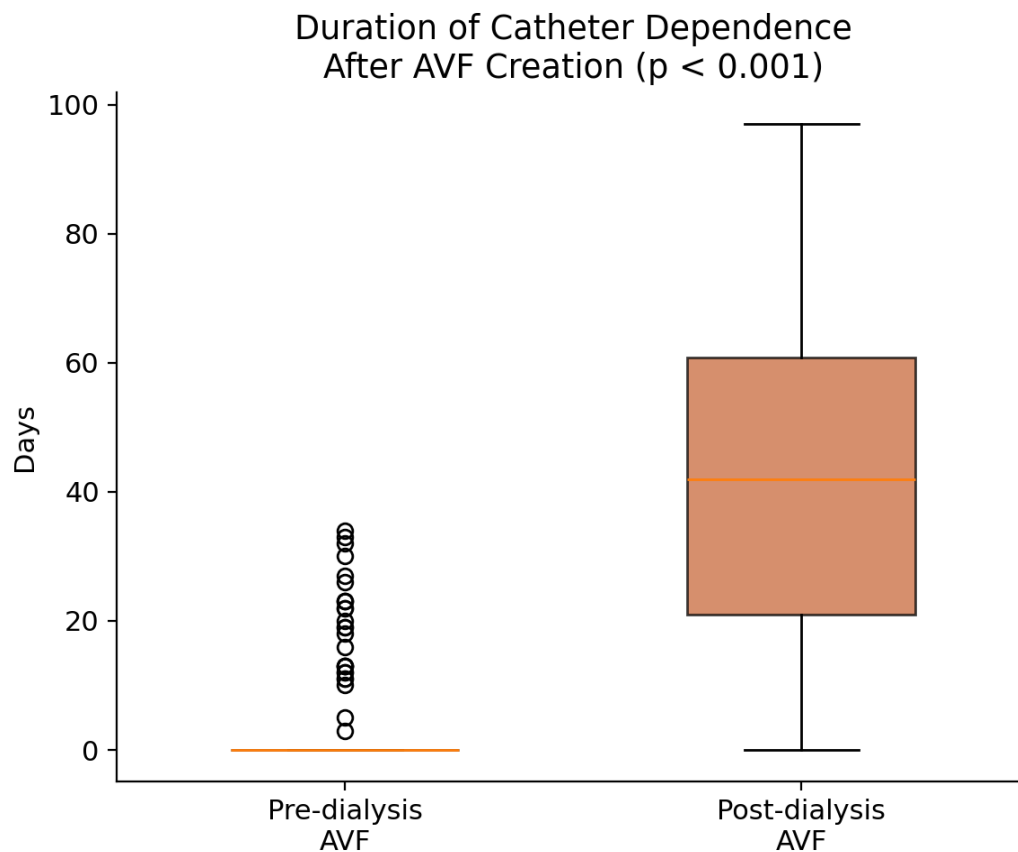


Figure 3. Duration of catheter dependence after AVF creation, by study group

The primary outcome, early AVF failure within 6–12 weeks of creation, occurred significantly more often in patients whose fistula was created after HD initiation: 45 of 122 patients (36.9%) in the post-dialysis group versus 22 of 122 patients (18.0%) in the pre-dialysis group ($\chi^2 = 10.19$, $p = 0.001$). This corresponded to an unadjusted odds ratio of 2.66 (95% CI 1.47–4.79) for early failure with post-dialysis AVF creation relative to pre-dialysis creation.

On multivariable logistic regression adjusting for age, sex, diabetes mellitus, preoperative artery diameter, vein diameter, and vessel quality, post-dialysis timing of AVF creation remained an independent predictor of early AVF failure, with an adjusted odds ratio of 3.24 (95% CI 1.71–6.15, $p < 0.001$). None of the other covariates included in the model (age, sex, diabetes, artery diameter, vein diameter, or poor vessel quality) was independently associated with early failure (all $p > 0.10$, Table 6).

Table 6. Multivariable logistic regression for independent predictors of early AVF failure

Predictor	Adjusted OR	95% CI	p-value
Post-dialysis AVF creation (vs. pre-dialysis)	3.24	1.71–6.15	<0.001*
Age (per year)	1.01	0.98–1.03	0.613
Diabetes mellitus (yes vs. no)	0.71	0.39–1.31	0.275

Male sex (vs. female)	0.80	0.43-1.47	0.465
Artery diameter (per mm)	1.71	0.84-3.46	0.138
Vein diameter (per mm)	0.62	0.35-1.12	0.113
Poor vessel quality (vs. good/moderate)	1.08	0.48-2.44	0.852

Model: Early AVF failure $\sim$ timing group + age + sex + diabetes + artery diameter + vein diameter + vessel quality (n=244). OR, odds ratio; CI, confidence interval. Pseudo- $R^2 = 0.062$; likelihood-ratio $p = 0.013$.

30-day mortality (4.1% vs. 0%, $p = 0.060$) did not differ significantly between groups, although all five deaths in the cohort occurred in the post-dialysis group.

Over a comparable follow-up period (14.3 ± 5.2 vs. 14.4 ± 5.3 months, $p = 0.828$), fistulas created before dialysis initiation were significantly more likely to remain functional at last follow-up (77.0% vs. 56.6%, $p = 0.001$), and both primary patency (69.7% vs. 45.1%, $p < 0.001$) and secondary patency (82.8% vs. 61.5%, $p < 0.001$) were significantly higher in the pre-dialysis group (Table 7, Figure 1).

Table 7. Long-term clinical outcomes by timing of AVF creation

Variable	Pre-dialysis AVF (n=122)	Post-dialysis AVF (n=122)	Test	p-value
30-day mortality, n (%)	0 (0.0)	5 (4.1)	Fisher	0.060
Follow-up duration (months), mean $\pm$ SD	14.4 ± 5.3	14.3 ± 5.2	$t = 0.22$	0.828
AVF functional at last follow-up, n (%)	94 (77.0)	69 (56.6)	$\chi^2 = 10.7$	0.001*
Primary patency, n (%)	85 (69.7)	55 (45.1)	$\chi^2 = 14.3$	<0.001*
Secondary patency, n (%)	101 (82.8)	75 (61.5)	$\chi^2 = 13.3$	<0.001*

In summary, the two study groups were well balanced with respect to baseline demographic, comorbid, and laboratory profiles, confirming that the observed differences in outcome are unlikely to be explained by baseline confounding. Creation of the AVF after initiation of hemodialysis was associated with significantly worse vascular access outcomes across nearly every measured domain: lower rates of early patency signs, more frequent early thrombosis and steal syndrome, delayed and less frequent functional maturation, longer catheter dependence, more reinterventions, and lower primary and secondary patency at follow-up. Post-dialysis AVF creation was an independent predictor of early AVF failure after adjustment for relevant clinical and vascular covariates

(adjusted OR 3.24, 95% CI 1.71-6.15, $p < 0.001$).

DISCUSSION

In this prospective cohort of 244 consecutive patients undergoing native AVF creation at a tertiary cardiovascular surgery department in Sialkot, Pakistan, fistulas created before the initiation of hemodialysis demonstrated significantly better outcomes across nearly every measured domain faster maturation, fewer early complications, shorter catheter dependence, fewer reinterventions, and higher primary and secondary patency than fistulas created after dialysis had already begun. Post-dialysis timing remained an independent predictor of early AVF failure (adjusted OR 3.24, 95% CI 1.71-6.15) even after adjustment for age, sex, diabetes, and

vascular anatomy, indicating that the observed disadvantage is not simply explained by differences in baseline comorbidity or vessel calibre.

Our finding that pre-dialysis AVF creation was associated with a markedly lower rate of early failure and higher long-term patency is broadly consistent with, and in some respects stronger than, the findings of Jeong et al., whose Korean cohort of 524 incident hemodialysis patients found that primary and secondary patency did not differ significantly between AVFs created before versus from an existing catheter, although overall survival was superior in the pre-dialysis group [5]. The discordance between our patency findings and theirs may reflect differences in population case-mix, definitions of early failure, and the fact that our post-dialysis group had a numerically greater burden of poor-quality vessels and larger, likely venous-hypertension-dilated, vein diameters at the time of surgery a pattern that is itself a marker of longer antecedent catheter dependence rather than a truly favourable vessel for fistula formation. Our results are, however, closely aligned with the international DOPPS analysis by Pisoni et al., which demonstrated that AVFs created pre-dialysis achieved catheter independence considerably faster than those created after dialysis initiation across multiple countries, reinforcing that the advantage of pre-emptive AVF creation in reducing catheter burden is a consistent, generalisable finding rather than a feature unique to any single health system [4].

The magnitude of early AVF failure observed in our post-dialysis group (36.9%) is considerably higher than pooled estimates from recent systematic reviews and large single-centre series, which report primary/early failure rates in the range of 6.5% to 20–60% depending on definition and population [8,9]. The 2025 systematic review and meta-analysis by Salih et al., synthesising data from 38 studies, identified distal fistula location, small arterial and venous diameter, low serum albumin, female sex, diabetes, and lower blood pressure as consistent predictors of early failure [9]. Notably, in our adjusted model neither vessel diameter nor

diabetes reached independent significance once timing of AVF creation was accounted for, suggesting that in our population the clinical milieu associated with post-dialysis creation including a more inflamed, uremic, and hemodynamically altered state at the time of surgery may exert an effect on fistula outcome that supersedes, or at least compounds, the purely anatomical risk factors emphasised in prior literature.

The higher rate of early thrombosis and steal syndrome observed in our post-dialysis group mirrors findings from Yap et al., who demonstrated in a Taiwanese cohort that early AVF dysfunction was independently associated with a 54% increase in overall mortality risk [17], and is consistent with the Hunan cohort study by Zhang et al., which identified sex, weight, and hyperphosphatemia as independent predictors of AVF dysfunction in a comparable East Asian hemodialysis population [16]. While our study was not powered to detect a difference in 30-day mortality, the observation that all five deaths in our cohort occurred exclusively in the post-dialysis group is directionally consistent with this body of evidence linking early access failure to excess mortality, and merits confirmation in larger, adequately powered local series.

Preoperative Doppler vascular mapping was performed in over 90% of patients in both groups in our cohort, in keeping with KDOQI recommendations [3]. Interestingly, patients in the post-dialysis group had a significantly larger mean vein diameter than the pre-dialysis group, yet still experienced worse maturation and patency outcomes. This illustrates a recurring theme in the vascular access literature: adequate vein diameter is generally necessary for successful maturation but is not sufficient on its own. El Khoury et al. similarly found that maximum target vein diameter on preoperative mapping did not independently predict maturation on multivariate analysis once other clinical factors were considered [10], while Doppler-based studies by Polavarapu et al. and Suraj et al. both demonstrated that a combination of preoperative vessel diameter and postoperative flow parameters, rather than diameter alone, best

predicts successful maturation and early complication risk [11,12]. Newly developed preoperative risk-scoring tools, such as the parsimonious risk score derived by Meng et al. from a Singaporean cohort and the nomogram developed by Zhao et al. in a Chinese cohort, incorporate demographic, comorbidity, and vessel data together and may offer a more clinically useful preoperative prediction of maturation than vessel calibre in isolation, an approach that could usefully be adapted and validated in Pakistani surgical practice [13,14].

The single most striking difference between our two groups was the duration of catheter dependence: patients in the post-dialysis group remained catheter-dependent for a median of 42 days after AVF creation, compared with essentially no catheter dependence in the pre-dialysis group. This finding has direct clinical relevance because central venous catheters are consistently the vascular access type most strongly associated with bloodstream infection, hospitalisation, and mortality in the hemodialysis population [15]. Farrington and Allon emphasise that catheter-related bloodstream infection remains one of the most serious and costly complications of prolonged catheter dependence, underscoring why minimising the time a patient spends catheter-dependent – achievable primarily through earlier, pre-emptive AVF creation – should be viewed as a key quality target for any vascular access programme [15]. Consistent with this, Gan et al. demonstrated in a large Chinese cohort that earlier conversion from CVC to AVF was independently associated with reduced hospitalisation and mortality in incident hemodialysis patients [19], reinforcing that the benefit of pre-dialysis AVF creation observed in our cohort is unlikely to be a statistical artefact of a single-centre series but reflects a broadly reproducible clinical phenomenon.

The principal reason patients in our post-dialysis group did not have a fistula ready before starting dialysis is, in most cases, late presentation or late nephrology referral a well-documented problem in South Asian healthcare systems. Cheng et al.'s updated systematic review and meta-analysis of over 630,000 patients found that early

nephrology referral was associated with a 33% relative reduction in all-cause mortality, an effect apparent within the first six months of dialysis and persisting for at least five years [6], while the northern Indian cohort study by Dhanorkar et al. similarly found that late-referred patients were far more likely to begin dialysis via a no tunnelled catheter and to have substantially higher mortality [7]. Given that Pakistan shares many of the same structural barriers to early CKD detection and nephrology referral as India including low community awareness, limited primary-care screening, and geographically concentrated specialist services [2] our finding that a considerable proportion of the 700 consecutively screened patients in this series required post-dialysis AVF creation reflects a systems-level referral gap as much as a surgical one, and argues for strengthening structured CKD referral pathways to cardiovascular/vascular access services well before stage V CKD is reached.

Comparable local data remain scarce, but the direction of our findings is consistent with the broader South Asian experience. Programmes that have systematically evaluated the relationship between preoperative optimisation, timely referral, and pharmacological adjuncts (for example, the ongoing Pakistani randomized controlled trial evaluating angiotensin-converting enzyme inhibitors for AVF patency being conducted at the Armed Forces Post Graduate Medical Institute, Rawalpindi) reflect a growing recognition within Pakistan's cardiovascular and nephrology community that vascular access outcomes can be meaningfully improved through structured, protocol-driven care rather than surgical technique alone [8]. Taken together with our findings, this supports a shift in local practice towards earlier vascular access planning as a defined component of pre-ESKD care, mirroring the ESKD Life-Plan approach recommended internationally [3].

This study benefits from a relatively large, consecutively enrolled surgical cohort with prospectively collected, comprehensive perioperative and follow-up data spanning ten clinically relevant domains, and from a rigorous

statistical approach incorporating both univariate comparisons and multivariable adjustment for the primary outcome. However, several limitations should be acknowledged. First, this is a non-randomized, single-centre observational study, and although the two groups were well balanced for most baseline characteristics, the timing of AVF creation was not randomly assigned; residual confounding by indication cannot be fully excluded, since patients requiring urgent post-dialysis AVF creation may differ from pre-dialysis patients in unmeasured ways (for example, acuity of presentation or degree of uremic inflammation) that were not captured in our proforma. Second, follow-up was limited to a mean of approximately 14 months, precluding assessment of very long-term (beyond two years) patency outcomes. Third, as a single tertiary-care referral centre in Sialkot, our findings may not be fully generalisable to primary or secondary care settings elsewhere in Pakistan. Finally, cost, quality-of-life, and patient-reported outcome data were not collected, limiting our ability to comment on the broader health-economic implications of delayed AVF creation in this population.

CONCLUSION

In this large, consecutive single-centre Pakistani cohort, native arteriovenous fistulas created before the initiation of hemodialysis demonstrated markedly better maturation, fewer early postoperative complications, dramatically shorter catheter dependence, fewer reinterventions, and significantly higher primary and secondary patency than fistulas created after dialysis had already begun, and post-dialysis timing remained an independent predictor of early AVF failure after multivariable adjustment. These findings support international guideline recommendations favouring pre-emptive, planned vascular access creation and reinforce the clinical importance of early nephrology referral and structured pre-ESKD care pathways, particularly in resource-limited settings such as Pakistan where late presentation remains common. Strengthening early CKD detection, timely nephrology referral, and coordinated

vascular-access planning should be prioritised as achievable, systems-level interventions to improve hemodialysis vascular access outcomes in this population.

DECLARATIONS

Ethical Approval: This study was approved by the Institutional Review Board (IRB) of Imran Idrees Teaching Hospital, Sialkot, Pakistan (Ref. No.: IITH/IRB/2025/02/147), and was conducted in accordance with the ethical standards of the Declaration of Helsinki.

Consent to Participate: Written informed consent was obtained from all participants (or their legal attendants) prior to enrolment.

Consent for Publication: Not applicable, no identifying patient information, images, or individual-level data are presented in this manuscript.

Conflict of Interest: The authors declare no conflict of interest.

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Data Availability Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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