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REDUCING CATHETER DEPENDENCE THROUGH A MULTIDISCIPLINARY VASCULAR ACCESS PATHWAY: A QUALITY IMPROVEMENT INITIATIVE FROM A HIGH-VOLUME CENTER IN PAKISTAN

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Abstract

Background: *Central venous catheter (CVC) dependence remains common at haemodialysis initiation in Pakistan despite arteriovenous fistula (AVF) being the guideline-preferred vascular access. We evaluated a multidisciplinary vascular access pathway designed to reduce catheter dependence at a high-volume cardiovascular surgery centre.*

Methods: *This prospective, single-centre, before-and-after quality improvement study included 464 consecutive patients undergoing AVF creation at the Department of Cardiovascular Surgery, Imran Idrees Teaching Hospital, Sialkot, Pakistan, between 20 February and 30 November 2025. A structured pathway comprising a dedicated coordinator, nephrology and vascular surgery assessment, patient education and counselling, mandatory pre-operative Doppler mapping, and weekly multidisciplinary team discussion was implemented mid-study, dividing the cohort into pre-intervention (n=232) and post-intervention (n=232) phases.*

Results: *Baseline characteristics were comparable between phases. Referral-to-clinic interval fell from 21.0 to 8.0 days and referral-to-surgery interval from 44.0 to 18.0 days (both p<0.001). Pre-operative Doppler mapping rose from 60.8% to 94.8%. CVC use fell from 74.6% to 43.1%, and catheter-free dialysis achievement nearly doubled, from 27.6% to 53.4% (p<0.001). AVF maturation, cannulation success, and early failure rates were unchanged, while hospital readmission fell from 28.0% to 19.0% (p=0.029).*

Conclusion: *A structured multidisciplinary vascular access pathway substantially reduced catheter dependence and accelerated referral and surgical timelines without compromising AVF outcomes, supporting its feasibility in resource-limited settings.*

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INTRODUCTION

Chronic kidney disease (CKD) has emerged as one of the fastest-growing non-communicable diseases worldwide. The 2023 Global Burden of Disease study estimated that 788 million adults now live with CKD, a burden that continues to rise disproportionately in low- and middle-income countries [2]. Pakistan carries a substantial share of this burden: community-based surveys report CKD prevalence ranging from 12% to as high as 30% among adults, with diabetic and hypertensive nephropathy as the leading causes, and recent hospital-based studies from Peshawar and Lahore confirm that both urban and rural populations are heavily affected [5,6]. Beyond the disease burden itself, patients frequently face substantial out-of-pocket costs despite partially subsidised dialysis care [3], and comorbidities such as anaemia remain prevalent and often sub-optimally managed even within the same region as the present study [4].

As increasing numbers of patients progress to end-stage kidney disease, timely creation of a functioning arteriovenous fistula (AVF) becomes central to a safe transition onto haemodialysis. International guidelines, most notably the 2019 KDOQI Clinical Practice Guideline for Vascular Access, continue to endorse the native AVF as the preferred access because of its superior patency and markedly lower infection risk compared with central venous catheters (CVCs) [1]. Despite this consensus, catheter-dependent dialysis initiation remains the norm rather than the exception in many health systems, including Pakistan's. CVC use exposes patients to catheter-related bloodstream infection (CRBSI), a complication associated with substantially elevated mortality, prolonged hospitalisation and disproportionate resource consumption, as recent multinational cohorts have consistently demonstrated [23,24,25,26].

A major driver of prolonged catheter dependence is late or fragmented referral. Systematic reviews and large cohort studies consistently show that patients referred late to nephrology and vascular surgery are far more likely to begin dialysis through an emergency catheter rather than a mature fistula, with markedly worse survival and access outcomes [7,8,9]. Local Pakistani audits reinforce this picture, reporting persistently high catheter dependence and delayed, uncoordinated access planning at the time of dialysis initiation [11,14]. A structured multidisciplinary vascular access pathway - integrating early nephrology and vascular surgery assessment, dedicated coordinator-led follow-up, systematic pre-operative Doppler vascular mapping, structured patient education and multidisciplinary team (MDT) discussion - has been proposed internationally as an effective strategy to reduce catheter dependence and accelerate access to a functioning AVF [10,27]. However, evidence describing the implementation and impact of such structured pathways from high-volume centres in Pakistan remains scarce, with most local studies limited to retrospective, single-domain audits [11,12,13].

This quality improvement (QI) initiative was therefore designed to implement and evaluate a multidisciplinary vascular access pathway at a high-volume Department of Cardiovascular Surgery in Pakistan, with the primary aim of assessing its impact on reducing central venous catheter dependence and increasing catheter-free dialysis initiation, alongside secondary referral, procedural and access-outcome indicators.

METHODOLOGY

Study Design and Setting

This was a prospective, single-centre, before-and-after quality improvement study conducted in the Department of Cardiovascular Surgery, Imran Idrees Teaching Hospital, Sialkot, Pakistan, a high-volume referral centre for vascular access surgery serving patients with chronic kidney disease from the surrounding districts of central Punjab.

Study Period and Population

All patients undergoing creation of a native AVF for haemodialysis access between 20 February 2025 and 30 November 2025 were enrolled consecutively. A total of 464 consecutive patients met inclusion criteria and were analysed: adults with chronic kidney disease referred for surgical creation of a native AVF for haemodialysis access. Patients with incomplete records or those

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undergoing arteriovenous graft rather than native fistula creation were excluded.

Intervention

A baseline audit at the start of the study period demonstrated high rates of catheter-dependent dialysis initiation, delayed referral and fragmented pre-operative work-up. In response, a structured multidisciplinary vascular access pathway was designed and implemented at the mid-point of the study period, dividing the cohort into a pre-intervention phase (n = 232) and a post-intervention phase (n = 232) of equal, consecutively enrolled size. The pathway comprised seven core components, modelled on the Plan-Do-Study-Act (PDSA) approach to quality improvement [28,29]: (i) a dedicated vascular access coordinator responsible for tracking referrals and scheduling; (ii) formal nephrology assessment; (iii) formal vascular surgery assessment; (iv) dialysis-nurse-led patient education; (v) structured pre-operative patient counselling; (vi) mandatory pre-operative Doppler vascular mapping; and (vii) weekly multidisciplinary team (MDT) discussion of the vascular access plan for each referred patient, followed by coordinator-led post-operative follow-up.

Data Collection

Demographic, clinical, referral, procedural and outcome data were prospectively recorded on a structured proforma by the vascular access coordinator and cross-verified against hospital records, operative notes and dialysis unit registers. Variables captured included baseline demographic and comorbidity profile; referral source and referral-to-clinic interval; completion of each of the seven pathway components; referral-to-surgery interval; operative characteristics; catheter use, site, dwell time and catheter-related complications; AVF maturation, cannulation and complication outcomes; and pre-specified quality improvement indicators, including the primary outcome of catheter-free dialysis achievement.

Statistical Analysis

Continuous variables were assessed for distributional normality and are presented as mean ± standard deviation or median (interquartile range, IQR) as appropriate, and compared using the independent-samples t-test or Mann-Whitney U test, respectively. Categorical variables are presented as frequency (percentage) and were compared using the chi-square test, or Fisher's exact test where an expected cell count was less than 5. A two-sided p-value < 0.05 was considered statistically significant. Analyses were performed using SPSS (version 26.0; IBM Corp., Armonk, NY, USA). A run chart of monthly catheter-free dialysis achievement was constructed to assess for a sustained shift in the process mean coinciding with pathway launch, consistent with standard quality-improvement methodology [28,29].

Ethical Considerations

The study was approved by the institutional ethics review committee of Imran Idrees Teaching Hospital, Sialkot, and was conducted in accordance with the Declaration of Helsinki. Given its quality improvement nature and its use of routinely collected clinical data, a waiver of individual informed consent was granted; all patient data were anonymised prior to analysis.

RESULTS

A total of 464 patients who underwent creation of an AVF at the vascular access service between 20 February 2025 and 30 November 2025 were included in this before-and-after quality improvement analysis: 232 patients (50.0%) were enrolled during the pre-intervention phase, prior to implementation of the multidisciplinary vascular access pathway, and 232 patients (50.0%) were enrolled during the post-intervention phase, following its launch. All continuous variables were assessed for distributional normality; approximately normally distributed variables are presented as mean ± standard deviation and compared using the independent-samples t-test, while skewed variables are presented as median (interquartile range, IQR) and compared using the Mann-Whitney U test. Categorical variables are presented as frequency (percentage) and were

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compared using the chi-square test, or Fisher's exact test where an expected cell count was less than 5. A two-sided p-value < 0.05 was considered statistically significant.

Baseline Demographic and Clinical Characteristics

The two study phases were well matched at baseline (Tables 1 and 2). Mean age was 52.2 ± 12.9 years in the pre-intervention group and 53.1 ± 13.5 years in the post-intervention group (p = 0.479), and the sex distribution was almost identical (60.8% vs 59.9% male, p = 0.924). Anthropometric measures (height, weight, BMI) and place of residence did not differ significantly between phases (all p > 0.05). Diabetes mellitus was the leading cause of CKD in both groups (34.1% pre vs 35.8% post), followed by hypertensive nephropathy, and the overall distribution of CKD aetiology, CKD stage, and comorbid burden (diabetes, hypertension, ischaemic heart disease, peripheral arterial disease, previous stroke) were comparable across phases (all p > 0.05), confirming that the two cohorts were clinically comparable and that any differences in outcome could reasonably be attributed to the pathway intervention rather than to case-mix variation. The only baseline difference observed was in the proportion of patients already established on haemodialysis at the time of referral, which was significantly lower in the post-intervention group (49.1% vs 71.6% pre-intervention, p < 0.001) itself an early signal of timelier referral after pathway implementation.

Table 1. Baseline demographic characteristics of patients undergoing AVF creation, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Age (years)		52.2 ± 12.9	53.1 ± 13.5	0.479
Height (cm)		163.0 ± 9.0	163.2 ± 9.3	0.828
Weight (kg)		65.2 ± 11.3	65.2 ± 12.8	0.966
BMI (kg/m²)		24.6 ± 4.3	24.6 ± 5.2	0.974
Gender	Male	141 (60.8)	139 (59.9)	0.924
	Female	91 (39.2)	93 (40.1)	
Residence	Urban	136 (58.6)	130 (56.0)	0.639
	Rural	96 (41.4)	102 (44.0)	

Data are mean ± SD or n (%). Continuous variables compared by independent t-test; categorical variables by chi-square test

Table 2. Baseline clinical characteristics, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Cause of CKD	Diabetes	79 (34.1)	83 (35.8)	0.885
	Hypertension	76 (32.8)	80 (34.5)	
	Glomerulonephritis	34 (14.7)	28 (12.1)	
	PKD	14 (6.0)	11 (4.7)	
	Other	29 (12.5)	30 (12.9)	
CKD Stage	Stage III	9 (3.9)	10 (4.3)	0.962
	Stage IV	35 (15.1)	36 (15.5)	
	Stage V	188 (81.0)	186 (80.2)	
Diabetes Mellitus	No	144 (62.1)	140 (60.3)	0.775
	Yes	88 (37.9)	92 (39.7)	
Hypertension	No	30 (12.9)	30 (12.9)	1.000

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	Yes	202 (87.1)	202 (87.1)	
Ischemic Heart Disease	No	184 (79.3)	185 (79.7)	1.000
	Yes	48 (20.7)	47 (20.3)	
Peripheral Arterial Disease	No	218 (94.0)	210 (90.5)	0.224
	Yes	14 (6.0)	22 (9.5)	
Previous Stroke	No	216 (93.1)	219 (94.4)	0.701
	Yes	16 (6.9)	13 (5.6)	
Duration of CKD (months)		26.7 ± 18.8	25.9 ± 17.4	0.623
On Hemodialysis at Referral	No	66 (28.4)	118 (50.9)	<0.001
	Yes	166 (71.6)	114 (49.1)	

Data are mean ± SD or n (%). CKD = chronic kidney disease. Duration of CKD compared by independent t-test; categorical variables by chi-square test

Referral Process and Multidisciplinary Pathway Implementation

Implementation of the multidisciplinary pathway was associated with marked acceleration of the referral process (Table 3, Figure 1). The median referral-to-clinic interval fell from 21.0 days (IQR 13.8–27.0) pre-intervention to 8.0 days (IQR 5.0–11.0) post-intervention ($p < 0.001$), and the proportion of patients referred beyond the 30-day guideline threshold fell from 16.8% to 0% ($p < 0.001$). Pre-referral Doppler vascular mapping was performed more frequently post-intervention (94.8% vs 60.8%, $p < 0.001$), while the distribution of referral source did not differ significantly between phases ($p = 0.924$).

Table 3. Referral process indicators, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Referral Source	Nephrologist	128 (55.2)	122 (52.6)	0.924
	Dialysis Unit	68 (29.3)	69 (29.7)	
	Medicine OPD	22 (9.5)	25 (10.8)	
	Emergency	14 (6.0)	16 (6.9)	
	Referral-to-Clinic Interval (days)	21.0 (13.8–27.0)	8.0 (5.0–11.0)	<0.001
Doppler Performed	No	91 (39.2)	12 (5.2)	<0.001
	Yes	141 (60.8)	220 (94.8)	
Referral Delay (>30 days)	No	193 (83.2)	232 (100.0)	<0.001
	Yes	39 (16.8)	0 (0.0)	

Data are median (IQR) or n (%). Referral-to-clinic interval compared by Mann-Whitney U test; categorical variables by chi-square or Fisher's exact test

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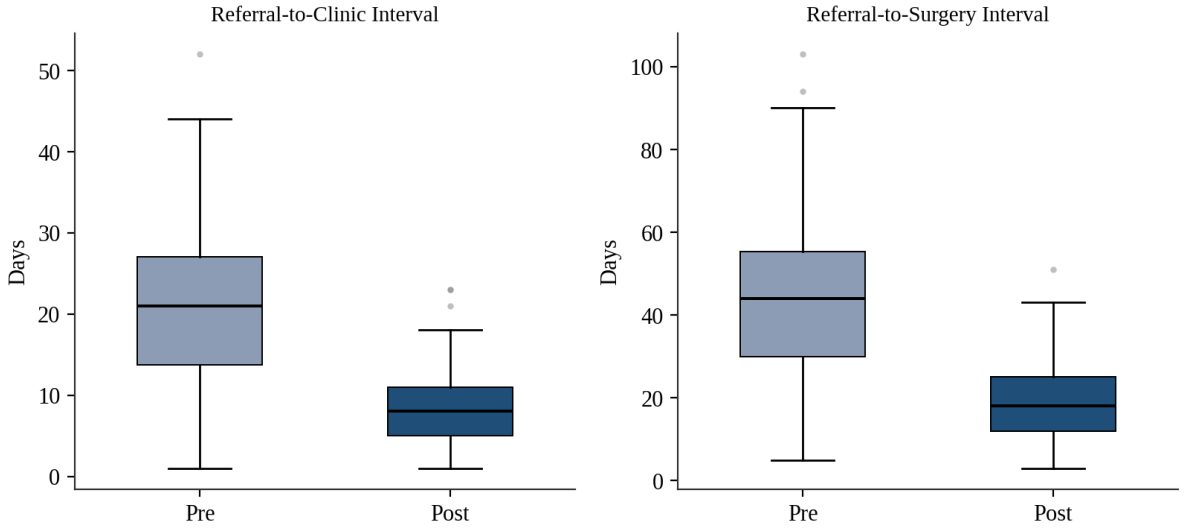


Figure 1. Referral-to-clinic and referral-to-surgery intervals (days), pre- versus post-intervention (both p < 0.001, Mann-Whitney U test). Boxes show median and IQR; whiskers show the range within 1.5×IQR; dots denote outliers

Completion of every individual component of the multidisciplinary pathway increased substantially after implementation (Table 4, Figure 2). The largest absolute gains were seen in coordinator follow-up (15.1% to 87.1%), MDT discussion of the vascular access plan (18.5% to 85.3%), and dedicated patient counselling (48.7% to 94.4%), while nephrology and vascular surgery assessments, which were already reasonably well-established pre-intervention, rose to near-universal completion (98.7% and 99.1%, respectively) post-intervention. All seven pathway components differed significantly between phases (all p < 0.001), confirming high fidelity of pathway implementation.

Table 4. Completion of multidisciplinary pathway components, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Nephrology Assessment Completed	No	57 (24.6)	3 (1.3)	<0.001
	Yes	175 (75.4)	229 (98.7)	
Vascular Surgery Assessment	No	51 (22.0)	2 (0.9)	<0.001
	Yes	181 (78.0)	230 (99.1)	
Dialysis Nurse Education	No	134 (57.8)	13 (5.6)	<0.001
	Yes	98 (42.2)	219 (94.4)	
Patient Counselling	No	119 (51.3)	13 (5.6)	<0.001
	Yes	113 (48.7)	219 (94.4)	
Preoperative Doppler Mapping	No	107 (46.1)	14 (6.0)	<0.001
	Yes	125 (53.9)	218 (94.0)	
MDT Discussion	No	189 (81.5)	34 (14.7)	<0.001
	Yes	43 (18.5)	198 (85.3)	
Coordinator Follow-up	No	197 (84.9)	30 (12.9)	<0.001

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	Yes	35 (15.1)	202 (87.1)	

Data are n (%). All variables compared by chi-square or Fisher's exact test

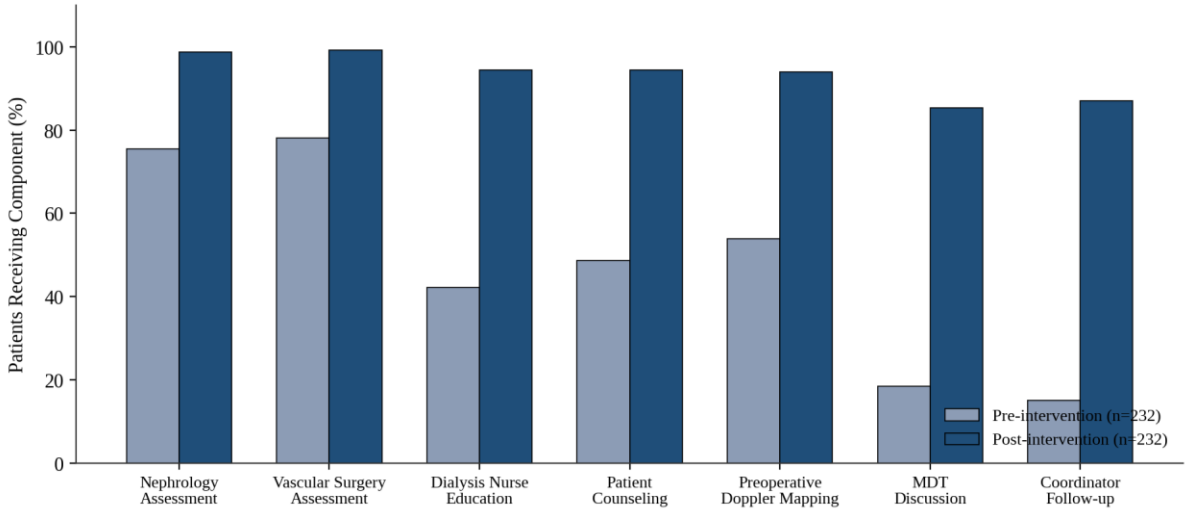


Figure 2. Completion rates of individual multidisciplinary pathway components, pre- versus post-intervention

Operative Characteristics

Following implementation of the pathway, the median referral-to-surgery interval was reduced by more than half, from 44.0 days (IQR 30.0–55.2) pre-intervention to 18.0 days (IQR 12.0–25.0) post-intervention ($p < 0.001$) (Table 5, Figure 1). The distribution of AVF configuration (radiocephalic, brachiocephalic, brachiobasilic), operative side, rate of immediate palpable thrill, operative duration, and intraoperative complications were all statistically similar between phases (all $p > 0.05$), indicating that the observed improvements in access timing were not achieved at the expense of operative case complexity or quality.

Table 5. Operative characteristics, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Referral-to-Surgery Interval (days)		44.0 (30.0–55.2)	18.0 (12.0–25.0)	<0.001
AVF Type	Radiocephalic	127 (54.7)	114 (49.1)	0.481
	Brachiocephalic	86 (37.1)	97 (41.8)	
	Brachiobasilic	19 (8.2)	21 (9.1)	
Operative Side	Right	5 (2.2)	8 (3.4)	0.574
	Left	227 (97.8)	224 (96.6)	
Immediate Thrill Present	No	23 (9.9)	26 (11.2)	0.763
	Yes	209 (90.1)	206 (88.8)	
	Operative Duration (minutes)	36.0 ± 14.8	34.8 ± 15.1	0.404
Intraoperative Complication	No	214 (92.2)	217 (93.5)	0.718
	Yes	18 (7.8)	15 (6.5)	

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Data are median (IQR), mean ± SD, or n (%), as appropriate. Referral-to-surgery interval compared by Mann-Whitney U test; operative duration by independent t-test; categorical variables by chi-square test

Primary Outcome: Catheter Dependence and Vascular Access Findings

The primary outcome of this study, reduction in central venous catheter dependence, improved significantly after implementation of the multidisciplinary pathway (Table 6, Figure 3). Overall CVC use for dialysis access fell from 74.6% of patients pre-intervention to 43.1% post-intervention ($p < 0.001$), and the proportion of patients who achieved catheter-free dialysis rose correspondingly from 27.6% to 53.4% ($p < 0.001$; see Table 8). Among patients who did require a CVC, median catheter dwell time fell from 39.0 days (IQR 0.0–58.0) to 0 days (IQR 0–21.2) ($p < 0.001$, reflecting the larger proportion of post-intervention patients avoiding catheter use altogether), and the number of catheter exchanges required was also lower post-intervention (median 0, IQR 0–1, versus median 0, IQR 0–0 post-intervention; $p = 0.028$). Catheter-related bloodstream infection (CRBSI) and catheter dysfunction rates did not differ significantly between phases ($p = 0.819$ and $p = 0.850$, respectively), suggesting that the reduction in catheter dependence was not accompanied by a change in catheter-related complication rates among catheters that were used.

Table 6. Catheter-related outcomes, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Central Venous Catheter Used	No	59 (25.4)	132 (56.9)	<0.001
	Yes	173 (74.6)	100 (43.1)	
Catheter Site	N/A (no CVC)	59 (25.4)	132 (56.9)	<0.001
	IJV	111 (47.8)	67 (28.9)	
	Subclavian	49 (21.1)	24 (10.3)	
	Femoral	13 (5.6)	9 (3.9)	
Duration of Catheter Use (days)		39.0 (0.0–58.0)	0.0 (0.0–21.2)	<0.001
Catheter-Related Bloodstream Infection	No	221 (95.3)	223 (96.1)	0.819
	Yes	11 (4.7)	9 (3.9)	
Number of Catheter Exchanges		0.0 (0.0–1.0)	0.0 (0.0–0.0)	0.028
Catheter Dysfunction	No	218 (94.0)	216 (93.1)	0.850
	Yes	14 (6.0)	16 (6.9)	

Data are median (IQR) or n (%). CVC = central venous catheter; IJV = internal jugular vein. Continuous variables compared by Mann-Whitney U test; categorical variables by chi-square test

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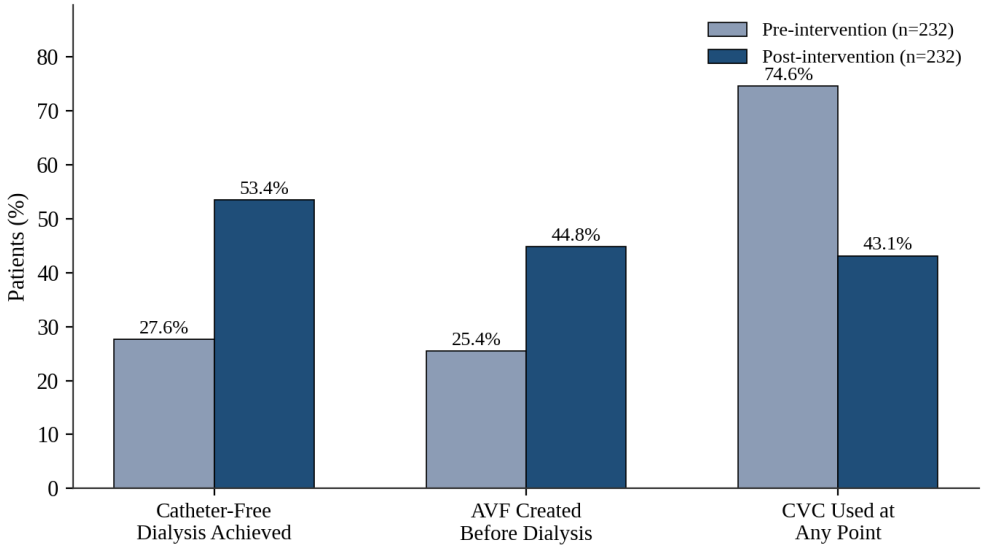


Figure 3. Primary vascular access outcomes, pre- versus post-intervention (all p < 0.001)

Arteriovenous Fistula Outcomes

AVF maturation and early functional outcomes were similar across the two phases (Table 7). Functional maturation was achieved in 84.9% of pre-intervention and 86.2% of post-intervention AVFs (p = 0.792), with a comparable median time to maturation (7.7 vs 7.8 weeks, p = 0.422). Successful first cannulation occurred in 81.0% versus 84.1% of patients (p = 0.463), and rates of early AVF failure (11.6% vs 12.9%), early thrombosis (10.8% vs 13.4%) and AVF-related infection (3.0% vs 4.7%) did not differ significantly between phases (all p > 0.05). Reintervention rates were identical between phases (13.4% vs 13.4%, p = 1.000). Hospital readmission, however, was significantly lower in the post-intervention group (19.0% vs 28.0% pre-intervention, p = 0.029), consistent with more coordinated post-operative follow-up under the multidisciplinary pathway.

Table 7. Arteriovenous fistula (AVF) outcomes, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Functional Maturation	No	35 (15.1)	32 (13.8)	0.792
	Yes	197 (84.9)	200 (86.2)	
Time to Maturation (weeks)		7.7 (6.5–8.8)	7.8 (6.4–9.2)	0.422
Successful First Cannulation	No	44 (19.0)	37 (15.9)	0.463
	Yes	188 (81.0)	195 (84.1)	
Time to First Cannulation (days)		66.0 ± 13.7	64.9 ± 12.1	0.371
Early AVF Failure	No	205 (88.4)	202 (87.1)	0.777
	Yes	27 (11.6)	30 (12.9)	
Early Thrombosis	No	207 (89.2)	201 (86.6)	0.476
	Yes	25 (10.8)	31 (13.4)	
Infection	No	225 (97.0)	221 (95.3)	0.471
	Yes	7 (3.0)	11 (4.7)	
Reintervention	No	201 (86.6)	201 (86.6)	1.000
	Yes	31 (13.4)	31 (13.4)	

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Hospital Readmission	No	167 (72.0)	188 (81.0)	0.029
	Yes	65 (28.0)	44 (19.0)	

Data are mean ± SD, median (IQR), or n (%), as appropriate. Time to first cannulation compared by independent t-test; time to maturation by Mann-Whitney U test; categorical variables by chi-square test

Quality Improvement Outcome Indicators

All pre-specified quality improvement process and outcome indicators showed statistically significant improvement after pathway implementation (Table 8, Figure 4). The proportion of patients referred within the guideline time frame rose from 28.9% to 88.8% ($p < 0.001$), surgery performed within the target time window rose from 25.9% to 90.5% ($p < 0.001$), and formal patient education was completed in 94.4% of post-intervention patients compared with 49.6% pre-intervention ($p < 0.001$). Good follow-up compliance increased from 49.1% to 88.8% ($p < 0.001$), while the median number of missed appointments fell from 2 (IQR 1–3) to 1 (IQR 0–1) ($p < 0.001$). AVF creation prior to dialysis initiation nearly doubled, from 25.4% to 44.8% of patients ($p < 0.001$), and the composite endpoint of catheter-free dialysis achievement rose from 27.6% to 53.4% ($p < 0.001$). The run chart of monthly catheter-free dialysis achievement (Figure 5) demonstrates a sustained shift in the process mean coinciding with pathway launch, with post-intervention monthly rates consistently exceeding the pre-intervention range, supporting a genuine improvement in the process of care rather than a transient or chance effect.

Table 8. Quality improvement outcome indicators, pre- versus post-intervention

Variable		Pre-intervention (n = 232)	Post-intervention (n = 232)	p-value
Catheter-Free Dialysis Achieved	No	168 (72.4)	108 (46.6)	<0.001
	Yes	64 (27.6)	124 (53.4)	
Referral Within Guideline Time	No	165 (71.1)	26 (11.2)	<0.001
	Yes	67 (28.9)	206 (88.8)	
Surgery Within Target Time	No	172 (74.1)	22 (9.5)	<0.001
	Yes	60 (25.9)	210 (90.5)	
AVF Created Before Dialysis	No	173 (74.6)	128 (55.2)	<0.001
	Yes	59 (25.4)	104 (44.8)	
Patient Education Completed	No	117 (50.4)	13 (5.6)	<0.001
	Yes	115 (49.6)	219 (94.4)	
Missed Appointments (number)		2.0 (1.0–3.0)	1.0 (0.0–1.0)	<0.001
Follow-up Compliance	Poor	118 (50.9)	26 (11.2)	<0.001
	Good	114 (49.1)	206 (88.8)	

Data are median (IQR) or n (%). Missed appointments compared by Mann-Whitney U test; categorical variables by chi-square test

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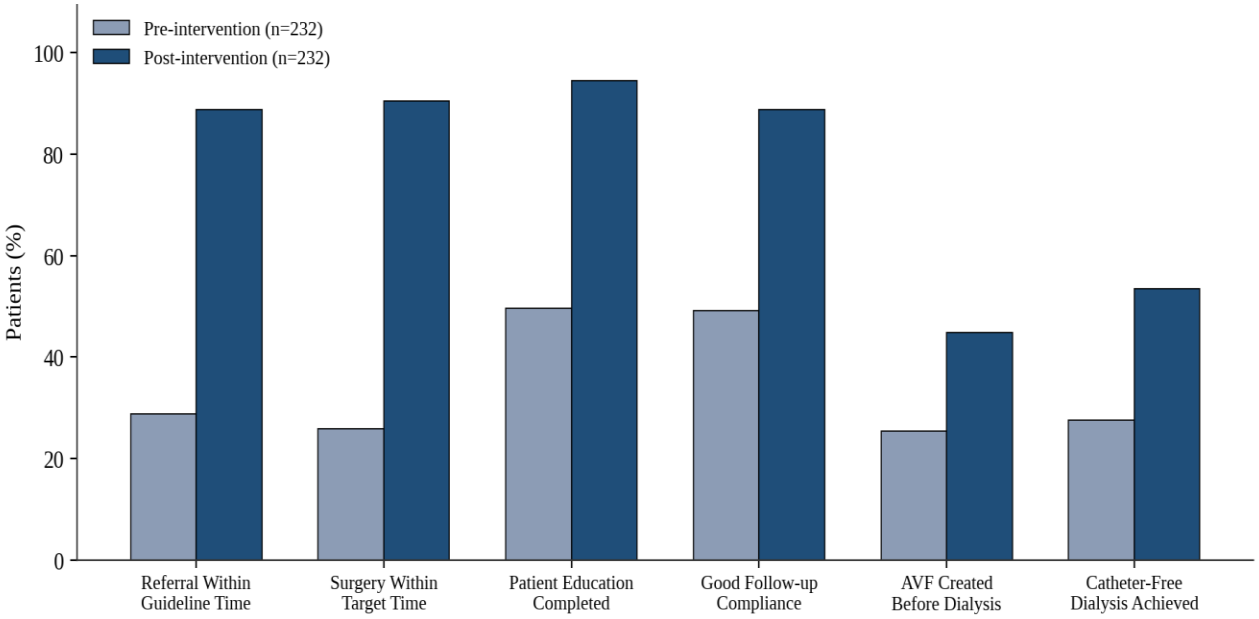


Figure 4. Achievement of pre-specified quality improvement targets, pre- versus post-intervention (all p < 0.001)

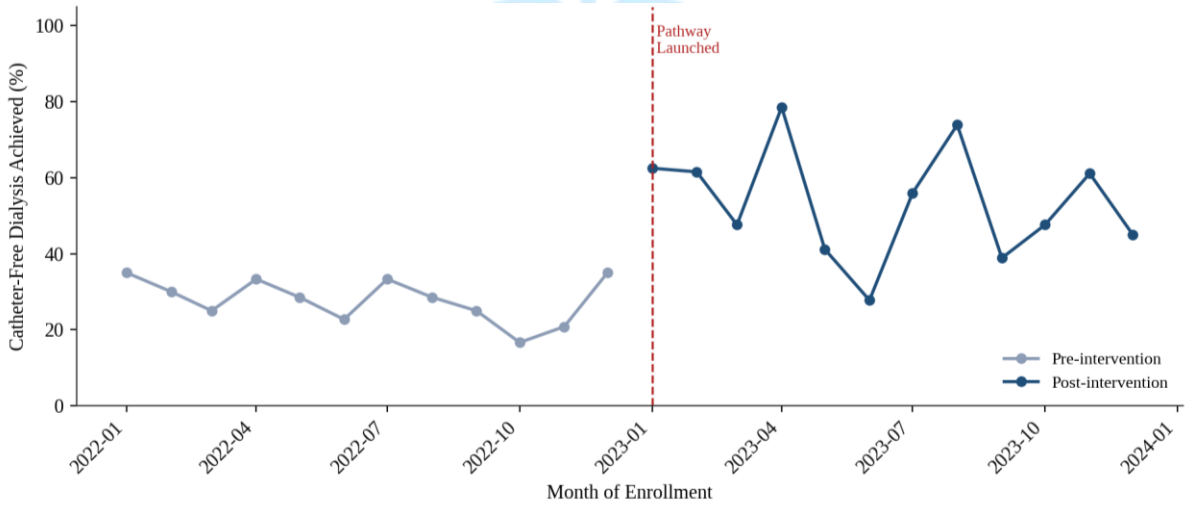


Figure 5. Run chart of the monthly catheter-free dialysis achievement rate across the study period, with the point of pathway launch indicated

DISCUSSION

This before-and-after quality improvement initiative, involving 464 consecutive patients undergoing AVF creation at a high-volume Pakistani cardiovascular surgery centre, demonstrated that implementation of a structured multidisciplinary vascular access pathway was associated with a substantial reduction in catheter-dependent dialysis initiation, from 74.6% to 43.1%, and a near doubling of catheter-free dialysis achievement, from 27.6% to 53.4%. These findings closely mirror international experience: the 2019 KDOQI update explicitly identifies multidisciplinary vascular access planning, incorporating an ESKD "Life-Plan," as central to reducing catheter reliance [1], and structured, coordinator-led programmes elsewhere have produced comparable gains in AVF-first dialysis

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initiation, largely by improving coordination of referral and surgical waiting lists rather than by changing surgical technique itself, a mechanism our supporting evidence also highlights [27]. Comparable before-after pathway data from Pakistan are limited, but the closest local analogue - a vascular surgery fellowship programme evaluated at a tertiary hospital in Lahore - likewise reported a rise in functional AVF use after structured programme introduction, from 54.1% to 68.1% of patients, albeit without reaching statistical significance in a smaller cohort [12], suggesting that our larger, more comprehensive pathway achieved a considerably greater and more clearly significant effect.

The marked acceleration we observed in referral-to-clinic (21.0 to 8.0 days) and referral-to-surgery intervals (44.0 to 18.0 days) is consistent with a wide literature linking late nephrology referral to catheter-dependent, emergency dialysis initiation. A recent updated systematic review and meta-analysis of over 630,000 patients found early referral associated with substantially lower all-cause mortality and reduced initial catheter use [8], while a large Indian cohort reported that late-referred patients almost universally began dialysis via non-tunnelled catheter (99%) compared with only 6.1% of early-referred patients [7]. Our finding that the proportion of patients referred beyond the guideline 30-day threshold fell from 16.8% to 0% therefore represents a clinically meaningful gain that plausibly explains much of the downstream reduction in catheter dependence, in keeping with Pakistani data showing that pre-dialysis vascular access planning strongly predicts subsequent AVF patency and fewer complications [13].

The near-universal adoption of pre-operative Doppler vascular mapping (60.8% to 94.8%) aligns with a growing international evidence base: an updated meta-analysis of 18 studies and over 3,600 participants found routine ultrasound mapping associated with significantly lower primary AVF failure and higher one-year patency [19], with randomised data confirming a similar benefit [20]. Colour Doppler parameters measured pre-operatively have also been shown to guide surgical decision-making in upper-arm fistula formation [21] and to predict maturation and detect complications in broader AVF cohorts [22], and comparable vascular-mapping-led navigation strategies from Jordan have reported analogous reductions in early failure [31]. Reassuringly, despite this shift toward routine mapping, AVF maturation (84.9% vs 86.2%), successful first cannulation and early failure rates in our cohort were statistically unchanged between phases and were broadly comparable to contemporary Pakistani and regional series reporting maturation rates in the 75-87% range [13,16,17], and our infection and reintervention rates were similar to those reported in a Karachi tertiary-centre series [14]. Together, these findings indicate that our timing-focused gains were not achieved at the expense of technical quality, a pattern also reported among nephrologist-led AVF programmes in Vietnam and among ultrasound-guided percutaneous AVF creation series achieving comparably high functional maturation [15,18].

Although catheter-related bloodstream infection and dysfunction rates did not differ significantly between phases, the absolute reduction in catheter use itself carries substantial clinical importance, given that CRBSI remains among the leading causes of hospitalisation and death in haemodialysis populations internationally, with reported mortality of 15-25% and markedly increased costs per admission, patterns replicated across diverse health systems in China and the Philippines [23,24,25,26]. The significantly lower hospital readmission rate observed post-intervention (19.0% vs 28.0%) is consistent with evidence that structured, coordinator-supported follow-up reduces downstream complications and unplanned care utilisation [27], and with data from a contemporary UK cohort demonstrating that pre-dialysis AVF creation is associated with preserved kidney function trajectory and reduced catheter exposure [30]. Limitations of this study include its single-centre, non-randomised before-after design, susceptibility to secular trends and Hawthorne effects, and the relatively short post-implementation observation window, which limits assessment of longer-term AVF patency. Multicentre studies with extended follow-up are

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needed to confirm the durability of these gains and their applicability to other resource-limited settings.

CONCLUSION

Implementation of a structured multidisciplinary vascular access pathway at a high-volume Pakistani cardiovascular surgery centre was associated with faster referral and surgical timelines, near-universal pre-operative vascular mapping, and a substantial, clinically meaningful reduction in catheter-dependent dialysis initiation, without compromising AVF maturation or safety outcomes. These findings support the feasibility and effectiveness of coordinated, protocol-driven vascular access care in resource-limited settings and provide a locally generated evidence base to guide similar quality improvement efforts across Pakistan and comparable low- and middle-income health systems. Sustaining and scaling this model, alongside longer-term follow-up of access patency and survival, should be prioritised as national initiatives increasingly emphasise pre-emptive, catheter-avoiding vascular access planning for patients approaching end-stage kidney disease.

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