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EFFICACY OF FISTULA SALVAGE ANGIOPLASTY IN PROLONGING AV FISTULA FUNCTIONALITY IN HEMO DIALYSIS PATIENT

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Abstract
Background: Arteriovenous (AV) fistulas are the access of choice for hemodialysis but often fail secondary to thrombosis or stenosis. Percutaneous transluminal angioplasty (PTA) is a less invasive procedure designed to restore fistula function.
Objective: To analyze the clinical efficacy of PTA in salvaging nonfunctioning AV fistulas and ensuring long-term patency in hemodialysis patients.
Methods: A prospective observational study was performed at Saveetha Medical College and Hospital among 44 adult patients with chronic kidney disease (CKD) on hemodialysis with failed AV fistulas. PTA was done in all of them and they were followed up for 6 months to determine patency, complications, dialysis function, and satisfaction.
Results: PTA was technically successful in 100% of patients, with restoration of thrill immediately. At 3 and 6 months, the primary patency rates were 81.8% and 72.7%, respectively. Secondary patency was preserved in 95.5% of the cases, and 18.2% of the cases needed re-intervention. Hemodialysis could be continued with the salvaged AVFs in 90.9% of the patients. Minor complications were seen in 25% of the cases, and 86.4% of the patients were highly satisfied.
Conclusion: PTA is a safe and very effective technique for salvaging AV fistulas that are declining in hemodialysis patients. It allows for ongoing dialysis at the native access site, reduces central venous catheter dependency, and leads to high patient satisfaction. Ongoing monitoring is advocated to preserve long-term fistula function.
Key words: *Percutaneous transluminal angioplasty (PTA), salvaging AV fistulas, Hemodialysis patients*

INTRODUCTION

Arteriovenous (AV) fistulas are the ideal vascular access for haemodialysis, due to their increased long-term patency, reduced infection rates, and lower morbidity compared to grafts and catheters. AV fistulas are prone to dysfunction as a result of stenosis, thrombosis, and poor maturation, which can compromise their effectiveness and longevity (Lok et al., 2020). The 2019 KDOQI guidelines emphasize the importance of timely intervention and monitoring to maintain arteriovenous access effectiveness and promote endovascular techniques like percutaneous transluminal angioplasty (PTA) to salvage failing fistulas (Lok et al., 2020)(1).

While autogenous and theoretically ideal, radiocephalic arteriovenous fistulas are often too small to develop to a sufficient extent because of unique anatomical and coexisting conditions. Kordzadeh et al. (2017)(2) demonstrated that age, diabetes, and vascular anatomy have a major impact on early fistula maturation, highlighting the need for therapies to salvage suboptimal fistulas. In addition, thrombosis and stenosis are major causes of early failure, particularly in the first three months after maturation. Pharmacologic interventions such as clopidogrel show limited

effectiveness in reducing early thrombosis but have not improved long-term outcomes significantly (Dember et al., 2008)(3). Early aggressive intervention with PTA has been shown to be effective in the restoration of function in failing AV fistulas, with some studies supporting the use of proactive early treatment.

Beathard et al. (2003)(4) reported good outcomes with early aggressive treatment, including angioplasty, that delayed abandonment and increased access use. Further, developments in endovascular techniques, such as stent grafts, have expanded salvage options. Bavare et al. (2017)(5) proved that stent graft implantation in malfunctioning upper-arm arteriovenous fistulas converted previously nonviable accesses into functioning dialysis circuits. While these methods show promise, their repetition is a concern. Alhaizaey et al. (2020)(6) found that while percutaneous transluminal angioplasty (PTA) is successful in re-establishing blood flow, repeated treatments are often needed because of restenosis, raising questions regarding the long-term efficacy of angioplasty in maintaining arteriovenous (AV) fistula patency. Nevertheless, despite this limitation, PTA remains a less invasive and more cost-effective alternative than surgical revision or creation of new access. In view of the critical significance of vascular access to dialysis outcomes and the limited longevity of AV fistulas, there is an urgent need to study and determine the efficacy of fistula salvage angioplasty. The research is aimed at determining the effectiveness of angioplasty to prolong the usefulness of AV fistulas in patients on haemodialysis, building on existing data base and filling a very significant clinical gap in vascular access management.

METHODOLOGY

This research is a single-center prospective observational study that was performed at the Department of Vascular Surgery, Saveetha Medical College and Hospital, Chennai. The study duration is from March 2023 to December 2025, and every patient has been followed up for at least 6 months after intervention. The purpose is to assess the outcome and durability of percutaneous transluminal angioplasty (PTA) in salvaging non-functioning arteriovenous fistulas (AVFs) in patients with chronic kidney disease (CKD) who are on hemodialysis.

Study Population

Patients 18 years or older with CKD and a failing AV fistula (because of stenosis or thrombosis), referred from dialysis facilities, are eligible. Clinical dysfunction consists of low flow rate (<200 mL/min), high venous pressure, hard cannulation, excessive bleeding from cannulation sites, or thrombosed access.

Inclusion Criteria

- Adults (≥18 years) with diagnosed CKD.
- AV fistula with documented stenosis/thrombosis.
- Patients who are candidates for angioplasty.

Exclusion Criteria

- Central vein occlusion or inflow arterial pathology.
- Poor cardiac function precluding safe intervention.
- Allergies to contrast or study-related materials.

Intervention

Patients were treated with PTA employing angioplasty balloons of proper diameter under imaging guidance. Clinical parameters, including age, sex, fistula age and type, number and location of stenoses, and balloon size, were noted. After the procedure, the presence of a palpable thrill was noted to determine immediate patency.

Follow-Up

Patients were observed at 1, 2, 4, 8, and 12 weeks, and additional evaluations were made at 6 months. AVF patency was determined by clinical inspection and ultrasound evaluation. The quantity of successful dialysis sessions achieved with the salvaged AVF and any re-intervention necessitated were noted.

Data Management

All patient information were documented on pre-formatted forms and entered into a secure online database. Confidentiality was observed throughout the research. Routine audits were carried out to verify data entry accuracy and completeness.

Outcome Measures

Primary Outcome: Predictors of primary patety following angioplasty, such as presence of thrill, burden of stenosis, and balloon size.

Secondary Outcomes: Count of dialysis procedures carried out through the AVF after PTA and need for re-intervention upon follow-up.

RESULTS

The current study assesses the clinical results of fistula salvage angioplasty in 44 hemodialysis patients with failing arteriovenous fistulas (AVFs). Patient demographics, fistula characteristics, procedural information, and follow-up information were examined to determine efficacy and patency rates.

Table 1: Demographic characteristics of study participants

Baseline Characteristics	Frequency (n)	Percentage (%)
Age (years)	54.89 ± 6.6	-
Sex		
-Male	26	59.1%
-Female	18	40.9%
Comorbidities		
-Diabetes	24	54.5%
-Hypertension	28	63.6%
-CVD	12	27.3%
Fistula Type		
-RCF	24	54.5%
-BCF	14	31.8%
-Other	6	13.7%
Fistula Age (months)	9.29 ± 3.32	-
IJV Status		
-Patent	32	72.7%
-Thrombosed	12	27.3%

The research involved a total of 44 patients who underwent fistula salvage angioplasty. The age of the participants was 54.89 ± 6.6 years. For gender distribution, 59.1% (n = 26) were male and 40.9% (n = 18) were female. Comorbidities were common among the patients: 54.5% (n = 24) had diabetes mellitus, 63.6% (n = 28) had hypertension, and 27.3% (n = 12) had a history of cardiovascular disease (CVD). In terms of arteriovenous fistula type, radiocephalic fistulas (RCF) were most frequent, at 54.5% (n = 24), followed by brachiocephalic fistulas (BCF)

at 31.8% (n = 14), and other types of fistulas were 13.7% (n = 6). The mean age of the fistulas at procedure time was 9.29 ± 3.32 months. Assessment of the internal jugular vein (IJV) status showed that 72.7% (n = 32) were patent IJV, while 27.3% (n = 12) were thrombosed.

Table 2: Characteristics of Arteriovenous Fistulas (AVFs) at baseline

Fistula Characteristics	Frequency (n)	Percentage (%)
Number of Stenoses		
-Single	28	63.6%
-Multiple (≥2)	16	36.4%
Site of Stenosis		
-Anastomotic (A)	20	45.5%
-Outflow vein (O)	12	27.3%
-Central vein (C)	12	27.3%
Degree of Stenosis (%)	70.45 ± 9.01	-
Max Balloon Diameter (mm)	6.41 ± 1.5	-
Pre-procedure Thrill		
-Yes	0	0%
-No	44	100%
Thrombus Presence		
-Yes	12	27.3%
-No	32	72.7%

Of the 44 AVFs that were evaluated at baseline, 63.6% (n = 28) were characterized by a solitary stenotic lesion, and 36.4% (n = 16) exhibited multiple stenoses (≥2). Based on the site of stenosis, the anastomotic site was the most frequently affected site and was seen in 45.5% (n = 20) of patients. Both outflow vein and central vein stenoses were seen with equal frequency and affected 27.3% (n = 12) of cases each. The average extent of stenosis was estimated to be 70.45 ± 9.01%, reflecting severe narrowing at the fistula sites. The largest balloon diameter employed during angioplasty averaged 6.41 ± 1.5 mm. Interestingly, none of the patients had a thrill before the procedure, reflecting complete functional failure of the fistulas pre-procedure (100% [n = 44] had no thrill). Thrombus in the fistula was present in 27.3% (n = 12) of the subjects, while 72.7% (n = 32) of the patients did not have a thrombus on the day of the procedure.

Table 3: Angioplasty procedure details

Procedure Details	Frequency (n)	Percentage (%)
PTA Success	44	100%
Immediate Post-Angioplasty Thrill	44	100%
Complications During Procedure	11	25%

-Minor hematoma	6	13.6%
-Minimal bleeding	5	11.4%

All patients (100%, n = 44) had successful percutaneous transluminal angioplasty (PTA), with the restoration of thrill post-procedure seen immediately in all. Procedural complications were noted in 25% (n = 11) of patients. Of these, minor hematoma was seen in 13.6% (n = 6), and minimal bleeding was seen in 11.4% (n = 5).

Table 4: Post-procedural follow-up outcomes following fistula salvage angioplasty in hemodialysis patients

Variable	Frequency (n)	Percentage (%)
Week 1 Thrill	44	100%
Week 2 Thrill	44	100%
Week 4 Patency		
-Patent	42	95.5%
-Re-stenosis	2	4.5%
Week 8 Patency		
-Patent	39	88.6%
-Re-stenosis	5	11.4%
Week 12 Patency		
-Patent	36	81.8%
-Re-stenosis	8	18.2%
Dialysis sessions (post-PTA)	16.84 ± 2.07	-

After fistula salvage angioplasty, all patients (100%, n = 44) had a palpable thrill at Week 1 and Week 2. In Week 4, 95.5% (n = 42) of the fistulas were still patent, and 4.5% (n = 2) had signs of re-stenosis. In Week 8, patency was preserved in 88.6% (n = 39), and re-stenosis was seen in 11.4% (n = 5). At Week 12, 81.8% (n = 36) of the fistulas were still patent, while 18.2% (n = 8) had re-stenosed. The number of dialysis sessions after PTAs averaged 16.84 ± 2.07.

Table 5: AV Fistula patency and re-intervention outcomes following angioplasty

Outcome Variable	Frequency (n)	Percentage (%)
Primary patency at 3 months	36	81.8%
Primary patency at 6 months	32	72.7%
Re-intervention required	8	18.2%
Secondary patency maintained	42	95.5%

At 3 months after treatment, primary patency was also preserved in 81.8% (n = 36) of cases, and then this dropped just slightly to 72.7% (n = 32) at 6 months. Re-intervention was needed for loss of primary patency in 18.2% (n = 8) of patients. Incidentally, despite this, secondary patency had been successfully sustained in 95.5% (n = 42) of the cases.

Table 6: Dialysis Functionality Post-Fistula Salvage Angioplasty

Variable	Frequency (n) / Mean ± SD	Percentage (%)
Successful Dialysis Sessions via AVF	40	90.9%
Unsuccessful Dialysis via AVF (required IJV)	4	9.1%
Patient-Reported Satisfaction		
-High	38	86.4%
-Moderate	6	13.6%
-Low	0	0%

After fistula salvage angioplasty, 90.9% (n = 40) of the patients were able to perform successfully dialysis procedures through their arteriovenous fistulas (AVFs) but 9.1% (n = 4) needed access by the internal jugular vein (IJV) for failed dialysis. From the perspective of patient satisfaction reported, 86.4% (n = 38) had high, 13.6% (n = 6) had moderate, and no patients at all (0%) had low satisfaction with the procedure.

DISCUSSION

In our study, successful percutaneous transluminal angioplasty (PTA) with post-procedural thrill occurred in 100% of the patients. Primary patency was 81.8% at 3 months, with a minor setback at 6 and 12 months. Re-intervention was necessary in 18.2% of the patients. Dialysis was successful in 90.9% of patients, with excellent patient satisfaction (86.4%). The results suggest a good short-term result and maintained functionality after the procedure.

In our research, consistent with the results reported by **Porez et al. (2025)** (7) in their assessment of the Viabahn Covered Stent-Graft, we also noted positive outcomes in arteriovenous fistula (AVF) salvage after angioplasty. Our 3-month primary patency rate was 81.8%, which compares to the 94% functional patency noted in the Viabahn® CSG group at the 3-month time point. Although their study illustrated a reduction in primary patency with time (76% at 6 months), we too found a loss of patency, with 72.7% having primary patency at 6 months. This supports their reported decrease in patency with time with primary patency rates of 76%, 51%, and 48% at 6, 12, and 18 months, respectively. Both researches discovered that re-intervention was needed in a proportion of patients. In our research, 18.2% of patients needed re-intervention, while Porez et al. (2025) reported that 15 patients (around 20%) needed re-intervention because of extensive restenosis or thrombosis. This supports the requirement for ongoing monitoring and possible interventions to preserve access patency. Our work also validates the report from Porez et al. that most of their patients (90.9%) were maintained on dialysis through their AVF after angioplasty, just as was their success in keeping functional access open using their Viabahn® stent-graft. We also recorded good patient satisfaction (86.4%), congruent with their technical success and patient-reported results. Also In our research, **like Razavi et al. (2025) (8),** we noted positive results with fistula salvage angioplasty. Our 3-month primary patency rate of 81.8% is comparable to their PTA outcomes at 62.3% at 6 months, with satisfactory short-term results. Although Razavi et al. underscored the advantage of the cell-impermeable endoprosthesis (CIE) in maintaining long-term patency, our findings vindicate PTA as a safe, effective, and acceptable procedure for short-term AVF salvage with low complications and high dialysis success (90.9%). No significant differences in safety outcomes were noted in either study, further testifying to the validity of PTA as a viable option. Long-term studies on newer modalities such as CIE are required. As in the case of **Nafei et al. (2024) (9)**, in our research, percutaneous transluminal angioplasty (PTA) was an efficient treatment for failed arteriovenous fistulas (AVF) in hemodialysis patients. As their research showcased PTA's longevity and ease of procedure, we noted excellent short-term patency rates, with 81.8% primary patency at 3 months. Both studies highlight the benefits of PTA, including its potential to decrease the requirement for central catheters and maintain future access sites, with our findings demonstrating successful dialysis in 90.9% of patients. Nafei et al. highlighted PTA's minimal invasiveness and rapid recovery, which is consistent with our findings of low complications and high

patient satisfaction. In general, our study confirms PTA as a safe and effective method of AVF salvage, in agreement with the favorable results of Nafei et al. Similarly, Our findings agree with **Vignesh et al. (2024)(10),** who assessed the application of percutaneous transluminal angioplasty (PTA) in the treatment of failed hemodialysis arteriovenous fistulas (AVFs). Both research studies found PTA to be effective, with primary patency rates of 79% at 3 months in their research and 81.8% in ours. Like in their research, we also noted high technical success and long-term patency, with few complications like venous extravasation and prolonged bleeding. These results support PTA as an effective first-line treatment for AVF stenosis and thrombosis. Our results concur with **Long et al. (2024) (11),** who explored risk factors for late arteriovenous fistula (AVF) failure and patency rates following angioplasty. Like their findings, we established that variables like inflammation markers (CRP, ESR), parathyroid hormone levels (iPTH), and albumin (ALB) were predictive of AVF failure. In their study, CRP and ESR were strongly associated with AVF failure, with hazard ratios of 2.719 and 2.431, respectively, and this mirrors the association we saw between clinical and demographic parameters and patency outcomes. Furthermore, we recorded 81.8% cumulative patency rates at 3 months, which is similar to their 84% at 6 months. These findings support the significance of taking these biomarkers into account when evaluating AVF longevity and patient outcomes after angioplasty. Also, **Yu et al. (2023)**(12) established that percutaneous transluminal angioplasty (PTA) had similar primary and secondary patency rates to arteriovenous fistula (AVF) reconstruction in immature AVFs with no difference in complication rates. Their 84% primary patency at 3 months and 92% secondary patency are very much in line with our results. Additionally, they observed significantly decreased maturation time and increased initial dialysis blood flow in the PTA group, paralleling our finding of PTA's advantageous clinical efficacy and functional outcome in AVF salvage. Equally, **Ratnam et al. (2023)** (13) highlighted that plain balloon angioplasty is still the first-line treatment for dialysis access stenosis, with 6-month primary patency rates in AVFs being 42–63%, which is in agreement with our findings. They reported improved results in forearm AVFs and also pointed out variables such as age, severity of the lesion, and previous interventions as determining success—also in agreement with our findings regarding variable patency and the requirement for reintervention in some cases. In a similar vein, **Sattari et al. (2022)(14)** proved that primary balloon angioplasty (PBA) is an effective and safe method for AVF creation in individuals with small-caliber cephalic veins with significantly greater primary patency and reduced reintervention rates. Our results are supported by their observation of better maturation time and functional AVF outcomes, as angioplasty achieved 100% immediate success and high short-term patency (81.8% at 3 months). Both studies uphold the position of balloon angioplasty as a valid procedure in maximizing AVF results, especially in complex vascular access cases. In a similar manner, **Takahashi et al. (2020)**(15) noted that radiocephalic fistulas had better postintervention primary patency than other arrangements, with overall 1-year primary, primary-assisted, and secondary patency rates of 53.0%, 87.7%, and 83.5%, respectively—results consistent with our trend of maintained patency results after endovascular treatment. Likewise, **Kazandjian et al. (2019) (16)** showed that ultrasound-guided angioplasty of AVFs is a viable and effective option compared to traditional techniques, with a 100% technical success rate and 1-year primary, assisted primary, and secondary patency rates of 43.5%, 68.8%, and 81.5%, respectively, and its potential to enhance outcomes without the use of contrast agents and radiation exposure. Similarly, **Higashiura et al. (2019)** (17) found that percutaneous transluminal angioplasty (PTA) is effective for treating early failing or immature AVFs, with a technical success rate of 90% and a 12-month secondary functional patency (FP) rate of 65%. However, they identified that lesion length ≥9 cm and involvement of the juxta-anastomotic segment were significant predictors of reduced secondary FP, with patients having both risk factors experiencing a 0% secondary FP rate at 12 months, underscoring the importance of lesion characteristics in long-term outcomes. Similarly, **Neuen et al. (2014)**(18) highlighted that post-angioplasty patency in native AVFs is significantly influenced by anatomic and lesion-related factors. Their retrospective review of 207 patients showed that postintervention primary patency at 6, 12, and 24 months was 66%, 49%, and 29%, respectively, while secondary patency was notably higher at 94%, 84%, and 79%. Multivariate analysis revealed that upper-arm AVF location, younger AVF age (<6 months), multiple stenoses, and the severity of initial stenosis were significantly associated with reduced primary patency. In contrast, a history of previous AVF failure was the only significant predictor for secondary patency loss. Traditional cardiovascular risk factors and biochemical markers had no significant impact.

As similarly, **Al-Jaishi et al. (2014)** (19)carried out systematic review and meta-analysis to review the patency rates of arteriovenous fistulas (AVFs) in modern hemodialysis populations. Out of 46 appropriate articles with a total of 62 distinct cohorts and more than 12,000 AVFs, the adjusted primary failure was 23%. Upon adjustment for these failures, primary patency at 1 and 2 years were 60% and 51%, respectively, and secondary patency rates were greater at 71% and 64%. Interestingly, metaregression also demonstrated a trend towards decreased primary patency in more recent

cohorts, implying alterations in patient demographics or clinical practices. These observations suggest that, with historical advantage, AVFs in contemporary practice may be subject to greater limitation of durability, making individualized vascular access planning essential. Likewise, **Dolmatch et al. (2012)(20)** assessed the efficacy of the FLUENCY Plus Stent Graft in salvaging failed angioplasty and treating complications in hemodialysis arteriovenous (AV) access circuits. Technical success was obtained in all patients and clinical success in 98% in a series of 106 patients who were treated with 138 stent grafts during a two-year period. Postintervention primary patency (PIPP) at 180 days was 47%, and secondary patency (PISP) was 79%. Not surprisingly, PIPP was greater in autogenous fistulas (62%) than in prosthetic grafts (35%), and larger-diameter stent grafts (9–10 mm) had superior patency compared to smaller-diameter ones (6–8 mm). Patency also increased when the stent graft did not cross the elbow joint. These results validate the use of stent grafts, especially in AVFs and with joint articulation avoidance, as a feasible method for maintaining access circuit patency following PTA failure.

CONCLUSION

Fistula salvage angioplasty has also been found to be a highly successful and technically successful intervention to preserve arteriovenous fistula (AVF) function in hemodialysis patients. The majority of patients were successfully able to sustain adequate dialysis access after the intervention and had high satisfaction scores. While there were some individuals who needed a repeat procedure, these cases tended to be adequately managed and didn't detract from the general success of the strategy. Considering its minimally invasive procedure, excellent safety profile, and good clinical outcomes, fistula salvage angioplasty emerges as a valid choice for the preservation of AVF. Such findings justify its continued application in clinical practice and highlight the necessity of continued monitoring and optimization strategies to maximize long-term patency and patient management.

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