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Comparison of upper forearm polytetrafluoroethylene grafts in hemodialysis patients: Curved or loop?

Deniz Demir, Nail Kahraman

Department of Cardiovascular Surgery, University of Health Sciences, Bursa Yüksek İhtisas Training and Research Hospital, Bursa, Turkey

ABSTRACT

Objectives: In this study, we aimed to evaluate arteriovenous (AV) grafts using polytetrafluoroethylene (PTFE) in hemodialysis patients.

Patients and methods: A total of 64 patients (31 males, 33 females; mean age 53.4±18.0 years; range, 15 to 82 years) who underwent operation between May 2009 and May 2017 were retrospectively evaluated. The patients were divided into two groups: Group 1 (n=32) included forearm brachial artery ante-cubital basilic vein loop with a PTFE AV graft and Group 2 (n=32) included upper arm brachial artery axillary vein curved with a PTFE AV graft. The patency and complication rates were compared between the groups.

Results: In Group 1, the primary patency rates at three, six, 12, 18, and 24 months were 78%, 68%, 25%, 9%, and 3%, respectively. In Group 2, the primary patency rates at three, six, 12, 18, and 24 months were 87%, 84%, 65%, 43%, and 31%, respectively. The patency rate was statistically significantly higher in the curved group (log rank: p=0.001). The rate of thrombosis in the postoperative period was 75% (n=24) and 40% (n=13) in Group 1 and Group 2, respectively, indicating a statistically significantly higher rate in Group 1 (p=0.011).

Conclusion: The results of our study suggest that curved AV grafts are superior than loop AV grafts regarding the primary patency rates and postoperative thrombosis.

Keywords: Arteriovenous fistulas; curved; loop; polytetrafluoroethylene.

More than 50 years have passed after Brescia and Cimino's defining native arteriovenous fistula (AVFs) which enables the patients with chronic renal failure (CRF) receiving dialysis. This method still continues to be the gold standard.[1] Native AVFs are used most frequently followed by polytetrafluoroethylene (PTFE) grafts for vascular access in patients with CRF. Surgical ease, easier puncture, and providing high blood flow for dialysis are the main reasons for the use of PTFE grafts. Outcomes of PTFE grafts are known to be poorer than native AVFs.[2] Despite the high rate of complications of PTFE, arteriovenous grafts (AVGs) have been approved as an acceptable technique in secondary access surgery for hemodialysis (HD).[3] Alternative access routes are required, when a native vessel cannot be used. In general, PTFE grafts are used as alternative grafts.[4,5] In the present study, we aimed to evaluate AVGs using PTFE in HD patients.

PATIENTS AND METHODS

This retrospective, multi-center study was conducted in three centers between May 2009 and May 2017. A written informed consent was obtained from each patient. The study protocol was approved by the local Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

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Correspondence: Deniz Demir, MD. SBÜ Bursa Yüksek İhtisas Eğitim ve Araştırma Hastanesi Kalp ve Damar Cerrahisi Kliniği, 16310 Yıldırım, Bursa, Turkey.
e-mail: denizzdr@msn.com

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A total of 64 patients (31 males, 33 females; mean age 53.4±18.0 years; range, 15 to 82 years) who underwent AVGs using PTFE were included. All patients included in the study were receiving HD due to CRF. All of the patients consisted of multiple-stage failed radiocephalic and brachiocephalic AVF. The patients were divided into two groups: Group 1 (the loop group) included the patients in whom a PTFE graft was applied as loop between the brachial artery and antecubital basilic vein in forearm region. Loop grafts were also preferred in patients with antecubital basilic vein and 3 mm greater ultrasonographic measurements. Group 2 (the curved group) included the patients in whom a PTFE graft was applied as curved between the brachial artery and axillary vein in upper arm region. Curved grafts were also preferred in patients with antecubital basilic vein and ultrasonographic measurements less than 3 mm. Patients with a brachial artery diameter of ≥2.5 mm were considered eligible for the arterial inflow. Calcified brachial arteries were not used. Patient data were obtained from the patient's files from the hospital archive or dialysis centers. Preoperative and demographic characteristics of the patients were recorded. In preoperative assessment, routine physical examination was performed for all patients. Blood tests were performed and arterial and venous mapping was done through a detailed Duplex ultrasonography examination. Distal arterial pressures were checked. The patients who had infection, edematous arm, ischemic appearance in the arm or central venous obstruction were not operated. Non-dominant arm was preferred for the operation. Brachial artery, antecubital basilic vein or upper arm axillary vein were used for the operation. During the operation, 6-mm PTFE (Carboflo® vascular grafts, UK and Flixene® vascular grafts, USA) grafts were used.

Surgical technique

The patients were operated under local anesthesia in a sterile operating room. Antibiotic prophylaxis was done in accordance with the hospital protocol. Artery and vein were prepared after proper incisions toward the target vessel. 50 to 100 units/kg of unfractionated heparin was applied before vascular clamping. The graft was used after washed with saline containing 5,000 units of heparin.

Group 1 (loop): The AVG was performed using the PTFE graft between the brachial artery and antecubital basilic vein. The PTFE graft was used to create a subcutaneous tunnel in a loop shape in the forearm region (Figure 1).

Group 2 (curved): The AVG was performed using the PTFE graft between the brachial artery and axillary vein. The PTFE graft was used to create a curved subcutaneous tunnel in the upper arm region (Figure 2).

Vascular anastomoses were performed using the end-to-side technique through 6/0-7/0 Prolene sutures. The operation was considered successful, if murmur was heard from the fistula. Fistula formation failed in patients who could not get thrill with palpation, did not listen to murmur with stethoscope and could not receive dialysis. All patients were given 100 mg/day aspirin after the procedure and underwent HD two to three weeks later. Primary and primary-assisted patency rates were evaluated. Primary patency was defined as the time that the PTFE graft worked without the need for an additional procedure after opening. Primary-assisted patency was defined as the time after the PTFE graft working with an additional procedure.

In all patients, mortality and the reasons for lost-to-follow-up were recorded. Bleeding, hematoma, infection, thrombosis, and pseudoaneurysm (PSA) were recorded as graft complications. Complications were classified as early (<30 days) and late (≥30 days).

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Continuous and ordinal variables were expressed in mean ± standard deviation (SD) and nominal variables were expressed in number and frequency. The Kolmogorov-Smirnov test of normality was used to test the distribution of variables. The chi-square test was used to compare two groups for nominal variables. The Mann-Whitney U test was used to compare two groups for continuous variables without normal distribution. Long-term results were analyzed using the Kaplan Meier curves, and the differences in subgroups were evaluated by the log-rank test. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 64 patients, 29 (45%) had diabetes mellitus, 39 (60%) had hypertension, 13 (20%) had coronary artery disease, and 11 (17%) had peripheral artery disease. The mean duration of HD was 85.5±37.4 months (Table 1).

In Group 1, the primary patency rates at three, six, 12, 18, and 24 months were 78%, 68%, 25%, 9%,

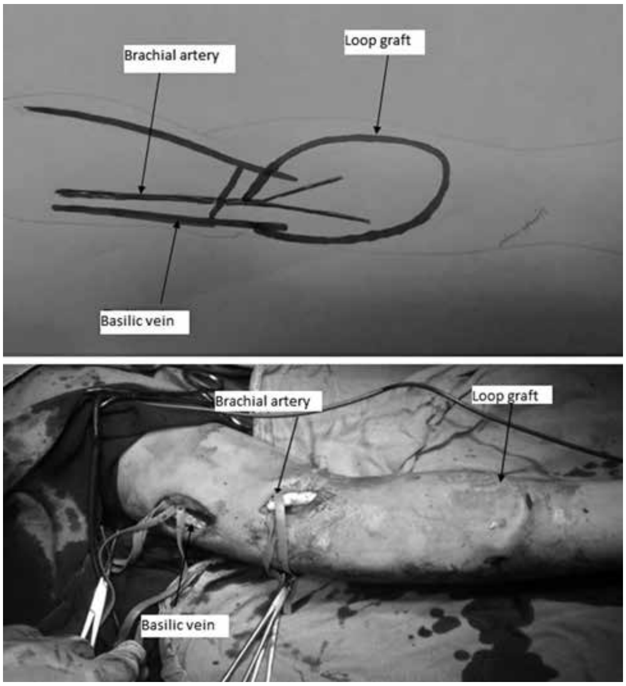

Figure 1. An intraoperative view of a loop graft.

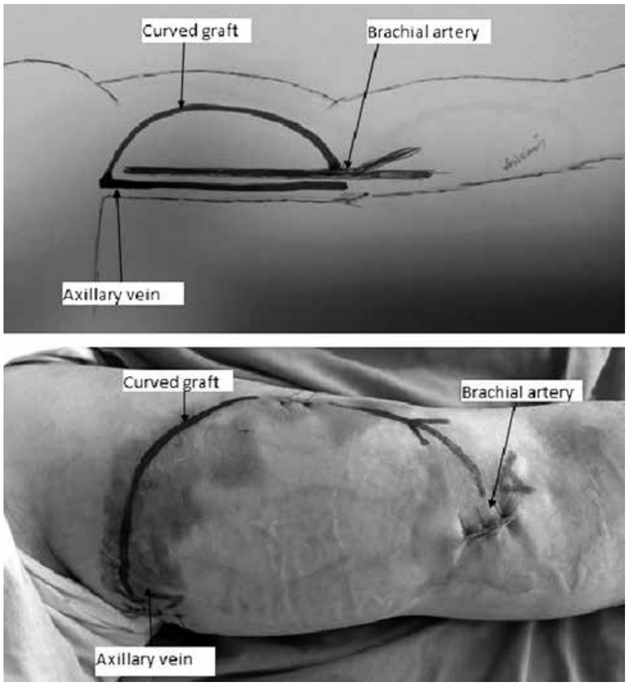

Figure 2. An intraoperative view of a curved graft.

and 3% respectively. In Group 2, the primary patency rates at three, six, 12, 18, and 24 months were 87%, 84%, 65%, 43%, and 31% respectively. The primary patency rates were statistically significantly higher in the curved group (log-rank p=0.001) (Figure 3). In Group 1, the primary-assisted patency rates at three, six, 12, and 18 months were 81%, 46%, 46%, and 9%, respectively. In Group 2, these rates at three, six, 12, and 18 months were 40%, 31%, 31%, and 6%, respectively (Figure 4). There was no statistically significant difference between the groups (log-rank p=0.066).

The mean primary patency duration was 8.5±7.2 (range, 1 to 38) months in Group 1 and 19.1±14.6 (range, 1 to 52) months in Group 2. There was a statistically significant difference between groups with higher rates in the curved group (p=0.001). The mean primary-assisted patency duration was 5.7±3.2 (range, 1 to 12) months in Group 1 and 7.9±5.6 (range, 1 to 20) months in Group 2. Although the curved group had a longer duration, there was no statistically significant difference between the groups (p=0.255). In addition, the mean total patency duration was 23.1±14.8 and

Table 1. Demographic data and preoperative risk factors

	Loop group (n=32)			Curved group (n=32)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			53.9±17.6			52.9±18.7	0.925#
Hemodialysis time (months)			98.5±43.6			72.6±24.5	0.021#
Gender							0.617*
Male	14	43.8		17	53.1		
Female	18	56.3		15	46.9		
Diabetes mellitus	15	46.9		14	43.8		1.00*
Hypertension	20	62.5		19	59.4		1.00*
Coranary artery disease	7	21.9		6	18.8		1.00*
Periferic artery disease	7	21.9		4	12.5		0.508*

SD: Standard deviation; Differences were considered statistically significant, when the p level was less than 0.05. Time expressed in months. # Mann-Whitney test; * Continuity correction.

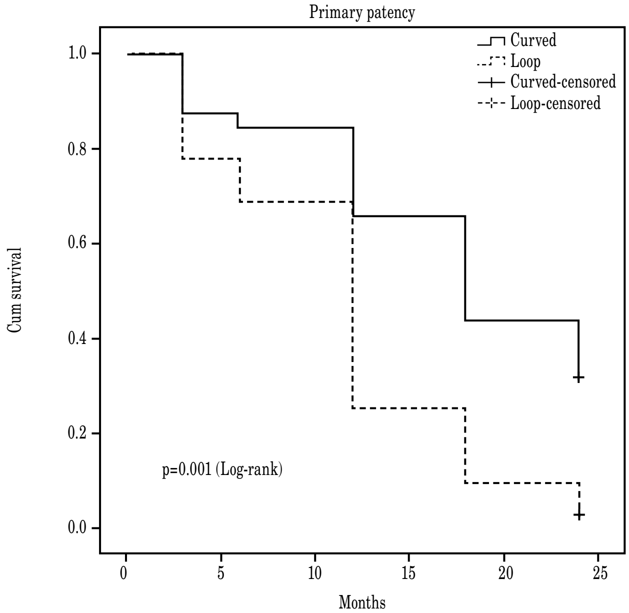

Figure 3. Primary patency rates. Patency rate is shown in percentage, and survival time in month. P values are calculated with log-rank test.

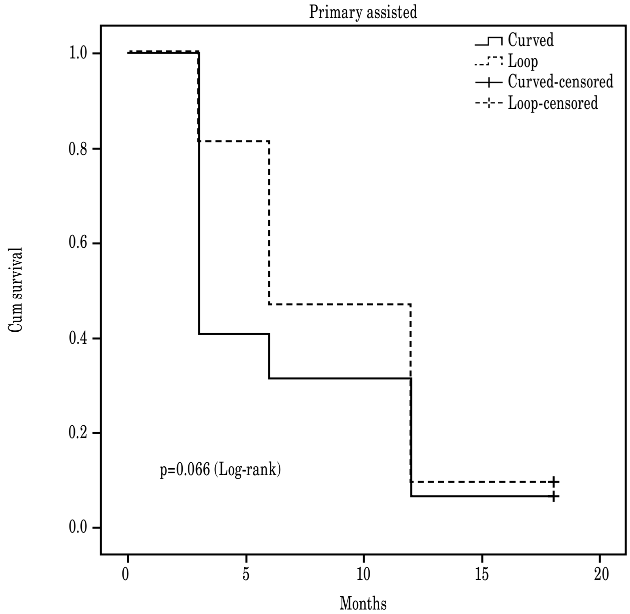

Figure 4. Primary-assisted patency rates. Patency rate is shown in percentage, and survival time in month. P values are calculated with log-rank test.

14.0±8.2 months for the curved and loop groups, respectively (p=0.004).

Postoperative complications are listed in Table 2. The rate of postoperative thrombosis was 75% (n=24) and 40% (n=13) in Group 1 and Group 2, respectively, indicating a statistically significantly higher rate in Group 1 (p=0.011). In addition, the rate of postoperative infection was 12% (n=4) and 9% (n=3) in Group 1 and Group 2, respectively. There was no significant difference between the groups (p=1.00). No PSA or infection was observed in the early period. However, PSA was later detected in three patients (9%) in Group 1 and in two patients (6%) in Group 2. There was no significant difference between the groups in terms of PSA development (p=1.00). Bleeding was also observed in two patients in both groups in the early period. A total of six deaths occurred in both groups (n=4 in Group 2 and n=2 in Group 1). No graft complication-related mortality was observed in any of the patients. One patient died from sepsis and the other patients died from cardiac events.

DISCUSSION

Complications such as infection or thrombosis are more common with AVGs, compared to AVF with lower patency rates. Therefore, AVFs are more frequently used. However, artificial grafts are used, when the vessels of the patients are not suitable.[6,7] Of note, AVGs have some advantages compared to native AVFs, including providing a large surface area for cannulation, short maturation time, having various shapes and configurations, and enabling vascular and endovascular repair.[8]

Table 2. Postoperative complication data

	Loop group		Curved group		
Complications	n	%	n	%	*p*
Infection	4	12.5	3	9.4	1.00†
Thrombosis	24	75.0	13	40.6	0.011*
Bleeding	2	6.3	2	6.3	1.00†
Pseudoaneurysm	3	9.4	2	6.3	1.00†
Death	2	6.3	4	12.5	0.672†

Differences were considered statistically significant, when the p level was less than 0.05. † Fisher's exact test; *Continuity correction.

However, the main disadvantage of AVFs is low secondary patency ratios, compared to AVGs.[5] Allemang et al.[5] reported that short-term secondary patency ratios were higher in AVGs, compared to AVFs; however the ratios were found to be similar in the late period. According to the American Journal of Kidney Disease Guideline,[8] the two preferred graft site types are the antecubital loop graft and upper-arm curved graft. Femoral placement of access has been also associated with proximal venous stenosis, which may be problematic later in patients receiving kidney transplantation. Potential areas for arterial inflow include the radial artery in the wrist, brachial artery in antecubital fossa, brachial artery in the inferior arm, and brachial artery, axillar artery, and femoral artery just below the axilla. Potential areas for venous outflow include the median antecubital vein, proximal and distal cephalic vein, basilic vein at the elbow level, basilic vein at the upper arm level, axillar vein, jugular vein, and femoral vein.[8]

Many alternative methods are used, when conventional radiocephalic vein does not work in patients with CRF. In the literature, several studies are available comparing native AVFs and PTFE grafts. Coburn and Carney[9] compared basilic vein AVFs and PTFE grafts and found that basilic vein AVF was significantly superior to AVGs (PTFE) in terms of the primary patency and complication rates. Keuter et al.[4] compared native and PTFE grafts in another randomized, multi-center study. The authors compared brachiobasilic AVFs and brachial antecubital forearm loop AVGs and found primary and secondary patency rates to be significantly higher than AVFs in the AVG group.

Studies are also available in the literature comparing PTFE grafts with each other. Han et al.[6] compared a 4-7-mm tapered PTFE graft and a 6 mm straight PTFE graft with regard to one-year patency and found no difference between the groups in terms of the patency rates and thrombotic events. Loop is recommended for forearm, while curved is recommended for upper arm in HD patients for whom PTFE would be used.[10] In our study, we divided the patients into two groups according to the type of PTFE for HD access and compared the groups with regard to primary and primary-assisted patency times. We observed that the curved group was statistically significantly primary patency rates (log-rank p=0.001). There was no statistically significant difference between the groups in terms of primary-assisted patency rates (log-rank p=0.066).

Ravari et al.[11] evaluated the results of the patients in whom AVFs PTFE and polyurethane vascular access graft were used. The one-year patency rate of PTFE grafts was reported to be 64%. The one-year primary patency rate was 65% in the curved group and 25% in the loop group. The primary patency rate in the curved group is similar to that of the literature.[11] However, the primary patency rates of the loop group is lower.

Postoperative complications were also evaluated in both groups in our study. The main complication was thrombosis, followed by infection, aneurysms, and bleeding. Bleeding (early) was observed in two patients in each group and they were repaired with revision and primary repair. The most common complication was graft thrombosis with a prevalence of 40% (n=13) in the curved group and 75% (n=24) in the loop group. Thrombosis was found to be more frequent in Group 1 (loop) (p=0.011). These patients were treated with thrombectomy through revision. We did not observe any comparative studies in the literature investigating graft configuration and thrombosis prevalence. However, in an almost similar study with ours, Rizzuti et al.[12] compared loop and straight grafts in the forearm region of HD patients and reported that loop fistulas were superior to the straight fistulas in terms of revision rate and cumulative patency rates. These findings are not consistent with our results. In our study, the prevalence of revision requiring thrombosis was found to be higher in the loop-shaped PTFE grafts, compared to the curved grafts. The patency rates were also lower in the loop group, different from the study of Rizzuti et al.[12]

Infection was detected in four patients (12%) in the loop group and three patients (9%) in the curved group; however, there was no significant difference between the groups. Infections were superficial and controlled with antibiotic and dressing. Another late complication was graft PSA which was seen in two patients (6%) in the curved group and in three patients (9%) in the loop group, indicating no significant difference between the groups. Reoperation was performed in the patients who developed PSA. Interposition was performed with PTFE after the aneurysmal segments were resected and fistula continuity was provided. In the curved group, graft dysfunction developed approximately 1.5 years after surgery in two patients who underwent graft interposition following PSA. Treatment of these two patients continued with permanent catheters. Hemodialysis was performed with a temporal catheter during revision (for two to three weeks) in patients who developed PSA and infection.

In a study, Odabasi et al.[13] evaluated HD patients in whom a PTFE graft was used and reported a thrombosis rate of 85% during a 48-month follow-up period. They reported primary patency rates at 24 months of 55%, infection rates of 25%, bleeding rates of 15%, and aneurysm rates of 5%. In addition, Khoshnevis et al.[14] divided the patients as loop and straight groups in their study and they used PTFE grafts in the upper arm region. The primary patency rate in the straight and loop groups at 24 months were 31% and 55.5%, respectively. The secondary patency rate in the straight and loop groups at 24 months were 37.9% and 66.7%, respectively. The thrombosis rate was found to be 46% in the straight group and 38% in the loop group. The infection rate was 12% in the straight group and 9% in the loop group. The aneurysm rate was 14% and 19% in the straight and loop groups, respectively. Our primary patency rate in the curved and loop groups at 24 months were 31% and 3%, respectively. Our primary-assisted (secondary) patency rate in the curved and loop groups at 18 months were 6% and 9%, respectively.

We consider that the results of curved group are similar those of Odabasi et al.[13] and Khoshnevis et al.[14] with regard to the thrombosis and primary patency rates. The primary-assisted patency rates of the curved and loop groups are lower than those of the study of the aforementioned authors. However, the thrombosis rates of the loop group are similar with or lower than those of the aforementioned studies. While the infection rates were found to be similar with the literature in our study, the PSA rates were found to be lower.[13,14] In our study, we found higher primary patency rates in the curved group, compared to the loop group, although the primary-assisted patency rates were similar. We also found longer primary patency durations (months) and lower thrombosis rates in the curved group, compared to loop group. Primary-assisted patency durations and infection, bleeding, and PSA rates were similar in both groups.

If the quality of the upper extremity veins is suitable, these are primarily used for AVFs.[7] Upper extremity axillary vein is known to be wider calibrated than the basilic vein. Inflow and outflow vessels of patients are also important in terms of the fistula patency. The upper extremity axillary vein is a good outflow option in terms of the venous fistula patency.[15] All fistula inflow in the brachial artery in our study was similar in both groups. However, our groups of fistula outflow were different. In the curved group, the outflow was the axillary vein, while in the loop group, the outflow was the basilic vein. We consider that this may be important for more successful outcomes in the curved group.

Nonetheless, there are some limitations to this study. Small sample size and its retrospective design are the main limitations. Further large-scale randomized studies are needed to better delineate the indications for curved or loop AVGs.

In conclusion, our study results showed higher patency and lower thrombosis rates in the curved group. Based on these findings, we suggest that curved AVGs are superior than loop AVGs regarding the primary patency rates and postoperative thrombosis and upper arm curved PTFE grafts can be used with good preoperative planning in HD patients.

Declaration of conflicting interests

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