Outcomes of surgical revision of stenosed and thrombosed forearm arteriovenous fistulae for haemodialysis

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Abstract

Background. Surgery is an established treatment for stenosed and thrombosed forearm arteriovenous fistulae (AVFs), but the literature on its outcome is limited. We report our experience of the surgical repair of stenosis in patent and thrombosed forearm AVFs and evaluate the outcome of two procedures, proximal neo-anastomosis (NEO) vs replacement of the stenosed segment with a polytetrafluoroethylene graft interposition (GI).

Methods. Sixty-four stenosed forearm AVFs underwent surgery, 32 pre-emptively and 32 post-thrombosis. End points of the study were initial success, restenosis and access loss rates. After treatment, AVFs were surveilled for restenosis by measuring access flow quarterly and performing at least one follow-up angiogram.

Results. Initial procedural success was 92%; 100% for patent and 84% for thrombosed AVFs. The restenosis rate was 0.189 events/AVF-year for both patent and thrombosed AVFs, while the access loss rate was 0.016 events/AVF-year in patent and 0.148 in thrombosed AVFs. Stenosis was corrected by NEO in 27 AVFs and by GI in 30. The restenosis and access loss rates were 0.151 vs 0.214 and 0.033 vs 0.019 events/AVF-year for NEO vs GI, respectively. At Cox’s hazard analysis, no variable was significantly associated with restenosis, while the timing of intervention was the only significant determinant of access loss, repaired clotted accesses carrying an 8.0-fold relative risk of access loss compared with patent AVFs (P = 0.048).

Conclusion. Our study shows that surgery remains a valid option for the pre-emptive repair of stenosis and to salvage clotted forearm AVFs, offering an excellent initial success rate and low restenosis rate. It confirms that it is better to treat stenosis pre-emptively than post-thrombosis (though the restenosis rate appears to be uninfluenced by the timing of intervention) and suggests that GI compares favourably with conventional NEO.

Keywords: arteriovenous fistula; graft interposition; haemodialysis; stenosis; surgery; thrombosis

Introduction

Both surgery and interventional radiology are established treatments for stenosis in patent and thrombosed arteriovenous fistulae (AVFs) [1]. In recent years, endovascular techniques have tended to supplant traditional surgery at many centres, because they are less invasive, preserve native vessels better and have excellent success rates (albeit with a high restenosis rate, making it necessary to repeat the procedure to maintain patency); in fact, many experts now recommend surgery only to treat stenoses in the anastomotic area of distal forearm AVFs [1–5].

The surgical correction of stenosis in AVFs has been done using several techniques, e.g. the creation of a more proximal neo-anastomosis (NEO) [6–14], vein-to-vein re-anastomosis [2,15], vein patching [10,11,13] and short vein [9,10,15–17] or poly-tetrafluoroethylene (PTFE) graft interposition (GI) [2,7,8,10,11,13,17,18]. The procedure can be performed under local anaesthetic, demands only a short segment of the vein, involves minimal intimal trauma, and is likely to be more durable than percutaneous transluminal angioplasty (PTA) (reported primary patency rates in surgical series are higher than after dilatation [3–5,6,12,13,18–24]).

The growing body of articles reporting on the results of interventional radiology is not balanced, however, by reports on the outcome of surgical treatment for stenosed and thrombosed forearm AVFs [2,6–18,25]. Moreover, many of the latter are retrospective [2,8,10,15,16,25], suffer from an inadequate sample...
size [6,9,14,25], combine forearm with upper arm [10,13,15,18,25], or patent with thrombosed AVFs [2,11,12,15–18] and provide cumulative results for different techniques [2,7–11,13,15,16]. The outcome and optimal timing and method of surgical repair for stenoses in forearm AVFs consequently deserve a more accurate definition and further data would be welcome.

We reviewed our experience on the surgical treatment of stenosis in patent and thrombosed native, mature forearm AVFs and evaluated the outcome of two widely-used surgical procedures, i.e. the conventional creation of a new proximal anastomosis (NEO) vs the interposition of a PTFE graft to replace the excised stenotic segment (GI).

Subjects and methods

This is an observational survey analysing data collected prospectively between June 1999 and December 2006 at the General and Vascular Surgery Department and Haemodialysis Unit, Division of Nephrology, Ospedale Policlinico in Verona, Italy. All subjects gave their informed consent to the study protocol.

Access eligibility

During the study period, 84 patent forearm AVFs (from 83 patients) with angiographically proven significant (>50%) venous stenosis underwent repair. Stenosis was identified on the strength of a surveillance programme based on clinical monitoring, the recording of dialysis arterial and venous pressures and blood pump flow rate (Qb) at each dialysis session and the measurement of access blood flow rate (Qa) by the ultrasound dilution method with a Transonic HDI 5000 machine (Royal Philips Electronics, the Netherlands) from January 2001 onwards. Linear 7.5 MHz (AU4), 7.5–12 MHz and 10–17 MHz (HDI 5000) electronic probes were used. The site of stenosis was documented intra-operatively by inspection; stenosis was located in the juxta-anastomotic area in 27 AVFs and in the needling area in four.

Intervention modalities

In patent AVFs, surgery was performed under axillary plexus anaesthesia and consisted of either creating a new anastomosis a few centimetres above to the venous stenotic segment (NEO), or inserting a PTFE interposition graft to replace the stenosed venous segment. The NEO was created using the (artery) side to (vein) end technique and a 6/0 or 7/0 polypropylene suture. The PTFE grafts (C. R. Bard, Murray Hill, New Jersey, USA or W. L. Gore & Associates, Flagstaff, Arizona USA) were 3–11 cm long and 5–7 mm in diameter (depending on the size of the native vessel). Arteriovenous grafts were used for juxta-anastomotic lesions (with side-to-end arterial and end-to-end venous anastomosis) and veno-venous grafts were used for lesions within the body of the access (with two end-to-end anastomoses). A 6/0 polypropylene suture was used in all cases. The shorter grafts (<4 cm) were not used for cannulation, while those >4 cm could be used for needling. The type of treatment was chosen case-by-case at the discretion of the attending surgeon and nephrologist, the arterio-venous jump graft being the preferred procedure whenever the NEO was expected to reduce the length of the vein suitable for cannulation by >6 cm.

Thrombectomy was performed for clotted AVFs via a small incision near the anastomosis, removing the clot with Fogarty catheters and correcting of underlying stenosis by means of a more proximal NEO or a GI. All clotted AVFs were operated within 72 h of their detection. The criteria for selecting one technique or the other were much the same as for the pre-emptively treated cases. Restoration of access flow was assessed intra-operatively by physical examination.

Anatomic success was evaluated by a post-procedure angiogram within two weeks of the operation. Fistulography and angioplasty were performed as explained elsewhere [27]. The haemodynamic effect of treatment was evaluated by a post-procedure Qa measurement within 2 weeks of the operation.

Surveillance for restenosis

After successful correction of the stenosis, all AVFs joined a restenosis surveillance programme, monitoring access Qa every 3–4 months. Dialysis arterial and venous pressures and Qb were also monitored at every session and any increase in venous pressure or inability to achieve the prescribed Qb in at least two consecutive haemodialysis sessions prompted additional Qa measurements. All AVFs
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had at least one follow-up angiogram, due either to a drop in Qa > 25% or to a Qa < 750 ml/min, or when patency was measured. The Qa criteria for fistulography were chosen because of their excellent sensitivity (95%) in detecting stenosis in our hands [26].

Outcomes

The primary outcomes of the study were initial procedural success rate and post-intervention primary patency and they were defined according to the Sidawy et al. [28] criteria. A secondary outcome of the study was post-intervention cumulative patency. Stenosed and thrombosed AVFs were considered as having been successfully repaired if adequate dialysis could be resumed through the access within 48 h and a <30% residual stenosis was observed at the post-procedure angiogram. Post-intervention primary patency was defined as the interval between surgery and any re-intervention (surgical or endovascular) or thrombosis or access abandonment (due to conversion to a more proximal fistula or replacement by a PTFE graft or a permanent central venous catheter). Since pre-emptive re-intervention was always due to restenosis and there was always a restenosis episode behind any thrombosis or access abandonment, for the purpose of this study the post-intervention primary patency was considered as equating to the restenosis-free interval.

Post-intervention cumulative (or secondary) patency was defined as the interval between surgery or PTA and access loss (due to thrombosis, replacement by a PTFE graft or conversion to a more proximal fistula), including all surgical and endovascular measures designed to maintain or re-establish patency. Subjects were censored due to death or transplantation, or if they ended the study with an event-free access. Outcomes also were expressed as rates (restenosis and access loss rates). Population restenosis and access loss rates were calculated by dividing the number of events by the total number of years of access follow-up and presented as events/AVF-year.

Statistical analyses

Data are given as percentages, means ± SD and medians (range or 5–95 percentile), as appropriate. Primary patency rates were calculated according to the Kaplan–Meier method. Cox’s multivariate proportional hazard regression model was used to identify variables associated with outcome. Since ours is a descriptive study, no comparisons were performed between different patient groups. Statistical analyses were performed using the SPSS software, rel.11 (SPSS, Chicago, IL, USA).

Results

The characteristics of the patients and stenosed AVFs involved in the study are given in Tables 1 and 2, respectively. Study participants and outcomes are shown in (Figure 1).

The procedural success rate was 92.2%, i.e. 100% for patent (32/32) and 84.4% for thrombosed AVFs (27/32). Four clotted AVFs were considered unsalvageable due to the extensive organization of the thrombus and/or inadequate forearm veins. One AVF was successfully repaired but proved unable to assure dialysis due to early re-thrombosis and was consequently abandoned.

Stenosis was corrected by proximal NEO in 27 AVFs (12 patent and 15 thrombosed) and by GI in 32 (20 patent and 12 thrombosed) (Figure 1).

The median procedure time was 76 min (range 35–170 min) for pre-emptive access revision and 127 min (range 45–195 min) for surgery after thrombosis. The median procedure time was 100 min (range 35–195) for NEO and 116 min (range 45–190) for GI. No major complications, such as infection, intraoperative bleeding sufficient to require blood transfusion and grade 2 or 3 haematoma [29], were observed

### Table 1. Patients’ characteristics

<table>
<thead>
<tr>
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</tr>
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<tbody>
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<td>Number of patients</td>
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</tr>
<tr>
<td>Gender (male/female)</td>
<td>39/25</td>
</tr>
<tr>
<td>Patient age (years)</td>
<td>62 ± 13</td>
</tr>
<tr>
<td>Proportion of diabetics (%)</td>
<td>18.7</td>
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<td>Proportion with cardiovascular disease (%)</td>
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### Table 2. AVFs’ characteristics

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Fistula age * (months)</td>
<td>21.4 ± 17.7</td>
</tr>
<tr>
<td>Anastomosis site (wrist/mid-forearm)</td>
<td>48/16</td>
</tr>
<tr>
<td>Proportion of juxta-anastomotic venous stenoses (%)</td>
<td>87.5</td>
</tr>
<tr>
<td>Proportion of multiple stenoses (%)</td>
<td>26.5</td>
</tr>
<tr>
<td>Proportion of long stenoses (&gt;2.5 cm) (%)</td>
<td>37.5</td>
</tr>
<tr>
<td>Proportion of associated arterial stenoses (%)</td>
<td>10.9</td>
</tr>
<tr>
<td>Patent/Thrombosed</td>
<td>32/32</td>
</tr>
</tbody>
</table>

*Defined as the interval between access construction and intervention.
after surgery. One case of grade 1 haematoma (requiring no surgery) was observed after NEO, however. No residual stenosis was documented at the post-procedure angiogram.

Successful treatment was associated with a significant increase in post-procedure Qa (within 2 weeks of the procedure): from $341\pm160$ to $817\pm297$ ml/min in patent AVFs, and from 0 to $887\pm191$ ml/min in thrombosed AVFs.

Twenty-one AVFs restenosed, 12 after pre-emptive surgery and nine after surgery following thrombosis. Restenosis was associated with thrombosis in four AVFs (one after pre-emptive surgery and three after surgery following thrombosis). Three of them were abandoned (one was converted in an elbow fistula and two were replaced with a PTFE graft), while one was successfully revised and stenosis was corrected by GI. Restenosis in patent AVFs was corrected surgically in five cases (two NEO, two GI and one conversion to an elbow fistula) and by PTA in 12. Median follow-up was 23 months (5–95 percentile: 14–33) in patent and 25 months (5–95 percentile: 10–31) in thrombosed AVFs.

Figure 2 shows the Kaplan–Meier curves of the unadjusted post-intervention primary patency (including initial failures) for patent and thrombosed AVFs.

The restenosis rate was 0.189 events/AVF-year for both groups and the access loss rate was 0.016 after pre-emptive surgery and 0.148 events/AVF-year after surgery following thrombosis.

The characteristics of the patients and fistulae that underwent NEO and GI are given in Table 3. Multiple or long venous stenoses were preferentially treated by GI, while NEO was the preferred treatment modality for venous stenoses associated with arterial stenoses.

NEO was associated with a minimal reduction of the needling area that did not change the nature of the access (median reduction 3 cm, range 2–6). No substantial loss of needling area (median reduction 0 cm, range 0–2) was observed after GI, since the longer grafts (>4 cm) were also used for cannulation.

Nine AVFs restenosed after NEO and 11 after GI. After NEO, the restenosis was located in the venous juxta-anastomotic area in eight cases and in the body of the access in one; after GI, it occurred in the venous outflow at or near the graft/vein anastomosis in nine cases and within the graft in two. Restenosis was associated with thrombosis in three AVFs (two after NEO and one after GI). Two of these accesses were abandoned (one substituted by a PTFE graft and one converted to an elbow fistula), while one was successfully retrieved by means of a GI. Restenosis in patent AVFs was corrected by PTA in 12 cases (three NEO and the nine AVFs that restenosed at the graft-vein anastomosis or the venous outflow after GI) and by surgery in five cases (two NEO, two GI and one conversion to an elbow fistula).

The median follow-up was 24 months [5–95 percentile: 20–33] for NEO and 17 months [5–95 percentile: 15–28] for GI. Figure 3 shows the Kaplan–Meier curves of the unadjusted post-intervention primary patency after proximal NEO and GI for stenosis repair. Closed circles indicate GI and open triangles indicate those treated following thrombosis.
patencies for the two techniques. The restenosis rate and the access loss rate were 0.051 and 0.033 events/AVF-year after NEO and 0.214 and 0.019 events/AVF-year after GI.

At Cox’s hazard analysis, none of the variables considered (gender, age of patients and AVF, diabetes and cardiovascular disease, location of anastomosis, surgical technique, timing of intervention, or post-treatment Qu) were significantly associated with restenosis, while the timing of intervention was the only significant determinant of access loss (repaired clotted AVFs carrying an 8.0-fold relative risk of access loss (95% confidence interval: 1.03–66.67) vs pre-emptively treated accesses, \( P = 0.048 \)).

During the study period, stenosis was corrected by PTA in 52 patent AVFs from 52 patients (31 males and 21 females, aged 60.0 ± 13.6 years). Stenoses were located in the juxta-anastomotic area in 46 AVFs and within the body of the access in six. The procedural success rate was 94.2% (49/52). The median follow-up was 19 months [5–95 percentile: 4–40]. Thirty-three AVFs (67.3%) restenosed during follow-up, for a total number of 51 restenoses and a restenosis rate of 0.539 events/AVF-year. Twenty-five restenosed AVFs were treated endovascularly for a total number of 38 repeat PTA. Five AVFs underwent pre-emptive surgical revision, two were replaced by a PTFE graft and one was transformed in an elbow fistula. Three AVFs thrombosed and were replaced by a PTFE graft or a Tesio catheter. The access loss rate was 0.063 events/AVF-year. At Cox’s multivariate hazard analysis, PTA was associated with a 3.5-fold relative risk of restenosis (95% confidence interval: 1.6–7.6) compared with NEO (\( P = 0.001 \)) and a 2.6-fold relative risk of restenosis (95% confidence interval: 1.3–5.3) compared with IG (\( P = 0.01 \)).

**Discussion**

Though many experts prefer surgery for treating stenosed and thrombosed distal forearm AVFs, the literature on its outcome is limited [2,6–18,25] (Table 4) and its role, ideal timing and method warrant further investigation. By showing that surgical repair of stenosed and thrombosed forearm AVFs has excellent initial success and low restenosis rates, our prospective study confirms that surgery remains a valid option for treating stenosis in forearm AVFs. We also confirmed that it is better to treat stenosis in patent than in clotted AVFs (though the restenosis rate seemed to be unaffected by the timing of intervention) and show that two widely used surgical techniques, proximal NEO and PTFE GI, both produce excellent results.

Our 92% initial success rate (100% in patent and 84% in thrombosed AVFs) compares favourably with the literature, which reports success rates of 100% or thereabouts for pre-emptive surgery [9,10] and from 38% to 100% in failing and thrombosed AVFs [2,6–8,11–18,25] (Table 4). Our initial success rates also compare favourably with those of interventional radiology, which is 89–98% for patent [3,4,19,22,24,29] and 75–100% for thrombosed AVFs [4,19–21,29], indicating that surgery remains an excellent alternative for salvaging clotted AVFs (especially when a skilled interventional radiologist is unavailable). In addition, our finding that the success rate of stenosis correction after thrombosis was significantly lower than in patent AVFs and was associated with an increased risk of access loss supports current recommendations that stenosis be corrected before the onset of thrombosis [1].

Our 1-year post-intervention primary patency rate of 81 ± 5% (89 ± 6% for pre-emptive surgery and 73 ± 8% for surgery following thrombosis) compares favourably with reported 1-year primary and cumulative patency rates of 19–95% for surgically treated failing and thrombosed forearm AVFs [2,6,7,10–14,16–18] (Table 4). Primary patency rates in our study also appear to be superior to virtually all those reported in endovascular series, which are 25–68% for patent [3,4,19,23,24,27] and 24–70% for thrombosed AVFs [4,19–21].

Thrombosis and access loss after surgical repair of stenosis were rare in our study (3/57 AVFs, corresponding to a post-treatment thrombosis and access loss rate of 0.027 events/AVF-year): this is probably thanks to the combination of the relatively low restenosis rate after surgery and the use of a strict surveillance programme (based on regular QA assessment) enabling the early and accurate identification of restenosis and its pre-emptive correction.

A variety of surgical techniques are available for managing uncomplicated venous stenosis in AVFs [2,6–18]. In the case of isolated and short (<1 cm) stenoses, resection of the stenotic segment is followed by veno-venous end-to-end anastomosis, or patch angioplasty is performed inserting a small patch of native vein or prosthetic material to widen the choked lumen. In the case of stenoses >1 cm and multiple stenoses, the most widely used method involves creating a more proximal NEO. This procedure involves minimal intimal trauma and can be performed under local anaesthesia. It may, however, have the drawback of sacrificing a long segment of the vein suitable for continued cannulation and extending the access further up in the arm, with the permanent loss of more proximal future access sites. An alternative strategy consists in replacing the resected stenotic segment with a PTFE interposition graft. This procedure has the advantage of better preserving the cannulation area and the venous capital available for future proximal access sites, but it carries the added risk of stenosis at the venous outflow and/or the graft/vein and graft/artery anastomoses [11,24] and many surgeons have been reluctant to use it for fear of disappointing results.

It is only recently that the GI technique has been prospectively compared with autologous repair in stenosed and thrombosed AVFs [17,18] and conflicting data are provided on post-intervention cumulative patencies between the two. The authors also failed to
## Table 4. Outcomes of surgical repair of stenosed (patent and failing) and thrombosed AVFs

<table>
<thead>
<tr>
<th>Author [ref.]</th>
<th>AVF type</th>
<th>$n$</th>
<th>Condition before revision</th>
<th>Type of intervention</th>
<th>Initial success rate (%)</th>
<th>1-year primary patency (%)</th>
<th>1-year cumulative patency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palder et al. [6]</td>
<td>Forearm</td>
<td>16</td>
<td>Thrombosed</td>
<td>Thrombectomy ± proximal NEO</td>
<td>100</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Kherlahian et al. [8]</td>
<td>Forearm: wrist</td>
<td>29</td>
<td>Thrombosed</td>
<td>Thrombectomy ± PTFE GI</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Romero et al. [7]</td>
<td>Forearm</td>
<td>26</td>
<td>Thrombosed</td>
<td>Proximal NEO/vein interposition</td>
<td>100</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Dapunt et al. [16]</td>
<td>Forearm</td>
<td>22</td>
<td>Failing and thrombosed</td>
<td>Thrombectomy + grafting/vein interposition/PTFE GI</td>
<td>84</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Pagano et al. [9]</td>
<td>Forearm</td>
<td>9</td>
<td>Failing</td>
<td>Proximal NEO/vein interposition</td>
<td>89</td>
<td></td>
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</tr>
<tr>
<td>Hingorani et al. [10]</td>
<td>Forearm and upperarm</td>
<td>49</td>
<td>Failing</td>
<td>Proximal NEO (n = 17)</td>
<td>100</td>
<td>89</td>
<td>80</td>
</tr>
<tr>
<td>Murphy et al. [11]</td>
<td>Elbow</td>
<td>22</td>
<td>Failing and thrombosed</td>
<td>Proximal NEO/PTFE GI/vein patch</td>
<td>82</td>
<td>56</td>
<td></td>
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<tr>
<td>Morosetti et al. [14]</td>
<td>Distal forearm</td>
<td>17</td>
<td>Thrombosed</td>
<td>Proximal NEO</td>
<td>82</td>
<td></td>
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</tr>
<tr>
<td>Tracy et al. [17]</td>
<td>Forearm &amp; upperarm</td>
<td>49</td>
<td>Failing &amp; thrombosed</td>
<td>Saphenous vein (n = 28) and PTFE graft interposition (n = 21)</td>
<td>64%</td>
<td></td>
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<tr>
<td>Mickley et al. [12]</td>
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<td>30</td>
<td>Failing and thrombosed</td>
<td>Proximal NEO</td>
<td>80</td>
<td>95</td>
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<tr>
<td>Georgiadi et al. [17]</td>
<td>Forearm and upperarm</td>
<td>59</td>
<td>Failing and thrombosed</td>
<td>PTFE GI (n = 30)</td>
<td>100</td>
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<td>34</td>
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<tr>
<td>Karakayali et al. [24]</td>
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<td>29</td>
<td>Thrombosed</td>
<td>Thrombectomy/thrombectomy + NEO or PTFE GI</td>
<td>87</td>
<td>75</td>
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<td>Present study</td>
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<td>64</td>
<td>Patent and thrombosed</td>
<td>Thrombectomy/thrombectomy + NEO or PTFE GI</td>
<td>87</td>
<td>75</td>
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<tr>
<td></td>
<td>Forearm</td>
<td></td>
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<td>52</td>
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<td></td>
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<td>Proximal NEO/PTFE GI</td>
<td>92</td>
<td>79</td>
<td>88</td>
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<td></td>
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<td>Proximal NEO (n = 27)</td>
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<td>88</td>
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<tr>
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<td></td>
<td></td>
<td>PTFE GI (n = 32)</td>
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<td>85</td>
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address the specific issue of whether the PTFE graft was associated with a higher risk of restenosis than autologous repair of stenosed AVFs.

The results of our study evaluating the outcome of proximal NEO and the GI in a population of stenosed AVFs, are consistent with those of Georgiadis et al. [18] by showing that the two techniques not only had access patencies comparable with said study but also equally low restenosis rates.

In addition, the 85 ± 7% 1-year post-intervention primary patency observed in our study for GI was better than all reported 1-year primary patency rates in endovascular series [3,4,19–21,23,24,27] and the 54 ± 8% 1-year primary patency rate of our contemporary group of stenosed AVFs treated by PTA. Moreover, in our hands, PTA showed a 2.5-fold adjusted relative risk for restenosis compared with GI.

Our findings provide no ground for the concern that GI may be associated with a higher complications rate [11,24], suggesting instead that GI may be the treatment of choice for stenosis in forearm AVFs. In fact, GI offers the advantage of a more limited loss of the cannulation area by comparison with the traditional NEO (while sharing the benefit of a low restenosis rate) and a lower restenosis and re-intervention rate than after PTA (while sharing the benefit of a better preservation of the venous capital). This impression should be considered with caution, however, because ours was an observational, single-centre, non-randomized study.

In conclusion, our study confirms that surgery is a suitable method for repairing stenosis in patent and thrombosed forearm AVFs, with an excellent initial success rate and primary post-intervention patency, the latter being superior to that of interventional radiology. We have also shown that the majority of thrombosed AVFs can be salvaged surgically, and the restenosis rate of repaired clotted AVFs is much the same as for pre-emptively treated accesses, though the access loss rate was worse in thrombosed than pre-emptively treated AVFs, largely due to the lower initial success rate of stenosis correction after thrombosis. Finally, in our hands, the results of GI compared favourably with those of traditional proximal NEO.

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