Liposuction to improve vascular access in hemodialysis patients with arteriovenous fistulas

Sanjna Rajput, BS,a Randall DeMartino, MD, MS,b Bernardo Mendes, MD,b and Basel Sharaf, MD, DDS,c Rochester, MN

ABSTRACT

Background: Arteriovenous fistulas (AVFs) are indispensable in the care of patients with end-stage renal disease requiring hemodialysis. Obesity is a common comorbidity in hemodialysis patients, often making AVF cannulation technically challenging. Liposuction can be performed for superficialization of the AVF without the need for an open superficialization procedure. The aim of the present study was to evaluate the outcomes of liposuction to improve AVF access for hemodialysis.

Methods: We performed a retrospective medical record review of patients who had undergone liposuction over an AVF at our institution from January 2000 to September 2021. Data were collected on the demographics, medical comorbidities, AVF site and depth, AVF diameter and flow, operative details, surgical complications, and follow-up.

Results: A total of 19 patients had been referred by the hemodialysis clinic for liposuction. Their mean age was 55.5 years, and their mean body mass index was 39.5 kg/m². Either liposuction alone or liposuction combined with minimal access direct lipectomy was performed to superficialize the AVF. All procedures were performed secondarily, after prior creation of the AVF. Of the 19 patients, 18 had had an upper AVF and 1 had had a lower extremity AVF graft. Of the 19 patients, 12 (63%) had proceeded to hemodialysis after one liposuction. The mean time to cannulation for 10 of these 12 patients was 52.1 ± 25.6 days. Two of the 12 patients were excluded from the mean calculation to prevent skewing from their prolonged time to requiring dialysis initiation. Of the 19 patients, 2 had required additional liposuction sessions, and 1 had required AVF intervention after the first liposuction attempt before achieving successful cannulation. Four patients (21%) had had unsuccessful cannulation despite additional liposuction or AVF interventions owing to AVF stenosis or thrombosis. Overall, 15 of the 19 patients (79%) had successfully proceeded to dialysis in the same extremity. The access depth had decreased from 1.75 cm before liposuction to 0.93 cm after liposuction. The mean volume of fat removed was 92.3 cm³. Of the 16 patients with prior dialysis catheters, 11 were eventually removed after surgery once the vascular site was accessible. The body mass index correlated positively with the interval to the first successful cannulation (r = 0.588; P < .05). The surgical complications included two cases of cellulitis treated with oral antibiotics. The mean follow-up time was 38.3 months.

Conclusions: Our results have shown that liposuction can be performed safely in obese patients requiring hemodialysis and was successful in improved AVF access for 15 of the 19 patients (79%) in our cohort. Larger studies are needed to compare the outcomes of this technique with those of open superficialization.

Keywords: Arteriovenous fistula; Hemodialysis; Lipectomy; Liposuction; Obesity; Superficialization

The prevalence of obesity, defined as a body mass index (BMI) of ≥30 kg/m², is particularly high in patients with end-stage renal disease (ESRD) and was estimated at 42.8% in 2016.1,2 Given that obesity is often a contraindication for renal transplant,3 most patients with ESRD who are obese will require hemodialysis to prolong survival.4

Arteriovenous fistulas (AVFs) are created for patients with ESRD to provide vascular access for hemodialysis, because a large proportion of these patients will require ongoing hemodialysis. Obesity increases the difficulty in accessing these AVFs owing to the presence of excess adipose tissue over the surgically created AVF. This difficulty in cannulation of the AVF can result in fistula infiltration, hematoma or thrombosis formation, and a continued requirement for central catheters.5-11

Up to 33.7% of AVFs could require surgical superficialization to facilitate vascular access.6 This requires a longer incision and dissection of the AVF, increasing the risks of surgical site infection. Also, the time required for wound healing will delay the time to access in a patient population with other comorbidities. Other techniques used have included fat debulking (lipectomy) using minimal access incisions or liposuction, or both.6-15
Liposuction offers a less invasive alternative method of superficialization of AVFs in obese patients. The procedure requires smaller incisions, can be performed with the patient under light sedation, and might result in speedier recovery than an open procedure. The literature on this approach has primarily consisted of case reports and studies with smaller cohorts. To the best of our knowledge, the present study has included the largest cohort to date of hemodialysis patients undergoing AVF superficialization via a liposuction technique. We have reported a potential solution to an increasing issue for hemodialysis patients with morbid obesity and multiple comorbidities, who, despite the creation of an AVF, will not be able to undergo hemodialysis owing to the local anatomy and increased subcutaneous fat. Our goal was to highlight the safety and feasibility of a multidisciplinary approach, including a plastic surgeon and vascular surgeon, to help this unique patient population proceed to successful lifesaving hemodialysis. We sought to determine the efficacy and safety of the liposuction technique to access underlying AVFs. These findings could help broaden our understanding about whether liposuction is a feasible and reliable technique for hemodialysis access in the ESRD patient population with multiple comorbidities. The patients provided written informed consent for the report of their vascular images.

METHODS

After receiving approval from the institutional review board, the electronic health record system at our institution was queried to identify all patients who had undergone liposuction (alone or combined with minimally invasive lipectomy) with an incision of <2 cm) to improve AVF access at the Mayo Clinic (Rochester, MN) from January 2000 to September 2021. All patients had been referred to plastic surgery by the dialysis clinic after consultation with the vascular surgeon and after AVF access for hemodialysis had failed. The data collected included the general patient demographics and medical comorbidities. The location of the AVF, AVF access depth before and after liposuction, and AVF diameter and flow were collected. The depth was calculated by recording the mean value of five equidistant locations along the AVF length to estimate the AVF depth below the skin. Operative details, including the liposuction cannula size and amount of fat removed, were also collected. The diameter and flow dynamics of the AVFs were also recorded. Postoperative complications, including hematoma, skin necrosis, infection, seroma, and limb edema, were also reviewed. Follow-up data on the frequency, duration, removal of the tunneled dialysis catheter, and additional requirements for AVF intervention were also collected. The primary outcome examined was successful cannulation of the AVF for hemodialysis after a single liposuction session or combination of liposuction and a minimally invasive lipectomy procedure. Descriptive statistics, including the mean value and tests of correlation and significance, were performed.

Surgical procedure. All liposuction and combined liposuction and minimally invasive lipectomy procedures were performed by an experienced plastic surgeon. All the procedures were performed with a vascular surgeon available if needed. All the procedures were performed in the operating room with the presence of anesthesiologists or certified anesthesiologists and the understanding that conversion to general anesthesia could be required if the patient could not tolerate the procedure with tumescence anesthesia and intravenous sedation.

All the patients had undergone ultrasound evaluation of arterial inflow and venous outflow and the subcutaneous fat thickness (distance from the skin surface to the AVF) before undergoing liposuction. The depth was measured at five equidistant locations along the length of the AVF. All the patients had undergone intraoperative ultrasound to confirm the path of the AVF and the depth of the AVF from the skin surface. Infiltration with tumescence Klein solution was used in the area of intended liposuction. This allowed for a vasoconstriction effect to minimize bleeding.

The liposuction cannula used was typically 3 mm in diameter, and all liposuction procedures were performed using a single-hole tulip cannula. During liposuction, the opening of the tulip cannula was directed toward the skin surface and away from the AVF to minimize injury to the AVF, treating only the subcutaneous plane. Wide undermining was also avoided because only the skin zone underlying the AVF needed treatment and was confirmed intraoperatively with ultrasound. Depending on the subcutaneous thickness above the AVF, some areas of the AVF were <1.5 cm deep and others along the AVF path were >1.5 cm deep. A combination of liposuction and minimal incision lipectomy was used if necessary when the depth of the AVF was <1.5 cm. Liposuction alone was primarily performed for patients with an AVF depth of >1.5 cm. When minimally invasive lipectomy was performed with liposuction, the incision was always <2 cm and was performed using a very narrow lighted retractor to help visualize the anatomy subcutaneously. Hemostasis was confirmed using bipolar cautery or vascular hemoclips.

All the patients who had undergone liposuction or liposuction combined with limited incision direct lipectomy had had a 0.25-in. Penrose drain placed in the area of liposuction to minimize the risk of seroma by allowing for egress of serous fluid. The drain was typically removed within 1 week. All the patients had also had a gentle elastic wrap placed from the hand to the upper arm postoperatively. The gentle wrap was applied for 5 to 7 days. All patients had undergone follow-up with the plastic surgery clinic ~5 to 7 days postoperatively for Penrose drain removal and evaluation of the wound. At
the follow-up visits, ultrasound was used to monitor the depth, diameter, and flow dynamics of the access site. The patients returned to their routine dialysis schedule after the surgery.

**RESULTS**

A total of 20 patients had been referred by the hemodialysis clinic for liposuction. One patient was referred for liposuction before requiring hemodialysis and was excluded from the present cohort because the patient had not had any attempts at cannulation performed at the latest follow-up. Of the 19 patients included, 17 (89%) were women and 2 (11%) were men. The mean age was 55.5 years, and mean BMI was 39.5 kg/m². Most of the patients were in the higher obesity classes, including 42% in class III and 31.6% in class II. A higher BMI was significantly associated with an increased interval to the first successful cannulation ($r = 0.5881; P < .05$). More than 58% of the patients had had multiple comorbidities such as diabetes, hypertension, and coronary artery disease. Of the 19 patients, 6 (32%) had had a history of deep vein thrombosis, and 15 (79%) were receiving antplatelet therapy. A detailed summary of the demographic data is presented in Table I.

All liposuction procedures were performed after prior creation of the AVF (Fig 1). Of the 19 patients, 18 had an upper AVF and 1 a lower extremity AVF graft. The AVF type included 14 brachiocephalic, 1 radiocephalic, 1 brachiobasilic, 1 brachioaxillary, 1 axilloaxillary, and 1 femoral loop graft. Of the 19 procedures, 6 were a combination of liposuction and minimally invasive lipectomy and 13 were liposuction alone. The procedure was performed with the patient under sedation with local anesthesia for 10 of the 19 patients (52.6%). The liposuction cannula size ranged from 3 to 4.6 mm. The mean volume of fat removed was 92.3 cm³ (Fig 2). All the patients had undergone ultrasound evaluation of the AVF arterial inflow and venous outflow and depth of the AVF from the skin surface before liposuction. The AVF depth before liposuction ranged from 0.9 to 3.1 cm (mean, 1.74 cm). A significant decrease ($P < .001$) occurred in the AVF depth to a mean of 0.94 cm after liposuction, with the postoperative values ranging from 0.4 to 1.55 cm. Four patients had had a decrease of <0.5 cm in depth, five patients had had a decrease of 0.5 to 1 cm, and six patients had had a decrease of ≥1 cm. The AVF diameter and flow had increased after liposuction but neither was significant ($P < .193$ and $P < .339$ respectively; Table II).

**Table I.** Demographic findings (N = 19)

| Demographics                      | Value |
|-----------------------------------|-------|
| **Sex**                           |       |
| Male                              | 2 (11) |
| Female                            | 17 (89)|
| **Age at liposuction, years**     |       |
| Mean                              | 55.5  |
| Range                             | 31-85 |
| **Body mass index, kg/m²**        |       |
| Mean                              | 39.5  |
| Range                             | 21.9-51.9 |
| **Comorbidities**                 |       |
| Diabetes                          | 13 (68.4) |
| Hypertension                      | 18 (94.7) |
| Cardiovascular disease            | 14 (73.7) |
| Venous thromboembolism            | 6 (31.6) |
| Anticoagulation therapy           | 15 (78.9) |
| Aspirin                           | 5 (26.3) |
| Warfarin/Xa inhibitor             | 10 (52.6) |
| **Vascular access location**      |       |
| Upper extremity                   | 18 (94.7) |
| Brachioccephalic                  | 14 (73.7) |
| Radiocephalic                     | 1 (5.3) |
| Brachiobasilic                    | 1 (5.3) |
| Brachioaxillary                   | 1 (5.3) |
| Axilloaxillary                    | 1 (5.3) |
| Lower extremity                   |       |
| Femoral loop graft                | 1 (5.3) |
| Dialysis with dialysis catheter   | 16 (84.2) |

Data presented as number (%), unless noted otherwise.
Of the 19 patients, 12 (63%) had successfully proceeded to hemodialysis after one liposuction. The mean time to cannulation for 10 of these 12 patients was 52.1 ± 25.6 days; 2 patients had not required hemodialysis initiation until >1 year after liposuction. Therefore, their time to cannulation was not included in the analysis. One of these two patients had had chronic kidney disease stage 5 secondary to focal segmental glomerulosclerosis and was followed up by our nephrology team for impending renal decline and uremia, which did not occur for multiple years after creation of the AVF. The second patient had had chronic kidney disease stage 4 secondary to autosomal dominant polycystic kidney disease. That patient’s progressive renal decline was seen as an indication for impending dialysis for which the AVF was created but also was not needed until 2 years later. However, both patients had achieved successful cannulation for hemodialysis at the first attempt. Of the 12 patients with successful dialysis after one liposuction session, 2 had required additional liposuction at a later time because of weight gain. Additionally, two patients had required two liposuction procedures before cannulation; their mean time to cannulation was 203.5 days. One patient had required balloon angioplasty of the AVF after the first liposuction procedure before achieving successful cannulation. That patient’s time to cannulation was 130 days. For four patients (21%), the cannulation was unsuccessful owing to AVF stenosis or thrombosis despite additional liposuction or AVF interventions (Tables III and IV). Three of these four patients with failed cannulation had had a postoperative depth of <1 cm, with a mean depth of 6.3 mm. One of these four patients had undergone an additional liposuction procedure 3 months after the first liposuction session, with a postoperative depth of 0.78 cm. These patients continued dialysis via a central dialysis catheter.

Overall, 15 of the 19 patients (79%) had successfully proceeded to dialysis using the intended AVF site. Of the 16 patients with a prior dialysis catheter, 11 had undergone removal after liposuction once the vascular site was accessible, and 5 patients had continued dialysis with a central dialysis catheter, 4 of whom were the patients with unsuccessful cannulation. One patient who had successfully undergone six dialysis sessions through the AVF after a second liposuction procedure developed AVF infiltration, with a subsequent decision made to rest the AVF and perform dialysis via a central catheter. However, when the AVF was noted to likely have successfully healed from the overlying tenderness and bruising, the patient was hesitant and unwilling to use the AVF again and died shortly thereafter.

Surgical complications from the liposuction procedure were limited to two cases of cellulitis, which were treated with oral antibiotics. All the patients had experienced mild bruising, as expected. No cases of postoperative hematoma, seroma, skin necrosis, or significant limb edema had developed. The mean follow-up time was 38.3 months.

**DISCUSSION**

Obesity is prevalent throughout the world, as well as in the United States, with as much as 42.4% of society affected in 2017 to 2018. Obesity has been reported to be an independent risk factor for failure of AVFs in patients requiring hemodialysis. Obese patients with ESRD present with additional challenges to achieve hemodialysis owing to the excess adipose tissue over the AVF, making cannulation success lower.

The rule of 6 outlines certain numerical guidelines for the maturation of AVFs, including a depth below the skin of <6 mm, a diameter >6 mm, and a flow >600 mL/min. Because obese patients with ESRD will often have an AVF depth that is >6 mm from the skin surface, superficialization procedures will be required over the AVF site to make it accessible for cannulation. Traditional superficialization procedures have included AVF transposition, AVF vein elevation, and direct lipectomy. These procedures will typically require longer skin incisions, dissection of the AVF, ligation of side branches, and movement of the vein, affecting the angle and torsion of the vessel. Liposuction or a combination of liposuction and minimally invasive lipectomy with an incision <2 cm offers an alternative to the traditional approaches.
All the patients in our cohort had been referred to plastic surgery after consultation with the vascular surgery team because of failure of AVF access in the dialysis clinic. The patients were referred in an attempt to use a less invasive procedure to increase cannulation success of the AVF. Our hope was to avoid a more invasive procedure and the potentially higher risk of wound healing complications and longer recovery for this medically complex patient population.

A significant benefit of the liposuction technique is less tissue dissection, smaller incisions, a lower risk of wound healing complications, and a potentially faster recovery. Previous case reports and smaller cohort studies have reported liposuction to be an effective and well-tolerated technique with a lower complication profile.\textsuperscript{8,9,11,16-18} Our cohort’s findings are reflective of this, with AVF cannulation successful in 79% of patients, with minor complications that were medically managed. We did not encounter any postoperative hematomas in our series using the technique of infiltration with tumescent Klein solution in the area of intended liposuction, which allowed for a vasoconstriction effect to minimize bleeding. The use of intraoperative ultrasound to confirm the residual depth of the AVF during liposuction improved the safety profile of this procedure. Additionally, minimally invasive superficialization was associated with the removal of tunneled dialysis catheters, which was achieved for 69% of the patients with a preexisting catheter.

The traditional approach would be to perform a more extensive fat debulking procedure that would typically require general anesthesia and could be associated with greater wound healing complications. Of the procedures performed in our cohort, 52.6% had been performed with the patient under minimal sedation. The tumescent solution contains a local anesthetic, making the liposuction procedure tolerable with minimal sedation. In our cohort, the decision for general vs local anesthesia was determined by patient factors, surgeon preference, and anesthesia recommendations. General anesthesia was chosen for patients with atypical AVF fistula sites such as our patient with a brachioaxillary AVF, because it would likely have been difficult to tolerate with local anesthesia alone. Additionally, the transition to performing the procedure with the patient under local anesthesia resulted in a learning curve as our surgical team became more comfortable and acquired more experience with local sedation and tumescent anesthesia. Local anesthesia with minimal sedation has, therefore, been the choice for most of the procedures performed in the later study period for the present cohort.

Debulking of the subcutaneous tract can be considered by the vascular surgery team at AVF creation. However, this can increase the risk of wound healing complications. Overthinning of the subcutaneous fat can compromise the blood supply to the wound edges, leading to wound healing complications in this patient population with known medical comorbidities.

Although the increase in the diameter and flow rate in our cohort was not significant, we found a significant decrease in the depth of the AVF from the skin surface by the removal of the overlying adipose tissue, which allowed for adequate access to the AVF for hemodialysis. The minimal increase in diameter observed in our study could have resulted from the reduction of adipose tissue weight on the AVF, which created additional scar tissue between the AVF and the skin, or from ultrasound measurement standard errors.

Although the ideal postoperative depth according the rule of 6 would be 6 mm, multiple factors were considered when determining the goal for the subcutaneous depth at the end of the procedure. The tumescent solution used for vasoconstriction will typically lead to tissue swelling, especially intraoperatively. Thus, our goal intraoperative depth, considering both the intraoperative

| Measure                                      | Value  |
|----------------------------------------------|--------|
| Mean access depth, mm                        | 17.4   |
| Before liposuction                            | 9.4    |
| Mean decrease                                | 8 (P < .001) |
| Mean access vessel diameter, mm              | 6.7    |
| Before liposuction                            | 8.9    |
| Mean decrease                                | 2 (P < .195) |
| Mean access vessel flow, mL/min              | 1174.9 |
| Before liposuction                            | 1398.4 |
| Mean decrease                                | 223.5 (P < .339) |

| Successful cannulation | Value  |
|------------------------|--------|
| After one liposuction procedures, No. | 12     |
| Mean time to cannulation, days         | 52.1*  |
| After two liposuction procedures, No.  | 2      |
| Mean time to cannulation, days         | 203.5  |
| After one liposuction + AVF intervention, No. | 1      |
| Mean time to cannulation, days         | 130    |
| Unsuccessful cannulation, No.           | 4      |

*Two patients did not require initiation of dialysis until >1 year after liposuction; therefore, their time to cannulation was not included in the mean calculation to prevent skewing; both achieved successful dialysis immediately on eventual initiation.
swelling and estimated postoperative scarring once healed, was <1 cm. Additionally, balancing the reduction of the subcutaneous thickness and protecting the safety of the AVF was an important consideration for not attempting to continue the procedure until the depth was at theoretical ideal of 6 mm immediately postoperatively. To protect the AVF from injury, a combination of liposuction and minimal incision lipectomy was used if necessary when the depth of the AVF was <1.5 cm for better visualization using a narrow lighted retractor. For patients with an AVF depth >1.5 cm, liposuction was primarily used because injury to the AVF was deemed less of a concern.

Only two patients had required an additional liposuction procedure and one had required balloon angioplasty intervention before achieving dialysis access. The patients who had required two liposuction procedures had had a preoperative AVF depth in the higher range of 1.9 to 2 cm. The patient who had required an AVF intervention had undergone a combination of liposuction and superficial lipectomy. However, a juxta-anastomotic stenosis in the AVF had required balloon angioplasty before successful cannulation. This was likely a function of the AVF itself with regard to flow dynamics and patency and was unrelated to the liposuction procedure.

No intraoperative injuries had been reported by the senior author for any of the procedures. The liposuction procedure was performed between the skin surface and the AVF, not circumferentially around the AVF. The medial, lateral, and deep tissue were not in the area of liposuction, because the liposuction was limited to the subcutaneous fat superficial to the AVF. It was, therefore, unlikely for liposuction to have caused a scar band to form that circumferential dissection with traditional superficialization would involve. However, many of the patients in our cohort had undergone multiple attempts at cannulation for dialysis access, typically three times per week. Thus, some might have had a borderline AVF hemodynamic flow velocity that might eventually have caused stenosis and the need for intervention at the AVF. This highlights the importance of confirming the presence of adequate AVF flow dynamics before attempting liposuction, because the latter will not be sufficient in the setting of a low flow state or stenosis.

Cannulation was not successful for four patients despite additional AVF interventions and liposuction. None of these patients had been offered traditional superficialization procedures and instead continued dialysis via a central dialysis catheter. Traditional superficialization remains an option after failed liposuction, as does a repeat attempt at liposuction vs lipectomy. The decision would be determined by the experience of the operators and their comfort with revisional attempts.

One of the four patients without successful cannulation was the single patient in our cohort with a brachiobasilic AVF. The liposuction procedure is typically ideal for radiocephalic, brachiocephalic, and brachiobasilic AVFs (if transposed). The brachiobasilic AVF in our series had been transposed but was still too deep for reliable cannulation, necessitating liposuction. We would not recommend this for basilic vein fistulas that have not been transposed owing to the risk of nerve injury.

In our experience, ≤30% of patients might not have successful dialysis through the AVF for a variety of reasons. These reasons include the greater obesity (class III

| Table IV. Interval from arteriovenous fistula (AVF) creation to liposuction and successful cannulation |
|-------------------------------------------------------------------------------------------------|
| Patient No. | Interval from AVF creation to liposuction, days | Interval from AVF creation to successful cannulation, days |
|------------|-----------------------------------------------|----------------------------------------------------------|
|            | After one liposuction procedure                |                                                         |
| 1          | 150                                           | 96                                                       |
| 2          | 269                                           | 21                                                       |
| 3          | 116                                           | 81                                                       |
| 4          | 222                                           | 22                                                       |
| 5          | 140                                           | 68                                                       |
| 6          | 181                                           | 28                                                       |
| 7          | 139                                           | 41                                                       |
| 8          | 286                                           | 71                                                       |
| 9          | 193                                           | 63                                                       |
| 10         | 253                                           | 30                                                       |
| 11         | 89                                            | 1457<sup>a</sup>                                          |
| 12         | 153                                           | 867<sup>a</sup>                                           |
|            | After two liposuction procedures              |                                                         |
| 13         | 185 and 397 (second liposuction attempt)      | 284                                                      |
| 14         | 93 and 177 (second liposuction attempt)       | 123                                                      |
|            | After one liposuction procedure + AVF intervention |                                                         |
| 15         | 245                                           | 130                                                      |
|            | Unsuccessful cannulation                      |                                                         |
| 16         | 211 and 317 (second liposuction attempt)      | –                                                        |
| 17         | 135                                           | –                                                        |
| 18         | 62                                            | –                                                        |
| 19         | 274                                           | –                                                        |

<sup>a</sup>Two patients did not require initiation of dialysis until >1 year after liposuction, therefore, their time to cannulation was not included in the mean calculation to prevent skewing; both achieved successful dialysis immediately on eventual initiation.
obesity), high preoperative AVF depth of 2.1 to 2.4 cm, and the reduced patency due to recurrent stenosis and thrombosis of the AVF, as discussed.

To the best of our knowledge, our cohort of patients is the largest to date in studies reporting the outcomes of liposuction for superficialization of AVFs to improve access for hemodialysis. Based on our experience with this small cohort, liposuction is safe to perform and can be considered for patients with an inaccessible AVF owing to thick subcutaneous fat but otherwise adequate AVF patency. When the AVF depth is <1.5 cm, a combination of minimal incision lipectomy with liposuction will be safer. Long-term follow-up and larger studies comparing the risks and benefits of traditional techniques vs minimally invasive approaches for AVF superficialization are needed.

CONCLUSIONS

The findings of our study have helped to elucidate the efficacy and safety of liposuction as a minimally invasive technique for superficialization of AVFs, with a 79% success rate and time to first successful cannulation within 52 days after the procedure. Our results have highlighted the value of collaboration between plastic surgeons, vascular surgeons, and nephrologists in the care of these patients. Additional studies are needed to compare the safety and efficacy of open vs minimally invasive approaches to superficialize AVFs in obese patients with difficult access.

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