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Endovenous management of venous leg ulcers

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Background: **Compression is the current "standard" in the treatment of venous leg ulcers, and corrective surgery is ancillary. The emergence of safe and effective minimally invasive corrective techniques prompts a reappraisal of this paradigm.**

Methods: **Among 192 consecutive limbs with venous leg ulcers, 189 were treated by (1) endovenous laser ablation (n = 30), (2) iliac vein stent placement (n = 89), or (3) both (n = 69). Residual deep reflux was *not* treated. No specialized wound care was used, and 38% of patients did not use stockings. Outcome measures were time to heal the ulcer and cumulative long-term healing.**

Results: **Sixty percent of the limbs were post-thrombotic. The median reflux segment score was 3 (range, 0-7). Thirty-seven percent had deep axial reflux. Median intravascular ultrasound-detected stenosis was 70% (range, 0%-100%) in stented patients. Sensitivity of venography to iliac vein obstruction was 52%. Postprocedural mortality was 0%, and 2% had deep venous thrombosis (<30 days). By 14 weeks, 81% of the small ulcers approximately ≤1 inch in diameter had healed. Larger ulcers were slower in healing ($P < .001$). Post-thrombotic etiology, presence of uncorrected deep reflux, demographic factors, or stocking use had no bearing on healing time. Long-term cumulative healing at 5 years overall was 75%. Healing was better in nonthrombotic limbs compared with post-thrombotic limbs (87% vs 66% at 5 years; $P < .02$) but was similar among the various demographic subsets, procedures, and whether or not patients used compression. Quality-of-life measures improved significantly. Cumulative long-term healing was unaffected by residual axial reflux and was unrelated to hemodynamic severity (air plethysmography, ambulatory venous pressure). However, long-term ulcer healing was inferior in limbs with reflux segment score of ≥3 ($P < .03$). Post-thrombotic limbs with a reflux score of ≥3 had the lowest cumulative healing among cohorts, but even in this category, 60% of limbs had durable healing with very few recurrences.**

Conclusions: **Most venous leg ulcers in this consecutive series achieved long-term healing with the described minimally invasive algorithm. Uncorrected residual reflux was not an impediment to ulcer healing. Ulcers sized ≤1 inch required no specialized or prolonged wound care. Compression was not necessary to achieve or maintain healing after interventional correction. (J Vasc Surg: Venous and Lym Dis 2013;1:165-73.)**

Compression, in use since antiquity, is the "standard" treatment for venous leg ulceration. Yet, it has several well-known shortcomings, including substantial noncompliance, nonusability, and inefficacy.[1-6] In the Effect of Surgery and Compression on Healing and Recurrence (ESCHAR) randomized study,[7] addition of saphenous ablation to compression reduced 12-month recurrence but did not improve short-term healing. However, there was no surgical arm without compression in the study design, and the independent efficacy of saphenous ablation (and other corrective procedures) in the short-term healing of venous leg ulcers remains a question.

Recently, many of the superficial and deep venous corrective surgeries have become minimally invasive due to new technology. They are safe and effective. Partial or piecemeal correction of multivariate pathology often heals venous ulcers—a feature that can be exploited in developing a clinical algorithm. Ongoing daily compliance (where compression often fails, causing recurrence) is not an issue with corrective procedures. However, compression care has shifted from offices to wound care centers, which tends to blur its presumed cost advantage. These developments suggest that the newer techniques should be integrated with compression to reduce the overall time to heal the ulcer.

The aim of the current analysis is to show that most venous leg ulcers resistant to conservative therapy can be successfully managed by endovenous technologies and to describe the related procedure selection protocols.

METHODS

Between July 2000 and September 2011, 192 limbs that failed conservative therapy (CEAP C_6) were exclusively managed by an endovascular approach, comprising percutaneous laser ablation (n = 39), iliac vein stenting (n = 99), or both (n = 59). The case series is consecutive, and no open surgical procedures were performed, except for split-thickness skin graft in two limbs.

The results are described for the entire group of 192 limbs and separately for a subset of 34 limbs closely monitored (monitored subset) to ascertain precise time of healing and related data. The results in the monitored subset help to validate findings in the larger set.

Outcome. For the larger group, clinical assessment and status of the ulcer (healed/unhealed) was recorded

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at each clinic visit at 6 weeks, 3 months, 6 months, and at 1 year after the intervention. Interval status of the ulcer between scheduled clinic visits was unavailable. In the monitored subset, initial ulcer size was measured by tracing paper and a graph grid, and postintervention healing progress and compression use were tracked by weekly phone calls and shorter follow-up visits. Ulcers were marked as healed only when 100% epithelialization was confirmed by clinical examination.

Compression. Compression was used after the intervention only if the patient had been using compression at the time of the intervention. Others who could not use compression because of comorbidities or local limb condition, or who had lapsed into noncompliance after some period of use, were monitored postoperatively without compression. No new compression was prescribed for such patients.

Wound care. No attempt was made to "stabilize" the wound in preparation for surgery. Purulent exudate or localized cellulitis surrounding the wound was not a contraindication for intervention. Generalized moderate or severe cellulitis of the limb was treated with a short course of antibiotics (1-3 weeks) before intervention. Postoperatively, patients were instructed to clean the wound with soap during showering and apply an absorbent nonadhesive dressing. Local treatment with chemicals or antibiotics was discouraged to prevent allergenization from the breakdown of the dermal barrier common in venous stasis.[8]

Indications and choice of corrective procedure. All patients who had venous leg ulceration were considered for one of the following procedures:

- Saphenous ablation alone was performed by endovenous laser (EVLA) if (1) reflux was present in a large (≥5 mm-diameter) saphenous vein and (2) specific clinical features associated with iliac vein obstruction (significant limb swelling, severe diffuse venous limb pain) were absent.
- Iliac vein stenting combined with saphenous ablation was used if the refluxing saphenous vein was small (≤5 mm) or features of clinical obstruction were dominant.
- Iliac vein stenting alone was performed in patients if saphenous reflux was absent in association with demonstrated iliac vein obstruction.

Preoperative investigations. Preintervention investigations included a thrombophilia panel, comprehensive venous laboratory investigations to include ambulatory venous pressure, air plethysmography, and duplex examination with assignment of a reflux segment score[9] (1 point each for the saphenous above knee, saphenous below knee, femoral, profunda femoris, popliteal, short saphenous and perforator veins; maximum score, 7), and axial grading.[10] Ascending or transfemoral venography, or both, were performed, except when contrast allergy or renal dysfunction was present. Venographic findings were helpful when positive to define the relevant venous anatomy, site, and nature of obstruction. Because the sensitivity of venography was only ~50% for iliac venous obstruction,[11,12] venography and intravascular ultrasound imaging (IVUS) were routinely performed in patients considered for a stent procedure and not when EVLA alone was planned.

Technique. Procedural details have been reported in detail elsewhere[13-18] and are not repeated here. Wallstents (Boston Scientific, Natick, Mass) were exclusively used with IVUS guidance. The stent surveillance protocol has been previously described.[19]

IVUS assessment. A 6F IVUS catheter system (Volcano Corp, San Diego, Calif) was used. The degree of stenosis was calculated from prestent and poststent luminal areas on IVUS planimetry. Because stent correction did not always restore normal lumen size in some cases, the degree of stenoses could be understated by this methodology. To correct for this error, the calculated degree of stenosis was predicated in these cases on a minimum expected "normal" luminal size of ~200, ~160, and ~115 mm^2, respectively, for the common iliac, external iliac and common femoral veins based on 16-, 14-, and 12-mm diameters. All IVUS stenoses ≥50% were stented. The iliac-caval-femoral vein segments were routinely "balloon sized"[11] as well, because some stenoses impervious to IVUS can be detected by balloon waisting and then are stented. Because balloon-waisting estimates are necessarily subjective, IVUS planimetry values, even if <50%, were retained to characterize the stenoses in all limbs.

Data collection and statistics. Clinical data were contemporaneously entered in a time-stamped electronic medical record and later analyzed. Some data elements were missing, in which case the numeric values available for analysis are indicated in context.

An event was defined as a healed ulcer. Time to ulcer healing was defined as the time from the date of surgery to the date the ulcer healed or the date of last contact if the ulcer did not heal. Kaplan-Meier curves were created, and the log-rank test was conducted to compare and test for differences in curves among groups. Several factors were examined for association with time to ulcer healing, and factors to be included in the final model were selected using a stepwise Cox regression procedure. The Fisher exact test was used to compare proportions, and nonparametric analyses, such as the Kruskal-Wallis test, were used to test differences among continuous variables. Statistical significance was defined as $P < .05$. All analyses were performed using SAS software (SAS Institute, Cary, NC), and graphics were generated using Prism software (GraphPad, La Jolla, Calif).

RESULTS

Demographics, etiology, reflux detail, hemodynamics, IVUS stenosis, and hemodynamics of the entire group and the enhanced follow-up subset are reported in Tables I and II, respectively. In the entire group, 37% of the limbs had axial deep reflux with (12%) or without associated axial superficial reflux. There was no significant difference in this or other parameters between the two cohorts except in the incidence of post-thrombotic disease, which

Table I. Demographics of study patients

Criteria	*All patients* (*n* = 192)	*Monitored subset* (*n* = 34)	P
Age, median (range), years	59 (15-92)	62.5 (33-91)	.08
Male/female	1:1	2:1	.06
Right limb/left limb	1:1	3:5	.16
Primary/post-thrombotic, %	2:3	2:5	.05

was marginally under-represented in the monitored series. Outcome and related parameters were also similar, as shown later. Follow-up (till censored) was available in 100% of the monitored series and in 92% of the entire series.

Venographic stenosis. Preoperative venograms (n = 160), as reported by the interpreting radiologist, suggested a stenotic lesion in 38 limbs, stenoses with collaterals in 34 limbs, and collaterals without visible stenoses in 11 limbs. Thus, direct or indirect venographic evidence for an obstructive lesion was present in 52% (83 of 160) of stented limbs.

IVUS stenosis. Median area stenosis by IVUS planimetry was 70% (n = 158). IVUS planimetry measured an area stenosis ≥50% stenosis in 135 limbs (85%) and a stenosis <50% in 23 limbs (15%). Balloon sizing in 14 of 23 of the latter limbs unmasked significant stenoses, which were then stented, and nine of these ulcers healed. Stenting was not performed in the other nine limbs, but saphenous ablation was performed for indications in six of these limbs. Neither stent placement nor saphenous ablation was performed in the remaining three limbs, but they were included in the survival analyses (intent to treat). Overall, IVUS or the balloon sizing maneuver, or both, revealed stentable stenosis in 94% of limbs with venous leg ulcers. IVUS-determined stenoses detail in stented limbs and reflux and hemodynamic information in the three treatment groups and treatment failures are reported in Table III.

Table II. Hemodynamic features in ulcerated limbs

Criteria[a]	*All patients* (*n* = 192)	*Monitored subset* (*n* = 34)	P
IVUS stenosis, %	70 (0-100)	80 (20-100)	.23
Reflux			
Axial superficial only	37 (19)	5 (15)	.34
Axial deep only	47 (25)	10 (29)	.61
Axial deep and superficial	23 (12)	4 (12)	.49
Segmental	69 (36)	8 (24)	.37
Reflux segment score	3 (0-7)	2 (0-6)	.17
Postexercise pressure, mm Hg	58 (18-94)	53.5 (18-55)	.32
Venous filling time, seconds	16 (1-123)	13 (1-31)	.68
VFI 90	3 (0.4-21.1)	3 (0.5-14.2)	.62
Wound size, mm^2	No data	300 (25-11000)	

IVUS, Intravascular ultrasound; *VFI 90,* Venous Filling Index 90%.
[a]Continuous data are shown as median (range) and categoric data as number (%).

Mortality and morbidity. There were no deaths. Deep venous thrombosis occurred in four limbs (2%). Thrombosis of the stent occurred in eight other limbs, and patency was re-established by lysis in one of these limbs. No infection involving the stent occurred.

Ulcer healing. Time to heal the ulcer and long-term cumulative ulcer healing were available parameters. A variety of factors related to ulcer healing were examined by multivariate analysis. Positive and negative correlations are described below.

Ulcer size. The time to heal the ulcer for limbs with large (≥500 mm^2) and small (<500 mm^2 or ~1-inch sized) ulcers in the monitored group is shown in Fig 1. By 14 weeks after endovenous correction, 81% of the small ulcers had healed and very few afterward. Time to heal was significantly slower ($P < .005$) in limbs with large ulcers, and their long-term cumulative healing (curve not shown) was significantly less than small ulcers (54% vs 95% at 3 years; $P < .005$). However, two of 13 (15%) large ulcers (1000 and 1800 mm^2, respectively), surprisingly, healed by 2.5 months. The rapid epithelialization was because of healing not only from the periphery but also from dermal islands sprouting from follicular remnants in the center (Fig 2).

Reflux. There was no difference in initial healing (time to heal) whether there was or was not residual deep reflux in the monitored subset ($P = .3$).

Long-term cumulative ulcer healing for all limbs in the entire series at 5 years was 75% (Fig 3). Cumulative healing at 5 years ranged from 66% to 85% for the various refluxive subsets. There was no difference in long-term ulcer healing between limbs with deep axial and nonaxial reflux ($P = .6$), and inclusion of axial superficial reflux in the comparison did not alter this finding ($P = .23$). Long-term healing was significantly lower for limbs with reflux segment scores ≥3 compared with cohorts with reflux segment scores <3 ($P < .03$). This is intertwined with post-thrombotic etiology (see below). There was no difference in cumulative healing between nonrefluxive limbs and the various refluxive subsets shown in Fig 3, except for the subset with segment reflux scores ≥3. Furthermore, this lack of correlation between many categories of reflux and ulcer healing extended to tests of its hemodynamic severity with air plethysmography (venous filling index to 90% of the baseline; $P = .3$) as well as ambulatory venous pressure measurement (venous filling time, $P = .6$; percentage drop, $P = .1$).

Etiology and pathology. There was no difference in time to heal between post-thrombotic and nonthrombotic ulcers in the monitored subset ($P = .3$; curve not shown), but long-term cumulative ulcer healing was significantly lower in post-thrombotic limbs (Fig 4). Post-thrombotic limbs with a reflux segment score of ≥3 had the lowest long-term cumulative healing among the various cohorts. Even in this disadvantaged group, however, 60% of ulcers had healed at 5 years, with very few recurrences (flat curve).

Stocking use. There was no difference in time to heal or long-term cumulative ulcer healing between patients who did and did not use compression after the intervention (Fig 5).

Table III. Distribution of intravascular ultrasound-detected stenosis, reflux, and hemodynamics in treatment groups

Treatment group	*IVUS obstruction*	*Reflux*	*VFI 90*	*VFT*
Saphenous ablation only (n = 30)				
	NA[a]	Axial superficial: 23% Axial deep: 23% Axial deep and superficial: 17% Segmental: 10% No reflux: 27%	0-1.9: 33% 2-4.9: 52% ≥5: 15%	0-9: 38% 10-17: 44% >17: 18%
Median (range)		Reflux segment score: 3 (0-7)	2.9 (0.4-13)	12 (3-24)
Saphenous ablation and stent (n = 59)[b]				
	0-24: 2% 25-49: 10% 50-74: 43% >75: 45%	Axial superficial: 36% Axial deep: 19% Axial deep and superficial: 20% Segmental: 13% No reflux: 14%	0-1.9: 13% 2-4.9: 54% ≥5: 33%	0-9: 44% 10-17: 22% >17: 34%
Median (range)	70 (20-100)	Reflux segment score: 3 (0-7)	3.8 (0.5-21.1)	11 (1-123)
Stent only (n = 99)[b]				
	0-24: 3% 25-49: 5% 50-74: 49% >75: 43%	Axial superficial: 9% Axial deep: 28% Axial deep and superficial: 6% Segmental: 22% No reflux: 35%	0-1.9: 28% 2-4.9: 51% ≥5: 21%	0-9: 42% 10-17: 33% >17: 25%
Median (range)	70 (8-100)	Reflux segment score: 3 (0-7)	2.7 (0.6-10)	12 (1-70)
Treatment failures in all groups (n = 47)				
	0-24: 12% 25-49: 10% 50-74: 32% >75: 46%	Axial superficial: 17% Axial deep: 32% Axial deep and superficial: 13% Segmental: 20% No reflux: 18%	0-1.9: 17% 2-4.9: 39% ≥5: 44%	0-9: 3% 10-17: 34% >17: 28%
Median (range)	72 (0-100)	Reflux segment score: 3 (0-7)	4.0 (1.3-15.3)	13 (1-52)

IVUS, Intravascular ultrasound; *NA,* not available; *VFI 90,* venous filling index to 90% of the baseline; *VFT,* venous filling time.
[a]IVUS not routinely performed.
[b]Only 14 of 23 limbs with IVUS stenosis with <49% that were stented and are included here; ulcers healed in 9 of these 14.

Type of corrective procedure. Initial time to heal (P = .3; curve not shown) and long-term cumulative healing was similar between the three interventional procedures: saphenous ablation, iliac vein stent, and combination, as shown in Fig 6. Notably, there was little degradation in long-term curves after healing; that is, long-term recurrences were relatively few after all three endovenous procedures.

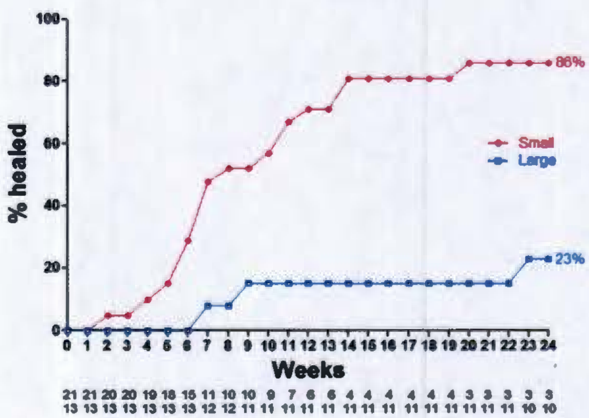

Fig 1. Time to heal of small (<500-mm^2) and large (≥500-mm^2) ulcers. By 14 weeks, 81% of the small ulcers were completely healed, but only 15% of large ulcers had healed by this time (P < .005).

Demographics. No discernible differences were noted in ulcer healing related to sex, side of limb, or age: 26 of 192 limbs (14%) in this experience were in the geriatric group (aged > 75 years).

Nonhealed and recurrent ulcers. There were 47 nonhealed ulcers or recurrences (24%) in the entire group and seven limbs (21%) in the monitored subset. Examination of individual limbs in the monitored series in which ulcers failed to heal or recurred showed that the stent had occluded in two limbs, and there was severe in-stent restenosis in three others. No identifiable cause was found in two other limbs.

Quality of life. Quality-of-life improvement[20] after interventional correction is reported in Table IV. Significant improvement was documented in pain intensity, activity limits, morale parameters, and overall score.

DISCUSSION

In a previous report,[14] cumulative ulcer healing after iliac vein stenting was 61%. However, there were large early

Fig 2. Rapid healing of venous ulcers. Epithelial growth occurs from the periphery, as well as from the center of the wound from follicular remnants, as seen in the middle photograph. Repeated or deep debridement may be harmful.

follow-up losses (<4 months), but the cumulative curve was extraordinarily "flat," with very few recurrences, suggesting that the ulcers might have healed in many of the limbs lost to follow-up. An effort was therefore made to accrue follow-up in this report.

The data reported here indicate that most venous leg ulcers can be treated successfully by newer minimally invasive endovascular techniques that are safe, effective, and durable. The flatness of the survival curve over many years is in sharp contrast to declining curves seen with prior corrective procedures, particularly in post-thrombotic subsets.[21-23] A new therapeutic algorithm with the following elements is suggested by this experience:

Wound care. Most venous leg ulcers that are approximately ≤1 inch in diameter require little specialized wound care or preparatory time before corrective intervention. Simple self-care is sufficient. Application of topical antibiotics and cleansing chemicals is unnecessary and may be harmful.[8] Surgical debridement—a common practice in wound care centers—should be avoided to preserve epithelial islands in the center to enhance the rate of healing. The data presented here suggest that a maximum of 2 to 3 months of conservative therapy is the desirable cutoff point before corrective intervention. Even if the initial conservative care is successful in healing the ulcer, specific correction of pathology appears to be necessary to prevent recurrence. Large venous ulcers lag in the rate as well as final healing in this and other reports.[24] A split-thickness skin graft or other biologic coverage may be considered after endovenous correction.

Stocking use. The data presented here and in earlier work by Scriven et al[25] show that compression stockings after interventional correction are unnecessary to speed up initial healing or prevent late recurrences. This is an advantage for patients who cannot or will not use compression. Many geriatric patients, in whom the endovenous techniques described above can be safely undertaken, are in this category. However, stocking use is desirable when tolerated to control associated symptoms of limb swelling or tiredness.

Choice of interventional procedure. This depends on the presence or absence of saphenous reflux and, particularly, if the refluxive saphena are large (≥5 mm). Saphenous vein size has been shown to correlate with hemodynamically significant reflux.[26,27] Saphenous ablation is an easy initial choice in these patients.

Another minimal and repeatable procedure (not used in this study) that may be considered in select patients is local perforator ablation when a large (>3.5-mm) perforator with reflux (>500 ms) is found directly under the ulcer bed.[28-30]

Iliac vein stenting is the procedure of choice when saphenous reflux is not present. Combined saphenous ablation and iliac vein stenting[15] is recommended when the refluxive saphenous vein is small or when symptoms specific for venous obstruction, such as significant leg swelling, are associated with the leg ulcer.

The presence of uncorrected deep reflux appears *not* to be a hindrance to ulcer healing after the stent procedure, confirming prior findings.[31,32] The ulcers in three-fourths of patients with uncorrected reflux healed in durable fashion, a statistic equal to or better than the historical experience with valve reconstruction. Limbs with nonthrombotic reflux, regardless of its duplex severity (axial/nonaxial or reflux segment score), had a cumulative rate of long-term ulcer healing that was no different from limbs without reflux. Post-thrombotic limbs had lower long-term healing than nonthrombotic limbs. Post-thrombotic limbs

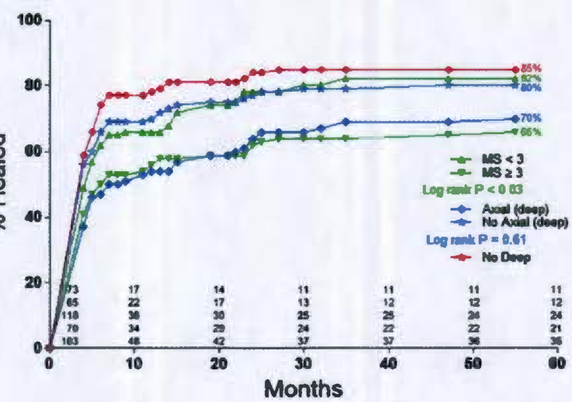

Fig 3. Long-term cumulative ulcer healing among reflux subsets. No difference is noted between axial and nonaxial reflux in cumulative ulcer healing, which is similar to limbs without deep reflux. The rate of ulcer healing is significantly lower in limbs with a reflux segment score of ≥3 than in limbs with a reflux segment score of <3. Long-term ulcer healing in the latter group is not different from limbs with no deep reflux. *MS*, Reflux Multisegment Score.

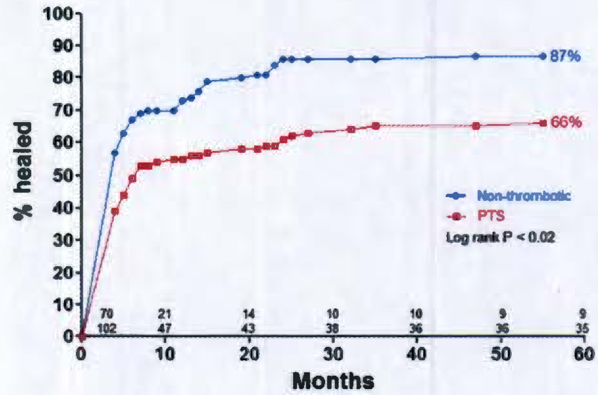

Fig 4. Long-term cumulative ulcer healing is shown in non-thrombotic and post-thrombotic limbs (*PTS*).

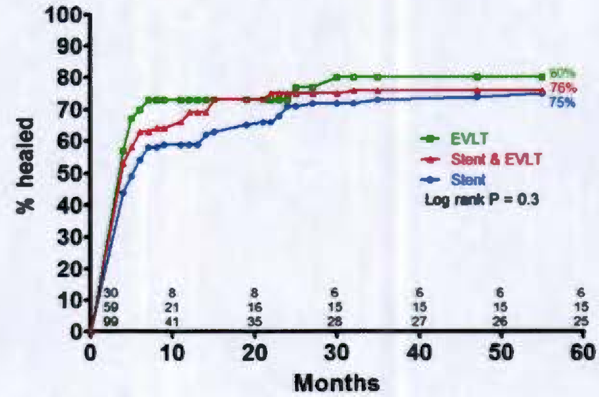

Fig 6. Long-term cumulative ulcer healing is shown with the three minimally invasive techniques used in the study. The curves are statistically similar. *EVLT*, Endovenous laser thermoablation.

with a reflux segment score ≥3 had the poorest healing in this respect. Even in this disadvantaged reflux category, however, 60% of limbs achieved cumulative healing that was sustained at 5 years, with few interval recurrences. A way to distinguish potential nonhealers in this post-thrombotic reflux category was not evident in this study.

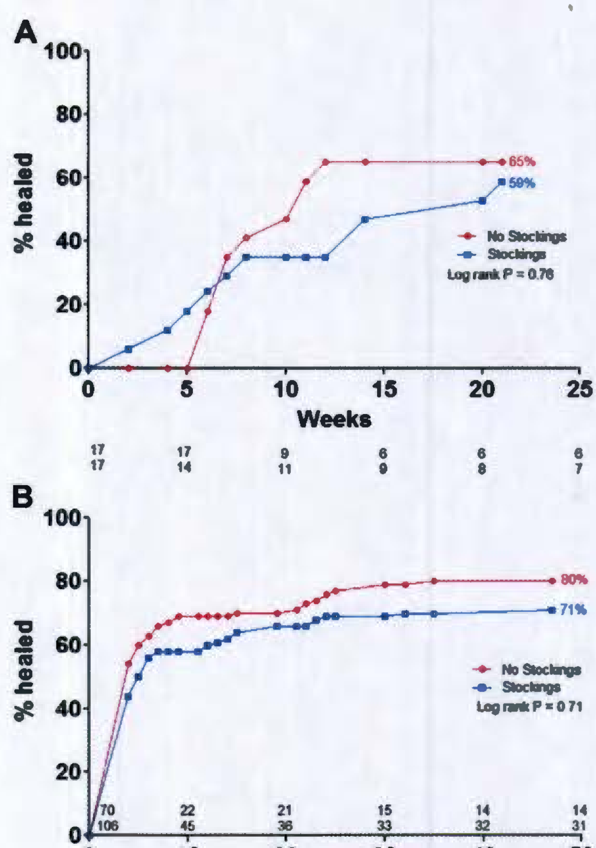

Fig 5. Influence of stockings is shown on **(A)** time to heal the ulcer and **(B)** long-term cumulative ulcer healing. There was no difference in short-term healing or long-term maintenance between stocking users and nonusers.

Preoperative investigations and IVUS assessment. The preoperative workup before stent placement is unsettled. We routinely perform transfemoral venography even though diagnostic sensitivity is known to be poor[11,12] as shown in the data presented here. It is useful in defining the anatomy and helpful when it is suggestive of obstruction. Imaging modalities may have a similar diagnostic yield.[33] We therefore recommend routine use of IVUS with planimetry measurements, even when venography or imaging is negative. The diagnostic yield is very high, especially when combined with the routine "balloon sizing" maneuver, as shown by us and others.[11,34] The criticality of the stenotic threshold that is desirable to treat in the venous system has not been established. The ~70% rule often used in the arterial system is probably not appropriate in venous lesions because numerous governing factors, including peripheral resistance, that influence criticality of the proximal stenosis are absent, and the degree of stenosis required to elevate peripheral venous pressure is likely less than in a flow-limiting lesion.[35] Diffuse stenoses spanning ≥20 cm in length are common in post-thrombotic iliac veins. Lesion length in the venous system may be relevant, unlike in the arterial system. Our prior experience and the data presented here indicate that most symptomatic iliac venous lesions are ≥50%. A post-thrombotic iliac vein of 10 mm in IVUS diameter (35% diameter reduction) represents ~50% area stenosis in an adult and may look deceptively normal due to only a slight diameter reduction on venography. IVUS planimetry is essential in proper assessment of these lesions.

There are several possible reasons why IVUS is unable to identify some lesions. Some membranous lesions[36] are probably sonolucent; for example, the commonly present femoral valve is visible to IVUS only in a fraction of limbs. The axial resolution of the IVUS catheter is 280 to 415 μm at 7.0-mm distance, and the image slice is relatively narrow

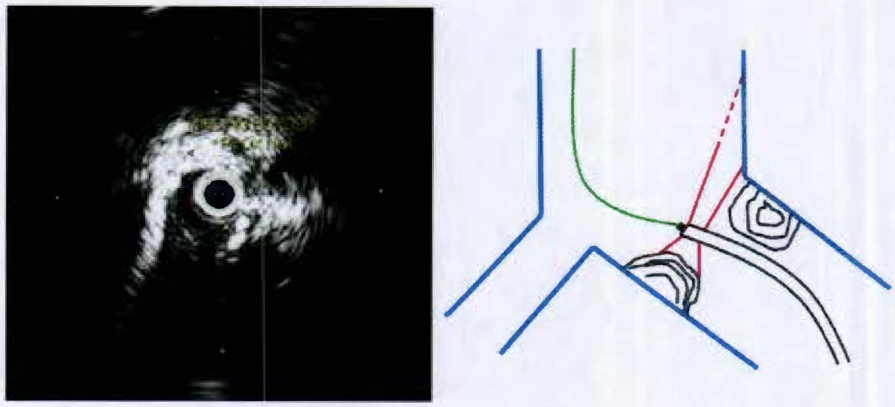

Fig 7. Left, Missing border appearance occurs when the intravascular ultrasound catheter is not coaxial in the center but tilted to the long axis. Only part of the lesion will be visible in the narrow image cross-cut. The lumen in the quadrant opposite from the lesion looks elongated due to the oblique cross-cut. **Right,** The schema illustrates how this might happen. The missing border appearance frequently occurs near the hypogastric or venocaval orifice. The blurred border is likely from image degradation due to distance.

(0.8 to 1.6 mm) at 8.0-mm distance from the catheter tip (data provided by the manufacturer). Optimal visualization of lesions requires that the catheter is centered, the tip is not tilted, and that the lesion is thicker than the image slice and concentric. The IVUS catheter, lacking a centering mechanism, often hugs one wall or another, and the tip is tilted to the long axis at course angulations and curvatures in the iliac vein anatomy.[18] Lesions at the iliac-caval junction are often eccentric and many are spiral, like a corkscrew. Such lesions will be only partially visible per image slice, with a characteristic "missing border" appearance (Fig 7).

Unhealed and recurrent ulcers. When the venous ulcer fails to heal or recurs, investigations to determine persistence or recurrence of saphenous reflux and appropriate correction when indicated are necessary. With iliac vein stenting, stent malfunction should be suspected and corrected if found. Beyond these correctible cases, there is a small subset (frequently post-thrombotic) in whom valve reconstruction, neovalve,[37] or vascularized flap[38] may be considered.

Table IV. Quality-of-life outcomes on the Chronic Venous Insufficiency Questionnaire (*CIVIQ*) before and after surgery (n = 41)[a]

CIVIQ category	*Preoperative median (range)*	*Postoperative median (range)*	P
Pain intensity	3 (1-5)	2 (1-5)	.019[b]
Activity limits	4 (1-5)	3 (1-5)	.012[b]
Sleep problems	3 (1-5)	3 (1-5)	.125
Social	3 (1-5)	2 (1-5)	.073
Morale	3 (1-5)	3 (1-5)	<.0001[b]
Total	66 (20-100)	53 (20-100)	<.0001[b]

[a]Data available with both presurgery and postsurgery questionnaires.
[b]Statistically significant.

Study limitations. The case series is intended to demonstrate a practical clinical algorithm. It is not randomized or controlled. However, the case series is consecutive and represents a large experience in a tertiary referral center. Many of the ancillary analytic findings derived from multivariate analysis or matched cohort comparisons are in variance with traditional concepts of venous pathology and practice conventions, many of which themselves have evolved over time from case series or single-arm studies without rigorous comparative trials. These will be required to establish the global validity of many of the observed variances.

CONCLUSIONS

The results reported here suggest the following algorithm to treat venous leg ulcers: Endovenous saphenous ablation is the initial procedure of choice if reflux is present in a large (≥5 mm) saphenous vein. If there is no saphenous reflux, an IVUS examination and stenting for stenosis is the procedure of choice. If the reflexive saphena are small (≤5 mm), combined saphenous ablation and iliac vein stenting should be considered. Local ablation of a large (≥3.5 mm) refluxive perforator (>500 ms) directly underneath the ulcer bed in nonthrombotic limbs may be a useful adjunct to this algorithm, although not used in this study.

AUTHOR CONTRIBUTIONS

Conception and design: SR
Analysis and interpretation: SR, OK
Data collection: SR, OK
Writing the article: SR
Critical revision of the article: SR
Final approval of the article: SR
Statistical analysis: OK, TJ
Obtained funding: Not applicable
Overall responsibility: SR

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INVITED COMMENTARY

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This article by a highly respected author in the venous world presents a significant personal study of 192 cases of venous ulcer that were evaluated and diagnosed by objective testing and treated aggressively for iliac vein compression by totally endovascular methods. It is an important work with a mass of data that have been thoughtfully organized. The analysis of its results has led the authors to draw a number of conclusions that are at variance with commonly held practices, such as questioning the need for compression to achieve healing in venous ulcers and the use of certain methods to manage the ulcers themselves to encourage healing, in addition to the place of stenting of the iliac veins in overall ulcer management.