Prospective randomized study of endovenous radiofrequency obliteration (Closure procedure) versus ligation and stripping in a selected patient population (EVOLVeS Study)

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Purpose: **This study was designed as a prospective multicenter randomized comparison of procedure-related complications, patient recuperation, and quality-of-life outcomes between patients undergoing vein stripping with high ligation and patients undergoing great saphenous vein (GSV) obliteration with temperature-controlled radiofrequency ablation without adjunctive high ligation (Closure procedure).**

Methods: **Eighty-five patients (86 limbs) from five sites (France, 2; Austria, 1; United States, 2) were randomly allocated to undergo radiofrequency obliteration (RFO) or stripping and high ligation (S&L). Final analysis included data for 44 limbs in the RFO group and 36 limbs in the S&L group. Follow-up examinations were performed at 72 hours, 1 week, 3 weeks, and 4 months. All patients completed the CIVIQ2 quality-of-life (QOL) questionnaire and underwent clinical and ultrasound examinations at each follow-up visit.**

Results: **Immediate success on the day of treatment was reported for 95% (42 of 44) of limbs in the RFO group and 100% (36 of 36) of limbs in the S&L group. In seven RFO limbs (16.3%) a scan obtained 72 hours after the procedure showed flow in the proximal GSV. Five of these segments had reflux in the open segment. At 1 week two of these closed, and an additional segment closed at 3 weeks. In no cases did flow reappear after complete occlusion of the GSV. Time to return to normal activities was significantly less in the RFO group (mean, 1.15 days; 95% confidence interval [CI], 0.05-2.34) compared with the S&L group (mean, 3.89 days; CI, 2.67-5.12; $P = .02$). In the RFO group, 80.5% of patients returned to routine activities of daily living within 1 day, compared with 46.9% of patients in the S&L group ($P < .01$). Patients in the RFO group were able to return to work in 4.7 days (CI, 1.16-8.17), compared with 12.4 days (CI, 8.66-16.23) for the S&L group ($P < .05$). Analysis of the QOL surveys showed statistically significant differences in favor of the RFO group for global score and pain score during follow-up. The magnitude of the difference, however, progressively decreased between 1 week and 4 months.**

Conclusions: **In the absence of significant complications, such as deep vein thrombosis and pulmonary embolism, severe neuritic sequelae, and skin burns, there are significant early advantages to endovascular obliteration of the GSV compared with conventional vein stripping. (J Vasc Surg 2003;38:207–14.)**

Conventional management of the incompetent saphenous vein in patients with symptomatic varicose veins is generally believed to be best treated with removal of the saphenous vein from the saphenofemoral junction to the level of the knee or below, along with individual ligation of the saphenous branches in the groin. Ligation and stripping is the standard treatment for varicose veins, with the highest rate of initial success and lowest rate of recurrence.[1,2] Any alternative technique to high ligation and stripping of the saphenous vein must have the same or better outcome, ideally without the associated morbidity. A new approach to management of saphenous vein reflux is endovascular obliteration of the vein with a radiofrequency-generated heating probe placed through a percutaneous puncture or mini-incision in the calf. This is known as the Closure procedure (VNUS Medical Technologies, San Jose, Calif).[3-6] We present early results of a comparative study of

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Competition of interest: VNUS Medical Technologies, Inc, San Jose, Calif, provided financial support for data collection, clinical monitors, and disposable catheters free of charge.

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conventional stripping versus the Closure procedure in a prospective randomized format designed to record intraoperative and immediate postoperative results of these quite different therapies. The limited follow-up of 4 months is adequate to define early response to each procedure.

Important comparisons between these two procedures are obliteration of the saphenous trunk with the endovascular approach versus removal of the vein in the stripping procedure, and sealing of the branches by means of internal heating ("internal ligation") with the Closure procedure versus external ligation outside of the vein with the stripping technique. In addition, the highest branch of the saphenous vein, usually the superficial epigastric branch, is left patent as it drains into the saphenous vein adjacent to the saphenofemoral junction in the Closure procedure. This aspect of the Closure procedure tests the validity of the conventional teaching that every branch of the saphenofemoral junction must be individually ligated to lower incidence of recurrence in the groin.

METHODS AND MATERIALS

This study was designed as a prospective multicenter randomized comparison of procedure-related complications, patient recuperation, and QOL outcomes between patients undergoing conventional vein stripping with high ligation (S&L) compared with patients undergoing great saphenous vein (GSV) obliteration with temperature-controlled radiofrequency obliteration (RFO) without adjunctive high ligation (Closure procedure).

Five widely dispersed sites (France, 2; Austria, 1; United States, 2) volunteered to cooperate in this study. Each site had performed at least 15 Closure procedures and had been proctored by representatives of VNUS Medical Technologies in performance of the technique, to provide continuity among sites in performance of the operation. These sites had previous experience with S&L as the historically preferred method of treatment of incompetent saphenous veins, and had a known professional reputation, scientific interest, and experience in clinical research in venous disease. Inclusion and exclusion criteria for the limbs to be treated were developed by the investigators in cooperation with VNUS Medical Technologies. The company provided financial support for data collection, clinical monitors, and disposable catheters free of charge.

Randomization was allocated via internet. The internet site was audited regularly to detect redundant randomization activity.

The purpose of the study was to compare intraoperative and early (4 month) postoperative experiences of treatment of comparable cases with S&L or RFO (Closure procedure) with a controlled radiofrequency current according to the protocol of VNUS Medical Technologies.

The study was approved by the Ethics Committee of each institution.

Study population. Eligible patients had symptomatic varicose veins and GSV incompetence, confirmed with duplex ultrasound scanning, and were candidates for conventional vein stripping and qualified under the inclusion and exclusion criteria of the study.

Inclusion criteria were as follows:

Reverse flow in the GSV lasting longer than 0.5 seconds in the standing position, as routinely used for definition of GSV incompetence by all investigators
Age between 21 and 80 years
CEAP[7] clinical classification C_2, C_3, or C_4
Ambulatory status
Segmental deep reflux allowable
Saphenous vein diameter less than or equal to 1.2 cm in the supine position
Availability for follow-up visits at 72 hours, 1 week, 3 weeks, and 4 months

Exclusion criteria were as follows:

Vein diameter greater than 1.2 cm or less than 0.2 cm
Duplication of saphenous trunk or incompetent accessory saphenous branch
Small saphenous vein reflux
Varices of the thigh
Previous deep venous thrombosis
Arterial insufficiency (ankle-brachial index [ABI] < 0.9)
Axial deep venous reflux, from groin through popliteal vein
Tortuosity of the GSV segment to be treated, subjectively assessed on the basis of appearance and ultrasound scan as unsuitable for catheterization

Investigation protocol. Signs and symptoms were recorded by a physician who used the clinical severity score (VCSS) described by Rutherford et al.[8] Each of 10 descriptors was ranked as 0 (absent), 1 (mild), 2 (moderate), or 3 (severe). The range of possible scores was 0 to 30. The physician also recorded the CEAP classification.

Each patient completed the 20-question CIVIQ2 QOL questionnaire, which has been validated for use in patients with chronic venous disease.[9,10] Response to each question was rated on a scale of 1 to 5, where 1 represents minimal negative effect on daily activities and well-being and 5 represents maximum negative effect. Each question was classified in one of four dimensions: Pain, Physical, Social, or Psychological; and the four dimensions were combined to form a single global score. At data analysis, each dimension score and the global scores were transformed to a scale of 0 to 100,[9] where 0 represents the least possible effect on daily activities and well-being, ie, highest QOL, and 100 represents maximum negative effect.

Primary end points included QOL score at each follow-up examination, time until return to routine activities, time until return to work, and recording of adverse sequelae related to the procedure.

Treatment. Treatment of the GSV was performed from the knee or upper calf to the saphenofemoral junction in both S&L and Closure procedures. Adjunctive procedures on varices and perforator vessels were limited to sites below the knee. Varices and perforator vessels above the knee were not treated, to prevent confusion postoperatively

between morbidity due to saphenous vein treatment with RFO versus S&L and that due to the adjunctive procedure.

Bilateral treatment was permitted, provided each limb received the same treatment and both limbs were treated during the same operation.

For patients randomized to RFO, the Closure catheter and system (VNUS Medical Technologies) was used according to described methods.[4,5] For patients randomized to S&L, physicians followed their standard practice, using either an olive-tipped device or a perforate invagination (PIN) stripper. The learning curve was minimized by ensuring that all participants were proficient in performing both S&L and the Closure procedure. Variability in individual stripping techniques was accepted as reflective of "real world" comparison of the standard Closure technique versus individual approaches to stripping. The type of anesthetic used varied between centers and included either tumescence infiltration with or without regional anesthesia, or general anesthesia.

Technical success of treatment was monitored with repeated ultrasound duplex scanning. Criteria for successful treatment included elimination of the GSV with the stripping procedure and obliteration of the lumen with echogenic material in the Closure procedure. In the RFO group the treatment starting point, and therefore the proximal obliteration point, was located distal to the saphenofemoral junction just below the entrance of the highest branch. For purposes of judging the postoperative scan, successful RFO was less than 5 cm of GSV patency from the saphenofemoral junction, with the distance measured from the junction along the curve of the GSV to the proximal obliteration point.

All patients, regardless of treatment assignment, were encouraged to return to their usual level of physical activity as soon as possible.

Follow-up. Postoperative follow-up was at 72 hours, 1 week, 3 weeks, and 4 months. Each visit included a clinical examination by a physician, duplex ultrasound scanning by an expert sonographer, and completion of the 20-question CIVIQ2 QOL questionnaire by the patient.

Study monitoring. Operation records and patient charts were reviewed by the sponsor (VNUS Medical Technologies) for completion of study data points. During and after data acquisition two investigators (L.K., F.L.) conducted a thorough audit of raw data handling and storage methods, data processing accuracy, and presentation of specific results. They reported all of these in order and that results accurately reflected raw data received from the investigator sites. The sponsor provided support for all of these functions and responded to specific inquiries during the course of analysis and preparation of this article, but did not interfere with analysis of data or formulation of conclusions.

Statistical methods. VCSS scores and health- related QOL dimension and global mean scores were analyzed with one-way analysis of variance and the Tukey-Kramer test. Repeated measures analysis of variance was used to compare scores before treatment (baseline) and scores after treatment. Alternatively, the absolute difference between baseline score and score after treatment for each individual patient was used to analyze the difference between groups. The general linear model of SPSS software (version 10.1; SPSS, Chicago, Ill) was used to compare QOL scores between groups at 72 hours after treatment to adjust for confounding variables (type of anesthesia, number of adjunctive procedures). The Cochran *Q* test and Mantel-Haenszel method were used to compare frequency of complications and adverse findings at each follow-up interval. The Student *t* test and Fisher exact test were also used when appropriate. Values represent mean ± SD or 95% confidence interval.

Table I. Distribution of cases among participating sites

	No. of cases		
Sites	*RFO*	*S&L*	*Total/site*
1	20	14	34
2	6	9	15
3	7	7	14
4	9	3	12
5	2	3	5
Total	44	36	80

RFO, Radiofrequency obliteration; *S&L,* stripping and ligation.

RESULTS

Patients were enrolled from August 2000 through October 2001. Of 85 patients (86 limbs) enrolled, 45 patients (46 limbs) were allocated to the RFO group and 40 patients to the S&L group. Three patients in the S&L arm, after receiving allocation notification, excluded themselves from the study before treatment. This reflected a problem with recruitment during the study due to patient reluctance to be blindly allocated to one or the other arm. One additional patient randomized to the S&L arm had repeated scheduling delays and failed to receive treatment over the entire study period. One patient in the RFO group was excluded after randomization when the physician learned of a previous surgical intervention in the target vein. The final result of these allocation problems was that RFO was performed in 45 limbs and S&L was performed in 36 limbs. Final distribution of cases among the participating sites is shown in Table I. There were no crossover or aborted procedures. Venous disease in one patient in the RFO group was classified as CEAP C_6, which was a protocol violation, and data for this patient were not included in the final analysis.

Similarity between the two patient groups in terms of demographics, CEAP classification, and clinical severity of venous disease is shown in Table II.

Procedural details, including anesthesia type, adjunctive procedures, and length of saphenous vein segment treated, are summarized in Table III. The original intent was to compare treatment time for the two techniques, but rules of recording separately venous access time, treatment time, and adjunctive procedure time were not uniformly

Table II. Demographics, VCSS, and maximum CEAP before treatment

	RFO (N = 44) (mean ± SD)	*S&L (N = 36) (mean ± SD)*	P
Age (y)	49 ± 4	47 ± 4	NS
VCSS	4.80 ± 0.34	4.39 ± 0.38	NS
	n (%)	n (%)	
Female gender	32 (74.4)	26 (72.2)	NS
Self-reported as working	25 (58.1)	25 (69.4)	NS
CEAP			
2	36 (81.8)	28 (77.8)	NS
3	4 (9.1)	4 (11.1)	NS
4	4 (9.1)	4 (11.1)	NS

RFO, Radiofrequency obliteration; *S&L,* stripping and ligation; *VCSS,* venous clinical severity score; *NS,* not significant.

Table III. Anesthesia type, adjunctive procedures, length of segment treated

	RFO n (%)	*S&L n (%)*
Anesthesia type		
Regional or local (includes tumescent)	32 (72.7)	17 (47.2)
General	12 (27.3)	19 (52.8)
Adjunctive procedures		
None	2 (4.5)	0 (0)
Phlebectomy	42 (95.5)	36 (100)
Perforator interruption	2 (4.5)	5 (13.9)
	Mean ± SD	Mean ± SD
Number of avulsions per extremity	8.6 ± 2.6	9.8 ± 2.8]
Mean length of segment treated (cm)	37 ± 2	40 ± 2

RFO, Radiofrequency obliteration; *S&L,* stripping and ligation.

followed. As a result, total treatment time for the S&L group was confused with isolated Closure treatment time in the RFO group. Closure treatment time, including vein access time of 41 ± 5 minutes, is reported as an isolated statistic, whereas total treatment time for the two groups was 74 ± 10 minutes for Closure and 89 ± 12 minutes for S&L. Since the number of phlebectomies and perforator vessel procedures were comparable between the two groups, total operating times represent a reasonable comparison of operating times.

There was a significant difference in anesthetic technique between the two groups, with general anesthesia used in 27% of patients in the RFO group and 53% of patients in the S&L group. Moreover, average number of phlebectomies per limb was significantly higher in patients who received general anesthetic (mean, 11.7; 95% CI, 8.5-14.9) compared with those who received local or regional anesthetic (mean, 7.2; 95% CI, 4.9-9.4). Perforator vessel interruption was performed only with the patient under general anesthesia in this study (2.3 ± 1.5 per limb). Therefore all comparisons between QOL scores in the two groups (RFO vs S&L) were adjusted for type of anesthesia and number of adjunctive procedures.

Management of the proximal end of the GSV was with surgical dissection and separate ligation of all saphenous branches in the femoral triangle in the S&L group and nonsurgical endovenous obliteration in the RFO group. The endovenous technique typically results in obliteration of all but the highest branch of the GSV, which usually means that the superficial epigastric branch is left patent. Treatment flush with the common femoral vein (CFV) is not recommended because of possible thermal injury to the CFV, which could lead to local thrombosis or later stenosis of the CFV. There were no instances of CFV thrombosis or other injury in RFO cases in this study, as confirmed at repeated postoperative duplex scanning.

In technique comparisons, vein access of the distal extent of the saphenous vein in the calf was with cutdown in all limbs in the S&L group and in 43% (19 of 44) of limbs in the RFO group; the other 25 limbs in the RFO group were accessed via percutaneous puncture of the GSV in the calf with ultrasound-guided technique and did not require a calf incision.

Procedural complications were infrequent in both groups. One intraoperative hematoma was reported in each of the two groups, one vein perforation was reported in the RFO group, and two vein tears were reported in the S&L group. There were no thermal injuries or perioperative hemorrhage in either treatment arm.

Immediate success on the day of treatment was reported in 95% (42 of 44) of RFO limbs and in 100% (36 of 36) of S&L limbs. The two failures in the RFO group were technical; there was failure of passage of the catheter all the way to the saphenofemoral junction, with the result that the upper 10 cm of the GSV was left untreated in one limb and there was indeterminate shrinkage of the GSV in another limb because a small (5 F) catheter was used inappropriately in a large vein with internal diameter of 8.6 mm. In both of these limbs reflux was demonstrated on postoperative scans and is reported as such in outcome statistics. One S&L case could not be confirmed as successful on the basis of the completion scan, because visualization of the groin was obscured by technical factors, but was found to be successful on all subsequent scans.

Postoperative follow-up. In the RFO group, postoperative follow-up examinations were performed in 44 limbs at 72 hours, 43 limbs at 1 week, 44 limbs at 3 weeks, and 43 limbs at 4 months; and in the S&L group, follow-up examinations were performed in 36 limbs at 72 hours, 36 limbs at 1 week, 36 limbs at 3 weeks, and 34 limbs at 4 months. The QOL questionnaire was completed in all but eight instances: one at initial follow-up and four at 4 months in the S&L arm, and one each at 1 week, 3 weeks, and 4 months in the RFO arm. Subsequent efforts to retrieve these results were not successful.

Clinical follow-up data. Two important statistics in the two groups were time until return to normal activity and time until return to work, because significant differences were reported. Time until return to normal activity was significantly less in the RFO group (mean, 1.15 days; 95% CI, 0.05-2.34) compared with the S&L group (mean,

Table IV. Distribution of patients in groups by time until return to normal physical activity after surgery

		Percent of patients who returned to normal physical activity at different time after surgery				
Group	*Anesthesia*	*Same day*	*1-3 days*	*3-5 days*	*5-15 days*	*>15 days*
RFO	General (n = 11)	9	91	—	—	—
	Local (n = 30)	33	64	3	—	—
S&L	General (n = 17)	—	41	18	23	18
	Local (n = 15)	—	100	—	—	—

RFO, Radiofrequency obliteration; *S&L,* stripping and ligation.

3.89 days; 95% CI, 2.67-5.12; $P = .02$). These figures are adjusted for type of anesthetic and number of adjunctive procedures performed, each of which influenced the results. In the RFO group, patients given general anesthetic returned to normal activity in 1.36 ± 0.92 days, compared with 0.93 ± 1.02 days for patients given local or regional anesthetic; and in the S&L group, patients given general anesthetic returned to normal activity in 6.65 ± 6.76 days, compared with 1.14 ± 0.36 days for patients given local or regional anesthetic (Table IV). In other words, 80.5% of patients in the RFO group returned to routine activities of daily living within 1 day, compared with 46.9% of patients in the S&L group ($P < .01$).

Mean values for return to work in the RFO group were 4.7 days (95% CI, 1.16-8.17) compared with 12.4 days (95% CI, 8.66-16.23) in the S&L group ($P < .05$). This result was not influenced by type of anesthetic ($P = .58$) and was not significantly associated with number of adjunctive procedures ($P = .72$). Time until return to normal activity and return to work values were not significantly different between sites. Complications and adverse findings reported at 72 hours, 1 week, and 3 weeks are presented in Table V. By 4-month follow-up there were no differences to report; thus these results are not detailed in the table.

Absence of all complications and adverse findings associated with a given procedure was included as one measure, and this was consistently favorable to the RFO group, with statistical significance throughout the 3-week follow-up but completely disappeared at the 4-month follow-up. Of the other individual categories, RFO was favored in tenderness, ecchymosis, and hematoma by significant margins. The S&L group was favored by nonsignificant margins in the paresthesia category through the 3-week follow-up, but these differences were negligible at the 4-month follow-up.

In patients with postoperative hematoma, estimation of degree of postoperative discomfort was patient-assessed at 72 hours and 1 week with a visual analog scale of 0 to 10 in seven patients in the RFO group and 13 patients in the S&L group. The comparison showed a trend for greater discomfort in the S&L group, but this was not statistically significant.

Four-month follow-up reports were available for 43 limbs in the RFO group and 34 limbs in the S&L group. At 4 months, 83.7% (36 of 43) RFO limbs and 76.5% (26 of 34) S&L limbs had no complications. Lingering findings included ecchymosis (n = 1), erythema (n = 2), and hematoma (n = 3), all in the S&L group. These were not deemed significant. No other complications were noted.

Complications other than those shown in Table V were minimal. There were no instances of deep vein thrombosis (at duplex scanning) or clinical pulmonary embolism, no thermal injuries, and no lymphatic complications. In the S&L arm one patient had a minor groin infection, which resolved quickly with antibiotic therapy, and one patient had an infection of the thigh and calf and required hospitalization for debridement and antibiotic therapy. The infection resolved between the 3-week and 4-month follow-up examinations. There were no postoperative hospitalizations in the RFO group.

Ultrasound follow-up. Comparative postoperative results for length of GSV occlusion, residual patent segments, and reflux findings are included in the ultrasound category.

All limbs in the S&L group were free of reflux at 72 hours and 1 week.

Postoperative ultrasound findings were analyzed in 43 patients in the RFO group. Because of deficiency in the case report, data for one patient were excluded from analysis. In that case, flow in the proximal segment was reported at 72 hours, but the length of the patent segment was not reported. There was no reflux in this segment, and flow was not detectable at 1-week follow-up or thereafter. There were also two missing data points, in one case at 1-week follow-up and in another at 4-month follow-up.

In the RFO group 36 of 43 limbs satisfied criteria for complete GSV occlusion (<5 cm of proximal patent vein and no reflux in the patent segment) at 72 hours. In 7 of these limbs flow was detected in the proximal 0.5 to 3.4 cm (mean, 2.3 cm) GSV segment. Flow was undetectable at 1 week in two of these limbs, at 3 weeks in two limbs, and at 4 months in one limb. The other two limbs demonstrated flow (2 and 4 cm, respectively) in the proximal segment of the GSV. In none of 36 limbs did flow recur.

In seven (16.3%) of 43 limbs, the 72-hour scan showed flow in the proximal GSV. All seven limbs had flow in the proximal segment of the GSV, but only five limbs had reflux in the open segment. Six of these segments were longer than 5 cm (mean, 21.4 cm; maximum, 34 cm). At 1 week two of these segments closed, and one additional segment closed at 3 weeks. Four limbs (9.5%) were left with open segments and are considered technically incomplete closures. These limbs were all asymptomatic at 4-month follow-up, and the ultimate clinical course remains to be seen. Patency and reflux in branch veins were not addressed in this protocol.

The diameter of occluded proximal GSV measured with ultrasound showed progressive shrinkage: 3.5 mm at 72 hours, 3.0 mm at 3 weeks, and 2.2 mm at 4 months.

Physician and patient assessment of outcome and compliance with wearing stockings were similar throughout the study. The cosmetic assessment after RFO was consistently

Table V. Complications and adverse findings reported through 3-week follow-up

Complications and adverse findings	*Follow-up*													
	72 h					*1 wk*					*3 wk*			
	RFO		*S&L*			*RFO*		*S&L*			*RFO*		*S&L*		
	n	*%*	*n*	*%*	P	*n*	*%*	*n*	*%*	P	*n*	*%*	*n*	*%*	P
None	19	43.2	6	16.7	<.05	15	34.9	5	13.9	<.05	31	70.5	14	38.9	<.01
Infection	0	0	2	5.6		0	0	1	2.8		0	0	1	2.8	
Superficial venous thrombosis	0	0	1	2.8		1	2.3	2	5.6		2	4.5	1	2.8	
Tenderness	2	4.5	9	25.0	<.01	5	11.6	10	27.8		4	9.1	9	25.0	
Lymphocele	0	0	0	0		0	0	1	2.8		0	0	0	0	
Bleeding from stab wound	3	6.8	3	8.3		0	0	0	0		0	0	0	0	
Ecchymosis	12	27.3	19	52.8	<.05	14	32.6	23	63.9	<.01	1	2.3	7	19.4	<.05
Erythema	6	13.6	3	8.3		2	4.7	1	2.8		1	2.3	3	8.3	
Hematoma	7	15.9	14	38.9	<.05	6	14.0	18	50.0	<.01	1	2.3	12	33.3	<.01
Paresthesia	5	11.4	2	5.6		10	23.3	5	13.9		7	15.9	2	5.6	
Hyperpigmentation	0	0	0	0		0	0	0	0		1	2.3	0	0	

RFO, Radiofrequency obliteration; *S&L,* stripping and ligation.

Table VI. Differences in global score and in Pain and Physical activity dimensions of quality-of-life measurement

Follow-up		*S&L*		*RFO*		P
		Mean	*SE*	*Mean*	*SE*	
72 h	Difference in global score*	13.3	3.1	−3	2.7	<.0001
	Difference in pain*	2.9	0.7	−1.77	0.6	<.0001
	Difference in physical score*	4.85	0.79	0.82	0.69	<.0001
1 wk	Difference in global score†	3.7	2.5	−9.2	2.3	<.0001
	Difference in pain†	1.2	0.7	−2.4	0.6	<.0001
	Difference in physical score†	2.02	0.72	−0.97	0.65	.003

S&L, Stripping and ligation; *RFO,* radiofrequency obliteration; *QOL,* quality of life.

*Differences compared with before treatment; adjusted by type of anesthesia and number of adjuctive procedures. Positive difference indicates worsening of QOL; negative difference indicates improvement.

†Differences compared with before treatment; adjusted by number of ajunctive procedures. Positive difference indicates declination of QOL; negative difference indicates improvement.

better than after S&L, to a significant degree. Signs and symptoms reported by patients were similar in all but the pain category, in which RFO showed a clear advantage. This was subjective assessment of pain, which was not measured routinely with an analog scale or consumption of pain pills, but was recorded with the VCSS. All other measures were virtual mirror images between the two study groups.

Analysis of QOL surveys showed that statistically significant differences in favor of the RFO group were present in global score and pain score during follow-up. The magnitude of the difference, however, progressively decreased from 1 week to 3 weeks and was negligible at 4 months.

Differences in global, pain, and physical scores on the QOL instrument, where statistically significant results were found, are shown in Table VI. The figures were adjusted for number of adjunctive procedures. Inasmuch as social and psychologic scores did not show significant differences, the difference in the global score was entirely due to changes in scores for pain and physical activity.

Analysis of the effect of type of anesthetic used showed that the chances of QOL score improvement at 72 hours after treatment were significantly higher in the Closure group ($P = .016$), regardless of anesthetic type (general or local with sedation; Table VII). When treatment was performed with the patient under general anesthesia the chances of QOL global score improvement were six times higher in the RFO group (odds ratio [OR], 6.0; 95% CI, 1.2-30.3), and the chances of physical activity score improvement were 10 times higher (OR, 10.0; 95% CI, 1.9-58.8), compared with the S&L group.

DISCUSSION

Rutgers and Kitslaar[1] and Jones et al[2] showed in separate randomized studies that high ligation with saphenectomy resulted in lower recurrence rate of reflux and varicosities than did high ligation alone. Because of morbidity consisting of post-procedural pain and bruising that resulted from the stripping procedure, modifications of the conventional stripping technique have been sought. PIN stripping is one such technique that has been embraced by many. Prospective randomized studies by LaCroix et al[11] and by Durkin et al[12] compared post-procedural morbidity rates between PIN stripping and conventional (olive tip) stripping and reported an absence of clear benefit from the new technique except that the exit wound is smaller with the PIN technique.[12] The present standard remains high ligation with stripping with either technique, and any alternative technique will need to demonstrate equal or better outcome with equal or reduced morbidity to be accepted.

This multicenter prospective randomized protocol provided direct comparison of the early postoperative course after conventional GSV S&L and after treatment with the Closure procedure. Because the series originated in the early days of use of the Closure procedure, and because improvements have been made in the procedure and the catheter used, we believe strongly that a similar study performed today would obviate some of the reported technical problems in the RFO group.

During early clinical application of the Closure procedure some investigators observed that high ligation of the saphenous vein and individual ligation of each of the saphenous branches with open dissection might not be necessary because this could be achieved with the endovenous route.[3] The present study was performed using the Closure technique, and is known as the Endovascular Vein Occlusion versus Ligation and Vein Stripping Study (EVOLVeS).

The instruments chosen for measurement, including duplex scanning, QOL measurement with CIVIQ2, CEAP, and VCSS severity scoring, are recognized as state-of-the-art for use in venous diseases. The trial was mediated by the sponsor to ensure comparability of the data to a significant degree. Investigators were selected on the basis of proficiency in performing both S&L and the Closure procedure.

Data analysis was performed by the principal authors independent of input from the sponsor other than to provide access to raw data. The article was prepared by the authors working as a group to ensure uniformity of reported results and conclusions. Care was taken to eliminate sources of sponsor influence in analysis of data. Funding from the sponsor was limited to cost of catheters and provision of study monitors. Reimbursement to the participants was limited to expenses incurred.

The cogent findings in this prospective study are earlier return to normal activity (80% vs 46% in 1 day) and earlier return to work (4.7 days vs 12.4 days) in the Closure group. Pain was less, recovery was quicker, early cosmesis was better, with fewer incisions, hematomas, and ecchymoses, and QOL analysis demonstrated significant early (up to 4 month) advantages of Closure to S&L in three of the five categories. Complications in both arms of the study were more annoying than serious.

The QOL instrument showed that early advantages of Closure were statistically significant with regard to amount of discomfort and cosmetic aspects related to the procedures. The early return to normal activity followed by a much more rapid return to work, within the first week after RFO, are consistent and real. These attributes are not only pleasing to the patient, but they also bear important considerations for overall cost of the procedure that may offset the higher specific costs for the Closure catheter and for duplex scanning in the operating room. For example, cost savings may be due to lower risk for infection. In this study, the only patient who required hospitalization for debridement and antibiotic treatment of infection was in the S&L group. By comparison, a prospective study examining infection rate in 126 patients after vein stripping performed by 11 surgeons, all of whom were fellows of the Royal Colleges, showed a surprisingly high overall infection rate of 13.7%, and an infection rate of 8% even after excluding results from two high-volume surgeons with the highest rates.[13]

Table VII. Proportion of patients with improved global score at 72-hour follow-up

Anesthesia		*No improvement (%)*	*Improvement (%)*
General	RFO (n = 12)	25	75
	S&L (n = 18)	67	33
		$P = .03$	
Local or regional	RFO (n = 32)	53	47
	S&L (n = 17)	82	18
		$P = .041$	

RFO, Radiofrequency obliteration; *S&L,* stripping and ligation.

Critical appraisal of RFO results must conclude that there remains room for improvement. In this series, there were two cases in which avoidable mistakes were made in placement of the catheter and choice of catheter size, both of which resulted in long-term reflux in the treated segment. The finding that only 91% of veins were completely closed in this series should be improved with further refinement of the Closure technique. For example, catheter models available today that were not available at the time of the study track over a 0.025-inch guide wire and significantly improve the likelihood of successfully navigating the catheter to the saphenofemoral junction. That all veins that were completely closed at initial follow-up remained completely closed throughout the study speaks to the efficacy of this method in achieving obliteration of the saphenous vein. These findings demonstrate the importance of a completely successful technical procedure in the operating room and to the permanence of initial successful vein obliteration.

There is an often expressed concern by the patient that vein stripping will be painful and will leave scars, and both of these points are addressed with the Closure technique. The demonstration in this study that the sequelae of vein stripping are also relatively mild and that the undesirable effects of stripping are ameliorated within 4 months of follow-up is testimony to the validity of this approach. In support of vein stripping, it could be argued that there are gentler techniques for performing vein stripping that reduce the aftereffects of the procedure, but our experience probably reflects the results that are achieved in the general care of patients who have undergone vein stripping.

Our results demonstrate that endovascular obliteration of the GSV is a patient-friendly technique that effectively eliminates the GSV from the circulation for at least 4 months. In the absence of significant complications, eg, deep vein thrombosis and pulmonary embolism, severe neuritic sequelae, and skin burn, it is evident that there are significant early advantages to RFO compared with conven-

tional S&L. The technique has limitations in terms of GSV size and configuration, and in such cases S&L is clearly the better choice. Longer term studies are needed to determine the ultimate fate of the GSV after RFO, and very long-term results will ultimately reveal the consequences of leaving the uppermost branch of the GSV patent.

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