Saphenectomy in the presence of chronic venous obstruction

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Background. *The results of saphenectomy in patients with morphologic and functional obstruction were compared with those in patients without obstruction. Excision of secondary saphenous varices associated with deep venous obstruction has long been considered contraindicated for fear of compromising its collateral contribution. Recent advances in accurate functional assessment of venous obstruction make it possible to test this concept.*

Methods. *Saphenectomy was carried out in 51 limbs without morphologic or functional obstruction and 64 limbs with varying grades of venous obstruction. Significant deep venous obstruction on ascending venography was present in the latter group. Functional assessment of obstruction was based on the arm/foot venous pressure differential technique, outflow fraction measurements, and outflow resistance calculations. Valve reconstruction was carried out in conjunction with saphenectomy in 81% of cases.*

Results. *Saphenectomy was clinically well tolerated in both groups, and there was no difference in outcome as measured by objective tests for obstruction; improvement in reflux and calf venous pump function was largely similar. Among seven limbs with severe preoperative venous obstruction (grade III or IV), five (70%) had significantly improved obstructive grading, presumably as a result of elimination of reflux flow.*

Conclusions. *The traditional admonition against removal of secondary varices should be reexamined. Saphenectomy may be indicated in postthrombotic syndrome with mixed obstruction/reflux. The procedure is clinically well tolerated and without malsequelae. Improvement in reflux parameters without significant worsening of objective measures of obstruction is documented in this group. (Surgery 1998;123:637-44.)*

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FOR ALMOST A CENTURY, IT HAS BEEN emphasized that excision of secondary varicosities is contraindicated.[1-8] It has been feared that stripping of secondary saphenous varices that result from deep venous obstruction and function as collaterals would lead to worsening of the obstruction,[1,2,4,7] possibly in catastrophic fashion jeopardizing the limb.[1-3] Confirmation of deep venous patency has been considered an essential part of preoperative workup, before stripping of saphenous varicosities is undertaken.[1,4-7,9] Ascending venography[1,4-6,9] and subsequently duplex ultrasonography[1,7] have superseded earlier clinical techniques, such as emptying of varicosities on leg elevation[10] or the Perthes test,[11] that were used to confirm deep venous patency. Although these concepts are well entrenched, there have been occasional suggestions in the literature[12,13] that excision of secondary varicosities may in fact be safe. However, such a hypothesis has not been tested heretofore according to reliable techniques for functional assessment of venous obstruction.

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MATERIAL AND METHODS

One hundred fifteen saphenectomy procedures performed in 111 patients from January 1982 were analyzed. The male/female ratio in the patient population was 5:6. Saphenectomy was carried out as an isolated procedure in 19% and in conjunction with valve reconstruction for reflux in 81% of the patients.

Technique of saphenectomy. The saphenofemoral junction was divided after ligation/division of primary tributaries. Then the entire long saphenous vein ($n = 89$) was stripped from ankle to groin. In 30 limbs only the proximal saphenous vein from knee to groin was stripped. In either case, the stripped saphenous segment had to span

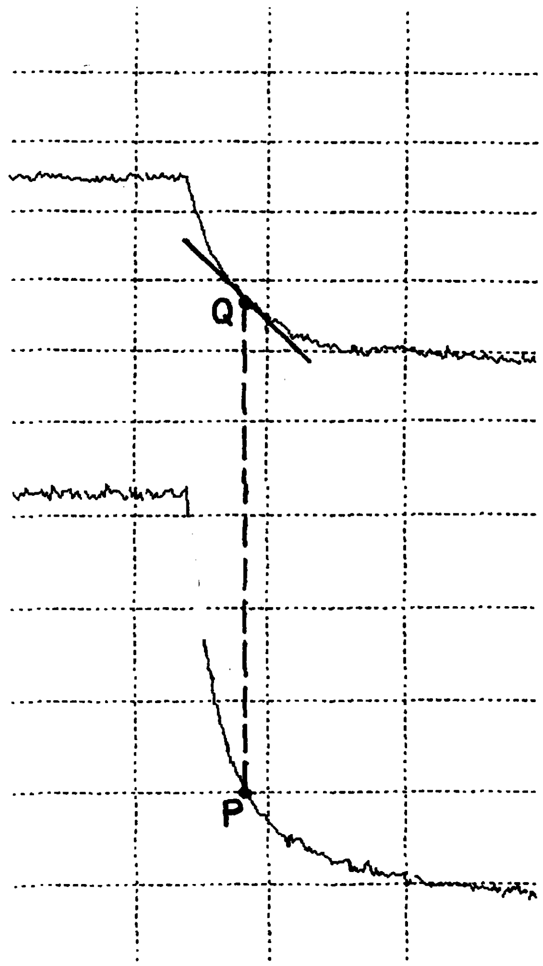

Fig. 1. Simultaneous outflow volume *(top)* and foot venous pressure *(bottom)* curves. Outflow fraction expressed as percentage of total outflow was calculated for timed fraction of 2 seconds after thigh cuff release. Resistance at given point in pressure curve is obtained by P/Q, where P is pressure and Q is flow at corresponding point in outflow curve. Q is derived by drawing tangent at particular point in outflow curve and is expressed as milliliters per minute. Resistance is expressed as millimeters of mercury per milliliter per minute and is typically plotted as a curve at multiple pressure points because resistance varies as venous filling (reflected in corresponding pressure change) varies during outflow curve.

an obstruction of the underlying main deep venous trunk (axial venous obstruction) to qualify as a secondary saphenous varix and to be included in our analysis. Saphenectomy was carried out when saphenous reflux was present on duplex or descending venography. Limbs with grade 0 obstruction that underwent saphenectomy had no morphologic or functional deep venous obstruction but had saphenous reflux (i.e., primary reflux).

Assessment protocol. The following preoperative and postoperative evaluations were carried out: detailed clinical examination; arm/foot venous pressure differential and reactive hyperemia foot venous pressure elevation,[14-17] supine Valsalva foot venous pressure elevation,[18] ambulatory foot venous pressure measurement,[18] air plethysmography (ACI Medical) with traditional parameters for measurement of reflux and calf venous pump function,[19] and calculation of outflow fraction,[17] outflow resistance[17] calculated from simultaneous flow, and pressure measurements; and color duplex examination with assessment of spontaneity, phasicity, augmentation, and reflux competence as described previously.[20] Rapid-deflation cuffs[21] were used for compression maneuvers when this technique became available. Ascending and descending venography was performed routinely before operation in those patients in whom valve reconstruction was anticipated.

Postoperative venous testing was carried out 3 to 12 months after operation. The arm/foot venous pressure differential technique was the mainstay in functional assessment of obstruction and was available in all of the 115 limbs analyzed. Other techniques were available for analysis in lesser numbers as indicated because of later introduction. Long-term venous testing data (1 to 3 years after operation) were available in 36 limbs, 25 belonging to the group undergoing secondary saphenectomy.

Clinical follow-up. All patients were seen in follow-up 3 to 6 months after operation. Patients with concomitant valve reconstruction continue to be followed up on a yearly basis thereafter. Mean follow-up of the entire group was 20 ± 15 months. Severity of clinical disease was classified according to recently recommended reporting standards.[22]

The above protocol allowed assessment of the following functional and morphologic parameters for venous obstruction: (1) functional grading based on the arm/foot venous differential technique, described in detail previously.[14-17] Briefly, the arm/foot venous pressure differential was measured at rest in a supine position. Foot venous pressure elevation in the patient in a supine position after induction of reactive hyperemia by a 3-minute ischemic thigh cuff occlusion was also measured. Obstruction was then graded as shown in Table I. Doppler duplex criteria were used to differentiate between grade 0 and grade I obstruction as shown in Table I. (2) The technique for measurement of outflow fraction has been described in detail elsewhere.[17] Outflow fraction was calculated from the outflow volume curve obtained with air plethysmography after release of the venous occlusion thigh cuff. (3) Outflow resistance was calculated

Table I. A method of grading venous obstruction based on arm/foot venous pressure differential and reactive hyperemia technique

Obstructive grade	*Obstruction on duplex/venogram*	*Arm/foot pressure difference (>4 mm Hg)*	*Reactive hyperemia foot pressure elevation (>6 mm Hg)*
Normal (0)	No	No	No
Compensated obstruction (I)	Yes	No	No
Partially compensated obstruction (II)	Yes	No	Yes
Partially decompensated obstruction (III)	Yes	Yes	Yes
Decompensated obstruction (IV)	Yes	Yes	No*

*Paradoxical response.[15]

from simultaneous calf volume and foot venous pressure tracings recorded after release of the occlusive thigh cuff of the air plethysmographic instrument as described previously.[7] For a given pressure (P), corresponding flow (Q) was calculated from the simultaneous point in the outflow curve and resistance was expressed as P/Q (in millimeters of mercury per milliliter per minute) (Fig. 1). Because resistance varied as the calf volume changed during outflow, resistance was calculated at multiple points for each limb (5, 10, 15, 20, 30, and 40 mm Hg) and plotted as a curve for comparison before and after operation. (4) The morphologic elements of venous obstruction were assessed by color duplex examination and ascending venography. The latter allowed more detailed morphologic assessment of deep venous obstruction than did duplex scanning.

The distribution of the case material based on the functional grading system according to the arm/foot venous pressure differential technique is shown in Table II. The 51 limbs with grade 0 obstruction before operation were considered control limbs. The outcome in 64 limbs that had preoperative obstruction grades I through IV was compared with that in the control group.

Morphology of venous obstruction. Duplex examination and ascending venography showed normal venous anatomy in the control group. Among 64 limbs with grades I through IV functional obstruction, 44% showed focal or extended axial venous stenosis and 56% had outright axial venous thrombosis with or without trabecular recanalization. In 83% of limbs, obstruction involved multiple venous segments. A typical venogram in a patient with severe multilevel venographic obstruction undergoing saphenectomy is shown in Fig. 2.

Despite the presence of significant morphologic axial venous obstruction, 57 of 64 cases were adequately collateralized and functionally well compensated, resulting in a functional obstruction

Table II. Distribution of case material according to preoperative obstructive grading by the arm/foot venous pressure differential technique

Obstructive grade	*Saphenectomy alone (n)*	*Saphenectomy + valve reconstruction (n)*	*Total*	
			n	*%*
0, Controls	12	39	51	44
I	9	40	49	43
II	0	8	08	07
III	0	1	01	01
IV	1	5	06	05

grade I or II by the arm/foot venous pressure differential technique. Only seven cases belonged to uncompensated obstruction grade III or IV (Table II). Rich collateralization of infrainguinal axial venous obstructions is well known, and the relative distribution of the various grades of obstruction in this series is similar to that in our previous report.[15]

Statistics. All categoric variables were summarized according to contingency tables. Means and standard deviations were computed for the quantitative variables. The two-tailed t test was used to compare outcome parameters for unpaired samples. The one-tailed t test was used for paired samples. Analysis of covariance was used for relevant parameters.

RESULTS

Change in functional obstruction grade by the arm/foot venous pressure differential technique after saphenectomy. The mean obstructive grade increased by 0.7 ± 1.1 in the control group and 0.2 ± 1.5 in the group with obstruction. This difference was not significant.

Valve reconstruction undertaken in conjunction with saphenectomy (81.5% of cases) had no bearing in the noted obstructive grade changes per multivariate analysis. Progression of obstruction by

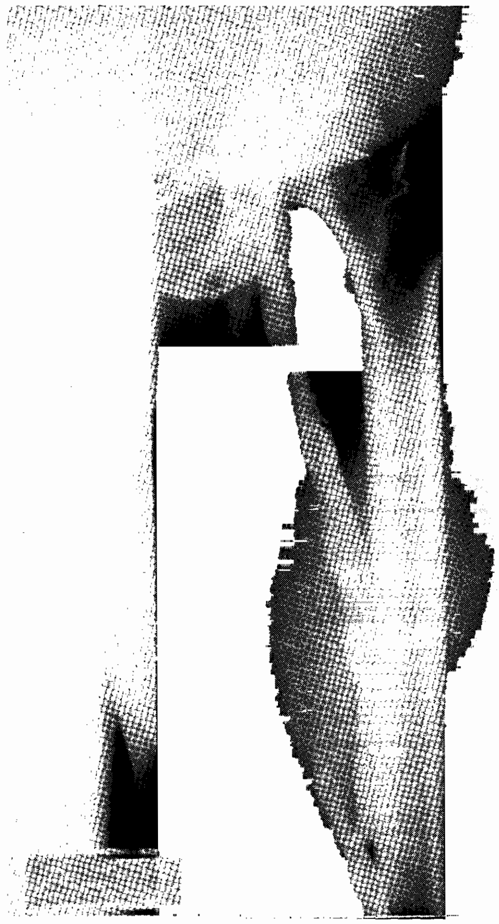

Fig. 2. Axial transformation of deep femoral vein through large profunda-popliteal connection. Major portion of superficial femoral vein except for distal portion is occluded. Removal of saphenous vein is well tolerated because of presence of profunda-popliteal collateral connection.

at least two grades (e.g., preoperative grade I to postoperative grade III or preoperative grade II to postoperative grade IV) after operation was noted in 14% of the control group, 18% with preoperative grade I obstruction, and 13% with preoperative grade II obstruction. The differences were not significant. All of the above cases (n = 17) were analyzed individually. In five cases the increased grade of obstruction noted after the operation was related to acute deep venous thrombosis and in eight others recurrent venous thrombosis (>3 months after operation). In the remaining four cases an identifiable cause could not be found. Among seven limbs with preoperative grade III or IV obstruction, in five limbs (70%) the obstructive grading improved by two or more grades after saphenectomy. The mean size of the saphenous vein measured from ascending venographic films was 8 ± 2.4 mm in the control group and 7.8 ± 3.1 mm in the group with obstruction (difference not significant). Analysis suggested no relationship between the size of the excised saphenous vein and the change in the obstructive grade after operation.

Outflow fraction and resistance calculations before and after saphenectomy. Preoperative and postoperative values for these parameters of obstruction in patients who have undergone saphenectomy are shown separately for the control group and the group with obstruction in Table III and Fig. 3. There was no significant difference between the two groups' change in outflow fraction (postoperative – preoperative; two-tailed t test for unpaired samples). There was, however, worsening of outflow fraction among normal subjects by 3% after operation. In the group with obstruction, outflow fraction worsened somewhat more at 6% (p < 0.0007, one-tailed t test for paired samples). There was no difference between the resistance curves for the normal group and those for the group with obstruction as calculated before or after operation; there was no progression of obstruction after operation in either group by this parameter. Taken together, these data suggest that there may be statistically significant but nonetheless small worsening of outflow fraction in quantitative terms in the group with obstruction after operation.

Reflux and other hemodynamic parameters. Values for Valsalva foot venous pressure, ambulatory venous pressure, and plethysmographic parameters before and after saphenectomy for the control group and the group with obstruction are shown in Table IV. The Valsalva foot venous pressure and the air plethysmographic parameters delineate reflux and calf venous pump function. The ambulatory venous pressure is a more global measurement of venous hemodynamics, reflecting reflux, obstruction, ejection of calf venous pump, and venous compliance as well. Except for venous refilling time or recovery time (VFT), there was no difference between the control group and the group with obstruction in these outcome parameters after saphenectomy (i.e., improvement after operation if any was similar in both groups). Significant postoperative improvement was noted in the following parameters: venous volume, VFT, and venous filling index (VFI_{90}) (Table IV). VFT appeared to improve significantly more (p < 0.03) in the control group (10.2 ± 16.8 seconds) compared with the group with obstruction (2.8 ± 15.9 seconds) after operation. This may be related to the poor compliance of the calf venous pump or high absolute residual volume (air plethysmography measures only relative volume changes from resting levels) in the group with obstruction. Plethysmographic venous volume

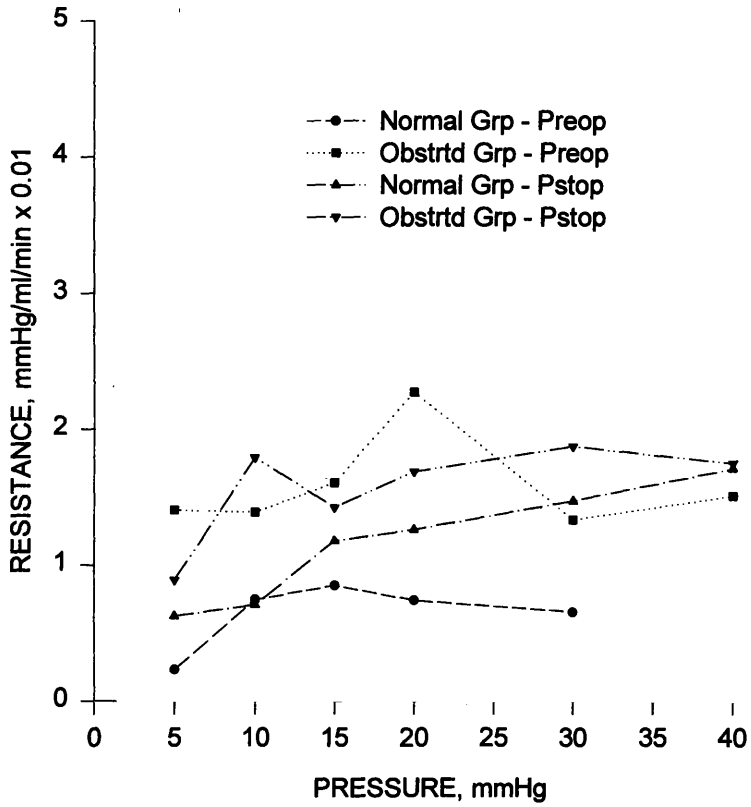

Fig. 3. Calculated resistance for control and test groups before and after saphenectomy.

Table III. Outflow fraction (2 seconds) before and after saphenectomy for control group and group with obstruction

Patient group	*n*	*Outflow fraction (%) (2 sec)* *Preoperative value*	*Postoperative value*	*p Value*
Control	37	64.1 ± 10	61.2 ± 12	NS
Obstructive	51	62.8 ± 12	57 ± 15*	

NS, Not significant.
*Preoperative versus postoperative value: $p < 0.0007$ (one-tailed t test for paired samples).

decreased significantly ($p < 0.00005$) (mean 17 ± 39 ml) after saphenectomy in both groups.

Clinical outcome. Saphenectomy was well tolerated clinically in both the short and long term after operation in the control and test groups regardless of whether the patients had morphologic or functional obstruction. Clinical progression of obstruction was not discernible in either group after saphenectomy. There was no incidence of skin necrosis, venous gangrene, or venous claudication in any of the patients in either group after operation. Clinical severity improved significantly after operation in the entire group: from preoperative clinical class 5.2 ± 1.3 to postoperative clinical class 4.0 ± 2.0 ($p < 0.00002$). In 10 limbs with obstruction undergoing saphenectomy alone without valve reconstruction, clinical severity improved from 3.7 ± 1.3 to 2.4 ± 2.5 after operation.

Long-term venous testing 1 to 3 years after operation was available in 25 patients with obstruction and showed that the functional obstructive grade remained stable in 92% and worsened (more than two grades) in 8% of patients.

DISCUSSION

Serial duplex examination of patients after deep venous thrombosis indicates that combined obstruction/reflux is the dominant pathologic manifestation of postthrombotic syndrome.[23] With evolution of time, the majority of patients with pre-

Table IV. Mean difference between preoperative and postoperative values in control group and group with obstruction after operation

	Mean preoperative-postoperative difference				
Parameter	*Control group*	*n*	*Obstructed group*	*n*	*p Value (obstructed vs control)*
% Drop in ambulatory venous pressure	−1.8 ± 17.5	40	−3.1 ± 15.6	56	NS
VFT (sec)*	−10.2 ± 16.7	45	−2.8 ± 15.8	57	<0.02
VFI_{90} (ml/sec)*	1.9 ± 4.2	35	1.3 ± 2.8	50	NS
Venous volume (ml)*	24.2 ± 51.1	36	12.0 ± 27.0	49	NS
Ejection fraction (%)	−2.7 ± 19.8	35	0.8 ± 25.4	50	NS
Residual volume fraction (%)	2.8 ± 20.2	35	2.5 ± 19.3	47	NS
Valsalva venous pressure (mm Hg)	1.7 ± 4.9	47	−0.2 ± 10.1	61	NS

NS, Not significant.

*These parameters improved significantly after operation for both control and test groups ($p < 0.0002$ for VFT, $p < 0.00005$ for VFI_{90}, and $p < 0.00005$ for venous volume).

vious deep venous thrombosis appear to suffer from the reflux component of the combined obstruction/reflux disease.[23-27] Venous stasis skin changes, including venous ulceration in the more severe cases, are typically present in such patients and are thought to be specifically related to the reflux component rather than the obstruction component.[28-30] Reflux corrective or ablative procedures including valve reconstruction[20,27,28] can provide clinical relief in these patients even when residual morphologic and functional venous obstruction is present. Because a dilated saphenous vein may be an important source of reflux in many of these patients, saphenectomy may be indicated alone or in conjunction with valve reconstruction to abolish reflux and improve calf venous pump function. The concern, however, is that the obstructive disease may be made functionally more severe by removing the saphenous vein that may be functioning as an important collateral. This study provides some assurance that this frequently expressed fear may be exaggerated. Infrainguinal venous obstructions are usually well tolerated because of rich collateralization.[15] As noted earlier, 57 of 64 limbs in this series with axial venous obstruction evident on venography were functionally well compensated, resulting in an obstructive grade of I or II. Axioaxial (intramuscular and intermuscular), tributary-axial (deep femoral, circumflex, pudendal, obturator, sciatic, gluteal, and epigastric), and saphenous collaterals contribute to this collateral effort. As such, these 57 limbs with grade I or II obstruction had the greatest potential for functional deterioration after saphenectomy, even more than the seven limbs with grade III or IV obstruction. The latter were already decompensated in functional terms and could not get any worse (except for clinical deterioration into venous gangrene or severe venous claudication). Current analysis indicates that the relative contribution of the saphenous vein in collateral compensation is minor and therefore it can be excised safely when saphenous reflux is present. No patient in this series, including those with severe preoperative functional obstruction, were made worse clinically in terms of worsening obstructive manifestations after saphenectomy. Of the 17 cases (control and test group) in which obstruction was measurably worse after saphenectomy, 13 were attributable to acute (five cases) or recurrent (eight cases) deep venous thrombosis and not to a significant reduction in outflow pathway available after saphenectomy. There was a similar incidence of outflow compromise caused by deep venous thrombosis in both control and test groups. In five of seven patients with high-grade (grades III and IV) preoperative venous obstruction, saphenectomy appeared to improve the obstructive grade after operation. It is assumed that elimination of reflux flow reduced calf venous overload in such cases, leading to functional improvement. It is further inferred that nonsaphenous venous collaterals (i.e., other subcutaneous or deep collaterals) compensate easily and rapidly for elimination of any collateral function provided by the dilated saphenous vein in the presence of deep venous obstruction. The dilation of the saphenous vein so frequently noted in cases of obstruction may be related to the reflux reverse flow rather than collateral flow alone. It is noted that the dilated saphenous vein (averaging about 8 mm) was similar in size regardless of whether the deep venous system was obstructed.

The outcome of the benign clinical and functional assessment of saphenectomy in 10 limbs with axial venous obstruction where it was carried out as an isolated procedure tends to argue against the possibility that concomitant valve reconstruction in 54 cases with axial obstruction could have somehow favorably influenced these results. We have previously noted[15] that interruption of perforator collaterals by the modified Linton technique in patients with thrombosis of the tibiopopliteal venous segment with venous stasis skin changes was well tolerated without clinical or functional worsening of existing deep venous obstruction. This study extends these observations to saphenectomy as well.

In evaluating chronic obstruction, the arm/foot venous pressure differential method is more accurate than outflow determinations or resistance calculations.[17] The latter two techniques have artifactual errors as a result of volume displacement by the venous occlusive cuff of the plethysmograph.[17] In addition, outflow fractions may be influenced substantially by venous compliance even in the absence of outflow obstruction.[31,32] For purposes of this study, however, because these two techniques were used to compare preoperative and postoperative values in the same limb, the sources of these errors tend to cancel out during the serial measurements and any noted change before and after operation probably reflects a true change in outflow after saphenectomy.

It is now well established that there is a wide disparity between the morphologic appearance of a venous obstruction and its functional importance.[14,16] Technical factors involved in performing ascending phlebography contribute to this disparity to a large extent. Deep collaterals that are undoubtedly present and functional in a given patient often fail to visualize on ascending venogram.[16] It is well recognized that contrast material introduced into a dorsal foot vein preferentially flows through the saphenous system, thus failing to opacify the deep system adequately unless contrast material is "forced" into the patent deep system by ankle tourniquets. Such contrast artifacts result from minor regional differences in centripetal flow and misleadingly exaggerate the importance of saphenous collaterals over deep collaterals that are functionally more important but fail to opacify because of technical reasons. These deep collaterals are invariably present in the presence of infrainguinal axial venous obstruction and are adequate to withstand the effects of saphenectomy when indicated in such cases.

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