Axial transformation of the profunda femoris vein

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Purpose: **To highlight a special subset of cases of venous stasis in which the profunda femoris vein enlarges to a variable extent (axial transformation) to compensate for severe postthrombotic changes in the accompanying superficial femoral vein.**
Methods: **Among 500 consecutively treated patients with severe venous stasis, 57 patients had axial transformation of the profunda femoris vein. Venous obstruction and reflux were assessed by means of arm-foot pressure differential, ambulatory venous pressure measurement, air plethysmography, and duplex examination. Ascending and descending venograms also were obtained. A variety of valve reconstruction techniques were useful in correcting reflux in the enlarged profunda femoris vein and the companion postthrombotic superficial femoral vein.**
Results: **In 55% of patients the profunda femoris vein was larger than normal and provided partial outflow from the leg through a profunda-popliteal connection, but the superficial femoral vein was still the dominant outflow tract (grades I and II). In 36% of patients the profunda femoris was the dominant outflow tract from the leg, and in another 9% it was the sole axial outflow tract (grades III and IV). The skin changes of advanced venous stasis were present among 92% of patients and frank ulceration among 88%. Antireflux operations on the profunda femoris vein and companion superficial femoral vein, including ligation and division in some instances, were well tolerated. Despite a postthrombotic cause, obstruction did not worsen after surgical treatment, and reflux improved according to most laboratory measurements. Complete ulcer healing was obtained with the surgical techniques described. The actuarial recurrence-free survival rates were 90% 1 year and 66% 5 years after treatment.**
Conclusion: **Axial transformation of the profunda femoris vein is present in a subset of instances in which severe postthrombotic changes are present in the companion superficial femoral vein. Profunda femoris reflux is invariably present in these instances because of compensatory dilatation and enlargement of this vessel. Simultaneous valve repair of the axially transformed profunda femoris vein and companion superficial femoral vein to abolish reflux yields excellent long-term results and healing of stasis ulceration.**
(J Vasc Surg 1998;27:651-9.)

The profunda femoris vein provides an important collateral pathway when the superficial vein is obstructed by thrombosis.[1] The profunda popliteal collateral connection may have an embryologic basis. The size of this connection depends on the degree of obstruction present in the superficial femoral vein. In extreme cases the profunda femoris vein completely replaces the superficial femoral vein as the main outflow source for the limb. This axial transformation of the profunda femoris vein can be strikingly similar to normal anatomy, with smooth contours that may be mistaken by the unwary for the superficial femoral vein (Fig. 1). Once formed the profunda popliteal connector persists and does not disappear even when the superficial femoral vein has recanalized satisfactorily.[1] We have previously emphasized the importance of multiple valve reconstructions in this setting.[2,3] Eriksson and Almgren[4] were the first to emphasize the importance of profunda femoris valve reconstruction. Depending on the degree of axial transformation present, the profunda popliteal collateral needs special consideration in venous valve reconstruction. Modification of technique often is necessary. Presumably because of compensatory dilatation, considerable reflux usually is present in the profunda femoris vein in these

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0741-5214/98/$5.00 + 0 **24/1/88732**

Fig. 1. Axially transformed profunda femoris vein. The appearance often mimics a normal superficial femoral vein and can be mistakenly read as normal. A more lateral course overlying the femoral shaft is the clue to the correct diagnosis.

instances, and valve reconstruction is required. We report our experience with 57 instances in which valve reconstruction for postthrombotic syndrome was attempted.

METHODS

The case records and phlebograms of 500 patients with venous stasis consecutively treated at the University of Mississippi Medical Center and River Oaks Hospital over a 9-year period (1987 through 1996) under the direct care of S. R. were analyzed. All patients with an occasional exception were referred after undergoing initial treatment elsewhere. A profunda popliteal connector was identified by means of ascending venography in 57 patients (11.4% incidence). The morphologic grading system used to assess the collateral (axial transformation grade) is shown in Fig. 2. Grading was based on radiologic findings and direct inspection at operation, the latter superseding in case of conflict in interpretation. The distribution of patients among the various grades was as follows: grade 1, 15%; grade 2, 40%; grade 3, 36%: and grade 4, 9%. Partial outflow from the infrapopliteal veins through the profunda femoris vein by way of a profunda-popliteal connector was present in grades 1 and 2 (55%). It was the dominant outflow tract (grade 3) in 36% of the patients and in another 9% functioned as the sole axial outflow (grade 4, complete axial transformation).

Among the 57 patients, clear postthrombotic changes were identified in the companion superficial femoral vein in 96%, either at preoperative ascending phlebography or direct operative inspection. According to the clinical picture, etiology, anatomic distribution, pathophysiology (CEAP) classification system[5] the cases were characterized as follows: for clinical features, class 3 = 8%, class 4 = 4%, class 5 = 18%, class 6 = 70%; for etiologic features, primary = 4%, secondary = 96%; for anatomic distribution, superficial = 0%, deep = 100%; and for pathophysiologic features, reflux = 69%, reflux with obstruction = 31%.

Functional and radiologic assessment. Detailed laboratory assessment included ambulatory venous pressure measurement, air plethysmography, and quantitative (valve closure times) duplex examination in the recumbent and erect positions. Ascending and descending venograms were obtained. The degree of venous obstruction in the limbs before and after surgical treatment was determined by means of arm-foot venous pressure differential[1] technique. Resting arm-foot pressure difference and foot venous pressure elevation with reactive hyperemia were measured. On the basis of the results, the patients' conditions were classified as fully or partially compensated (obstructive grades 1 and 2) or decompensated (obstructive grades 3 and 4). This method of functional assessment of obstruction is considered the most reliable among current techniques used for this purpose.[6] Despite postthrombotic compromise of the companion superficial femoral vein, increased outflow through the profunda femoris and other collateral blood vessels was adequate. The degree of functional obstruction was quite

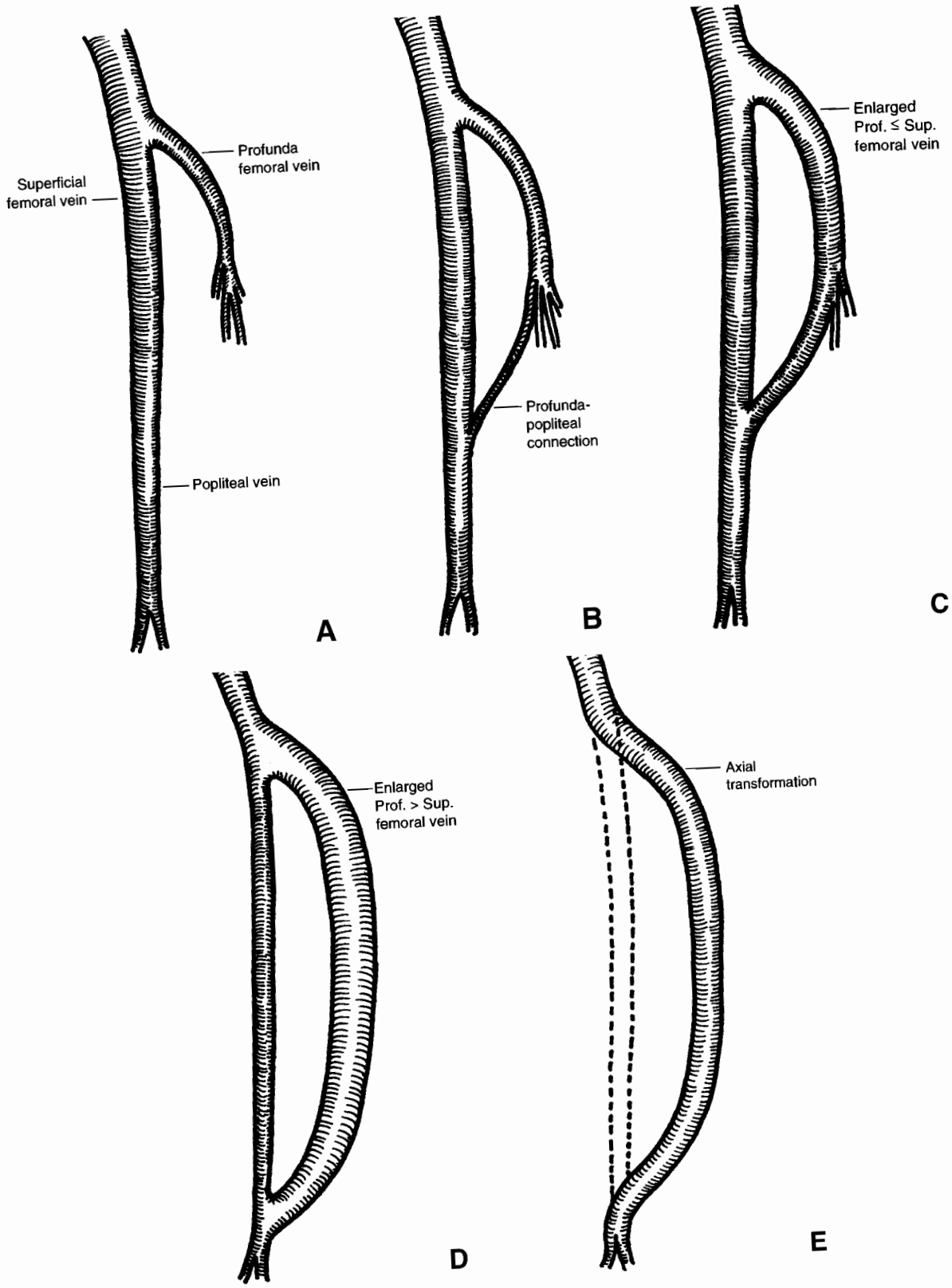

Fig. 2. Grading system for the axially transformed profunda femoris vein. **A,** Grade 0, normal presentation of venous anatomy. **B,** Grade 1, profunda-popliteal collateral connection with normal profunda caliber. **C,** Grade 2, profunda enlarged but smaller than or equal to the size of the superficial femoral vein. **D,** Grade 3, profunda femoris vein enlarged more than superficial femoral vein and marked stenosis of the superficial femoral vein. **E,** Grade 4, axial transformation of the profunda femoris vein with total occlusion of the superficial femoral vein.

Table I. Axial transformation: Assessment of functional obstruction (n = 32)*

	Before surgical treatment		*After surgical treatment*	
Obstruction grade	*n*	*Percentage*	*n*	*Percentage*
0	4	13	3	9
1	18	56	12	38
2	9	28	11	34
3	0	0	3	9
4	1	3	3	9

Preoperative mean, 1.25 ± 0.8; postoperative mean, 1.72 ± 1.08 (*t* test p = NS).
*Data available for only 32 of 57 patients (32 of 44 profunda repairs) because either preoperative or postoperative values were missing because of technical problems or lack of availability for follow-up data collection.

Table II. Valve reconstruction of axially transformed profunda femoris and companion superficial femoral veins

	Profunda femoris		*Superficial femoral vein*	
Surgical procedure	*n*	*Percentage*	*n*	*Percentage*
Axillary vein transfer	25	57	11	33
De novo valve reconstruction	2	5	—	—
Transcommissural valvuloplasty	10	23	8	24
Prosthetic sleeve in situ	4	9	4	12
External valvuloplasty	2	5	5	15
Ligation	1*	2	2	6
Division	—	—	3	9

*Ligation performed on a patient with grade 1 configuration.

mild (obstructive grades 1 and 2) in all but one limb in the group (Table I).

Reflux in the profunda femoris vein was detected with duplex scanning in 56% (23/41) of the patients and with descending venography in 86% (19/22). Reflux was identified with a strip test at operation[7] in 91% (41/45) of the patients. With the strip test as the standard, duplex scanning (n = 26) yielded a false-negative rate of 50%. Descending venography (n = 17) had a false-negative rate of only 6% for detection of profunda femoris reflux.

Indications for surgical treatment. The primary indications for surgical treatment were as follows: frank stasis ulceration for 50 patients (88%), stasis dermatitis for two patients (4%), and pain for five patients (8%). Thus venous stasis ulceration or dermatitis was present in all but five patients in the entire group (92%). Because of the high prevalence, a dose response (axial transformation grade versus stasis ulceration) was not evident. Surgical treatment was considered only when conservative therapy failed after adequate trial (nonhealing, recurrence, and pain), intolerance or inability to comply (infirmity, socioeconomic factors), or development of complications (recurrent cellulitis, infection, recurrent phlebitis) during prolonged compression therapy.

Surgical technique. The common femoral, superficial femoral, and profunda femoris veins and the trifurcation are completely dissected out and exposed through an oblique groin incision. Sharp dissection may be required in the presence of postthrombotic periphlebitis or fibrosis. Division of small postthrombotic collateral blood vessels frequently is necessary. Access to the distal profunda femoris is obtained by means of extending the oblique incision vertically and distally along the medial thigh. The vein is accessed by means of entering the subsartorial tunnel medial to the muscle. The accompanying profunda femoris artery helps in positive identification and helps one avoid mistaking the circumflex femoral vein for the profunda femoris vein. Once exposed, the profunda femoris vein is amenable to a variety of different valve reconstruction techniques.[8]

For 44 of the 57 patients an antireflux procedure (valve reconstruction for 43, ligation for one) was performed on the profunda femoris vein. For the other 13 patients a profunda reconstruction was either not considered (early in this experience, four patients) or not considered feasible (nine patients) for a variety of technical reasons (poor exposure, distally located or absent profunda valve, unavailable or refluxive axillary valve, time considerations). Valve reconstruction in the patent superficial femoral vein was performed alone for six of these patients. For the other seven (two with axial transformation grade 4), neither vessel was repaired.

The techniques used for elimination of reflux in the profunda femoris vein in the 44 patients are listed in Table II. Direct repair of the existing valve structure[8] was feasible for 16 patients. A more involved indirect repair such as axillary vein transfer or de novo valve reconstruction[8] was performed on 27 patients. When the profunda femoris vein was the dominant or sole outflow tract, valve repair in the common femoral vein was the functional equivalent of valve repair in the profunda femoris vein itself (Fig. 3). Eleven such common femoral valve repairs were included in this series. For the 44 patients who underwent a profunda

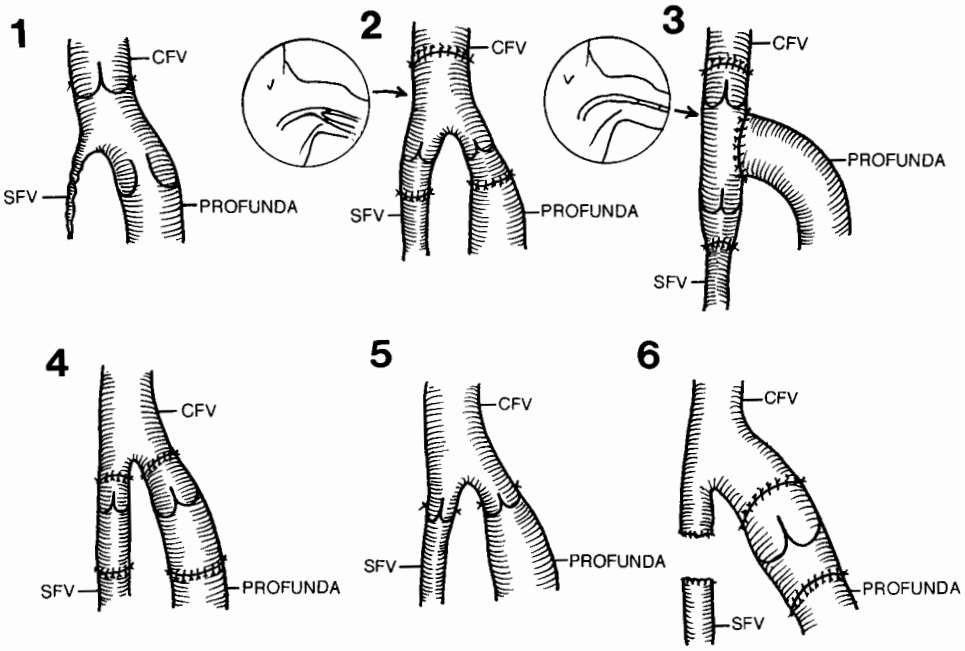

Fig. 3. Technical variations in valve reconstruction of axially transformed (partial or complete) profunda femoris vein. *1,* Common femoral vein (*CFV*) valvuloplasty as a proxy profunda valve repair. *SFV,* Superficial femoral vein. *2,* Axillary vein transfer to superficial femoral and profunda vein with use of bifurcating axillary veins. *3,* Repair of superficial femoral and profunda femoris veins with two sequential valves in the axillary vein. *4,* Two separate axillary vein transfers to profunda femoris and superficial femoral veins. *5,* Valvuloplasty in the superficial femoral and profunda femoris veins. *6,* Division of poorly recanalized superficial femoral vein with axillary vein transfer to profunda femoris vein.

femoris procedure, the companion superficial femoral vein if open also was repaired with a concomitant antireflux procedure (Table II). Despite the presence of postthrombotic changes, direct valve repair in the superficial femoral vein was feasible in a surprising 17 of 33 patients. In five instances in which the superficial femoral vein was considered virtually occluded with little outflow function, ligation and division of the vein was performed. All patients received intraoperative and long-term postoperative anticoagulation as previously described.[7]

Follow-up care. Patients were seen three to four times during the first year and on a yearly basis thereafter. Besides a complete clinical examination during each visit, a full laboratory assessment including duplex scanning as detailed earlier was obtained 3 to 6 months after the operation and at 1- to 2-year intervals thereafter. Postoperative contrast studies were selectively obtained if there was recurrence of disease or a change in clinical status, such as onset of new pain or swelling.

RESULTS

The patients in this series had varying degrees of chronic morphologic obstruction of the deep venous system. Almost all patients, however, were in functionally well-compensated condition (Table I) at preoperative testing, and only one patient had high-grade (grade 3 or 4) obstruction. For this reason there was no relation between axial transformation grade and functional obstruction (p = not significant). In 29 of 32 patients (91%) preoperative obstruction grade was the same or within one grade of postoperative obstruction grade (Table I). A significant increase in functional obstruction after surgical treatment (more than two grades) occurred among three patients. All three patients with a significant increase in functional obstruction underwent valve reconstruction (not ligation). In two patients recurrent postoperative thrombosis of the superficial femoral vein (both late thrombosis more than 3 months after the operation) was identified as the basis for the change in obstruction grade. No

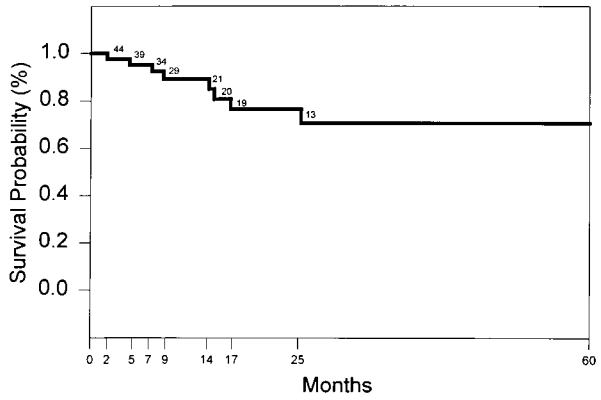

Fig. 4. Actuarial recurrence-free survival rate among 44 patients with axial transformation of the profunda femoris vein after surgical correction of reflux. Survival up to 60 months is shown. One patient had a recurrence 84 months after treatment (not shown).

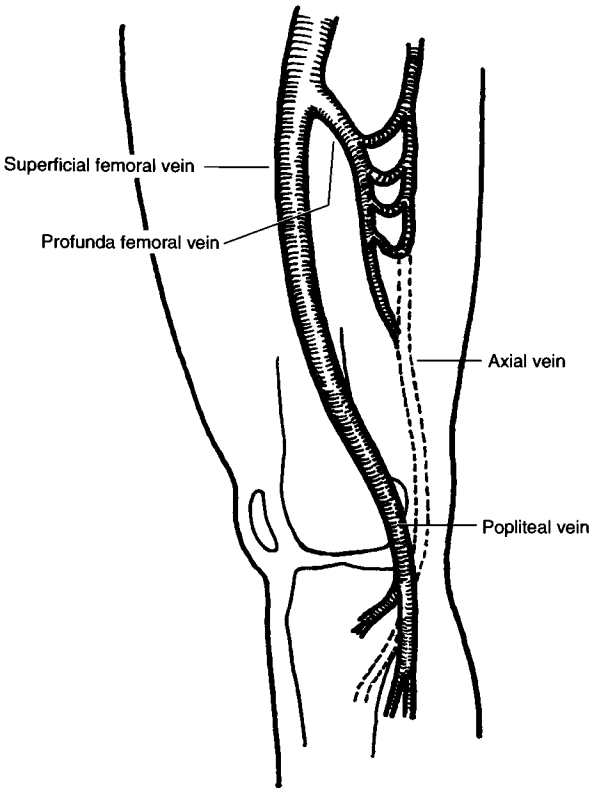

Fig. 5. Embryologic features of the profunda femoris vein.

explanation could be found for the third case. In none of the patients in this series, including the three patients with a significant increase in obstruction grade, was there exacerbation of clinical symptoms or signs to suggest the onset of acute limb-threatening venous obstruction. On a clinical basis, valve reconstruction appeared to be well tolerated by this group, as it would be in the presence of primary reflux.

Clinical outcomes were considered good to excellent (outcome grade +2 to +3 according to reporting standards)[9] with the primary indication resolved for 90% of patients at 1 year. For patients with ulceration, complete and sustained healing without recurrence was required for these outcome categories. For five patients who sought treatment because of pain, absence of dependent venous pain after the operation was required for characterization of outcome as good or excellent. On the basis of these criteria, the actuarial recurrence-free survival rate for patients who underwent surgical treatment is shown in Fig. 4. There were nine recurrences. The causes of recurrence were as follows: preexisting uncorrected tibiopopliteal obstruction or reflux (five patients), late thrombosis of repair (one patient), late recurrence of reflux of the repaired valve (one patient), and undetermined cause (two patients). No difference in outcome was discerned on the basis of axial transformation grade or type of valve reconstruction technique used in the profunda femoris vein or the superficial femoral vein. Among the 13 patients for whom profunda femoris repair was not feasible (six had superficial femoral repairs), four ulcers never healed and three others recurred early. The difference from the group who underwent profunda repair was not statistically significant because of the small sample size.

Duplex examination of the repaired valve 3 years after treatment showed competence among 70% of patients when the repair was in the profunda femoris vein and among only 40% when the common femoral valve was repaired. The difference was not significant (Fisher exact test $p < 0.27$). There was dichotomy between clinical and duplex outcomes of valve reconstruction.[10]

Improvement in certain laboratory measurements of venous reflux after surgical treatment is shown in Table III. Repair of the superficial femoral vein alone in the presence of axial transformation (n = 6) resulted in no improvement in ambulatory venous pressure (preoperative mean value ± SD 73 ± 9 mm Hg, postoperative 81 ± 14 mm Hg; p = not significant) or recovery time (preoperative mean value ± SD 9.8 ± 4 seconds, postoperative 10.3 ± 4 sec; p = not significant).

Table III. Improvement in measurements of venous reflux after surgical correction

Measurement	*Mean preoperative value ± SD*	*Mean postoperative value ± SD*	*p Value**
Ambulatory venous pressure (n = 23)			
Percentage drop	31.7 ± 9	37.0 ± 12	<.02
Recovery time (sec)	7.8 ± 5.6	13.2 ± 13.9	<.05
Air plethysmography (n = 16)			
Venous filling index 90% (ml)	6.1 ± 4.1	3.7 ± 2.2	<.05

* *t* test.

DISCUSSION

The profunda femoris vein represents the cephalad remnant of the embryonic axial vein of the lower limb, and the popliteal vein represents the caudal end of the axial vein. The intervening portion largely disappears, and the popliteal vein joins the anterior limb bud vein to form the superficial femoral vein. A portion of the reabsorbed axial vein may persist in many persons as a nonfunctional high-resistance conduit between the popliteal and profunda femoris veins (Fig. 5). In the presence of thrombosis and obstruction of the superficial femoral vein, this potential collateral blood vessel is already in place to enlarge rapidly and become functional. This is suggested by the rapidity with which this collateral vessel develops in some persons, becoming visible at venography within hours after developing outflow obstruction from superficial venous thrombosis.

When fully developed, the profunda popliteal communicator, with an enlarged profunda femoris vein proximally and the popliteal vein distally, assumes a course in the limb so smooth that the transformed axial vein is easily mistaken for the superficial femoral vein even by experienced radiologists. A more lateral course in the thigh than the superficial femoral vein, overlying the femoral shaft, provides the clue to the altered anatomy in this setting. The diagnosis becomes clear when a remnant of the thrombosed superficial femoral vein is visualized on a venogram (Fig. 6). In all but a few patients the profunda popliteal connector provides excellent outflow function. Only one of 32 such patients had high-grade functional venous obstruction before surgical treatment (Table I).

Although congenital absence of the superficial femoral vein probably occurs occasionally, symptoms invariably result from postthrombotic occlusion of this vein in patients with axial transformation of the profunda femoris vein. Postthrombotic changes in the superficial femoral vein were identified in 96% of patients in this series. The presence of profunda-popliteal connection appears to be specific for prior thrombosis of the superficial femoral vein. We have only rarely seen a case of severe postthrombotic changes in the superficial femoral vein in which the connection was absent.

Ninety-two percent of patients with varying grades of axial transformation of the profunda femoris vein had frank stasis ulceration or stasis dermatitis. The overall incidence of stasis ulceration in our clinical practice is only 20% (odds ratio 37.5; 95% confidence bounds 16.6 to 85). This discrepancy suggests that axial transformation of the profunda femoris vein may be associated with a high prevalence of stasis skin changes, particularly frank ulceration. Venography on which the diagnosis is based tends to be performed more often on patients with ulcers than on others. Because of this selection bias and possibility of Type I error, this observation needs reconfirmation and further study. Among patients in whom the profunda femoris vein provides substantial outflow function, it would appear that a valve reconstruction procedure must be preferentially directed toward this vessel when it is refluxive.

The results for this series of patients indicates that reflux is invariably present when the profunda femoris vein dilates to compensate for loss of superficial femoral vein outflow and is partially or completely transformed into the axial vein of the lower limb. A valve in the proximal profunda femoris vein normally is present in about 84% of patients.[8] Direct repair of a dilated leaky valve when present is therefore feasible for many patients. Postthrombotic changes in the profunda femoris vein may, however, preclude direct repair. The high rate of false-negative results with duplex scanning in this series confirms that duplex scanning may be less reliable than descending venography in identifying profunda femoris reflux. Although ligation of the profunda popliteal connector can relieve reflux into the calf venous pump and may be considered over valve repair for patients whose superficial femoral vein has become adequately recanalized, it is a distinctly risky approach. Severe outflow obstruction may result if

Fig. 6. Axial transformation of profunda femoris vein in a patient. Remnant of postthrombotic superficial femoral vein can be seen in the distal thigh.

residual obstructive lesions are present in the recanalized superficial femoral venous segment. Such high-grade residual lesions can be very focal and are not reliably detected with either contrast venography for duplex scanning.

Once the profunda femoris vein has been reconstructed to abolish reflux, the surgical approach to the recanalized postthrombotic superficial vein is a matter of debate. It has been our operative experience that even severely postthrombotic superficial femoral veins retain a considerable amount of reflux. Often this can be visually confirmed by means of observing an impressive flow or retrograde jet of blood shooting from the upper cut end of the superficial femoral vein when it is divided, even with the patient in the recumbent position. Complete division or interruption of the postthrombotic superficial femoral vein definitively abolishes reflux through this vessel and is likely to be well tolerated as to outflow function, particularly if the profunda femoris vein is enlarged and is not itself postthrombotic. Five such superficial femoral interruptions were included in this series. Our preference, however, is to reconstruct a valve in the superficial femoral vein concomitantly with the profunda femoris vein reconstruction to abolish reflux and to maximize outflow possibilities for the present and future. Recurrent thrombosis remains a continuing threat among these patients, and long-term anticoagulation is recommended.

Fortunately, direct valve repair can be undertaken for many of these patients, in either or both the profunda and superficial femoral veins, although segments of the superficial femoral vein are postthrombotic. Direct repairs, especially with transcommissural technique,[8] are rapidly executed. This facilitates simultaneous repair of both of these veins even if an indirect technique such as axillary vein transfer is needed for one of these veins. With practice, axillary vein transfers to both the superficial femoral and profunda femoris veins (Fig. 3) can be performed within reasonable operative times. Valve repair in the profunda femoris vein in this setting appears durable. An aggressive approach to valve reconstruction has yielded excellent clinical results similar to experience with the axial superficial femoral vein.[10]

We have previously advocated multiple valve reconstruction in postthrombotic syndrome based on perceptions of collateral reflux.[2,3,10,11] This recommendation appears rational on the basis of pathophysiologic findings and excellent clinical outcomes[10]; single valve reconstructions in a similar setting have fared poorly,[12] but the issue is far from settled.

Another unsettled controversy in valve reconstruction is the choice between conservative and surgical therapy and the role of use of postoperative stockings in ulcer healing. Most patients abandon stockings after successful valve reconstruction.[7] As a practical matter, the question is moot because for the patients in this series who underwent surgical treatment, compression therapy had already failed. The ulcers of 30% of patients do not heal even after intensive prolonged compression therapy with Unna boots.[13] Thirty-seven percent to 47% of patients in one study were unable to apply or had great diffi-

culty applying stockings; 30% had contact dermatitis.[14] For these and other reasons (binding, hot weather, appearance) noncompliance with compression therapy is high. Noncompliance invariably leads to recurrence.[14,15]

There have been few long-term studies of compression therapy and stasis ulceration. Rates of initial treatment failure and recurrence have ranged from 54% to 69% even in short-term studies of 1 to 3 years.[13-18] After excluding initial treatment failures, Franks et al.[14] reported an actuarial recurrence rate of 20% with compression therapy for ulcers less than 10 cm in diameter and 54% for larger ulcers 12 months after treatment. One widely quoted recent study was performed by Mayberry et al.[15] They conducted a follow-up study with patients who participated in a program of ambulatory compression therapy. After initial treatment failures were excluded and a large early follow-up loss of about 33%, data for 73 patients were subjected to actuarial analysis. The patients were further divided into compliant and noncompliant groups with a recurrence rate of 29% among the compliant group at 5 years and 100% among the noncompliant group at 3 years. Recalculation of these data without exclusions or fractionalization would yield a recurrence rate of about 30% at 1 year. This figure is probably an underestimation, because a large fraction of early follow-up loss is most likely caused by treatment failure or noncompliance. The advent of a uniform classification[5,9] and quality-of-life criteria[19] has set the stage for valid randomized trials to compare the outcomes of compression and surgical therapy.

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Submitted Sep. 18, 1997; accepted Jan. 5, 1998.