Percutaneous Sodium Tetradecyl Sulfate Sclerotherapy for Peripheral Venous Vascular Malformations: A Single-Center Experience

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PURPOSE: To evaluate the efficacy, safety, and long-term outcomes of percutaneous sodium tetradecyl sulfate (STS) sclerotherapy for peripheral venous vascular malformations (VVMs).

MATERIALS AND METHODS: A retrospective review of a prospectively compiled database was performed to identify patients with a VVM who were referred from 1997 to 2004. Of the 132 patients identified, 78 underwent sclerotherapy. Six of the 78 patients were lost to follow-up. Of the remaining 72 patients (24 male and 48 female patients; mean age, 31.7 years; age range, 14–62 years), 42 (58%) had lower limb VVMs, 19 (26%) had upper limb VVMs, and nine (12%) had truncal and/or central VVMs. Two patients (2.8%) had multifocal lesions. Seven of the 72 patients (9.7%) had Klippel-Trénauney syndrome. Treatment response was assessed clinically and by means of lesion size measurement with magnetic resonance (MR) imaging.

RESULTS: A total of 226 treatment sessions were performed (mean, 3.1 sessions per patient; range, 1–13 sessions). The mean follow-up was 41 months (range, 21–84 months). After treatment, 11 patients (15%) became asymptomatic, 20 (28%) rated the response to therapy as good, 17 (24%) improved, 20 (28%) were unchanged, and four (5.6%) worsened. Thirty-five patients underwent MR imaging before and after treatment. The size of the VVM was seen to decrease in 19 patients (54%), be unchanged in 11 (31%), and increase in five (14%). A reduction in lesion size at MR imaging did not necessarily correlate with a positive clinical response. Overall, patients with infiltrative lesions had a poorer outcome than did those with localized lesions. There were no major complications and seven minor complications (3.1% per session, 9.7% per patient).

CONCLUSIONS: An improvement in symptoms was observed in 70% of the patients with VVMs treated with percutaneous STS. Although the treatment is safe, complete cure is unusual and multiple treatment sessions are almost always required.

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Abbreviations: STS = sodium tetradecyl sulfate, VVM = venous vascular malformation

VASCULAR malformations can be classified according to the endothelial characteristics and flow dynamics of the lesions, from which the principles of treatment are based (1,2). Approximately two-thirds of vascular malformations are predominantly venous, and one-fourth of these are completely or partly lymphatic in origin. The latter type is considered a low- or slow-flow malformation. The remaining third are high-flow malformations (3–6). In general, the treatment of high-flow malformations is well established and involves transcatheter embolization of the nidus with or without surgery to control the disease process (7,8). Conversely, transcatheter embolotherapy for low-flow or venous vascular malformations (VVMs) is not useful owing to the absence of clear feeding vessels to the lesions. A surgical approach is indicated in well-circumscribed malformations of moderate size, in which the possibilities of anatomic and functional restoration are maximal. Surgical treatment of more extensive lesions, however, can often lead to a loss of motor function, nerve damage, and massive bleeding. Sclerotherapy is an alternative method for treating VVMs and is used to reduce the size of the lesion, whether preoperatively as a support to surgery, as a postoperative complement,

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or as a stand-alone treatment option (4,9–12).

A wide variety of sclerosants have been described in the literature, and these include chemical agents (ethanol or iodine solution), detergent sclerosants (sodium tetradecyl sulfate [STS], morrhuate sodium, polidocanol, and diatrizoate sodium), and hyperosmotic solutions (hypertonic saline) (4,9–18). Although each sclerosant has a different mechanism of action, the end result—the damage or destruction of the vascular endothelium causing thrombosis of the malformation—is similar. All sclerosants are associated with potential complications. Currently, there is no consensus as to the best sclerosant; however, because of the relative rarity of this condition, it is unlikely that a randomized trial in which the available sclerosants are compared will ever be conducted. In our institution, we have been using STS, a detergent sclerosant, as the first choice agent for more than 10 years. It is one of the most widely used agents for esophageal varices and varicose veins and has a good safety profile and clinical efficacy. We reviewed our experience with all patients referred to our tertiary unit with VVMs during the past 7 years, with emphasis on the clinical outcomes after percutaneous STS sclerotherapy. Finally, we compared our results with those from other published series in the literature on percutaneous sclerotherapy of VVMs.

MATERIALS AND METHODS

A retrospective review approved by our institutional review board was conducted of a prospectively compiled database of all patients with VVM of the extremities and truncal regions who were referred to our peripheral arteriovenous malformation clinic from July 1997 to July 2004. One hundred thirty-two patients were identified. These patients were seen in the vascular malformation clinic attended by an interventional radiologist. The VVMs were confirmed with a combination of clinical examination and noninvasive studies such as magnetic resonance (MR) imaging, duplex ultrasonography (US), and computed tomography. In the beginning of the study, due to inexperience, catheter angiography was performed in seven patients with clinical findings suspicious for a high-flow component. During the past few years, however, MR imaging and duplex US have completely replaced catheter angiography. Once the results of the preliminary investigations were obtained, the findings were discussed in a multidisciplinary meeting attended by an interventional radiologist and a plastic, orthopedic, or vascular surgeon. All patients with moderate to severe symptoms were offered sclerotherapy. We routinely performed three treatment sessions spaced 6–8 weeks apart before reevaluating the patient. If benefit was seen, sclerotherapy was repeated until there was no further clinical improvement. Those patients in whom clinically significant symptoms remained after treatment would then be considered for surgical excision. All patients, including those who underwent conservative treatment, were reviewed every 6 months but more frequently after sclerotherapy or surgery. Patients were also instructed to contact the vascular malformation coordinator if their conditions deteriorated between clinic reviews, in which case the patient would be seen urgently in an outpatient clinic. Follow-up MR imaging and/or duplex US were performed in patients who underwent sclerotherapy or had symptomatic deterioration.

Classification of the Malformation

After clinical, duplex US, and MR imaging assessment, the VVM was classified into three different categories, as follows: (*a*) malformation limited to the subcutaneous tissue (localized), (*b*) malformation with intramuscular infiltration, and (*c*) diffuse complex malformation with limb hypertrophy (eg, Klippel-Trénaunay syndrome).

Decision to Treat

Indications for intervention included (*a*) hemorrhage, (*b*) disabling pain necessitating the regular use of oral analgesia, (*c*) functional impairment secondary to swelling or pain, and (*d*) tissue loss or ulceration. Cosmetic deformity, unless severe, was considered as a relative indication for intervention, which was performed only after careful consultation with the patient.

Sclerotherapy Technique

For sclerotherapy, a tourniquet was applied to the limb well above the location of the malformations to decrease the venous flow and, hence, maximize the contact time between the sclerosant and the endothelium of the malformation. Unless the VVM was easily palpable, direct percutaneous cannulation was performed with US guidance by using a 22–25-gauge needle. Once a flashback was observed, iodinated contrast medium was gently injected to confirm an intralesional location and exclude arterial cannulation. Digital subtraction venography was then performed to assess the nature of the lesion and its drainage, to determine how much of the lesion is accessed, and to calculate the volume necessary to displace the intralesional blood into the draining vein. The contrast medium was then displaced or "chased" with the calculated volume of sclerosant. The sclerosant used was a mixture of 3% STS detergent sclerosant (Omega, Montreal, Quebec, Canada) and Omnipaque 300 or Visipaque-320 (GE, Amersham, United Kingdom) in a 2:1 ratio to give a final concentration of 2% STS. With larger volume lesions, that is, those that necessitated more than 6 mL of contrast medium to fill the lesion and opacify the draining vein during preliminary venography, we used a mixture of 3 mL of 3% STS with 4–6 mL of room air, mixed together with a three-way stopcock to make a foam (**Fig 1**). Foam STS is composed of microbubbles of air coated with STS and, therefore, creates an enormous increase in the surface area compared with the liquid form. It displaces the blood from the lesion and permits contact between the endothelium and sclerosant, facilitating endothelial destruction. Furthermore, because of the high surface tension of the microbubbles, the foam flows less rapidly than does a liquid.

During the procedure, the injection is fluoroscopically evaluated to ensure the intralesional administration of the sclerosant without extravasation into the surrounding soft tissues or draining veins. The maximum total volume of 6 mL of 3% STS was injected at one

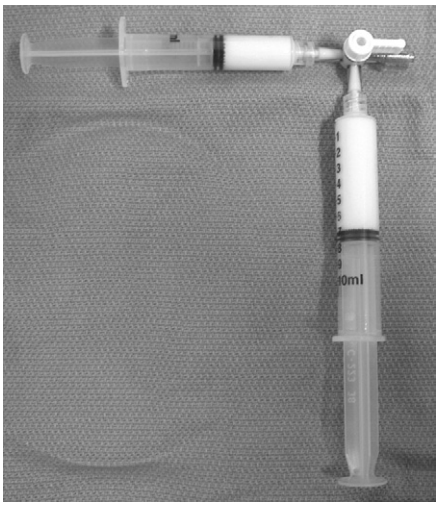


Figure 1. Foam STS obtained by mixing 2 mL of 3% STS and 6 mL of room air with a three-way stopcock.

sitting, as recommended by the manufacturer. The injection was terminated before this volume was reached if the lesion was completely opacified, resistance to injection or extravasation was encountered, or opacification of the venous drainage beyond the lesion was seen. If a foam sclerosant mixture is used (STS and air), the air in the mixture is a good negative contrast agent. The air will displace the iodinated contrast medium in the malformation administered from the initial evaluation. The injection of the foam sclerosant is stopped once the iodinated contrast medium in the malformation is completely displaced or the air is visualized in the draining vein (**Fig 2**).

We routinely inject at least two to three different sites at one sitting, provided that the volume of the 3% STS does not exceed 6 mL. In large malformations, we divide the lesion into arbitrary segments or quadrants. The segments are then treated systematically from the center of the lesion to the periphery. Random injections into a large malformation are not advisable and may lead to multiple pockets of untreated area. After the injection of the sclerosant, the tourniquet was kept tied for 5 minutes to maximize the duration of the contact between the sclerosant and the endothelium. The tourniquet was released with the needle still in situ, ensuring that the sclerosant is not under pressure within the lesion and thereby reducing the possibility of extravasation, which may cause skin necrosis. The needles were then removed and a pressure dressing immediately applied. A 3-inch tensor bandage/wrap (Sorus Medical, Toronto, Ontario, Canada) was used, applied from the distal portion of the treated area to the central portion. The patient was instructed to keep the pressure dressing on for 7 days, removing the bandage to bathe and sleep.

Typically, we perform a course of three sessions, spaced 6–8 weeks apart. We believe that spacing the treatments enables us to evaluate the results of each injection. Furthermore, the malformations are often large and, hence, the amount of STS required for complete treatment exceeds the amount that can be given safely at one session.

Most procedures are performed with the patient under moderate sedation with midazolam and fentanyl. General anesthesia is used only when patients insist. Most patients are treated on an outpatient basis and discharged home with oral analgesia (5 mg of oxycodone and 400 mg of ibuprofen). We do not routinely administer corticosteroids for the procedure.

Evaluation of Efficacy

The primary measures of efficacy included pain reduction, cosmetic improvement, and functional improvement as reported by the patient. The patients were also asked to grade their end result as cured (asymptomatic), substantial improvement (good), moderate improvement (improved), or no change or worse at the end of the treatment. The secondary efficacy end point was defined as a reduction in the size of the malformation after completion of treatment, as determined with clinical and radiologic assessment. Surgical resection was considered in those patients with a poor response to sclerotherapy.

Data Collection

Data with regard to patient demographics, clinical assessments, imaging studies, treatments, treatments complications, and outcomes were obtained from the charts, as were the results of follow-up consultations, examinations, and imaging. Major complications were defined as complications that required either intervention or prolonged hospitalization. These included extensive tissue necrosis, infection, and hemorrhage. Minor complications were defined as events that did not require intervention or prolonged hospitalization. The final clinical data were updated with a telephone consultation made to all patients who had not been reviewed during the past 6 months before the completion of this study.

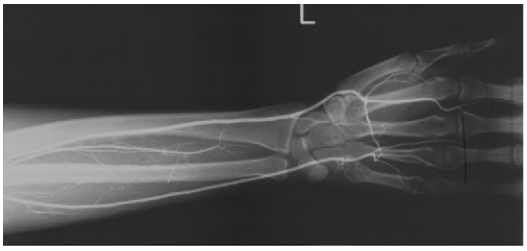
RESULTS

One hundred thirty-two patients were referred to the malformation clinic in the 7-year period reviewed. Forty-four patients were found to have minor symptoms (eg, occasional pain and swelling that were exacerbated by local trauma). Because of the minimal symptoms, this group of patients was treated conservatively with a compression stocking and/or bandage and given general advice with regard to limb care.

The remaining 78 patients presented with substantial symptoms that affected their lifestyle and, therefore, warranted treatment. Six patients were lost to follow-up after the initial treatment session. Most patients presented with a combination of symptoms: 70 of the 72 patients (97%) had disabling pain, 50 (69%) had swelling, two (3%) had ulceration, and 15 (21%) had loss of function. There were 48 female patients (67%) and 24 male patients (33%), and the mean age at presentation was 31.7 years (range, 14–62 years).

Forty-two of the 72 patients (58%) had lower limb involvement, 19 (26%) had upper limb involvement, and nine (12.5%) had truncal involvement. One patient (1.4%) had upper limb and truncal malformations, and one patient (1.4%) had lower limb and truncal lesions. Seven of the 72 patients (9.7%) had Klippel-Trénaunay syndrome (**Fig 3**). Three patients had previously undergone surgical resection, and four had undergone embolization. **Table 1** shows the baseline clinical characteristics of the patients.

A total of 226 treatment sessions were performed in the 72 patients (mean, 3.1 sessions per patient; range, 1–13 sessions). STS was used as the sclerosant agent in all treatment sessions. The mean length of follow-up



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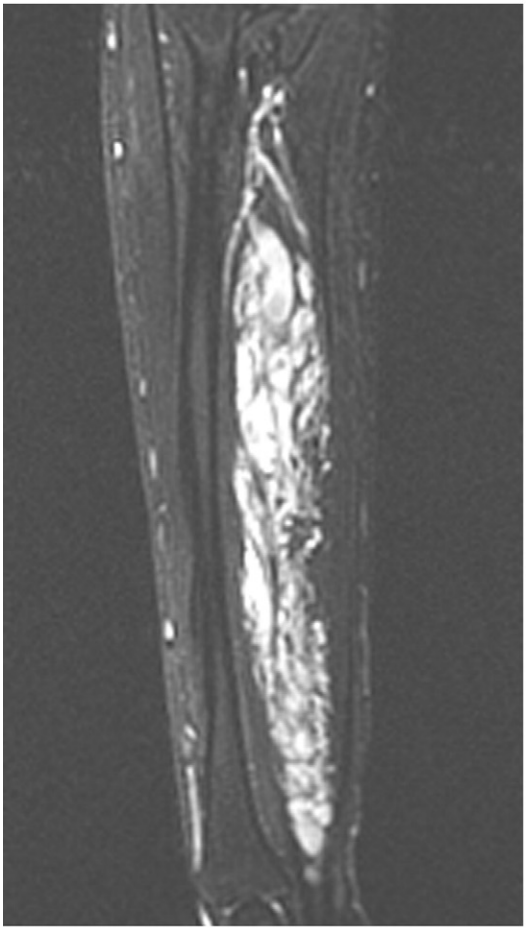

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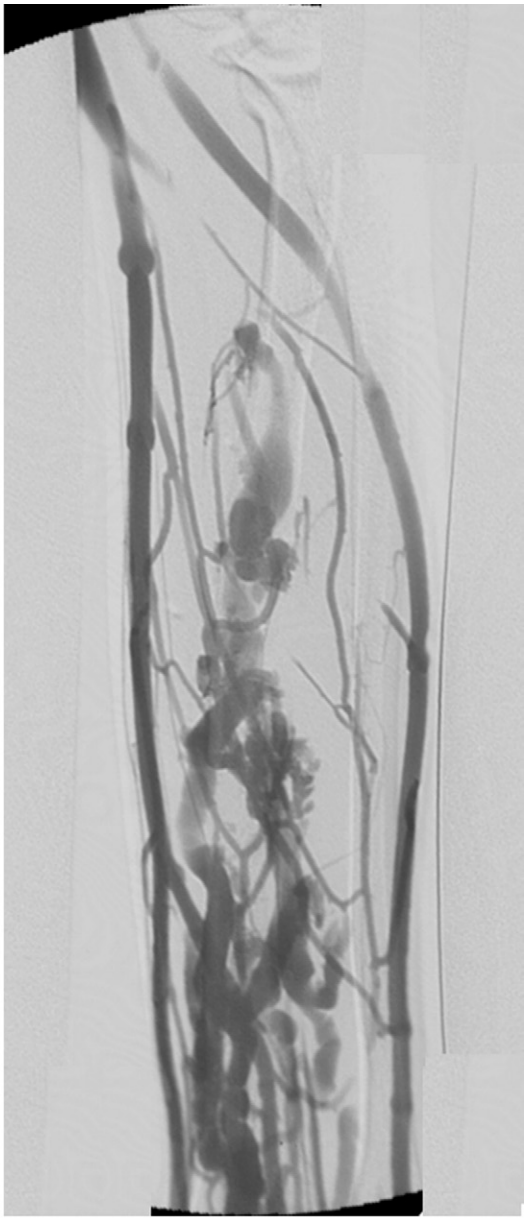

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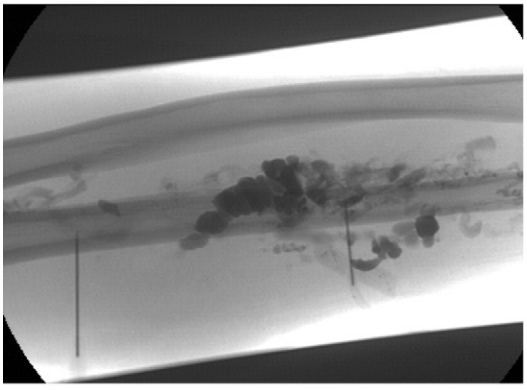

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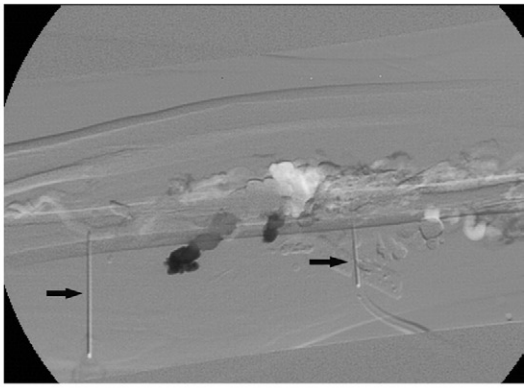

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(Table 2) after the first sclerotherapy session was 41 months (range, 21–84 months). Eleven patients (15%) became asymptomatic after treatment, 20 (28%) reported good clinical improvement, 17 (24%) had some improvement, 20 (28%) were unchanged, and four (5.6%) had worsening of symptoms. Three patients with localized lesions that did not respond to sclerotherapy underwent successful surgical excision of the malformation. None of the patients with infiltrative lesions underwent surgical excision. Thirteen patients who initially reported clinical improvement subsequently returned for further sclerotherapy when the symptoms recurred; the mean time to recurrence was 23 months (range, 7–37 months). Objective size measurements obtained with MR imaging before and after treatment were available for 35 patients. After treatment, the malformations decreased in size in 19 patients (54%), were unchanged in 11 (31%), and increased in size in five patients (14%). A reduction in size, however, did not necessarily correlate with symptomatic improvement and vice versa (Fig 4).

Table 3 shows the results of sclerotherapy according to VVM location (upper, lower, and truncal) and type (localized, subcutaneous, or infiltrative). Twenty-one of 25 patients with localized lesions (84%) had a positive response (improved, good, or asymptomatic) to treatment; only 30 of 49 patients with infiltrative lesions (61%) had a positive response. Furthermore, only 19 of 32 patients with lower limb infiltrative lesions (59%) had a positive response after treatment, compared with eight of 13 patients with upper limb lesions (62%) and three of four patients with truncal lesions (75%). These data, however, are too small for meaningful statistical analysis.

No major complications occurred during the study period. Seven minor complications (Table 4) occurred in the 226 treatment sessions (3.1% per session or 9.7% per patient). These minor complications included five episodes of skin necrosis and/or ulcer (71%), one episode of temporary paresthesia (14%), and one episode of minor allergic reaction (14%). All cases of skin necrosis resolved with conservative treatment, and none ne-

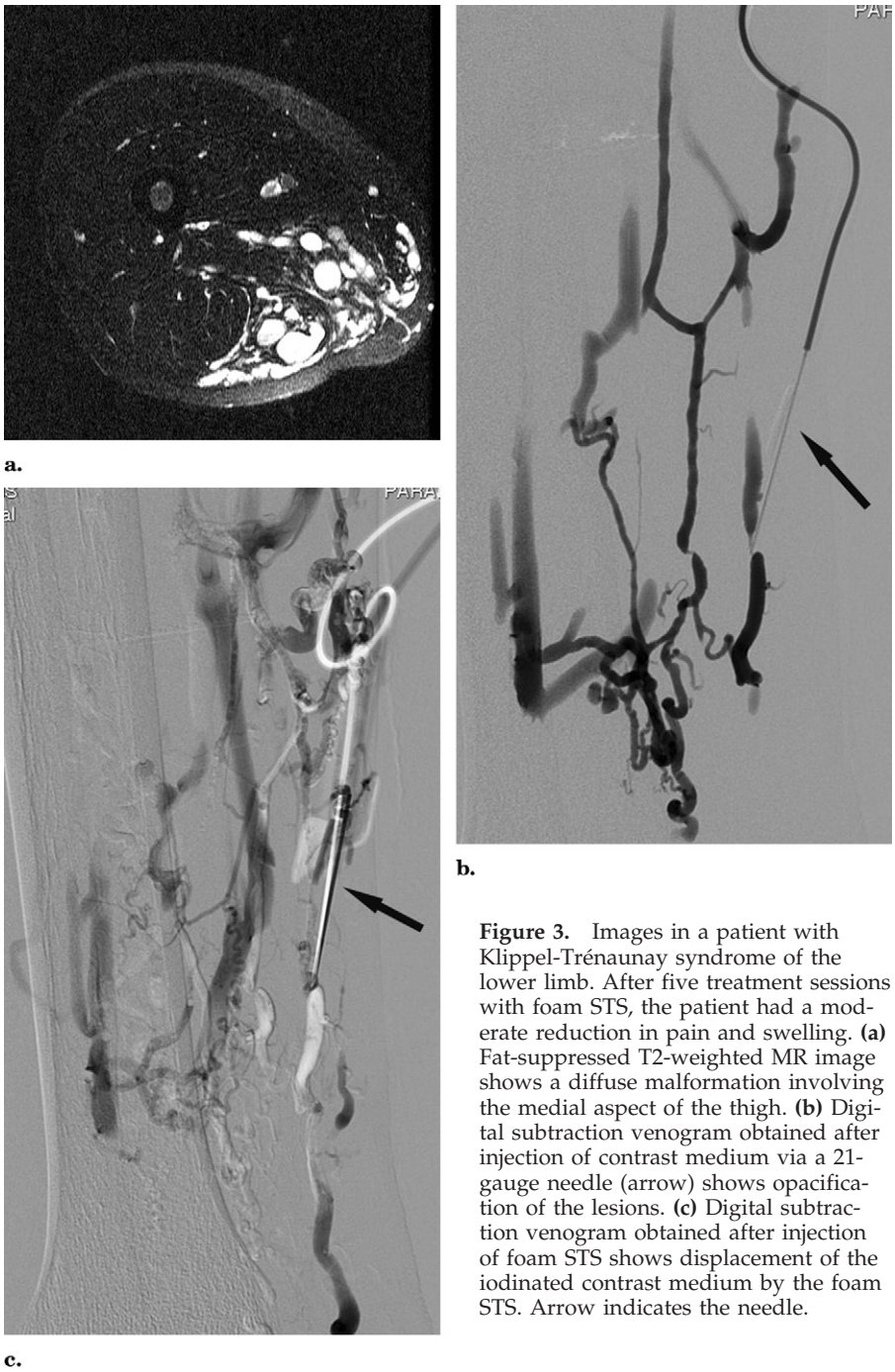


Figure 3. Images in a patient with Klippel-Trénaunay syndrome of the lower limb. After five treatment sessions with foam STS, the patient had a moderate reduction in pain and swelling. **(a)** Fat-suppressed T2-weighted MR image shows a diffuse malformation involving the medial aspect of the thigh. **(b)** Digital subtraction venogram obtained after injection of contrast medium via a 21-gauge needle (arrow) shows opacification of the lesions. **(c)** Digital subtraction venogram obtained after injection of foam STS shows displacement of the iodinated contrast medium by the foam STS. Arrow indicates the needle.

Figure 2. Images in a patient with a painful forearm VVM. The patient had a good result after three treatment sessions. **(a)** Normal arteriogram. **(b)** Venogram shows a diffuse venous malformation of the deep system with normal superficial veins. **(c)** Fat-suppressed T2-weighted MR image shows a large infiltrative malformation. **(d)** Venogram obtained after injection of iodinated contrast medium via a percutaneous 21-gauge needle shows opacification of the lesion. **(e)** Digital subtraction venogram obtained after injection of foam STS shows the negative contrast medium displacing the iodinated contrast medium. Arrows indicate the position of the 21-gauge needles.

Table 1
Summary of Clinical Characteristics at Baseline

Characteristics	Klippel-Trénaunay Syndrome (n = 7)	Localized Lesions (n = 22)	Infiltrating Lesions (n = 43)	Total (n = 72)
Sex				
Male	2	7	15	24
Female	5	15	28	48
Mean age (y)	26.1	35.3	29.8	31.7
Site				
Upper limb	1	7	12	20
Lower limb	6	11	26	43
Trunk	2	6	3	11
Symptoms				
Pain	9	22	39	70
Swelling	8	14	28	50
Ulceration	1	0	1	2
Bleeding	1	0	0	1
Loss of function	2	1	12	15
Previous treatment				
Surgery	1	1	1	3
Embolization	2	0	2	4

cessitated skin grafting. The patient with temporary paresthesia had an infiltrative forearm VVM. After the second treatment session, the patient developed numbness along the medial aspect of her forearm, which settled within 3 months. The numbness was likely due to superficial nerve injury from the sclerosant injected. One patient developed extensive urticaria after the first treatment, and this was likely secondary to the iodinated contrast medium. Prophylactic prednisone was administered at the subsequent treatment session, with no further reaction.

DISCUSSION

Sclerotherapy is the mainstay of treatment for VVM, with ethanol, STS, and polidocanol being the most commonly used agents. Unquestionably, absolute ethanol is a highly effective chemical agent in permanently occluding vessels but is also very toxic to the tissue. In a recent publication of their experience in the management of low-flow arteriovenous malformations, Lee et al (4) advocated the use of ethanol as their embolic/sclerosant agent of choice. Of the 87 patients treated in their study (mean, three sessions per patient), 83 (95%) had a fair to good clinical response after treatment. Impressively, the authors stated that they found no clinical evidence of recurrence in 71 patients (82%) after 24-month follow-up. However, the authors did not distinguish the anatomic locations of the malformations in their results (ie, head and/or neck, trunk, or limbs), which might reveal whether the locations of the lesions have an effect on the outcome of treatment. Lee et al (4) also reported a high complication rate of 12.4% per session (27.9% per patient); 51 complications were documented (17 major, 34 minor). Major complications were as follows: Six patients (6.9%) needed reconstructive surgery for tissue necrosis, five (5.7%) had deep venous thrombosis or pulmonary embolism, two (2.3%) had permanent nerve injury, and four (4.9%) needed treatment for foot flexion deformity secondary to calf muscles fibrosis. Moreover, most serious complications occurred in patients with lower limb lesions. In another smaller series involving 21 patients, Rimon et al (19) reported that only three of eight patients who underwent ethanol sclerotherapy for lower limb malformations had complete resolution of symptoms. The symptoms partially resolved in one patient, were unchanged in three patients, and deteriorated in one patient. Conversely, four of six patients with upper limb malformations became asymptomatic after treatment and two had partial resolution of symptoms. Six of the seven patients with trunk or head/neck malformations had a good response to treatment. In accordance with the study by Lee et al (4), the complication rate was high (24% per patient). This finding was also demonstrated in a quality-of-life analysis after ethanol sclerotherapy by Rautio et al (20), who showed that the outcome in patients with lower limb lesions was worse than that in patients with upper limb malformations. Rautio et al also stated that the outcome in patients with large infiltrative lesions that involved the muscular compartment was worse than that in patients with localized subcutaneous lesions.

It has recently become popular to use polidocanol, a detergent agent that has been used for 20 years (usually for treating venous varices), in the treatment of low flow malformations—especially in its foam form (21–23). The authors maintain that, in foam form, a large volume of sclerosant could be administered, enabling homogenous contact between the sclerosant and the endothelium and facilitating endothelial destruction. Cabrera et al (21), who performed the largest study of polidocanol foam in the treatment of venous malformations, showed an impressive 92% beneficial response rate after treatment of 50 patients; 39% of patients showed complete disappearance of the malformations at clinical examination after an average follow-up period of 30 months. Furthermore, there were no major complications and only three minor complications (skin necrosis). It is interesting that the patients underwent a mean of 12 treatment sessions, which was considerably more than that reported for ethanol sclerotherapy. As with the study by Lee et al (4), the authors did not state if the outcome was related to the locations of the malformations. Pascarella et al (22), who treated 10 patients with foam polidocanol (mean, 3.6 sessions per patient), reported a 100% clinical improvement with only one minor complication (skin necrosis). Because of the excellent safety profile of foam polidocanol, its lack of systemic side effects, and its low incidence of skin necrosis, Pascarella et al advocate its use as the main line treatment for venous malformations.

STS, another widely used sclerosant agent, has been available in Canada and Europe for many years and is pri-

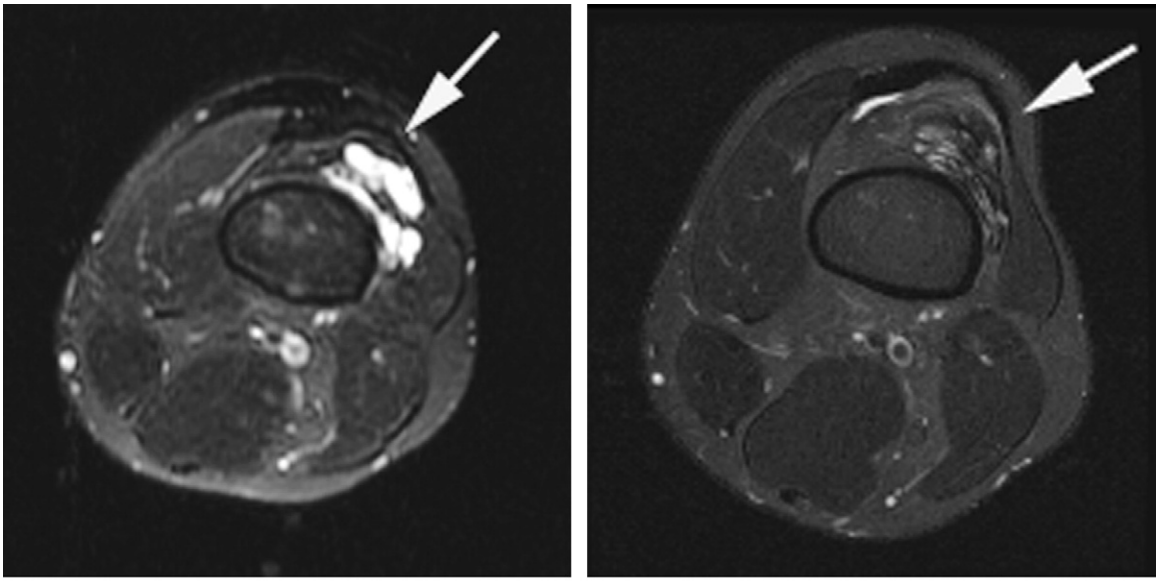
Table 2
Outcome after Sclerotherapy

Parameter	Klippel-Trénaunay Syndrome (n = 7)	Localized Lesions (n = 22)	Infiltrating Lesions (n = 43)	Total (n = 72)
No. of treatments				
1–3	3	20	31	54
4–6	1	2	9	12
7–10	2	0	3	5
>10	1	0	0	1
Mean follow-up (mo)*	47 (33–73)	39 (21–66)	41 (13–84)	41 (21–84)
Symptoms				
Pain				
Decreased	5	18	22	45
Increased	0	1	3	4
Unchanged	2	3	16	21
Swelling				
Decreased	5	9	15	29
Increased	0	1	3	4
Unchanged	1	3	10	14
Ulceration				
Decreased	1	0	1	2
Increased	0	0	0	0
Unchanged	0	0	0	0
Bleeding				
Decreased	1	0	0	1
Increased	0	0	0	0
Unchanged	0	0	0	0
Loss of function				
Decreased	1	1	5	7
Increased	0	0	2	2
Unchanged	1	0	5	6
Malformation size (at clinical examination)				
Decreased	4	18	21	43
Increased	0	0	4	4
Unchanged	3	4	18	25
Subjective results				
Asymptomatic	0	8	3	11
Good	2	5	13	20
Improved	3	6	8	17
Unchanged	2	2	16	20
Worse	0	1	3	4

* Numbers in parentheses are ranges.

marily used in the treatment of varicose veins. STS was approved by the U.S. Food and Drug Administration in November 2004 for sclerotherapy of varicose veins. Although valuable in the treatment of varicose veins, there is a paucity of data in the currently available literature about the efficacy of STS in the treatment of peripheral venous malformations. Two small studies have been performed with regard to the use of STS for head/neck venous malformations (15,24). The first study (15) included 34 patients who underwent a mean of 2.2 treatment sessions per patient. Twenty-three patients (68%) had a good response to treatment, eight patients (24%) had a moderate response, three patients (9%) were unchanged, one patient (3%) deteriorated, and one patient (3%) had a serious complication (15). In the second study of 15 patients who underwent an average of 3.2 sessions each (24), 13 had beneficial effect from the treatment and two had an equivocal response; no major complications were reported. Although these reported results are good, it is doubtful that they could be applied to peripheral or extremity malformations.

It is surprising that our results did not mirror those published by the authors mentioned earlier (4,19–23). After an average follow-up of 41 months and a mean of 3.1 treatment sessions per patient, only 15% of our patients remained asymptomatic; 28% had marked improvement, 24% had slight improvement, 28% were unchanged, and 6% worsened. Possible explanations for the discrepancy are as follows. First, our cohort has a high proportion (60%) of infiltrative intramuscular lesions, which are recognized to be more difficult to treat, and may, therefore, account for the lower success rate (20,25). Second, STS may not be as effective as polidocanol or absolute alcohol when used as a sclerosant. Third, our treatment protocol may not be as aggressive as others, that is, we use a longer interval between sessions (6–8 weeks rather than



a. b.

Figure 4. Images in a 35-year-old man with a painful infiltrative thigh malformation who underwent two treatment sessions with foam STS. This case demonstrates that a good radiologic outcome does not always translate to a good clinical outcome. **(a, b)** Fat-suppressed T2-weighted MR images obtained before **(a)** and after **(b)** treatment show almost complete resolution of the malformation (arrow). Despite a good radiologic outcome, the patient remains symptomatic.

Table 3
Clinical Response after Sclerotherapy according to VVM Location and Type

	Lower Limb		Upper Limb		Trunk	
Symptoms	Infiltrative	Localized	Infiltrative	Localized	Infiltrative	Localized
Asymptomatic	1	3	1	2	0	3
Good	9	2	6	3	1	0
Improved	9	5	1	1	2	2
Unchanged	11	1	4	0	1	2
Worse	2	0	1	1	0	0
Total	32	11	13	7	4	7

Table 4
Complications of Treatment

Complication	Klippel Trénaunay Syndrome (n = 7)	Localized Lesions (n = 22)	Infiltrating Lesions (n = 43)	Total (n = 72)
Skin necrosis	1	2	2	5
Neurologic	0	0	1	1
Allergic reaction	0	1	0	1

7–14 days) and fewer numbers of sessions. Finally, foam STS may not be as effective as foam polidocanol. Despite the fact that our success rate is lower than that of other studies in which different sclerosant agents were used, we believe it is important to present a large series in the literature about the effectiveness of STS in the treatment of VVM, particularly with the recent approval of this agent by the U.S. Food and Drug Administration.

Is STS actually less effective than polidocanol? Is foam STS more or less effective than the liquid form? These are the questions we believe will not be answered without a randomized trial comparing these agents. Because of the relative rarity of this condition, however, it is extremely difficult to perform a trial, and, hence, we must currently rely on the information obtained from case series. We hope that other institutions that perform sclerotherapy routinely report their results so that our knowledge and management of this problematic condition can be improved. It is also prudent

that the results be subdivided into anatomic location and types of malformations (subcutaneous or intramuscular). In view of the suboptimal results, our institution is currently starting to treat the next cohort of patients with VVM by using foam polidocanol. In addition, it is hoped that, during the few years, we may have results of the effectiveness of this agent in our patient population.

The results of this study confirm that the outcome in patients with lower limb infiltrative lesions (**Table 3**) is worse than that in patients with lesions in other locations. Infiltrative lesions are, in general, difficult to treat because of the diffuse nature of the lesions. If infiltrative lesions are located in the lower limb, however, the effectiveness of treatment may be diminished because of the fact that blood pooling occurs constantly at the dependent area, causing engorgement and dilatation of the malformations. Perhaps the same reason may also help explain the poor outcome of patients with high-flow vascular malformations involving the lower limb (8). In addition, we noticed that malformations located in the foot are the most problematic and difficult to treat, likely due to the constant trauma sustained during weight bearing.

Although many of our patients underwent MR imaging before and after treatment, we did not find the posttreatment examination to be very useful. Despite good clinical results, many lesions were still unchanged in appearance and size at MR imaging, and many even enlarged. Similarly, some patients had a marked reduction in lesion size at MR imaging without corresponding symptomatic improvement. We also noticed that the severity of the symptoms did not usually correlate with the size of the malformation. More important was the location and nature of the malformation, which gave some indication of the treatment outcomes.

There were several limitations of this study. Some minor complications may have been missed because the study was retrospective. In addition, no objective scoring system was used to assess the patient's response to treatment. Assessment with use of MR imaging was performed in only about half of our patients. Finally, two sclerotherapy techniques (foam or liquid) were used in this series, and this introduces more variables to our results.

Venous malformation is a therapeutically challenging condition, and invasive treatment should be offered only to symptomatic patients. In general, infiltrative lower limb lesions are the most problematic and difficult to treat. Percutaneous STS sclerotherapy is a safe technique, and we observed a symptomatic improvement in up to 70% of patients treated. Complete cure is unusual, and multiple treatment sessions are almost always required.

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