Cardiovasc Intervent Radiol (2019) 42:213–219
https://doi.org/10.1007/s00270-018-2099-5

Radiofrequency Ablation of the Marginal Venous System in Patients with Venous Malformations

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Received: 29 August 2018 / Accepted: 16 October 2018 / Published online: 29 October 2018

Abstract
Purpose To evaluate radiofrequency ablation (RFA) for closure of marginal veins in pediatric and adult patients with venous malformations.
Materials and methods Medical records, imaging and procedure details were retrospectively reviewed in patients who underwent RFA of the marginal vein in a 17-month period. Additional sclerotherapy ($n = 19$) and coil embolization of the marginal vein were performed ($n = 2$).
Results A total of 23 marginal veins were treated in 20 patients. Mean age at treatment was 16 years ± 9.4 (1–37 years). Pre-procedural magnetic resonance imaging revealed thoracoabdominal marginal veins in 3 patients. A type I marginal vein (draining in the great saphenous vein below the popliteal vein) was identified in 1 and type IIa/IIb (draining in a median/lateral accessory saphenous vein) in 2/8 cases. Type III (draining into the profunda femoral vein) was detected in 8, and type IV (draining into gluteal veins) in 1. Mean diameter of the marginal veins was 13.2 mm ± 4 (7–20 mm). Patency was found in 1 during follow-up (22 months ± 9.8). Complete or partial occlusion was achieved in 94.5% of the veins. One patient showed signs of thrombophlebitis after the procedure, and another incomplete paresis of the peroneal nerve.
Conclusion RFA is effective as minimally invasive treatment of the marginal venous system. These veins should be treated early in life. Marginal veins with large diameter, residual tributaries and the intrafascial courses usually require adjunct coil embolization and sclerotherapy.
Level of Evidence Case series, Level IV.

Keywords Venous malformation · Radiofrequency ablation · Marginal venous system · Marginal vein · Embryologic vein

Introduction

Venous malformations of the lower extremities may be associated with the presence of ectatic superficial marginal veins. These dysplastic veins have failed to regress and are typically located on the lateral aspect of the lower limb. Based on extent and type of connection to the deep venous system, a classification system of the marginal veins on the lower extremities was proposed by Weber [1]. Normally, they arise near the lateral aspect of the foot or the lateral malleolus and course along the lateral aspect of the lower limb. Type I drains into the great saphenous vein (GSV) below the popliteal vein. Type IIa drains into a medial accessory saphenous vein, and type IIb into a lateral

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accessory saphenous vein. Both type IIa and IIb may show perforating veins connecting the marginal vein to the profunda femoral vein. Type III drains only into the profunda femoral vein, and Type IV into gluteal veins [1]. Marginal veins located superficially on the lateral abdominal or thoracic wall are not included in this classification system.

Since the marginal vein system is valveless, an increased risk of venous stasis, thrombosis and pulmonary embolization exists [2]. Furthermore, venous insufficiency worsens with age, making early diagnosis and treatment of the marginal venous system necessary to prevent further complications [3, 4]. Surgical resection is often complicated by additional venous, capillary or lymphatic malformations and soft tissue hyperplasia. Percutaneous, minimally invasive management is a favorable alternative to treat these veins. However, to date there is no consensus on the most appropriate therapy management of the marginal venous system.

The purpose of this study was to retrospectively evaluate a minimally invasive closure of marginal veins using endovascular radiofrequency ablation (RFA) in pediatric and adult patients.

Patients and Methods

Institutional review board approval was obtained. A retrospective review of the radiology information system was performed to identify patients who underwent RFA of the marginal vein within a 17-month period. Patient demographics and follow-up were recorded.

All patients underwent magnetic resonance imaging (MRI) using a 3 Tesla scanner (Skyra, Siemens Healthcare, Erlangen, Germany) and a prospectively determined MR protocol at our interdisciplinary vascular anomalies center [5]. Type of marginal vein was determined using pre-procedural MRI including dynamic contrast-enhanced angiography and the classification system according to Weber. Largest diameter of the marginal veins was measured using axial T2-weighted fat-saturated MRI. Additionally, extent and patency of the deep venous system were analyzed using MRI.

Radiofrequency Ablation

All procedures were performed under sterile conditions and general anesthesia in an angiography suite after written informed consent was obtained. The ClosureFast™ (Medtronic, Minneapolis, Minnesota) RFA system was used. The distal aspect of the marginal vein was accessed percutaneously under ultrasound guidance, and a 7-F introducer sheath was inserted. After venography, a 7-F RFA catheter was advanced over a 0.018-inch guide wire into the proximal aspect of the marginal vein (Fig. 1). Ablation was performed stepwise at 120 degree Celsius treating a 3-cm or 7-cm segment for 20 s. The skin was cooled by applying water directly on the surface of the skin in case of very superficial location of the vein. Percutaneous sclerotherapy using polidocanol 3% foam was followed to address residual tributaries of the marginal vein. In two cases, the deeper intrafascial aspects of the marginal veins were embolized with coils and plugs to reduce the risk of sciatic nerve injury or thromboembolic events within the same session. MRI revealed close proximity of the sciatic nerve and the marginal vein in these cases. Furthermore, the risk of thromboembolism was considered significant since these marginal veins were very large and drained directly in large deep veins.

Immediately following the procedure, sonographic studies of the marginal veins were performed to evaluate immediate therapy success and compression garments were applied and worn for at least 6 weeks. Patients received low-molecular-weight heparin in prophylactic dosage (0.5 mg/kg in children and 40 mg s.c./day in adults) starting 4–6 h after the procedure and continued for 7 days postprocedural.

Procedure-related minor and major complications were categorized according to the classification system of the Cardiovascular and Interventional Radiological Society of Europe (The CIRSE Classification System) [6].

Follow-up consisted in clinical examination and imaging using MRI, ultrasound or phlebography. Patients were asked to get in touch with our department in case of any possible side effect including also pain, bruising or skin affections. In addition, all patients were scheduled to an outpatient visit about 6–12 months after the procedure. Furthermore, some patients presented later since they were scheduled for treatment of residual venous malformations that did not involve the marginal vein.

Results

Subjects

In a 17-month period, a total of 23 marginal veins were treated with RFA in 20 consecutive patients. Ten patients presented with Klippel–Trenaunay syndrome (KTS; capillary, venous, lymphatic malformation and limb overgrowth). Other syndromes included CLOVES (congenital lipomatous overgrowth, vascular malformation, epidermal nevi, scoliosis $n = 3$) and Proteus ($n = 1$). Two patients suffered from simple venous malformations, and 4 from combined capillary and venous malformations. The mean age at first treatment was 16 years ± 9.4 (1–37 years); 10 patients were children < 18 years (13 treated marginal

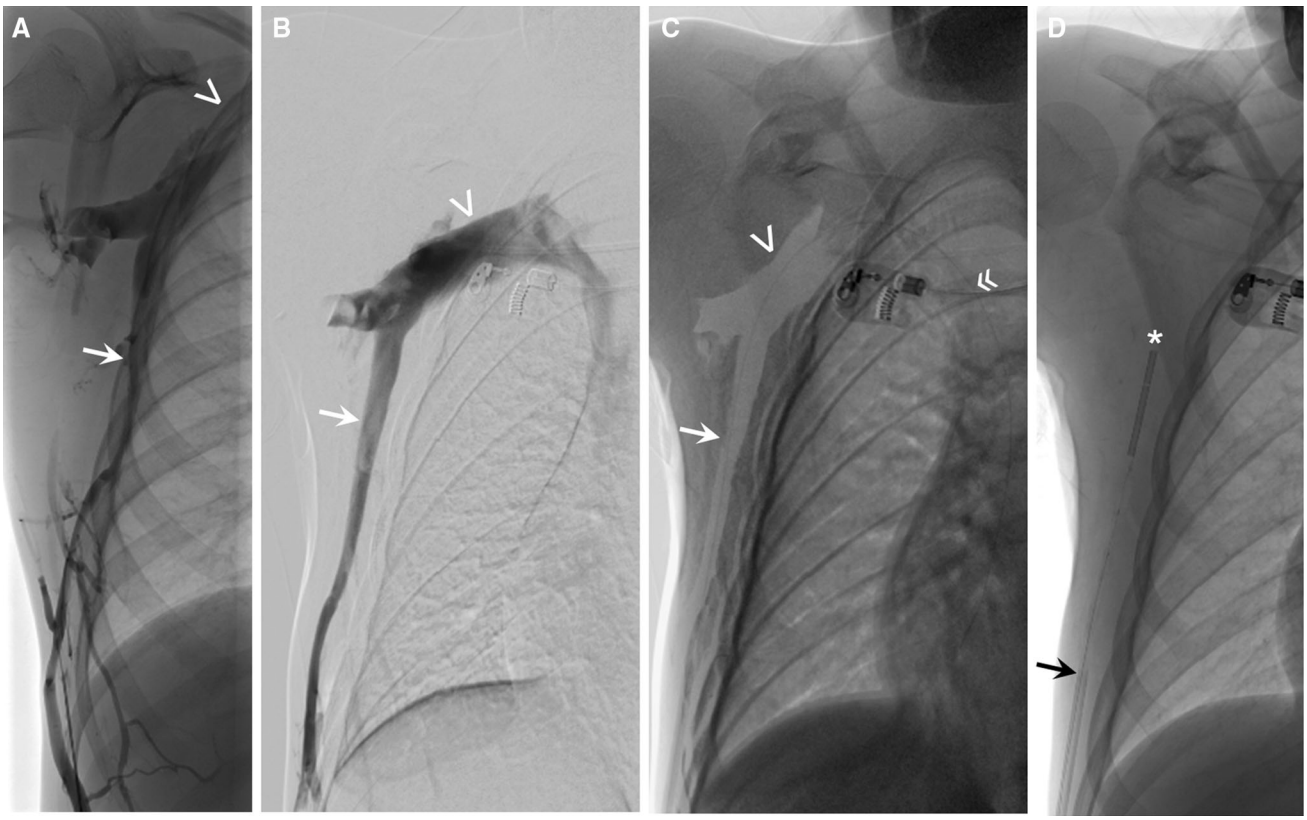

Fig. 1 Radiofrequency ablation of a thoracic marginal vein. **A**, **B** The thoracic marginal vein (arrows) drains into the subclavian vein (arrowhead). **C** A 0.018-inch guide wire (small arrowheads) is lanced into the superior caval vein. **D** A 7-F introducer sheet (black arrow) and the RFA catheter (asterisk) are placed in the proximal aspects of the marginal vein

veins). Eleven patients were female and 9 were male. Three patients underwent previous endovascular laser therapy of the marginal veins with incomplete results. Deep venous system was patent in all treated patients (Fig. 2). Patients presented with marginal veins type I (n = 1), type IIa (n = 2), type IIb (n = 8), type III (n = 8), type IV (n = 1) and thoracic-abdominal locations (n = 3). Mean diameter of the marginal veins was 13.2 mm ± 4 (7–20 mm). The patient characteristics are given in Table 1.

Radiofrequency Ablation

A total of 23 marginal veins were treated with this technique. In 19/23 cases, sclerotherapy was followed to address residual tributaries of the marginal venous system and to reduce the risk of recanalization. In 4/23 cases, ultrasound detected immediate complete closure of the vessel after RFA. The risk of recanalization was considered low in these 4 patients. Accordingly, additional sclerotherapy was not performed. In 2/23 cases, the deeper intrafascial aspects of the marginal vein were embolized prior to radiofrequency ablation. Sonography and phlebography immediately performed after RFA revealed occlusion of all treated vessels.

Follow-up

Follow-up was available in 18 cases with a mean follow-up time of 22 months ± 9.8 (3–42 months). Seventeen (94.5%) marginal veins showed complete or partial occlusion (complete occlusion: n = 12, 66.7%; partial occlusion n = 5, 27.8%) (Fig. 3). One (5.5%) vessel was patent during follow-up (Table 1). One marginal vein showed clinical signs of thrombophlebitis after ablation, which was managed with conservative therapy only without prolonged overnight stay (CIRSE classification system grade 2, no postprocedure sequelae). One patient presented with paresis of the peroneal nerve; hypoesthesia resolved completely, but the ability to lift toes and foot remained reduced (CIRSE classification system grade 4: complication causing a permanent mild sequelae—resuming work and independent living).

Discussion

Treatment of the marginal venous system is recommended early in life since the risk of venous stasis, chronic venous hypertension, thrombosis, venous thromboembolism and

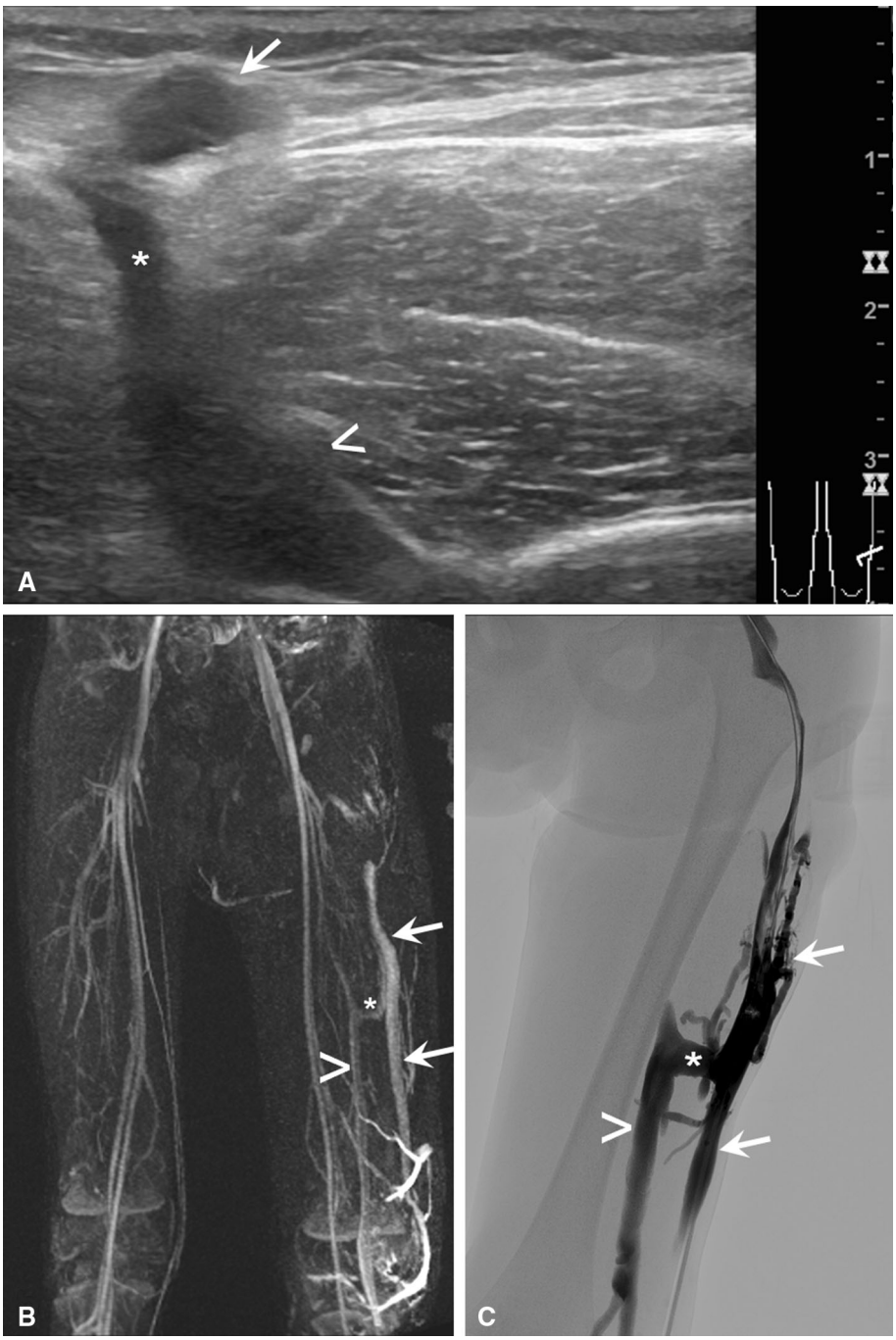

Fig. 2 Nine-year-old boy with Klippel–Trenaunay syndrome (KTS) and marginal vein type III. Ultrasound (**A**), magnetic resonance angiography (**B**) and phlebography (**C**) detect large perforator vein (asterisk) connecting the marginal vein (arrows) with the deep femoral vein (arrowhead)

pulmonary embolization typically worsens with age [3, 4, 7].

Marginal veins are located superficially and involve large perforator veins to the deep veins that make successful treatment of the marginal vein increasingly challenging: (1) Sclerotherapy alone may result in extension of the thrombosis to the deep venous system, (2) laser therapy may result in skin scar and painful thrombophlebitis in superficial marginal veins, and (3) closed stripping is risky because of excessive bleeding, hematomas and coexisting vascular anomalies, especially lymphedema. In the past, surgical resection including clear exposure of the veins and ligation of large perforators was recommended [2, 8]. More recently, endovenous laser treatment (EVLT) of the extrafascial ectatic segments of the marginal venous system has been reported to be an effective treatment without complications in 4 toddlers. Follow-up was available in 3 cases and revealed occlusion of the laser-treated venous segment in 2 cases and residual flow in the distal segment of the treated vein in 1 case [9]. The experience of EVLT

Table 1 Summary of patients with marginal veins treated with endovenous radiofrequency ablation

Age	16 years ± 9.4 (1–37 years)
Sex (female)	11 (55%)
Type of marginal vein	
Type I	1 (4.3%)
Type IIa	2 (8.6%)
Type IIb	8 (34.0%)
Type III	8 (34.0%)
Type IV	1 (4.3%)
Thoracoabdominal	3 (13.0%)
Diameter	13.2 mm ± 4 (7–20 mm)
Outcome/follow-up[a]	22 months ± 9.8 (3–42 months)
Closed	12 (66.7%)
Partially closed	5 (27.8%)
Patent	1 (5.5%)
Complications	
Thrombophlebitis	1 (5.5%)
Nerve injury	1 (5.5%)

Continuous data are presented as means ± SD. Categoric data are given as numbers of cases with percentages in parentheses

[a]Follow-up was available in 18 cases

for treatment of several venous disorders in 35 children included also 23 children with venous malformations or KTS. Of these, 12 embryologic veins and 15 dysplastic veins (including the great and short saphenous vein and immediate lesion draining veins) were ablated [10]. Imaging follow-up was available concerning 22 veins and revealed closure in 10 cases, partial closure in 8 cases and patency of the vessel in 4 cases. One patient suffered from temporary sensory nerve injury, and another from pain. An ulceration in the popliteal fossa was thought to be caused by reflux of additionally used STS (sodium tetradecyl sulfate) [10].

RFA has already been extensively used to treat the great saphenous vein in the setting of chronic varicose veins. Both RFA and EVLT have proven to be highly effective technique for varicose veins with closure rates $> 80\%$. There are no significant differences in higher closure and recurrence rates for either technique [11, 12]. Serious complications like thrombotic events occur infrequently considering both techniques, but postprocedural pain and bruising were experienced significantly less using RFA [11, 13–15].

The reported experience of endovenous RFA in patients with venous malformations and marginal veins is very limited. Fraiser et al. reported on endovenous radiofrequency ablation in 3 patients with KTS. They treated the GSV in 2 patients and one marginal vein in 1 patient. Ablation was successful in only one case: In one case, the treated vessel reopened several months after RFA, and in another case the ablation failed (GSV, diameter of the vessel 15 mm). One patient developed propagation of thrombus into the tibial vein, and another developed a cutaneous ulceration [16]. Sermsathanasawadi et al. reported on complete occlusion of the incomplete anterior accessory vein in 2 patients with KTS using RFA and serial injection of polidocanol 3% [17].

In this series, we achieved complete or partial closure of the marginal vein in 94.5%. This rate is higher compared to EVLT of embryonic veins and dysplastic veins in children with venous malformation (81.8%) [10]. Although Patel et al. did not stress on the diameter of the treated vessels, it is likely that the marginal veins treated in our study (that included also adult patients) are probably even higher than the diameter of marginal veins, dysplastic veins and immediate lesion draining veins in children. In one case, we were not able to achieve occlusion at all, possibly due to the large vessel diameter (19 mm) in an adult patient. Tamura et al. selected only patients with a preoperative diameter of the GSV < 10 mm for RFA and accordingly reported that 99.4% of the veins were occluded successfully [18]. In this series, only 4/23 vessels showed a diameter < 10 mm that may be a hint toward the high partial occlusion rate (27.8%) and the one patent vessel.

Complications of RFA of the GSV include endovenous heat-induced thrombosis, pain, numbness, induration, muscle cramping and edema. Procedural pain and bruising were experienced in 11.5% and 12.5% patients with varicose veins, respectively [16]. Major complications can be serious, including burns, nerve injury, deep vein thrombosis and pulmonary emboli [11]. In this series, RFA of the marginal vein resulted in one major complication (5.5%): paresis of the peroneal nerve. Nerve injury can occur due to the closeness of nerves to ablated veins [10]. Moreover, dysplastic, irregular dilated marginal veins are located in closer proximity to nerves than anatomical veins. The common peroneal nerve (a motor and sensory cutaneous nerve) is at the highest risk for injury in the region of the sapheno-popliteal junction, a region that also involved the marginal vein in this patient [10]. It is very hard to prevent this complication in patients with marginal veins in this localization by tumescence. This technique usually plays an important role in protection against nerve injury, but since the marginal venous system does not have any surrounding envelope the injected fluid often disperses very quickly and adequate tumescence is difficult to achieve and maintain [10]. Additionally, in deep intrafascial localizations of the marginal vein tumescence is not possible. To reduce the risk of damage to surrounding structures, the marginal vein should be embolized using additional coil or plug embolization in these cases. Additionally, this technique reduces the risk of failure of RFA. It was used in this


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C
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◀**Fig. 3** Eight-year-old girl with venous malformation (VM) of the calf and marginal vein type I. **A**–**C** T2-weighted fat-saturated MR image shows marginal vein (arrow) arising near the lateral malleolus, coursing along the lateral aspect of the right calf and draining into the great saphenous vein below the popliteal vein. **D** Dynamic contrast-enhanced TWIST angiography shows complete course of the marginal vein (arrow). **E** Phlebography reveals the deep vein system (arrowhead) and the distal aspects of the marginal vein (arrow) after placement of a 7-F sheet (asterisk). **F** Placement of the RFA catheter (black arrow). Asterisk: sheet. **G**, **H** Phlebography after RFA shows residual contrast media on the tip of the sheet and the distal marginal vein (arrow). Asterisk: sheet. **I** T2-weighted fat-saturated MR image shows compete occlusion of the marginal vein during follow-up (arrowheads)

series in case of intrafascial localizations of the marginal vein. Furthermore, adjunct sclerotherapy was performed owing to the size and tributaries of the embryologic veins.

Conclusion

RFA is an effective minimally invasive technique to treat the marginal venous system. To achieve higher closure rates, it is crucial to treat marginal veins early in life since these vessels may increase in size (diameter and length) as the child grows. Adjunct coil embolization and sclerotherapy might be required owing the large diameter, residual tributaries and the intrafascial courses of the embryologic vessels.

Compliance with Ethical Standards

Conflict of interest Authors WU, SH, WM, MWR, GH and WAW declare that they have no conflicts of interest.

Ethical Approval This retrospective study was approved by the institutional review board of the University of Regensburg; for this type of study, formal consent is not required.

Informed Consent This study has obtained IRB approval from ethical committee of the University of Regensburg, and the need for informed consent was waived.

Consent for Publication For this type of study, consent for publication is not required.

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