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Treatment Modalities for Small Saphenous Vein Insufficiency: Systematic Review and Meta-analysis

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Abstract

Purpose: To investigate and compare the anatomical success rates and complications of the treatment modalities for small saphenous vein (SSV) incompetence. **Methods:** A systematic literature search was performed in PubMed, EMBASE, and the Cochrane Library on the following therapies for incompetence of SSVs: surgery, endovenous laser ablation (EVLA), radiofrequency ablation (RFA), ultrasound-guided foam sclerotherapy (UGFS), steam ablation, and mechanochemical endovenous ablation (MOCA). The search found 49 articles (5 randomized controlled trials, 44 cohort studies) reporting on the different treatment modalities: surgery (n=9), EVLA (n=28), RFA (n=9), UGFS (n=6), and MOCA (n=1). A random-effects model was used to estimate the primary outcome of anatomical success, which was defined as closure of the treated vein on follow-up duplex ultrasound imaging. The estimate is reported with the 95% confidence interval (CI). Secondary outcomes were technical success and major complications [paresthesia and deep vein thrombosis (DVT)], given as the weighted means. **Results:** The pooled anatomical success rate was 58.0% (95% CI 40.9% to 75.0%) for surgery in 798 SSVs, 98.5% (95% CI 97.7% to 99.2%) for EVLA in 2950 SSVs, 97.1% (95% CI 94.3% to 99.9%) for RFA in 386 SSVs, and 63.6% (95% CI 47.1% to 80.1%) for UGFS in 494 SSVs. One study reported results of MOCA, with an anatomical success rate of 94%. Neurologic complications were most frequently reported after surgery (mean 19.6%) and thermal ablation (EVLA: mean 4.8%; RFA: mean 9.7%). Deep venous thrombosis was a rare complication (0% to 1.2%). **Conclusion:** Endovenous thermal ablation (EVLA/RFA) should be preferred to surgery and foam sclerotherapy in the treatment of SSV incompetence. Although data on nonthermal techniques in SSV are still sparse, the potential benefits, especially the reduced risk of nerve injury, might be of considerable clinical importance.

Keywords

endovenous laser ablation, foam sclerotherapy, incompetent vein, mechanochemical ablation, meta-analysis, pharmacomechanical ablation, radiofrequency ablation, reflux, small saphenous vein, varicose vein, venous insufficiency

Introduction

Chronic venous insufficiency (CVI) of the lower limbs is a common disorder: the Bonn Vein Study demonstrated a prevalence of superficial vein reflux of 21% in the adult population, which increased linearly with age.[1] Some clinical signs of CVI are present in ~10% of all adults.[2] CVI has been associated with decreased general and disease-specific quality of life.[3,4] Although superficial venous disease has frequently been associated with great saphenous vein (GSV) incompetence, small saphenous vein (SSV) reflux is responsible for ~15% of all varicose vein disease.[5] In addition, saphenopopliteal and SSV incompetence may result in complaints of equal severity compared with GSV incompetence.[5]

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For more than a century, surgical high ligation with or without stripping or compression therapy was the only treatment option of truncal venous incompetence.[6] In contrast with the surgical treatment of GSV incompetence, there was no uniformity in the surgical treatment of SSVs among vascular surgeons. SSV surgery is considered more challenging and is associated with higher recurrence and complication rates.[7] The close anatomical location of the sural nerve to the SSV poses increased risks of nerve injury. Owing to anatomical variations, the proximal SSV/saphenopopliteal junction (SPJ) is not adequately identified in 22% of patients, even after preoperative ultrasound localization.[8] There is a higher rate of recurrence in limited surgical exploration, whereas the risk of complications increases with the extent of exploration.[9]

The treatment of varicose veins has been revolutionized in recent decades by the introduction of minimally invasive endovenous ablation techniques. Many clinical studies of endothermal ablation in the GSV have shown excellent results; however, less is known about the optimal therapy for SSV incompetence.[10]

This systematic review and meta-analysis summarizes and compares the outcomes and major complications of the available treatment modalities for incompetent SSVs, including surgery, endovenous laser ablation (EVLA), radiofrequency ablation (RFA), ultrasound-guided foam sclerotherapy (UGFS), steam ablation, and the more recently introduced mechanochemical ablation (MOCA).

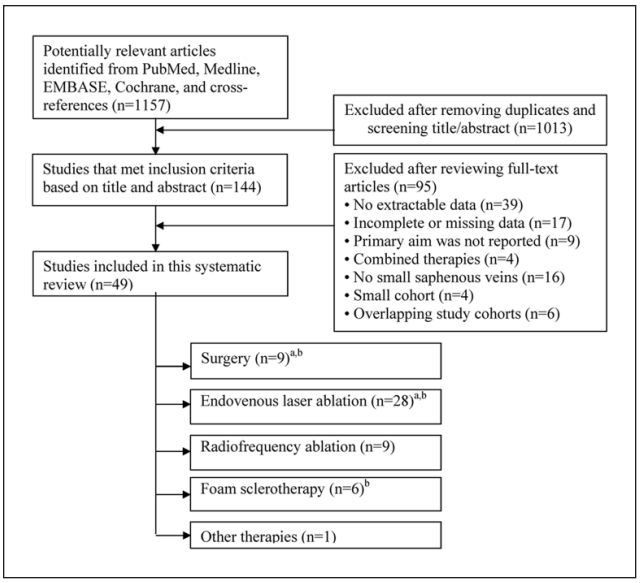

Figure 1. Flowchart of the search strategy.
[a] Two studies described surgery vs endovenous laser ablation.
[b] One study described surgery vs endovenous laser ablation vs foam sclerotherapy.

Methods

Search Strategy

A structured literature search was performed using the guidelines outlined in the Cochrane Handbook for Systematic Interventions (version 5.1.0) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[11,12] Three different biomedical bibliographic databases (PubMed, EMBASE, and the Cochrane Library) were used to perform a systematic search for all English-language literature. Search terms were all differently spelled text words or abbreviations on ("vein incompetence," "varicose vein," "small saphenous vein," "venous reflux") *and* ("stripping," "saphenopopliteal ligation," "saphenopopliteal disconnection," "endovenous laser," "endovenous ablation," "foam sclerotherapy," "radiofrequency ablation," "mechanochemical ablation," "steam," "VNUS," "ClariVein," "Sapheon," "cyanoacrylate glue") *and* ("outcome," "results," "success rate," "failure rate," "complications," "obliteration," "occlusion," "recurrence," "recanalization," "reflux," "pain," "return to normal activities or work," "hematoma," "paresthesia," "nerve injury," "wound infection," "deep vein thrombosis," "thromboembolism") in the title, abstract, and medical subject heading (MeSH). The new subspecialty journal, the *Journal of Vascular Surgery: Venous and Lymphatic Disorders*, which is not currently indexed in the databases, was also searched. The latest search was performed on July 1, 2015.

Selection Criteria and Selection

Studies were included if they involved patients treated for SSV incompetence with surgical stripping, SPJ ligation/disconnection, EVLA, RFA, foam sclerotherapy, MOCA, steam ablation, or cyanoacrylate glue ablation and if they provided the primary outcome. Exclusion criteria were unavailable full text (in 5 different Dutch university medical libraries), case reports, studies with ≤5 treated legs, studies on GSV incompetence, and recurrent SSV incompetence. Studies describing mixed cohorts with vein incompetence were included only if the data for patients with SSV incompetence could be specifically extracted from the results. If more than one study reported the same patient cohort, only the most recent and complete manuscript was included in this review. Finally, the same criteria were used to screen all cross-references for potentially relevant studies not identified by the initial literature search.

Two independent reviewers (D.B., V.N.N.K.) selected the articles according to these criteria with differences resolved by consensus. Of the 1157 abstracts (Figure 1) initially scanned, 1013 were excluded for the following reasons: not written in English, review articles, case reports, solely concerning GSVs, duplicate studies, and other study

aim or subject (ie, hemodynamic assessment, different analgesics, skin condition, anomalies). Of the 144 full text articles analyzed, 95 articles were excluded, leaving 49 studies appropriate for this systematic review (Figure 1).

Data Extraction and Quality Assessment

Two authors (D.B., V.N.N.K.) extracted the following data from the studies on patients undergoing SSV therapy using a standardized extraction form: year of publication, authors, study design, study period, sample size (legs treated), treatment modality, type of anesthesia, procedure details, additional therapy, follow-up period, definition of outcome, anatomical/technical success, and major complications. The same authors assessed the methodological quality of the articles using the Cochrane collaboration checklist and MINORS (methodological index for non-randomized studies) quality score.[13] The Oxford Centre for Evidence-Based Medicine levels of evidence was noted for each included study.[14] Disagreement was resolved by discussion and consensus.

Outcome Measures and Definition

The primary outcome was anatomical success, defined as closure, occlusion, obliteration, or ablation of the incompetent vein and absence of reflux on duplex ultrasound imaging.[15,16] In some studies, failure was described instead, using terms such as recurrence, reflux, recanalization, patent, or open. Failure rates were deducted from 100% to standardize the primary outcome.

Secondary outcomes were initial technical success and major complications. Technical success, defined as the absence of technical failure, was the ability to complete the procedure as planned and the absence of recurrent reflux in target veins as demonstrated with duplex scanning.[15] Two major complications were scored: deep venous thrombosis (DVT) and nerve injury. The latter was reported differently throughout the manuscripts as (sural) nerve injury, numbness, or paresthesia. The different terms describing persisting or transient nerve injury were pooled and defined as paresthesia in this review. Other (minor) complications (eg, superficial phlebitis, hematoma, superficial infection, and skin staining), postinterventional pain, clinical success, and satisfaction were poorly described and were excluded from analyses.

Data Analysis

Raw data were pooled into a database according to the treatment modality, and outcomes were separately described. For follow-up, the mean duration of follow-up per study was used. The secondary outcomes of technical success and major complications were calculated for each treatment modality and were corrected for the number of treated legs for each treatment modality (weighted means).

A meta-analysis was performed for the primary outcome of anatomical success (loss to follow-up was not considered). To provide a reliable outcome and to gain sufficient homogeneity of the pooled data, only studies with MINORS scores of at least 8 and a minimum follow-up of 6 months were used for the pooled analyses. Rates were pooled using a random-effects model that produced incidence estimates with 95% confidence intervals (CIs). The presence of heterogeneity among the studies was determined by applying a chi-square heterogeneity test and constructing forest plots. The I^2 index was calculated. Differences between treatments were assessed using the Mann-Whitney U test. All probability values were 2-tailed, and $p<0.05$ was the threshold of significance. Data were analyzed using SPSS statistical software (version 21.0; IBM Corporation, Somers, NY, USA) and the open access MetaAnalyst software (version 3.1; http://metaanalyst.software.informer.com).

Results

Study Characteristics

Data from the included studies were pooled and divided over the different treatment modalities: surgery (n=9), EVLA (n=28), RFA (n=9), foam sclerotherapy (n=6), and other therapies (n=1). Two studies[17,19] described 2 patient cohorts (surgery and EVLA) and another study[18] reported 3 patient cohorts (surgery, EVLA, and foam sclerotherapy).[18] No data meeting inclusion criteria were available on steam ablation or cyanoacrylate glue embolization in the SSVs. All of the included studies used duplex imaging to evaluate patients and all were of moderate to good quality according to the MINORS scoring scale (Supplemental Tables 1 and 2; supplementary material available at http://jet.sagepub.com/content/by/supplemental-data).

Treatment Modalities

Nine articles[8,17–24] described surgical treatment of 798 SSVs (Table 1). One study included 679 legs, of which only 52 underwent follow-up with duplex imaging.[24] Only these 52 legs were included in the analysis of anatomical and technical success. Uniformity was lacking among the chosen surgical procedures, which included ligation and/or disconnection of the SPJ, with or without stripping. The anatomical success rates were 24% to 94% with a mean follow-up of 17.3 months. Two studies randomized between surgery and EVLA; both showed inferior anatomical success rates for surgery.[17,19] One study randomized between surgery, EVLA, and foam and showed inferior anatomical success rates compared with EVLA but comparable results

Table 1. General Characteristics and Results of Surgery for Small Saphenous Vein Incompetence.

First Author, Year, Country	Design, Period	Level of Evidence[a]	MINORS	Sample Size, Legs	Anesthesia	Additional Therapy	Follow-up, mo	Definition of Outcome	Anatomical/ Technical Success, %	DVT/ Paresthesia, %
Nandhra, 2015[17] UK	RCT, 2005–2010	1b	22	53	GA	Phlebectomy, stripping	24	Recurrence	66/100	NR/6.8[d]
Brittenden, 2015[18] UK	RCT, 2008–2012	1b	23	37	GA, RA	Phlebectomy	6	Recurrence	56/NR	0/NR
Roopram, 2013[19] Netherlands	RCT, NR	1b	22	57	GA, SA	NR	1.5	Occlusion	67/NR	0/31.0
Ikponmwosa, 2010[20] UK	P, NR	2b	11	90	GA	NR	2	Recurrence	62/97	0/9
O'Hare, 2008[21] UK	P, 2002–2005	2b	13	234	GA, SA	NR	12	Recurrence	40/NR	0/23
Allegra, 2007[22] Italy	P, 1989–2001	2b	13	132	GA + TA	NR	60	Recurrence	70/NR	NR/NR
Dumas, 2007[23] Netherlands	RCT, 2001–2004	1b	18	84	GA, SA	Sclerotherapy/surgery GSV	3.8	Recurrence	24/NR	2/27
Whiteley, 2006[24] UK	NR, NR	NR	7	52[b]	GA	Surgery GSV and/or perforators	NR	Recurrence	94[c]/100	2/11[e]
Rashid, 2002[8] UK	R, 1998–2001	2b	10	59	GA	Surgery GSV	1.5	Recurrence	39/59	3/NR

Abbreviations: DVT, deep vein thrombosis; GA, general anesthesia; GSV, great saphenous vein; MINORS, methodological index for non-randomized studies; NR, not reported; P, prospective; R, retrospective; RA, regional anesthesia; RCT, randomized controlled trial; SA, spinal anesthesia; TA, tumescent anesthesia.

[a]Level of evidence: 1b, individual randomized controlled trial; 2b, individual cohort study.

[b]Only 52 of 679 legs underwent follow-up duplex sonography.

[c]Minor revascularization of treated track in 3 of 52 legs.

[d]Paresthesia occurred in 26% at 6 weeks and persisted in 7% at 24 months.

[e]Percentage of the total 679 legs after small saphenous vein surgery.

Table 2. General Characteristics and Results of Endovenous Laser Ablation for Small Saphenous Vein Incompetence.

First Author, Year, Country	Design, Period	Level of Evidence[a]	MINORS	Sample Size, Legs	Anesthesia	Additional Therapy	Follow-up, mo	Definition of Outcome	Anatomical/ Technical Success, %	DVT/ Paresthesia, %
Nandhra, 2015[17] UK	RCT, 2005–2010	1b	22	53	TA	Phlebectomy, stripping, sclerotherapy	24	Recurrence	81/100	NR/2.4
Brittenden, 2015[18] UK	RCT, 2008–2012	1b	23	14	LA, TA	Phlebectomy, foam	6	Recurrence	100/NR	0/NR
Aktas, 2015[25] Turkey	P, 2013–2014	2b	14	52	TA	Retreatment EVLA	12	Recurrence	100/NR	0/NR
Park, 2014[26] Korea	R, 2011–2013	2b	10	103	TA	Sclerotherapy	12	Recurrence	98/100	0/NR
Spreafico, 2014[27] Italy	P, 2008–2012	2b	14	62	TA	Phlebectomy, sclerotherapy	12	Recurrence	100/100	0/NR
Moul, 2014[28] USA	R, 2007–2011	2b	10	105	TA	Phlebectomy, sclerotherapy	24	Occlusion	100/100	0/0
Murli, 2013[29] Malaysia	R, 2010–2011	2b	13	57	GA, SA	Phlebectomy, sclerotherapy	24	Recurrence	98/NR	NR/NR
Von Hodenberg, 2013[30] Germany	P, 2008–2009	2b	13	41	TA	Sclerotherapy	12	Occlusion	100/100	0/0
Roopram, 2013[19] Netherlands	RCT, NR	1b	22	118	TA	NR	1.5	Occlusion	91/NR	0.9/6.7
Ozkan, 2012[31] Turkey	P, NR	2b	11	28	TA	Retreatment EVLA, sclerotherapy	6	Recurrence	96/100	0/0
Doganci, 2011[32] Turkey	RCT, 2009–2010	1b	19	68	TA	None	6	Recurrence	100/100	0/10.3
Desmyttere, 2010[33] France	P, 2003–2006	2b	12	147	TA	Phlebectomy	36	Occlusion	97/100	NR/40
Janne d'Othee, 2010[34] USA	R, NR	2b	12	67	TA	Sclerotherapy	8	Recurrence	99/100	0/3
Ravi, 2009[35] USA	R, 2002–2009	2b	11	269	LA	Phlebectomy, sclerotherapy	0.5	Occlusion	93/NR	0/NR
Huisman, 2009[36] Netherlands	P, 2006–2008	2b	12	169	GA, TA	Phlebectomy, sclerotherapy	3	Occlusion	98/NR	0/1.3
Konthothanassis, 2009[37] Italy, France	NR, 2003–2007	NR	9	229	TA	Phlebectomy, sclerotherapy, surgery perforators	36	Recurrence	99/100	1.3/2.2
Nwaejike, 2009[38] UK	P, 2004–2009	2b	13	66	LA	Phlebectomy, sclerotherapy	1,5	Occlusion	100/100	0/0
Myers, 2009[39] Australia	P, 2002–2007	2b	12	96	TA	Sclerotherapy	48	Occlusion	95/99	2.1/1
Pannier, 2009[40] Latvia, Netherlands	P, 2006–2007	2b	12	26	TA	Phlebectomy	11	Occlusion	100/100	0/9.5
Hamel, 2009[41] France, Switzerland	R, NR	2b	8	309	TA	Phlebectomy, sclerotherapy	6	Occlusion	100/99	0.3/1
Elmore, 2008[42] USA	R, 2001–2006	2b	9	32	TA	Sclerotherapy	15	Occlusion	96/NR	0/9.4
Trip-Hoving, 2008[43] Netherlands	R, 2007	2b	12	52	TA	NR	6	Occlusion	100/100	2/6
Jung, 2008[44] Korea	R, 2003–2006	2b	10	41	TA	Phlebectomy, sclerotherapy	3	Occlusion	93/NR	0/12
Park, 2008[45] Korea	P, 2003–2006	2b	12	390	TA	Phlebectomy, sclerotherapy	9	Occlusion	94/100	0/2
Gibson, 2007[46] USA	P, NR	2b	12	210	TA	EVLA GSV, phlebectomy, sclerotherapy, perforator surgery	4	Occlusion	96/100	5.7/1.6
Theivacumar, 2007[47] UK	P, 2004–2006	2b	10	68	TA	Sclerotherapy	6	Occlusion	100/100	0/4
Perkowski, 2004[48] USA	NR, 2002–2003	NR	9	37	TA	Phlebectomy	12	Occlusion	100/100	0/0
Proebstle, 2003[49] Germany	P, NR	2b	11	41	TA	None	6	Recurrence	100/95	3/11

Abbreviations: DVT, deep vein thrombosis; EVLA, endovenous laser ablation; GA, general anesthesia; GSV, great saphenous vein; LA, local anesthesia; MINORS, methodological index for non-randomized studies; NR, not reported; P, prospective; R, retrospective; RA, regional anesthesia; RCT, randomized controlled trial; SA, spinal anesthesia; TA, tumescent anesthesia.
[a] Level of evidence: 1b, individual randomized controlled trial; 2b, individual cohort study.

with foam sclerotherapy.[18] Allegra et al[22] reported long-term anatomical success in 70% of 132 SSVs after 5 years of follow-up. Paresthesia occurred in up to 31% (mean 19.6%) and DVT in 0.7%. Data were inconclusive to show superiority of any one of the surgical treatment modalities.

EVLA in 2950 SSVs was described in 28 reports[17–19,25–49] (Table 2), which were mostly individual cohort studies. Two randomized controlled trials (RCTs) randomized between EVLA and surgery[17,19] and one study between EVLA, surgery, and foam.[18] Another study randomized patients between cannulation of the SSV at the malleolar level vs cannulation at the midcalf level.[32] Studies were heterogeneous regarding energy delivery. Wavelengths differed between and even within the 28 studies: 810 nm (n=14), 940 nm (n=3), 980 nm (n=8), 1320 nm (n=1), and 1470 nm (n=7). One study did not clearly describe the wavelength of the laser. Moreover, pulsed and continuous modes were both used, with no uniform amount of force discernable (range 15–300 J/cm). Mean follow-up was 12.5 months (range 0.5–48) for all studies. In almost all studies, patients underwent additional therapies. Mean technical success was almost 100% (range 95%–100%). DVT was seen in 0.8% of all patients, and postprocedural paresthesia was described in 4.8%.

Nine articles[50–58] reported the results of RFA in 386 legs (Table 3). Three studies included only patients with SSV incompetence.[52,53,57] The studies reported an initial technical success rate of 100%. The anatomical success after a mean follow-up of 14.3 months ranged from 82% to 100%. Five studies reported results of the ClosureFast device (VNUS, San Jose, CA, USA/Covidien, Mansfield, MA, USA).[54–57] One study analyzed the use of a double heat cycle during RFA with the ClosureFast device.[50] One study used the ClosurePlus catheter in the initial stages of the study but changed to ClosureFast in the latter stages.[52] Studies by Doerler et al[51] and Boon et al[58] used the bipolar Celon device (Olympus, Hamburg, Germany). Complications were poorly reported: 5 studies described a mean DVT rate of 1.2%, ranging from 0% to 8%. Paresthesia was seen in 9.7% (mean). Park et al[52] described paresthesia in 26% of patients; RFA in some patients in this cohort was performed by proximal ligation and retrograde ablation.[52]

Six articles[18,59–63] reported the results of UGFS in 494 SSVs (Table 4). The Tessari method was mostly used to produce foam. A 1:4 liquid-to-air ratio was used in 2 studies,[59,60] and the remaining 4 groups used a 1:3 ratio.[18,61–63] Two research groups used 1% or 3% concentrations of polidocanol.[59,62] Sodium tetradecyl sulfate (1% or 3%) was used in 3 studies.[18,60,61] One study described treatment of foam sclerotherapy with polidocanol (1%) and with sodium tetradecyl sulfate (1% or 3%).[63] The mean anatomical success rate ranged from 20% to 96%. Five studies allowed retreatment with foam sclerotherapy. Only 2 studies described postprocedural complications. DVT was noted in just 1 patient. Major complications after SSV treatment were not recorded in the remaining 4 studies.

One study[62] described the result of MOCA in patients with SSV incompetence. In this recent prospective study, 50 patients were treated with the ClariVein catheter (Vascular Insights, Madison, CT, USA) along with polidocanol under local anesthesia. Initial technical success was 100%, and a 94% anatomical success rate was determined after a follow-up of 12 months. The absence of major complications, for example, DVT and especially nerve injury, could be considered an important finding. The MINORS quality score was 13.

A summary of the treatment of small saphenous vein incompetence is given in Table 5.

Pooled Data

The pooled anatomical success rates of 98.5% in EVLA (95% CI 97.7% to 99.2%) and 97.1% (95% CI 94.3% to 99.9%) in RFA were significantly higher ($p<0.001$) than for surgery (58.0% 95% CI 40.9% to 75.0%) and UGFS (63.6%, 95% CI 47.1% to 80.1%). The pooled data of EVLA and RFA were associated with moderate heterogeneity (I^2=54% and I^2=50%, respectively). Pooled data for surgery and UGFS showed considerable heterogeneity (I^2=92% and I^2=94%, respectively; Figure 2).

Discussion

There is abundant literature on the treatment of GSV incompetence; however, large comparative trials for the treatment of SSV are lacking so far. Only 3 RCTs, randomizing between different treatment modalities were included in this review[17–19]; nonetheless, the meta-analysis showed that EVLA and RFA techniques to treat SSV incompetence will lead to higher anatomical success rates compared with surgery and UGFS.

The available SSV literature remains heterogeneous regarding techniques and treatment protocols. In the manuscripts regarding UGFS, different types and concentrations of sclerosant as well as liquid-to-air ratios were described.[65,66] In the EVLA studies, 5 different laser wavelengths were used, and in some studies, subgroups of patients were treated with different wavelengths.[34,37,41] Although anatomical success of the various laser wavelengths seems similar, there may be differences in adverse effects.[67,68] Another important drawback is the mixture of additional treatments as well as renewed SSV treatments during the primary procedure or as a staged procedure (ie, phlebectomy and sclerotherapy after EVLA, repeated UGFS after initial foam sclerotherapy, etc). To be able to adequately extract and compare data, the terms "anatomical" and "technical success" were used to reduce bias and to draw conclusions.[10,15,16]

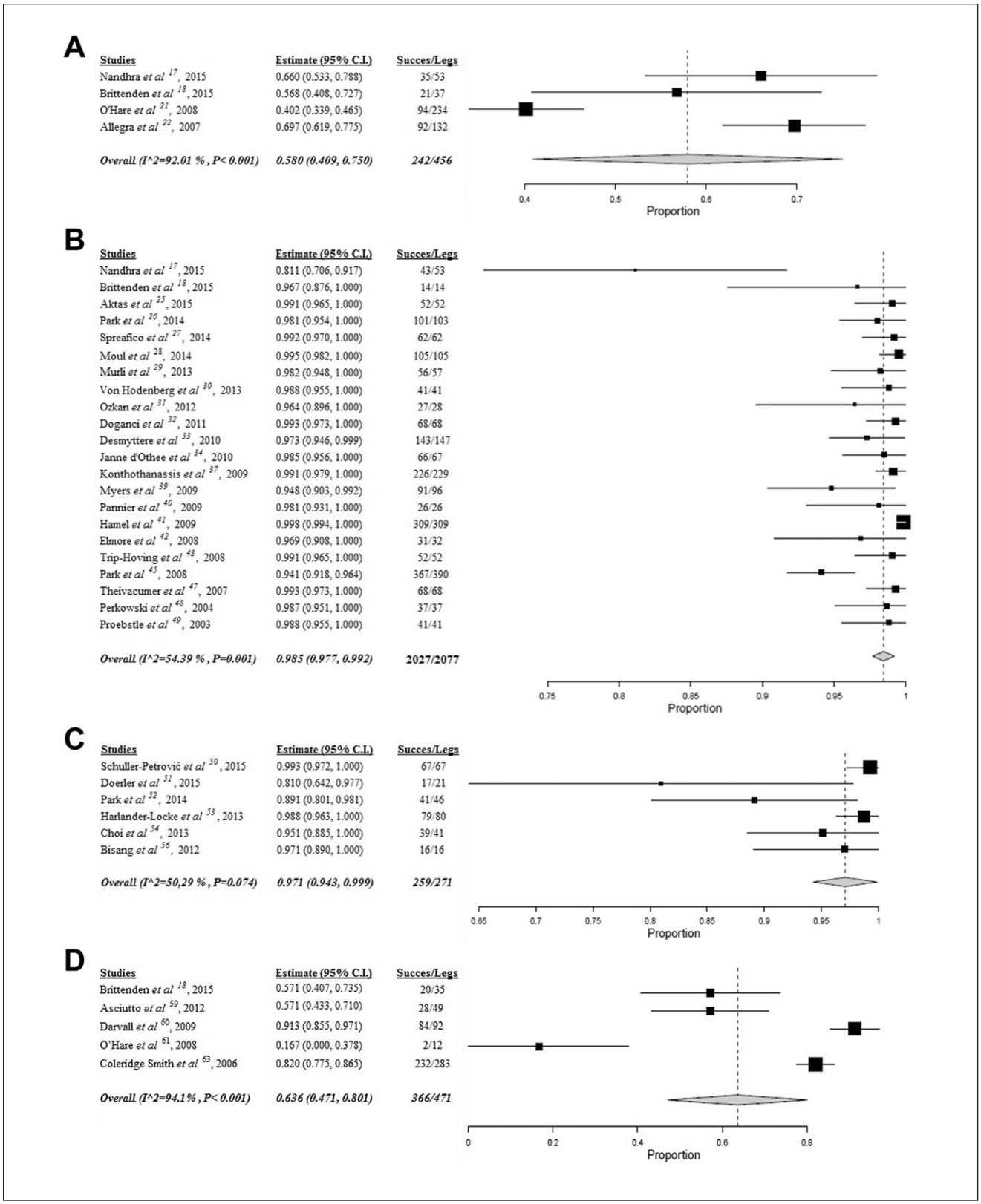

Figure 2. Forest plots of pooled data on anatomical success: (A) surgery, (B) endovenous laser ablation, (C) radiofrequency ablation, and (D) ultrasound-guided foam sclerotherapy. The solid squares denote the mean difference, the horizontal lines represent the 95% confidence intervals (CIs), and the diamonds denote the weighted mean differences.

Table 3. General Characteristics and Results of Radiofrequency Ablation for Small Saphenous Vein Incompetence.

First Author, Year, Country	Design, Period	Level of Evidence[a]	MINORS	Sample Size, Legs	Anesthesia	Additional Therapy	Follow-up, mo	Definition of Outcome	Anatomical/ Technical Success, %	DVT/ Paresthesia, %
Schuller-Petrović, 2015[50] Slovenia, Austria	R, 2007–2011	2b	9	67	TA	Phlebectomy, sclerotherapy	36	Recurrence	100/100	NR/NR
Doerler, 2015[51] Germany	R, 2009–2011	2b	10	21	TA	NR	22	Occlusion	82/NR	NR/9.5
Park, 2014[52] Korea	NR, 2007–2012	NR	10	46	TA	High ligation	27	Recurrence	89/NR	0/26.1
Harlander-Locke, 2013[53] USA	NR, 2008–2012	NR	10	80	GA, LA	Phlebectomy	6	Occlusion	99/NR	0/NR
Choi, 2013[54] Korea	R, 2009–2011	2b	12	41	GA, SA, TA	Phlebectomy	14	Occlusion	95/100	NR/NR
Gabriel, 2012[55] USA	R, 2005–2011	2b	12	12	NR	None	0.1	Occlusion	100/100	0/0
Bisang, 2012[56] Switzerland	R, 2007–2009	2b	10	16	TA	NR	12	Occlusion	100/100	0/NR
Monahan, 2012[57] USA	R, 2007–2008	2b	12	27	TA	Phlebectomy/RFA GSV	3	Occlusion	96/100	8/NR
Boon, 2010[58] Netherlands	P, 2007–2009	2b	11	76	SA or GA ± TA	Phlebectomy, crossectomy, sclerotherapy	0.7	Occlusion	100/100	NR/1.3

Abbreviations: DVT, deep vein thrombosis; GA, general anesthesia; GSV, great saphenous vein; LA, local anesthesia; MINORS, methodological index for non-randomized studies; NR, not reported; P, prospective; R, retrospective; RA, regional anesthesia; RFA, radiofrequency ablation; SA, spinal anesthesia; TA, tumescent anesthesia.
[a]Level of evidence: 2b, individual cohort study.

Table 4. General Characteristics and Results of Foam Sclerotherapy for Small Saphenous Vein Incompetence.

First Author, Year, Country	Design, Period	Level of Evidence[a]	MINORS	Sample Size, Legs	Anesthesia	Additional Therapy	Follow-up, mo	Definition of Outcome	Anatomical/ Technical Success, %	DVT/ Paresthesia, %
Brittenden, 2015[18] UK	RCT, 2008–2012	1b	23	35	NR	Retreatment UGFS	6	Recurrence	57/NR	NR/NR
Asciutto, 2012[59] Sweden	P, 2006–2010	2b	13	49	LA	Retreatment UGFS	12	Occlusion	58/100	NR/NR
Darvall, 2009[60] UK	P, 2004–2007	2b	14	92	NR	GSV sclerotherapy	12	Occlusion	91/100	1/0
O'Hare, 2008[61] UK	NR, 2005–2007	NR	10	12	NR	Retreatment UGFS	6	Occlusion	20/NR	0/NR
Darke, 2006[62] UK	NR, NR	NR	11	23	NR	Retreatment UGFS	1.5	Occlusion	96/100	NR/NR
Coleridge Smith, 2006[63] UK	NR, NR	NR	10	283	NR	Retreatment UGFS	11	Occlusion	82/100	NR/NR

Abbreviations: DVT, deep vein thrombosis; GSV, great saphenous vein; LA, local anesthesia; MINORS, methodological index for non-randomized studies; NR, not reported; P, prospective; RCT, randomized controlled trial; UGFS, ultrasound-guided foam sclerotherapy.
[a]Level of evidence: 1b, individual randomized controlled trial; 2b, individual cohort study.

Table 5. Summary for Treatment of Small Saphenous Vein Incompetence.

Treatment	No. of Studies	Mean Follow-up, mo	No. of Treated Legs	Mean Technical Success, %	Mean Complication Rates, %	
					DVT	Paresthesia
Surgery[8,17–24]	9	17.3	798	89.4 (n=4)	0.7 (n=7)	19.6 (n=9)
Endovenous laser ablation[17–19,25–49]	28	12.5	2950	99.7 (n= 20)	0.8 (n=24)	4.8 (n=22)
Radiofrequency ablation[50–58]	9	14.3	386	100 (n=6)	1.2 (n=5)	9.7 (n=3)
Foam sclerotherapy[18,59–63]	6	10.4	494	100 (n=4)	0.9 (n=2)	0 (n=1)
Other therapies[64]	1	12	50	100 (n=1)	0 (n=1)	0 (n=1)

Abbreviation: DVT, deep vein thrombosis; n, number of studies on which the percentage is based.

Follow-up can be considered the major drawback in SSV research of most of the included studies. Within the current meta-analysis, the pooled data included only studies with follow-up periods >6 months to provide a homogenous and reliable outcome. Moreover, approximately two-thirds of the included studies had substantial loss to follow-up or failed to report on loss to follow-up, thereby inducing potential bias regarding the calculation of success rates during follow-up.

A considerable part of the studies included in the present review were of moderate methodological quality. Statistical power calculations were not performed in any of the prospective cohort studies. Another drawback of the available studies was the study design: almost half of the studies were retrospective analyses or the design was not reported. The interpretation of this systematic review might have been hampered by publication bias. In addition, selective reporting can never be excluded.

A possible explanation for the low anatomical success of the surgical results may be due to more complex anatomy and anatomical variations of the proximal SSV and the SPJ.[9] Rashid et al[8] showed that even despite preoperative duplex identification, SPJ ligation was technically successful in only 59% of patients; moreover, one-third of these patients showed superficial venous residual flow.[8]

The risk of neurological damage is a clinically important downside of surgical treatment and thermal ablation. Paresthesia is seen in 19.6% of patients after surgery vs 9.7% after RFA and 4.8% after EVLA. An important advantage of nonthermal techniques is that no paresthesia was described. The incidence of paresthesia may be underreported due to mild or transient complaints and because no specific neurologic examination was performed routinely. Even in cases with recurrent varicosis after SPJ disconnection, EVLA remains a good option in terms of technical success and low occurrence of paresthesia.[69] DVT occurred rarely (0% to 1.2%) but remains a dreaded complication after venous intervention. DVT rates seem comparable after both surgical and endovenous therapy.

Patient-reported outcome measures could not be reviewed due to the variety in the reporting results or missing data. As recently reported by Brittenden et al,[70] clinical outcome and patient-reported disease-specific quality of life scores were similar after EVLA or surgery (of both GSV and SSV), despite the expected differences in anatomical success. Similar results were shown in a recent RCT; EVLA of the SSV was associated with a superior success rate, fewer complications, and earlier return to work compared with surgery, but no significant differences in quality of life measures were found.[19] A recently started RCT comparing nonthermal ablation (MOCA) and endothermal ablation (RFA) in SSVs might give further information on patient-reported clinical success.[71]

To date, innovative nonthermal techniques are very limited; only 1 study covered new treatments and included MOCA. Although a single study limits the ability to draw firm conclusions, this new technique shows excellent 1-year results and some important advantages: no paresthesia, less postoperative pain compared with RFA and EVLA, and earlier return to work.[72,73] No data on cyanoacrylate glue ablation in SSV is available; nevertheless, this tumescentless and nonthermal technique should be considered promising due to the results in GSVs and the reduced risk of nerve injury.[74] Innovation for surgery and even for UGFS seems to have reached a plateau, but the techniques for EVLA and RFA are updated continuously. Therefore, it might be expected that future results will evolve even more favorably for the endovenous techniques.

Conclusion

Endovenous thermal ablation (both EVLA and RFA) should be preferred to surgery and foam sclerotherapy in the treatment of SSV incompetence. Surgical treatment and UGFS should be reserved for patients in whom thermal ablation is technically not possible (eg, extreme tortuosity, intraluminal thrombus, or short segment neovascularization). Although the evidence on nonthermal techniques in the treatment of SSV incompetence is still sparse, the potential benefits, especially the reduced risk of nerve injury, might be of considerable clinical importance.

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