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REVIEW

Application and outcomes of compression therapy for people living with lymphatic, venous and arteriovenous malformations: a scoping review

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Plain English Summary

Why we undertook the work: Compression therapy is commonly used to manage vascular malformations, but it is unclear how it is being used and how strong the evidence is to support its benefits. We reviewed the available research to understand how compression therapy is used, what outcomes have been reported and where further research is needed.

What we did: We searched five research databases for studies that reported the use of compression therapy in people with vascular malformations. Sixteen studies were included. We examined how compression therapy was used, the types of compression prescribed, the outcomes reported and the strengths and limitations of the available research.

What we found: Compression therapy was widely used, either on its own or alongside other treatments. Some studies reported improvements in areas such as the size of the vascular malformation, limb swelling and symptoms. However, there were considerable differences in the type, pressure and duration of compression used. Studies also measured outcomes differently, and much of the available evidence came from observational studies and individual or small groups of patient cases.

What this means: Compression therapy may provide benefits for people living with vascular malformations, but there is currently not enough evidence to determine the best type, pressure or duration of compression, or which patients are most likely to benefit. Better-quality research using more consistent approaches to compression therapy and measuring outcomes is needed.

Abstract

Objective: To map the available evidence on the use and reported outcomes of compression therapy for vascular malformations and identify gaps within the existing evidence base.

Methods: A scoping review was undertaken and reported in accordance with PRISMA-ScR. CINAHL, Cochrane, Embase, SPORTSDiscus and Ovid MEDLINE were searched for studies reporting compression therapy in people with vascular malformations. Screening was performed independently by two reviewers. Data were extracted and synthesised descriptively and thematically.

Results: Sixteen studies were included. Four themes were identified: (1) compression therapy is widely adopted despite limited evidence; (2) marked heterogeneity exists in compression prescription; (3) outcome measurement lacks standardisation; and (4) methodological weaknesses limit confidence in treatment effectiveness. Compression was used as a standalone intervention and within multimodal and procedural management. Potential improvements in lesion size, limb circumference and symptoms were reported; however, compression type, pressure and duration varied considerably. Objective and patient-reported outcomes were inconsistent, while observational studies and case reports predominated.

Conclusion: Compression therapy is widely used for vascular malformations, but evidence is insufficient to determine optimal prescription or which patients are most likely to benefit. Standardised compression protocols and outcome measures are required.

Key words: compression therapy; vascular malformations; compression garments; vascular anomalies; scoping review

Introduction

Vascular anomalies represent a heterogeneous group of disorders involving abnormalities of the vascular and lymphatic systems. Presentations can be simple and isolated (slow-flow, fast-flow), multifocal (eg, lymphovenous) or syndromic (eg, Klippel–Trenaunay syndrome) requiring multidisciplinary management.[1,2] Prevalence estimates range from 1.5% for congenital malformations which grow proportionally, to 10% for acquired malformations occurring due to damage later in life.[3,4] The classification of vascular anomalies was first proposed by Mulliken and Glowacki[5] and subsequently refined by the International Society for the Study of Vascular Anomalies (ISSVA),[6] which distinguishes vascular tumours such as infantile haemangiomas from congenital vascular malformations. Congenital vascular malformations arise due to abnormalities in vascular development and include venous, lymphatic, capillary, arteriovenous and combined malformations.

Venous malformations represent the most common congenital vascular malformation and may range from small localised lesions to extensive disorders associated with pain, swelling, functional impairment, thrombosis, localised intravascular coagulopathy and psychosocial consequences.[7–9] Lymphatic malformations occur most commonly in paediatric populations and may present as fluid-filled cystic lesions associated with swelling, infection risk and treatment complexity, particularly in microcystic disease.[10,11] Owing to their chronic nature, vascular malformations frequently require lifelong monitoring and individualised management strategies.

Management depends on malformation subtype, anatomical location and symptom burden, with treatment options including sclerotherapy, embolisation, pharmacological therapies and surgery; while recurrence remains a common challenge.[9,12] Compression therapy is frequently incorporated into management pathways to reduce oedema, improve venous and lymphatic return, and relieve symptoms.[13,14] Proposed mechanisms by which compression therapy can benefit vascular malformations include reduced intravascular coagulation and blood stasis leading to reduced intravascular pressure, reduced oedema, increased comfort and protection from minor trauma.[13,15,16]

Despite widespread use, uncertainty remains regarding the evidence supporting compression therapy in people living with vascular malformations. Studies have reported the potential benefits for symptom control, limb volume, pain, function and quality of life, but substantial variation exists in compression prescription, outcome measures and reporting.[13,14] Tools are available to evaluate compression materials and devices in lymphoedema and chronic venous disease,[17] but little evidence is available to inform clinical prescription and evaluation, and consensus-based guidance regarding compression type, grade and duration of use is not available.

Understanding the available evidence can inform clinical decision-making, identify knowledge gaps and guide future research priorities. Accordingly, a scoping review was undertaken to map the current evidence relating to the application of compression therapy in people living with lymphatic, venous and arteriovenous malformations. Capillary malformations were not included in the initial search as these cutaneous malformations are unlikely to benefit from the proposed haemodynamic effects of compression therapy in the same way as venous and lymphatic malformations. The review question was: What is the current evidence on the application of compression therapy for people living with lymphatic, venous or arteriovenous malformations?

Methods

Design

A scoping review methodology was selected to systematically identify and map the extent, range and characteristics of available evidence examining the use of compression therapy for people living with lymphatic, venous, arteriovenous or mixed malformations. This approach was appropriate given the anticipated heterogeneity of the evidence across vascular malformation subtypes, compression therapy approaches, study designs and reported outcomes. The review was conducted using the methodological framework proposed by Arksey and O'Malley,[18] with enhancements informed by Levac *et al*,[19] comprising five stages: (1) identifying the research question; (2) identifying relevant evidence; (3) selecting evidence; (4) charting the data; and (5) collating, summarising and reporting the findings. Evidence selection and data charting were undertaken iteratively, and findings were synthesised using a descriptive numerical summary and thematic analysis. Reporting was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR; see (see Appendix 1 online at www.jvsgbi.com).[20]

Search strategy

A comprehensive search strategy was developed to identify published evidence relating to compression therapy in people living with vascular malformations. Searches combined controlled vocabulary and free-text terms relating to vascular malformation and compression therapy, adapted for each database using Boolean operators (AND/OR). Electronic searches were undertaken across five databases (CINAHL, Cochrane, Embase, SPORTSDiscus and Ovid MEDLINE) on 9 February 2026, covering the period from inception. A total of 417 records were retrieved before duplicate removal and screening. Conference abstracts identified through Embase were excluded prior to screening due to insufficient methodological detail and outcome reporting. Reference lists of included studies and relevant review articles were also searched to identify additional eligible evidence. An example of the completed database-specific search strategy is shown in (see Appendix 1 online at www.jvsgbi.com).

Eligibility criteria

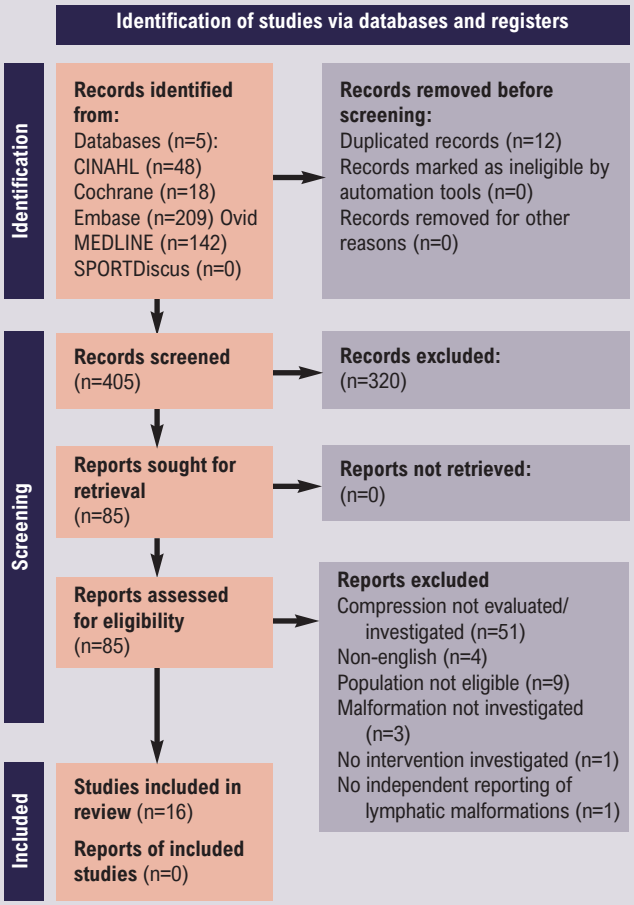
Studies were eligible where participants of any age had a diagnosed lymphatic, venous, arteriovenous or combined/complex

vascular malformation. Syndromic presentations associated with vascular malformations were also eligible where the underlying vascular anomaly was clearly described. Eligible interventions included compression garments, stockings or hosiery, flat-knit compression systems, compression bandaging, adjustable compression devices, intermittent pneumatic compression and other forms of sustained external compression. Compression could be used as the primary intervention or alongside other treatments provided information relating to its application or outcomes could be extracted. Evidence from any healthcare or self-management setting was eligible. Studies were excluded where they focused exclusively on acquired vascular conditions without congenital vascular malformation; secondary lymphoedema without vascular malformation; animal or laboratory research; compression therapy unrelated to vascular malformation management; or did not provide sufficient clinical information relating to the use of compression therapy.

Screening

Evidence selection followed a two-stage screening process. Following duplicate removal, titles and abstracts were screened independently by two reviewers against the predefined eligibility criteria. Any disagreements were resolved through joint review and consensus. Potentially eligible records underwent full-text assessment to confirm vascular malformation subtype, use of compression therapy and sufficient information regarding its application or outcomes. Reasons for full-text exclusion were recorded. The study selection process is shown in the PRISMA-ScR flow diagram (Figure 1).

Figure 1 PRISMA 2020 flow diagram for scoping reviews.



Data analysis

A structured, independent, iterative data-charting framework was developed to extract relevant information,[19] which was collated and summarised to provide an overview of the current evidence landscape.[18] Charting was performed independently by both reviewers. Data was limited to that provided in the published article only. The extracted study characteristics are presented in Table 1. A descriptive numerical summary was used to map publication characteristics, study designs, populations, vascular malformation types, compression approaches and reported outcomes. Evidence was then compared across included sources and organised into four analytical themes: (1) characteristics of compression therapy application; (2) objective and clinical outcomes; (3) patient-reported outcomes and experiences; and (4) methodological limitations and remaining evidence gaps. These themes are presented using an integrated findings and discussion approach, whereby descriptive findings are presented alongside interpretation of their implications for clinical practice and future research.

Findings and discussion

Characteristics of the included evidence

The 16 included studies were conducted across Europe (n=11), North America (n=2), Asia (n=2) and Oceania (n=1) (Table 1). The evidence base was dominated by case reports and series (n=8), followed by retrospective observational (n=4) and prospective interventional (n=3) studies. There was one systematic review of five case series.[13] The prospective studies included a single-arm study,[21] a randomised trial comparing garments with medication and sclerotherapy[22] and a randomised crossover trial of class I (18–21 mmHg) and class II (23–32 mmHg) garments.[14] Female participants comprised the majority in all studies reporting participant sex, except for case reports, and age ranged from 0 to 82 years, with no studies reporting ethnicity or socioeconomic characteristics. Venous (n=7) and mixed (n=7) malformations were the most frequent, followed by arteriovenous (n=6). Among the eight case reports were mixed (n=5) and arteriovenous malformations (n=3). Compression therapy was used as a standalone intervention (n=5), before or after procedural interventions (n=5), and as part of multimodal conservative management (n=2), providing the basis for the themes presented below. Table 2 summarises the objective and patient-reported outcomes across the included studies.

Table 1 Summary of studies retrieved in the review.

Year	Author	Country	Study design	Sample size (% male/ female)	Age range	Malformation type	Anatomical site	Co-morbidities reported (Y/N)	Compression type	Compression class	Compression duration
2016	Akbayrak *et al*	Turkey	Quantitative, single case study	N=1 (100% / 0%)	11 years	Mixed (L / V)	Upper limb	N	Bandaging and garments	Not reported	8 weeks intensive + 12 months maintenance
2014	Reynolds *et al*	New Zealand	Quantitative, single case study	N=1 (0% / 100%)	11 months	Mixed (L / V)	Lower limb	N	Inelastic bandaging	20-30 mmHg	1 month (3x/week)
1991	McDonagh *et al*	England	Quantitative, single case study	N=1 (100% / 0%)	35 years	AVM	Lower limb	Y (Vasc)	Four-layer bandaging	Not reported	8 months
2023	Gueifao *et al*	Portugal	Qualitative, single case study	N=1 (0% / 100%)	3 years	AVM	Lower limb	N	Garments	Class II	10 years
2023	Hyvonen *et al*	Finland	Qualitative, single case study	N=1 (100% / 0%)	0 years	Mixed (V, L, and KTS)	Lower limb	N	Custom-made garment	Foot and lower leg: Class II at 1.5 months and III at 10 months. Thigh and gluteal: Class I at 1.5 months and II at 10 months.	12 years
2021	Geraghty *et al*	England	Qualitative, single case study	N=1 (0% / 100%)	2 years	Mixed (V & AVM)	Lower limb	Y (Ortho)	Four-layer bandaging	Not reported	5 months
2020	Cheung *et al*	USA	Quantitative, retrospective case series	N=19 (21% / 79%)	0–14 years	Mixed (L / V)	Upper limb	Y (Neuro, MSK)	Garments	Not reported	Not reported
2026	Sasa and Nassiri	USA	Qualitative, case series	N=2 (100% / 0%)	43–56 years	AVM	Upper limb	Y (Vasc, CV, MH)	Multi-layer wraps and garments	Not reported	P1: 12 months P2: 8 months
2018	Langbroek *et al*	Netherlands	Quantitative, systematic review (5 retrospective case series)	N=101 (n/a)	0–28 years	V and KTS	Any	Y (Coag, MSK)	Not reported	Not reported	Not reported
2019	Serizawa *et al*	Japan	Quantitative, retrospective, cross-sectional observation	N=14 (50% / 50%)	Mean 70 ±11.7 years	AVM	Lower limb	Y (R, Vasc, Met, CV)	Elastic garments	20–30 mmHg	At least 2 months
2002	Mazoyer *et al*	France	Quantitative, retrospective, cross-sectional observation	N=24 (25% / 75%)	20–62 years	V	Upper and lower limb	Y (Coag, MSK)	Elastic garment	Not reported	Not reported
2024	Strubing *et al*	Germany	Quantitative, retrospective, cross-sectional observation	N=593 (41% / 59%)	0–82 years	C, L, V, AVM, mixed (various)	Any	N	Garments	Not reported	Not reported
2022	Stor *et al*	Netherlands	Quantitative, retrospective, cross-sectional observation	N=164 (36% / 64%)	Median: 29 years (IQR = 18–50)	C, L, V, AVM, mixed (various)	Any	N	Garments	Not reported	Not reported
2025	Noguchi *et al*	Japan	Quantitative, prospective, single-arm interventional	N=20 (35% / 65%)	2–54 years	V	Lower limb	N	Custom-made garments	30 mmHg	6 months
2022	Aydin *et al*	Turkey	Quantitative, prospective randomised trial	N=90 (0% / 100%)	Mean (years): G1: 40 ±8.5 G2: 39 ±8.7 G3: 41 ±9.5	V	Lower limb	N	Garments	20–28 mmHg	6 months
2023	Li *et al*	Germany	Quantitative, prospective, randomised, double-blinded cross-over study	N=18 (33% / 67%)	9–62 years	V	Lower limb	Y (R, Vasc)	Garments (flat-knit)	Class I (18–21 mmHg) Class II (23–32 mmHg)	8 weeks (4 weeks per class)

C, capillary; L, lymphatic; V, venous; AVM, arteriovenous; KTS, Klippel–Trenaunay Syndrome; Neuro, neurological; MSK, musculoskeletal; R, renal; Vasc, vascular; Met, metabolic; CV, cardiovascular; Coag, coagulopathies; MH, mental health; Ortho, orthopaedic; P1/P2, participant 1/2, respectively; G1/G2/G3, group 1/2/3, respectively.

Table 2 Outcome measures and findings reported.

Year	Author	Study design	Measurement tools	Patient outcomes	Results
2020	Cheung *et al*	Case series	Imaging Grip strength	Pain	No improvement reported with compression. Strength reduced to less than 30% contralateral limb (values not provided). Pain relieved.
2023	Li *et al*	Randomised crossover study	Imaging Perometry	SF-12 quality of life	Significant reduction in lesion volume (MRI) with Class I and II ($p<0.001$). Greater reduction with Class II vs Class I ($p=0.04$). Mean volume reduction: Class I = 16.4 mL Class II = 23.7 mL No significant change in limb volume (perometry). No significant changes in SF-12 QoL.
2019	Serizawa *et al*	Cross-sectional observational	Imaging Clinical assessment	Symptom resolution	Micro-AVFs detected in 13% of limbs. Symptom resolution with compression in 2 months for 82% limbs. Surgery required in 3 limbs.
2018	Langbroek *et al*	Systematic review	Not standardised	No standardised	Effects inconsistently measured and not quantified. Overall evidence quality is poor. Patient outcomes poorly reported and no standardised use across studies.
2016	Akbayrak *et al*	Case study	Water displacement Goniometry Clinical assessment	Visual analogue scale (VAS)	Reduction in limb volume: Baseline = 1750 mL 8 weeks = 1250 mL 12 months = 1350 mL Improved joint range of motion. Skin quality improved. Improved VAS: Baseline = 8.1 8 weeks = 4.2 1 year = 5.3
2014	Reynolds *et al*	Case study	Circumferential measurements Clinical assessment	n/a	Reduction in limb circumference (3 cm over 4 weeks). Able to progress to garment use.
2002	Mazoyer *et al*	Cross-sectional observational	Imaging Blood test Clinical assessment	Pain	Compression reduced malformation volume only while worn. Reduced blood stasis and improved localised intravascular coagulation (LIC). Rapid increase in lesion size and symptoms when not wearing compression. Compression improved pain, comfort and function.
1991	McDonagh *et al*	Case study	Clinical assessment	n/a	Ulcer healing achieved.
2026	Sasa and Nassiri	Case series	Imaging Clinical assessment	n/a	Reduced flow rate: P1 = 4341 to 132 mL/min P2 =530 to 75 mL/min Full range of motion restored. Visual reduction in volume. Improved wellbeing and daily life. Reduction in hypertensive medication.
2025	Noguchi *et al*	Single-arm interventional	Perometry (circumference ratio) Body composition Clinical assessment	Pain Modified Rankin Score (mRS)	Statistically significant reduction in circumference ratio: Tibial tuberosity: $p=0.02$ Ankle: $p<0.001$ Downward (but not significant) trend in water content of both legs, pain, and mRS. No change in vital signs. Significant reduction in garment elasticity to less than 50% original.
2024	Strubing *et al*	Cross-sectional observational	n/a	n/a	23.8% patients treated with compression prior to referral to vascular anomaly centre. 33.3% incorrectly diagnosed patients were prescribed compression garments.
2023	Gueifao *et al*	Case study	Clinical assessment	n/a	Pain reduced. Quality of life improved.
2023	Hyvonen *et al*	Case study	Clinical assessment	n/a	Visual reduction after enhanced compression therapy.
2022	Stor *et al*	Cross-sectional observational	n/a	Pain	Significantly higher rate of pain in those wearing compression: $p=0.001$.
2022	Aydin *et al*	Randomised trial	n/a	Modified venous clinical severity classification (mVCSC)	Significantly greater reduction in swelling at 6 months in medical group and appearance at all timepoints in sclerotherapy group Greater reduction in swelling at 6 months in medical group: 92.6%, $p=0.009$. Greater reduction in appearance concerns in sclerotherapy group at all time points: 1 month: 86.7%, $p=0.002$ 3 months: 96.7%, $p<0.001$ 6 months: 100%, $p<0.001$
2021	Geraghty *et al*	Case study	Clinical assessment	n/a	Limb viable, intact, and functionally improved. Limb hypertrophy remained.

Theme 1: Compression therapy is widely adopted despite limited evidence

Compression therapy was widely adopted across the included studies, although relatively few evaluated its independent effectiveness. Five investigated compression therapy as a standalone intervention,[14,16,21,23,24] two within multimodal conservative management,[25,26] and five before or after procedural interventions, including embolisation, surgery and wound care.[27–31]

None included a no-treatment control group, preventing determination of compression therapy's independent contribution to treatment outcomes.

Among the studies evaluating compression therapy as a standalone intervention, several reported improvements in objective clinical outcomes. Continuous compression garments were associated with reduced transmural pressure, parietal distension and improved patient comfort,[16] whilst Reynolds[23] reported a reduction in limb circumference of approximately 3 cm following four weeks of compression bandaging. Serizawa *et al*[24] similarly reported improvements in the appearance of micro-arteriovenous malformations, although two participants remained symptomatic and subsequently required surgery. Li *et al*[14] demonstrated significant reductions in venous malformation volume, whereas Noguchi *et al*[21] reported reductions in affected limb circumference following six months of compression garment use. However, despite these objective improvements, neither study demonstrated significant improvements in patient-reported outcomes, including quality of life or pain. Collectively, these findings suggest potential improvements in objective outcomes, particularly lesion size and limb circumference, while evidence for symptoms and quality of life remains less consistent. The limited use of validated patient-reported outcomes is particularly important for a therapy that may require prolonged or lifelong use.

When compression therapy was incorporated into multimodal management, attributing improvements specifically to compression was not possible. Akbayrak *et al*,[26] Gueifão *et al*[25] and Hyvönen *et al*[30] combined compression therapy with other conservative pharmacological or procedural interventions. Although improvements in limb volume, skin condition, function and symptom severity were reported, the contribution of compression therapy could not be distinguished, with similar attribution problems surrounding procedural interventions. Sasa and Nassiri[28] reported substantial reductions in arteriovenous malformation flow following cyanoacrylate embolisation, whilst McDonagh *et al*[31] and Geraghty and Allaway[29] described reductions in oedema and successful ulcer healing using four-layer compression bandaging alongside wound care and vascular intervention. In contrast, Cheung *et al*[27] found that compression garments, propranolol and sclerotherapy were ineffective in managing fibroadipose vascular anomaly before definitive surgery, suggesting that compression therapy may not provide similar benefit across all vascular malformation subtypes. Outcome measurements of strength, range of movement and walking ability were notably absent across all studies, and it is not clear at present whether compression garment use can improve characteristics important to daily function in people with vascular malformations.

Evidence from observational studies further illustrates the uncertainty surrounding treatment effectiveness. Stor *et al*[32] reported greater pain among patients wearing compression garments, particularly females and those with lesions involving muscle or bone, although a range of malformation localities and tissue involvements were included and it is possible that pain influenced the prescribing of compression garments, limiting the application of this finding. Strübing *et al*[33] demonstrated that compression therapy was frequently prescribed before referral (23.8%) and following specialist assessment (43.2%), but did not evaluate clinical outcomes. Likewise, Aydin *et al*[22] reported similar symptomatic improvement between compression therapy, medical treatment and sclerotherapy in patients with telangiectasia and reticular veins, although cosmetic outcomes favoured sclerotherapy. These findings are consistent with the systematic review by Langbroek *et al*,[13] which concluded that compression therapy may reduce pain, oedema, intravascular coagulation and minor trauma, but that the evidence remains heterogeneous and predominantly observational. Overall, compression therapy was routinely incorporated into the treatment of vascular malformations, but observational designs, frequent use of co-interventions and clinical heterogeneity limited confidence in its independent effectiveness. This uncertainty also highlights the considerable variation in compression therapy prescription, explored in the following theme.

Theme 2: Marked heterogeneity exists in compression prescription

Compression therapy prescription varied considerably across studies, limiting identification of the most appropriate strategy. Garments were the most frequently reported compression intervention, being used alone in nine studies.[14,16,21,22,24,25,27,32,33] Bandaging alone was reported in two studies,[29,31] whilst four studies combined garments with bandaging, intermittent pneumatic compression or adjustable wraps.[23,26,28,30]

Reporting of prescribed compression pressure was inconsistent. Five studies reported compression pressure or class with corresponding pressure values,[14,21–24] while two described garments by compression class only.[25,30] Where pressure was reported, the most frequently prescribed range was 20–30 mmHg. The British Standard (BS 661210) for compression garments defines 14–17 mmHg as class 1, 18–24 mmHg as class 2 and 25–35 mmHg as class 3. While higher levels of compression have been shown to reduce lesion size,[14] a trade-off between comfort and physiological benefit is required to ensure patient compliance, but limited reporting of compliance prevents recommendations being derived. Importantly, while treatment duration ranged from one month to over 12 years, with 6–8 months most reported, five studies did not report how long garments were worn for,[13,16,27,32,33] despite published recommendations to renew garments every six months to maintain elasticity and therapeutic benefit.[21]

The chronic nature of vascular malformations makes compliance an important outcome measure for informing clinical practice, particularly when prescription can prevent medical or surgical intervention. Only one study reported compliance relating to two different garment classes worn for 4 weeks each.[14] Satisfactory compliance was reported (~12 hours per day) without

any change in patient reported outcomes, but longer-term studies are needed to support clinical decision making.

Garment characteristics were inconsistently described; only one study explicitly evaluated flat-knit garments,[14] two reported custom-made garments[21,30] and only Serizawa *et al*[24] specified circular-knit garments. Circular-knit garments provide support for regularly shaped limbs, flat-knit provide stronger containment of fluid where chronic oedema is present, and custom-made are used in unique cases which, despite providing useful insight, have limited potential for generalisation. Cost implications differ with garment type and consistent reporting is necessary to enable practical consideration. The findings of Li *et al*[14] further highlight the importance of consistently reporting compression class and pressure due to the physiological effect. Overall, heterogeneity in garment type, compression class, interface pressure and treatment duration, together with inconsistent reporting and limited comparative evidence, precluded identification of an optimal compression strategy for specific vascular malformation subtypes.

Theme 3: Outcome measurement lacks standardisation

Considerable heterogeneity existed in the objective measures used to evaluate compression therapy (Table 2). Fifteen of the 16 studies reported at least one objective outcome.[14,16,21–33] However, 16 different objective measures were identified, including magnetic resonance imaging (MRI), computed tomography (CT), ultrasound, clinical assessment, limb circumference, perometry, water displacement, body water content, range of motion and physiological measures. MRI, CT and clinical assessment were the most frequently reported measures.[14,16,24,27,29,31] This variability in outcome measurement limited comparison between studies and reduced confidence in comparing treatment outcomes.

A similar lack of standardisation was evident in patient-reported outcomes. Although all studies reported some form of subjective assessment, including quality of life, pain, functional outcomes or symptom improvement, the use of validated measures was limited. Li *et al*[14] used the 12-Item Short Form Health Survey (SF-12) while Akbayrak *et al*[26] used a visual analogue scale to assess pain. The remaining studies relied on study-specific symptom reporting, functional assessments or descriptive clinical observations.[16,21–25,27–32] Pain was the most frequently reported patient outcome, being assessed in nine studies.[14,16,21,22,24–27,32] Importantly, only one study included mental health status as a measurement of patient reported outcomes.[28] Overall, inconsistent objective and patient-reported outcome measures limited comparison between studies and confidence in evaluating the effects of compression therapy. This could be addressed by developing and validating a vascular malformation-specific patient reported outcome measure in future work which could also support the development of consensus-driven standardised outcome measures for monitoring the condition in the long term. Based on the limitations identified in this review, a standardised measurement set should include objective, functional, patient reported outcomes, garment characteristics, use and adherence, and clinically important measures to support consistency across future studies and enable generalisation of findings.

Theme 4: Methodological weaknesses limit confidence in treatment effectiveness

The methodological characteristics of the included studies further limited confidence in the reported effectiveness of compression therapy. Although 16 studies were identified, the evidence base was dominated by lower-level study designs, as previously reported.[13] Eight studies were case reports or series,[23,25–31] four were observational[16,24,32,33] and three were interventional.[14,21,22] There was only one randomised crossover trial that directly evaluated compression therapy[14] and one systematic review synthesised the available evidence, although this study only included five retrospective case series.[13]

Across the included studies, methodological limitations were common. Sample sizes were generally small, with many studies reporting single patients or a limited number of participants, impacting generalisability. Furthermore, compression therapy was frequently delivered alongside pharmacological, surgical or interventional treatments, making it difficult to isolate its independent therapeutic effect. Follow-up ranged from one month to over 12 years, limiting comparison of treatment durability and longer-term outcomes. Noguchi *et al*[21] reported a significant reduction in garment elasticity after six months of use and recommended replacement at this interval, with implications for future study design and clinical practice. Participant characteristics were inconsistently reported. Although most studies described age and sex, none reported ethnicity or socioeconomic characteristics and the impact of vascular malformations across society is not clear, limiting the design of equitable approaches. In addition, there was no direct exploration of whether treatment response differed according to vascular malformation subtype, lesion severity or anatomical location. Consequently, it remains unclear which patient groups are most likely to benefit from compression therapy.

Taken together, the four themes demonstrate that compression therapy is widely incorporated into the management of vascular malformations despite a heterogenous and methodologically limited evidence base. There remains a need for larger prospective comparative studies using standardised compression protocols and agreed outcome measures to better establish its effectiveness across different vascular malformation subtypes and patient groups.

Strengths and weaknesses

This scoping review provides an updated mapping of the evidence relating to compression therapy for vascular malformations, including its use as a standalone intervention and alongside multimodal management. The review identifies important variation in compression prescription and outcome measurement, highlighting priorities for future research. However, the conclusions

KEY MESSAGES

- Compression therapy is widely used in the management of lymphatic, venous and arteriovenous malformations despite a limited evidence base.
- Considerable variation exists in compression type, pressure, duration and outcome measurement.
- Current evidence is insufficient to determine optimal compression prescription or which patients are most likely to benefit.
- Prospective comparative research using standardised compression protocols and outcome measures is needed.

that can be drawn from this review are limited by a small and heterogeneous evidence base dominated by observational studies, case reports and case series. Frequent use of co-interventions, together with variation in vascular malformation subtype, compression prescription, follow-up duration and outcome measurement, further restricted comparison between studies.

Conclusion

This review identified a limited but evolving evidence base for compression therapy in vascular malformations. Although evidence suggests potential benefits for lesion size, limb circumference, symptoms and other clinical outcomes, substantial variation in compression prescription, outcome measurement and study methodology limits confidence in determining its effectiveness. Current evidence remains insufficient to determine the optimal type, pressure and duration of compression therapy or identify which vascular malformation subtypes are most likely to benefit. Future prospective comparative studies using standardised compression protocols, objective and patient-reported outcomes and adequate follow-up are needed to strengthen the evidence base and inform clinical practice. A stronger evidence base can also facilitate the development of consensus-based guidance for the use of compression in vascular malformations.

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Appendix 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist and Search Strategy Example

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	n/a
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	7
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	7
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 1
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	7
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	9

Appendix 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist and Search Strategy Example *continued*

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	9
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	n/a
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	9
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	n/a
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Table 1 / Table 2
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	9
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	9
Limitations	20	Discuss the limitations of the scoping review process.	15
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	16
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	n/a

Appendix 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist and Search Strategy Example *continued*

Search Strategy Example

Database: Embase (1974 to 2026 Week 05)

Concept 1: Arteriovenous and vascular malformations

1	exp arteriovenous malformation/	53008
2	(arteriovenous adj2 malform*).ti,ab.	24047
3	(arterial adj2 malform*).ti,ab.	594
4	exp congenital blood vessel malformation/	154561
5	(vascular adj2 malform*).ti,ab.	14398
6	(vascular adj2 abnormal*).ti,ab.	12318
7	exp lymphatic malformation/	19959
8	(lymphatic adj2 abnormal*).ti,ab.	954
9	(lymphatic adj2 malform*).ti,ab.	2726
10	(venolymphatic adj2 malform*).ti,ab.	140
11	(venolymphatic adj2 abnormal*).ti,ab.	1
12	(venus adj2 malform*).ti,ab.	2
13	(venus adj2 abnormal*).ti,ab.	0
14	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13,	**n = 191580**

Concept 2: Upper and lower limb

15	exp lower limb/	584049
16	exp leg/	423287
17	(below adj2 knee*).ti,ab.	8946
18	(low* adj2 limb*).ti,ab.	118442
19	(low* adj2 extremit*).ti,ab.	114299
20	leg*.ti,ab.	561194
21	exp upper limb/	416377
22	exp arm/	296353
23	exp hand/	108668
24	exp forearm/	37641
25	arm*.ti,ab.	606203
26	hand*.ti,ab.	1115752
27	forearm*.ti,ab.	65686
28	(upper adj2 arm*).ti,ab.	18166
29	(upper adj2 limb*).ti,ab.	61465
30	(upper adj2 extremit*).ti,ab.	53765
31	15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30	**n = 2967447**

Concept 3: Compression therapy

32	exp bandage/	25030
33	exp compression bandage/	5072
34	bandag*.ti,ab.	10632
35	compression*.ti,ab.	201204
36	exp compression stocking/	5163
37	(compress* adj3 bandag*).ti,ab.	2260
38	(compress* adj3 garment*).ti,ab.	1302
39	(compress* adj3 hosiery).ti,ab.	301
40	(compress* adj3 sock*).ti,ab.	172
41	(compress* adj3 stocking*).ti,ab.	3647
42	(compress* adj3 therap*).ti,ab.	4798
43	(compress* adj3 tight*).ti,ab.	241
44	(compress* adj3 wrap*).ti,ab.	333
45	(compress* adj3 sleev*).ti,ab.	338
46	(elastic* adj3 compress*).ti,ab.	2506
47	(inelastic* adj3 compress*).ti,ab.	107
48	(graduated* adj3 compress*).ti,ab.	909
49	garment*.ti,ab.	5460
50	hosiery.ti,ab.	419

Appendix 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist and Search Strategy Example *continued*

51 stocking*.ti,ab. 10500
52 tights.ti,ab. 156
53 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52, **n = 240741**

Concept 4: Outcomes
54 (limb* adj2 volume).ti,ab. 1526
55 (limb* adj2 circumference).ti,ab. 697
56 (volume adj2 reduc*).ti,ab. 43706
57 (volume adj2 chang*).ti,ab. 26395
58 (circumference adj2 reduc*).ti,ab. 1487
59 (circumference adj2 chang*).ti,ab. 655
60 (swelling adj2 reduc*).ti,ab. 4088
61 (swollen adj2 reduc*).ti,ab. 130
62 (size adj2 reduc*).ti,ab. 48959
63 (size adj2 chang*).ti,ab. 13327
64 exp edema/ 437955
65 edema.ti,ab. 225648
66 oedema.ti,ab. 49301
67 exp "quality of life"/ 872788
68 quality of life.ti,ab. 792388
69 QoL.ti,ab. 126084
70 HRQoL.ti,ab. 46579
71 exp patient-reported outcome/ 91302
72 patient reported outcome*.ti,ab. 84798
73 PROMS.ti,ab. 12738
74 exp treatment outcome/ 3224153
75 (treatment adj2 outcome*).ti,ab. 199213
76 (function* adj2 outcome*).ti,ab. 129059
77 effectiv*.ti,ab. 4247098
78 efficacy.ti,ab. 2063436
79 circumference.ti,ab. 120628
80 (dielectric adj2 constant).ti,ab. 6610
81 exp impedance/ 53991
82 bioimpedance.tw,kf. 11298
83 perometry.ti,ab. 137
84 ((water or fluid) adj2 displac*).ti,ab. 2421
85 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 **n = 9264113**

Final search
86 14 and 31 and 53 and 85, **n = 360**

Limits
87 limit 86 to (article-in-press status or embase status or in-process status) **N = 209**