A COMPARATIVE STUDY ON GRADUATED COMPRESSION VERSUS SURGICAL INTERVENTION IN MANAGEMENT OF THE VENOUS LEG ULCERS – AN OBSERVATIONAL STUDY

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Abstract
Aim-To compare the clinical outcomes of graduated compression therapy alone versus surgical/endovenous intervention combined with compression therapy in the management of venous leg ulcers. Methodology-This hospital-based observational comparative study was conducted in the Department of General Surgery, Shri Sathya Sai Medical College & Research Institute over a period of 18 months. A total of 124 patients with duplex-confirmed venous leg ulcers (CEAP C5/C6) were included and allocated into two groups: Group 1 received graduated compression therapy alone, while Group 2 underwent surgical/endovenous intervention followed by compression therapy. Baseline clinical assessment included CEAP classification, Venous Clinical Severity Score (VCSS), CIVIQ-20 quality-of-life score, duplex Doppler evaluation, and ulcer measurements. Patients were followed up at regular intervals to assess ulcer healing, healing time, recurrence, quality of life, complications, and treatment compliance. Statistical analysis was performed using IBM SPSS Version 24, with $p < 0.05$ considered statistically significant. Results-The baseline demographic, clinical, duplex, and severity characteristics were comparable between the two groups. The majority of participants belonged to the 50–69 year age group, with male predominance and high prevalence of prolonged standing occupations and obesity. Most patients demonstrated severe baseline disease based on VCSS and CIVIQ-20 scoring. Surgical/endovenous intervention combined with compression demonstrated superior clinical outcomes compared to compression therapy alone, with faster ulcer healing, greater reduction in ulcer size, improved VCSS and quality-of-life scores, and lower recurrence rates during follow-up. Complication rates remained acceptable and manageable in both groups. Conclusion-Graduated compression therapy remains an effective first-line treatment modality for venous leg ulcers; however, surgical/endovenous intervention combined with compression provides superior healing outcomes and better long-term disease control by correcting the underlying venous reflux pathology. Early intervention combined with sustained compression therapy may significantly reduce recurrence and improve patient quality of life in chronic venous ulcer disease.

Keywords-Venous leg ulcer, chronic venous insufficiency, compression therapy, endovenous ablation, venous reflux, VCSS, CIVIQ-20, CEAP classification.
How to cite this article: Monica N, Naren Kumar A. A Comparative Study on Graduated Compression Versus Surgical Intervention in Management of the Venous Leg Ulcers – An Observational Study. Int J Drug Deliv Technol. 2026;16(69s): 2064-2071. DOI: 10.25258/ijddt.16.69s.203

Introduction

Venous leg ulcers (VLUs) represent the most advanced and debilitating stage of chronic venous insufficiency (CVI), resulting from persistent venous hypertension, venous reflux, valve incompetence or obstruction of venous outflow.1 The pathological sequence begins with sustained ambulatory venous pressure, microcirculatory dysfunction, leukocyte trapping and progressive tissue hypoxia, eventually leading to ulceration around the gaiter region of the lower limb.2 VLUs significantly reduce mobility, impair functional capacity, and contribute to long-term physical, psychological and financial burden.3

Globally, VLUs constitute 70–90% of all chronic lower-limb ulcers, making them the most common ulcerative etiology in surgical and wound-care practice.4 The lifetime risk is rising, particularly due to increasing obesity, aging population and sedentary lifestyle patterns.5 Although prevalence varies by geography, studies report active leg ulceration rates between 1.5–3 per 1,000 population, increasing up to 20 per 1,000 adults above 80 years. 4 In India, limited epidemiological data exist, yet clinical audits and tertiary-care records suggest a growing incidence, especially in older patients, manual laborers and occupations involving prolonged standing.7

Compression therapy remains the gold-standard, first-line treatment for VLUs, aiming to reverse venous reflux, decrease edema, improve microcirculation and facilitate granulation tissue formation.7 Evidence indicates that dedicated, sustained compression can achieve healing in 40–70% of ulcers within 12–24 weeks, depending on ulcer size and patient compliance.8 However, the challenge lies in recurrence: more than 50% of VLUs recur within 6–18 months, particularly when the underlying venous pathology is untreated or when adherence to compression is poor.9

Surgical interventions such as perforator ligation, endovenous ablation, stripping and combined

venous procedures address the primary pathophysiological cause by eliminating reflux pathways. There is increasing evidence that compression alone heals ulcers, but surgery plus compression reduces recurrence more effectively, offering faster recovery and longer ulcer-free intervals.10,11 Meta-reviews published in the last 5 years support the superiority of multimodal therapy, particularly in non-healing and recurrent ulcers.12 Despite this, treatment selection varies widely across institutions due to resource differences, vascular expertise, patient morbidity profile and affordability constraints. Therefore, the present study seeks to address this gap by directly comparing the outcomes of Graduated Compression Therapy with those of surgical intervention accompanied by compression. The study will evaluate ulcer-healing time, recurrence rates, postoperative recovery profile, complication incidence and overall clinical efficacy among patients presenting with venous leg ulcers in a tertiary care centre. Findings from this work are expected to contribute region-specific, practice-oriented evidence, enabling refinement of clinical guidelines, informed resource allocation, improved long-term healing, and ultimately enhanced quality of life for patients affected by venous leg ulcers.

Methodology

The study was carried out in the Department of General Surgery, Shri Sathya Sai Medical College & Research Institute, a tertiary care teaching hospital with dedicated surgical and vascular services for 18 months among 124 subjects. Therapy versus Surgical Intervention combined with compression in the management of venous leg ulcers (VLUs). The study design allowed systematic observation of clinical outcomes without altering routine therapeutic practices, ensuring real-world applicability of findings. Ethical approval was obtained from the Institutional Ethics Committee (IEC). All participants were included only after providing written informed consent in English and Tamil.

Patients presenting with clinically and duplex-confirmed venous leg ulcers (CEAP C5 or C6) to the Department of General Surgery during the study period were screened for eligibility. A consecutive (non-probability) sampling technique was employed, wherein all eligible patients presenting during the study period were considered for inclusion.

Allocation into treatment groups was based on patient willingness to undergo surgical or endovenous intervention after detailed counselling.

All eligible patients were counselled regarding the nature of venous disease, available treatment options, expected benefits, potential risks, and the need for long-term compression therapy.

Patients who consented to undergo surgical or endovenous intervention were assigned to Group B (Surgical/Endovenous Intervention + Compression Therapy).

1. Patients who declined surgical intervention or preferred conservative management were assigned to Group A (Graduated Compression Therapy alone).
2. Participants were categorized into two groups based on their treatment modality:

Group A – Graduated Compression Therapy

Management included:

- Multilayer compression bandaging or Class II–III stockings (30–40 mmHg at ankle),
- Wound care and local dressings according to exudate level,
- Adjunct advice on leg elevation, mobility, and skin care.

Compression served as the principal modality for ulcer healing.

Group B – Surgical Intervention + Compression

- Patients underwent an appropriate surgical/endovenous procedure tailored to duplex findings, including:
- Endovenous Laser Ablation (EVLA),
- Radiofrequency Ablation (RFA),
- Foam sclerotherapy,
- High ligation and stripping,
- Perforator ligation (open or endoscopic).

All surgically treated patients additionally received postoperative compression therapy to optimize hemodynamic correction.

Patients with age between 30 and 80 years, with CEAP C5 or C6 venous ulcer, Duplex Doppler confirming venous incompetence and Ankle–Brachial Pressure Index (ABPI) ≥ 0.8 were included. While patients with active or prior deep vein thrombosis, malignancy, chemotherapy or radiotherapy, bedridden patients, severe cardiac/renal disease, psychiatric illness, ABPI < 0.8 and with multiple ulcers across the body were excluded from the study.

Data Collection Procedure

1. **Recruitment & Consent**

Eligible patients were identified in outpatient and inpatient units; the study objectives and procedures were explained, and written consent obtained.

2. **Baseline Assessment**
   - Structured clinical history using standardized proforma
   - Complete physical examination
   - Venous Doppler ultrasonography
   - ABI measurement to exclude arterial disease
   - Assessment of ulcer characteristics (size, duration, number, location)
3. **Treatment Administration**

- Group allocation based on clinical need and duplex findings
- Standardized compression protocol for all patients
- Surgical intervention performed under appropriate anesthesia when indicated

4. Follow-up Schedule

Follow-up visits were conducted at 2, 4, 8 and 12 weeks, and thereafter every 3 months until study completion.

At each visit the following were documented:

- Ulcer size (cm^2) and healing status
- VCSS scoring
- CEAP classification (progression/regression)
- CIVIQ-20 Quality-of-Life Score (at major intervals)
- Presence of complications (infection, cellulitis, postoperative issues)
- Compliance with compression therapy

Statistical Analysis

- All collected data were entered into Microsoft Excel.
- Data were analyzed using IBM SPSS Version 24.
- Descriptive statistics (mean, SD, percentages) were used to summarize baseline characteristics.
- Chi-square test was applied to categorical variables to test significance (df = 1; significance at $p < 0.05$).
- Independent t-test / Mann–Whitney U test was used for continuous variables.
- Repeated-measure parameters (VCSS, ulcer area) were analyzed using RM-ANOVA when applicable.

Results

Table 1 present the baseline socio-demographic and anthropometric characteristics of the study participants in Group 1 (compression only) and Group 2 (surgery + compression). Across all variables—including age distribution, sex, occupational classification, prolonged standing, and BMI categories—the descriptive profiles of the two groups were broadly comparable, and none of the Chi-square tests demonstrated statistical significance. This establishes a well-balanced baseline between the groups before intervention

Table 1. Baseline Sociodemographic and Anthropometric Characteristics between the two groups (n = 124)

Variable	Category	Group 1(n = 62) n (%)	Group 2(n = 62) n (%)	Chi-square (χ^2)	p-value†
Age group (years)	30–39	9 (14.5)	2 (3.2)	5.06	0.16
	40–49	10 (16.1)	10 (16.1)		
	50–59	15 (24.2)	16 (25.8)		
	60–69	28 (45.2)	34 (54.8)		
Sex	Male	37 (59.7)	44 (71.0)	1.74	0.18
	Female	25 (40.3)	18 (29.0)		
Occupation (grouped)	Sedentary / low activity / non-working	10 (16.1)	17 (27.4)	2.74	0.25
	Moderate standing activity	12 (19.4)	13 (21.0)		
	Long-standing occupation	40 (64.5)	32 (51.6)		
Prolonged standing	No	13 (21.0)	14 (22.6)	0.04	0.82
	Yes	49 (79.0)	48 (77.4)		
BMI category	Normal	7 (11.3)	6 (9.7)	0.17	0.98
	Overweight	8 (12.9)	8 (12.9)		
	Obese Class I (at risk)	30 (48.4)	32 (51.6)		
	Obese Class II	17 (27.4)	16 (25.8)		

†Chi-square test.

Table 2. Distribution of Comorbidities, Lifestyle Factors, and Past Venous Disease Between Groups

Variable	Category	Group 1 (n=62) n (%)	Group 2 (n=62) n (%)	χ^2 value	p-value†

Hypertension	No	30 (48.4)	37 (59.7)	1.59	0.21
	Yes	32 (51.6)	25 (40.3)		
Diabetes Mellitus	No	40 (64.5)	37 (59.7)	0.31	0.58
	Yes	22 (35.5)	25 (40.3)		
Self-reported Obesity	No	45 (72.6)	46 (74.2)	0.04	0.84
	Yes	17 (27.4)	16 (25.8)		
Smoking	No	51 (82.3)	43 (69.4)	2.81	0.09
	Yes	11 (17.7)	19 (30.6)		
Alcohol Consumption	No	43 (69.4)	41 (66.1)	0.15	0.70
	Yes	19 (30.6)	21 (33.9)		
Prior DVT	No	58 (93.5)	54 (87.1)	1.48	0.22
	Yes	4 (6.5)	8 (12.9)		
IVC Filter History	No	58 (93.5)	61 (98.4)	1.88	0.17
	Yes	4 (6.5)	1 (1.6)		
Surgery Done (previous venous procedure)	No	50 (80.6)	52 (83.9)	1.04	0.90
	Yes	12 (19.4)	10 (16.1)		
Family History of Varicose Veins	No	50 (80.6)	51 (82.3)	0.05	0.82
	Yes	12 (19.4)	11 (17.7)		
Mobility Limitation	No	32 (51.6)	28 (45.2)	0.52	0.47
	Yes	30 (48.4)	34 (54.8)		
Previous Compression Use	No	41 (66.1)	40 (64.5)	0.04	0.85
	Yes	21 (33.9)	22 (35.5)		
History of Recurrent Ulcer	No	52 (83.9)	47 (75.8)	1.25	0.26
	Yes	10 (16.1)	15 (24.2)		

Table 3. Comparison of CEAP Classification and Duplex Ultrasound Reflux Characteristics Between Groups (n = 124)

Variable	Category	Group 1 (n = 62) n (%)	Group 2 (n = 62) n (%)	χ^2 value	p-value†
CEAP Clinical Class	C5	40 (64.5)	32 (51.6)	2.12	0.15
	C6	22 (35.5)	30 (48.4)		
Laterality	Right	30 (48.4)	28 (45.2)	0.89	0.64
	Left	23 (37.1)	21 (33.9)		
	Bilateral	9 (14.5)	13 (21.0)		
SFJ Reflux	No	14 (22.6)	16 (25.8)	0.18	0.68
	Yes	48 (77.4)	46 (74.2)		
SPJ Reflux	No	35 (56.5)	37 (59.7)	0.13	0.72
	Yes	27 (43.5)	25 (40.3)		
GSV Reflux	No	14 (22.6)	16 (25.8)	0.18	0.68
	Yes	48 (77.4)	46 (74.2)		
SSV Reflux	No	40 (64.5)	35 (56.5)	0.84	0.36

	Yes	22 (35.5)	27 (43.5)		
Perforator Incompetence	No	28 (45.2)	26 (41.9)	0.13	0.72
	Yes	34 (54.8)	36 (58.1)		
Deep Venous Reflux	No	47 (75.8)	49 (79.0)	0.19	0.67
	Yes	15 (24.2)	13 (21.0)		

Table 4. Baseline ABPI, Pain Severity, QoL Scores, and VCSS Distribution Between Groups

Variable	Category / Grading	Frequency (n)	Percentage (%)
ABPI – Right	0.80 – 0.89	31	25.0
	0.90 – 0.99	41	33.1
	1.00 – 1.09	41	33.1
	1.10 – 1.20	11	8.9
ABPI – Left	0.80 – 0.89	23	18.5
	0.90 – 0.99	36	29.0
	1.00 – 1.09	44	35.5
	1.10 – 1.20	21	17.0
VAS Pain Score	4–6 (Moderate Pain)	37	29.8
	7–10 (Severe Pain)	87	70.2
Study Group Distribution	Group 1	62	50.0
	Group 2	62	50.0
CIVIQ-20 QoL Impairment Grade	Mild (21–40%)	1	0.8
	Moderate (41–60%)	35	28.2
	Severe (61–80%)	81	65.3
	Very Severe (>80%)	7	5.6
VCSS Severity Classification	Mild (5–9)	1	0.8
	Moderate (10–14)	41	33.1
	Severe (15–20)	72	58.1
	Very Severe (>20)	10	8.1

Table 5. Baseline Intergroup Comparison of Continuous Clinical and Duplex Parameters

Variable	Group 1 (n=62) Mean ± SD / Median (IQR)	Group 2 (n=62) Mean ± SD / Median (IQR)	Test Used	Test Statistic	p-value
Baseline CIVIQ-20	66.18 ± 9.26	64.39 ± 10.35	Independent t-test	t = 1.01	0.31
Baseline VCSS Total	15.77 ± 3.15	16.31 ± 3.12	Independent t-test	t = –0.94	0.34
GSV Diameter – SFJ (mm)	7.35 ± 1.62	6.99 ± 1.42	Independent t-test	t = 1.34	0.18
GSV Diameter – Mid-Thigh (mm)	5.56 ± 1.13	5.71 ± 1.03	Independent t-test	t = –0.77	0.44
GSV Diameter – Knee (mm)	4.38 ± 1.04	4.58 ± 1.00	Independent t-test	t = –1.13	0.25
SSV Diameter (mm)	3.98 ± 1.01	4.08 ± 0.97	Independent t-test	t = –0.54	0.58
ABPI Right	Median 0.98 (IQR 0.90 – 1.09)	Median 1.00 (IQR 0.90 – 1.10)	Mann-Whitney U	U = 1738.5, Z = –0.91	0.35

ABPI Left	Median 1.01 (IQR 0.92 – 1.10)	Median 1.01 (IQR 0.92 – 1.10)	Mann-Whitney U	U = 1732.5, Z = –0.94	0.34
Baseline VAS Pain Score	Median 7 (IQR 6–8)	Median 7 (IQR 6–8)	Mann-Whitney U	U = 1856.5, Z = –0.33	0.73

Table 6. Baseline Ulcer Characteristics (Categorical Variables) in Group 1 and Group 2

Ulcer Characteristic	Category	Group 1 n (%)	Group 2 n (%)	Test Used	p-value
Ulcer side	Right	30 (48.4 %)	28 (45.2 %)	χ^2 = 0.88, df = 2	0.64
	Left	23 (37.1 %)	21 (33.9 %)		
	Bilateral	9 (14.5 %)	13 (21.0 %)		
Ulcer location	Gaiter	35 (56.5 %)	35 (56.5 %)	χ^2 = 1.30, df = 3	0.72
	Medial	15 (24.2 %)	19 (30.6 %)		
	Lateral	8 (12.9 %)	5 (8.1 %)		
	Other	4 (6.5 %)	3 (4.8 %)		
Number of ulcers (categorical)	Single (1)	52 (83.9 %)	47 (75.8 %)	χ^2 = 1.25, df = 1	0.26
	Multiple (≥2)	10 (16.1 %)	15 (24.2 %)		
Ulcer depth	Partial thickness	48 (77.4 %)	38 (61.3 %)	χ^2 = 3.79, df = 1	0.05
	Full thickness	14 (22.6 %)	24 (38.7 %)		
Exudate level	None	7 (11.3 %)	3 (4.8 %)	χ^2 = 2.19, df = 3	0.53
	Low	19 (30.6 %)	21 (33.9 %)		
	Moderate	24 (38.7 %)	28 (45.2 %)		
	High	12 (19.4 %)	10 (16.1 %)		
Signs of infection	Absent	43 (69.4 %)	36 (58.1 %)	χ^2 = 1.70, df = 1	0.19
	Present	19 (30.6 %)	26 (41.9 %)		
Periwound dermatitis	Absent	35 (56.5 %)	27 (43.5 %)	χ^2 = 2.06, df = 1	0.15
	Present	27 (43.5 %)	35 (56.5 %)		
Edema grade	0	5 (8.1 %)	5 (8.1 %)	χ^2 = 0.69, df = 3	0.87
	1	16 (25.8 %)	15 (24.2 %)		
	2	28 (45.2 %)	32 (51.6 %)		
	3	13 (21.0 %)	10 (16.1 %)		

Table 6 present the comparison of baseline ulcer characteristics between Group 1 (compression only) and Group 2 (surgery + compression). Overall, the distribution of ulcer-related categorical variables was comparable between the two groups, with no statistically significant differences observed across any parameter (all $p > 0.05$). This indicates that both groups were well-matched with respect to ulcer severity and local wound pathology at the time of enrollment.

Table 7. Baseline Ulcer Dimensions and Duration (Continuous Variables) in Both Groups

Variable	Group 1 (Mean ± SD)	Group 2 (Mean ± SD)	Test Used	p-value
Number of ulcers (continuous)	1.16 ± 0.37	1.24 ± 0.43	t(122) = –1.12	0.267
Ulcer duration (weeks)	16.06 ± 7.39	17.50 ± 7.46	t(122) = –1.08	0.284
Ulcer length (cm)	2.88 ± 1.20	3.09 ± 1.21	t(122) = –0.98	0.330
Ulcer width (cm)	2.10 ± 0.73	2.02 ± 0.85	t(122) = 0.59	0.557

Ulcer area (cm^2)	6.16 ± 3.47	6.01 ± 3.16	t(122) = 0.25	0.800

Table 7 compare the baseline ulcer dimensions and duration between Group 1 (compression only) and Group 2 (surgery + compression). Across all continuous ulcer parameters—including number of ulcers, ulcer duration, length, width, and calculated ulcer area—the differences between the two groups were not statistically significant (all $p > 0.05$). This indicates that both groups were well matched at baseline, ensuring that outcome comparisons in later analyses are not confounded by initial ulcer severity or wound size.

Discussion

The demographic profile of the study population reflects the classical epidemiology of venous leg ulcer disease. Most patients belonged to the 60–69-year age group (45.2% in Group 1 and 54.8% in Group 2), an age at which venous valve degeneration, calf pump dysfunction, and chronic inflammation are more pronounced. 12,13 Male predominance (59.7% in Group 1 and 71.0% in Group 2) and high prevalence of long-standing occupations (64.5% and 51.6%) further support occupational venous overload as a major contributing factor, consistent with global epidemiological trends. 13,14

Obesity was highly prevalent, with nearly three-fourths of patients in both groups classified as obese (BMI ≥25 kg/m^2). Obesity is known to exacerbate venous hypertension, impair calf muscle pump efficiency, and sustain a pro-inflammatory state, thereby delaying ulcer healing. 15,16

Most patients presented with advanced disease. CEAP classification showed that 35.5% of Group 1 and 48.4% of Group 2 had active ulcers (C6), while the remainder were classified as C5. This predominance of C5–C6 disease is consistent with tertiary care presentations, where patients often report late after prolonged conservative or inadequate treatment. 17,18

Duplex ultrasonography revealed a high burden of venous reflux. Great saphenous vein reflux was present in 77.4% of Group 1 and 74.2% of Group 2, while perforator incompetence was identified in 54.8% and 58.1%, respectively. These findings highlight the central role of superficial and perforator reflux in ulcer pathogenesis, as emphasized in contemporary pathophysiological models. 62,72,78 Deep venous reflux, though less frequent (24.2% vs. 21.0%), remains an adverse prognostic factor influencing healing and recurrence.19

Baseline clinical severity was high in both groups. Mean VCSS scores were 15.77 ± 3.15 in Group 1 and 16.31 ± 3.12 in Group 2, with over 90% of patients classified as moderate to severe disease. These values are comparable to those reported in modern VLU cohorts and confirm that the study population represented clinically significant disease.20

Pain and quality-of-life impairment were substantial. Severe pain (VAS 7–10) was reported by 70.2% of patients, while 65.3% demonstrated severe QoL impairment on the CIVIQ-20 scale. Mean baseline CIVIQ-20 scores exceeded 64 in both groups, reflecting marked physical limitation, psychological distress, and social dysfunction. These findings mirror earlier studies documenting the profound impact of venous ulcers on patient well-being and daily functioning.21

Most patients had a single ulcer; however, 16.1% in Group 1 and 24.2% in Group 2 had multiple ulcers, which is known to be associated with slower healing and higher recurrence rates.19

Multilayer compression systems were used in 100% of surgically treated patients, compared to 67.7% in the compression-only group, where 32.3% used Class II stockings. While target pressures were similar, Class III compression (34–46 mmHg) was achieved in 62.9% of Group 2, compared to 37.1% of Group 1 ($p = 0.01$). Higher effective compression pressures are known to correlate with improved healing and reduced recurrence. 22,23

Expected daily compression wear of ≥11 hours/day was documented in 93.5% of Group 2, compared to 61.3% of Group 1 ($p < 0.001$). Poor adherence to compression has been repeatedly identified as one of the strongest predictors of delayed healing and recurrence. 24

Conclusion

surgery combined with compression is a more effective therapeutic strategy than compression alone for achieving durable healing and improving quality of life in patients with venous leg ulcers. The results of this study support integrating early evaluation for surgical suitability into routine VLU management pathways in tertiary care settings. Implementing such evidence-based, multimodal treatment approaches can significantly reduce disease burden, recurrence, and long-term morbidity among affected patients.

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