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Clinical Outcomes of Venous Leg Ulcers Treated with Four-Layer Compression Bandage: A Prospective Study from a Tertiary Care Centre

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ABSTRACT

Background: Venous leg ulcer is the most severe manifestation of chronic venous disease and is associated with delayed healing, high recurrence and significant impairment of quality of life. Multicomponent compression systems are the cornerstone of management, and the four-layer compression bandage is widely used, but Indian prospective data remain limited.

Aim: To study the clinical outcome of patients with venous ulcer treated with a four-layer compression bandage in a tertiary care setting.

Methods: This observational prospective study was conducted in the Department of General Surgery of a tertiary care medical college and hospital from May 2020 to December 2021 (18 months). Thirty consecutive adult patients (>18 years) with clinically and duplex-confirmed venous disease presenting with venous leg ulcers and fulfilling predefined inclusion and exclusion criteria were enrolled. All patients underwent standard clinical assessment, bedside venous tests (Brodie–Trendelenburg, multiple tourniquet, modified Perthes), and arterial/venous Doppler evaluation. A standard four-layer compression bandage protocol was applied, and patients were followed up clinically. Ulcer characteristics (size, edge, bed, discharge), limb edema and early response at day 4 were recorded, along with subsequent progress until healing or last follow-up.

Results: A total of 30 patients with venous leg ulcers received four-layer compression bandaging. On assessment at day 4, 28 (93.3%) ulcers had developed healthy granulation tissue over the ulcer bed, 30 (100%) retained a sloping edge, 22 (73.3%) showed reduced or absent discharge, 23 (76.7%) demonstrated reduction in ulcer size, and 22 (73.3%) had significant reduction in limb swelling. No serious bandage-related complications were recorded during the early follow-up period. [To be updated with mean age, sex distribution, mean ulcer duration and overall time to complete healing based on thesis tables].

Conclusion: Four-layer compression bandage therapy provides favourable early clinical outcomes in patients with venous leg ulcers, with rapid improvement in ulcer bed granulation, reduction in exudate, size and limb edema. These findings support the routine use of multicomponent four-layer compression systems as a simple, effective and well-tolerated modality in the management of venous leg ulcers in resource-constrained tertiary care settings. Larger studies with longer follow-up are needed to confirm healing rates and recurrence outcomes.

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INTRODUCTION

Chronic venous disease (CVD) of the lower limb is a common condition worldwide and encompasses a spectrum ranging from telangiectasia and varicose veins to edema, skin changes and venous leg ulceration. Venous leg ulcer represents the most severe clinical stage of CVD and is associated with prolonged morbidity, loss of productivity, high treatment costs and substantial impact on quality of life for affected patients.

The pathophysiology of venous leg ulcer involves sustained ambulatory venous hypertension due to valvular incompetence, obstruction or a combination of both. Persistent venous hypertension leads to microcirculatory changes, leukocyte activation, inflammatory mediator release, fibrin cuff formation and eventual breakdown of the skin and subcutaneous tissues, culminating in chronic ulceration. Management aims to correct the underlying hemodynamic abnormality and to promote ulcer healing while preventing recurrence.

Compression therapy is universally regarded as the cornerstone of conservative management of venous leg ulcers. By reducing venous hypertension, improving venous return and enhancing microcirculatory flow, compression bandaging facilitates edema reduction and ulcer healing. Various compression systems are available, including single-layer elastic bandages, short-stretch bandages, Unna's boot and multicomponent systems. Among these, four-layer compression bandage systems have gained wide acceptance because they provide sustained graduated compression, accommodate limb shape, and require relatively infrequent changes.

Randomized trials from Western populations have shown that multicomponent high-compression systems, particularly four-layer bandages, achieve superior healing rates compared with single-component systems or less intensive compression. However, published Indian data on the use of four-layer compression bandage in venous leg ulcers remain limited, and local factors such as climate, skin characteristics, patient compliance and resource constraints may influence outcomes.

The present prospective observational study was undertaken at a tertiary care teaching hospital to evaluate the clinical outcome of venous leg ulcers treated with a standardized four-layer compression bandage protocol. Early changes in ulcer bed, size, discharge and limb edema, as well as overall progress during follow-up, were assessed with the aim of generating local data to support evidence-based use of multicomponent compression therapy in our setting.

MATERIALS AND METHODS

Study design and setting

This was an observational prospective study conducted in the Department of General Surgery at a tertiary care medical college and hospital. The study period extended from May 2020 to December 2021 (18 months). All eligible patients presenting to the surgical outpatient department or wards with features of chronic venous disease and venous leg ulcer were evaluated for inclusion.

Study population

Adult patients aged more than 18 years with clinically and duplex-confirmed venous disease presenting with venous leg ulcer were considered for enrolment. Clinical evaluation included a detailed history and physical examination with documentation of symptoms, duration of ulcer, limb edema, skin changes and presence of varicose veins. Bedside venous tests including Brodie–Trendelenburg test, multiple tourniquet test and modified Perthes test were performed where appropriate to assess superficial, perforator and deep venous involvement.

Inclusion criteria were: (i) age >18 years, (ii) presence of venous leg ulcer in the gaiter area of the lower limb with clinical features suggestive of chronic venous insufficiency, and (iii) duplex Doppler evidence of superficial or perforator venous incompetence with or without deep venous involvement, as defined in the original thesis protocol. Exclusion criteria included: (i) active or previous deep vein thrombosis, (ii) superficial thrombophlebitis, (iii) pregnancy, (iv) arterial, diabetic, traumatic or vasculitic ulcers, (v) isolated telangiectasia or reticular veins without ulceration, and (vi) patients unwilling or unable to comply with compression therapy.

All patients underwent arterial and venous Doppler ultrasound of the affected limb to document reflux, obstruction and arterial perfusion. The extent of superficial, perforator and deep venous involvement was recorded. Ankle–brachial pressure index was measured where indicated to exclude significant arterial disease before applying high compression.

Four-layer compression bandage protocol

After appropriate wound cleansing, debridement if necessary and application of a suitable primary dressing over the ulcer, a standardized four-layer compression bandage system was applied to the affected limb. The protocol followed in the thesis comprised: (i) an orthopaedic wool padding layer to equalize limb shape and protect bony prominences, (ii) a crepe bandage layer to provide light compression, (iii) an elastic bandage layer to generate graduated compression from ankle to calf, and (iv) an outer cohesive bandage layer to secure the system and maintain compression. Bandages were applied in a spiral or figure-of-eight fashion with approximately 50% overlap, ensuring maximal pressure at the ankle progressively decreasing towards the knee.

Bandages were generally left in place for several days unless soiling, slippage or patient discomfort mandated earlier change. Patients were counselled regarding leg elevation, ankle exercises, avoidance of prolonged standing and adherence to follow-up.

Outcome measures and follow-up

Baseline ulcer characteristics including location, size (maximum length and width), edge, floor, presence and type of discharge, surrounding skin changes and limb edema were recorded at enrolment. Early response to compression was assessed on day 4 following application of the four-layer bandage. Parameters evaluated at day 4 included: (i) presence of healthy granulation tissue in the ulcer bed, (ii) persistence of a sloping edge, (iii) reduction or absence of ulcer discharge, (iv) reduction in ulcer dimensions, and (v) improvement in limb swelling.

Patients were subsequently followed up at regular intervals in the outpatient department. At each visit, progress of healing, change in ulcer size and appearance, patient-reported symptoms and any complications related to compression (such as pain, bandage intolerance, skin maceration, pressure damage or ischemic changes) were documented. Overall time to complete healing and recurrence, where available, were noted. [Details of exact follow-up schedule and healing definitions may be inserted here as per thesis protocol].

Statistical analysis

Data were entered into a spreadsheet and analysed using standard statistical software. Categorical variables such as presence of granulation tissue, reduction in discharge, size reduction and limb swelling were expressed as frequencies and percentages. Continuous variables such as age and ulcer size were summarised as mean ± standard deviation or median with range, as appropriate. Given the descriptive nature and modest sample size, emphasis was placed on descriptive statistics. Where applicable, comparisons were made using chi-square or Fisher's exact test for categorical variables and t-test or non-parametric tests for continuous variables, with a p-value <0.05 considered statistically significant.

Ethical considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Institutional ethics

committee approval was obtained prior to commencement of the study, and written informed consent was taken from all participants before enrolment.

RESULTS

Baseline characteristics

A total of 30 patients with venous leg ulcer were included in the study during the 18-month period. The mean age of the cohort was [mean age ± SD] years with a slight predominance of [male/female] patients ([percentage]%). The majority of ulcers were located in the gaiter region of the lower leg, most commonly around the medial malleolus. The mean duration of ulcer prior to presentation was [value] months. Many patients had associated features of chronic venous insufficiency such as limb edema, hyperpigmentation and lipodermatosclerosis.

Duplex ultrasound demonstrated superficial venous reflux involving the great saphenous vein, small saphenous vein and/or incompetent perforators in the majority of cases, with or without deep venous involvement as detailed in the original thesis tables. Significant arterial disease was excluded before initiation of high-compression therapy.

Early response to four-layer compression bandage

Early clinical response was assessed on day 4 following application of the four-layer compression bandage. Of the 30 ulcers, 28 (93.3%) demonstrated healthy granulation tissue formation over the ulcer bed, indicating early progression towards healing. All 30 ulcers (100%) retained a sloping edge, suggesting a favourable healing margin. Reduction or absence of ulcer discharge was observed in 22 patients (73.3%), while 23 patients (76.7%) showed measurable reduction in ulcer size compared with baseline. Limb swelling was significantly reduced in 22 patients (73.3%) at day 4.

No major bandage-related complications such as ischemia, severe pain, blistering or pressure necrosis were recorded during the early follow-up period. Minor complaints, including discomfort and pruritus under the bandage, were managed conservatively by reassurance, adjustment of padding and topical agents.

Progress during follow-up

Patients were followed up in the outpatient department at regular intervals until ulcer healing or last contact. [Insert here summary statistics for median time to complete ulcer healing, proportion of ulcers healed by 6 and 12 weeks, and any observed recurrence, based on thesis data.] Overall, the majority of ulcers demonstrated progressive reduction in size and improvement in surrounding skin changes over successive visits under continued four-layer compression therapy.

Tables summarising baseline patient characteristics, ulcer characteristics and early response outcomes can be constructed directly from the thesis master chart for inclusion in the final version of the article.

DISCUSSION

The present prospective study evaluated early clinical outcomes in 30 patients with venous leg ulcers treated using a standardized four-layer compression bandage protocol at a tertiary care centre. The findings demonstrate that four-layer compression produced rapid favourable changes in ulcer bed, size and limb edema, with more than 90% of ulcers showing healthy granulation tissue and nearly three-quarters of patients experiencing reduction in discharge and swelling within the first four days of therapy.

Compression therapy is widely recognised as the mainstay of conservative management for venous leg ulcers. High-compression multicomponent systems, particularly four-layer bandaging, have been shown in randomised controlled trials to achieve superior healing rates compared with single-layer or low-compression regimens. Our observations are consistent with this body of evidence, supporting the use of multicomponent high compression to rapidly reduce venous hypertension, improve microcirculation and create an optimal environment for ulcer healing.

Several landmark studies have reported healing rates of 55–70% at 12 weeks and up to 80% at 24 weeks with four-layer compression bandages in Western populations. Although the present study was not powered or designed to provide precise estimates of overall healing rates, the early response indicators observed—high proportion of ulcers developing healthy granulation and reduction in exudate and edema—suggest that similar healing trajectories may be achievable in our patient population under appropriate follow-up. The absence of serious bandage-related complications in this series also reinforces the safety and tolerability of the four-layer system when applied correctly and with due attention to arterial status.

Indian data on multicomponent compression therapy for venous leg ulcers remain relatively sparse. Factors such as hot and humid climate, socioeconomic constraints, occupational demands and variable patient compliance can influence the effectiveness of compression-based strategies. Our study adds to the limited local evidence by demonstrating that, even in a resource-constrained public sector setting, four-layer compression bandage can be successfully implemented with good short-term outcomes and acceptable tolerability.

The strengths of this study include its prospective design, uniform application of a standardised four-layer compression protocol and systematic documentation of early clinical response parameters. However, several limitations must be acknowledged. The sample size was modest, and there was no comparison group treated with alternative compression systems or without high compression, which precludes direct inference on relative efficacy. Follow-up duration and completeness may have been limited by logistical constraints and patient socioeconomic factors, potentially affecting the accuracy of long-term healing and recurrence

estimates. In addition, detailed quality-of-life measures and validated venous disease scoring systems were not systematically applied.

Despite these limitations, the present findings have important practical implications. They support the routine use of four-layer compression bandage as a simple, cost-effective and clinically effective modality for the management of venous leg ulcers in similar tertiary-care environments. Wider dissemination of training in correct bandaging technique, careful patient selection to exclude significant arterial disease, and structured patient education to enhance compliance are essential to maximise the benefits of this therapy.

Future research from our region should focus on larger, possibly multicentric studies comparing different compression systems, integrating objective hemodynamic parameters and patient-reported outcomes, and evaluating strategies to improve long-term adherence and reduce recurrence. Such data will further refine local guidelines for comprehensive management of chronic venous disease and venous leg ulcers.

CONCLUSION

Four-layer compression bandage therapy resulted in favourable early clinical outcomes in this prospective series of patients with venous leg ulcers, with rapid development of healthy granulation tissue, reduction in ulcer discharge and size, and improvement in limb edema. The technique was safe and well tolerated in appropriately selected patients. These findings support the use of multicomponent four-layer compression as a cornerstone of venous ulcer management in resource-constrained tertiary care settings. Larger comparative studies with longer follow-up are warranted to better define healing rates, recurrence patterns and long-term patient-reported outcomes.

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