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Compression therapy: revolutionizing venous ulcer care with precision and innovation

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Abstract

Compression therapy is a cornerstone in the management of Venous Leg Ulcers (VLU), promoting healing, reducing edema, and preventing recurrences. Despite its proven efficacy, patient adherence remains a critical challenge due to discomfort and application complexity. Recent innovations, including custom-fit compression garments and smart devices, are improving both clinical outcomes and patient compliance. This editorial explores the current evidence supporting compression therapy, the barriers to its effective use, and the future potential of personalized care through advanced technologies. Compression therapy remains a cost-effective and essential treatment for chronic venous disease.

Key words: compression therapy, venous leg ulcers, patient adherence, personalized care, chronic venous disease.

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Introduction

Venous Leg Ulcers (VLU) are chronic conditions that not only deteriorate patients' quality of life but also place a significant economic burden on healthcare systems due to prolonged healing, high recurrence rates, and extensive treatment costs. Compression therapy is considered the gold standard in managing these ulcers, demonstrating robust clinical efficacy in promoting tissue healing and preventing recurrences. This editorial examines the current evidence supporting compression therapy, challenges related to patient adherence, and future perspectives on enhancing treatment outcomes through technological innovation.

Clinical efficacy of compression therapy

Compression therapy is a cornerstone in the management of Chronic Venous Disease (CVD) and its most severe manifestation, venous ulcers. The physiological basis of compression therapy lies in its ability to reduce venous hypertension, enhance venous return, decrease edema, and improve tissue perfusion. These effects are achieved through the application of external pressure, which counters the increased venous pressure and reduces blood pooling in the legs.

Systematic reviews and Randomized Controlled Trials (RCTs) have consistently demonstrated that compression therapy accelerates the healing process of VLUs. A meta-analysis by Chunhu Shi *et al.* (2021)[1] reported that patients undergoing compression therapy had significantly faster healing times, with a higher proportion of ulcers closing within a 12-week observation period compared to those receiving no compression. Additionally, studies such as that by Samantha Haynes *et al.* (2022)[2] confirm that Compression Strapping (CS) not only promotes wound healing in patients with retromalleolar ulcers but also reduces pain and improves overall quality of life.

The effectiveness of compression therapy is not solely dependent on the type of compression applied, but also on patient adherence, which plays a crucial role in determining clinical outcomes. While various compression devices are available – including elastic and inelastic bandages, compression stockings, and intermittent pneumatic compression – ensuring consistent and correct use remains a primary challenge. Studies have shown that personalized compression strategies, tailored to the individual patient's anatomical and clinical characteristics, can further enhance therapeutic outcomes.

Challenges of patient adherence to compression therapy

Despite the proven efficacy of compression therapy, patient adherence remains a significant barrier to achieving optimal outcomes. Factors contributing to poor adherence include the discomfort associated with prolonged use of compression garments, the complexity of application, and the lack of proper patient education. For many patients, the sensation of tightness and discomfort when wearing compression stockings or bandages can lead to inconsistent use or early discontinuation, compromising the therapeutic

benefits. A study by Amoura Soliman Behairy *et al.* (2022)[3] highlights that targeted nursing education can significantly improve adherence to compression therapy. Patients who received structured education on the importance of compression and proper techniques for donning and doffing the garments showed improved compliance, leading to a reduced rate of ulcer recurrence. Similarly, Carolina D. Weller *et al.* (2021)[4] found that understanding patient experiences and barriers to adherence is crucial in developing more effective, patient-centered care strategies.

Additionally, factors such as age, mobility, and comorbidities can affect adherence. Elderly patients with limited dexterity or strength may struggle to properly apply compression garments, underscoring the need for innovations in garment design that are easier to use. Buset *et al.* (2021)[5] demonstrated that two-layer compression stockings designed for easier application were not only more comfortable for patients but also as effective as standard stockings in reducing edema and preventing ulcer recurrence.

Cost-effectiveness of compression therapy

From an economic perspective, compression therapy represents a cost-effective intervention for the management of VLUs. Elisabeth Webb *et al.* (2023)[6] conducted a cost-analysis study demonstrating that compression therapy significantly reduces the recurrence of cellulitis in patients with chronic leg edema. The study found that the reduction in hospital admissions, emergency care visits, and antibiotic use offset the costs of providing compression garments, resulting in substantial healthcare savings.

Moreover, the prevention of ulcer recurrence through consistent use of compression therapy not only alleviates the physical and emotional burden on patients but also decreases the long-term healthcare costs associated with chronic wound care. Compression therapy proves to be an economically sound option for both patients and healthcare providers by reducing complications such as infection and the need for advanced wound care products.

Innovations in compression therapy: the future of personalized care

Emerging technologies are transforming compression therapy, not only by enhancing efficacy but also by directly addressing the major challenge of patient adherence. Innovations such as customized compression garments, real-time pressure monitoring, and AI-assisted therapy adjustments are shifting the focus toward personalized treatment strategies that can optimize patient compliance and long-term outcomes. One promising development is the integration of 3D scanning and computational modeling in the design of custom-fit compression garments. A novel study by Yu Shi *et al.* (2024)[7] introduced an optimization approach for creating therapeutic stockings based on individual leg morphology. By using 3D scanning to generate precise models of a patient's legs, compression garments can be tailored to provide optimal pressure distribution, enhancing both comfort and therapeutic effectiveness.[8]

Additionally, there is growing interest in the development of "smart" compression devices equipped with sensors to monitor pressure levels and ensure the correct application of compression. These devices could provide real-time feedback to both patients and clinicians, helping to maintain consistent pressure levels and reduce the risk of incorrect application, which is a common issue with traditional bandaging techniques.

The role of Artificial Intelligence (AI) in compression therapy is another area of exploration. AI algorithms could analyze large datasets to predict which compression strategies would be most effective for individual patients, taking into account variables such as skin integrity, venous pressure, and mobility. This data-driven approach could revolutionize how clinicians prescribe compression therapy, making treatment plans more personalized and adaptive to each patient's evolving condition.

Conclusions

Compression therapy remains the cornerstone of venous ulcer management, with strong evidence supporting its role in accelerating wound healing, reducing edema, and preventing recurrences. However, clinical success is not solely dependent on compression itself, but rather on a multifaceted approach that includes patient education, adherence strategies, and technological innovation. However, the success of compression therapy hinges on patient adherence, the correct application of compression garments, and the personalization of treatment plans based on individual patient needs.[8-12] Future innovations in compression therapy, including custom-fit garments and smart devices, hold the potential to improve both clinical outcomes and patient compliance. As the field continues to evolve, the integration of new technologies and the development of more patient-centered care strategies will be key to maximizing the benefits of compression therapy in managing venous ulcers.

References

1. Shi C, Dumville JC, Cullum N, et al. Compression bandages or stockings versus no compression for treating venous leg ulcers. Cochrane Database Syst Rev 2021;7:CD013397.
2. Haynes S, Holloway S. A service evaluation to examine the use of compression strapping for the management of patients with retromalleolar leg ulcers in a specialist community setting. Int Wound J 2022;19:1232-42.
3. Behairy AS, Masry SE. Impact of educational nursing intervention on compression therapy adherence and recurrence of venous leg ulcers: a quasi-experimental study. Ocul Oncol Pathol 2022;8:120-32.
4. Weller CD, Richards C, Turnour L, Team V. Patient explanation of adherence and non-adherence to venous leg ulcer treatment: a qualitative study. Front Pharmacol 2021;12:663570.
5. Buset CS, Fleischer J, Kluge R, et al. Compression stocking with 100% donning and doffing success: an open label randomised controlled trial. Eur J Vasc Endovasc Surg 2021;61:137-44.
6. Webb E, Bissett B, Neeman T, et al. Compression therapy is cost-saving in the prevention of lower limb recurrent cellulitis in patients with chronic edema. Lymphat Res Biol 2023;21:160-8.
7. Shi Y, Liu R, Ye C. Personalized compression therapeutic textiles: digital design, development, and biomechanical evaluation. Front Bioeng Biotechnol 2024;12:1405576.
8. Marsocci A, Santandrea S, Lanfranchi E, et al. Beyond water: 3D laser scanning offers a cutting-edge alternative for upper limb volume assessment. Phlebology 2024;2024:26835 55241310358.
9. De Michele M, Mastrullo M, Melotto G, Tedeschi R. Phlebological insole: can it help in the lymphoedema treatment? A scoping review. Phlebology 2023;38:300-6.
10. Freguia S, Platano D, Donati D, et al. Closing the gaps: an integrative review of yoga's benefits for lymphedema in breast

cancer survivors. Life (Basel) 2024;14:999.
11. Tedeschi R. Biomechanical alterations in lower limb lymphedema: implications for walking ability and rehabilitation. Phlebology 2023;38:496-502.
12. Santandrea S, Benassi M, Tedeschi R. Comparison of short-stretch bandage and long-stretch bandage for post-traumatic hand edema. Int J Surg Case Rep 2023;111: 108854.

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