Good-bye slippage - a new fusion to tackle bandage slippage on the foot

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Introduction

Compression therapy with bandages and stockings is the cornerstone and golden standard in the prevention and treatment of chronic venous leg diseases.[1] A common problem related to compression treatment with bandages is slippage at and around the foot and heel. *Stiff* bandages in particular tend to cause slippage due to reduction in limb size during compression treatment, and the inherent inability of the material to recover post-stretch.[2] Bandage slippage can create local high-pressure areas that may cause tissue damage and even necrosis.[3] The use of stockings can often reduce this risk of slippage.[4,5] Moreover, stockings are typically less bulky, help to preserve ankle range of motion, and permit patients to wear normal footwear. However, stockings can be tricky to don, especially when ulcers are involved. An optimal solution for indications that are best treated with bandages on lower extremities seems to be a compression sock on the foot and a bandage on the leg. The transition from sock to bandage, however, must be seamless in order to provide proper compression treatment. Furthermore, the combination needs to be easy to apply, and the transition from sock to bandage must not create local high- or low-pressure zones on the ankle. In order to control pressure at the transition, both the sock and bandage need to have well-defined pressures, which cannot be affected by the applier's experience or the patient's leg size or shape. The need for consistency in contact pressure rules out traditional bandages as they are prone to exert extreme variations in applied pressure.[6-9]

Aim

To find a compression sock-bandage fusion method that provides well-defined pressure on the foot, around the ankle and along the leg.

Materials and Methods

Thirteen healthy subjects (six females, seven males) were enrolled.

Three pressure sensors were placed unilaterally on all subjects (A) on the foot, (B) at the ankle and (C) on the calf (Figure 1A).

A short ankle sock (*Lundatex*® sock, PressCise, Sweden) was applied on the foot, ending just above the malleoli. The sock is designed to provide a pressure of 20 mmHg except for the cuff that is designed to apply only 10 mmHg. The same smart textile technology used in the sock has previously been evaluated in a knee-high stocking.[10] An elastic bandage (*Lundatex*® medical, PressCise, Sweden) with built-in well-defined and controlled pressure[11-13] was wrapped along the leg, starting on the cuff of the sock. By this application approximately 5 cm of bandage covered the cuff (Figure 1B). The bandage is designed to provide 20 mmHg of pressure along the leg, with a 50% overlap (*i.e.*, each bandage layer provides 10 mmHg of pressure). Hence, the first bandage turn applied a pressure of only 10 mmHg on top of the cuff so that the theoretical total pressure equaled 20 mmHg. The bandage was secured to the sock cuff with a MiniLock™ (PressCise, Sweden), a new type of fastening device in a hook-material (Figure 2). The interface pressure from the three sensors was measured with a *Picopress*®[14] in supine and standing neutral positions. The pressure sensor was turned on after application of the sock and bandage. This procedure ensured that the applied pressures were blinded to the applier during application of the compression products. Mann-Whitney U-test was used for comparisons, significance set at $P<0.05$. Correlations are given with Pearson's r.

Results

The sock-bandage fusion method applied a well-defined pressure at the foot, ankle and leg (Table 1). No significant differences in interface pressures were found between locations A, B or C in supine ($P>0.7$) or in standing ($P>0.11$) positions.

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Foot, ankle and leg circumference ranges were 20.5-29 cm, 19.7-29 cm and 23.2-35 cm, respectively.

Low correlation was found between interface pressures from the compression solution and circumference in both supine ($r=0.17$) (Figure 3A) and standing positions ($r=0.29$) (Figure 3B).

Discussion

The presented fusion method of using a short compression sock together with a bandage applied a well-defined pressure without creating high- or low-pressure areas where the compression sock ended and the bandage began. The sock applied 20 mmHg in mean pressure although the sensor placement on the foot occurred in a rather flat location (low curvature). This result is likely due to the pressure-control textile technology used in the sock.

Applied pressures on the leg from the bandage were very consistent with a minimal standard deviation despite the differences in leg sizes among the patients. Furthermore, there was no correlation between leg size and pressure (Figure 3), which demonstrates that the bandage applied correct pressure regardless of leg

Table 1. Interface pressures (mmHg) with standard deviation measured simultaneously with three sensors in supine and standing positions.

	Foot (A)		Ankle (B)		Leg (C)	
	Mean	SD	Mean	SD	Mean	SD
Supine	20	2.9	20	2.4	21	1.6
Standing	20	3.9	21	3.2	22	2.0

size and shape. This feature is unique to the bandage and may improve the safety and effectiveness of the compression treatment it offers. The results were achieved despite the fact that the applier was not using the pressure sensor readings for feedback. Interface pressures are rarely stated in papers on bandage compression treatment.[15] The consistent pressures presented in the current study are in contrast to reports on application of traditional bandages that usually exert extremely variable pressures.[6-9,16,17] The results in the present study confirm previous studies on this special bandage.[11-13]

Interface pressures on the foot and ankle areas were fairly consistent between subjects despite the same sock sample was used on all subjects. This indicates that correct compression is ensured without a need for custom-fitting of the sock.

The fusion method was easy to apply partly due to the patented MiniLock™. The lock secures the initial turn of the bandage without the need for a locking bandage turn first. This may be an important feature to make self-management easier.

The patients' compliance to compression treatment is influenced by factors such as pain, discomfort and bulkiness of the compression garment.[18-20] Furthermore, bulky compression garments over the ankle area may obstruct a normal range of motion, inhibiting the natural venous pumping function of the foot/ankle, hindering the usage of normal footwear, and thereby possibly reducing the patients' ability to keep up with daily exercise. Maintaining daily exercise and a normal gait is key to preserving tissue viability. The proposed fusion solution may not only prevent bandage slippage on the foot, but it may help patients preserve their full ankle range of motion and allow them to wear normal footwear.

Limitations

This fusion method will not be possible with traditional bandages; it requires a bandage with built-in pressure control[11-13] and a sock with assured pressure regardless of foot/ankle size.

Other possible applications of the smart textile sock

The sock could potentially be used separately when a well-defined compression is needed. Layering a sock on top of a bandage-wrapped foot could be an option when higher compression on the foot is desired.

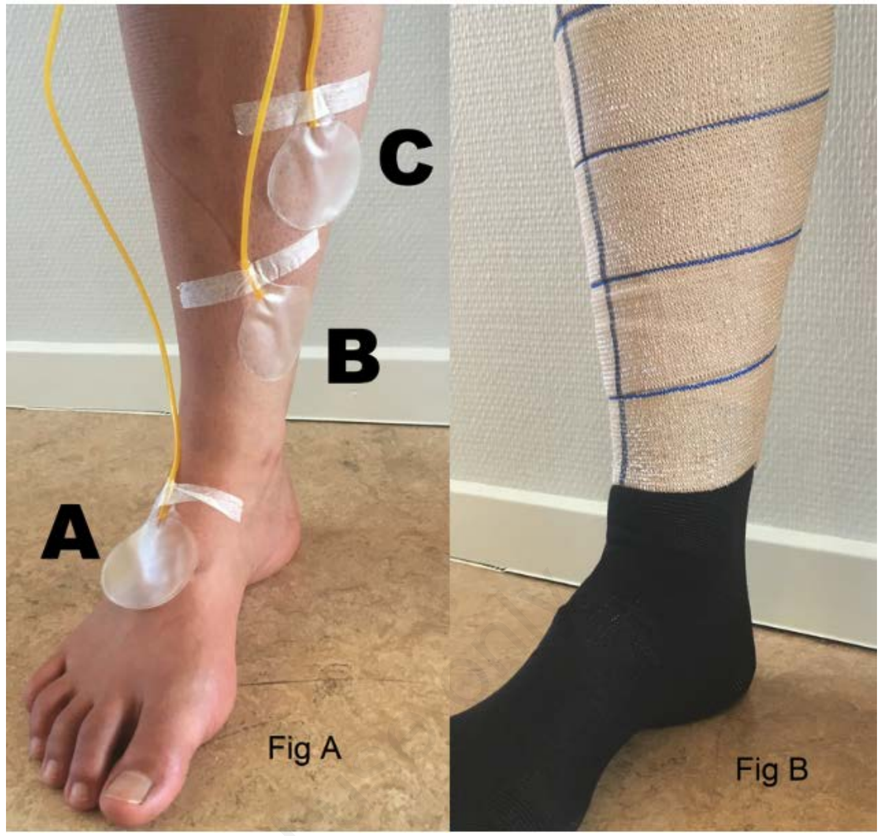

Figure 1. A) Pressure sensor location A, B, and C; and B) sock-bandage fusion method.

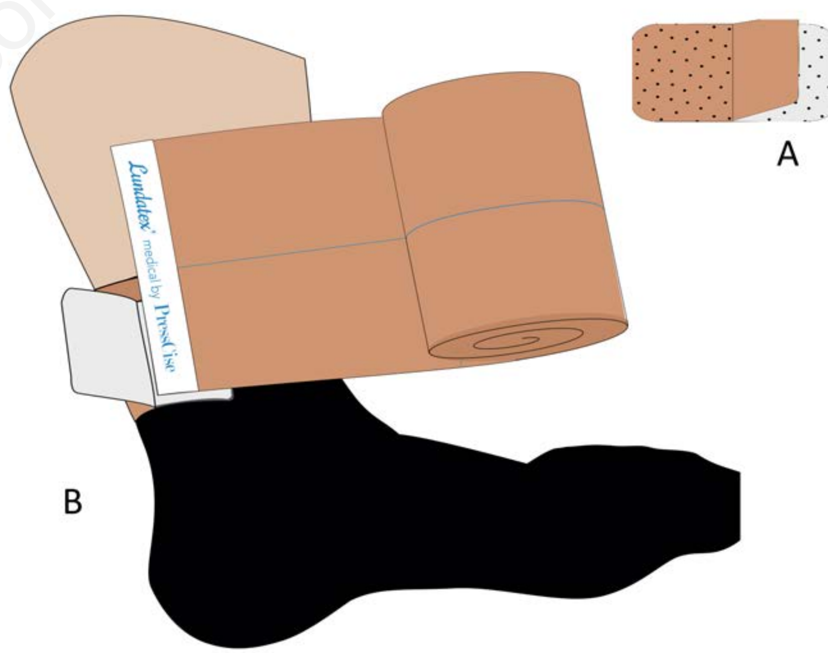

Figure 2. A) The MiniLock, a special fastening device, and B) The transition between sock and bandage using the MiniLock.

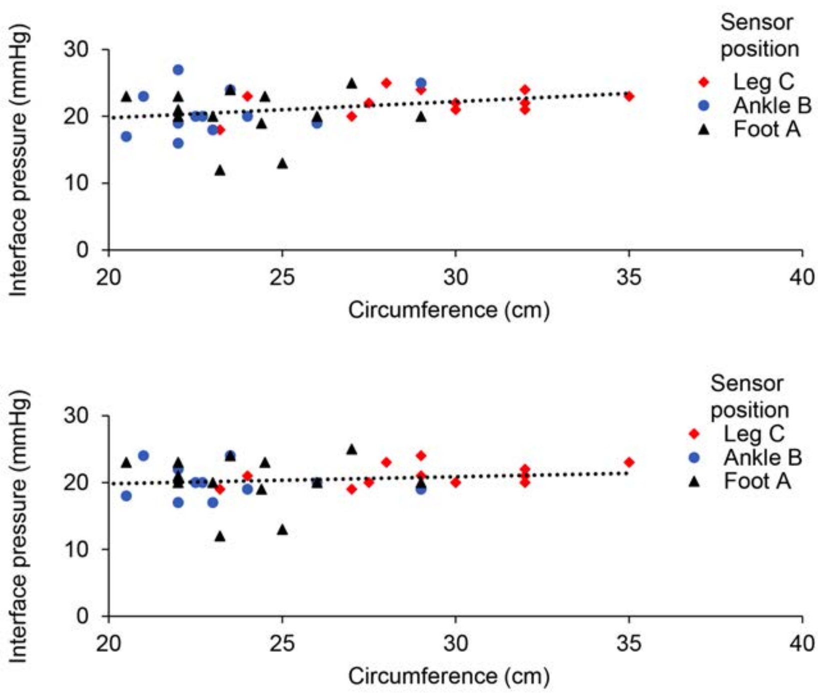

Figure 3. Interface pressures measured simultaneously with three sensors at location A, B, and C showed low correlation to circumference both in supine position (3A) and in standing position (3B).

Conclusions

This solution provides a safe, well-controlled pressure on the foot, around the ankle and along the leg. The sock eliminates bandage slippage on the foot and makes self-management easier. It may also help patients preserve their full ankle range of motion and allow them to wear normal footwear.

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