

Innovation in compression: smart bandage technology to improve bandage application and monitoring

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Introduction

Although high compression delivered by elastic bandages or hosiery is widely accepted as the standard first line care for patients with venous disease but without significant arterial impairment¹⁻⁶ the application of bandages in particular is subject to significant variation. In most cases the interface pressure, effectively the compression *dose*, is not accurately known and is likely to be different from the ideal graduated compression intended on application.^{7,8} Furthermore, as the dimensions of the affected limb change under the influence of external compression, the interface pressure changes (REF).¹ Variability in the application and sustainability of interface pressure is likely to lead to variable clinical efficacy, for example, healing rates. Indeed, the healing rates reported for VLU vary considerably.⁹⁻¹⁹

Technical solutions to variability in application of bandages include printed ovals or rectangles that change to circles or squares at the correct bandage extension; markings on orthostatic devices that are matched to a scale; bandage application at full stretch. Direct measurement of interface



Figure 1. Functional prototype Smart Bandage showing three transducers knitted into a compression bandage.

pressure may be used on application and for monitoring²⁰ but pressure is usually measured at only one anatomic location. Despite these solutions bandage application remains variable, and the application of reduced compression by reduced stretch in the presence of arterial impairment is largely semi-quantitative at best.

A new technology to report interface pressure

Laplace's Law governs the calculation of interface pressure applied by a material on a surface with a circular cross section. The accuracy of Laplace's algorithm is known.²¹ The extension of an elastic material can be measured accurately using strain gauge technology and the tension throughout its range of extension can be measured. The tension value is used with the radius of the surface to derive the interface pressure. This principle has been used to develop a functional prototype smart bandage (SB).

The components of SB are an elastic bandage with the desired stretch properties into which three silver strain gauge transducers are knitted (Figure 1); a connection point at a bandage extremity; digital electronics to detect the transducer output and wirelessly connect to a user interface; a Bluetooth user interface, for example a Smartphone or tablet, with an app that reports the consistency and values of applied pressure in real time. Pressure is calculated using Laplace's Law. The tension in the bandage material is derived from its known properties which are pre-programmed into the electronics. Upon application the bandage extension, from which tension is computed, is reported by the transducer. Limb dimensions are derived by direct measurement of the patient's leg and manually entered via the user interface. As the bandage is applied the system uses its integrated algorithm to show a real-time visual display of the accuracy of application, reporting the interface pressure as an absolute value. A colour-based scale shows yellow when pressure is too low, green when it is as intended, and red when over the target value. The bandager can thereby adjust the extension to achieve target pressure in real time.

At the time of writing, a functional prototype is developed and is subject to a development agreement with a commercial partner. The anticipated benefits of SB include higher quality of bandage application; real-time monitoring of compression in-use; improved healing through greater accuracy in bandage application and main-

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tenance of dose; ability to account accurately for lower compression in patients with significant arterial impairment; washability in re-usable products.

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