THE FUNCTION AND COMPOSITION OF NEXT GENERATION BANDAGES

KEY WORDS

- Compression
- Inelastic bandages
- Elastic bandages
- Sub-bandage pressure
- Components
- Stiffness Index.

In the management of venous and lymphatic disease, the beneficial effect of compression is well recognised. However, the terms 'non-elastic' and 'elastic' need to be reviewed following the introduction of a new generation of bandage systems.

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Compression is the key intervention in the management of venous and lymphatic disease (Lymphoedema Framework, 2006; RCN Institute, 2006). Ongoing innovations in compression systems allow the practitioner to choose from a variety of effective systems to meet the individual requirements of the patient.

The classification of compression systems has been addressed by the International Compression Club (www.icc-compressionclub.com) and bandaging in lymphatic disease has been discussed in the European Wound Management Association (EWMA) Focus Document (EWMA, 2006).

The four properties of compression bandages, known collectively as P-LA-C-E, as suggested by Partsch et al (2006) are:

- Pressure
- Layers
- Components
- Elastic properties.

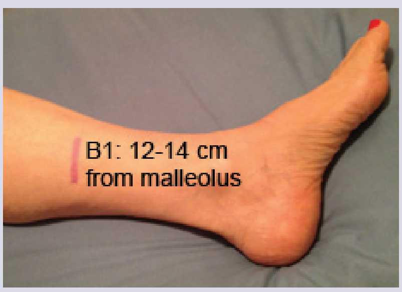

Figure 1: The static-stiffness index (SSI) can be measured at the B1 point of the leg.

A more detailed description of each property is:

- 'Pressure' relates to the level of the compression applied, i.e. mild, moderate, strong or very strong
- 'Layers' refer to the overlapping layers of a bandage when applied, i.e. single layer or multiple layers
- 'Components' of a compression bandage are the different materials used to create it
- 'Elastic' relates to the extensibility of a bandage.

SUB-BANDAGE PRESSURE

Effective compression therapy should provide a balance between exerting too little pressure, which is ineffective, and too much pressure, which causes damage or is not tolerated by the wearer. In venous disease, compression should work on the veins and exert a therapeutic resting pressure and an intermittent high working pressure, i.e. when the calf muscle is active.

With the application of an effective compression bandage system during leg exercise, intermittent pressure peaks act as a massage and allow the superficial and deep leg veins to narrow and expand in rhythm with the exercise pressure. These intermittent pressure peaks also provide pressure in vein segments that do not have full functioning venous valves and this will help to mimic the normal closing action of damaged valves. This effect has been demonstrated using duplex scanning (Partsch and Partsch, 2005) and is beneficial in reducing venous hypertension and oedema.

Venous pressure in the standing position (in both healthy individuals and in patients with venous insufficiency) is about 80–100mmHg in a dorsal foot vein and 50–70mmHg at calf level. In normal individuals this intravenous pressure will fall during walking to around 20mmHg (Partsch, 2006) with normal functioning valves. However, in patients with valvular insufficiency, intermittent refluxes (i.e. backflow) will occur with each step; resulting in constant venous hypertension, which, in turn, results in oedema (Arnoldi, 1966; Clark, 2010).

LAPLACE'S LAW

One of the principles for lower limb compression is derived from Laplace's Law (Thomas, 2002). The lower limb has been compared with a cylindrical object. Laplace stated that, as the radius of a cylindrical object decreases, the resulting pressure increases, i.e. the pressure at the ankle is greater than at the calf (given that the bandage is applied with constant tension and overlap on the leg). Pressure (P) is directly proportional to the bandage tension (T) and inversely proportional to the radius of the leg (R) — ($P=T/r$) (Thomas, 2002; EWMA, 2003).

When applying a bandage, the tension is determined by the amount of force needed to elongate or extend the bandage. For a patient with a skinny leg and, subsequently, a small radius, a lower bandage tension should be considered. For a large, or swollen leg, with a larger radius, a higher tension may be used. Practitioners must be aware that vulnerable areas, such as the tibia or dorsum of the foot, need to be protected and adequate padding has to be applied before bandage use (Beldon, 2006).

LAYERS

When a bandage is applied there is always some degree of overlap. The bandaging technique and the shape of the leg will determine how many layers are applied. If a bandage is applied spirally with a 50% overlap this produces two layers. If applying a multilayer bandage system there will be several layers. Nurses need to be aware that further overlaps may increase sub-bandage pressure. An example of a single-layer application is that of a single compression hosiery.

INELASTIC VERSUS ELASTIC

The terms 'inelastic' and 'elastic' are based on the physical properties of bandages tested in a laboratory and should only be used in defining the elasticity of a single bandage. By definition, elastic bandages can only be stretched less than 100% their original length. Elastic bandages are capable of stretching more than 100% their original length (Nelson, 2009; Todd, 2011).

COMPONENTS

Compression bandage systems use combinations of inelastic and elastic materials. These combinations of different materials will have an influence on the sub-bandage actions and pressure and these pressures need to be measured.

'When applying a bandage, the tension is determined by the amount of force needed to elongate or extend the bandage'

Compression bandage systems that are made of different components may have different functions, for example, padding, protection, retention and/or compression. Understanding the properties of a bandage being used, as well as the degree of elasticity, will help clinicians understand how different pressures can be achieved and maintained. Bandages with inelastic components contain few, or no elastomeric fibres and are made of non-stretch materials, for example cotton.

In practice, after inelastic bandages have been applied immediate drops in pressure can occur even without movement. This loss of applied bandage pressure is mainly due to the immediate reduction of oedema/leg volume. This has been demonstrated by volumetric measurements (Partsch, 2006). Therefore, when this type of inelastic/short-stretch bandage becomes loose, it is essential to

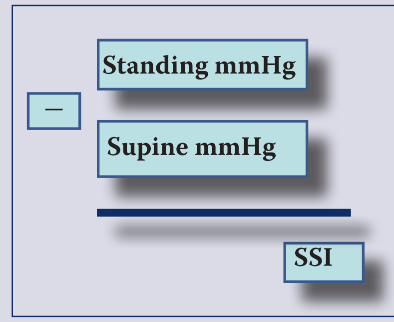

Figure 2: Static Stiffness Index formula.

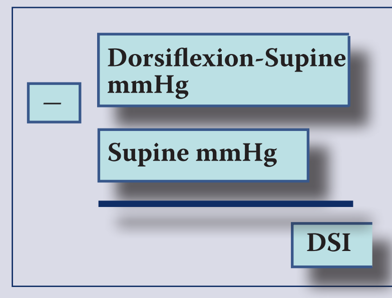

Figure 3: Dynamic Stiffness Index formula.

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re-apply it so that it regains its full efficacy. This will mean that in the initial treatment phase when oedema is present, it may be necessary to re-apply the bandage several times each week or even every day, especially in the presence of massive oedema.

Bandages with elastic components are sometimes referred to as long-stretch bandages and are made of fibres containing synthetic yarns. They can sustain pressure for longer periods of time due to their ability to accommodate changes in limb shape and movement.

With the innovation of bandage kits and multilayer bandages, which often consist of different bandage materials and weaves, the final bandage will become increasingly inelastic. An example is the four-layer bandage system. The single components are elastic, but the final bandage application is less elastic. The reason for this change is the influence of friction between the different layers. With this ongoing change from the single non-elastic/elastic bandage to the multilayer and multicomponent bandage systems, it is more reasonable to talk about the lower or higher stiffness of the bandage system and to reserve the terms 'elastic' and 'inelastic' for single bandages (Partsch, 2006).

STIFFNESS INDEX

The stiffness of a bandage or bandaging system characterises the relationship between the resting and working pressures, i.e. when the calf muscle is relaxed (resting) and when the calf muscle is active (standing, exercising or walking). The stiffness index is defined as the increase in sub-bandage pressure based on the difference of pressure from the resting to the standing or working pressure (Spence and Cahal, 1996; CEN, 2001). This pressure difference is the result of a change in the leg's circumference. The static stiffness index (SSI) can be measured at the B1 point of the leg (*Figure 1*). The B1 point is at the medial aspect of the lower leg where the tendon changes into the muscular part of the gastrocnemius muscle about 12–14 cm above the medial malleolus.

A pressure increase of 10mmHg or more from the lying/supine to the standing position indicates a high SSI and is characteristic of an inelastic bandage/system. If the pressure difference is less than 10mmHg, this is considered a low SSI and is characteristic of an elastic bandage/system (Mosti et al 2008; Partsch et al, 2008; Clark, 2010) *(Figure 2)*.

The dynamic stiffness index (DSI) is defined as the change in sub-bandage pressure measured at B1 when a person exercises her/his leg from either a supine or standing position, i.e. dorsiflexion or walking *(Figure 3)*.

An additional parameter of interest is the amplitude. It is measured by taking the difference between the maximal-minimal pressure during dorsiflexion and characterises the massaging effect of a bandage. It is dependent on the bandage/system and a person's ability to flex her/his ankle (*Figure 4*).

It is recommended by the International Compression Club that all bandage compression systems state their pressure values, including the SSI (Partsch et al, 2008).

The graph *(Figure 5)* details the inelastic sub-bandage pressure measurements — supine, dorsiflexion and standing. It was taken with a Pico Press pressure measuring device (Microlab Elettronica), allowing continuous monitoring of sub-bandage pressures. The bandage pressure in the supine position was 40mmHg. On the right side of the graph the pressure increase from the supine to the standing position is visible. It has increased to just below 60mmHg. In this example the SSI is calculated by subtracting supine pressure (40mmHg) from the standing pressure (59mmHg). This gives a SSI of 19. It also classifies the bandage/system as being stiff (inelastic or 'short stretch').

In a similar manner, the DSI can be calculated from the graph, i.e. 40mmHg (supine) – 76mmHg (dorsiflexion). The amplitude is derived by the difference between the maximum pressure during dorsiflexion and the minimum pressure at muscle relaxation, i.e. 76mmHg – 28mmHg.

DISCUSSION

In practice, there is no single element in making a decision about which bandage or bandage system to use in order to treat venous or lymphatic disease. Certainly

KEY POINTS

- In venous disease, compression should work on the veins and exert a therapeutic resting pressure and an intermittent high working pressure.
- When applying a bandage on a patient's leg the radius needs to be considered, i.e. low tension for small and skinny legs, high tension for large or swollen legs.
- Bandages with inelastic components contain few, or no elastomeric fibres and are made of non-stretch materials, for example cotton.

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the priority will be the effectiveness that a bandage system provides in reversing venous hypertension, reducing oedema and controlling associated pain. The SSI and DSI rank high on the list of priorities. With current knowledge derived from pressure measurements and clinical experience, clinicians can expect that reputable bandage/systems have this information. The safety and ease of application are also essential elements.

Establishing patient-practitioner concordance is enhanced when the clinician has knowledge and confidence in the effectiveness of the product. This might mean choosing a bandage/bandage system that is acceptable in terms of comfort, mobility and/or appearance. During the treatment period the dynamics of the intervention might change, for example there may be infection, oedema reduction or wound healing. The compression treatment needs to be adapted accordingly.

Other considerations include the skill and knowledge of the practitioner. Training is essential and this certainly needs to be specific for the type of compression used. The specific nature of training and knowledge are often required in conjunction with clinical guidelines developed within the practitioner's setting. Furthermore, it is of great importance to consider the overall cost implications of materials and time for the total treatment. Ongoing reassessment is essential for monitoring the treatment process.

Selecting a compression system for venous disease

10 elements to consider in the decision naking process and use

- The SSI
- Clinical effectiveness
- Concordance and acceptability of the patient
- Comfort and appearance
- Knowledge and training
- Safety issues and ease of application
- Guidelines — manufacturer and local/national
- Cost in time
- Material cost
- Ongoing assessment.

CONCLUSION

The above list of elements gives the practitioner a guide when selecting a compression system. They address the efficacy, practical use, patient acceptability, clinical compliance and cost. These elements are based upon overall positive results in the selection of a compression bandage system.

It is the clinician's responsibility to choose an effective bandaging system that combines scientific findings with the skilled art of bandage application. WUK

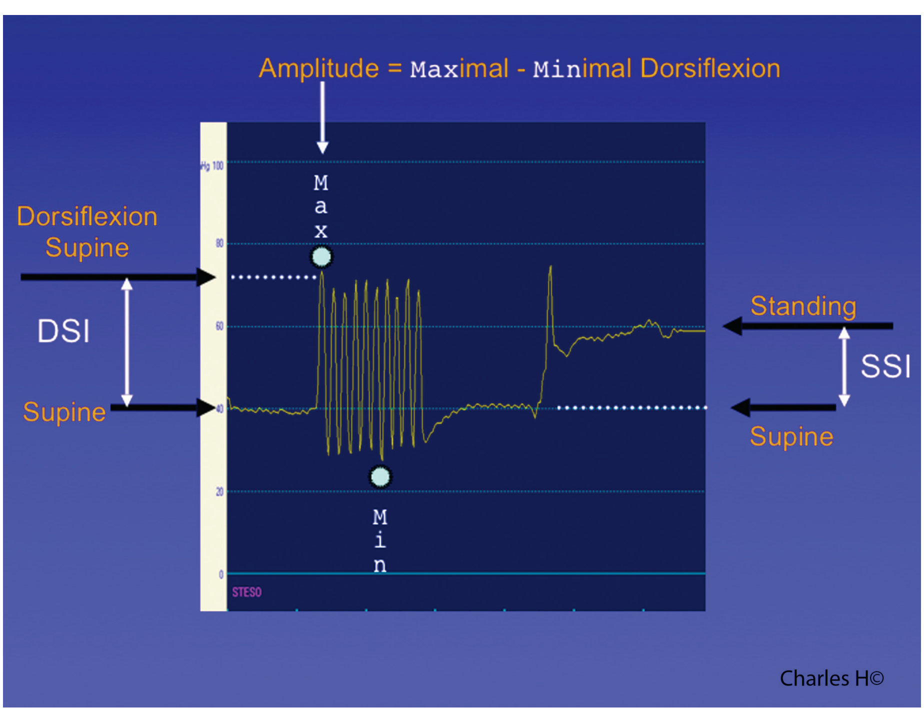

Figure 5: Inelastic sub-bandage pressure measurements — supine, dorsiflexion and standing.

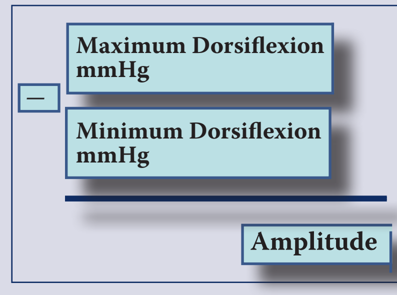

Figure 4: Amplitude formula.

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