Journal of Textile Science & Engineering
ISSN: 2165-8064
Fadhel et al., J Textile Sci Eng 2012, 2:6
DOI: 10.4172/2165-8064.1000122
Research Article Open Access

# Factors Influencing the Pressure Exerted by a Compressive Knit

**Jaafar Fadhel***, **Sahnoun Mehdi and Cheikhrouhou Morched**

*Textile Research Unit of ISET Ksar Hellel, Ksar Hellel, University of Monastir, Tunisia*

## Abstract

The use of compressive garments for severe burns is usually necessary for a long time. They consist of relatively stiff fabric but very elastic that compresses skin layers in order to flatten them. As the healing of the skin that tends to hypertrophy, the skin is forced to grow up but not by remaining relatively thin. Compression, defined as the pressure applied by a garment on the member burned , depends on a complex interaction between physical properties and manufacture of compressive garment, size and shape of the limb to which it is applied and the wearer's activity. The compression level is directly proportional to the tension application of the compressive garment and inversely proportional to the size of the member (Laplace's Law). Thus, there are other factors influenced directly or indirectly to the interface pressure. The change in pressure by muscular activities can have a big effect on the compressed member.

**Keywords:** Pressure; Factors; Compressive garment; Burned human skin

## Introduction

The medical sector is one of the main sectors in assets and strong attraction for the producers of technical textiles. Several researchers have been treated as potentially represent significant opportunities for development of medical products: orthotics, hygiene and care. This has assessed the application areas in which privileged textile technologies have the potential for greater innovation. As part of this last theme, we conduct this research paper on developments and applications of textile technology in medicine.

Compressive garments are medical devices used to immobilize a body part, restrict or assist movement, reduce stress forces of weight or correct a deformity. A compressive garment must have qualities of comfort, in terms of pressure. Others share the garments, by their mesh, hinders the development of skin cheloidien. Compressive garments provide excellent results, are the reason why they should be prescribed in cases of deep and extensive burns. The use of local pressure on the scar is certainly not new and is applied as a form of therapy. Several researches popularized the use of pressure and compression therapy in the medical sector [1]. Compressive garments provide excellent properties due to their compositions and their manufacture. They are intended to avoid the appearance of hypertrophic scars or retractile or improve appearance. They are used for care of burns affecting the deeper tissues. They prevent inflammation and reduce the lack of cohesion of collagen fibers cross, and are worn for several weeks to several months [2].

Own investigation has recently shown that the effective compression therapy accelerated the maturation of the scar and made the scars flatter. The compression therapy also reduces the hardness and redness of the scar [3]. Several authors [4-6] however, postulated that a pressure of at least 15 mmHg is necessary, especially when we want to help accelerate the maturation of the scar. Continuous pressure above 40 mmHg increases the risk of complications such as paresthesia and maceration.

Compression is an effective treatment. Used correctly, it can enhance healing and change the quality of life of a patient; used incorrectly, it can result in delayed healing, pain, trauma, simply put, the compression works by squeezing the limb, reducing edema and stimulating venous return to heart. It has effects on the venous, arterial and lymphatic.

The compression exerted by garment depends on several factors. Including those related to the mechanical properties of compressive garment: extensibility and elasticity, Young's modulus, coefficient of Poisson; and those are related to the patient: the morphology of the member pressed, the limb circumference and its variations, the activity of muscles; and others are related to the mode and the pose technique, the elongation and the number of layers.

During the establishment and during muscle activity, a compressive garment undergoes changes along the three dimensions. The variation in the length and width are related by the coefficient of Poisson, but variation of the thickness isn't considered by several research studies. The variation of the thickness of a compressive garment is result in increased elongation and shrinkage of the mesh. This is a desirable effect for a burnt skin; this is a therapeutic used to the flexibility of the skin depending on the thickness variation.

## Materials and Methods

We realized four different types of compressive garment ($Z_1$, $Z_2$, $Z_3$ and $Z_4$) on a circular knitting machine type SANTONI English gauge E=28.

Samples $Z_1$ and $Z_2$ are manufactured by assembling the following thread:

- A polyamide yarn 34 dtex
- Two pieces of yarn: spandex covered with polyamide 44/34

***Corresponding author:** Jaafar Fadhel, N° 27 Ahmed Tlili Street, Jemmel Monastir, Tunisia, Tel: 00 216 97 77 44 22; Fax: 00 216 73 475 163; E-mail: jaafarfadhel@yahoo.fr

**Received** July 23, 2012; **Accepted** September 17, 2012; **Published** September 24, 2012

**Citation:** Fadhel J, Mehdi S, Morched C (2012) Factors Influencing the Pressure Exerted by a Compressive Knit. J Textile Sci Eng 2:122. doi:10.4172/2165-8064.1000122

dtex and a polyamide yarn 33 dtex

Samples $Z_3$ and $Z_4$ are manufactured by assembling the following thread:

- A polyamide yarn 60 dtex
- Two pieces of yarn: spandex covered with polyamide 44/34 dtex and a polyamide yarn 60 dtex (Figure 1)

### Choosing the type of knitting

The circular knitting produces a seamless tube that requires comparatively less finishes to produce the final compression.

Generally, circular knitting is thinner and therefore more acceptable aesthetic, that knitting flat.

### Choosing the type of bonding

The binding of knitting done is chosen in a way to obtain desirable effects of pressure and biocompatibility with human skin burned. Indeed, the pressure is obtained by the composition and form of stretch mesh. The alloys used are derived from jersey knit to have a flexible interfacial area does not cause painful irritation to skin burned. The samples are thermally fixed by automated machines. This step gives their dimensional stability and excellent sustainable final appearance. Samples will not change shape even after multiple washings.

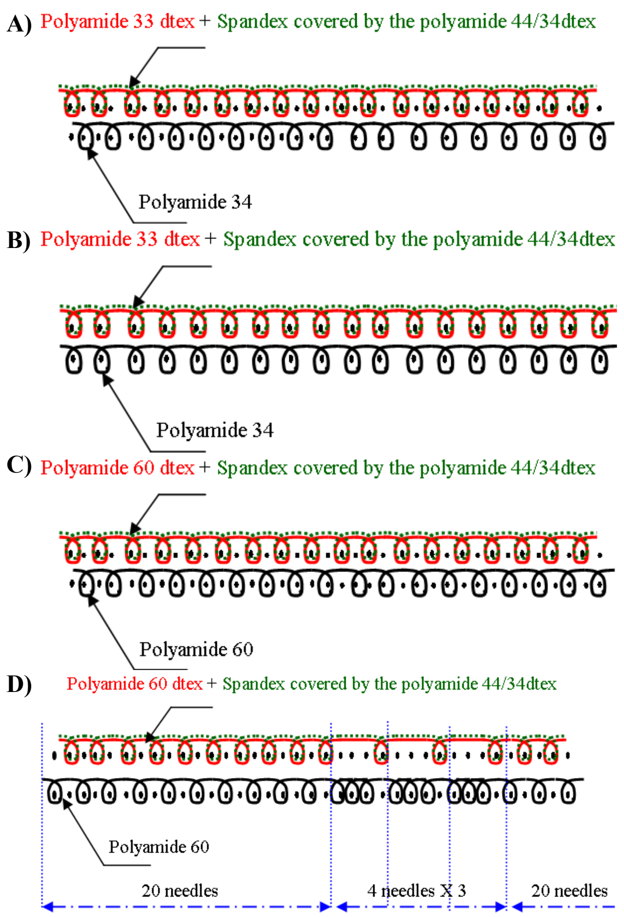



**Figure 1:** Binding of compressive garment $Z_1$ (a), $Z_2$ (b), $Z_3$ (c) and $Z_4$ (d).

### Elongation test

The samples are packaged and tested with a dynamometer LET5DYN01 to elongation with rate 100 mm/min according to the Norm ISO13934-1.

### Laplace's law

The static pressure point exerted on a body, assuming cylindrical of the radius R, can be roughly estimated by Laplace's law:

p=(T/L)/R, {1}[7]

p: interface pressure (N/m$^2$),

T: tensile strength (N),

L: width of the compressive garment (m),

R: radius of the body pressed (m).

Theoretically, the static pressure [8] exerted at a point by a compressive garment depends on:

- Technical intrinsic characteristics of compressive garment,
- Circumference at the application point,
- Method of installation.

### Relationship between the Laplace's law and the pressure *in vivo*

The pressure exerted by the compressive garment depends on the manufacturing technique, elastomeric characteristics of the fabric, the applied tension and anatomical features of the limb (size and shape). The amount of the interaction of these events is expressed by Laplace's law [9,10]. According to Laplace's law, by applying a compressive garment with the same tension, the pressure will increase when the radius of the member decreases. So we must change the tension compressive garment with its range of membership. The pressure exerted by the compressive garment varies depending on conditions (static or dynamic).

## Results and Discussion

### Factors affecting the pressure in the compressive garment

It is crucial to recognize many factors that affect the pressure in the compressive garment.

### Factors related to the compressive garment

The pressure in the compressive garment is determined by the principles of the Laplace's law. Some factors may affect the principles of the Laplace's law. It notes, for example, some mechanical properties of compressive garment can be changed after prolonged use or after a large cycle of washing.

**Influence of the compressive garment tension:** A compressive garment is characterized by the restoring force that opposes the stretch**.** Depending on the type of compressive garment chosen**,** for a return force identical, it will stretch the compressive garment in proportions ranging from 30 to 150%. Changes are considered "short-stretch" when the maximum elongation is below 70% and "middle elongation" when the maximum elongation is between 70% and 140% [11].

**Mode of application:** At **the** static state of the patient, assuming that the muscle remains inactive at any given moment, in this case the circumference of the limb becomes unchangeable (constant radius). You can have the same effect by four different garments by changing the rate of elongation at the time of installation. Indeed, from table 1, when applying a tension of 100 N, we obtained different elongation on the four garments: $Z_1$ to 85%, $Z_2$ to 80%, $Z_3$ to 45% and $Z_4$ to 44%. At dynamic state these results will not be valid.

## Factors related to patient

Laplace's law evaluates theoretically static pressure; we must not forget the influence of patient mobility on the dynamic pressure.

The muscle pump function, the shape and the morphology of limb and the patient's ability to tolerate compression can all have an impact on its effectiveness. The technique and application method used is also critical to achieving success.

**Influence of limb circumference:** Regardless of other factors, more the circumference of the limb is important, and then the interface pressure is low (for a given compressive garment, with a tension and a method of installation unchanged).

Therefore it is essential to take into account this parameter and thereafter the morphological variations of the burned body. The limb circumference at the measuring point is a parameter of major importance in determining the pressure delivered and the effectiveness of compression therapy.

The Laplace equation $p = (T/L)/R =$ constant $\rightarrow$ if R varied from $R_1$ to $R_2$ then T/L must varied from $T_1/L$ to $T_2/L$.

And we have $(T_1/L)/R_1 = (T_2/L)/R_2 \rightarrow (T_2/L) = (R_2/R_1).(T_1/L)$, it is assumed that the width of the fabric remains constant (L=constant), then $T_2 = (R_2/R_1).T_1$

If we put the same type of compressive garment with the same tension and the same method of installation of two peoples whose ankle circumferences are different, for example, 25 cm and 18 cm, then the pressure delivered will be greatly different.

**Patient's morphological and anatomical diversity:** According to Laplace's law, in the absence of changes in other factors, if the limb circumference increases, pressure decreases inversely. Indeed, over bony prominences such as the Achilles tendon or the tibial crest, the pressure will be stronger than those on flat areas or low spots as the region retromalleolar. Since the radius of curvature of these areas is protruding much smaller than that of the member [12,13]. The pressure exerted by a compressive garment changes in the calf. In fact, this part represents a sponge venous anatomy [14]; therefore the circumference at the calf can be reduced by the action of pressure and consequently the pressure increases (Figure 2). The behavior of the muscle and that of the fat differ in pressure at the interface. Indeed, the Poisson's ratio for fat is around 0.46 and that for the muscle is in the order of 0.36 [14].

$$\vartheta = \frac{\text{transverse contraction}}{\text{axial elongation unit}} \tag{2}$$

And ϑ {2} is the Poisson's ratio. Poison's ratio is the ratio of stress (contraction) normal to the applied load, constraint (extension) in the direction of load application.

According to figure 3, the pressure increases in the calf and this phenomenon is caused by the decreasing radius of the member upon application of compressive garment. But this reasoning is not always valid because the decrease in limb circumference is also reflected by the decrease in tension compressive garment applied. The Laplace equation in two variables involves the effect of the tension and the radius of limb simultaneously. In fact, p=(T/L)/R with L constant; if T decreases and R remains constant then p decreases. If R decreases and T remains constant, then p increases. In our case, T decreases and R simultaneously decreases, so just study from the curves the variations of T and R.

Example: A calf with circumference of 400 mm is equivalent to a radius R=63.7 mm. The decrease of circumference of the calf during compression can attend 5% is equivalent to a radius P = 60.5 mm, figure 4. The slope of the line of 1 / R is in order of -0.64' According to the table 2, the only line admits a positive slope in the vicinity of 0.6 with difference of elongation less to 10% is the tangent to the force-elongation curve of $Z_3$ for an elongation between 0% and 10%; in which case the slope is equal to 0.7. We can conclude that in this case the effect of decreasing the circumference is almost canceled by the effect of reducing of the tension of compressive garment (0.7-0.64=0.06 a very low slope almost horizontal). Therefore, at these conditions, the pressure remains constant if the calf circumference varies. For example, if we applied a pressure of 25 mmHg over the calf is equivalent to 3333.6667 $N/m^2$ equivalents to a compressive garment tension of 33.34 N with 200mm length and 50mm wide. The elongation of compressive garments and the slope of tangent line are given in table 3. The nearest slope of 0.64 is that of the tangent to $Z_1$ such as 1.2 for an elongation between 50% and 60%; and the tangent to $Z_2$ for an elongation between 40% and 50%.

In the four cases studied the effect of the tension of compressive garment is more important than the effect of a change in radius to circumference of a calf under a compression exerted on the order of 25 mmHg.

**Influence of the dynamic state of the member:** Many researchers [10,15-18] are interested in measuring the pressure change caused by the interaction of changes in the size of

| Elg% | 0 | 10 | 15 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T ($Z_1$) | 5 | 10 | 12 | 14 | 17 | 25 | 30 | 42 | 68 | 80 | 110 | 130 | 170 | 200 | 250 | 310 | 340 |
| T($Z_2$) | 5 | 7 | 8 | 12 | 20 | 28 | 40 | 60 | 80 | 100 | 130 | 170 | 200 | 260 | 300 | 350 | - |
| T($Z_3$) | 5 | 12 | 17 | 20 | 40 | 50 | 80 | 120 | 165 | 200 | 270 | 330 | 380 | 400 | - | - | - |
| T($Z_4$) | 5 | 10 | 15 | 25 | 42 | 80 | 130 | 190 | 260 | - | - | - | - | - | - | - | - |

Elg%: Elongation in percent (%) expressed in percentage
T ($Z_i$): is the tension in Newton (N) of the compressive garment $Z_i$ applied for a corresponding elongation.

**Table 1:** Tension in Newton of samples studied in terms of extensions.

the compressed member. The reason behind this interest is the fact that activated the muscles in the limb will result in a change in the extension of the compressive garment. This will lead to a change in the tension forces in the fabric and therefore a modification of the interface pressure applied by the fabric compression. In fact, once a compressive garment is applied to a member, the material stiffness and the type of bonding plays the biggest role in producing the difference between static and dynamic pressure **1** [7,19,20]. The pressure exerted by a compressive garment applied to a member in a static state is different to that exercised by the same compressive garment applied to that member in a dynamic state. Indeed, in dynamic conditions, the change of circumferential member will result in increments of elongation [18]. The ability to oppose muscular work increases the volume in motion can generate high peak pressure (60-80 mmHg). However, the interface pressure is directly proportional to the tension of the garment [9].

**Calculating the change in pressure caused by the change in the shape of the member:** If we consider surface element dS of normal n, undergoing a force F then the pressure p is defined by: dF.n=p. dS

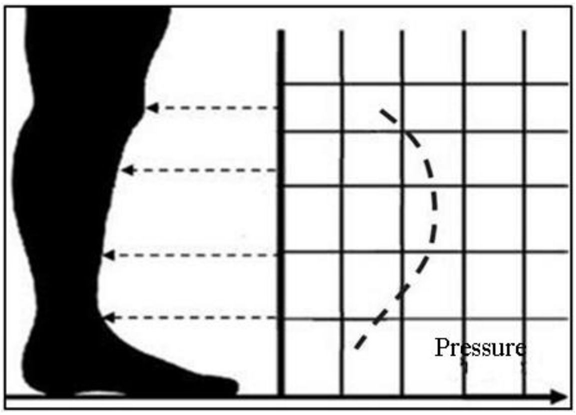
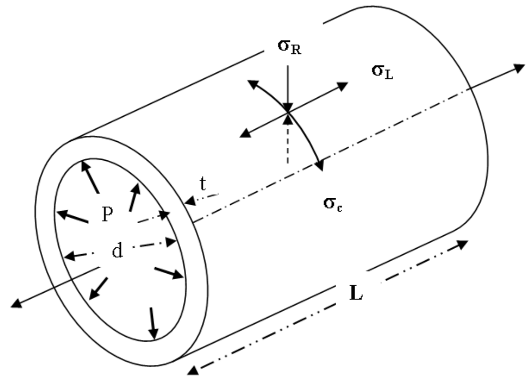
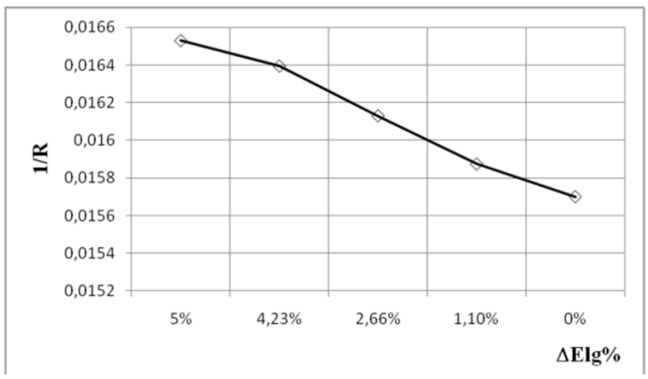



**Figure 2:** Curve of circumference-pressure effect of the calf.




p is the pressure expressed in N/m²,
d is the initial diameter of the inner cylinder expressed in m,
L is the length of the cylinder which is the width of the garment expressed in m
t its thickness expressed in m,
E is the chord modulus for compressive garment expressed in N/m²,
$\sigma_C$ is the circumferential stress expressed in N/m²,
$\sigma_L$ is the longitudinal stress expressed in N/m²,
$\sigma_R$ is the radial stress expressed in N/m²
And {2} is the Poisson's ratio. Poisson's ratio is the ratio of stress (contraction) normal to the applied load, constraint (extension) in the direction of load application

**Figure 3:** Cylinder subjected to an internal pressure.




R is the radius of compressed member,
And ΔElg% is the variation of the elongation of compressive garment.

**Figure 4:** Variation of the inverse of the radius of the calf in terms of the variation of the elongation of compressive garment.

| | $Z_1$ | $Z_2$ | $Z_3$ | $Z_4$ |
|---|---|---|---|---|
| Elg% (T= 33,34N) | between 50% and 60% | between 40% and 50% | between 20% and 30% | between 20% and 30% |
| Slope of the Tangent line | 1,2 | 1,2 | 1,9 | 2,2 |

Elg% (T= 33,34N) is the elongation of compressive garment in percent to have a Tension=33,34N

**Table 2:** Slope of line tangent to the force-elongation curve for a tension of 33.34 N applied to compressive garments.

| Samples | Chord modulus E | Thichness t (m) | $\Delta p \frac{Et}{\pi d^2} \Delta d$ |
|---|---|---|---|
| $Z_1$ | 0,25 | 0,001 | $\Delta p_1 = 5{,}97 \Delta d$ |
| $Z_2$ | 0,65 | 0,00113 | $\Delta p_2 = 17{,}55 \Delta d$ |
| $Z_3$ | 1,15 | 0,00128 | $\Delta p_3 = 35{,}145 \Delta d$ |
| $Z_4$ | 1 | 0,00095 | $\Delta p_4 = 22{,}68 \Delta d$ |

$\Delta p_i$ is the variation of pressure,
E the Chord modulus of garment (N/m²),
t is the thickness of garment (m),
d is the diameter of member (m),
And Δd is the variation of diameter of member (m).

**Table 3:** Chord modulus of compressive garments studied.

In the case of a force perpendicular to a flat surface of area S, is obtained: p=F/S.

The term obtained by constructing the ratio of the component of force tangential to the surface of the exercise is called shear stress. It is homogeneous pressure. In this section we are interested to find a mathematical relationship used to estimate the variation of the pressure caused by changing the diameter of a pressed member.

Increasing the size of the member may be done instead to circumferential stresses, longitudinal and diametrical applied to the surface of compressive garment.

In the case of linear elasticity, the stress field is related to the strain field by the generalized Hooke's law:

$$\sigma = E\varepsilon \tag{3}$$

**Citation:** Fadhel J, Mehdi S, Morched C (2012) Factors Influencing the Pressure Exerted by a Compressive Knit. J Textile Sci Eng 2:122. doi:10.4172/2165-8064.1000122



This law can so easily relate the elasticity of the material to its elongation as a function of the stress that is exerted on it.

$$\varepsilon_C = \frac{1}{E}\left[\sigma_C - \vartheta(\sigma_L + \sigma_R)\right] \tag{4}$$

$$\varepsilon_L = \frac{1}{E}\left[\sigma_L - \vartheta(\sigma_C + \sigma_R)\right] \tag{5}$$

$$\varepsilon_R = \frac{1}{E}\left[\sigma_R - \vartheta(\sigma_C + \sigma_L)\right] \tag{6}$$

or by solving the constraints:

$$\sigma_C = \frac{E}{(1+\vartheta)(1-2\vartheta)}\left[(1-\vartheta)\varepsilon_C + \vartheta(\varepsilon_L + \varepsilon_R)\right] \tag{7}$$

$$\sigma_L = \frac{E}{(1+\vartheta)(1-2\vartheta)}\left[(1-\vartheta)\varepsilon_L + \vartheta(\varepsilon_C + \varepsilon_R)\right] \tag{8}$$

$$\sigma_R = \frac{E}{(1+\vartheta)(1-2\vartheta)}\left[(1-\vartheta)\varepsilon_R + \vartheta(\varepsilon_C + \varepsilon_L)\right]p \tag{9}$$

With

$$\varepsilon_C = \left(\frac{d-d_0}{d}\right) = \frac{\Delta d}{d} \quad \varepsilon_L = \left(\frac{L-L_0}{L}\right) = \frac{\Delta L}{L} \quad \varepsilon_R = \left(\frac{t-t_0}{t}\right) = \frac{\Delta t}{t}$$

Equation (4) gives

$$\frac{\Delta d}{d} = \frac{1}{E}\left[\sigma_C - \vartheta(\sigma_L + \sigma_R)\right] \tag{10}$$

Assuming that compressive garment is an isotropic material, so the Poisson ratio can be written:

$$\vartheta = \frac{(d-d_0)/d_0}{(L-L_0)/L_0}$$

Longitudinal, transverse and radial constraints can be expressed as follows:

$$\sigma_C = \frac{pd}{t}\pi \tag{11}$$

$$\sigma_L = \frac{pL}{t} \tag{12}$$

$$\sigma_R = p \tag{13}$$

The equations (10), (11), (12) and (13) give:

$$\frac{\Delta d}{d} = \frac{p}{E}\left(\frac{d\pi}{t} - \vartheta\frac{L}{t} - \vartheta\right) \tag{14}$$

And consequently the pressure variation caused by changes in the size of members

$$\left(\frac{\Delta d}{d}\right) :\to \Delta p = \frac{\Delta d}{d}\,\frac{Et}{d\pi - \vartheta(L+t)} \tag{15}$$

With Δp is the change in the pressure expressed in N/m$^2$ that is caused by the change of the diameter of member expressed in N/m$^2$ and E is the chord modulus expressed in N/m$^2$.

Assuming that the deformation in the circumferential direction will not change in the width of the garment or in its thickness, while the Poisson's ratio becomes zero, then equation (15) becomes:

$$\Delta p = \frac{Et\Delta d}{\pi d^2} \tag{16}$$

This is a variation of the pressure exerted by the compressive garment due to the variation of the circumference of the limb in a dynamic state.

For a member of diameter d=20 cm, = 0.20 m, one seeks the variation of the pressure exerted by the muscle on the four compressive garments studied.

Figure 5 shows the change of the interface pressure as a function of change in the shape of the member caused by the action of the muscle. The garment $Z_1$ represents the minimum pressure induced during muscle activity. Figure 5 shows that the model presented in equation 16 can be used to visualize the change of the interface pressure due to changes in diameter of the member. This could be useful in selecting appropriate type of compressive garment according to the needs of patients. For example, by measuring the change in the size of the limb for a patient, clinicians can select appropriate materials that provide the best care for this particular patient and can use the mathematical model to estimate the change of interface pressure that occur in a compressive garment when the patient begins to exercise. The result shown in figure 5 improves the capacity of the chord modulus to classify garments.

**Modeling of variation in the dimensions of the compressive garment according to the variation of pressure at the dynamic state:** In the real case the compressive garment is not an isotropic material**.** There is also a technical formulation**,** which shows the elastic modulus and Poisson's ratios**.**

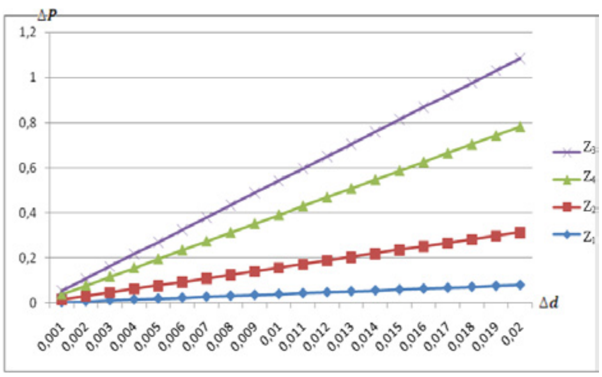
$$\vartheta_{CL} = \vartheta_{LC} = \frac{(L_0 - L)/L_0}{(C - C_0)/C_0}, \vartheta_{Lt} =$$

$$\vartheta_{tL} = \frac{(t_0 - t)/t_0}{(L - L_0)/L_0}, \vartheta_{Ct} = \vartheta_{tC} = \frac{(t_0 - t)/t_0}{(C - C_0)/C_0}$$

So the equations (4), (5), (6), (7), (8) and (9) become:

$$\varepsilon_C = \frac{1}{E_C}\left[\sigma_C - \vartheta_{CL}\sigma_L - \vartheta_{Ct}\sigma_R\right] \tag{17}$$

$$\varepsilon_L = \frac{1}{E_L}\left[\sigma_L - \vartheta_{LC}\sigma_C - \vartheta_{Lt}\sigma_R\right] \tag{18}$$




ΔP the variation of pressure expressed in (N/m$^2$),
Δd the variation of diameter of the limb pressed by compressive garment expressed in (m). The variation of the limb does not exceed 5% of the initial diameter of limb which correspond to 2cm.

**Figure 5:** Curves of variation of the pressure in terms of the variation of the diameter of member.

**Citation:** Fadhel J, Mehdi S, Morched C (2012) Factors Influencing the Pressure Exerted by a Compressive Knit. J Textile Sci Eng 2:122. doi:10.4172/2165-8064.1000122



$$\varepsilon_t = \frac{1}{E_t}\left[\sigma_R - \vartheta_{tC}\sigma_C - \vartheta_{tL}\sigma_L\right] \tag{19}$$

$$\sigma_C = \frac{1}{3-\vartheta_{CL}^2-\vartheta_{tL}^2-\vartheta_{Ct}^2}\left[\frac{(1-\vartheta_{Lt}^2)}{E_C}\varepsilon_C + \frac{(\vartheta_{CL}+\vartheta_{tL}\vartheta_{Ct})}{E_L}\varepsilon_L + \frac{(\vartheta_{Ct}+\vartheta_{CL}\vartheta_{Lt})}{E_t}\varepsilon_t\right. \tag{20}$$

$$\sigma_L = \frac{1}{3-\vartheta_{CL}^2-\vartheta_{tL}^2-\vartheta_{Ct}^2}\left[\frac{(\vartheta_{LC}+\vartheta_{Lt}\vartheta_{tC})}{E_C}\varepsilon_C + \frac{(1-\vartheta_{Ct}^2)}{E_L}\varepsilon_L + \frac{(-\vartheta_{Lt}+\vartheta_{LC}\vartheta_{Ct})}{E_t}\varepsilon_t\right. \tag{21}$$

$$\sigma_R = \frac{1}{3-\vartheta_{CL}^2-\vartheta_{tL}^2-\vartheta_{Ct}^2}\left[\frac{(\vartheta_{tC}+\vartheta_{LC}\vartheta_{tL})}{E_C}\varepsilon_C + \frac{(\vartheta_{tL}+\vartheta_{tC}\vartheta_{CL})}{E_L}\varepsilon_L + \frac{(1-\vartheta_{CL}\vartheta_{LC})}{E_t}\varepsilon_t\right. \tag{22}$$

Variation of the width of the compressive garment

The equation of the variation of the width of the compressive garment according to the pressure variation induced is given by the following relationship:

$$\frac{\Delta L}{L} = \left(\frac{L}{t} - \vartheta_{LC}\frac{d\pi}{t} - \vartheta_{Lt}\right)\frac{\Delta p}{E_L} \tag{23}$$

Variation of the length of the compressive garment $C = 2\pi(R+t)$

The equation of the change in the length of the compressive garment according to the variation of the pressure member and the diameter is given by the following relationship:

$$\frac{\Delta C}{C} = \left(\frac{d\pi}{t} - \vartheta_{CL}\frac{L}{t} - \vartheta_{Ct}\right)\frac{\Delta p}{E_C} \tag{24}$$

Variation of the thickness of the compressive garment

The equation of the variation in the thickness compressive garment according to the variation of the pressure member and the diameter is given by the following relationship:

$$\frac{\Delta t}{t} = \left(1 - \vartheta_{tC}\frac{d\pi}{t} - \vartheta_{tL}\frac{L}{t}\right)\frac{\Delta p}{E_t} \tag{25}$$

## Conclusion

This document describes the mechanisms by which compression is achieved and maintained, and discusses the factors influenced the pressure value in the compressive garment. The degree of compression produced by any type of compressive garment over a period of time is determined by complex interactions of five main factors such as physical properties of compressive garment; the elastic properties of the compressive garment (composition); the size and shape of the member to which it is applied; the ability and the insertion technique; and the nature of physical activity undertaken by the patient. These factors may change in the pressure of the interface. The change in the shape of the member is considered important. This leads to a mathematical model which determines the variation of the pressure as a function of the variation in the circumference of the member caused by the muscular activity. This model uses the Chord modulus and is based on the assumption that the change in limb circumference lead to changes in the circumferential direction of compressive garment and all other changes are expected to be low. Compressive garments can be classified according to their Chord Modulus associated with the different dynamic changes in its members by muscle activity. So it is important to classify garments in dynamic situations and manufacturers need to provide users with information on the stress-strain curves and tension-extension for dynamic ranges.

### References


1. Linares HA, Larson DL, Willis-Galstaun BA (1993) Historical notes on the use of pressure in treatment of hypertrophic scars and keloids. Burns 19: 17-21.
2. Gachie E, Casoli V (2011) Sequelae of hand burns. Ann Chir Plast Esthet 56: 454-465.
3. Johnson CL (1984) Physical therapists as scar modifiers. Phys Ther 64: 1381-1387.
4. Reid WH, Evans JH, Naismith RS, Tully AE, Sherwin S (1987) Hypertrophic scarring and pressure therapy. Burns Incl Therm Inj S29-S32.
5. Giele HP, Liddiard K, Currie K, Wood FM (1997) Direct measurement of cutaneous pressures generated by pressure garments. Burns 23: 137-141.
6. Van Den Kerckhove E (2003) Assessment of the influence of silicone and pressure on burn related scars. Department of Kinesiology and Rehabilitation Sciences of the Catholic University of Leuven, Belgium.
7. Thomas S (2003) The use of the Laplace equation in the calculation of sub-bandage pressure. EWMA J 3: 21-23.
8. Stemmer R (1995) Teoria e pratica del trattamento elastocompressivo. In P Belardi, Chirurgia vascolare, 2: 575-593.
9. Haid H, Schoop W (1965) Eine neue Methode zur Messung und Registrierung des Andruckes unter Kompressions verbanden. Med Welt 37: 2110-2113.
10. Partsch H, Clark M, Bassez S, Jean-Patrick B, Francois B, et al. (2006) Measurement of Lower Leg Compression In Vivo: Recommendations for the Performance of Measurements of Interface Pressure and Stiffness. Dermatol Surg 32: 224-233.
11. Rochet JM (1998) Rééducation de la main brûlée et appareillage. Annales de Réadaptation et de Medecine Physique 41: 369-70.
12. Moffatt CJ (2006) Guide pratique : Les compressions élastiques dans le lymphœdème de la partie supérieure du corps. MEP Ltd, London.
13. Serge C, Jean FP (2010) Nouvelles acquisitions sur la contention - compression élastique des membres inférieurs. clinique Mutualiste, France.
14. Partsch (2005) The static stiffness index: a simple method to assess the elastic property of compression material in vivo. Dermatol Surg 31: 625-630.
15. Partsch H (2005) The use of pressure change on standing as a surrogate measure of the stiffness of a compression bandage. Eur J Vasc Endovasc Surg 30: 415-421.
16. Partsch H, Clark M, Bassez S, Benigni JP, Becker F, et al. (2006) Measurement of lower leg compression in vivo: recommendations for the performance of measurements of interface pressure and stiffness: consensus statement. Dermatol Surg 32: 224-232.
17. van der Wegen-Franken CP, Mulder P, Tank B, Neumann HA (2008) Variation in the dynamic stiffness index of different types of medical elastic compression stockings. Phlebology 23: 77-84.
18. Stolk R, Wegen van der-Franken CP, Neumann HA (2004) A method for measuring the dynamic behavior of medical compression hosiery during walking. Dermatol Surg 30: 729-736.
19. Bassi G, Stemmer R (1983) Traitements mécaniques fonctionnels en phlébologie, Piccin Padova.
20. Liu R, Lao TT, Kwok YL, Li Y, Ying MT (2008) Effects of graduated compression stockings with different pressure profiles on lower-limb venous structures and haemodynamics. Adv Ther 25: 465-478.