COMPRESSION MATERIAL PARADIGM

IN VITRO MEASUREMENT WHY NOT

GOTHENBURG, SWEDEN

5 – 7 JUNE 2019

Ferdinand Tamoue, M.Sc.

International Compression Club

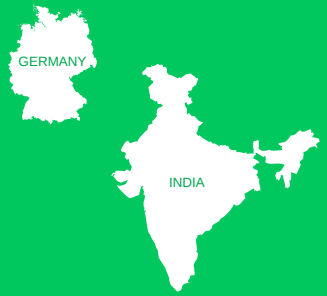
EUROPEAN · WOUND · MANAGEMENT · ASSOCIATION

EWMA NEWS

KOB PROFILE

What distinguishes us

Quality
managed in
Germany



1903
GERMANY

€
117 MILLION
ANNUAL
TURNOVER

1,300
EMPLOYEES
WORLDWIDE

INNOVATIVE
POWER

HARTMANN

MEDICAL SOLUTIONS

Global market leader in elastic medical bandages and fabrics

PHLEBOLOGY AND LYMPHOLOGY

WOUND CARE

SPORTS MEDICINE AND ORTHOPAEDICS

179 MILLION

BANDAGES PER YEAR

22× THE LENGTH OF THE EQUATOR

BANDAGES AND FABRICS

B2B

2,358 VARIANTS

56 COUNTRIES

INTRODUCTION

In vitro measurement Why not !

“FACT ARE RARE IN MEDICINE BUT OPINIONS ARE VERY COMMON!”

- Compression devices combines different materials (consensus 2006)
- Physical properties of compression material can be assessed only by sub-bandage pressure and stiffness in vivo (consensus 2006)
- Stiffness is increase of compression per centimeter increase of leg circumference (consensus 2006)
- Elastic property drives the sub-bandage pressure (consensus 2006)
- Stiffness from in vivo pressure values should be encouraged in all clinical studies (consensus 2008)
- Static Stiffness Index (SSI) in vivo characterizes of compression material (paper 2016)

H. Partsch et. al., *Measurement of Lower Leg Compression In Vivo: Recommendations for the Performance of Measurements of Interface Pressure and Stiffness.* Dermatol Surg 2006;32:224–233
E. Rabe et. al., *Guidelines for Clinical Studies with Compression Devices in Patients with Venous Disorders of the Lower Limb. Eur J Vasc Endovasc Surg Vol25 (2008)*
H. Partsch et al., The Static Stiffness Index: an important parameter to characterize compression therapy in vivo. Journal of Wound Care WUWHS Supplement Vol 25, N°9, (2016)

“FACT ARE RARE IN MEDICINE BUT OPINIONS ARE VERY COMMON!”

Recapitulation of literature review

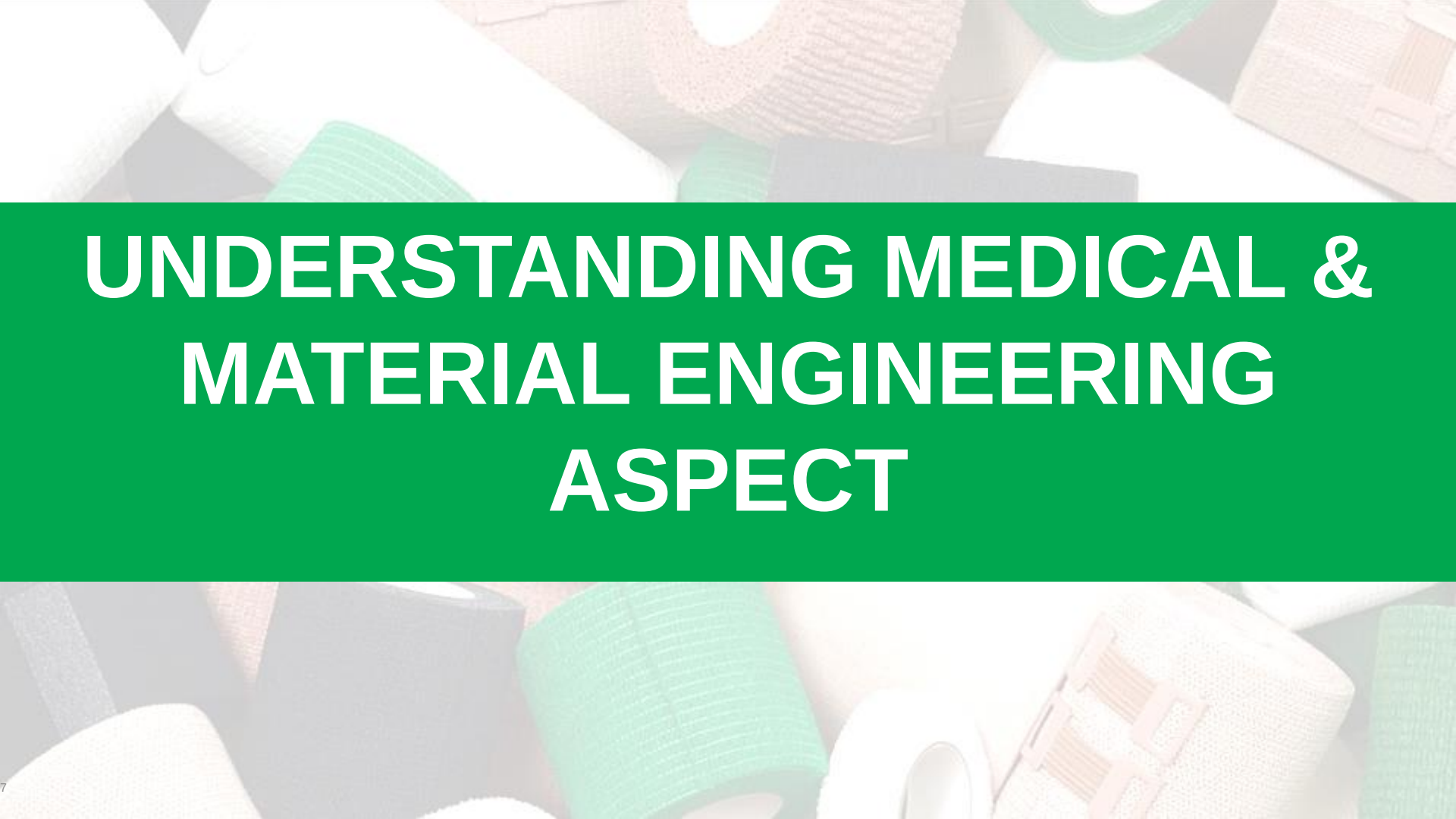
MY UNDERSTANDING

- Stiffness characterization is difficult due to material combination.
- Stiffness result are variable due to sensor positioning on subjects.
- Elastic properties are not linear.

SELF QUESTIONING

- What is Sub-bandage Pressure?
- What is Stiffness?
- What relationship exist between Elasticity and Stiffness?

H. Partsch et. al., *Measurement of Lower Leg Compression In Vivo: Recommendations for the Performance of Measurements of Interface Pressure and Stiffness.* Dermatol Surg 2006;32:224–233
E. Rabe et. al., *Guidelines for Clinical Studies with Compression Devices in Patients with Venous Disorders of the Lower Limb. Eur J Vasc Endovasc Surg Vol25 (2008)*
H. Partsch et al., The Static Stiffness Index: an important parameter to characterize compression therapy in vivo. Journal of Wound Care WUWHS Supplement Vol 25, N°9, (2016)



UNDERSTANDING MEDICAL & MATERIAL ENGINEERING ASPECT

UNDERSTANDING TERMINOLOGY ON MEDICAL POINT OF VIEW

Vascular societies

SELF QUESTIONING

- **What is Sub-bandage Pressure?**

- Compression involves the application of pressure to the lower extremities.
- Compression material are distinguish based on the maximal extensibility of the fabric (in vitro aspect).

- **What is Stiffness?**

- Fabric stiffness is determined by the increase of interface pressure per centimeter muscle enlargement.
- Static Stiffness Index (SSI) is a prerequisite for reducing the venous reflux and improve the venous pumping function during movement.

H. Partsch Compression Therapy: Clinical and Experimental Evidence. Annals of Vascular Diseases (2012) 5: 416–422
H. Partsch Classification of Compression Bandages: practical Aspects. Dermatologic Surgery (2008), 34:5 , 600-609

UNDERSTANDING TERMINOLOGY ON MEDICAL POINT OF VIEW

Vascular societies

SELF QUESTIONING

- **What is Stiffness?**

- Stiffness characterizes the elastic property of a compression device
- Pressure difference between standing and lying
- SSI > 10 mmHg → Inelastic

- SSI < 10 mmHg → Elastic

In vivo SSI provides information about how good a compression system would support the muscle pumping function

H. Partsch, C. Moffatt, An overview of the science behind compression bandaging for lymphoedema and chronic oedema. Best Practice of the management of Lymphoedema – 2nd edition (2012)

UNDERSTANDING TERMINOLOGY ON MEDICAL POINT OF VIEW

Summary

SELF-QUESTIONING

→ What is sub-bandage pressure ? → *Pressure difference between the compression material and limb*

→ What is stiffness? → *SSI provides information about how good a compression system would support the muscle pumping function*

→ What relationship exist between Elasticity and Stiffness? → **?**

SYSTEMATIC DIFFERENTIATION APPROACH SUB-BANDAGE PRESSURE

COMPRESSION

PHYSIOLOGICAL OCCURRENCES !!!

- Muscle function (trained/untrained)
- Venous valves or angio in the Lymph
- Posture (supine, standing)

All patient or healthy subjects related → in vivo

(Partsch et. al, Veins and Lymphatics 2012)

Human factor dependent”

PHYSICAL OCCURRENCES !!!

- Material = narrow woven or knitted fabric
- Tension /Strength (N)
- Strain (express as % of initial length at a given tension)
- Material Stiffness

Rely on material engineering → (in vitro)

Literatures about material engineering report that material stiffness relies

- Type of polymer (natural or synthetic)
- Molecular structure of the material

PARADIGM APPROACH

F. Tamoué, A. Ehrmann, T. Blachowicz
Predictability of sub-bandage pressure in compression therapy based on material properties.
Textile Research Journal First Published 11 Mar 2019.
https://doi.org/10.1177/0040517519833969

PRESSURE ESTIMATION'S METHODS USING A LONG-STRETCH BANDAGE

Two approaches for stiffness estimation

1ST APPROACH : PRESSURE & STIFFNESS CALCULATION

Dynamometer approach

Specimen extension up to a maximum specific force (30 N)

- Sub-bandage pressure combining Young Laplace and Pascal's theories:

$$p = \frac{2\gamma}{r} \ (1) \Leftrightarrow p = \frac{\frac{F}{w}}{r} \ (2)$$

$$= \frac{F}{Cw} \cdot 2\pi \cdot \frac{0.0075006\ mmHg}{1\ Pa}$$

$$= \frac{m \cdot g}{Cw} \cdot 2\pi \cdot \frac{0.0075006\ mmHg}{1\ Pa} = \frac{m\ in\ kg}{C\ in\ cm \cdot w\ in\ cm} \cdot 2\pi \cdot 9.81 \cdot 10{,}000 \cdot 0.0075006\ mmHg$$

- $p = \frac{m\ in\ kg}{C\ in\ cm \cdot w\ in\ cm} \cdot 4623\ mmHg$

According to Hooke's Equation "F" is proportional to T (stiffness)

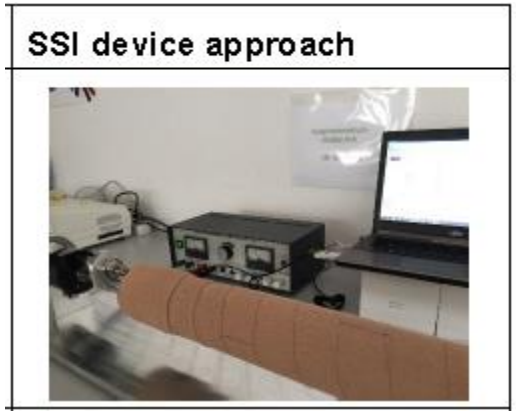
T (N/cm) = F/Δ𝒍

Heyer K, Protz K, Augustin M. Compression therapy – cross-sectional observational survey about knowledge and practical treatment of specialized and non-specialised nurses and therapists. Int. Wound J. 2017; 14: 1148-1153

PRESSURE ESTIMATION'S METHODS USING A LONG-STRETCH BANDAGE

Two approaches for stiffness estimation

2ND APPROACH: INTEGRATION MODIFIED EQUATION IN THE SSI-DEVICE – IN VITRO



The pressures calculated for the specimens under investigation depict a significant consistency:

$p1$ = (48.2 ± 1.6) mmHg and $p2$ = (47.69 ± 1.7) mmHg;

for a given probability p=0.95;

$p1$: 1st approach

$p2$: 2nd approach

RECOMMENDATION

IN-VITRO INSTEAD OF IN-VIVO FOR MATERIAL CLASSIFICATION

interface between physics and medicine

IN VIVO

Figure 1. Cotton material narrow-woven elasticated bandage for short-stretch compression therapy (product 530).

- Due to body shape and anatomy variability, SSI from the sub-bandage pressure shall not be used to compare bandages !

Figure 2. Now-woven compression bandage, stitch-bonded with an elastomer yarn (two-component system used for the treatment of venous leg ulceration; product 730).

- Due to body shape and anatomy variability, material combination SSI from the sub-bandage pressure shall not be used to compare bandages!

Human Factor dependent !

IN VITRO

Figure 1. Cotton material narrow-woven elasticated bandage for short-stretch compression therapy (product 530).

Figure 2. Now-woven compression bandage, stitch-bonded with an elastomer yarn (two-component system used for the treatment of venous leg ulceration; product 730).

- Due to uniform test body, SSI from the sub-bandage pressure may be used to compare bandages

- Human Factor not relevant
- Material type and number component has not negative influence on results

THANK YOU!

Ferdinand Tamoue, M.Sc.
Innovation Manager Phlebology & Lymphology
Phone +49 6304 74-394
Ferdinand.Tamoue@kob.de