Vacuum Massage in the Treatment of Scars

Peter Moortgat, Jill Meirte, Ulrike Van Daele, Mieke Anthonissen, Tine Vanhullebusch, and Koen Maertens

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Background

Vacuum massage is also known as depressomassage, vacuotherapy, or Endermologie®. It is a non-invasive mechanical massage technique performed with a mechanical device that lifts the skin by means of suction, creates a skin fold, and mobilizes that skin fold [1, 2] as displayed in ■ Figs. 54.1 and 54.2.

Vacuum massage originates from cupping therapy, a traditional Chinese medicine therapy dating back 2000 years or more. A local suction on the skin is created using heat or mechanical forces in order to create vasodilatation. In the late 1970s, Louis-Paul Guitay suffered from severe skin burns after a car accident. During his rehabilitation, he had to endure hours of manual massages every day. This multi-month process was normal practice for burn victims with extensive scar tissue in the late 1970s. Massage sessions typically lasted 3–4 hours a day and consisted of rigorous routines. The therapist rolled skin and tissue back and forth to regain elasticity. As days grew into weeks, Guitay became dissatisfied with these incessant treatments. They were time-consuming, labor intensive, and he noticed his results varied drastically based on the skills of each individual therapist. Endermologie®, taken from the French term meaning “through the dermis”, was Louis-Paul Guitay’s way of standardizing massage therapy to maximize the effect of each treatment. He developed a mechanical device to copy the manual massage techniques by means of negative pressure. This method allowed him to perform the massage in a more consistent way and was less time consuming. From then onward, Endermologie® or vacuum mas-

sage has been frequently used to treat traumatic or burn scars.

Although vacuum massage was invented to treat burns and scars, very little literature is available on the effects of this intervention. Soon after its development, the device was used extensively in Europe to treat trauma and burn scars [2]. In the course of its use, care providers soon noticed its ability to improve the appearance of cellulite, and consequently most studies mainly focused on lipodystrophy to investigate its working mechanism. The number of studies concerning cellulite is three times higher than those of burns or scars.

The aim of this chapter is to present an overview of the available literature with the physical and physiological effects of vacuum massage. This was done in order to find the underlying working mechanisms of Endermologie® that could benefit the healing of burns and scars. Analyzing the physical and physiological effects of this treatment can increase insights in the influence on the scarring process and may clarify the outcome.

■ Fig. 54.1 Vacuum massage creates a skin fold and mobilizes that skin fold

■ Fig. 54.2 Vacuum massage on scars

54.1 Working Mechanism of Vacuum Massage in Relation to Pathological Scarring

In recent years, there has been an increasing interest in the mechanobiology of scars. The influence of mechanical forces on skin has been examined since 1861 when Langer first reported the existence of lines of tension in cadaver skin [3]. Internal tension in the dermis leads to cell–extracellular matrix (ECM) and cell–cell interactions transferring external mechanical forces into biochemical signals inside the cell [4]. Khan et al. reclaimed the term “mechanotherapy” and presented the current scientific knowledge underpinning how mechanical load may be used therapeutically to stimulate tissue repair and remodeling. It has long been thought that the effectiveness and efficiency of physical therapy would improve if our understanding of the cell biology/biochemistry that participates in mechanics could be improved. Traditional physical therapy focuses primarily on rehabilitation, but recent developments in mechanobiology that illuminated the effects of physical forces on cells and tissues have led to the realization that the old therapy model should be updated. Recent studies showed how mechanotherapies target particular cells, molecules, and tissues. The role of mechanical force in various therapies, including micro-deforming soft tissue techniques, shock-wave, vacuum massage, tissue expansion, skin stretching, and tension reduction (tissue targeting) therapies is the subject of numerous ongoing clinical trials [5–7].

All adherent cells including endothelial cells, fibroblasts, and myofibroblasts sense tension originate from the environment. Tension is transmitted via cell–ECM contacts, leading to reorganization of the cytoskeleton and the elicitation of specific signals that modulate gene expression. In skin, alterations of mechanical forces are continuously recognized by cells, and their functions are adapted according to the biological requirements. If mechanical tension is removed, those tissues undergo atrophy, indicating the important role of mechanical signals for maintaining proper functioning of the organism. Obviously, fibroblasts and myofibroblasts are cells implicated in scarring, which is strongly influenced by mechanical tension.

The precise mechanisms by which different cell types transmit mechanical signals are not fully understood. They might involve stretch-activated ion channels, direct interactions between structural and signaling components, or activation of small GTPases. As outlined above, many cooperative interactions exist between integrins and growth factor signaling. In particular, fibroblast to myofibroblast conversion and α -smooth muscle actin (α -SMA) expression crucially depend on a combination of mechanical tension and TGF- β . Thus in scarring, generation of tension can induce myofibroblast formation, causing a self-perpetuating loop. A similar autocrine loop

is discussed for the induction of collagen synthesis in fibroblasts by mechanical tension. In this case, TGF- β is induced by tension, which in turn activates collagen synthesis via the classic pathways. In addition, fibronectin is induced by the application of cyclic strain to fibroblasts. In parallel, many proteases are downregulated, whereas protease inhibitors are upregulated. As a result of these events, modulation of mechanical tension results in alterations of fibroblast and myofibroblast activity. Tension directly modifies gene transcription, induces signaling from integrins affecting small GTPases, or induces/inhibits growth factor signaling, which then indirectly affects ECM protein synthesis by fibroblasts/myofibroblasts [8]. By a combination of these mechanisms, mechanical tension induces an activated, contractile fibroblast/myofibroblast phenotype characterized by high levels of synthesis of ECM proteins, low protease activity, and high production of fibrogenic cytokines. Translated into a clinical situation, this means a retractile scar with adhesions between the dermal tissue and the underlying viscera.

The mechanotransduction theories provide possible evidence for several physical non-invasive treatment options. It was suggested that many of the physical scar management methods, including compression therapy, silicone therapy, adhesive tape, and occlusive dressing therapy, are related to mechanotransduction mechanisms. Mechanical compression seems to induce apoptosis and to regulate cytokine release, thus reducing hypertrophic scarring. The effects of mechanical tension on TGF- β 1 and collagen synthesis leads to the hypothesis that brief, moderate stretch of scar tissue seems to downregulate hypertrophy and retraction of scars and could be the best option for splinting, positioning, and postural stretching [9].

54.2 The Effects of Vacuum Massage on Scars

54.2.1 General Effects [1, 10–12]

General effects are defined as the effects inherent to the intervention itself or to the individual who performs the treatment. A number of studies mentioned the measured effects were dependent on the number of treatments. The more the treatment, the higher the effect. After this ascertainment, Adcock et al. also discovered that the principal force applied to the tissue during the therapy depended on the particular type of maneuver performed, with the suction and the roller tension being of minor importance. Moreover, they observed a major decrease of tension in thicker tissue.

In four studies performed, the results showed a setback after a follow-up period without treatment, but one study demonstrated the opposite. All these results are shown in [Table 54.1](#).

Table 54.1 Basic information available in the literature describing effects of vacuum massage on several skin layers

Literature	Etiology	Study design	Targeted skin layer	No. of patients	Assessment	LESS score
Moortgat et al. [16]	Burn scars	CCT	Epidermis/dermis	48	POSAS, touch pressure threshold, DermaLab elasticity	18
Anthonissen et al. [15]	Burn scars	CCT	Epidermis/dermis	47	POSAS, Tristimulus colorimetry, trans-epidermal water loss	18
Adcock et al. [1]	Pig skin	RCT	Dermis/hypodermis	12	Histology	17
Adcock et al. [12]	Pig skin	RCT	Hypodermis	4	Intra-dermal tonometry	16
Revuz et al. [11]	Aging skin	CCT	Dermis	24	Subjective assessment of skin laxity and skin loosening, stereophogrammetry, cutometer	16
Moseley et al. [18]	Scar like	RCT	Dermis/hypodermis	10	Likert scale, tonometry	16
Lucassen et al. [19]	Healthy skin	Pre/post	Dermis/hypodermis	19	High frequency ultrasound	13
Watson et al. [2]	Healthy skin	RCT	Epidermis/dermis	5	Laser-Doppler imaging, lymphoscintigraphy, venous flowmetry	13
Innocenzi et al. [14]	Lipodystrophy	CCT	Epidermis/dermis	12	Descriptive histology	11
Innocenzi et al. [20]	Lipodystrophy	CCT	Epidermis/dermis	15	Quantitative histology	10
Ortonne et al. [21]	Lipodystrophy	RCT	Dermis/hypodermis	30	High frequency ultrasound, fringe projection, skin fold thickness	13
Bourgeois et al. [13]	Scars	RCT	Epidermis/dermis	20	Subjective assessment of pain, itch, tightness, erythema and skin smoothening, profilometry	13
Monteux et al. [22]	Lipodystrophy	Pre/post	Dermis/hypodermis	9	Skin fold thickness	11
Marques et al. [10]	Healthy skin	Pre/post	Hypodermis	12	Gene profiling, micro-array	11
Scuderi et al. [23]	Healthy skin	RCT	Epidermis/dermis	10	Subjective assessment of skin smoothening and skin tone	10
Majani et al. [24]	Scars	Pre/post	Epidermis/dermis	26	Subjective assessment of skin smoothness, pain, tenderness, oedema and aesthetic improvement, histology	10
Marquez-Rebollo et al. [25]	Scar like	Pre/post	Epidermis/dermis	70	Number of indurations	10
Gavroy et al. [26]	Scars	CCT	Details not available	606	Test de glissement	7
Lattarulo et al. [27]	Healthy skin	Pre/post	Epidermis/dermis	34	Laser-Doppler imaging, $tcpO_2$	7
Worret et al. [28]	Scar like	Pre/post	Dermis	10	Subjective assessment of pain, color and elasticity, quality of life, cutometer	7
Delprat et al. [29]	Scars	Pre/post	Details not available	132	Test de glissement	5

RCT randomized controlled trial, *CCT* controlled clinical trial, *tcpO₂* transcutaneous oxygen pressure

54.2.2 Physical Effects [13–16]

An improvement of the tissue hardness and the elasticity of the skin were the two most observed effects. However, most of the studies used subjective methods to quantify these effects. Other reported physical effects were decreased skin fold thickness, decreased face volume, improved skin laxity, increased epidermal thickness, and improved skin roughness. Recent studies have shown that elasticity and redness, measured with subjective and objective assessment tools, were significantly improved after 1 year when the scar was treated for 6 months. The results of one study also revealed that the vacuum massage had minimal value as additive treatment to pressure garments and silicone when it concerned redness. For elasticity, on the other hand, vacuum massage + pressure therapy and silicone seemed to perform better than pressure therapy and silicone alone. The results are set out in ■ Table 54.2.

54.2.3 Physiological Effects [2, 10, 13, 15, 17]

An improvement in blood perfusion was noticed in four studies. Fibroblast proliferation was enhanced together with an increase in collagen content. Two studies mentioned an improved venous and lymphatic flow together with increased transcutaneous oxygen pressure. Smoothing of the dermo-hypodermal junction and a decreased dermal interstitial space were also observed. One study mentioned altered gene expression profiles in adipose tissue. In another study, a significant decrease of trans-epidermal water loss (TEWL) was found and indicated a recovery of the skin barrier. After correction for baseline and age of scar, there was evidence for lower mean TEWL values in the vacuum massage group, significant after 3 months ($p = 0.006$). Humbert et al. investigated the histological effects of vacuum massage and discovered an increased migratory ability of fibroblasts together with increased elastin and hyaluronic acid presence which indicated induced remodeling capacity. The upregulation of MMP-9 suggests degradation of the existing damaged ECM to induce remodeling. These findings were somehow confirmed by the study of

Meirte et al., where an increased dermal thickness together with a decreased dermal density were already noticed in the first 2 hours after a vacuum massage treatment. These results are shown in ■ Table 54.3.

54.2.4 Mechanical Effects

The suction forces generated by vacuum massage could elicit an array of mechanical forces within the tissues, associated with a relaxation of those mechanical forces. Once stress forces on a wound were relieved, apoptosis of myofibroblasts would occur. This finding implies that vacuum massage may release the mechanical stress associated with scar retraction, and thus induce apoptosis. This can be another plausible theory for its mechanism of action to improve the outcome of (burn) scars.

54.3 Conclusion

Although vacuum massage initially had been developed for the treatment of burn scars, literature reveals little evidence for the efficacy of this treatment. Very few studies investigated the effects of vacuum massage on human models with scars. The heterogeneous population and the wide diversity of study designs make it very hard to translate the previously mentioned results toward the burns and scars population in humans. Although the present study contributes additional evidence for the working mechanism of vacuum massage as an anti-scarring agent, the results should be confirmed by studies on human models. Variations in duration, amplitude, or frequency of the treatment have a substantial influence on collagen restructuring and reorientation, thus implying possible beneficial influences on the healing potential by mechanotransduction pathways. Vacuum massage may release the mechanical tension associated with scar retraction, and thus induce apoptosis of myofibroblasts. Suggestions for future research include upscaling the study design, investigating molecular pathways and dose dependency, comparing effects in different stages of repair, including evolutionary parameters and the use of more objective assessment tools.

■ Table 54.2 Overview of the physical effects of vacuum massage on epidermis/dermis/hypodermis

Paper	Tissue hardness subjective	Tissue hardness objective	Elasticity subjective	Elasticity objective	Skin fold thickness	Scar adhesions	Face volume	Skin laxity	Epidermal thickness	Skin roughness	Color subjective	Color objective
Delprat et al. [29]						Decreased						
Gavroy et al. [26]						Decreased						
Adcock et al. [12]		Decreased										
Revuz et al. [11]				No changes			Decreased	Decreased				
Innocenzi et al. [14]									Increased			
Innocenzi et al. [20]									Increased			
Ortonne et al [21].					Decreased					Decreased		
Worret et al. [28]	Decreased		Increased	Increased							Decreased	
Moseley et al. [18]	Decreased	Decreased	Increased									
Bourgeois et al. [13]	Decreased									Decreased	Decreased	
Monteux et al. [22]					Decreased							
Scuderi et al [23].	Decreased							Decreased				
Marquez-Rebollo et al. [25]	Decreased		Increased									
Majani et al. [24]	Decreased		Increased									
Moortgat et al. [16]			Increased	Increased								
Anthonsen et al. [15]												Decreased

■ Table 54.3 Overview of the physiological effects of vacuum massage on epidermis/dermis/hypodermis

Paper	Blood perfusion	Dermo-hypodermal junction	Collagen content	Collagen orientation	TEWL	Lymphatic flow	tcpO ₂	# fibro-blasts	Fibro-blast phenotype	Dermal interstitial space	Superficial vascular surface	Pain	Itch	Altered gene profile
Lucassen et al. [19]		Smoothed												
Adcock et al. [1]			Increased	Dense longitudinal bands										
Watson et al. [2]	Increased					Increased								
Lattarulo et al. [27]	Increased						Increased							
Revuz et al. [11]				Dense longitudinal bands										
Innocenzi et al. [14]								Increased	Secreting					
Innocenzi et al. [20]								Increased	Secreting	Decreased	Increased			
Ortonne et al. [21]		Smoothed												
Worret et al. [28]												Decreased		
Bourgeois et al. [13]											Increased	Decreased	Decreased	
Marques et al. [10]														Yes
Majani et al. [24]										Decreased				
Moortgat et al. [16]												Decreased	Decreased	
Anthonsen et al. [15]					Decreased									

tcpO₂ transcutaneous oxygen pressure, TEWL trans-epidermal water loss

Take-Home Messages

- Vacuum massage is a way of standardizing massage techniques to optimize the treatment.
- Mechanotransduction is the presumed working mechanism behind vacuum massage.
- Improved tissue hardness and elasticity are the two most observed physical effects.
- The effect of vacuum massage is highly dependent on the type of maneuver performed.
- The more treatments are carried out, the higher the effect.
- Fibroblast migratory and proliferative capacities are enhanced by vacuum massage.
- Vacuum massage improves scar elasticity, which will probably lead to amelioration of function.
- Vacuum massage may release the mechanical stress associated with scar retraction.

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