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V-EMF treatment of facial scar: First results

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ABSTRACT

Aim of study: This is a retrospective study aimed at evaluating the effectiveness of the use of electromagnetic fields and negative pressure treatment (V-EMF) for facial scars, from an aesthetic and functional point of view, and considering the variations in the levels of hydration.
Material and methods: 25 subjects with facial scarring were re-evaluated after being treated with the V-EMF method. The hydration levels of the scars before and after treatment were compared. The results were evaluated considering the satisfaction levels of the patients with the VAS, and of the medical specialists who performed the treatment, and of 3 independent dermatologists with the Likert scale.
Results: Mean hydration levels of scars went from 41.8 to 53.3, with mean hydration levels of healthy reference points equal to 54.6. The minimum patient satisfaction level was 2 in the VAS. The minimum level of satisfaction of specialists and dermatologists was equal to IV on the Likert scale for all patients, except for 1 subject in which it was III for the specialist who had treated him. Anti-aging and re-pigmentation effects were also noted as secondary results.
Conclusions: From an aesthetic and functional point of view, and for the overall anti-aging effect of the treated area, V-EMF applied to facial scars has shown extremely promising results.

1. Introduction

In developed countries alone, about 100 million new wound cases resolve into visible scars each year. Of these scars, 55 million are outcomes of elective surgeries, 25 million are outcomes of emergency surgery to resolve trauma, and 20 million have different causes [1]. These numbers do not include a very large number of injuries, again resulting from traumatic events, that do not require surgery.

The impact of scars is not only physiological, but the more they are visible, the more they cause a sense of discomfort in the subjects, with consequent effects on social life, reduction of self-esteem and worsening of interpersonal relationships [2]. These effects are exacerbated when scars are found on the face. They can escalate into emotional blocks and anxiety [3–5].

Although the wounds are of different nature, they all involve, on a superficial level, the laceration of the epidermis, in particular of the stratum corneum, with consequent alteration of the functionality of the epithelial barrier. This functionality is restored only after the complete restructuring of the stratum corneum, with a timing of over a year from the traumatic event [6].

One of the main functions of the epidermis is to maintain the balance of skin homeostasis, which includes the prevention of excessive transepithelial water loss (TEWL) [7]. An increase in TEWL, which causes an alteration in skin hydration levels, also results in a delay in wound healing, and in the formation of hypertrophic forms of scars or other skin alterations [8,9]. The lesion of the stratum corneum alone can consequently induce an alteration of skin homeostasis, an increase in TEWL, and the subsequent alteration of keratinocytes [8].

The risk of a scar degeneration is particularly relevant on the face, which has one of the thinnest stratum corneum in the human body [10], and for this reason it is subject to a greater physiological TEWL.

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Abbreviations

TEWL = transepithelial water loss
V-EMF = vacuum and electromagnetic fields
VAS = visual analog scale

Table 1
Demographics.

Patient	Gender	Age	Cause of scar	Previous therapies
P01	F	28	Trauma	No
P02	F	32	Cut	No
P03	F	25	Trauma	No
P04	F	21	Cut	No
P05	M	35	Trauma	No
P06	M	56	Surgery	No
P07	M	61	Burn	No
P08	F	50	Cut	NAFL
P09	F	48	Trauma	No
P10	M	36	Trauma	No
P11	M	57	Trauma	No
P12	F	48	Burn	No
P13	F	51	Surgery	NAFL
P14	M	51	Burn	No
P15	F	25	Cut	No
P16	F	32	Trauma	Needling
P17	F	41	Trauma	No
P18	F	46	Cut	No
P19	M	37	Surgery	Carboxitherapy
P20	M	41	Surgery	No
P21	F	36	Trauma	No
P22	M	45	Trauma	Carboxitherapy
P23	F	32	Cut	No
P24	F	53	Cut	Needling
P25	M	55	Trauma	No

Abbreviations: F, female; M, male; NAFL, non-ablative fractional laser.

An effective restoration of the epithelial barrier, and the reduction of TEWL, with increased hydration of the stratum corneum, allow both the improvement of the scarring process and of the entire epidermal structure, with morphological restoration of the stratum corneum, increase in cell volume, and a regenerative action similar to an anti-aging effect [11].

The therapies currently used for the reduction of the visual effect of the scars and the functional restoration of the tissues involved in the wound do not always produce appreciable results, especially in the presence of hypertrophic scars and keloids [12–14]. New therapies based on the use of medical devices are gaining momentum, but verifying their effectiveness requires further studies [15–17].

In this study we want to evaluate the use of electromagnetic fields and negative pressure treatment (V-EMF) for facial scars, both from an aesthetic and functional point of view, paying particular attention to the changes in hydration induced in the tissues.

2. Material and methods

This is a retrospective study that analyzes data from a group of subjects undergoing V-EMF treatment for the resolution of facial scars. Written informed consent was collected to use the data, in full compliance with complete anonymity to ensure respect for privacy.

2.1. Subjects

The data from 25 subjects between the ages of 25 and 61, 10 males and 15 females, i.e. 25 scars on the face, of which 3 caused by burns, 4 post-surgical, 7 caused by cuts, and 11 caused by trauma, were re-evaluated. 18 scars had never undergone any treatment, while 7 had undergone minimizing treatments, with no effect. Further personal and etiological data are shown in Table 1.

Patients were selected for treatment based on the following inclusion criteria: healthy (specifically, non-epileptic) subjects with fully healed facial wounds.

The criteria for exclusion from treatment were: presence of pacemakers, presence of acute inflammatory conditions of the skin, subject to oncological pathologies in the previous 5 years, with problems of anemia and bulimia in the previous 2 years.

2.2. Treatment

All subjects were appropriately informed about all the procedures implemented, and signed a written informed consent. The treatments were conducted in private clinics in Italy, in full compliance with ethical principles. All procedures and subsequent evaluations were conducted in accordance with the Declaration of Helsinki, as revised in 1983.

Before each session, the patients' skin was cleaned with a neutral non-alcoholic cleanser.

The V-EMF technique, already used for stretch marks [18,19], was adapted for application on scars. The treatments were delivered according to the Biodermogenesi® method, using the Bi-one® LifeTouchTherapy device (Expo Italia Srl, Florence, Italy). The subjects underwent a cycle of 4–8 sessions, lasting 6–20 min each (depending on the size of the scar), with a frequency of 1–2 sessions per week, based on the clinical evaluation of the scar.

The vacuum was delivered in the range of 100–130 mbar, in order to induce a dilation of the epidermal tissue equal to 1 mm, according to the principle of mechano-transduction [20,21], for the conversion of mechanical stimuli into biochemical signals, aimed at increasing the cellular metabolism [22,23]. In a vacuum regime on the face, this increase also induces an anti-aging action [24,25].

During the vacuum state, an electromagnetic field was applied to promote cell and molecular proliferation [26]. The magnetic field was generated by means of a capacitive system with a capacitor composed of a 1st type armature, covered with electrical insulating material, and a 2nd type armature, consisting of a return electrode and the tissues themselves. The application of the magnetic field induces a migration of ionic charges (principally, Na+, K+) towards the opposite poles of the generator, and, due to the Joule effect, a localized temperature increase, not higher than 1–2 °C with respect to the basal body temperature [27]. It is known that the crossing of the ions of the membranes of fibroblasts and dermal cells favours the absorption by the cells of both nutrients and oxygen [28,29].

It should be noted that the device used for the treatment was able to carry out an automatic feedback control of the telemetry of the subjects, to adapt the output frequency (between 0.5 and 2 MHz) and the power supplied (average power = 4 W), in order to avoid side effects, such as the subject's thermal discomfort [18,30].

At the end of the various sessions no protective, soothing or moisturizing product was applied.

2.3. Evaluations

Before the first (T0) and 2–3 days after the last treatment (T1) a comparison was made between the hydration level of the scar and the hydration level of a control point. The control point was taken at a distance of 3 cm from the scar. If it was impossible to consider this reference, the mirror point on the other side of the face was taken as a control point. The degree of hydration was measured using the Corneometer CM825 instrument (Courage + Khazaka electronic GmbH, Köln, Germany), and levels in the 50–70 range were assumed to be normal hydration levels.

At T1, patient satisfaction was assessed using the transepithelial water loss (TEWL with scores of 0 = not satisfied, 1 = slightly satisfied, 2

Fig. 1. Examples of the results obtained with the treatment. Man with surgical scar along the nasal sulcus and nasolabial line on the left, immediately after surgery (A), after complete wound healing (B), and after treatment with V-EMF (C). Woman with frontal longitudinal scar on the left, after complete wound healing (D), and after treatment with V-EMF (E).

Table 2
Mean hydration levels.

Normal range	T0			T1		
	Scars	Reference points	Scars and intact skin difference	Scars	Scars and intact skin difference	Scars hydration improvement
50/70	41.8 range: 36.2–46.5[a]	54.6 range: 51.1–57.8[a]	−23.45%	53.3 range: 49.8–57.1[a]	- 2.44%	+21.01%

[a] Range of hydration values available for 16 of the 25 subjects.

Table 3
Rating scale at T1.

VAS – Patients [number of subjects (percentage of subjects)]		Likert scale [number of subjects (percentage of subjects)]		
			Specialists	Independent dermatologists
Not satisfied	0 (0%)	No improvement	0 (0%)	0 (0%)
Slightly satisfied	0 (0%)	Mild improvement	1 (4%)	0 (0%)
Satisfied	2 (8%)	Moderate improvement	3 (12%)	2 (8%)
Very satisfied	11 (44%)	Good improvement	11 (44%)	10 (40%)
Extremely satisfied	12 (48%)	Excellent improvement	10 (40%)	13 (52%)

= satisfied, 3 = very satisfied, 4 = extremely satisfied. The medical specialists who performed the treatment evaluated the results obtained using the Likert Scale (I = none, II = slight improvement 1–25%, III = moderate improvement 26–50%, IV = good improvement 51–75%, V = excellent improvement 76–100%). Analyzing the photographic data collected at T0 and T1, three independent dermatologists, completely unaware of the type of treatments performed evaluated the final results using the Likert Scale.

3. Results

A sample of the visual differences observed before and after full treatment, in both a male and a female, is shown in Fig. 1.

Table 2 reports the hydration values measured at T0 and T1 for all subjects, both at the scar level, and at the reference point. At T0 the mean hydration level of the scars showed the presence of TEWL. The reference points had average values in the normal range of hydration. At T1, the mean hydration level of the scars was significantly increased, and the values returned to the normal range, with a minimal difference from the reference points.

Table 3 shows the results of the rating scales at T1. On the VAS scale, patients indicated level 2 as the minimum level of satisfaction. Therefore, no patients were dissatisfied or slightly satisfied with the treatment results. On the Likert scale, all medical specialists assigned scores between IV and V, with the exception of one specialist who chose a level III, for one of the subjects treated. All the independent dermatologists classified the final results of the treatments at levels IV and V.

The entire treated area also visually showed an anti-aging effect, and an unexpected secondary outcome, i.e. exposure to the sun, led to an increase in scar pigmentation.

4. Discussion

Facial scars are particularly critical both because they are difficult to treat, given that the skin of the face has a very thin stratum corneum which determines a greater physiological predisposition to TEWL [10], and because they often involve psychological outcomes relevant to people [2–5].

The thickness of the stratum corneum differs significantly in a subject in the various anatomical sites [10]. This is related to TEWL. On average, the face has TEWL values $> 10\ gm^{-2}h^{-1}$, much higher than other parts of the body. It should be noted that these are average values, since a considerable variability has also been demonstrated in the different parts of the face [10]. However, this allows us to state that the

treatment of scars on the face is more complex than the treatment of scars in other locations, precisely because of the greater difficulty and longer times that the wounds show to heal in dry environments compared to humid ones [31,32].

The lesion of the stratum corneum causes a further increase in TEWL levels, and a consequent overproduction of inflammatory cytokines. In cascade, this determines the stimulation of the uncontrolled production of myofibroblasts [8,33,34]. In the face, a wound causes an exacerbation of TEWL, resulting in an increased susceptibility to the formation of hypertrophic scars, keloids, and skin fibrosis [6]. Taking into account that profibrotic growth factors TGF-β1 and TGF-β2 are predominantly present in adult wounds [34], it is clear that a scar on the face in an adult subject almost certainly has fibrotic sequelae, with associated chronic inflammation [35]. Fibrosis consists mainly of an alteration of the extracellular matrix, with structural and functional impairment. Initially there is an increase in the generation of type III collagen, followed in a short time by the production of type I collagen, which increases the mechanical resistance of the scar, thus determining a deteriorative evolution [36–38].

The methods most commonly used for the treatment of scars, especially if hypertrophic or keloid, do not seem to be particularly effective [39,40], and further studies are need, also aimed at optimizing them [12,15,41]. Silicone gel sheeting and topical therapies with extra-moisturizing creams appear to be particularly promising therapies [8]. In fact, these are methods that aim to restore the right level of skin hydration, reducing TEWL, and preventing the scar from degenerating into hypertrophic scar or keloid [16,42]. Both procedures allow the restoration of the functionality of the epithelial barrier, with a consequent reduction of both the existing inflammations and the secretion of proinflammatory cytokines [43–45].

The method described in this study fully embraces the principle of regeneration of epidermal lesions in order to fully restore the structure and functionality of all the layers involved in the scar. The results obtained in terms of improving the hydration levels of scars seem to confirm the effectiveness of the technique in this sense. Further studies are needed to re-evaluate long-term hydration to understand if the results obtained are consolidated, and the formation of hypertrophic and keloid scars is prevented.

The same technology applied to stretch marks has shown, from a histological point of view, an increase in the thickness of the epidermis, the reorganization of collagen, and the restoration of microcirculation [18,19]. It makes sense to expect the same kind of results on scars. But further studies with adequate histological evaluations are needed.

The correspondence between the levels of patient satisfaction and the satisfaction levels of both medical specialists and independent dermatologists is noted. The coincidence of the evaluations of the two different groups of doctors is particularly relevant, considering that medical specialists could overestimate the results of the treatments, having chosen them.

The anti-aging effect was expected, considering that the technique combines vacuum application and simultaneous electromagnetic stimulation [24,25,28,29]. The tanning effect of the scars was also predictable, as already evidenced in their studies, on the treatment of stretch marks with the same technology, by Bacci et al. [18] and by Scarano et al. [19].

5. Conclusion

A scar is a permanent aesthetic, functional and psychological damage. Identifying a method that solves all these aspects is undoubtedly a challenge for regenerative medicine.

The method described in this study, applied to what are considered the most difficult scars to treat, i.e. facial scars, has shown extremely interesting and promising results, from an aesthetic and functional point of view, with the restoration of hydration levels, and for the overall anti-aging effect of the treated area. Undoubtedly, further studies involving a larger number of patients and with longer follow-ups are needed.

What is certain is that the synergy of multiple treatments, vacuum and electromagnetic fields combined in a single instrument and in a single method, is a fascinating novelty both in the treatment of scars, and in regenerative medicine in general.

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Declaration of competing interest

All authors have no conflicts of interest to disclose.

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