

Bioengineering of the skin – combo makes the difference

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More and more beauty institutes use devices and equipment to optimize their skin care treatments. It also is a fact that most of the device-assisted techniques are inconceivable without the appropriate preparations.

Just to start with an example: the ultrasound unit to stimulate microcirculation and metabolism in the epidermis additionally requires a medium or in other words a specific preparation for the sound transmission. If this preparation now contains active agents, the ultrasound will accelerate their penetration into the skin and improve their efficacy – a typical example of multifunctional work. The following four factors are characteristic for a multifunctional interaction of devices and preparations:

- physical-physiological treatment (device)
- improved penetration of cosmetic active agents
- active agent stimulation under the influence of energy
- onset of the particular active agent action.

If, in addition, appropriate measurements of the skin condition are taken before and after the treatment, we can speak of a perfect bioengineering of the skin. The different factors still may vary intrinsically but what finally matters are the metrologically monitored results. Multifunctionality also is utilised in dermatological treatments – with the difference that the dermatologist by virtue of his education is allowed to apply laser techniques or medical needling with long needles. He also can use pharmaceutical active agents besides the cosmetic actives.

Different forms of energy

In the context of device-assisted treatments, the energy input into the skin and the associated stimulation of active agents and physiological processes play the major role. Energy can be provided by

- electromagnetic waves such as light, infrared, UV and radio frequency radiation including collimated energy in the form of laser or IPL,

- mechanical energy such as ultrasound, shock waves and cavitation, and
- direct heat transfer by means of vaporisation or thermo packs.

Particularly in the field of LED and infrared radiation, treatments have become established with specific emphasis on a selective stimulation of biochemical processes instead of a non-specific heating. LED blue light for instance is used in the context of acne treatments and interacts with the metabolites of bacteria by radical formation. The phototoxic effect damages the bacteria. Similar effects occur with LED red light which is used as part of the photodynamic therapy (PDT) in order to destroy tumor cells. In this case the photosensitizing substance (5-aminolevulinic acid) is topically applied before the treatment.

As with other forms of radiation, the positive anti-inflammatory and healing effects of infrared light, an energy form that for a long time has been regarded as harmless, lie close together with the unwanted radical formation¹. That is why intensity, duration and wave length of the treatment have to be carefully calculated. Since radiation deeply penetrates into the skin in certain areas, the standard cosmetic antioxidants are almost ineffective. With regard to the infrared fraction of sunlight, they even are counterproductive as more or less all the antioxidants inhibit the tyrosinase; they even form radicals when used in the high dosages that would be required in sun protection preparations.

Electric techniques

Mesotherapy, medical needling and abrasive techniques such as microdermabrasion, dermabrasion or hydro dermabrasion with micro

¹ Zastrow L, Groth N, Klein F, Kockott D, Lademann J, Ferrero L, UV, sichtbares Licht, Infrarot – Welche Wellenlängen produzieren oxidativen Stress in der menschlichen Haut? Der Hautarzt 60 (4), 310-317 (2009)

water jets are mechanical techniques without energy transfer. In the context of radiation free electric techniques, the energy only is used for the substance transport.

- **Iontophoresis:** Direct current and pulsed direct current serve for the transport of salt-like, i.e. electrically charged active agents into the skin. Uncharged particles are not affected.
- **Electroporation**, which also relates to **mesoporation**, works in a completely different way. It is supposed to increase the permeability of the cell membranes and the skin barrier by means of electric fields and thus facilitate the passage of larger active agent molecules. Since the technique is based on electrostatic voltage pulses in the kHz range the contact gels with charge carriers (salts) as used in the iontophoresis treatments are counter-productive. Only poorly conducting non-ionic gels and uncharged active agents can be used. Example (INCI): aqua, glycerin, pentylene glycol, xanthan gum.
- **Physical electrotherapy:** The technique is based on alternating current and definitely not appropriate for the transport of active agents. The goal is to stimulate nerves and muscles.
- The cosmetic **high frequency wand** has similar features however with the difference that the high voltages (frequently more than 10,000 V) cause an ionization of the air and hence electric discharges when the (glass) electrode approaches the skin; the electric discharges at minimal flow of electricity generate low amounts of ozone and nitric oxide. Both the gases have disinfecting effects and are used for the local cleansing of acne comedones or for the treatment of inflamed skin areas. The principle has become known as Violet Wand. The ozone in cosmetic vaporisation units (Vapozon) by contrast is generated by conducting the hot water vapour past a quartz lamp that radiates off UV light. The emerging, ozone-containing water vapour serves for the cleansing of the skin.

Simultaneous or consecutive application

In many device-assisted treatments, as for instance with the above described ultrasound unit, the preparations are simultaneously applied. Other treatments, such as energetic

laser, IPL, UV and abrasive techniques, and in certain cases also medical needling, require a different approach. In these cases a triad of cosmetic pre-treatment, instrument-based treatment and cosmetic after-care is beneficial since the preparations will be modified or harmed either by the intensity (laser, IPL) or by the wave length (UV) of the radiation or just interfere with the treatment (abrasive techniques). In the case of medical needling, the physiologically tolerable composition and the absence of sensitizing and irritating substances are the factors that decide whether a certain preparation can be applied simultaneously.

Questions of liability

The compositions (INCI) of all the preparations destined for the device-assisted treatment – including the preparations recommended by the device manufacturers – need to be tested for plausibility and potential adverse effects anyhow. Otherwise creative cosmeticians run the risk of being held liable for damages. Dermatologists too are strongly recommended to attend medical device trainings and carefully read the manuals. An adequately adjusted energy input is essential in order to avoid burns or irreversible tissue damage.

Meanwhile the terms and conditions of sale and delivery of many of the cosmetic manufacturers exclude liability for damages occurring with the use of their preparations in connection with non-ionizing radiation. They point to the fact that compliance with legal regulations² is required. They also claim to pay careful attention to the continuously modifying state of the art in the field of appliances and health care.

By the way, quite a number of theories and new terms circulate in the field of devices, active agents and successful treatments. The favourite terms today grow around “poration” which relates to electroporation and analogously is supposed to illustrate an infiltration. Just to mention an example: By influencing the aquaporins or in other words, the peptides of the cellular water channels, the “aquaporation” induces the cells to absorb more water and water-soluble substances. Concerning the application, aquaporation is modulated by

² Gesetz zum Schutz vor nichtionisierender Strahlung bei der Anwendung am Menschen [NiSG] von 2009 und entsprechende Ausführungsbestimmungen (German Act on the protection against non-ionising radiation for human applications [NiSG], as of 2009 and regulatory statutes)

mesoporation or radio frequency. The complementary preparations contain e.g. glyceryl glucoside (INCI) which is an adequate active agent to retain water and stimulate the aquaporins. If liposomal carrier systems are used which support the penetration of active agents anyhow, it is a debatable point whether the transport into the cells mainly is to be ascribed to the use of devices.

Devices & preparations: an overview on synergies

The following chart summarizes the synergies of devices and preparations and outlines the targeted effects and the principles of devices for facial, neck and décolleté treatments. Whether rejuvenating effects of the skin are

involved and whether the device-assisted treatments are beneficial in the particular case and for the longer term is not evaluated in this context. A number of application details cannot be covered either. It is recommended to closely examine the references and studies in the manuals regarding their practicability before purchasing a particular device. It also is well worth considering what kind of device generally is required for the institute. When it comes to the transport of active agents, effective carrier systems such as liposomes and nanoparticles already can be an alternative to cosmetic microneedling and iontophoresis. A non-instrument-based transport is as effective and not dependent on charge carriers (iontophoresis).

Device principle	Device characteristics	Active agents and preparations
Iontophoresis ³	Transport of ions at about 10-30 mA and max. 60 V direct current	<ul style="list-style-type: none"> • Transport of anions of complex organic acids and salts – frequently as components of extracts. Examples: sodium ascorbyl phosphate and green tea, or transport of cations such as pyridoxine (vitamin B₆). • Uncharged active agents do not travel. An effective alternative are liposomes and nanodispersions – among others also for strong polar acids such as azelaic acid and fumaric acid. • Tap water iontophoresis with pulsed direct current (10 kHz) in the case of hyperhidrosis.
Alternating current	Weak alternating current from 10 to 100 Hz for the stimulation therapy	<ul style="list-style-type: none"> • Stimulation (so-called "pins and needles") of nerves, muscles and cell metabolism – for instance for the treatment of neuralgia. • The adjuvant use of topical pharmaceutical and cosmetic active agents depends on the particular indication and the skin condition. • Alternating current is inappropriate for the penetration of active agents.
Radio frequency (RF)	Local heating of skin and tissue at about 300 kHz - 2.5 MHz ⁴ and 10 - 20 W wattage. It is frequently pulsed with bi and multipolar handheld probes.	<ul style="list-style-type: none"> • Recovery (collagen), cellulite- and wrinkle treatment. Monopolar RF penetrates deeper into the skin since the receiving electrode is located outside of the handheld probe. In the case of high energy input local anaesthetics are applied in order to suppress pains. • Monopolar RF: Improves the penetration of active agents which partly are dissolved in fatty gels by means of heat effect, and stimulation of the microcirculation. Counterproductive are preparations with sensitizing preservatives, declarable perfumes and denatured alcohol. • Bi- and multipolar RF: If at all, only non-aqueous, lipophilic glide media and active agents can be used.

³ "Galvanic microcurrent" (battery current) is a marketing term for home treatments and has a similar function.

⁴ Jabs HU, Radiowellen und Boswellia-Nanopartikel – ein neues Verfahren zur Derma-Rejuvenation, Ästhetische Dermatologie (mdm) 2010 (4), 18-25

Device principle	Device characteristics	Active agents and preparations
Mesoporation	Pulsed electric fields of the same polarity, as e.g. 2 kHz to 37 V at max. 12.5 mA	<ul style="list-style-type: none"> • Opens lamellar structures (skin barrier, cell membranes) for larger molecules as for instance glycosides, analogous to electroporation⁵. • Use of moisturizers⁶ • Adjuvants are cosmetic gels without charge carriers
Infrared (IR)	Heating of skin and tissue – penetrates a few cm	<ul style="list-style-type: none"> • Medium wave IR-B and long wave IR-C⁷ heat the tissue; short wave IR-A light can generate radicals similar to blue light. Radical formation initiates the healing process. Near infrared (NIR) consists of IR-A and IR-B. • Improved circulation is beneficial in the treatment of inflammations, among others also in the case of juvenile acne. • Improved penetration and activation of anti-inflammatory active agents such as for instance boswellic acids⁸. • High radiation power of unfiltered IR light (see above) is counterproductive (cf. IR fraction of sun radiation).
Laser (Light Amplification by Stimulated Emission of Radiation)	Collimated monochromatic, coherent radiation of different wave lengths that are well-adjusted to the absorption in the target tissue or to the substances to eliminate (dermatology).	<ul style="list-style-type: none"> • Used in laser surgery; removal of age spots, of hyperpigmentation, tattoos, superficial wrinkles, scars and other skin alterations; epilation, and spider veins. • Short wave infrared laser (IR-A: 800-1500 nm) liquefy fat depots before the liposuction treatment. • Pre-treatment and after-care with liposomal tyrosinase inhibitors as for instance Sodium Ascorbyl Phosphate (INCI)^{9 10} eliminate radicals and avoid post-inflammatory hyperpigmentation (PIH)¹¹. In the case of irritated skin and redness, alpha-linolenic acid containing linseed oil and kiwi seed oil nanodispersions are recommended.¹²
IPL (Intense Pulsed Light)	Pulsed collimated light (polychromatic)	<ul style="list-style-type: none"> • Used for instance for the photoepilation. • The adjuvant skin care is similar to laser treatments.⁹
Red light (cool)	630-635 nm (dermatology)	<ul style="list-style-type: none"> • Stimulation of the skin metabolism.¹³ • Photodynamic therapy (PDT) to treat actinic keratosis and skin cancer. Irritated skin and erythema are part of the therapy. • PDT pre-treatment: liposomes improve the penetration of 5-amino levulinic acid (5-ALA)

⁵ The original electroporation uses electric fields generated by capacitor charging and discharging.

⁶ Lautenschläger H, Wasserhaushalt der Haut – Moisturizer & Co. medical Beauty Forum 2014 (1), 18-20

⁷ IR-C is equivalent to the common heat radiation – i.e. heating or sauna heat.

⁸ Lautenschläger H, Weihrauch – Harz mit Heilkraft, medical Beauty Forum 2015 (4), 12-16

⁹ Lautenschläger H, Laser- & IPL-Behandlungen – Hautgerechte Pflege, Beauty Forum 2009 (9), 70-72

¹⁰ Lautenschläger H, Hautpflege vor und nach Eingriffen, medical Beauty Forum 2015 (1), 34-37

¹¹ Lautenschläger H, Haut ohne Makel – Wirkstoffe und Wirkstoffsysteme, medical Beauty Forum 2014 (5), 32-35

¹² Lautenschläger H, Das ABC der Fettsäuren, Beauty Forum 2009 (12), 40-47

¹³ Wunsch A, Lichttechniken, medical Beauty Forum 2015 (4), 30-34

Device principle	Device characteristics	Active agents and preparations
Blue light	425-475 nm	<ul style="list-style-type: none"> Blue light induces radical formation similar to the IR-A radiation. Radical formation initiates the healing process. Radiation of bad and acne-prone skin Pre-treatment and after-care with azelaic acid (inhibits 5-alpha-reductase), boswellic acids (inhibit protease), linoleic and linolenic acids and vitamin B₆ (inhibits inflammations).
Ultraviolet-A-radiation (UV-A)	315-380 nm (dermatology)	<ul style="list-style-type: none"> PUVA (Psoralen + UV-A): Phototherapy after the oral intake or topical application of 8-methoxypsoralen (photosensitizing substance) as e.g. in the case of psoriasis. Skin care with liposomal fumaric acid (psoriasis)
Gamma radiation	Cancer treatment (medical)	<ul style="list-style-type: none"> Skin care in cases where the skin is a passage organ, particularly with preparations to treat dry and inflamed skin¹⁴
Microwaves	1-300 mm (dermatology)	<ul style="list-style-type: none"> Permanent elimination of the sweat glands and adjacent nerves with the microwave handpiece – local heat effect¹⁵ Adverse effects are redness and swellings. Barrier focused skin care with recovering vitamins as for instance liposomal Niacinamide (INCI).
Ultrasound	Usually 1-40 MHz.	<ul style="list-style-type: none"> Stimulation of the microcirculation, tightening of the connective tissue, mobilization of fat cells (cellulite) Combination of sera with ultrasound gels.¹⁶ Examples are lipolytic active agents such as caffeine, green tea extract and phosphatidylcholine (cellulite). Hyaluronic acid and amino acids in the case of dry and wrinkled skin. Vitamin A – optional Retinyl Palmitate (INCI) – and vitamin B₆ (Niacinamide) for the recovery. Tissue tightening with the saponin-rich butcher's broom, kigelia, aescin, centella asiatica and horsetail extracts. Gels with sensitizing preservatives, declarable perfume components and denatured alcohol are counterproductive. If the treatment is focused on the substance transport and liposomal or nanoparticulate active agent concentrates are used there is no need for ultrasound application.

¹⁴ Lautenschläger H, Hautpflege bei Strahlentherapie – Beruhigen, stärken & schützen, Beauty Forum 2008 (8), 32-34

¹⁵ Jokisch R, Neues nicht-invasives Thermolyse-Verfahren gegen Hyperhidrosis axillaris und Bromhidrose, Ästhetische Dermatologie (mdm) 2014 (8), 6-9

¹⁶ Lautenschläger H, Ultraschallgele – Wirkungsweise, Aufbau, Spezialanwendungen, Beauty Forum 2008 (12), 50-52

Device principle	Device characteristics	Active agents and preparations
Shock waves	Treatment example: 2,000 pulses with 0.35 mJ/mm ²	<ul style="list-style-type: none"> • Mobilization of lipids and disordered lymphatic flux (Cellulite¹⁷) with extracorporeal radial and focused shock wave therapy (ESWT). Tightening of connective tissue and scar treatment.^{18 19} • Shock and acoustic waves alternately produce positive and negative pressure. High negative pressure generates gas bubbles (cavitation) and can destroy fat cells. • Contact gels with similar active agents as for the ultrasound treatment can be used.
Mesotherapy	Microinjections (dermatology)	<ul style="list-style-type: none"> • Replacement therapy for the injection-based lipolysis by a multitude of microinjections to transport sera into intermediate skin layers ("meso") • Wrinkle, scar and cellulite treatments with hyaluronic acid and peptides (wrinkles), vitamin A and derivatives (scars) as well as caffeine and phosphatidylcholine (cellulite). • Rollers with a needle length of 0.2 to 0.3 mm belong to the cosmetic needling (see above).
Medical Needling	Needle length 0.5 - 3 mm (dermatology)	<ul style="list-style-type: none"> • Recovery of scars and ageing skin as well as treatment of wrinkles and pigment disorders; stimulation of the collagen synthesis²⁰. • Pre-treatment and after-care with tyrosinase inhibiting active agents such as liposomal Ascorbyl Phosphate (INCI) to impede post-inflammatory hyperpigmentation (PIH). • Pre-treatment and after-care with antiseptic needling tonics. • After-care of exudate free areas with the vitamins A, C, E, D-panthenol and lamellar barrier creams to support the recovery. • Rollers with a needle length of up to 0.2 to 0.3 mm can also be used in beauty institutes. The aim is to facilitate the passage of active agents through the horny layer. Active agents cf. ultrasound treatment. An alternative are liposomes and nanodispersions.
Device-assisted abrasive techniques	Abrasion (rotating), microdermabrasion ("sanding" with aluminium oxide or silicon dioxide), water jets ("high pressure cleanser"), skin scrubber	<ul style="list-style-type: none"> • Treatment of scars, cornification disorders, wrinkles, hyperpigmentation and ageing skin. The water jet technique allows for the application of active agents dissolved in water. • The treatment intervals between abrasive treatments (peelings) have to allow for a sufficient recovery of the skin, which means that several weeks of recovering skin care should be planned between the treatments. • After-care with recovering sera, tyrosinase inhibitors, barrier creams and UV filters, where applicable.²¹

¹⁷ Lübberding S, Evidenzbasierte Methoden zur Behandlung der Cellulite, Ästhetische Dermatologie (Springer) 2015 (4), 18-21

¹⁸ Knobloch K, Redeker J, Vogt PM, Stoßwellentherapie in der plastischen Chirurgie, Plastische Chirurgie 2, 9-16 (2009)

¹⁹ Wess O, Physikalische Grundlagen der extrakorporalen Stoßwellentherapie, Journal für Mineralstoffwechsel 11 (4), 7-18 (2004)

²⁰ Setterfield L, The Concise Guide to Dermal Needling, Acacia Dermacare, Canada, 2013, ISBN 978-0-9920604-0-4

²¹ Lautenschläger H, Mechanisch, chemisch, enzymatisch – Peelings für alle Fälle, Beauty Forum 2009 (7), 56-58

Device principle	Device characteristics	Active agents and preparations
Thermal techniques	Vaporisation, packs (body wrapping)	<ul style="list-style-type: none"> • Both vaporisation (external heat; vaporising device „Vapozon“) and packs (body heat) stimulate the micro-circulation and the receptivity of the skin for active agents. • Occlusion and the associated swelling of the skin accelerate the substance transport in the case of packs (body wrapping). • The active agents in packs depend on the respective skin condition hence there is quite a broad range of potential actives.²² • Ozone affects organic substances and that's why the ozone valve needs to be shut off (see above) in the case of adjuvant aroma treatment and application of active agents.
Cryo techniques	Cryo chambers, small probes (until minus 190 °C); large probes (about plus 4 °C until minus 10 °C)	<ul style="list-style-type: none"> • Cryo chambers (cryotherapy): Tissue tightening, stimulation of the microcirculation, rheumatic indications. • Small probes for cryopeeling: Treatment and removal of age spots, scars (as e.g. acne), warts, moles, tumours. Adverse effects: redness, blisters, necroses. Skin care only after a complete healing with active agents that are individually adapted to the indication and the skin reaction (see ultrasound and scar treatment²³). • Large probes for cryolipolysis: suction of subcutaneous lipids with negative pressure and application of freeze-proof contact gels. Reduction and destruction of fat cells. Adverse effects are redness and irritated skin. Skin care, see ultrasound (cellulite).

Addendum: Concluding, it should be mentioned that almost all the device-related studies reporting on anti-aging effects are of short term nature. Also controversial points of view are omnipresent. Just to mention an example: radical formation through electromagnetic waves for instance is described as harmful on the one hand and inhibiting measures using radical scavengers are postulated. On the other hand, the function of radicals as an important natural trigger for repair and healing processes is described.

What is sure is that too much of a good thing is harmful. Or in other words, Paracelsus' following quotation also applies for instruments and devices: "All things are poison and nothing (is) without poison; only the dose makes that a thing is no poison". Whether the sentence is observed in practice is anyone's guess. In any case, a well-trained and experienced staff is the main prerequisite for perfect bio-engineering and long term success.

Dr. Hans Lautenschläger

²² Lautenschläger H, Muntermacher – Masken und Packungen, Kosmetik International 2002 (8), 34-37

²³ Lautenschläger H, Narbenbehandlung – kosmetische Prävention und Pflege, Kosmetik International 2008 (8), 36-38