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On the Use of Thermoelectric Cooling In Cosmetology

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This paper presents the analysis of modern cryotherapy methods that are used to remedy skin defects in cosmetology. It is shown that traditional cryotherapy methods have a number of shortcomings, such as impossibility to assure controlled temperature mode and visual control of skin surface cooling temperature during a therapeutic procedure, etc. The above shortcomings are absent with the use of thermoelectric cooling which makes it possible to avoid them and improve the efficiency of curative procedures. The prospects of using thermoelectric cooling in cosmetology are determined.

Keywords: cosmetology, cryotherapy, thermoelectric cooling.

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Introduction

Cryotherapy is a cosmetology procedure based on the artificial effects of cold on the heat receptors of skin (epidermis). Liquid nitrogen is most commonly used for cryotherapy; its temperature reaches -196 °C. Such temperature impact on the human skin is a kind of stress for the body, though it has only a positive effect. Under the influence of low temperatures, at first there is a sharp vasoconstriction, followed by vasodilatation, which contributes to saturation of cell structures with nutrients, oxygen, stimulates the flow of metabolic processes at the cellular level. It should be noted that any cosmetic treatments (peeling, masks, wraps, nourishing compresses, etc.) in combination with cryotherapy will have better performance and a more pronounced effect [1-5].

Low temperatures, in addition to the healing and toning effect, accelerate the treatment of skin diseases, promote the healing of scars, bruises, cuts and strengthen weakened hair, etc. The cryotherapy procedure can have a general (whole body of the patient) or local temperature effect whereby cold affects the problem areas of human skin. During the general procedure of cryotherapy, nerve cells independently determine the problem areas in the human body and start the processes of self-healing. It has been established that the use of cryotherapy helps to strengthen the immune system, to prevent and cure some diseases and pathologies and to normalize the processes of metabolism in the human body [6-11]. However, traditional methods of cryotherapy are not perfect and have certain disadvantages. In case of improper use of liquid nitrogen or deviation from the treatment method, serious complications may occur (overcooling, frostbite, allergic reaction, etc.). When conducting therapeutic procedures on the basis of liquid nitrogen, there is no control of working tool temperature, which may cause the corresponding frostbite risks. Therefore, the possibility of using thermoelectric cooling in cosmetology should be investigated, which excludes the above-mentioned drawbacks of traditional methods of cryotherapy [12-17].

The purpose of the work is to analyze the current state of using traditional methods of cryotherapy to eliminate cosmetic skin defects and determine the promising trends of thermoelectric cooling in cosmetology.

I. Methods of cryotherapy in cosmetology

Cryotherapy is a section of physiotherapy that studies the artificial effects of cold on the heat receptors of the skin (in particular, the epidermis). Most commonly, in medical practice, liquid nitrogen is used whose temperature reaches -196 ° C. Such a temperature effect on the human skin is a kind of stress for the body, which has an exclusively positive effect. Under the influence of low temperatures, there is a sharp vasoconstriction followed by vasodilatation, which helps to increase the rate of metabolic processes inside the tissues, stimulate the processes of cell regeneration and

increase the flow of blood supplying oxygen and nutrients to the cells. Active metabolism inside the tissues leads to a renewal of the body at the cellular level, saturation of cellular structures with nutrients, oxygen and stimulates the course of metabolic processes [3].

Methods of cryotherapy include [1-11]:

cryopeeling (aerocryopeeling) is a method of removing the upper keratinous layer of skin cells using therapeutic manipulations based on liquid nitrogen and cold air. In this case, cosmetologists use liquid nitrogen in the form of spray, the required skin area is treated for no more than 40 seconds. As a result of cryopeeling, one can get rid of various slight defects (small scars, traces of acne, pigment spots, fine wrinkles, etc.), refresh the skin and rejuvenate it. After the procedure, the skin becomes reddened for several days, but after that the upper layer (epidermis) is exfoliated, and it becomes even, smooth and light. Cryopeeling is usually carried out in autumn or winter, when the sun is less active, and there is no risk of the appearance of pigment spots on the site of grinding;

cryoplasty (cryolifting) is a method of rejuvenating the skin with the help of drugs and moderate temperatures. In this case, the procedure is carried out without the use of liquid nitrogen, but with the aid of medical devices based on the Peltier effect. At -15÷-20 °C, under the influence of cold, the superficial vessels of the skin constrict, and then reflexively dilate, increasing the permeability of the skin and promoting penetration of therapeutic and moisturizing substances into the deepest skin layers. After the procedure, the skin becomes more elastic and smooth, there is a natural healthy flush, pores narrow, bags disappear under the eyes, etc. Cryoplasty is something like mesotherapy, but this method avoids the unpleasant sensations of piercing with a needle, leaving traces and discomfort after the procedure;

cryodermabrasion is a method designed to reduce cellulite, rejuvenate the skin, as well as to smooth out scarring and any atrophic and hypertrophic skin changes. During cryodermabrasion, the problem area of the skin is divided into several sections and each of them is treated with special rollers and cryodestructor layer by layer. The process lasts 5-7 minutes, and cycles are repeated until complete skin leveling. Ultralow temperatures stimulate the formation of elastic fibers, which allows, even in the presence of coarse scars, to achieve a positive result. It should be noted that for those who are afraid of any surgical interventions, this method is the most optimal option;

cryodestruction is a method for removing various skin formations by deep freezing of biological tissues. The mechanism of damage to tissues by cryogen is due to destructive effect on cellular elements as a result of formation of ice crystals inside the cells. During thawing, the concentration of electrolyte in cells increases, which is accompanied by recrystallization, which accelerates their destruction. Under the influence of low temperatures, there occur microcircular disorders in the form of vascular stasis (stop of blood flow in vessels for a short period of time). Repeated freezing cycles are accompanied by maximum cell destruction. The destructive effect of cryogen on skin formation is due to its action on the cells. In this case, the structural composition, collagen fibers and the ability to regenerate nerve fibers are retained. This ensures normal healing of the wound after cryodestruction;

cryoelectrophoresis is a method that helps to get rid of cellulite and wrinkles on the face, neck and decollete area, etc. The mechanism of action of cryoelectrophoresis is based on the effects of cold, active substances and microcurrents on skin cells and subcutaneous fat. The procedure is carried out through use of two electrodes, one of which contains a frozen drug, and the other passes pulsating electric current. The therapeutic procedure lasts until all the ice has melted and drugs completely penetrate inside the skin. Computer programs used in this method make it possible to program the administration of drugs into the skin at a certain depth. After the course of cryoelectrophoresis, the inflammatory process in the skin decreases, acne and pigment stains disappear, salivation is normalized, etc;

cryolipolysis is a method of destroying subcutaneous fat tissue using a special device with a vacuum nozzle, which during the procedure draws the skin and cools it with liquid nitrogen. In frozen zones, fat cells break down naturally. Thus, the thickness of fat tissue of the human body can be reduced by 30 %. Cryolipolysis is an alternative to the liposuction procedure, which is known to be performed by surgical intervention. With this cryoprocedure, it is possible to remove unwanted subcutaneous fat from the abdomen, knees, back, the inner and outer surfaces of the thighs;

cryoscarping is a method of complete freezing of the upper skin layer (epidermis). This method is efficient when removing superficial vascular formations, as well as pigment neoplasms of the skin. The procedure is carried out using liquid nitrogen. With prolonged temperature exposure, a cryogenic burn of 1-2 degree occurs with subsequent exfoliation of pigmentation. Cryoscarping is an alternative to surgical intervention;

cryomassage is a kind of hardware massage which uses the effect of cold on human skin. Cryomassage is performed using liquid nitrogen which does not directly contact the skin. The cosmetologist uses a wooden stick with a roller, which is immersed in liquid nitrogen, and conducts contactless massage of the face or other parts of the body (along the massage lines). An “air cushion” is formed between the cotton swab and the skin of the patient which provides healing and rejuvenating effect. The duration of the temperature effect during cryomassage is chosen by the cosmetologist individually for each patient and can be performed both pointwise (directly on the required skin area), and throughout the patient’s body. After the procedure of cryomassage, the patient experiences blood flow and the skin begins to breathe vigorously;

cryosauna is used to rejuvenate the body, in the treatment of skin diseases, and in the fight against cellulite. Cryosauna is a small chamber filled with liquid nitrogen, which includes wearing special warm clothes, mittens and socks for the patient. Under the influence of cold, the temperature of skin surface in a moment is

Table 1

Disadvantages of existing cryotherapy methods [1, 12-17]

Cryogen	Cryogen temperature	Disadvantages
Liquid nitrogen (N_2)	-196 °C	• For transportation, a Dewar vessel is required, in which liquid nitrogen is stored (inconvenience); • therapeutic procedures with liquid nitrogen should be carried out in a special room; • if liquid nitrogen gets onto unprotected skin, there is a danger of frostbite; • in case of misuse of cryogen or deviation from treatment, serious complications may occur; • lack of temperature control during therapeutic manipulations.
Carbon dioxide snow (CO_2)	-78 °C	• carbon dioxide is stored and transported in steel cylinders at a pressure of 60-70 atm, which is a great danger; • with slight deviations from the treatment method, you can get all four degrees of frostbite skin; • during the course of medical procedures, a secondary infection may occur; • lack of control of the temperature of working instrument and skin surface during therapeutic treatment.
Chlorethyl (C_2H_5Cl)	(-13 ÷ +12) °C	• flammable, toxic; • lack of temperature control, which can lead to overcooling and frostbite.

Table 2

Advantages of thermoelectric cooling [12-20]

Method of temperature exposure	Working tool temperature	Advantages
Thermoelectric cooling	(-80 ÷ 0) °C	• possibility of creating miniature cooling devices with a virtually unlimited service life; • absence of working fluids and gases in cooling systems; • possibility of work with large mechanical overloads; • possibility of temperature control by changing the supply current through the Peltier thermoelectric module; • possibility of visualization, maintenance at given level and control of working tool temperature during therapeutic treatment; • possibility of cyclic change in the temperature of working tool (-80 ÷ +50) °C according to a predetermined law in order to avoid its freezing to the skin, which increases the efficiency of treatment process; • possibility to use in the treatment of pollen disease (allergic reaction to cold), since the thermoelectric method can smoothly change the temperature of therapeutic effect.

reduced to +2°C. There is no danger to health because in only 2-3 minutes (during the procedure) only the upper skin layer, where the heat receptors are located, can be cooled down. During a two-minute session in a cryochamber in case of intense heat exchange, a person can lose up to 2000 Kcal. Due to such a therapeutic procedure, the skin is renewed, cellulite almost disappears, body weight decreases and muscle tightening occurs.

However, the above methods of cryotherapy have contraindications - cold allergy (pollen disease). Such an allergy manifests itself in contact with cold: with frosty air, cool water, snow, etc. These are the so-called pseudo-allergic reactions, because the true allergy is the response of the organism to a foreign stimulus. In this case, there is no foreign stimulus, but unpleasant symptoms appear due to the physical effects of low temperature. Pollen disease is manifested at any age, but mainly affects women between the ages of 25-30 years. The following are the symptoms of pollen disease: severe nasal congestion and its slight edema (sometimes it may be a manifestation of vasodilatory rhinitis), redness of the skin, skin peeling, the appearance of spots and even blistering (cold urticaria or dermatitis), redness of the eyes, itching, tears (conjunctivitis). In case of pollen disease, cryotherapy is prohibited, because the employed chemical elements quickly cool the skin, and this is unacceptable for this disease [18]. That is why the above

methods of cryotherapy can only be used with the permission of the doctor.

II. Application potential of thermoelectric cooling in cosmetology

The above methods of cryotherapy are based on the use of liquid nitrogen, carbon dioxide and chlorethyl. However, these cryogens have a number of disadvantages that are endangering both the patient and the physician (Table 1).

The aforementioned shortcomings are not present with the use of thermoelectric cooling [19, 20], which is an effective means for the creation of a variety of thermoelectric devices for medical use. Constructive plasticity, reliability, ease of management and the ability to accurately control the temperature create favourable conditions for the wide practical application of such devices in medical practice. Application potential of thermoelectric cooling in cosmetology is due to a number of advantages (Table 2):

Thus, the use of thermoelectric cooling is promising for cryomassage, stimulation of metabolism and smoothing of skin wrinkles in cosmetology; elimination of cosmetic skin defects in plastic surgery; treatment of suppurative inflammatory processes and various skin diseases in dermatology; for the removal of skin tumors in dermato-oncology

Conclusions

1. It has been established that thermoelectric cooling has a bright outlook for conducting cryomassage, stimulation of metabolism, smoothing skin wrinkles in cosmetology and eliminating cosmetic skin defects in plastic surgery.

2. Thermoelectric cooling has several advantages over traditional methods of cryotherapy, namely: the possibility of creating controlled temperature regimes of thermal effects on human skin; the possibility of regulating and cyclically changing the temperature of the working tool by changing the supply current through thermoelectric Peltier module; the possibility to visualize, maintain at a given level and control the temperature of the working tool during the therapeutic effect.

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Про застосування термоелектричного охолодження у косметології

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У роботі наведено аналіз сучасних методів кріотерапії, що використовують для усунення дефектів шкіри у косметології. Показано, що традиційні методи кріотерапії мають низку недоліків, зокрема неможливість забезпечення контрольованого температурного режиму та візуального контролю температури охолодження поверхні шкіри під час терапевтичної процедури тощо. Вказані недоліки відсутні при використанні термоелектричного охолодження, що дає можливість позбутися вказаних вище недоліків та підвищити ефективність лікувальних процедур. Визначено перспективи застосування термоелектричного охолодження у косметології.