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## ON THE USE OF THERMOELECTRIC COOLING IN DERMATOLOGY AND COSMETOLOGY

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*A review of current status of thermoelectricity application in dermatology and cosmetology is given. The paper presents currently used thermoelectric devices for treatment of skin diseases, their classification and a brief description of technical specifications.*

*It has been established that thermoelectric devices for treatment of skin diseases offer a number of advantages over medical equipment based on liquid nitrogen, namely: temperature control of work instrument, high temperature accuracy, self-containment, compactness, reliability, simplicity and safety of application. The priority lines of using thermoelectric devices in dermatology and cosmetology have been determined.*

**Key words:** thermoelectric cooling, dermatology, cosmetology.

### Introduction

*General characterization of the problem.* Thermoelectric cooling is widely used in many fields of science and technology, in particular, medicine [1 – 3]. It is commonly known in medical practice that thermal effect is an important factor of treatment of many human health problems, including skin diseases.

The scientific line and methods related to effect on the organism of extremely low temperatures is called cryotherapy. Cryotherapy methods are conventionally divided into cryodestruction and cryomassage. During cryodestruction, specialists remove warts, including pointed condylomas, as well as molluscum contagiosum, benign skin neoplasms (keratomas, papyllomas, etc), various scars, restricted hyperkeratoses, etc. At the same time, cryomassage is widely used for treatment of acne vulgaris, acne rosacea, alopecia, lochen rubber planus, patchy neurodermatitis and other dermatoses. In cosmetology, low temperatures are used for cryorejuvenation, whereby skin elasticity is enhanced, cellulite signs disappear or are reduced, and all skin aging processes on human face and body are decelerated [4 – 8].

However, devices used for this purpose in medical practice in the majority of cases are cumbersome, without proper opportunities of temperature control and thermal modes simulation. In order to achieve low temperatures, in national dermatology and cosmetology use is preferably made of liquid nitrogen, which is quickly evaporated and requires special storage, which restricts considerably the possibilities of its use in medical and cosmetology institutions. That is why the use of thermal effect of low temperatures on patient organism is involved today with certain difficulties and disadvantages, which motivates the *relevance* of development of novel, more state-of-the-art and controlled equipment for cryotherapy realization in medical practice. This, in turn, creates certain difficulties with the use of temperature effect on human body.

The relevance of the work lies in creation of new up-to-date thermoelectric medical equipment and its proof of concept study for the purpose of development of practical recommendations and treatment of skin diseases.

All known thermoelectric devices for treatment of skin diseases by the temperature effect can be divided into the following groups [9]:

- Thermoelectric devices using strong cooling ( $-60 \div -25$ )°C for freezing out (cryodestruction) of skin defects, treatment of skin neoplasms and carrying out surgical interventions;
- Thermoelectric devices using moderate cooling (for performance of cryomassage) or heating ( $-25 \div +60$ )°C, for treatment of skin diseases by contrast temperature effect.

Therefore, the purpose of this work is to analyze current status of thermoelectric cooling application in dermatology and cosmetology, as well to develop recommendations as to the use of thermoelectric device ALTEC-7010 for treatment of skin diseases in medical practice.

### Thermoelectric devices for dermatology

An example of modern developments in the field of medical equipment that are based on thermoelectric modules is Kryotur 600 (Fig. 1, a). The device is intended for local cryotherapy, in particular, for arrest of bleeding, pain control, prevention of inflammation, avoidance of edemas, and is used in case of dislocations, strains, shocks, damages of muscles or joints, preoperative preparation of patients. The temperature of device working applicator is set with a step of 1°C to -10°C and maintained at given level during the therapeutic procedure. The applicator temperature is controlled by means of temperature sensor and displayed on computer screen. Apart from the applicator, a changeable applicator-cuff can be connected to the device for moderate cooling to +12°C, as well as a changeable applicator with a head that can be cooled to -35°C for dermatocosmetology [10].



Fig. 1. a) Kryotur 600 (Germany) [10]; b) Kholod-01 (Russia) [11]; c) Cryos Card (Italy) [12]; d) Ar Tek Spot (USA) [13]; e) Ar Tek Air (USA) [14]; f) Cryocell (Korea) [15].

Apparatus for local contrast cooling of surface layers of biological tissue Kholod-01 (Fig. 1, *b*) is used to achieve therapeutic effect and cryomassage performance [11]. Structurally, the apparatus is composed of thermoelectric therapeutic device and power supply unit. Maximum cooling temperature is  $-12^{\circ}\text{C}$ .

One of modern devices for cryotherapy is a compact medical apparatus Cryos Card (Fig. 1, *c*), intended for cryotherapy, thermotherapy, treatment of inflammatory processes, pain control, posttraumatic rehabilitation, treatment of rheumatic diseases, psoriasis, etc. Analgetic end-point is achieved due to temperature effect on sensitive nerve fibers. The apparatus is equipped with a cryoradiator and thermal cone for cryotherapy, with possible control of temperature range from  $-10^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$  [12].

Cryomassage device ArTek Spot (Fig. 1, *d*) is intended for local cooling of damaged human body area and is used in various medical institutions and beauty salons for pain syndrome control at depilation and removal of tattoos, reduction of edemas, sores and thermal traumas. The device is composed of cooling and control unit, as well as of several work of various shape intended for therapeutic procedures on the face, back, hands and legs. Precise temperature control of work instruments eliminates the risk of freeze burn and damage of biological tissues. The operating temperature range of device is  $0 \div +40^{\circ}\text{C}$  [13].

Cryotherapy device ArTek Air (Fig. 1, *e*) is intended for cooling of human skin surface. It is used for cryomassage, pain control, reduction of edemas and temporary pain relief at injections. The device operating principle is based on air flux cooling by means of thermoelectric Peltier modules. Later on, using air cooled to the required temperature, therapeutic procedures on patient skin are performed. The device is composed of cooling thermoelectric unit and operating probe for delivery of “cold” or “hot” air [14].

Cryocell device (Fig. 1, *f*) is intended for cryomassage and treatment of human skin diseases by means of cryoelectrophoresis method. Such device makes it possible to perform cryotherapy, “hot” therapy, ionophoresis, electric therapy, as well as combined thermal effect on patient skin. The device is used for pain attenuation at traumas [15].

Table 1 lists examples of patented developments of thermoelectric devices for dermatology (Figs. 2 – 13) [16 – 27].

### **Thermoelectric devices for cosmetology**

Modern apparatus Cryolift 3 (Fig. 14, *a*) is used in many beauty salons for cryotherapy and luminotherapy. For pain abatement when performing cosmetic procedures, use is made of local cooling of patient skin by means of work applicator with an embedded thermoelectric cooler. Apparatus Cryolift 3 provides for two modes of light effect: pulsed and continuous. Pulsed mode assures more effective stimulation of collagen synthesis due to deep penetration to biological tissues and influence on intracellular organs. Luminotherapy is successfully used in anti-cellulite programs, for correction of age skin changes, for treatment of inflammatory processes (erythema, edema, etc.), in a complex treatment of alopecia, in the prophylaxis of hypertrophic scars and post-inflammatory hyperpigmentation, to accelerate their healing. Combination in one procedure of luminotherapy and cryotherapy creates a synergetic “anti-age” effect (biorevitalization and skin amelioration) [28].

Table 1

Patented developments of thermoelectric devices for dermatology

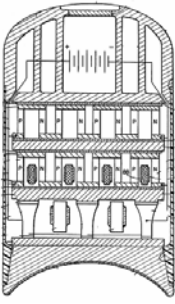
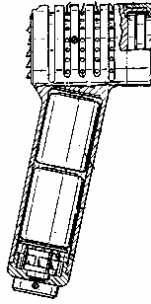
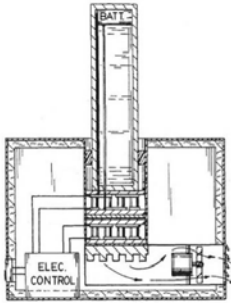
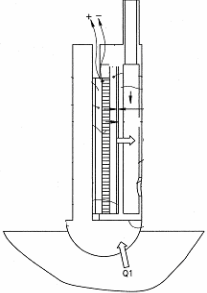
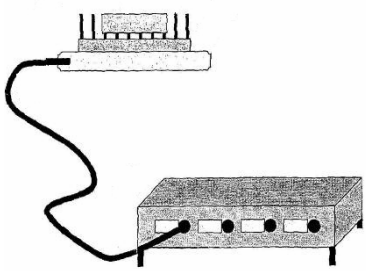
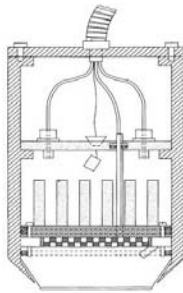
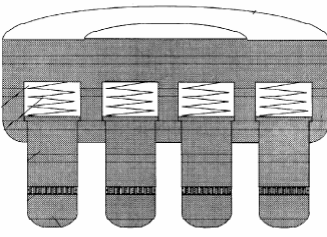
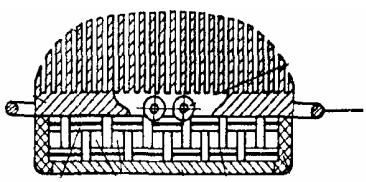
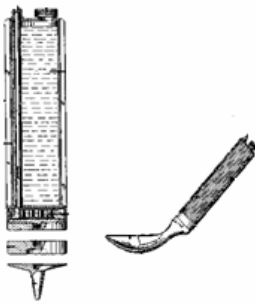
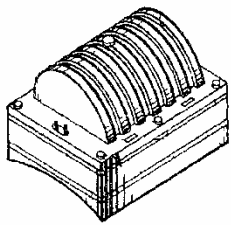
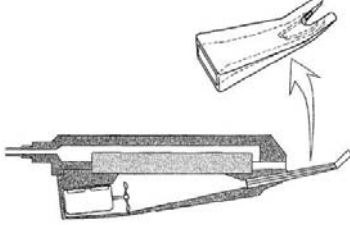
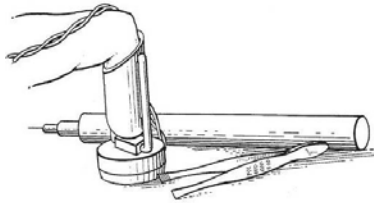
 <p>Fig. 2. Instrument for therapeutic hypothermia (US 4483341A) [16].</p>	 <p>Fig. 3. Device for heating and cooling of skin (US 5097828, US5209227) [17].</p>	 <p>Fig. 4. Support for precooling of probe (US 5277030) [18].</p>
 <p>Fig. 5. Cryocatheter (WO 2013164820A1) [19].</p>	 <p>Fig. 6. Device for thermal exposure of skin (DE 10147563) [20].</p>	 <p>Fig. 7. Cryoprobe (US 6017337) [21].</p>
 <p>Fig. 8. Thermoelectric device for treatment of head skin diseases (RF 2341737) [22].</p>	 <p>Fig. 9. Microcooler for treatment of skin diseases [23].</p>	 <p>Fig. 10. Thermoelectric medical device – cold lancet (US3133539) [24].</p>
 <p>Fig. 11. Hypothermal device (US 3327713) [25].</p>	 <p>Fig. 12. Device for treatment of skin diseases and surgical operations (US 7037326) [26].</p>	 <p>Fig. 13. Cooling probe for skin (US 4614191) [27].</p>



Fig.14.: a) Cryolift 3 (Italy) [28]; b) FormaxPlus (Israel) [29]; c) Broad Band Light (BBL)(USA) [30]; d) HS 810 diode laser (China) [31]; e) SkinPulse 500 (Germany) [32]; f) ProShockIce (China) [33].

Device FormaxPlus (Fig. 14, b) is used for depilation, reduction of wrinkles and scars after acneiform rash, reduction of vessels and pigment spots on patient skin. With a contact cooling the device allows maintenance of constant epidermis temperature, close to  $+5^{\circ}\text{C}$ , due to thermoelectric cooling. Cooling temperature is shown on device display and kept constant during long-term procedures. This unique method guarantees maximum safety, cooling control, patient comfort and eliminates the need for anesthesia [29].

BroadBand Light (BBL) (Fig. 14, c) is a system of high-intensity broadband light radiation for depilation, vessel pathology, benign pigment formations, photorejuvenation, treatment of acne, etc. The device employs integrated thermoelectric system for monitoring of cooling temperature of work instruments which provides for precise temperature control from  $0^{\circ}\text{C}$  to  $30^{\circ}\text{C}$  to an accuracy of  $1^{\circ}\text{C}$ . Large radiation range allows a wide spectrum of procedures without additional heads. Adapters of various sizes assure flexible adaptation even to skin areas difficult of approach [30].

HS 810 diode laser (Fig. 14, d) is used for laser epilation and rejuvenation of patient skin. To achieve prompt effect, HS 810 diode laser makes 10 laser flashes per second, making the epilation procedure less sensitive and painless. The apparatus utilizes thermoelectric cooling of a system with water reservoirs, as well as work instrument tip to the temperature of  $0\div 5^{\circ}\text{C}$ . Continuous operating mode of the apparatus is 24 hours [31].

Compact apparatus SkinPulse 500 (Fig. 14, e) is a desktop device intended for epilation by means of light pulses technology. It is helpful for treatment of skin vessel injuries, acme, pigmentation, and erythema. Contact cooling of local area of patient skin is done by means of thermoelectric modules and varies in the temperature range of  $-4^{\circ}\text{C} \div +10^{\circ}\text{C}$  [32].

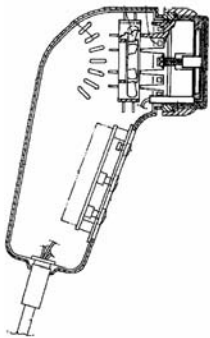
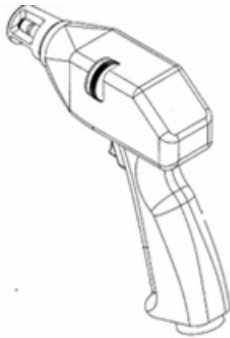
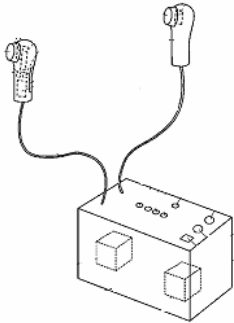
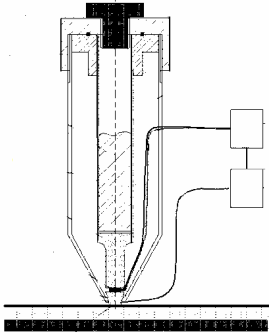
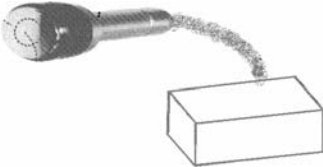
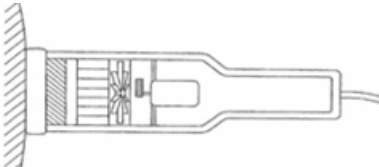
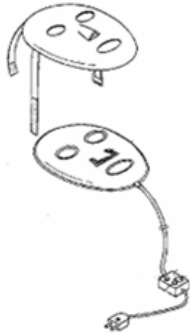
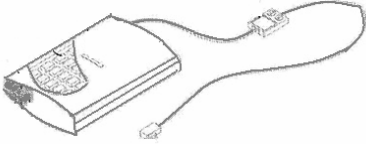
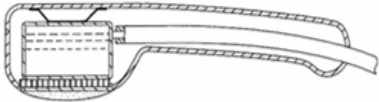
ProShockIce (Fig. 14, f) is a device reducing local depot fact and cellulite signs using Ice-shock-lipolysis technology. It is a novel method which consists in the reduction of subcutaneous fat and fibrous cellulite in the areas where only liposuction has been used so far. For the first time this technology employs a combination of two methods: cryolipolysis and shock wave effect of acoustic

waves. During local freezing of problematic area by means of special cooling head with imbedded thermopile, hardening and destruction of subcutaneous fat tissue takes place [33].

Table 2 lists examples of patented developments of thermoelectric devices for cosmetology (Fig. 15 – 23) [34 – 42].

*Table 2*

Patented developments of thermoelectric devices for cosmetology

 <p><i>Fig. 15. Cooling device (JP 2000037412A) [34].</i></p>	 <p><i>Fig. 16. Skin care device (KR 20100060222(A) [35].</i></p>	 <p><i>Fig. 17. Device for cooling local areas of face skin (JP 2012152307(A) [36].</i></p>
 <p><i>Fig. 18. Cryotherapy apparatus (JP 2006130055(A) [37].</i></p>	 <p><i>Fig. 19. Skin care apparatus (KR 20130043299(A) [38].</i></p>	 <p><i>Fig. 20. Device for face massage (KR 20010077967(A) [39].</i></p>
 <p><i>Fig. 21. Cosmetic mask (CN 1640370(A) [40].</i></p>	 <p><i>Fig. 22. Cooling belt (KR 20120090862(A) [41].</i></p>	 <p><i>Fig. 23. Device for cold and hot soaking therapy (US 6311497) [42].</i></p>

Thus, from the foregoing review of the literature it follows that today there are numerous developments of thermoelectric medical devices for dermatology and cosmetology. However, information is still lacking on the methods of using such devices and the expected treatment result. In particular, it is important to study the curative effect of moderate skin cooling. For this purpose, the work employs a device “ALTEC-7010” developed at the Institute of Thermoelectricity of the NAS and MES of Ukraine for treatment of skin diseases in the operating temperature range  $(-35 \div +5)^\circ\text{C}$  [43].

### Thermoelectric device for treatment of skin diseases “ALTEC-7010”

Device “ALTEC-7010” developed at the Institute of Thermoelectricity [43] is intended for cryomassage the mechanism of which lies in a stimulated effect on the microcirculation flow and skin nerve terminals, which ameliorates metabolic and reparation processes and accelerates the regression of inflammatory processes with chronic dermatoses. Owing to positive effect on the skin, cryomassage method is used in complex treatment of such skin diseases as patchy alopecia, acne rosacea and acne vulgaris, Vidal’s disease, skin itch, chronic eczema, lichen planus, flat warts, granulema annulare, etc. The general view of device is shown in Fig. 24.

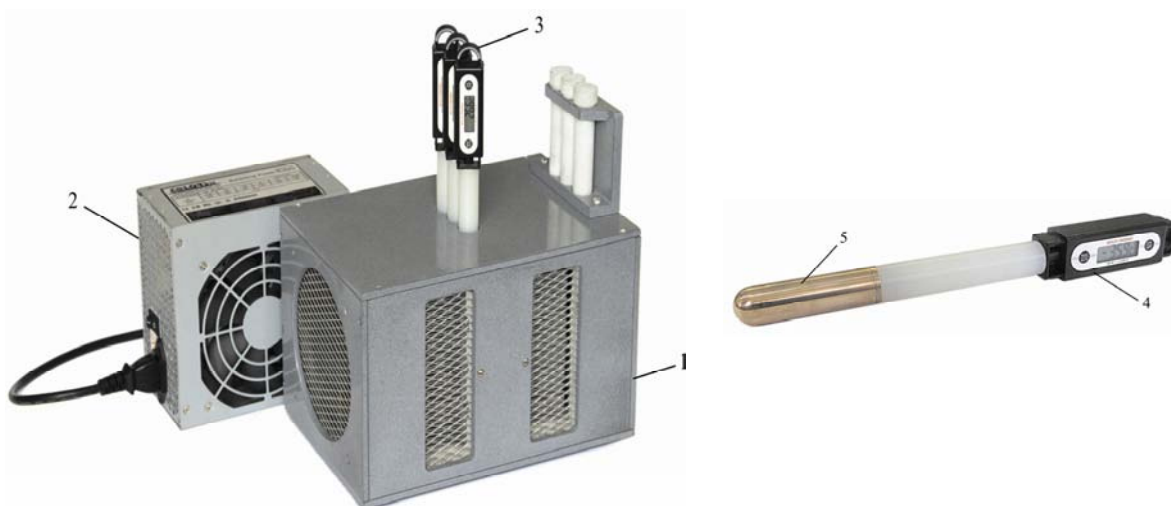


Fig.24. External view of thermoelectric device for treatment of skin diseases [43]:

- 1 – thermoelectric cooling unit, 2 – power supply unit,
- 3 – kit of work instruments, 4 – embedded electronic thermometer,
- 5 – cylinder container filled with a liquid with high heat capacity.

The device is composed of three main functional units: cooling unit 1, power supply unit 2 and a kit of work instruments 3 (Fig. 24). In turn, cooling unit has a case, cooling chamber for work instruments, two-stage thermoelectric modules “Altec-11” and air heat exchangers with the fans for cooling the hot sides of thermoelectric modules. Device work instruments comprise embedded electronic thermometers 4 with autonomous power supply sources and cylinder empty heads 5 with a liquid with high heat capacity.

The operating principle of “Atec-7010” device lies in cooling work instruments by means of thermoelectric Peltier modules. Cooled work instrument is used to produce a thermal effect on the respective areas of human skin. the advantages of this device include: the availability of electronic thermometers of work instruments for controlled thermal effect on the respective skin area, absence of work instruments connection to cooling unit and small dimensions of work instruments. Technical specifications of this device are given in Table 3.

*Table 3*

Technical specifications of device for treatment of skin diseases“ALTEC-7010”

№	Device technical characteristics	Parameter values
1.	Device operating temperature range	$(-35 \div +5) ^\circ\text{C}$
2.	Time to achieve temperature mode by device	10 min.
3.	Temperature measurement accuracy	$\pm 1 ^\circ\text{C}$
4.	AC current supply voltage of device	$(220 \pm 10) \text{ V}$
5.	Device power requirement	250 W
6.	Thermoelectric cooler dimensions	$(240 \times 160 \times 15) \text{ mm}$
7.	Work instrument dimensions	$(18.5 \times 23 \times 215) \text{ mm}$
8.	Work instrument weight	0.08 kg
9.	Device weight	6.5 kg
10.	Device continuous work duration	8 h.

From the known counterparts the most similar in technical characteristics is thermoelectric device for treatment of skin diseases [44] which is composed of supply unit, cooling unit and a kit of work instruments with replaceable tips of different shape. Cooling of work instruments takes place in cooling unit based on thermoelectric Peltier modules, the heat from the hot junctions of thermoelectric modules is rejected by cooling liquid flowing through liquid heat exchangers. The unique feature of this device is that the work instruments are galvanically isolated from the supply and cooling units. The device offers the opportunity to maintain the temperature of work instruments in the range of  $-50 \div 0 ^\circ\text{C}$ . However, the main disadvantages of this device is connection to central water supply, restricting its application potential, and the absence of temperature control of the surface of work instruments during therapeutic procedures.

The proposed device “Altec-7010” is different in that the heat from the hot sides of thermoelectric modules is rejected to environment by means of air heat exchangers, and each work instrument has an electronic thermometer with a digital display for temperature control of work instrument tip. This device allows therapeutic procedures under unstationary treatment conditions with a possibility of simultaneous visual control of work instruments temperature.

### **Results of clinical use of thermoelectric device for treatment of skin diseases “ALTEC-7010”**

Inspected were 24 patients (among them 19 women and 5 men) of the age from 19 to 69 years who suffered from chronic skin diseases (acne rosacea, acne vulgaris, patchy alopecia, psoriasis and lichen amyloidosis), the complex therapy of which employed cryomassage method with the use of thermoelectric device “Altec-7010”. Clinical investigations were performed at Department of Dermatovenerology of Bukovonian State Medical University. Examples of device clinical application are given below.

**Acne rosacea.** Acne rosacea were diagnosed in 9 persons. Acne rosacea is chronic dermatosis with a poly-factor etiopathogenesis resulted from the effect of external factors (alimentary, meteo- and professional factors, activity of Demodex mites) against the background of hormone, immune, metabolic, microcirculation disorders, etc. Dermatosis is localized on face skin, shown as erythema, surface vasodilatation (telangiectasia), small indurated nodes (papules), pustules. According to known



classification, 5 patients had erythematic-papular-pustular form of rosacea, 4 persons – erythematic-papular form of dermatosis. All the patients were prescribed standard dermatosis therapy which included methods of systemic and external (topical) actions, as well as cryomassage method with the use of thermoelectric device “Altec-7010” – immediately for patients with the erythematic-papular form of dermatosis, and for patients with erythematic-papular-pustular form only after the regression of pustules (on the 6 – 7 day after the initiation of treatment).

Cryomassage sessions were prescribed for 30 – 40 seconds 2 – 3 times on each area (with total exposure 10 min) daily for 5 days and every second day during the next 10 – 12 days (altogether 10 – 11 procedures per course). The dynamics of rash elements regression with patients suffering from acne rosacea as a result of employment in complex therapy of cryomassage sessions with the use of thermoelectric device “Altec-7010” (in scores according to known classification of V.P. Adaskevich, 2004 [45]) is represented in Fig. 25 and in the pictures in Fig. 26.

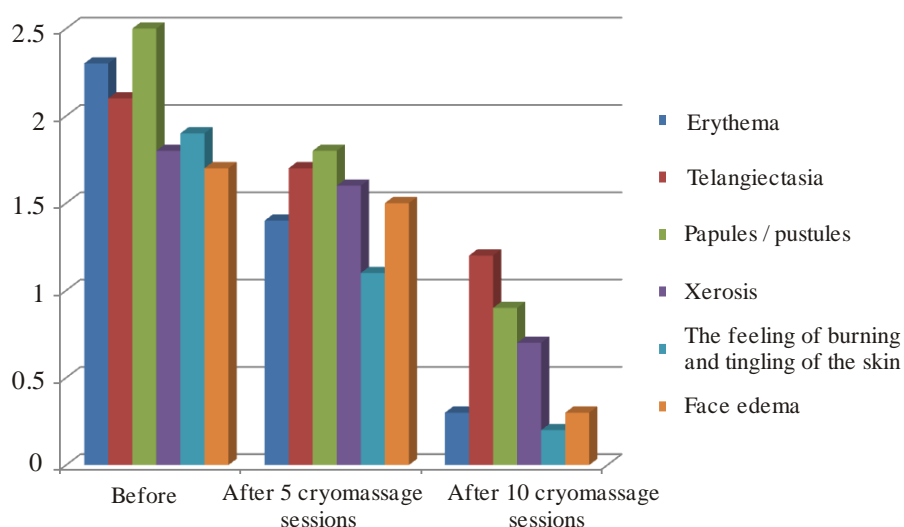


Fig. 25. Dynamics of rash elements regression with patients suffering from acne rosacea due to cryomassage with the use of thermoelectric device “Altec-7010” (in scores according to V.P. Adaskevich’s classification, 2004 [45]).

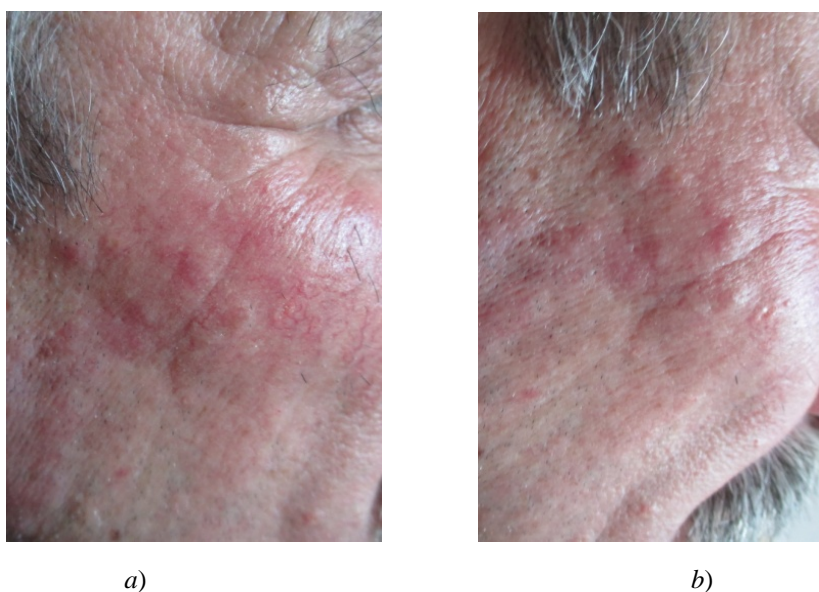


Fig. 26. Patient K., 69 year. Diagnosis: Acne rosacea, erythematic-papular form, prior to (a) and after (b) the course of treatment (disappearance of greater part of telangiectasias, size reduction of papular rash elements).

**Acne vulgaris.** Acne vulgaris were diagnosed in 11 patients. Acne vulgaris is a polyetiologic chronic skin disease caused by a number of microorganisms (Propionibacterium acnes, Staphylococcus epidermidis and other cocci), developed against the background of neuroendocrinal, immune, metabolic disorders, microcirculation disorders, etc. Dermatitis is localized on the skin of face, shoulders and body, is manifested as comedones, popular acne, pustular acne, nodes (indurative, acne conglobata). According to severity, there can be light, mean and severe forms of acne [46]. Among the investigated patients, acne vulgaris of mean severity were diagnosed in 7 persons, severe form was diagnosed in 3 persons and light form – in 1 person. All the patients were prescribed standard dermatosis therapy which included methods of systemic and external (topical) actions, as well as cryomassage method with the use of thermoelectric device “Altec-7010” (Fig. 27).



Fig.27. Patient N., 19 years. Diagnosis: Acne vulgaris, mean severity.

Patients suffering from acne vulgaris were prescribed cryomassage sessions for 30 – 40 sec 3 – 4 times on each area (with total exposure time 10 min) daily for 5 – 8 days and every second day 10-12 days (total course – 11 – 14 procedures). According to the dynamics of rash elements regression on completion of treatment course, a light degree of acne vulgaris was diagnosed in 4 patients, mean degree – in 6 patients and severe form – in 1 patient (Fig. 28).

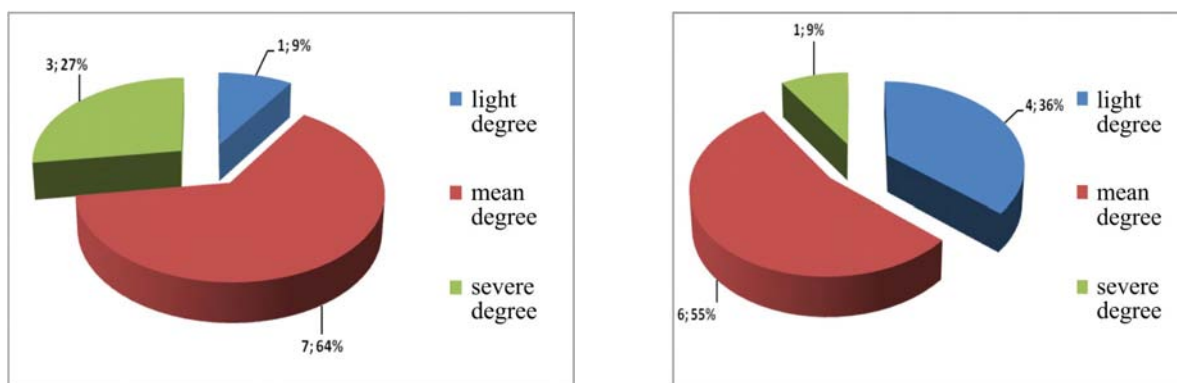
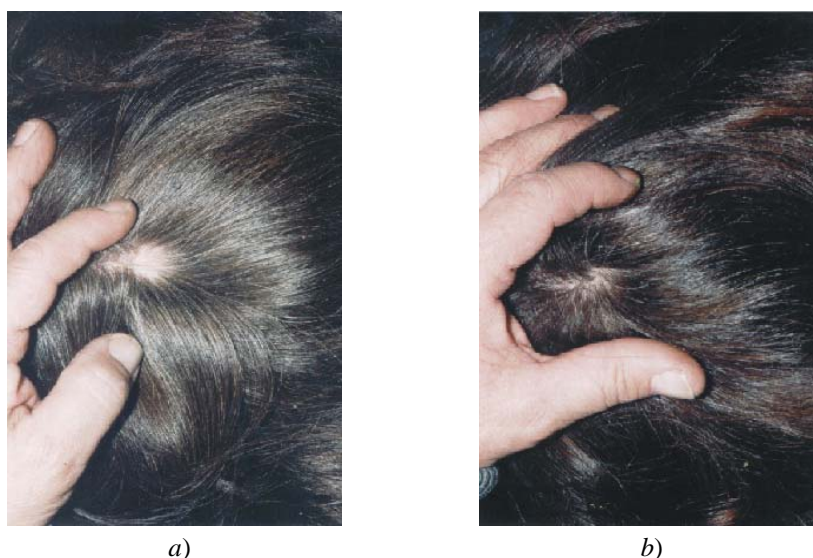


Fig.28. Distribution of patients suffering from acne prior to and after treatment according to dermatosis severity.

**Patchy alopecia (circumscribed)** was diagnosed in 2 patients. Dermatitis has a multi-factor pathogenesis and is created, as a rule, against the background of combined co-morbidity of inner organs, chronic sites of focal infection, etc. Treatment of this disease provides for complex

observation of patient and correction of diagnosed co-morbid pathology. Cryomassage has long since been an important component of this dermatosis treatment.

Patients suffering from patchy alopecia were prescribe cryomassage sessions for 40 – 50 seconds in 2 – 3 steps for 5 min daily (total course – 15 – 20 procedures). In a month, on completion of treatment, a refresher course of treatment by the same scheme was prescribed. The results of patient treatment after 5 months are represented in Fig. 29.



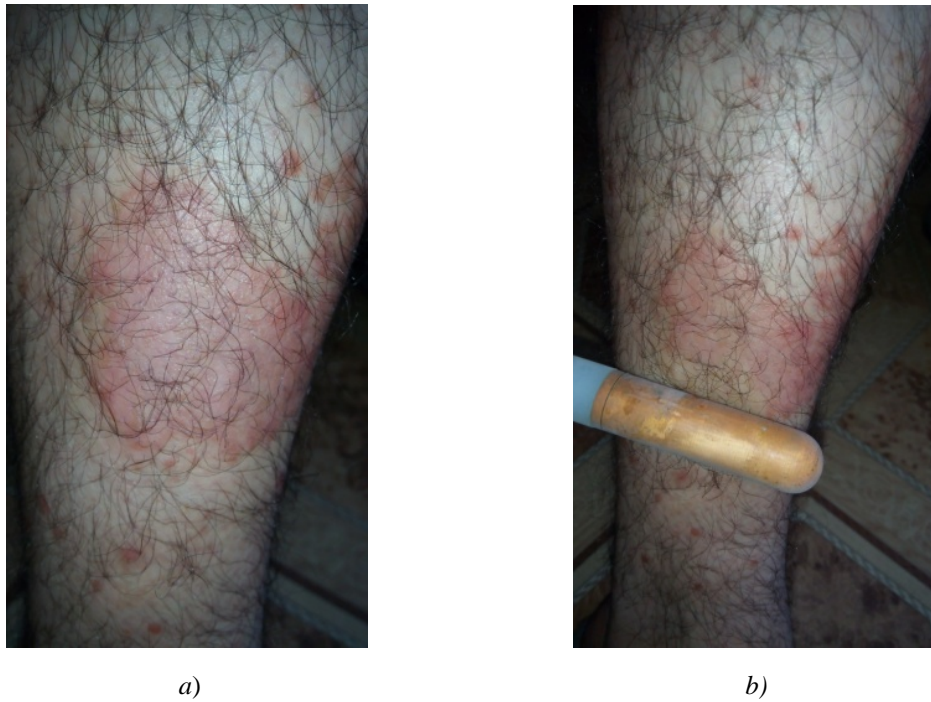
*Fig. 29. Patient M., 39 years. Diagnosis: Patchy alopecia of hair area (prior to (a) and after (b) 5 months of treatment).*

**Psoriasis** is a common chronic skin disease characterized by benign hyperproliferation of surface skin layers with formation of inflammatory plaques and massive lamellar exfoliation of their surface. There are progressive, stationary and regression stages in the course of this disease. Complex therapy of such patients widely employs phototherapy which has a cytostatic effect, namely it suppresses a hypernormal division of cells. Physiotherapy methods are recommended to be used during stationary dermatosis stage and regression stage. Information on using cryotherapy methods in the available home literature was not found. We used this method for patient with the diagnosis: common psoriasis, exudative form, regression stage. The dermatosis of this patient had a lengthy torpedo course that did not respond easily to standard treatment methods. After 3 weeks of standard therapy, moderately infiltrated plaques remained on the skin of lower limbs, for which cryomassage sessions were prescribed with the use of thermoelectric device “Altec-7010” (Fig. 30).

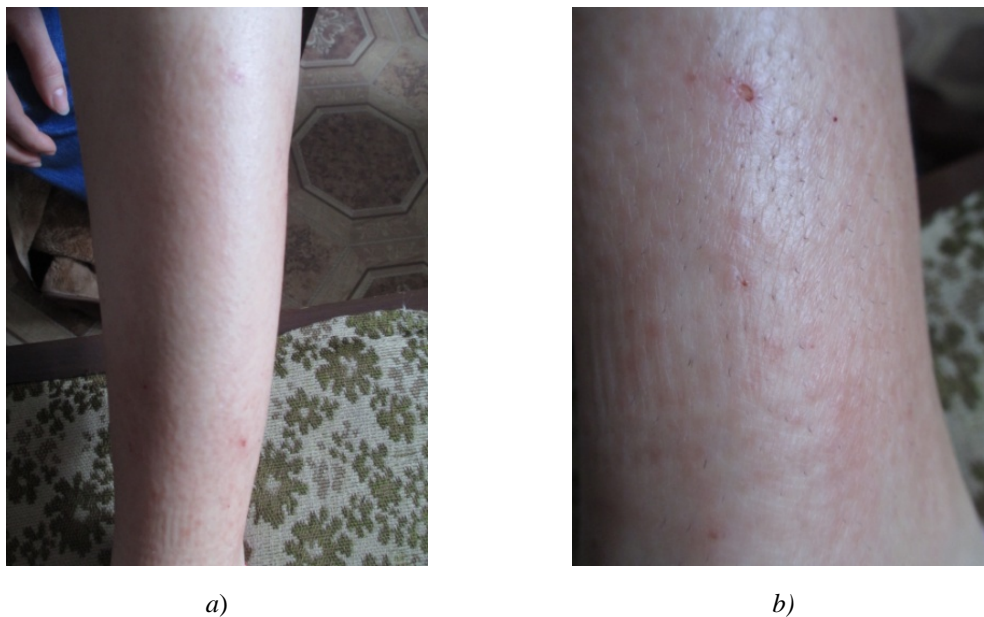
Patients suffering from psoriasis were prescribed cryomassage sessions for 30 – 40 sec in 2 – 3 steps for 5 min daily (total course – 10 procedures, following which the process on the skin was gradually solved, and only signs of secondary hyperemia remained.

**Lichen amyloidosis** is a rare skin disease occurring as a consequence of metabolic, neuroendocrinal and microcirculation disorders with formation mostly on the legs skin of small semiround nodes accompanied by intensive itch.

Patient C., 29 years was the case with a diagnosis: lichen amyloidosis of legs. In parallel with standard therapy, the patient was subject to a course of cryomassage with the use of thermoelectric device “Altec-7010” for 30 – 40 sec in 3 – 4 steps for 8 min daily (total course – 10 procedures), following which the status of skin was considerably ameliorated, the itch practically ceased, and papules on the skin became flat (Fig. 31).



*Fig. 30. Patient T., 53 years. Diagnosis: Common psoriasis, exudative form (a), regression stage (b).*



*Fig.31. Patient C., 29 years.  
Diagnosis: lichen amyloidosis of legs (prior to(a) and after(b) treatment course).*

On completion of treatment course, the patient was recommended to repeat the therapy course in 3 – 4 weeks with the use of regression cryomassage by thermoelectric device “Altec-7010”.

## **Conclusions**

1. Analysis of current status of using thermoelectric devices for treatment of various skin diseases in dermatology and cosmetology has been made. The priority lines of using such devices have been determined and their technical specifications have been given.

2. It has been established that thermoelectric devices can be used in dermatology and cosmetology with curative purpose, in particular, for treatment of chronic dermatoses (acne rosacea, acne vulgaris, residual symptoms of psoriasis, patchy alopecia and other skin diseases). This is because thermoelectric devices are convenient in application, do not require additional maintenance on operation, and easily realize temperature control of work instruments.

3. It has been established that thermoelectric device for treatment of skin diseases "Altec-7010", providing for cooling of work instruments to  $-35^{\circ}\text{C}$ , makes it possible to perform cryomassage in a complex therapy of chronic skin diseases, nevertheless, its design should be improved for the purpose of expanding its operating temperature range and treatment efficiency.

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