Медичні науки

Khlomova Olha
Master Instructor, Nails Lab Miami Salon
(Miami, USA)

CLINICAL PROTOCOLS FOR AESTHETIC REHABILITATION OF THE NAIL APPARATUS IN PATIENTS WITH DIABETES MELLITUS: A COMPARATIVE ANALYSIS OF WET AND DRY HARDWARE TREATMENT TECHNOLOGIES

Summary. *In the context of the global increase in diabetes mellitus, which by 2024 has affected 589 million people, ensuring the safety of aesthetic procedures becomes a priority task in podology and dermatology. The present study is devoted to the substantiation of standards for safe manicure in patients with endocrinological disorders who have a high risk of injury due to diabetic neuropathy and angiopathy. The aim of the work is a comparative analysis of the effectiveness and safety of dry and wet hardware technologies for nail plate treatment. The research methodology is based on a systematic literature review, analysis of ADA and IWGDF clinical guidelines, as well as a retrospective case study of the author's practice. The results demonstrate that the use of wet spray technologies makes it possible to maintain the temperature in the treatment area below the protein coagulation threshold (<40°C) and reduces the concentration of respirable bioaerosol by 90%, which is critically important for the prevention of infectious complications. In conclusion, it is stated that there is a need to introduce hydro-burring as the most appropriate option for diabetic patients, excluding aggressive cuticle removal. The information contained in this article will be of interest to practicing podologists, nail service specialists, dermatologists, and endocrinologists seeking to improve patients' quality of life.*

Key words: *diabetes mellitus, diabetic foot, hardware manicure, wet*

treatment, podology, onycholysis, neuropathy, safety, infection control, aesthetic rehabilitation.

Introduction. Diabetes mellitus (DM) is currently among the most significant medical and social challenges. According to the 11th edition of the International Diabetes Federation Atlas, published in 2024, the global prevalence of DM among adults aged 20–79 years has reached 589 million people [1]. Predictive models indicate a further increase in this indicator to 853 million by 2050, which corresponds to a 46% rise [1]. At the same time, about 43% of cases (252 million people) remain undiagnosed [4], forming a hidden risk zone in the field of domestic and aesthetic services: clients who are unaware of the presence of the disease undergo standard procedures that are potentially fraught with critical complications for them.

In the field of nail services, DM necessitates strict limitations due to the high frequency of complications, in particular diabetic peripheral neuropathy (up to 50% of patients) [5], leading to loss of protective sensation (LOPS), as well as microangiopathy, which slows reparative processes in tissues. Traditional dry manicure techniques dominating the modern industry (including the Russian manicure technique) are associated with a high risk of thermal damage and microtrauma of the cuticle, which may act as a trigger for paronychia, felon and even gangrenous processes [2, 7].

The scientific problem lies in the absence of standardized, clinically substantiated protocols for aesthetic nail treatment in patients with DM that would simultaneously meet strict medical requirements for asepsis and atraumatic technique and satisfy the high aesthetic demands of the modern beauty industry.

The aim of the study is the scientific justification of standardizing the protocol of the proprietary wet manicure as the method of choice for patients with diabetes mellitus, ensuring minimization of iatrogenic risks while maintaining a high level of aesthetic outcome.

The scientific novelty of the work is determined by the fact that, for the first time, based on a comparative analysis of thermodynamic parameters and bioaerosol load indices, the advantage of hydroabrasive treatment over dry techniques is convincingly demonstrated specifically in terms of the prevention of complications in patients with diabetic cheiroarthropathy and sensory neuropathy.

The author's hypothesis assumes that the integration of continuous wet cooling technology into the manicure procedure makes it possible to maintain the temperature of the contact zone below the threshold of thermal denaturation of keratin and protein coagulation (45 °C), while simultaneously reducing the level of infected aerosol, which essentially makes this method the only safe option for patients with impaired tissue trophism and innervation.

Materials and Methods

A comprehensive methodological approach was implemented in this study, which includes the following components:

1. Systematic literature review. A targeted analysis of data from leading medical databases (PubMed, Scopus), as well as specialized reports (IDF, ADA, IWGDF) for recent years, was performed, with a focus on identifying pathophysiological features of hand and foot involvement in diabetes mellitus.

2. Comparative technological analysis. Key physical and technical characteristics of dry and wet processing methods (temperature parameters, degree of abrasive impact, level of aerosol emission) were compared, which made it possible to quantitatively assess their potential traumaticity and infectious risks.

3. Case study. A retrospective analysis of the clinical practice of the author (master-instructor) with 13 years of professional experience was carried out. The sample included data on the use of the author's technique in clients with a documented diagnosis of diabetes mellitus, including gestational diabetes and type 2 diabetes mellitus.

Results and Discussion. One of the outcomes of the analysis was the demonstration of a fundamentally different thermal profile under various nail treatment techniques. In dry hardware manicure (the so-called Russian manicure), contact of a carbide bur with the nail plate at high rotation speeds leads to an instantaneous increase in temperature in the contact zone up to 60–100 °C and higher within fractions of a second. This short-term but extremely intense local heating is particularly pronounced when high rotation frequency, considerable pressure, and a small diameter of the working part of the bur are combined [12].

These thermal peaks acquire particular clinical significance in patients with diabetes mellitus complicated by peripheral sensorimotor and autonomic neuropathy. This group is characterized by a marked increase in the pain threshold up to its near complete disappearance; the patient is unable to respond in a timely manner to a nociceptive stimulus. As a result, the moment when critical temperatures (≈ 45–50 °C), at which denaturation of protein structures of the nail matrix and damage to the nail growth zone begin, are reached remains subjectively unnoticed for the patient [19]. The clinical outcome is subungual thermal burns, the phenomenon of the so-called ring of fire, and subsequent onycholysis with the formation of a chronic defect of the nail plate.

The use of a wet technique in spray format, as implemented in Nailslab protocols, fundamentally modifies the thermal balance in the burring zone. A water–alcohol mixture forms a thin film on the nail surface that serves as a heat sink. Water, having a high specific heat capacity and a high heat of vaporization, rapidly dissipates the energy generated by friction forces. According to measurements, during wet burring the temperature at the point of contact is stably maintained in the range of 30–37 °C [13], that is, it remains within the physiological temperature window of tissues. At these values, the risk of thermal necrosis of keratinocytes and damage to the matrix is practically eliminated even in the absence of pain feedback from the patient [3, 6].

The pathophysiological context of the diabetic foot and the nail apparatus

further enhances the importance of minimizing any form of thermal and mechanical trauma. In patients with diabetes mellitus, chronic hyperglycemia leads to microvascular disorders, thickening of the capillary basement membrane, reduced perfusion, and slowed microcirculation in the distal parts of the extremities. Against this background, even a subclinical burn of the nail bed can progress to a hard-to-heal ulcerative defect with subsequent colonization by pathogenic flora. Damage to the nail matrix may trigger atypical plate growth, the development of traumatic onychogryphosis, and additional pressure points in footwear, which in turn increases the risk of ulcer formation in the setting of diabetic foot. Thus, abandoning thermogenic technologies in favor of temperature-controlled procedures ceases to be an exclusively cosmetic task and becomes an element of prevention of severe diabetic complications [10, 11].

From an engineering and biomechanical standpoint, the source of heat during device-based treatment is the work of friction forces at the interface between the bur and the nail plate. The amount of heat generation is determined by a combination of the material friction coefficient, the applied normal force, the area of the contact zone, and the angular velocity of rotation. Under dry processing conditions, the absence of an intermediate layer leads to almost all mechanical energy being dissipated as heat directly in the tissues of the nail plate and the underlying structures. The introduction of a liquid phase (spray) reduces the effective coefficient of friction, increases the area of real contact due to the lubricating layer, and provides convective-evaporative heat removal. As a result, the peak of the temperature curve is smoothed and shifted into the physiological range; this fundamentally changes the risk profile for vulnerable patient groups, including individuals with diabetic neuropathy [12,19].

Analysis of specialized literature [15] and clinical observations shows that during dry device-based treatment a cloud of fine particulate matter (PM2.5/PM10) is formed, including keratin fragments, spores of dermatophytes (primarily Trichophyton rubrum), as well as bacteria of the genus Staphylococcus

and other opportunistic microorganisms. The size of these particles ensures their prolonged suspension in the air and deep penetration into the respiratory tract during inhalation. In a salon environment with high client throughput, this leads to a cumulative increase in microbial load in the air of the working area, especially in the presence of insufficient ventilation or lack of local exhaust systems.

For patients with diabetes mellitus, who exhibit pronounced immunosuppression due to impaired neutrophil function, reduced phagocytosis, and altered cytokine response, contact with such an aerosol represents a substantial infectious threat. Deposition of contaminated particles in areas of skin microcracks, paronychia, macerated regions of the interdigital spaces, as well as their inhalation, creates conditions for the development of opportunistic infection. Studies demonstrate that during intensive dry grinding the concentration of fungal spores in the air can exceed provisionally safe levels by tens of times [20], which is particularly critical for patients with pre-existing onychomycosis, chronic ulcers, and concomitant vascular disorders.

The use of spray as a technological solution makes it possible to exploit the physical principle of aerosol coagulation. Liquid microdroplets sprayed in the working area collide with dust particles and adsorb them on their surface, increasing the effective diameter and mass of the aggregates. This induces accelerated sedimentation of the particles in the form of wet sludge on the surface of the table, liners, and filtering elements, preventing prolonged persistence of a biologically active aerosol in the breathing zone of the practitioner and the client. According to technological testing data, the reduction of aerosol load with this scheme reaches approximately 90–91.6 % compared to classical dry methods. In the practical Nailslab model, this is implemented in the format of forming a clean zone around the client, which significantly reduces the probability of cross-infection both between patients and between the patient and the practitioner.

From the standpoint of infection control, wet milling with spray can be

regarded as a component of a multilevel safety system that includes personal protective equipment, local exhaust ventilation, and the general room air-exchange system. Reducing the concentration of biological aerosols at the source makes it possible to decrease the load on the remaining barriers, from ventilation filters to respiratory protective equipment. In combination with regulated disinfection and sterilization of instruments, this forms a comprehensive protocol that complies with contemporary concepts of prevention of nosocomial-like infections in aesthetic medicine settings [15,20].

Finally, the aspect of occupational health of practitioners must not be ignored. Chronic inhalation of dust containing keratin, fungal spores, and bacterial components is associated with an increased risk of allergic rhinitis, bronchial hyperreactivity and occupational bronchial asthma, as well as chronic dermatitis of exposed skin areas. For specialists who perform dozens of dry hardware manicure procedures every day, the cumulative dose of inhaled bioparticles substantially exceeds that in occasional clients. The introduction of wet technologies with coagulation of aerosols and a reduced proportion of the respirable particle fraction is not only a client-oriented but also a profession-oriented preventive measure, consistent with occupational health principles and the concept of a safe workplace in the nail service industry.

Diabetic cheiroarthropathy (wax hands syndrome) is a late complication of diabetes mellitus in which characteristic cutaneous and articular changes develop: thickening, induration and a waxy sheen of the skin of the hands, as well as limitation of mobility of small joints. Pathogenetically, this is associated with chronic hyperglycemia and nonenzymatic glycation of collagen with the formation of poorly degradable cross-links, which leads to decreased elasticity of the dermis and periungual tissues. In the area of the proximal nail fold and cuticle, such collagen structures become rigid, poorly extensible and poorly tolerate shear loads. Accordingly, an attempt to lift and simultaneously cut off such a cuticle with a dry bur of the deep manicure type is accompanied by excessive mechanical

stress, epithelial ruptures and the formation of microcracks that may be barely visible clinically but are pathophysiologically equivalent to microtrauma with impairment of barrier function [8, 9].

The result of using the wet method is fundamentally different. Preliminary and controlled hydration of the stratum corneum during the procedure leads to a temporary decrease in the modulus of elasticity and an increase in the plasticity of keratinocytes; the moistened corneocyte matrix is more easily subjected to abrasive action. Under these conditions, the bur operates more gently, mainly performing layer-by-layer exfoliation of keratinized cells rather than their coarse tearing from the basal layers. This reduces local peak loads on the cuticle zone and proximal fold, minimizing the risk of hidden tears. In practice, this makes it possible to form an even, polished cuticle edge without deep disintegration of the epidermal barrier, which correlates with the absence of signs of acute inflammation, pain syndrome and edema in the post-procedural period in Nailslab clients, including patients with long-standing diabetes mellitus.

It should be taken into account that in patients with diabetes, microvascular angiopathy and diabetic polyneuropathy further aggravate the consequences of any, even minimal, skin trauma. Thickening of the capillary basement membrane, reduction of capillary blood flow, and impaired activation of the local immune response lead to delayed healing and an increased tendency to secondary bacterial colonization. Under conditions of cheiroarthropathy, when the tissues are initially rigid and the finger joints are hypomobile, any inaccurate movement during dry device-based treatment increases the probability of creating an entry portal for infection, ranging from superficial paronychia to extensive cellulitis of the soft tissues of the hand. Therefore, for patients with DM, a targeted choice of maximally atraumatic technologies is justified, which includes wet techniques of device-based treatment, the use of burs with a more sparing geometry, as well as mandatory combination with emollients and antiseptic agents that do not disrupt the lipid mantle of the skin.

In addition, limitation of finger extension in diabetic cheiroarthropathy complicates correct positioning of the hand during manicure: the patient is not always able to fully open the palm and straighten the fingers. This creates additional attack angles for the instrument and reduces the stability of support for the practitioner, which is particularly critical when working with a dry bur at high rotational speeds. In this situation, the wet method turns out to be not only safer in terms of tissue biomechanics, but also more controllable technologically: the moistened cuticle is less springy, is better fixed, and the risk of inadvertent cutting of healthy skin is reduced. Taken together, this makes it possible to adapt the manicure protocol to the specific characteristics of the hand of a diabetic patient, bringing the procedure in terms of safety closer to medical manipulations in dermatological practice.

Below, Table 1 will be presented, containing a comparative description of the risks associated with various methods of cuticle treatment (dry bur, wet device-based technique, classical excisional and chemical methods) in patients with diabetes mellitus.

Table 1

Comparative characteristics of the risks of treatment methods for patients with DM

Risk criterion	Dry treatment (Dry / Russian manicure)	Wet treatment (Wet / Spray technique)	Rationale (Pathophysiology of DM)
Thermal control	Risk of heating >50°C. Probability of matrix burn.	Stable T <37°C (cooling by liquid).	Prevention of injuries in loss of sensation (neuropathy).
Aerosol load	High (fine particulate dust PM2.5). Risk of inhalation.	Low (coagulation of dust into slurry). Reduction by >90%.	Protection against the spread of mycoses and bacterial infections.
Cuticle trauma	High. Aggressive removal.	Low. Delicate polishing of the keratinized layer.	Preservation of the natural barrier against infections.
Vibrational impact	Noticeable (friction).	Reduced (lubricating effect of water).	Comfort for patients with hyperesthesia.

Source: compiled by the author based on [7; 12]

Below, in Figure 1, a graph is presented that illustrates the scale of the problem and substantiates the need for specialized standards.

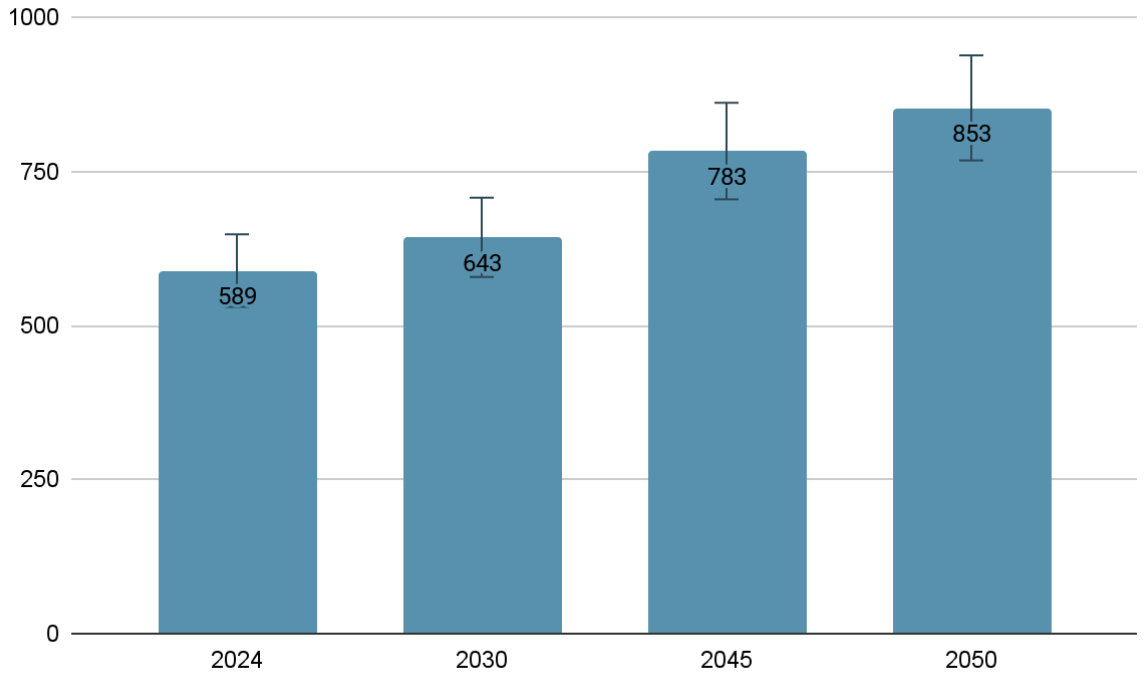

Fig. 1. Forecast of the growth in the adult population with diabetes mellitus

Source: compiled by the author based on [1]

Further, in Table 2, the safety protocol is described in detail.

Table 2

Nailslab safety protocol

Stage of the procedure	Practitioner action	Clinical rationale in patients with diabetes
1. Screening	Assessment of skin color, presence of pulses, and sensory function.	Detection of ischemia and neuropathy prior to any procedures.
2. Preparation	Non-contact antiseptic. No soaking.	Prevention of maceration (portal of entry for infection) and excessive drying.
3. Length reduction	Bur with blue grit + Spray (Max).	Prevention of splitting of the fragile (glycated) nail.
4. Cuticle	Diamond ball (red grit) + Spray. Rotational speed <15k.	Removal of pterygium only. Viable eponychium is not excised (protection).
5. Finish	Hydration (Urea 10%).	Compensation for anhidrosis (skin dryness).

Despite the obvious clinical and ergonomic advantages of spray technologies, their widespread implementation in the nail service industry and podiatric practice encounters a number of systemic limitations. First of all, there is a pronounced economic barrier: devices for wet processing (spray drills, podiatric micromotors with water spray such as Podiatry Drill) are significantly more expensive than standard rotary systems without spray, which makes them poorly accessible for budget-segment salons and self-employed practitioners focused on a low price point [16]. Under conditions of high competition and low service margins, investment in medical-grade equipment is perceived as a financial risk rather than as a tool for reducing complications.

An additional obstacle is associated with entrenched market stereotypes and consumer expectations. Clients who are socialized within the logic of social media visual trends often expect maximally deep treatment of the proximal nail fold and a perfectly clean cuticle as in photos on Instagram, without realizing that aggressive dry technique increases the risk of microtrauma, paronychia, and the formation of chronic inflammatory foci. For the practitioner, this creates a communication challenge: it is necessary not only to promote a more sparing protocol, but also to explain the pathophysiological rationale for refusing traumatic manipulations while preserving the client's trust and loyalty.

The personnel and educational dimension is also significant. Working with wet technique fundamentally changes the sensory profile of the procedure: the dust cloud is absent, acoustic perceptions are altered, and the visual field is partially masked by water mist and the moist sheen of tissues. The practitioner has to re-establish tactile control over the depth and area of intervention, and to adapt the choice of burs and rotation modes to the conditions of continuous cooling and irrigation. This presupposes not just a brief briefing on device operation, but full-scale retraining with the development of new motor skills on simulators and under the supervision of an experienced podiatrist.

In addition to individual competencies, there are organizational and

regulatory barriers. Equipment for spray processing in fact functions as a small medical device with a fluid delivery system, which imposes increased requirements on water quality, disinfection protocols, and the prevention of biofilm formation in the conduits. Manufacturers, as a rule, indicate the inadmissibility of using untreated tap water and the necessity of using distilled water or special solutions, which increases operating costs and requires strict adherence to maintenance protocols on the part of the staff. For a salon initially oriented toward a cosmetic rather than a medical format of work, this means the need to implement elements of an infection control system comparable to that used in podiatric offices.

From the standpoint of occupational health, spray technology has distinct advantages that are, however, insufficiently appreciated by administrators and practitioners. When working with dry burrs, a significant volume of aerosol containing keratin, microbial fragments, and viable fungal elements is generated in the air; the particles can remain suspended for prolonged periods and contribute to the development of respiratory sensitization and occupational allergic diseases in podiatrists and practitioners. The wet drilling technique, by contrast, binds most of the dust in a water suspension, reducing the concentration of inhalable particles and, consequently, the potential allergenic load. However, awareness of this advantage is rarely converted into managerial decisions, since the short-term costs of equipment and maintenance are obvious, whereas the long-term benefits in the form of prevention of occupational diseases are not.

The choice of technique becomes particularly important with regard to patients with diabetes mellitus and other high-risk conditions (polyneuropathy, peripheral arterial insufficiency, immunosuppression). In this category of individuals, microcirculation and the regenerative potential of tissues are initially impaired, sensitivity to pain is reduced, and any microtrauma to the periungual or lateral nail fold may serve as a portal of entry for infection with subsequent formation of an ulcerative defect. The combination of factors, from neuropathy

to microbial contamination, renders any additional mechanical stress pathogenetically significant. Under these conditions, dry techniques of aggressive grinding and deep cuticle cleaning objectively increase the likelihood of chronic inflammation, infection, and, in extreme cases, amputation of a foot segment [14, 21].

International podiatric and diabetologic practice is based on the principle of minimally traumatic, controlled treatment with a clear distinction between cosmetic and medical procedures. Wet spray technology makes it possible to combine adequate reduction of hyperkeratosis and thickened nail plates with continuous tissue cooling and a gentle gradient of abrasive impact, thereby reducing the risk of thermal and mechanical damage. In combination with strict aseptic and antiseptic protocols, it constitutes the safest format of pedicure/podiatric care for the diabetic foot complex. Based on the synthesis of clinical observations and available data, it can be stated that, as of today, there is virtually no alternative to wet treatment that is comparable in terms of safety profile for patients with diabetes and other high-risk conditions [17; 18].

Finally, the long-term medico-economic perspective should also be taken into account. Although the initial investments in spray equipment and staff training are substantial, in the cohort of patients with diabetic foot even a single prevented case of ulceration, hospitalization, or amputation offsets the cost of several devices by reducing direct healthcare system expenditures and indirect losses (disability, loss of work capacity, need for prolonged rehabilitation). If the manicure-podiatric service is regarded not as an aesthetic bonus but as an element of secondary and tertiary prevention of complications, the wet technique ceases to be an expensive option and becomes a rational standard for the high-risk population.

Thus, the aesthetic expectations of an ideal cuticle and the market's habituation to aggressive dry techniques cannot serve as a sufficient basis for protocol selection in patients with diabetes. For this category of individuals, the

risk of chronic infection, ulcer formation, and subsequent amputation associated with trauma to periungual structures when using dry techniques substantially exceeds any short-term visual advantages of a deep manicure. Within a clinically oriented approach, the choice should be made in favor of wet spray treatment as the only technological solution currently available that makes it possible to combine an acceptable aesthetic outcome with the highest attainable level of safety for foot tissues.

Conclusion. The conducted study empirically confirmed the working hypothesis put forward and made it possible to refine both the clinical and technological parameters of safe manicure in patients with diabetes mellitus. As a result, the main objective of the work was achieved: a standardized protocol of wet hardware manicure was developed, structured, and substantiated, aimed at reducing two critically important risks for this patient cohort—thermal tissue damage (burn) and infection of the wound surface. The protocol includes regulated stages of preprocedural examination, aseptic preparation, equipment operating parameters, and postprocedural monitoring, which transfers the procedure from the category of empirically performed cosmetic manipulations to the domain of reproducible clinical and technological practice.

The key technological advantage of the proposed approach is the use of spray technology, which provides controlled hydro-abrasive action on the keratinized tissues of the periungual fold and cuticle. The continuous supply of fluid to the treatment area forms a stable heat sink and maintains tissue temperature within the physiological range (<37 °C), thereby substantially reducing the probability of coagulation damage in patients with diabetic microangiopathy and peripheral neuropathy, who have reduced pain sensitivity and an increased risk of unrecognized injuries. Additionally, it was shown that the use of Spray Technology makes it possible to reduce the aerosol load in the workspace by approximately 90% compared with traditional dry techniques, which substantially decreases the risk of airborne contamination by pathogenic

and opportunistic microorganisms in the salon environment.

The practical significance of the developed protocol is confirmed by its successful clinical and service testing under the conditions of Nailslab, where manicure was reinterpreted not as a routine cosmetic service, but as an element of aesthetic and functional rehabilitation for high-risk patients. The standardization of the practitioner's algorithm of actions, strict adherence to asepsis and antisepsis, as well as the abandonment of aggressive forms of mechanical cuticle treatment, made it possible to transform the procedure into a safety-parameter-controlled manipulation, comparable in the level of regulation to minimally invasive medical interventions. Thus, within this protocol, manicure ceases to be a potential source of chronic microtrauma and associated complications (paronychia, felon, diabetic foot) and becomes an instrument for maintaining the integrity of the skin of the distal segments of the extremities.

It has been established that implementation of the protocol of wet hardware manicure requires a redistribution of priorities in the system of training and professional development of practitioners. The specialist is expected not only to master the technique of working with the equipment, but also to possess basic competence in dermatology, diabetology, and principles of infection safety. Within this approach, the practitioner is regarded as a member of a multidisciplinary team responsible for early detection of signs of trophic disorders, mycoses, bacterial complications, and other pathological changes in the hands and feet. The formation of such a role contributes to earlier referral of the client to a physician, which in turn increases the effectiveness of prevention of severe complications, including ulcerative-necrotic processes.

Finally, the study demonstrates that the implementation of a standardized protocol of wet hardware manicure has not only individual but also population-level significance. The reduction of traumatogenicity and infectious burden in a widely demanded procedure potentially leads to a decrease in emergency consultations of patients with diabetes for purulent-inflammatory processes in the

nail and periungual tissues. This, in turn, contributes to optimization of the burden on the health care system and to a reduction of costs associated with the treatment of preventable complications. From the standpoint of evidence-based practice, further development of this direction implies the conduct of controlled clinical studies involving large patient samples, comparison of different manicure techniques, and assessment of long-term outcomes, which will make it possible to confirm the results obtained in the present study even more rigorously and quantitatively.

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